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Potential of *Cotesia flavipes* (Cameron) to manage sugarcane stem borer, *Chilo infuscatellus* (Snellen) under field conditions

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Abstract

Chilo infuscatellus Snellen. is one of the severe pests of sugarcane that causes significant losses to its every year. However, *Cotesia flavipes* parasitoid has shown a prominent impact on its population regulation in many countries of the world. Therefore, a two-year (2013 and 2014) study was undertaken to evaluate the efficiency of the augmentative release of *C. flavipes* in the population and infestation reduction of *C. infuscatellus* in sugarcane in Sindh, Pakistan. Thatta-10 variety was sown over 0.5 acres of land that comprised of a parasitoid release treatment along with control arranged in a randomized complete block design, replicated four times. Release of *C. flavipes* was done on fortnightly basis one month after planting of sugarcane and continued till harvesting, whereas, data were recorded monthly. The results indicated a significant impact of the release of the parasitoid in lowering both population and infestation of *C. infuscatellus* over two years of study, where significantly higher infestation and population of larvae and pupae were recorded in control than parasitoid release treatment. In contrast, a comparatively higher population of *C. flavipes* was recorded in parasitoid treatment. Therefore, the periodic release of *C. flavipes* could be helpful in reducing the population and infestation of *C. infuscatellus* in sugarcane.

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Introduction

Sugarcane (*Saccharum officinarum* L.) is presently considered as a cash crop in Pakistan due to high cash values (Hussain *et al.,* 2007). However, presently many factors are responsible for its lower yield and marketing values in the country i.e., low per acre yield, sugar recovery and higher cost of production (Arian *et al.,* 2011). Although. There are many reasons for the lower yield of sugarcane in the country, but the yield losses due to the attack of the borer are the most significant. Among the borers, stem borer, *Chilo infuscatellus* Snellen. is the most notorious and destructive (Raza *et al.,* 2014). *Chilo infuscatellus* is more active and damaging from March to November, whereas, overwinters in stubbles as full-grown larvae. The most significant symptoms of its damage are dead hearts as yield losses of 30-70% are reported due to its attack (Shahid *et al.,* 2007; Sajjad and Hamed, 2011). Mainly, the granular pesticides are used for the management of *C. infuscatellus,* however, their continuous indiscriminate use has caused many negative impacts i.e., resistance development, environmental pollution and hazards to humans and livestock (Mohyuddin *et al.,* 1997; Soerjani, 1998).

Cotesia flavipes Cameron is a gregarious larval endo-parasitoid that feeds on large to medium-sized larvae of borers attacking Gramineae family1 (Ngi-Song *et al.,* 1995; Raza *et al*., 2014). Although native to South and South-east Asia, *C. flavipes* has successfully established in many countries of the world against many noxious lepidopteran borers (Muirhead *et al.,* 2006). It has also shown promising impacts against *C. infuscatellus* in Sindh, Pakistan (Khan *et al.,* 2013). Therefore, this study was conducted to determine the impact of the augmentative release of *C. flavipes* in the population regulation and infection reduction of *C. infuscatellus* under field conditions.

Materials and methods

A two-year study i.e., 2013 and 2014 was conducted to evaluate the performance of parasitoid, *C. flavipes* in the management of sugarcane stem borer, *C. infuscatellus*. The experiment was conducted at NIA experimental farm, Tandojam, where, *C. flavipes* adults were released under field conditions to determine their influence on the management of *C. infuscatellus*. The experiment consisted of a treated plot where adult parasitoids were released and a control plot, where no release of parasitoids was done. Thatta-10 sugarcane variety was cultivated in the experiment at the recommended seed rate over an area of half an acre. All the agronomic practices since sowing till harvesting i.e., fertilizers, inter-culturing, etc. were applied as per recommended field operations, whereas, irrigations were applied at 15 days' interval. The coupled adults of *C. flavipes* were released at the rate of 2000 parasitoids per acre using test tubes as each test tube having a maximum of 45 cocoons. The release of parasitoids was done at 15 days' intervals one month after the planting of canes until the harvesting of the crop from March to October.

