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RESEARCH PAPER

Status of parasitization of fall armyworm, *Spodoptera frugiperda* (J. E. Smith) in Punjab maize ecosystem

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Abstract: Fall armyworm (FAW) is a devastating pest that voraciously feeds on the foliage of maize and has been recognized as a potential threat to the crop. The natural enemies establishment is the key to the integrated pest management (IPM) of FAW in different maize agro-ecosystems. The present study showed the increase in the rate of natural enemies i.e., parasitoids in Punjab maize fields under natural conditions during the rainy season in 2021. The parasitoids of FAW larvae were recorded from 1st week of June 2021 up to the 2nd week of October 2021. The parasitoids observed were *Chelonus formosanus* Sonan and *Temelucha* sp. and the former is more prevalent with per cent parasitism rate ranging from 1.1 to 34.2%, followed by *Temelucha* sp. with parasitism of 0.8–14.7%. *C. formosanus* resulted in a maximum parasitism rate in the 3rd week of July (34.17%) while the minimum rate was observed in the 2nd week of October (1.07%). The per cent parasitism due to *Temelucha* sp. was maximum in 1st week of August (14.67%) whereas the value was minimum in 4th week of June as well as in 3rd week of July 2021. The total parasitism rate of FAW was maximum in the 3rd week of June 2021 (36.84%), and the minimum rate (2.86%) was observed in the 2nd week of October 2021. The maximum and minimum survival rate of parasitoids was recorded in 1st week of August 2021 (76.19%) and 2nd week of October 2021 (37.50%), respectively. The correlation between per cent parasitism and the survival rate of parasitoids was observed to be positively significant.

Keywords: *Chelonus formosanus* · Fall armyworm · Natural enemies · Parasitoids · Parasitism rate · Punjab · *Temelucha* sp.

Introduction

Fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) is a noctuid moth that originates from tropical and sub-tropical America (Agboyi *et al.,* 2020). It is a polyphagous pest, known to be a dominant feeder of maize and other cereals (Montezano *et al.,* 2018). Outside its natural range, a severe outbreak of FAW was reported in Africa in 2016 in maize agroecosystems, since then this pest has been reported in 100 countries across the globe including India (Rwomushana *et al.,* 2018; Baloch *et al.,* 2020). In India, FAW was first reported from Karnataka in 2018 (Sharanbassapa *et al.,* 2019) and subsequently it attacked almost all the maize-growing areas in the country including Punjab where it was reported in 2019. It is estimated that the yield losses in maize due to FAW in sub-Saharan African countries account for about US$13 billion per annum (Tefera *et al.,* 2019).

As a quick line of defense, synthetic insecticides are being used to control this pest (Sisay *et al.,* 2019). But an integrated approach is required for sustainable control of the pest, especially with biological control for managing FAW in the long-term. This invasive pest has been established recently in the Indian conditions, its biotic regulatory factors i.e. the native natural enemy diversity

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of other closely related pest species present in our conditions need to be identified and used for effective biological control. Species such as *Temelucha biguttula* (Munakata), *Temelucha philippinensis* (Ashmed) and *Trathala flavo orbitalis* (Cameron) have been reported from Southern India (Daniel *et al.,* 2020). Whereas under Punjab conditions, two major parasitoids were observed for the first time i.e., *Chelonus formosanus* Sonan (Hymenoptera: Braconidae) and *Campoletis* sp. (Hymenoptera: Ichneumonidae) (Jindal *et al.,* 2021).

Spodoptera sp. is a well-established pest of various host crops in India harbouring a rich source of native natural enemies (Sharanbassapa *et al.,* 2019). These natural enemies can broaden their spectrum of control by parasitizing FAW and controlling its further spread. Keeping these points in mind, the present study has been planned to know the status of the parasitization of FAW in the Punjab (North Indian) maize ecosystem.

