Effectiveness of *Trichogramma chilonis* (Ishii) against Sugarcane Stem Borer, *Chilo infuscatellus* (Snell) in Different Sugarcane Varieties

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Abstract

These studies were conducted to find out the efficacy of different release methods of *Trichogramma chilonis* (Ishii) in different sugarcane varieties for the management of sugarcane stem borer, *Chilo infuscatellus* (Snell) in sugarcane plant crop. The results showed that the infestation of *C. infuscatellus* in different sugarcane varieties started in April and continued till the end of the October. Significantly lowest percent infestation of *C. infuscatellus* (1.76%) was recorded in variety CP-77/400 followed by SPSG-79 (2.80%). While significantly highest percent infestation (3.36%) of *C. infuscatellus* was recorded in variety Mardan-92. The data also showed significant differences in the different release methods of *T. chilonis*. Significantly lowest percent infestation (1.74%) of *C. infuscatellus* was recorded in different plots treated with inundative release method followed by plots treated with inoculative release method, where 2.68% infestation of *C. infuscatellus* was recorded. Maximum percent infestation of C. *infuscatellus* 3.50% was recorded in control. The data regarding the yield of sugarcane revealed that significantly highest yield, 89.38 tones ha^{-1} was recorded in CP-77/400 through inundative release method. Overall, inundative release method and variety CP77/40 was found most effective in reducing the percent infestation of sugarcane stem borerand increasing the yield of sugarcane.

Keywords: sugarcane stem borers, *Trichogramma chilonis*, inoculative&inundative release methods, sugarcane varieties

Introduction

Sugarcane is an important cash crop of Pakistan and an important source of income and employment for the farming community of Pakistan (Hussain et al., 2007). Sugarcane provides raw materials for industries like paper and chipboard manufacturing. Its shares in value added agriculture and GDP is 3.4 percent and 0.7 %, respectively (Malik and Gurmani, 2005) Total cane area in Pakistan during 2011-12 was 1029.4 thousand hectares with cane production of 50045.4 thousand tones. Among this Khyber Pakhtunkhwa has 98.2 thousand hectares with 4408.5thousand tones (Food and Agriculture Division, 2012).

The average sugarcane yield in Pakistan ranges from 44-47 tons ha^{-1}, which is much lower as compared with other sugarcane growing countries of the world such as India (69 tons ha^{-1}), USA (84 tons ha^{-1}) and Egypt (107 tons ha^{-1}). The yield is not only due to the climatic barriers but also involves improper cultural practices, lack of irrigation, adaptation of uncertified seed, late sowing and harvesting, bad ratooning, insect pests and diseases. Due to these constraints, present yield of sugarcane in the country is nearly 80 % below the demonstrated achievable potential (Riaz, 2003). Among all these factors insect pests are the most important one. Insect pests are threat to sugarcane crop. About 103 insects are associated with

sugarcane (Kumarasinghe, 1999). Insect pests cause heavy losses in terms of cane yield and lower sugar recovery (Rosa, 2005). Among these the sugarcane borers are most damaging one (Aheer et al., 1994).

Sugarcane stem borer, *Chilo infuscatellus* (Snellen), is one of the serious pests of sugarcane in Pakistan especially in Khyber Pakhtunkhwa (Gul, 2007). The plants attacked by this pest produce dead hearts from April to June and after formation of canes, its attacks are confined to internodes only. The stem borer reduce sugarcane yield up to 30-45 percent (Anwar et al., 2004).

Extensive and injudicious use of insecticides not only creates the health hazards problem and environmental pollution but also created resistance problem in large number of insect pests (Mohyuddin et al., 1997). It has been reported that more than 500 pest species have developed resistance against insecticides (Georghion and Lagunes, 1991). Indiscriminate use of pesticides kill the natural enemies resulting in flare up of pest population (Yousaf, 1996). All these problems associated with use of the pesticides have renewed the interest in Integrated Pest Management programs that emphasize the biological control which is very effective pest control strategy (Mohyuddin et al., 1997). The safety of biological control is outstanding as many natural enemies are restricted to their host and hence no effect on non-targets species. Biological control is relatively permanent, safe, economical and environment friendly (Shenhmar et al., 2003).