The experiment was arranged in a randomized complete block design, where each treatment was replicated four times. The data recording was done after the release of parasitoid at monthly intervals from ten randomly selected sugarcane plants per replication of each treatment.

The data was recorded for the infestation percentage of *C. infuscatellus,* number of *C. infuscatellus* larvae, and percentage parasitism of *C. flavipes* by rearing the collected larvae of *C. infuscatellus* in the laboratory of NIA, Tando Jam till the adult emergence. Weather data for temperature, relative humidity and rainfall were also obtained from the Meteorological Department, Tando Jam to correlate them with the population of both pest and parasitoid. ANOVA was used to analyze the data using STATISTIX 8.1 software.

Results

Performance of C. flavipes against C. infuscatellus through augmentative release during 2013 under field conditions

Study results indicated that the population of *C. infuscatellus* appeared on sugarcane one month after the sowing i.e., April 2013. Accordingly, its parasitoid *C. flavipes* also get established through augmentative releases. The population of both pest and parasitoid showed a gradual rise throughout the growth of sugarcane (Table 1). Thus, the maximum number of exit holes (23.2±3.03 holes per cane) made by *C. infuscatellus* was recorded in the control plot during October 2013, whereas, the exit holes recorded in the treated plot were 11.6±1.87 holes per cane during September. Similarly, the maximum population of *C. infuscatellus* larvae (18.95±3.94) and pupae (13.81±3.74) was also recorded in the control plot at the end of the season i.e., October 2013, whereas, the population of larvae and pupae observed in the parasitoid release plot were 5.81±1.51 and 2.84±0.45, respectively. Overall, the results of the study indicated a highly significant difference (P < 0.05) in the population of exit holes, larvae and pupae recorded between parasitoid and control treatments, where comparatively higher populations i.e., 16.31±2.70 exit holes, 11.33±2.12 larvae and 10.82±0.91 pupae were recorded in the control treatment. Moreover, overall the number of exit holes, larvae and pupae recorded in parasitoid release treatment were 8.33±1.47, 3.42±0.73 and 1.48±0.92, respectively (Table 1).

Table 1. Performance of *C. flavipes* against *C. infuscatellus* through augmentative release during 2013 under field conditions (Mean + SE).

Months	*Chilo infuscatellus*						*Cotesia flavipes*			
	Exist holes		No. of larvae		Pupae		No. of cocoon		No.of larvae	
	Parasitoid	Control	Parasitoid	Control	parasitoid	Control	parasitoid	Control	Parasitoid	Control
March	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00
April	4.5±0.18	12.1±1.65	1.45±0.15	8.21±1.11	1.1±0.11	7.1±0.55	9.2±0.75	3.4±0.75	4.51±0.12	1.54±0.12
May	7.4±0.43	14.7±2.22	2.24±0.22	9.11±1.62	1.16±0.17	8.41±1.11	13.5±1.55	4.5±1.55	6.7±0.42	2.4±0.34
June	10.1±1.15	17.1±3.03	3.5±0.44	10.7±2.02	1.30±0.10	9.15±1.65	14.2±1.31	5.2±1.31	8.84±1.41	3.2±0.42
July	10.6±1.95	19.6±3.02	3.7±0.52	11.43±2.41	1.50±0.22	11.7±1.94	16.7±2.31	6.7±0.31	11.13±2.01	4.1±1.02
August	11.2±2.10	21.2±3.29	5.1±1.22	14.51±3.32	1.85±0.21	12.65±.2.34	18.2±2.71	8.2±1.71	14.51±1.92	5.8±1.22
September	11.6±1.87	22.6±4.02	5.52±1.33	17.7±4.13	2.10±0.31	12.91±3.06	20.7±2.31	9.7±1.31	15.1±2.32	7.62±1.43
October	11.2±1.76	23.2±3.03	5.81±1.51	18.95±3.94	2.84±0.45	13.81±3.74	23.2±4.21	11.2±1.21	16.5±2.14	9.1±2.11
Overall Mean	8.33±1.47b	16.31±2.70a	3.42±0.73b	11.33±2.12a	1.48±0.92a	10.82±0.91b	14.46±2.58a	6.11±1.28b	9.66±2.03a	4.22±1.10b

*Mean followed by the same letters in a final row are significantly different (LSD < 0.05).

