Pakistan J. Zool., vol. 46(6), pp. 1503-1509, 2014.

Efficacy of *Trichogramma chilonis* (Ishii) (Hymenoptera: Trichogrammatidae) for Management of Sugarcane Stem Borer, *Chilo infuscatellus* (Snell) in Different Varieties of Ratoon Sugarcane Crop

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Abstract.- The study evaluated *Trichogramma chilonis* (Ishii) as a potential biological control agent against sugarcane stem borer, *Chilo infuscatellus* (Snellen) in different sugarcane varieties in ratoon crop. The aims were to study the effectiveness of inundative and inoculative field release methods of *T. chilonis* and varietal response against *C. infuscatellus* and yield of sugarcane ratoon crop. The experiment was laid out in Randomized Complete Block Design. The results showed that the infestation of *C. infuscatellus* in different sugarcane varieties started in April and continued till the end of the October. Inundative release method and variety CP77/400 was found most effective in reducing the percent infestation of sugarcane stem borer and increasing the yield of sugarcane. The data revealed that the percent infestation of *C. infuscatellus* of sugarcane was found highly significant in different varieties. Significantly lowest percent infestation of *C. infuscatellus* (3.45%) was recorded in variety CP-77/40. This was followed by variety SPSG-79 where the percent infestation of *C. infuscatellus* was 4.55. While significantly maximum percent infestation of *C. infuscatellus* of 5.31 was recorded in variety Mardan-92. The data further revealed that significant differences in the percent infestation of *C. infuscatellus* were observed in different plots treated with different release methods of *T. chilonis*. Significantly lowest percent infestation of *C. infuscatellus* of sugarcane 3.26% was recorded in different plots treated with inundative release method followed by plots treated with inoculative release method, where 4.71% of C. *infuscatellus* were recorded. Maximum percent infestation of *C. infuscatellus* (5.34%) was recorded in the control. The data regarding the yield of sugarcane revealed that significantly highest yield was recorded in all varieties in the inundative release method as compared with the inoculative release method. Highest yield 68.70 tones ha^{-1} was recorded for CP-77/400 through inundative release method.

Key words: *Trichogramma chilonis*, Inoculative & Innudative release methods, Sugarcane stem borers, *Chilo infuscatellus*, Ratoon crop, Sugarcane varieties.

INTRODUCTION

Sugarcane, *Saccharum officinarum* L., is one of the important cash crops which provides raw material to sugar industry, the 2nd largest industry after textile in Pakistan having share of in value-added of agriculture is 3.6 and to GDP is 0.8%. Sugarcane provides raw materials for industries like paper and chipboard manufacturing. Its shares in value added agriculture and GDP are 3.4% and 0.7%, respectively. During the year 2009, sugarcane was grown on an area of 1029 thousand hectares of 17.1% less than under crop during past year with total production of 50.0 million tons. A decrease of 21.7% in production as compared to the previous years, but the yield remained 48635 Kg/ha with 5.6% less/ha which is below the yield potential of existing sugarcane cultivars (Anonymous, 2009).

Various insect pests like, borers, termites, pyrilla, whitefly, thrips, bugs and mites attack sugarcane crop and cause heavy losses in terms of cane yield and lower sugar recovery (Rosa, 2005).

Sugarcane stem borer, *Chilo infuscatellus* (Snellen), is one of the serious pests of sugarcane in Pakistan especially in Khyber Pakhtunkhwa. 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 (Saljoqi and Walayati, 2013). The stem borer reduce sugarcane yield up to 30-45 percent (Anwar *et al.*, 2004). The damage is done by larvae which feed inside the cane and are difficult to control with insecticides. More over the heavy use of pesticides created problems

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0030-9923/2014/0006-1503 $ 8.00/0

like pest resurgence, outbreak of secondary pests, environmental pollution. To overcome these problems, the use of biological control and host plant resistance can give effective pest control (Huffaker, 1980). Biological control of these borers with parasitoids and predators is therefore gaining importance (Shenhmar *et al*., 2003).

