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Research Article

Management of spotted stem borer, *Chilo partellus* (Swinhoe) in maize crop through augmentative releases of *Cotesia flavipes* (Cameron) in Bihar

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ABSTRACT: The management of spotted stem borer of maize *Chilo partellus* through augmentative releases of the parasitoid *Cotesia flavipes* was conducted at Dr Rajendra Prasad. Central Agricultural University, Pusa, Bihar during *Kharif* 2014, 2015 and 2016. *Cotesia flavipes* (Cameron) was the dominant natural enemy of *Chilo partellus* (Swinhoe) in maize fields of Bihar agro-climatic condition and its maximum parasitization was 57 per cent. In the augmented experimentation lay out, the maximum natural infestation of *Chilo partellus* and its parasitoid was as 41.21 per cent during last week of September and 42.30 per cent during second week of November, respectively. In the augmented maize field, the maximum infestation and parasitization were found as 11.36 and 51 per cent, respectively.

KEY WORDS: *Chilo partellus*, *Cotesia flavipes,* ecologically dominant parasitoid

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INTRODUCTION

Augmentation is the establishment of existing natural enemies in specific area because it exhibits selective evolutionary adaptations to the distinct geographic populations of the target species. The relative efficacy or virulence of the chosen biocontrol agents across the variations in the population of target pest should be regarded as an important factor for their successful deployment (ICIPE, 2001). The interaction between plants' herbivores and its natural enemies cannot be fully understood without considering the natural enemies' action against herbivores because it regulates pest density (Price *et al*., 1980). Mohyuddin *et al*., (1981), Mohyuddin (1991) and Smith *et al.,* (1993) emphasized the need to give due consideration of parasitoid plant preference and suitability during attempts to introduce *Cotesia flavipes* (Cameron) and they reported that *C. flavipes* developed ecological strains that are adapted to searching specific host plants infested by stem borers.

Maize is one of the most important multipurpose cereal crops in the world and the third most important food crops after rice and wheat. In India, maize is grown in all the seasons, i.e., *kharif, rabi* and summer. Of these nearly 90 per cent of the production is from *kharif* season, 7 to 8 per cent during *rabi* and remaining 1 to 2 per cent during summer season. For Bihar, winter maize covers larger area than *kharif* due to very severe pest problem in *kharif* maize (ICRISAT, 1992). In India it is grown in states like Andhra Pradesh, Karnataka, Rajasthan, Maharashtra, Madhya Pradesh, Uttar Pradesh, Bihar and Himachal Pradesh.

Maize is attacked by about 139 species of insect pests, among these *Chilo partellus* (Swinhoe) is a key pest of maize in different agroclimatic regions of India (Bhanukiran and Panwar, 2000; Shukla and Kumar, 2005). Farid *et al*. (2007) stated that *C. partellus* is a key pest of maize crop in Asia and African countries. *C. partellus* is a polyphagous pest and has several graminaceous and other non-cultivated wild host plants (Harris, 1990 and Khan, 1991) and it can inflict severe damage and serious yield losses to maize and sorghum if not managed properly form the early growth stage of the crop. Khan *et al.* (1997) reported that the yield losses caused by stem borers to maize vary widely in different regions which ranged from 25-40 per cent according to the pest population density and phonological stage of the crop at infestation. Ahad *et al.* (2008) reported that mean infestation of stem borer *C. partellus* ranged up to 23.16 per cent during *kharif* season.

There is various control options of *C. partellus* which include cultural, biological, and chemical along with host plant resistance and habitat management. Agricultural research institutions with a mandate to improve production techniques and insect pest management have directed efforts towards an integrated approach particularly in developing countries which incorporate biological control (Betbeder, 1989).