Materials and methods

The present studies were carried out at the experimental area of Punjab Agricultural University, Ludhiana, India during the rainy season of 2021. Plants were visually examined regularly for the presence of FAW eggs and larvae. Different larval stages of the pest and 10–20 egg masses were collected randomly on weekly basis. The collected egg masses were placed in Petri dishes with a piece of moistened filter paper while the larvae were individually placed in plastic vials (3 cm × 4.5 cm). These were maintained at standard conditions (temperature of 25±1°C and 70% relative humidity) in Maize Entomology Laboratory, Punjab Agricultural University (PAU), Ludhiana. The holes were made in the lid of vials for the ventilation. The larvae were fed separately, untreated natural food (maize whorls) in plastic vials. The food was changed every 3rd – 4th day or whenever needed. The culture was observed regularly and the emerged parasitoids were preserved in 70 per cent ethanol. The parasitoid emergence was checked by examining the parasitized FAW larvae which were found to be shrinked, and blackish in colour on the parasitoid arrival (Plate 1). The observations on parasitism rate and the survival rate of parasitoids were made and calculated as per Canico *et al.* (2020) as given below:

The parasitism rate of each parasitoid species (Pp) was determined by dividing the number of parasitized larvae (Lp) by the number of collected larvae (TL) and converted to per cent values by multiplying with 100 (Equation 1).

Plate 1. Emergence of the parasitoid (*Chelonus formosanus*) from FAW larvae

$$Pp = \frac{Lp}{TL} \times 100\% \quad \text{.....(1)}$$

The survival rates of different larval parasitoids (SR) were determined by dividing the number of individuals reaching the adult stage (Pa) by the number of individuals emerging from field collect FAW larvae (Pe) and converted to per cent values (Equation 2).

$$SR = \frac{Pa}{Pe} \times 100\% \quad \text{.....(2)}$$

Results and discussion

Different stages of FAW were collected from PAU fields during the rainy season of 2021 from 1st week of June to the 4th week of October 2021. The parasitism rate observed was 10.81% during the 1st week of June 2021 which increased up to 36.84% (maximum) by the 3rd week of June 2021 and fluctuated between 25–35% up to August 2021. Then the parasitism rate started decreasing steadily after the 4th week of August up to the 2nd week of October 2021 (Table 1). No parasitoid emergence was recorded from the 3rd week of October 2021 onwards due to the termination of the crop. The per cent parasitism ranged from 2.9–36.8% with an overall

Table 1. The parasitism rate and survival rate of parasitoids on fall armyworm under natural conditions at PAU, Ludhiana, in rainy season maize 2021

Week No.	Week of month	Percentage parasitism	Survival rate of parasitoids (%)
23	1st week of June 2021	10.8	62.5
24	2nd week June 2021	12.0	66.7
25	3rd week June 2021	36.8	68.6
26	4th week June 2021	25.0	70.0
27	1st week of July 2021	26.9	60.0
28	2nd week July 2021	30.3	75.8
29	3rd week July 2021	35.0	66.7
30	4th week July 2021	35.0	53.6
31	1st week August 2021	28.0	76.2
32	2nd week of August 2021	21.7	73.7
33	3rd week of August 2021	25.0	61.8
34	4th week of August 2021	29.4	72.0
35	5th week of August 2021	26.3	71.7
36	1st week of September 2021	23.3	68.6
37	2nd week of September 2021	18.9	55.9
38	3rd week of September 2021	16.9	65.2
39	4th week of September 2021	10.6	48.0
40	1st week of October 2021	10.0	50.0
41	2nd week of October 2021	2.9	37.5

parasitism rate of 22.1%. However, Jindal *et al*. (2021) also recorded the emergence of parasitoids in the Punjab ecosystem on late-season crop in *Kharif* 2020 from the 4th week of October 2020 up to the 1st week of January 2021 in which the total parasitism rate in the study ranged from 10-60%with overall per cent parasitism of 38.3%. The maximum total parasitism (60%) was observed in the 2nd week of December 2020.