Trichogramma chilonis (Ishii) (Hymenoptera: Trichogrammatidae) is one the important polyphagous egg parasitoids of lepidopterous pests. It has been used as an effective bio-control agent against sugarcane borers for the last two decades in Pakistan (Hashmi and Rahman, 1985). *T. chilonis* is a host specific, economical favorable, environment friendly, long lasting affects and easy to handle. Inundative releases of *Trichogramma* during 1989-91 in experimental plots of BL-4 variety reduced the borer infestation to 4.2% as compared to 16.2% in check plots (Ashraf *et al*., 1995). Mustafa *et al.* (2006) released 16 cards of *T. chilonis* per acre fortnight and each card having 400-500 eggs per card, in farmer fields from April to September 2003 and recorded internodes damage from 3.9 to 10.5% in treated and 9.6 to 18.6% in untreated plots. *T. chilonis* releases have given successful control of *Acigona steniella* (Hampson) (Hamid *et al*., 1998) and *C. infuscatellus* Snellens (Gul, 2007; Shahid *et al*., 2007). Effective release rate of *T. chilonis* for sugarcane borers is 15000 to 30000 parasitoids per acre (Khan and Alam, 2001). *T. chilonis* have been exploited against havoc of lepidopterous pests as triumph of integrated pest management of sugarcane borers (Ashraf *et al*., 1993; Goebell *et al*., 2006).

In case of varietals resistance, it is revealed that in early, maturing varieties of 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 the infestation of stem borer ranged from 0.68 to 0.89 % in MS. 91, CP. 716 and MS. 92 varieties. In early maturing 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).

Present study was therefore conducted to see the effectiveness of *T. chilonis* as bio-control agent against sugarcane stem borer and on yield of sugarcane crop in different sugarcane varieties in ratoon crop by utilizing innoculative and inundative release methods.

MATERIALS AND METHODS

The experiment was laid out in Randomized Complete Block Design (RCBD). The *Trichogramma* was applied through inundative and inoculative release methods in ratoon crop of sugar cane in different varieties *i.e.*, CP 77/400, SPSG-79-79 and Mardan-92 against sugarcane stem borer (Ashraf *et al*., 1995).

Agronomically well managed farmer's fields/plots with sugarcane crops were selected. The size of each plot was 200 $m^2$and the distance between each plot was 400 meters as a buffer zone. The parasitized egg cards ready to emerge in 24 h were stapled to the leaves of sugarcane in the fields. These egg cards were applied on inoculative and inundative release methods. In inundative release method large number of Trichocards were applied 10 cards/acre and in this release method the control of the pest was normally expected from the natural enemies which are applied at that time. In this method 80 *Trichocards*/acre each having 500 eggs, ready to emergence in 24 h, were applied during the entire season, at 15 days intervals. The Trichocards application through inoculative release method is practiced once a year to re-establish a species of natural enemy. In this method 10 trichocards each have 500 eggs were stapled once at the beginning of pest emergence in ratoon crop of sugarcane.

Percent infestation

The effectiveness of *T. chilonis* on sugarcane stem borer in treated and checks plots in ratoon crop in different verities of sugarcane crops were determined by selecting 100 canes from four different places (plots) representing four replications in each plot of sugarcane. 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 June to the end of October as described by Hall (1986). The data collected were converted into mean percent infestation. The following formula was used for the determination of the percent parasitism rate

in each treatment.

$$\text{Percent infestation:} \quad \frac{\text{Total number of infested sugarcane plants}}{\text{Total number of sugarcane plants}} \times 100$$

Yield

Yield data were collected for each treatment in Kg and then converted in to tones ha^{-1}.

Data was subjected to statistical analysis by using MSTATC package by applying ANOVA techniques and means were subjected to Duncan's new multiple range test for pair wise comparison (Steel *et al*., 1997).