Trichogramma chilonis (Ishii) is one of the most important and widely used bio-control agents against sugarcane stem borer (Sen, 2003; Saljoqi and Walayati, 2013). The inundative releases of bio-agents for control of lepidopterous pests are being practiced in more than 32 million hectares each year around the world (Hassan, 1993; Saljoqi et al., 2012). *T. chilonis* releases in China, Switzerland, Canada and former USSR reduced the damage up to 70-92% on sugarcane, corn and cotton crops (Lily, 1994), while in Asia, releases of *T. Chilonis* remarkably reduced the incidence of cotton boll worm (*Helicoverpaarmigera*) and sugarcane early shoot borer (*Chiloinfuscatellus*) by 43 and 82%, respectively (Bharati et al., 2002; Bhut et al., 2004). In sugarcane *T. chilonis* reduces stalk borer incidence by 55-60% (Shenhmar et al., 2003; Saljoqi and Walayati, 2013).

In case of sugarcane varietals resistance against stem borer infestation, it is revealed that in early maturing varieties of sugarcane plant crop average infestation of stem borer ranged from 0.76 to 1.67 % in varieties MS. 91, CP. 1154 and Mardan 93. In mid maturing varieties of sugarcane the infestation of stem borer ranged from 0.68 to 0.89 % in MS. 91, CP. 716 and MS. 92 varieties. In early maturing sugarcane varieties of ratoon crop infestation of stem borer was significantly the lowest (1.75 %) in varieties MS. 91, CP. 1157 and MS. 91 and highest (2.90 %) in CP. 77/400 (Gul, 2007).

Keeping in view the importance of the pest and its parasitoid, the present studies was initiated to study the field effectiveness of *T. chilonis* through inoculative and inundative field release methods, different sugarcane varieties and their interaction against sugarcane stem borer and also to find out their effects on the yield of sugarcane crop.

Materials and Methods

The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The *Trichogramma* was applied on inundative and inoculative release methods in different sugarcane varieties i.e CP 77/400, SPSG-79-79 and Mardan-92 followed procedures of Saljoqi and Walayati (2013). The data recorded were statistically analyzed through by MSTAT-C (Michigan State University, 1991), and means for different parameters were separated by applying least significant difference (LSD) testat 0.05 % level of probability (Gomez and Gomez, 1984).

Rearing of *Trichogramma chilonis* (Ishii)

T. chilonis culture was maintained on the eggs of *Sitotrogacerealella* (olive) in controlled environmental conditions at bio-control lab in the Department of Plant Protection, The University of Agriculture, Peshawar-Pakistan. For rearing of the host and parasitoid procedures of the Saljoqi and He-Yurong (2004) and Saljoqi et al. (2012) were followed.

Field Release of *T. chilonis* Against Sugarcane Stem Borer

Agronomically well managed farmer's fields/plots with sugarcane crops were selected in Mardan, Khyber Pakhtunkhwa-Pakistan during cropping season 2009. The parasitized egg cards ready to emerge in 24 hrs were stapled to the leaves of sugarcane in the fields. These egg cards were applied on innocultive and inundative release methods. The Trichocards application through innocultive release method is practiced once a year to re-establish a species of natural enemy that is periodically killed out in an area by unfavorable conditions during part of the year but which operates very effectively the rest of the year. Control is expected from the progeny and subsequent generations, not form the release itself. In this method 10 tricho cards each having 500 eggs were stapled once at the beginning of pest emergence in plant crop of sugarcane.

In inundative release method, large number of Trichocards was applied where control of the stem borer is normally expected from the *Trichocards* which were applied at that time in the field. In this method 80 Trichocards per acre each having 500 eggs and ready to emergence in 24 hrs, was applied during the entire season, at 15 days intervals. The schedule for inundative release of *T. chilonis* in sugarcane crop is given in Table 1.