The results also indicated that the augmentative release of *C. flavipes* exhibited a positive impact on the population build-up of its population against *C. infuscatellus* in the field. Thus, a rise in *C. flavipes* population was recorded with the release throughout the growth of sugarcane. Accordingly, the highest population of cocoons (23.2±4.21) and larvae (16.5±2.14) during October 2013 in parasitoid release treatment, whereas, the same population of larvae and cocoons recorded in the control treatment were 9.1±2.11 and 11.2±1.21, respectively. A highly significant difference (P < 0.05) was observed in the number of *C. flavipes* cocoons and larvae as the maximum number of cocoons (14.46±2.58) and larvae (9.66±2.03) was recorded in parasitoid release treatments, whereas, the same parameters recorded in the control plot were 6.11±1.28 and 4.22±1.10, respectively (Table 1).

Performance of C. flavipes against C. infuscatellus through augmentative release during 2014 under field conditions

An almost similar trend in the population of both pest and parasitoid was recorded during 2014, where a steady increase in their populations was recorded (Table 2). Thus, the maximum number of exit holes (24.25±4.13 holes per cane) made by *C. infuscatellus* was recorded in the control plot during October 2013, whereas, the exit holes recorded in the parasitoid release plot were 14.2±2.93 holes per cane during

September. Similarly, the maximum population of *C. infuscatellus* larvae (19.20±2.14) and pupae (13.25±2.04) was also recorded in the control plot at the end of the season i.e., October 2014, whereas, the population of larvae and pupae observed in the parasitoid release plot were 6.25±1.11 and 2.44±0.54, respectively. Overall, the results of the study indicated a highly significant difference (P < 0.05) in the population of exit holes, larvae and pupae recorded between parasitoid and control treatments, where comparatively higher populations i.e., 15.56±2.78 exit holes, 11.38±2.19 larvae and 8.32±1.55 pupae were recorded in the control treatment. Moreover, overall the number of exit holes, larvae and pupae recorded in parasitoid release treatment were 9.17±1.71, 3.47±0.77 and 1.47±0.25, respectively (Table 2).

Table 2. Performance of *C. flavipes* against *C. infuscatellus* through augmentative release during 2014 under field conditions (Mean + SE).

Months	*Chilo infuscatellus*						*Cotesia flavipes*			
	Exist holes		No. of larvae		Pupae		No. of cocoon		No. of larvae	
	Parasitoid	Control	Parasitoid	Control	parasitoid	Control	parasitoid	Control	Parasitoid	Control
March	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00	0.0±0.00
April	5.5±0.74	10.2±1.9	1.75±0.22	7.50±0.45	1.22.±0.21	5.44±0.25	10.2±0.75	2.96±0.82	3.95±0.65	1.34±0.22
May	6.75±1.02	12.76±2.15	1.95±0.45	8.90±1.12	1.24±0.27	6.75±1.01	12.75±1.35	3.76±0.77	5.78±0.96	1.74±0.4
June	9.50±2.03	15.75±2.63	3.15±1.04	10.85±1.15	1.48±0.25	7.35±1.25	13.50±1.25	4.76±0.94	8.30±1.22	2.92±0.72
July	11.6±2.32	18.90±2.84	3.90±0.82	11.60±1.35	1.66±0.30	9.73±1.34	15.85±1.51	6.22±1.31	10.77±1.44	3.95±0.80
August	12.2±2.09	20.2±3.09	4.87±0.98	15.10±1.72	1.78±0.40	11.85±2.04	17.65±1.71	8.45±1.32	13.51±1.72	5.10±1.02
September	13.6±3.02	22.40±3.72	5.91±1.23	17.85±2.13	1.97±.32	12.21±1.66	19.35±1.82	9.50±2.05	17.1±2.13	6.82±1.30
October	14.2±2.93	24.25±4.13	6.25±1.11	19.20±2.14	2.44±0.54	13.25±2.04	21.95±2.11	10.85±1.51	19.5±2.44	8.67±1.81
Overall Mean	9.17±1.71b	15.56±2.78a	3.47±0.77b	11.38±2.19a	1.47±0.25b	8.32±1.55a	13.91±2.39a	5.81±1.29b	9.86±2.36a	3.82±1.04b