RESULTS AND DISCUSSION

The data in Table I revealed the population trend of *C. infuscatellus* in ratoon crop of sugarcane variety CP-77/400 as affected by different release methods of *T. chilonis* including control at different time intervals. The table showed that initially no infestation of *C. infuscatellus* was recorded in all plots. With the passage of time a rapid increase in the population was observed. Peak infestation of *C. infuscatellus* was observed in the month of September by recording 7.06 % in control. This was followed by plots treated with inoculative release method of *T. chilonis* where 5.88 mean percent infestation of *C. infuscatellus* was recorded. While significantly lowest mean percent infestation of *C. infuscatellus* (5.31%) was recorded in plot treated with inundative release method of *T. chilonis* as compared to inoculative release method and control, during the peak infestation time (15-09-2009). The data also showed that both inundative and inoculative release methods of *T. chilonis* were found effective in reducing the mean percent infestation of. *infuscatellus* in sugarcane variety CP-77/400. The data shows that significantly reduced infestation of *C. infuscatellus* (2.75 %) was recorded in fields treated with inundative release method followed by fields treated with inoculative release method, where the mean percent infestation of *C. .infuscatellus* was 3.20 %.

Table II showed the same trend of *C. infuscatellus* population, after different release methods of *T. chilonis* in sugarcane ratoon crop variety SPSG-79 as observed in variety CP-77/400. Initially the recorded percent infestation was very low with the passage of time the population buildup was started and significant differences were observed in the mean percent infestation of *C. infuscatellus* in different plots. Peak population (10.75percent) was recorded in control in the month of September. This was followed by inoculative released plots by recording 8.94 mean percent infestation of *C. infuscatellus,* whereas significantly lowest mean percent infestation of 6.94 was observed in inundative treated plots compared to

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

Dates	Inundative % infestation	Inoculative % infestation	Control % infestation	Mean % infestation
15-04-2009	0.00 w	0.00 w	0.00 w	0.00 j
30-04-2009	0.69 v	1.50 u	2.00 rst	1.40 i
15-05-2009	1.38 u	2.19 qrs	2.69 nop	2.08 h
30-05-2009	2.44 o-r	3.00 mn	3.75 jkl	3.06 fg
15-06-2009	2.94 n	2.94 n	3.69 kl	3.19 f
30-06-2009	2.38 pqr	2.63 n-q	3.44 lm	2.81 g
15-07-2009	2.44 o-r	2.88 no	4.06 ijk	3.13 f
30-07-2009	3.50 l	4.19 ij	4.69 gh	4.13 e
15-08-2009	4.88 hi	5.19 ef	5.75 cd	5.10 c
30-08-2009	4.38 fg	5.56 bc	6.25 b	5.67 b
15-09-2009	5.31 def	5.88 cde	7.06 a	5.98 a
30-09-2009	3.75 jkl	4.31 hi	5.44 cde	4.50 d
15-10-2009	2.75 nop	2.88 no	3.44 lm	3.02 fg
30-10-2009	1.75 stu	1.69 tu	1.56 tu	1.67 i
Mean	**2.75 c**	**3.20 b**	**3.84 a**	-

LSD value (P≤0.05) for dates: 0.29
LSD value (P≤0.05) for Release Methods: 0.13
LSD value (P≤0.05) for Interaction: 0.49
Means followed by different letter(s) are significantly different at P≤0.05, using DMR test.

Table II.- Effect of different release methods of *Trichogramma chilonis* (Ishii) on percent infestation of sugarcane stem borer, *Chilo infuscatellus* (Snell) in ratoon crop of sugarcane in variety SPSG-79, during 2009

Dates	Inundative % infestation	Inoculative % infestation	Control % infestation	Mean % infestation
15-04-2009	0.25 st	0.06 t	0.50 rst	0.27 h
30-04-2009	1.56 q-t	1.50 q-t	2.00 pqr	1.69 g
15-05-2009	2.31 opq	3.00 m-q	3.88 k-o	3.06 f
30-05-2009	3.75 k-o	4.13 k-n	5.44 g-k	4.44 de
15-06-2009	4.25 j-n	6.88 e-h	7.09 d-g	6.07 bc
30-06-2009	2.94 n-q	5.25 h-k	7.19 def	5.13 cd
15-07-2009	3.06 m-q	3.44 l-p	4.62 j-n	3.71 ef
30-07-2009	4.81 i-l	4.69 j-m	5.25 h-k	4.92 d
15-08-2009	6.44 e-i	7.00 d-g	7.31 c-f	6.92 b
30-08-2009	5.88f-j	8.69 bcd	10.19 ab	8.33 a
15-09-2009	6.94 e-h	8.94 bc	10.75 a	8.79 a
30-09-2009	4.51 j-n	7.50 c-f	7.63 cde	6.55 b
15-10-2009	3.31 l-p	4.69 j-m	4.44 j-n	4.15 de
30-10-2009	1.44 q-t	1.94 p-s	2.31 opq	1.90 g
Mean	**3.68 c**	**4.84 b**	**5.61 a**	-

