Original Research Article

Oviposition behaviour of Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on different host plants

Abstract

The selective ovipositional behaviour of Fall armyworm (FAW), *Spodoptera frugiperda* was studied at Centre for Agro Climatic Studies under field and laboratory conditions through cage experiments to provide the basis for its oviposition preference on different crops to find an ecological solution for its management. Oviposition preference of *S. frugiperda* was evaluated under free choice and no choice conditions with maize, sorghum, groundnut, cotton, cabbage, chickpea and tomato. The results of the experiment revealed that the number of eggs laid by the FAW on maize (208.7± 7.00) was high when compared to sorghum (110.3± 10.0) under filed conditions. But, in case of laboratory conditions under no choice test females preferred to oviposit on maize, sorghum, groundnut, cotton and cabbage except on chickpea and tomato. Egg masses per plant was maximum on maize in both field and laboratory conditions followed by sorghum. Information of hierarchies of *S. frugiperda* host plant oviposition preference by females will be useful in developing strategies for the management of this pest.

Keywords: Maize.Fall armyworm. Choice test. No choice test. Oviposition behavior

Introduction

Fall armyworm (FAW), *Spodoptera frugiperda* (J E Smith) (Lepidoptera: *Noctuidae*) is one of the most destructive worldwide polyphagous pest that has a wide range of host plants (Sharanabasappa et al.2018). India is of serious concern owing to its voracious feeding as well as its polyphagous nature. This notorious pest spread across the world in short period of time because of its high dispersing ability, wide host range, high fecundity, lack of diapause mechanism makes it one of the most severe economic pests (Chormule et al. 2019). FAW has high biotic potential wherein, adult females can lay egg mass containing 100-200 eggs on

leaves and they hatch in 2-4 days under optimum temperature. The developing larvae can cause damage in all the phenological stages and host plant depending on stage of the crop.

Oviposition of insects is a chain of behavioural activities includes searching, landing and contact. Studies on ovipositional behavior need to determine the function of plant kairomones in the host finding and orientation behavior of gravid moths. Insects use visual and semiochemical stimuli to discover a host plant. Variations in oviposition orientation on different host plants initiated by volatiles or chemical cues.

To qualify as a host plant, female moths need to find and accept the plant for oviposition and the larvae should accept the plant as a food source (Saminathan et al.2022). Because of the polyphagous nature of fall armyworm, in this study we aimed to recognize oviposition choice of fall armyworm moths on various hosts *viz.*, maize, sorghum, groundnut, cotton, cabbage, tomato and chickpea. The most preferred host plant can be utilized as a trap crop in IPM programmes.

Materials and Methods

Oviposition preference of *S. frugiperda* on different host plants.

A. Field condition

Free choice studies

Oviposition preference studies were carried out according to Silva et al. (2017) with slight modifications. Two experiments (free-choice and no-choice tests) were conducted to evaluate the oviposition preference of *S. frugiperda* adults on maize, sorghum, cotton, cabbage, tomato, groundnut and chickpea in the field conditions. Different host plants were sown at different dates in order to obtain the same growth stages for all the plants (8 to 10 completely opened leaves). Under the free choice test (21 pots/block) each pot having three plants/pot were covered with the nylon mesh cage (4 × 3 × 2.5 m) (Fig.1a)**.** Later 25 pairs of old of three day old adults of *S. frugiperda* were released in free choice. The observation on the number of egg masses and number of eggs per mass laid on each host plant till cease of oviposition.

(a).Free choice

(b)No choice

Fig. 1(a-b) Oviposition preference studies under field condition

No choice studies

Under no choice test four pots of each host were covered with the nylon mesh cage(Fig. 1b). Five pairs of three day old were inside cages and observed the number of egg masses and number of eggs per mass laid on each host plant till cease of oviposition.

B. Laboratory condition

Free choice studies

Under this experiment the seedlings of maize, sorghum, groundnut, cabbage, cotton, chickpea and tomato were raised in a paper cup filled with soil and vermicompost. Once those seedlings attain four to five leaf stage placed inside the oviposition cages and adults of male and female three-day old were released inside the cages (5:5) under choice condition for egg laying and ten per cent honey solution was provided as food for the adults (Fig.2a). Observation on number of eggs laid by females under choice.

Fig. 2a Oviposition preference studies under laboratory condition with free choice

No choice studies

In no choice condition paper cups containing each host seedlings were placed separately in individual oviposition cages and adults of male and female of three-day old adults were released inside the cages (1:1) for egg laying and ten per cent honey solution was provided as food for the adults (Fig.2b). Number of eggs laid by females under no choice condition were recorded after three days from releasing of adults and observations on number of egg masses and number of eggs for each mass were also counted.