Israel and Padmanabhan (1976) and Rao *et al.* (1981) reported that the *Cotesia flavipes* Cameron (Hymenoptera: Braconidae) is the most common larval parasitoid of *Chilo partellus*. It is found in nature during *kharif* season throughout India and is a provendominant larval parasitoid of *C. partellus* reducing the population up to 32 to 55 per cent (Divya*et al*., 2009). The parasitoid, *C. flavipes* is reported to cause varying extent of parasitism on *C. partellus* from different states in India, viz., 36.67 per cent in Pantnagar (Uttarakhand), Chaudhary and Sharma, 1987); 35 to 50 per cent in Himachal Pradesh (Nirmala and Desh Raj, 1996); 6.0 to 21 per cent in Assam (Borah and Arya, 1995); 2 to 33 per cent in Haryana Mohan *et al*. (1999) and 80 per cent in Punjab (Singh *et al*. 1975).

Maize is grown throughout the year in the experimental site Bihar i.e., as *kharif* (during June / July to November / December), *rabi* (October to April) and spring crop (January / February to May). There is no systematic study for the quantification of interaction result between *Chilo partellus* and its major and dominant enemy, *Cotesia flavipes.* The chances of appearance and existence of *C. flavipes* natural enemies of *C. partellus* is more in the agro - climate of Bihar because maize is grown throughout the year. Augmentative management of *C. partellus* by native dominant natural enemies especially with *C. flavipes* is much more relevant for this locality from ecological point of view as it will derive support from the continued maize agro-ecosystem. Taking these points in consideration, present investigation is taken up with the objective of studying the "impact of *C. flavipes* on *C. partellus* (Swinhoe) in maize crop through its release and recovery".

MATERIALS AND METHODS

Experiments were conducted at Research field of Rajendra Prasad Central Agricultural University, Pusa, Bihar during *Kharif*, 2014, 2015 and 2016. The experiment was subdivided into two sub - experiment. The first sub - experiment was the selection of predominant natural enemy and second was the impact study of selected natural enemy.

First sub - experiment

Selection of Ecologically dominant parasitoid

The most common composite variety of maize, *Lakshmi* was raised in 1 - hectare area with all recommended cultivation practices except insecticides application during late *kharif* 2014 and 2015. There were 100 numbers of infested plants showing symptoms of entry and/or exit holes and were randomly selected at five places in the field and these five places were distributed throughout in the field. The selected plants were deep cut at soil surface and brought into the laboratory for splitting and collection of *C. partellus* larvae and / or its natural enemies present. Alive larvae were transferred into the 2 feet fresh maize stalks for further development of transferred larvae. These stalks were kept into 3' x 2' wooden cages and changed at two days interval. The process of collection of infested plants in the field, its cutting, splitting and collection of alive larvae or natural enemy was started at the start of infestation i.e., during 1st week of August and continued till December. At collection generally, cocoon was also found, and these cocoons were kept in a vial for emergence of parasitoid. Data collection period was divided into 10 days interval considering the fact of larval period of *Cotesia flavipes* and divided duration of a month was designated as 1st, 2nd, 3rd and 4th part. The collected parasitoid was identified and found to be *C. flavipes* (Cameron).

Second sub - experiment

Augmentation study of selected natural enemy *Cotesia flavipes* (Cameron)

The experiment was conducted at two places about 6 kilometers apart from each other in the University area i.e., one at Pusa farm and second at Dholi farm during late *kharif* 2015 and 2016. The maize variety *Lakshmi* was raised in 1 - hectare area at both the placesduring 1st week of July. The objective of late sowing i.e., in the month of July is to attract more *Chilo partellus* from neighboring area at all phonological stages of the host plants to increase host infestation as well as host availability in the experimental field.

Part 1. Parasitization study in natural infestation condition on maize crop

This observation was done by selecting five blocks of 10 x 10m^2 area distributed in the whole maize field. In each block 15 numbers of plants with moist or fresh exit holes were selected and it was cut and brought into the laboratory. The plants were split to collect the alive or dead larvae or empty *Cotesia* puparia. Alive larvae were reared as mentioned earlier for parasitization. Per cent parasitization of *C. partellus* larvae was calculated on the basis of parasitoid larvae and total numbers of larvae found.