LSD value (P≤0.05) for dates: 0.99
LSD value (P≤0.05) for Release Methods: 0.46
LSD value (P≤0.05) for Interaction: 1.72
Means followed by different letter(s) are significantly different at P≤0.05, using DMR test.

Table III.- Effect of different release methods of *Trichogramma chilonis* (Ishii) on percent infestation of sugarcane stem borer, *Chilo infuscatellus* (Snell) in ratoon crop of sugarcane in variety Mardan-92 during 2009

Dates	Inundative % infestation	Inoculative % infestation	Control % infestation	Mean % infestation
15-04-2009	0.38 u	0.44 u	0.75 tu	0.52 i
30-04-2009	1.94 st	2.19 rs	3.50 o-r	2.54 h
15-05-2009	3.06 p-s	4.06 n-q	5.19 j-n	4.10 g
30-05-2009	4.06 n-q	5.13 k-n	6.44 f-k	5.21 ef
15-06-2009	4.50 l-o	8.13 cd	7.75 def	6.79 bc
30-06-2009	3.38 o-r	6.75 d-i	7.94 de	6.02 cd
15-07-2009	3.69 opq	4.44 m-p	6.44 f-k	4.85 fg
30-07-2009	5.50 i-m	5.81 h-m	6.38 f-k	5.90 de
15-08-2009	6.56 e-j	7.25 d-g	7.50 def	7.10 b
30-08-2009	5.75 h-m	9.44 bc	10.81 ab	8.77 a
15-09-2009	7.06 d-h	9.75 ab	11.00 a	9.17 a
30-09-2009	3.69 opq	7.25 d-g	7.75 def	6.23 cd
15-10-2009	3.50 o-r	5.31 j-n	5.88 g-l	4.90 fg
30-10-2009	1.75 stu	2.69 qrs	3.38 o-r	2.60 h
Mean	3.92 c	5.62 b	6.48 a	-

LSD value (P≤0.05) for dates: 0.80
LSD value (P≤0.05) for Release Methods: 0.37
LSD value (P≤0.05) for Interaction: 1.38
Means followed by different letter(s) are significantly different at P≤0.05, using DMR test.

inoculative release method and control, during the peak infestation time (15-09-2009). Pooled mean percent infestation data showed that minimum infestation of *C. infuscatellus* (3.68) was recorded in fields treated with inundative release method followed by fields treated with inoculative release method where the mean percent infestation of *C. infuscatellus* was 4.84.

Statistical analysis of the data (Table III) showed that the mean percent infestation of *C. infuscatllus* differed significantly in ratoon crop of sugarcane variety, Mardan-92 after different released methods of *T. chilonis*. It also showed that the release methods were found highly significant (P<0.05). The Table showed that the infestation of *C. infuscatellus* was started in the month of April and continued till the end of October. Maximum infestation was recorded in the month of September and after this again the population was found in the decreasing rate. Maximum percent infestation was observed in control by recording 11.00%. While in inoculative and inundative treated plots significantly reduced (9.75 and 7.06%) were recorded respectively as compared with control. The pooled mean data in Table IV revealed that both methods of *T. chilonis* have proven effectiveness against *C.*

infuscatellus by recording lower infestation. The results showed that significantly reduced percent infestation (3.92) was recorded in inundative treated plots followed by inoculative release plots, where 5.62 mean percent infestations was recorded.