*Mean followed by the same letters in a final row are significantly different (LSD < 0.05).

The augmentative release of *C. flavipes* in the second year also showed a promising influence on the population build-up of its population against *C. infuscatellus*. Accordingly, the highest population of cocoons (21.95±2.11) and larvae (19.50±2.44) during October 2014 in parasitoid release treatment, whereas, the same population of larvae and cocoons recorded in the control treatment were 10.85±1.51 and 8.67±1.81, respectively. A highly significant difference (P < 0.05) was observed in the overall number of *C. flavipes* cocoons and larvae as the maximum number of cocoons (13.91±2.39) and larvae (9.86±2.36) was recorded in parasitoid release treatments, whereas, the same parameters recorded in the control plot were 5.81±1.29 and 3.82±1.04, respectively (Table 2).

Discussion

The two-year study conducted showed that the augmentative release of *C. flavipes* has shown a good result in lowering the population of *C. infucatellus* in the sugarcane field as a comparatively less number of *C. infuscatellus* larvae and pupae were recorded in the parasitoid release plot than control. Wang *et al.* (2019) reported that biological control is a safe, sustainable approach that takes advantage of natural enemies such as predators, parasitic insects, or pathogens to manage pests in agroecosystems. Parasitoid wasps, a very large evolutionary group of hymenopteran insects, are well-known biological control agents for arthropod pests in agricultural and forest ecosystems. The present results are in accordance with those of Songa *et al.* (2001) who observed that the borer population reduced markedly after being parasitized by *Cotesia* spp. Sohati *et al.* (2001) reported that the larval parasitoid, *C. flavipes* releases in the field to control *C. partellus* showed a significant difference in pest population and crop performance between treatment and control. Rossi and Fowler (2003) reported a remarkable decrease in stem borer infestation in sugarcane fields since the introduction of *C. flavipes* in the field. Another study also confirmed that *C. infuscatellus* population was significantly reduced in the field with the release of *C. flavipes* (Omwega *et al.,* 2006). Moreover, field experiments of Cugala and Omwega (2001) confirmed that with the release of *C. flavipes* was found highly effective to reduce the population of *C. infuscatellus* and lowered its infestation in sugarcane. Kfir *et al.* (2002) reported that *C. flavipes* was introduced for control of *C. partellus* and caused a 32-55% decrease in stem borer densities. Furthermore, studies on the development of *C. flavipes* indicated that stem borers' population reduced markedly after the release of *Cotesia* spp. (Ofomata *et al.,* 2000; Songa *et al.*, 2001). Although *C. flavipes* has remarkably diminished the populations of stem borers, its impact and rate of parasitism varied from one agro-ecological zone to another as Maneerat *et al.* (2017) observed that augmentative release of parasitoid done over two consecutive cropping seasons, confirmed higher yields in control plots due to the less infestation of *C. infuscatellus*.

Conclusion

The augmentative release of *C. flavipes* during both years (2013 and 2014) was found effective in reducing the population of *C. infuscatellus* in sugarcane fields as comparatively less number of exit holes, larvae and pupae of stem borer were recorded in parasitoid release plots. Moreover, a higher number of *C. flavipes* cocoons and larvae were also recorded in the treated plots than control.

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