Maize

Groundnut

Cabbage

Tomato

Chickpea

Cotton

Sorghum

Fig 2b. Oviposition preference studies under laboratory condition with no choice

Statistical analysis

Data were compared using one way ANOVA procedure and the means were separated by Tukey post hoc test using IBM SPSS (version 21) and Microsoft Excel (version 2010).

Results

Field condition

For lepidopteran species, larval preference is mainly associated with adult choice for oviposition. In terms of ovipositional preference, females select to oviposit on hosts with the highest nutritional quality for offspring and hence, the selected host would allow the offspring to shorten the developmental time, increase biomass, as well as reproductive potential. In the field cage experiment of ovipositional preference of *S. frugiperda*females selected only maize and sorghum for oviposition under free choice conditions in Table 1. Furthermore, the number of egg masses and number of eggs per mass were recorded more on maize ($3.60^{a} \pm 1.10$) and number of egg masses per plant ($208.7^{a} \pm 7.00$) followed by sorghum ($2.30^{b} \pm 0.60$) and number of egg masses per plant ($110.3^{b} \pm 10.0$). Wherein, no egg masses as well as eggs were found on other host plants (cotton, groundnut, cabbage, tomato and chickpea) as a choice Table 1. So free choice experiment suggests that *S. frugiperda* females strongly preferred maize as their host over other crops due to its higher nutritional quality. These findings are in line with Wijerathna et al. (2021) where maize was highly preferred host under free choice conditions than any other vegetable crop (cabbage, radish, brinjal and okra). No choice test was performed in order to confirm the preference or avoidance of the most and least preferred host plants. Under no-choice condition, similar results were recorded as in case of free choice condition, where female moths preferred to oviposit on maize ($1.70^{a} \pm 0.60$) with ($202.2^{a} \pm 7.7$) number of eggs per mass followed by sorghum ($1.30^{b} \pm 0.50$) with ($102.1^{b} \pm 5.9$) number of eggs per mass whereas, other crops were not preferred for egg laying Table 1.

Table 1 Oviposition preference of FAW under choice and no choice condition in feild.

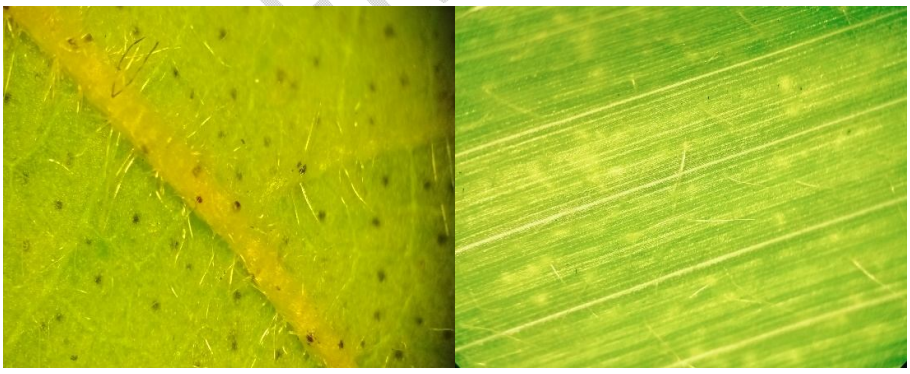
Tr. No.	Host	Choice condition		No choice condition	
		No. of egg masses	No. of eggs/mass	No. of egg masses	No. of eggs/mass
T_1	Maize	$3.60^{a} \pm 1.10$	$208.7^{a} \pm 7.00$	$1.70^{a} \pm 0.60$	$202.2^{a} \pm 7.7$
T_2	Sorghum	$2.30^{b} \pm 0.60$	$110.3^{b} \pm 10.0$	$1.30^{b} \pm 0.50$	$102.1^{b} \pm 5.9$
T_3	Groundnut	*	*	*	*

T_4	Cotton	*	*	*	*
T_5	Tomato	*	*	*	*
T_6	Chickpea	*	*	*	*
T_7	Cabbage	*	*	*	*
SEM		1.67		1.63	
CD(5%)		4.86		4.76	