Part 2. Parasitization in augmented condition on maize crop

The extent of larval parasitization study of *Chilo* *partellus* larvae by *Cotesia flavipes,* was recorded from five blocks of 10x10m^2 demarcated in the maize field and on each plant, a 3rd instar stage of *Chilo* larvae were released to ensure host of *C. flavipes*. Infestation activity was initiated just after start of *Chilo* infestation observed in the natural lay out field crop. One day after infestation one maize stalk containing one bunch of mature cocoons of *C. flavipes* was tied with one infested plant in a block (Fig.1). Infested plants were cut and brought to the laboratory after 10 days of infestation and all the processes were repeated for rearing and recording the data on parasitization.

Fig. 1. Release method of *Cotesia puparia* in the maize field

Mass production of *Chilo partellus* and *Cotesia* parasitoid

Chilo partellus host larvae and *Cotesia* were reared according to the methodology given by Siddiqui *et al.* (1972) and PDBC, 1993, respectively.

RESULTS AND DISCUSSION

Selection of effective parasitoid

The observed parasitoids were *Sceliphron madraspatnam pictum* (F.Smith), (Sphecidae); *Xanthopimpla punctata* (F.) (Ichneumonidae); *Ischnojoppa luteator (*F.) (Ichnemonidae) and *Cotesia flavipes* (Cameron). Among the observed parasitoids, *C. flavipes* (Cameron) showed highest percentage of parasitization.

The data on larval parasitization assessment of parasitoid; Cotesia flavipes is presented in Table 1. Data showed that parasitoid action started during the 3rd part of August and peaked (57%) during 4th part of November. Divya *et al*. (2009) observed that there was 29 per cent of maximum parasitization during kharif season. Kafir (1992) observed peak parasitization (80 %) of *Cotesia sesamae* (Cameron) in South Africa that was also in-line with the present finding. Data presented in Table 1 also shows that the range of parasitization was 0.00 to 57.00 per cent this is in accordance with the findings of different workers; Nirmala and Desh Raj (1996) 35 to 50 per cent, Borah and Arya (1995) 2 to 21 per cent and Mohan *et al*. (1999) 2 to 33 per cent in different states of India. The parasitization trend showed gradual increase from 0.00 to 57 per cent till the 4th part of November which is in accordance to the findings of Divya *et al*. (2009) and the parasitization decreased to 49.46 per cent on stubbles.

Impact study

Natural infestation

The data in Table 2 showed that *C. partellus* infestation started during early August when the crop was about one month old. Infestation showed an increasing trend and peaked with 41.21 per cent during last part of September and a decreasing was observed with 21 per cent during last part of December. Thus, the infestation of *C. partellus* was in the range of 0.00 to 41.21 per cent during 1st part of August to 2nd part of November. Patel *et al*. (2016) reported similar finding on the *C. partellus* infestation during 3rd week of August in Gujarat. Maximum level of infestation was found during September and October in the present study which corroborated with the observation of Siddig (1972) who reported maximum level of incidence during November. It was also observed that during the last part of November and 1st part of December the infestation was found at around 21 per cent which was found in-accordance with findings of Manzoor *et al*., (2015). Similar results were also reported by Firke and Kadam (1978), Panwar and Sarup (1980).

Parasitization in augmentation plot

Cotesia flavipes parasitization was found in the range of 0.00 to 51.00 per cent with a peak (51%) during 2nd part of November. The result of parasitization showed a definite trend i.e., continuous increasing from 1st part of August to 2nd part of November and continuous decreasing trend (18.00 %) 2nd part of December (i.e., at crop harvest). Nagarkatti and Nair (1973) reported parasitization of 25 to 44 per cent of *C. partellus* in sorghum crop and Singh *et al*., (1975) revealed 80 percent parasitization in maize crop. Neupane *et al*. (1985) reported 30 per cent *C. partellus* parasitization. Omega *et al*. (1997) reported that 44 per cent *C. partellus* parasitization at Tarime and Magu districts of Tanzania. Matama–Kauma *et al*., (2001) recovered 4.00 to 32.90 per cent parasitization of *C. partellus* in eastern Ugenda. The above study done in Ugenda was in - line with the present study of natural parasitization recovery study.