Percent Infestation

The effect of *T. chilonis* on sugarcane stem borer in treated and checks plots in different sugarcane verities were determined by selecting 100 canes from four different places representing four replications in each plot of sugarcane. The distance between each plot was 400 meters and the plot size was 200 square meters. The percent infestation data were collected on dead hearts, from May till the end of June, while percents infestation data on the internodes damage were taken by inspecting 100 canes at four different places in each plot from Juneto the end of October. Similar procedure was used for collecting data in plots treated with inundativeand inoculative release methods of *T. chilonis*. The data collected were converted into mean percent infestation. The percent infestation was determined by using the following formula.

Table 1 Schedule for inundative release of *Trichogramma chilonis* (Ishii) in sugarcane crop during, 2009

S. No	Treatment	Interval (day)	Dose (cards acre^{-1})
1	1st release	0 days	10
2	2nd release	15	10
3	3rd release	30	10
4	4th release	45	10
5	5th release	60	10
6	6th release	75	10
7	7th release	90	10
8	8th release	105	10

$$\text{Percent Infestation} = \frac{\text{No. of dead hearts}}{\text{Total No. of canes}} \times 100$$

Yield

Yield data were collected in kilograms and then converted in to Tones ha^{-1}.

Results and Discussion

Percent Infestation of *C. infuscatellus*

The infestation of *C. infuscatellus* in different sugarcane varieties started in April and continued till the end of the October. The data presented in Table 2 shows the percent infestation of *C. infuscatellus* in sugarcane variety CP-77/400 at different time intervals. The mean data of the percent infestation of *C. infuscatellus* as affected by release methods including control shows that initially the percent infestation was found very low. With the passage of time a progressive increase in percent infestation of *C. infuscatellus* was observed. Peak infestation (2.69 %) was recorded in the month of September (15-09-2009). Later on decline was recorded in the percent infestation and 0.87 % infestation was recorded at the end of October, 2009.

Mean percent infestation data on *C. infuscatellus* showed that both inundative and inoculative release methods of *T. chilonis* were found effective in reducing the mean percent infestation caused by *C. infuscatellus* in sugarcane variety CP-77/400 as compared to the control.. Mean percent infestation data showed that minimum infestation of *C. infuscatellus* (0.96 %) was recorded in fields treated with inundative release method followed by fields

Table 2 Effect of different release methods of *Trichogramma chilonis* (Ishii) on the mean percent infestation of sugarcane stem borer, *Chilo infuscatellus* (Snell) in sugarcane variety CP-77/400 during the cropping season 2009.

Private dates	*Trichogramma* release methods			Mean
	Inundative	Inoculative	Control	
	(---------- % infestation ----------)			
15-04-2009	0.00 q	0.00 q	0.00 q	0.00 j
30-04-2009	0.19 q	0.44 pq	1.25 k-n	0.62 i
15-05-2009	0.56 opq	1.19 lmn	1.75 h-l	1.17 h
30-05-2009	0.94 nop	2.00 f-j	2.50 c-f	1.81 efg
15-06-2009	1.25 k-n	2.25 e-h	3.19 ab	2.23 cd
30-06-2009	1.06 mno	1.75 h-l	3.19 ab	2.00 c-f
15-07-2009	0.94 nop	1.56 i-m	2.87 bcd	1.79 fg
30-07-2009	1.00 m-p	2.00 f-j	2.75 b-e	1.92 def
15-08-2009	1.38 k-n	2.38 d-g	3.25 ab	2.33 bc
30-08-2009	1.69 h-l	2.58 c-f	3.50 ab	2.59 ab
15-09-2009	1.81 g-k	2.70 b-e	3.56 a	2.69 a
30-09-2009	1.44 j-n	2.00 f-j	3.00 abc	2.15 cde
15-10-2009	1.00 m-p	1.50 i-n	2.06 f-i	1.52 g
30-10-2009	0.13 q	1.00 m-p	1.50 i-n	0.87 hi
Mean	0.96 c	1.67 b	2.46 a	-

Means followed by different letter(s) are significantly different at P≤0.05 using LSD test; LSD value (P≤0.05) for dates = 0.33; LSD value (P≤0.05) for Release Methods = 0.15; LSD value (P≤0.05) for interaction = 0.58

treated with inoculative release method where the mean percent infestation of *C. infuscatellus* was 1.67 % (Table 2). The data regarding interaction of different time intervals and release methods including control shows that almost in all cases initially the recorded infestation was very low. A progressive increase was recorded with the passage of time. Peak mean percent infestation, 1.81, 2.70, and 3.5 was recorded in plot treated with inundative release method, inoculative release method and control, respectively. After that the percent infestation of *C. infuscatellus was* found decreasing (Table 2).