Among different parasitoids, *C. formosanus* was found to be the most prevalent parasitoid followed by *Temelucha* sp. during the rainy season 2021. Whereas, during *Kharif* 2020, *Campoletis* sp. was the predominant parasitoid with a weekly parasitism rate of 2.5–46.7% (Jindal *et al.,* 2021). *Chelonus* genus is an egg-larval parasitoids that is the most common and widely distributed parasitoid of FAW in various countries (Prasanna *et al.*, 2018; Firake and Behere, 2020; Gupta *et al.,* 2020; Otim *et al.*, 2021). The maximum parasitism rate caused by *C. formosanus* was observed in the 3rd week of July (34.2%) followed by the 4th week of July (33.8%) and 3rd week of June (33.7%) respectively (Figure 1). The minimum per cent parasitism caused by *Chelonus* was found in the 2nd week of October (1.07%) which might be due to the maturity of the crop. Similar observations were given

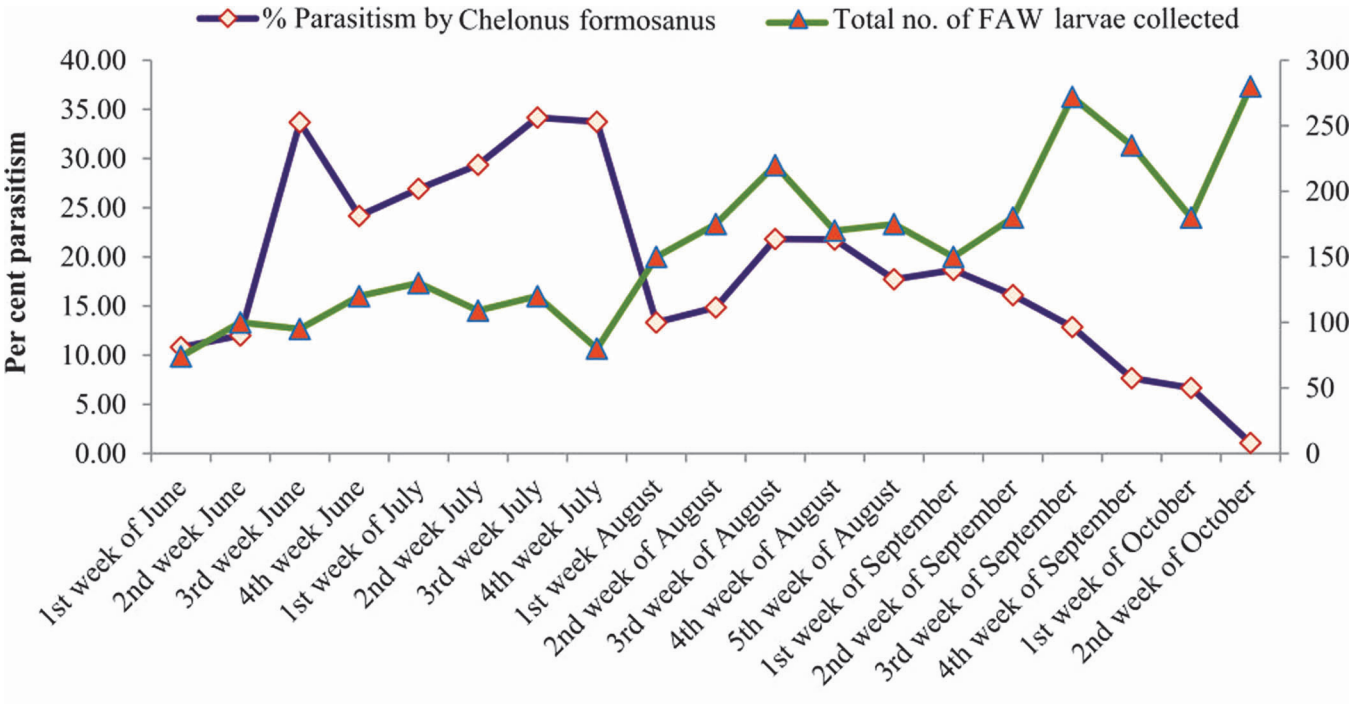

Figure 1. Parasitization of fall armyworm larvae by *Chelonus formosanus* under natural conditions in rainy season 2021 at PAU, Ludhiana