Effect of parasitization in augmentated plot

Table 2 showed that the infestation of *C. partellus* before and after *Cotesia* release. The infestation ranged from of 0.00 to 11.36 per cent after release of *Cotesia,* and it was in the range of 0.00 to 41.21 per cent before

Table 1. Parasitization of *Cotesia flavipes* Cameron on *Chilo partellus* larvae (Swinhoe) during different parts of months in the maize crop during *kharif* 2014-15 and 2015-16

Sl. No.	Month of observation	Different parts of the month	Date of observation	Average parasitization (%)
1	August	1st part	1.8.2014 & 2015	0.00
2		2nd part	10.8.2014 & 2015	0.00
3		3rd part	20.8.2014 & 2015	8.33
4		4th part	30.8.2014 & 2015	11.01
5	September - October	1st part	9.9.2014 &15	19.94
6		2nd part	19.9.2014 &15	29.78
7		3rd part	29.9.2014 &15	36.08
8		4th part	9.10.2014 &15	43.43
9	October - November	1st part	19.10.2014 & 15	41.00
10		2nd part	29.10.2014 & 15	43.77
11		3rd part	8.11.2014 & 15	46.91
12		4th part	18.11.2014 & 15	57.00
13	November - December	1st part	28.11.2014 &15	56.06
14		2nd part	28.11.2014 &15	50.01
15		3rd part	28.11.2014 &15	53.52
16		4th part	28.11.2014 &15	49.46 (stubbles observation)

Table 2. Impact of augmentation of *Cotesia flavipes* Cameron on its host *Chilo partellus* during *kharif* 2016 and 2017 on maize crop

Date of *Cotesia flavipes* puparia release	Date of *Cotesia flavipes* observation	Av. Natural infestation (%)	Av. Natural parasitization (%)	Augmentation av. Parasitization (%)	Corresponding infestation after parasitization (%)
29.7. 2016 & 2017	7.8. 2016 & 2017	0.00	0.00	0.00	0.00
8.8.2016 &2017	16.8.2016 &2017	9.12	8.50	18.50	11.36
17.8. 2016 &2017	26.8. 2016 &2017	13.75	15.70	18.68	9.87
27.8.2016 &2017	5.9.2016 &2017	31.00	19.90	27.01	9.12
6.9.2016 &2017	15.9.2016 &2017	37.25	23.01	25.00	6.51
16.9.2016&2017	25.9.2016&2017	40.90	27.30	36.33	5.21
26.9.2016 &2017	5.10.2016 &2017	41.21	28.90	37.00	5.00
6.10.2016 &2017	15.10.2016 &2017	39.60	34.30	40.25	4.12
16.10.2016 &2017	25.10.2016 &2017	33.00	35.20	46.00	4.00
26.10.2016 &2017	4.11.2016 &2017	29.25	39.40	47.00	3.67
5.11.2016 &17	14.11.2016 &17	28.31	41.90	47.65	3.12
15.11.2016&2017	24.11.2016&2017	22.01	42.30	51.00	3.00
25.11.2016 &2017	4.12.2016 &2017	21.67	18.70	21.00	3.00
5.12.2016 &2017	14. 12.2016 &2017	21.01	15.80	18.00	3.00
15.12.2016 &2017	-	21.00	14.60	18.00	3.00
Summary statistics					
Particulars	Natural infestation (%)	Natural parasitization (%)	Augmentation parasitization (%)	Corresponding infestation (%)	
Mean	25.94	24.37	30.09	4.93	
SD	12.10	12.66	14.77	3.06	
CV (%)	46.65	51.95	49.08	62.13	

the release. Peak infestation was 41.21 per cent and 11.36 per cent during last part of September and 1st part of August respectively in natural and augmentative fields. The trend of infestation was as continuous increase and continuous decreasing in natural as well as augmentative field. Reduced level was maintained during the last phase of crop stand that would be beneficial for maintaining the parasitoid in field to ensure crop protection. Summary statistics revealed that the mean infestation in the augmentation plot decreased to 4.93 per cent from the 25.94 per cent in natural set.

CONCLUSION

The release of local dominant and maize specific *Cotesia* strain of parasitoid is effective in reducing the pest status of *C. partellus*. Augmentative release of the parasitoid is required to supplement natural parasitism for effective suppression of the pest.

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