The data in Table 3 showed the same trend of *C. infuscatellus* population after different release methods of *T. chilonis* in sugarcane plant crop as observed in sugarcane variety CP-77/400. Initially no significant difference was observed in the mean percent infestation of *C. infuscatells* after different release methods of *T. chilonis*. With the passage of time increase in the percent infestation population was observed. Maximum infestation was found in the month of September by recording 7.31 % in plots with no release of *T. chilonis*. This was followed by plots where *T. chilonis* was used as inoculative release method by recording 6.31 % infestation. While significantly lowest infestation of 3.31 % was recorded in inundative released plots. Analyses of data further showed that both inundative and inoculative release methods of *T. chilonis* were found effective in reducing the mean percent infestation caused by *C. infuscatellus* in sugarcane variety SPSG-79. Mean percent infestation data showed that minimum infestation of *C. infuscatellus* (1.78 %) was recorded in fields treated with inundative release method followed by sugarcane plot treated with inoculative release method where the recorded mean percent infestation of *C. infuscatellus* was 2.95 % (Table 3).

Statistically analyzed data presented in Table 4 showed that the mean percent infestation of *C. infuscatellus* differed significantly in sugarcane variety Mardan-92 after different release methods of *T. chilonis.* It shows that the treatments were found highly significant (P<0.05). The table showed the mean percent infestation of *C. infuscatellus* in sugarcane variety Mardan-92. The values in Table 4 showed that in the beginning there was very low infestation of *C. infuscatellus* in different plots treated with *T. chilonis*. The

Table 3 Effect of different release methods of *Trichogramma chilonis* (Ishii) on the mean percent infestation of sugarcane stem borer, *Chilo infuscatellus* (Snell) in sugarcane variety SPSG-79 during the cropping season 2009.

Private dates	*Trichogramma* release methods			Mean
	Inundative	Inoculative	Control	
	(---------- % infestation ----------)			
15-04-2009	0.00 s	0.13 rs	0.25 rs	0.12 j
30-04-2009	0.69 qrs	1.31 opq	2.19 lmn	1.40 i
15-05-2009	1.50 nop	2.44 i-m	3.06 ghi	2.33 fg
30-05-2009	2.44 i-m	3.31 fgh	3.88 ef	3.21 d
15-06-2009	2.56 i-l	2.94 h-k	3.13 ghi	2.87 de
30-06-2009	1.81 mno	2.25 klm	2.31 j-m	2.12 gh
15-07-2009	1.25 opq	1.81 mno	2.19 lmn	1.75 hi
30-07-2009	1.25 opq	2.94 h-k	3.38 e-h	2.52 efg
15-08-2009	2.31 j-m	3.88 ef	5.63 cd	3.94 c
30-08-2009	3.00 g-j	5.19 d	7.00 ab	5.06 b
15-09-2009	3.31 fgh	6.31 bc	7.31 a	5.65 a
30-09-2009	2.50 i-m	4.06 e	5.31 d	3.96 c
15-10-2009	1.50 nop	3.00 g-j	3.69 efg	2.73 ef
30-10-2009	0.81 pqr	1.81 mno	2.31 j-m	1.64 i
Mean	1.78 c	2.95 b	3.69 a	-

Means followed by different letter(s) are significantly different at P≤0.05 using LSD test; LSD value (P≤0.05) for dates = 0.41; LSD value (P≤0.05) for Release Methods =0.19; LSD value (P≤0.05) for interaction =0.71

Table 4 Effect of different release methods of *Trichogramma chilonis* (Ishii) on the mean percent infestation of sugarcane stem borer, *Chilo infuscatellus* (Snell) in sugarcane variety Mardan-92 during the cropping season 2009.