Table IV.- The effect of different field release methods of *Trichogramma chilonis* (Ishii), sugarcane varieties and their interaction against sugarcane stem borer, *Chilo infuscatellus*_(Snellen) in sugarcane ratoon crop, during 2009

Release methods	CP-77/40	SPSG-79	Mardan-92	Mean
Inundative	2.75g	3.69e	3.92d	3.26 c
Inoculative	3.20f	4.84c	5.62b	4.71 b
Control	3.84de	5.61b	6.48 a	5.34 a
Mean	3.45c	4.55b	5.31a	-

LSD value (P≤0.05) for Varieties: 0.09
LSD value (P≤0.05) for Release Methods: 0.04
LSD value (P≤0.05) for Interaction: 0.16
Means followed by different letter(s) are significantly different at P≤0.05, using DMR test.

The data presented in Table IV further revealed that significant differences in the percent infestation of *C. infuscatellus* were observed in different plots treated with different release methods of *T. chilonis*. Significantly lowest percent infestation of *C. infuscatellus* of sugarcane 3.26 was recorded in different plots treated with inundative release method followed by plots treated with inoculative release method, where 4.71 percent infestation of *C. infuscatellus* were recorded maximum percent infestation of *C. infuscatellus* 5.34 was recorded in the control.

Over all, the present findings pertaining to percent infestation in Tables I-IV 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 ratoon crop varieties. All these results are in agreements with the findings of Ashraf *et al.* (1993; 1995), Gul (2007), Rana *et al.* (2007) who reported that inundative method of releasing *T. chilonis* is highly effective control method and recorded significant reduction in the infestation of *C. infuscatellus.*

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

Release methods	CP-77/40	SPSG-79	Mardan-92	Mean
Inundative	68.70a	67.67c	66.50e	67.64a
Inoculative	67.85b	66.56e	65.62f	66.68b
Control	66.72d	65.67f	64.71g	65.70c
Mean	67.77a	66.63b	65.61c	-

LSD value (P≤0.05) for Varieties: 0.07
LSD value (P≤0.05) for Release Methods: 0.07
LSD value (P≤0.05) for Interaction: 0.13
Means followed by different letter(s) are significantly different at P≤0.05, using DMR test.

The data in Table IV showed the percent infestation of *C. infuscatellus* of sugarcane ratoon crop in different sugarcane varieties after different release methods of *T. chilonis*. The data revealed that the percent infestation of *C. infuscatellus* of sugarcane was found highly significant in different varieties. Signicantly lowest percent infestation of *C. infuscatellus* of 3.45 was recorded in variety CP-77/400. This was followed by variety SPSG-79 where the percent infestation of *C. infuscatellus* was 4.55. While significantly maximum percent infestation of *C. infuscatellus* of 5.31 were recorded in variety Mardan-92. The difference in susceptibility in different varieties in the present study may be because of the difference in hardness of the varieties. Gul *et al.* (2008) also tested the effect of different control methods including the use of different resistant cultivars and found that resistant cultivars with hard internodes rings and toughness significantly reduce the sugarcane borers infestation.

The data regarding yield of sugarcane (Table V) was found highly significant in different varieties. Signicantly highest yield of 67.77 tones hac^{-1} per hectare was recorded in variety CP-77/400. This was followed by variety SPSG-79 where the average cane yield was 66.63 tones hac^{-1}. While significantly lowest yield of 65.61 hac^{-1} were recorded in variety Mardan-92. The data further revealed that significant differences in the sugarcane yield were observed in different plots treated with

different release methods of *T. chilonis*. Significantly highest yield of sugarcane (67.77 hac^{-1}) was recorded in different plots treated with inundative release method followed by plots treated with inoculative release method, where 66.63 hac^{-1} yield of sugarcane were recorded. lowest yield 65.61 hac^{-1} was recorded in the control. Our findings are in conformity with those of Bharati *et al.* (2002), Shenhmor *et al.* (2003), Soula *et al.* (2003), Bhat *et al.* (2004) and Gul *et al.* (2008). They found highest yield in the inundative release method among all other treatments.

CONCLUSION

The present findings showed that sugarcane stem borer, C. *infuscatellus* significantly affected the sugarcane ratoon crop, but the use of sugarcane variety CP77/400 in combination with inundative release method of *T. chilonis* showed better performance regarding the yield of sugarcane and in reducing the *C. infuscatellus* infestation as compared with all other treatments.

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(Received 5 May 2011, revised 18 September 2014)