by Agboyi *et al*. (2020) in which *C. bifoveolatus* caused an average parasitism of 18.9%. On the other hand, *Temelucha* spp. is a well-established parasitoid of *Phthorimaea operculella* (potato tuber moth) which is an endo larval parasitoid (Townes, 1971; Ashley *et al.*, 1983; Pair *et al.,* 1986). The per cent parasitism caused by *Temelucha sp*. was recorded as very low ranging from 0.83% to 14.7% (Figure 2). It caused maximum parasitism in 1st week of August (14.7%) followed by the 4th week of August (4.7%). The minimum parasitism rate i.e., 0.83% was observed in the 4th week of June as well as in the 3rd week of July 2021.

In the present study, the maximum survival rate was recorded in the 1st week of August 2021 i.e., 76.2% and the minimum rate (37.5%) were observed in the 2nd week of October 2021. The survival of parasitoids ranged from 37.5–76.2% and the overall survival rate was 62.9% (Table 1). Two more parasitoids also recorded during

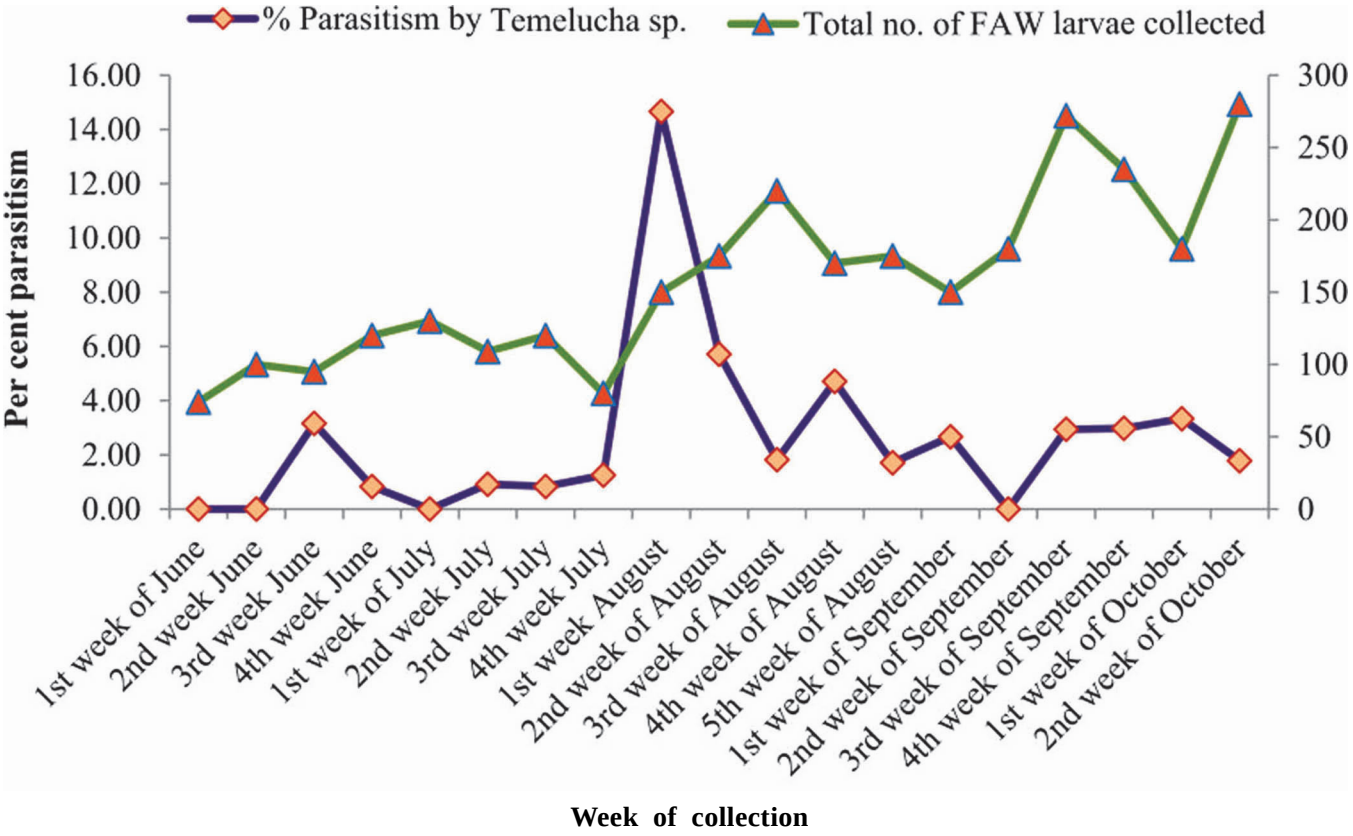

Figure 2. Parasitization of fall armyworm larvae by *Temelucha* sp. under natural conditions in rainy season 2021 at PAU, Ludhiana

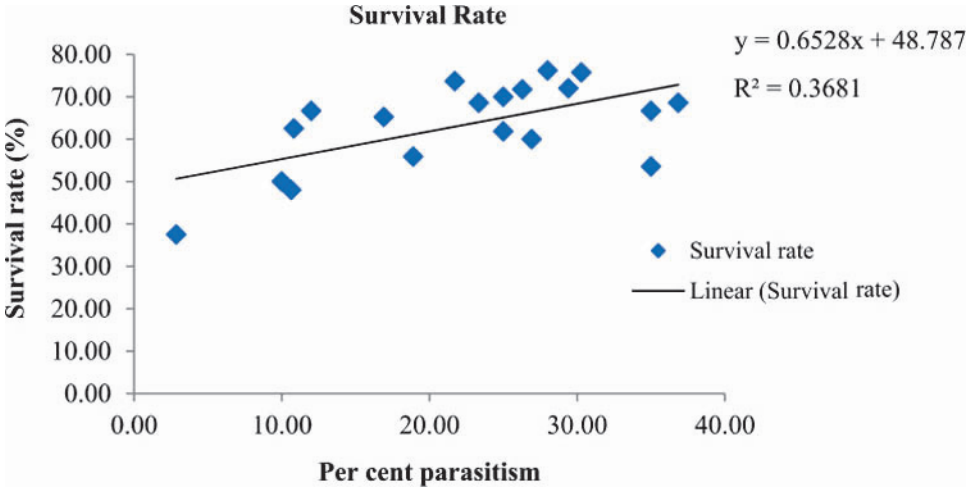

Figure 3. Survival rate of parasitoids in relation to its per cent parasitization on fall armyworm during rainy season 2021 at PAU, Ludhiana. The black line represents the linear model, Y = 0.652x + 48.78, where R^2 = 0.368

Kharif 2021, have been sent to the National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru for their correct identification and description.

A statistically significant correlation (0.607, **p < 0.01) was observed between per cent parasitism and the survival rate of parasitoids. The linear regression line between per cent parasitism and survival rate of parasitoids (Y) was Y = 0.652x + 48.78 (Y=bX–a) (Figure 3). The per cent parasitism shows 36.8% variability in the survival rate of parasitoids (R^2=0.368). Therefore, it can be inferred that the survival of parasitoids is dependent on the abundance of the parasitoids in the habitat.

Conclusion

The native natural enemies are establishing as a key factor in IPM of Fall armyworm in different maize agro-ecosystems. Therefore, the emphasis should be given to mass rearing programmes of the prevalent native natural enemies of FAW in specific agro-ecozones. From the present study, it can be suggested that the inoculative release of these natural enemies could be incorporated as a tool in IPM to keep the pest below the threshold levels. Also, the stakeholders i.e., farmers should be made aware of the potential of these natural enemies with more emphasis on conservative biological control programmes and encouraging the use of natural enemies friendly practices.

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