Private dates	*Trichogramma* release methods			Mean
	Inundative	Inoculative	Control	
	(---------- % infestation ----------)			
15-04-2009	0.00 w	0.13 w	0.38 w	0.17 k
30-04-2009	1.38 uv	1.75 tuv	2.38 o-t	1.83 j
15-05-2009	2.00 r-u	2.88 k-o	3.94 fgh	2.94 fg
30-05-2009	2.88 k-o	3.50 g-k	4.63 de	3.67 d
15-06-2009	3.06 j-n	3.13 i-m	3.94 fgh	3.37 de
30-06-2009	2.44 n-s	2.69 m-q	2.94 j-o	2.69 gh
15-07-2009	1.88 stu	2.13 q-t	2.94 j-o	2.31 hi
30-07-2009	2.06 q-t	3.38 h-l	4.88 d	3.44 de
15-08-2009	3.06 j-n	4.38 def	6.75 b	4.73 c
30-08-2009	3.56 g-j	5.75 c	7.75 a	5.69 b
15-09-2009	3.81 fgh	6.81 b	7.94 a	6.19 a
30-09-2009	2.81 l-p	5.56 c	6.00 c	4.79 c
15-10-2009	2.00 r-u	3.75 f-i	4.06 efg	3.27 ef
30-10-2009	1.19 v	2.19 p-t	2.56 m-r	1.98 ij
Mean	2.29 c	3.43 b	4.36 a	-

Means followed by different letter(s) are significantly different at P≤0.05 using LSD test; LSD value (P≤0.05) for dates = 0.38; LSD value (P≤0.05) for Release Methods = 0.18; LSD value (P≤0.05) for interaction =0.65

population build up was started with the passage of time and reached to the peak in the month of September by recording 7.94 % infestation of *C. infuscatellus* in the control plots.

This was followed by plots treated with inoculative release methods of *T. chilonis* by recording 6.81 % infestation, while significantly reduced infestation of *C. infucatellus* was recorded in plots treated with inundative release method of *T. chilonis* by recording 3.81 % infestation. Analyses of the data regarding the pooled mean infestation further revealed that different release methods of *T. chilonis* effectively reduced the mean percent infestation of *C. infuscatellus* population in sugarcane variety Mardan-92. The data showed that significantly reduced mean percent infestation of 2.29 was recorded in plots, where inundative release method of *T. chilonis* was used. This was followed in the plots treated with inoculative release method of *T. chilonis* where mean percent infestation, 3.43 was recorded (Table 4).

The data pertaining the effectiveness of different release methods, varieties and their interaction against percent infestation of *C. infuscatellus* is presented in Table 5. Significantly lowest percent infestation of *C. infuscatellus* was recorded in variety CP-77/400 where of 1.76 was recorded. This was followed by variety SPSG-79 where percent infestation of *C. infuscatellus* was 2.80. While significantly maximum percent infestation of *C. infuscatellus* 3.36 was recorded in variety Mardan-92. The data also showed significant differences in the different release methods of *T. chilonis*. Significantly lowest percent infestation of *C. infuscatellus* of 1.74 was recorded in different plots treated with inundative release method followed by plots treated with inoculative release method, where 2.68 percent infestation of *C. infuscatellus* were recorded maximum percent infestation of *C. infuscatellus* 3.50 was recorded in control.

Over all the present findings regarding the percent infestation in Table 2, 3, 4 and 5 showed that significantly reduced mean percent infestation was recorded in plots where inundative release method of *T. chilonis* was used as compared with the inoculative release method in all the sugarcane plantcrop varieties. All these results are in agreements with the findings of Shenhmar et al. (2003), Soula et al. (2003), Bhat et al. (2004), Gul (2007), Shahid et al. (2007) and Saljoqi and Walayati (2013)who reported that inundative method of releasing *T. chilonis*is highly effective control method and recorded significant reduction in the infestation of *C. infuscatellus.*

The data regarding the percent infestation of *C. infuscatellus* of sugarcane plant crop in different sugarcane varieties after different release methods of *T. chilonis* is shown in Table 5. The data expressed that the percent infestation of *C. infuscatellus* of sugarcane was found highly significant in different sugarcane varieties. Significantly lowest percent infestation of *C. infuscatellus* of 1.76 was recorded in variety CP-77/400. This was followed by variety SPSG-79 where the percent infestation of *C. infuscatellus* was 2.80. While significantly maximum percent infestation of *C. infuscatellus* of 3.36 were recorded in variety Mardan-92. In the present study the difference in susceptibility in different varieties may be because of the difference in hardness of the varieties. Gul et al. (2008) also studied the effect of different control methods including the use of different resistant varieties and reported that resistant varieties with hard internodes rings and toughness significantly reduce the sugarcane borers infestation.

Yield of sugarcane

The yield data is presented in Table 6. Significantly highest yield was recorded in variety CP-77/400 where average cane yield of 86.63 tones ha^{-1} was recorded. This was followed by variety SPSG-79 where the average cane yield was 84.92 tones ha^{-1}. While significantly lowest yield of 80.96 tones ha^{-1} was recorded in variety Mardan-92. The data also showed significant differences in the different release methods of *T. chilonis*. Significantly highest yield of 87.67 t ha^{-1} was recorded in different plots treated with inundative release method followed by plots treated with inoculative release method, where 84.71 t ha^{-1} yield of sugarcane were recorded lowest yield 80.13 tones ha^{-1} was recorded in the control. Our findings confirm the work of Gul et al. (2007), who reported that the effect of different control methods on the infestation of borers in sugarcane plant crop and reported that all the control methods specially the use of *T. chilonis* significantly controlled borers infestation and increased the cane yield. Results are

Table 5 The effect of different field release methods of *Trichogramma chilonis* (Ishii), sugarcane varieties and their interaction against mean percent infestation of sugarcane stem borer, *Chilo infuscatellus* (Snellen) in sugarcane plant crop during the cropping season 2009.

Private release methods	Varieties			Mean
	CP-77/40	SPSG-79	Mardan-92	
Inundative	1.16 g	1.67f	2.46 e	1.74 c
Inoculative	1.78f	2.95d	3.67b	2.68 b
Control	2.29e	3.43c	4.36 a	3.50 a
Mean	1.76 c	2.80 b	3.36 a	-

Means followed by different letter(s) are significantly different at P≤0.05 using LSD test; LSD value (P≤0.05) for variety = 0.11; LSD value (P≤0.05) for Release Methods = 0.17; LSD value (P≤0.05) for interaction = 0.19.

Table 6 Effect of different release methods of *Trichogramma chilonis* (Ishii) against sugarcane stem borer, *Chilo infuscatellus* (Snell) on the yield in different sugarcane varieties (plant crop) during the cropping season 2009.

Private release methods	Yield (t ha^{-1})			Mean
	CP-77/40	SPSG-79	Mardan-92	
Inundative	89.38a	88.12ab	85.50cd	87.67a
Inoculative	86.75bc	84.25de	83.13de	84.71b
Control	83.75de	82.38e	74.25f	80.13c
Mean	86.63a	84.92b	80.96c	-

Means followed by different letter(s) are significantly different at P≤0.05 using LSD test.; LSD value (P≤0.05) for variety = 1.44; LSD value (P≤0.05) for Release Methods = 1.44; LSD value (P≤0.05) for interaction = 2.49.

also in agreement with the findings of Saljoqi and Walayati (2013) who recorded highest yield through inundative release method as compared with all other treatments. The findings of Bharati et al.(2002), Bhat et al. (2004) and Gul et al. (2008) also confirms the present findings by recording increased yield of sugar cane by utilizing *T. chilonis* as inundative release method against sugar cane stem borer infestation.

Conclusions

The present finding showed that sugarcane stem borer, *C. infuscatellus* significantly affected sugarcane yield, but the use of comparatively more resistant sugarcane variety like, CP77/400 in combination with inundative releases of *T. chilonis* showed better performance in reducing the *C. infuscatellus* infestation and increasing yield as compared to all other biological treatments.

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