'*' Indicates no oviposition observed

Laboratory condition

Under laboratory conditions, in choice test different hosts were provided for oviposition preference. Adult females showed more preference to maize ($2.60^{a} \pm 0.50$) eggs per plant with ($214.2^{a} \pm 8.4$) number of eggs per mass followed by sorghum ($0.80^{b} \pm 0.40$) with ($95.0^{b} \pm 0.00$) number of eggs per mass. However, no egg laying was noticed on other hosts (cabbage, chickpea, tomato and groundnut) (Table 2). Under no choice conditions in the laboratory, females preferred to oviposit on host *viz.*, maize, sorghum, groundnut, cotton, and cabbage except on chickpea and tomato (Fig.3). Among different hosts studied, maize was highly preferred over other crops ($4.60^{a} \pm 1.10$) egg masses/ plant with ($211.6^{a} \pm 7.01$) eggs per mass. Adult females oviposit ($3.20^{b} \pm 0.40$) egg masses per plant with ($134.6^{b} \pm 3.6$) eggs per mass on sorghum followed by groundnut ($2.20^{c} \pm 0.40$) egg masses /plant with ($127.6^{c} \pm 1.7$) eggs/mass. The least number of eggs was recorded on cotton ($1.00^{e} \pm 0.00$ egg masses /plant with ($77.0^{e} \pm 2.50$eggs/ mass) followed by cabbage ($1.40^{d} \pm 0.50$ egg masses/ plant with $93.20^{d} \pm 1.81$eggs/mass) Table 2.



Cotton Maize

Fig. 3 Leaf trichomes

Table 2 Oviposition preference of FAW under choice and no choice condition in laboratory

Tr. No.	Host	Choice condition		No choice condition	
		No. of egg masses	No. of eggs/mass	No. of egg masses	No. of eggs/mass
T_1	Maize	2.60^{a}± 0.50	214.2^{a}± 8.4	4.60^{a}± 1.10	211.6^{a}± 7.01
T_2	Sorghum	0.80^{b}± 0.40	95.0^{b}± 0.00	3.20^{b}± 0.40	134.6^{b}± 3.6
T_3	Groundnut	*	*	2.20^{c}± 0.40	127.6^{c} ± 1.7
T_4	Cotton	*	*	1.00^{e}± 0.00	77.0^{e}± 2.50
T_5	Tomato	*	*	*	*
T_6	Chickpea	*	*	*	*
T_7	Cabbage	*	*	1.40^{d}± 0.50	$93.2.00^{d}$± 1.81
SEM		1.42		1.46	
CD(1%)		5.6		5.70	

'*' Indicates no oviposition observed

Discussion

Fall armyworm fed on grasses such as rice, wheat, maize, sorghum, sugarcane and millets. Even though fall armyworm is a polyphagous pest, it primarily affects crops of Poaceae family (Montezano et al. 2018). According to Murua et al. (2008) maximum number of egg masses/female was reported on maize (8.80 ± 1.13) in line with this study, in our experiment maximum number of egg masses recorded on maize in both no choice and free choice test under both field and laboratory conditions. Most of the eggs were laid on upper surface of the leaves. Oviposition on walls of cages was also recorded despite the presence of host plants. The presence of egg masses on the walls of mesh cages interprets that tactile stimuli (corrugated surfaces) are more important than plant volatiles for oviposition (Rojas etal. 2003). The present findings suggested that in absence of a preferred host (maize) other hosts *viz.*, sorghum, groundnut, cabbage and cotton can act as an alternative host for *S. frugiperda*. Similaroutcomes were noticed by Wijerathnaet al. (2021) wherein, *S. frugiperda* females oviposited on cabbage under no-choice condition.

The results are in accordance with Rajavamsi et al.2020 the oviposition behavior of *S. frugiperda*, and noted that tactile stimuli are more important than plant volatiles and found more females ovipositing on corrugated surfaces rather than surfaces treated with host plant extracts as corn, tomato and cotton.

Even though fall armyworm is a polyphagous pest, it primarily affects crops of Poaceae family. The present findings are in line with (Saminathan et al. 2021) where more number of eggs were laid on maize 97.2 ± 9.54 which is monocot plant and least number of eggs were laid on cotton (41.8 ± 4.02) being dicot plant.

For some insects, dense pubescence on plant leaves act as an alluring substrate for oviposition (Renwick and Chew. 1994) likewise in our study among the different hosts studied the maize had comparably least trichomes that had favored females for oviposition leads to lay more number off eggs (211.6^{a} ± 7.01) whereas, cotton had denser trichomes that has resulted in least oviposition rate (72.0^{e} ± 8.00) under choice test in laboratory condition (Fig. 4). Multi-layer of scale covering was observed on egg mass laid on groundnut and cabbage and single layer scale noticed on maize and sorghum. In cotton, egg masses were not covered with abdominal scales and eggs were laid sparsely on groundnut. Variations in oviposition behavior of *S. frugiperda* can be associated with the chemical and physical characteristics of different plants (Fig. 4).

Sorghum

Cotton

Groundnut

Maize

Cabbage

Fig. 4 Egg laying by *S. frugiperda* under no choice in laboratory condition

Differences in oviposition preference noticed in the free-choice and no-choice conditions might be due to flexibility of the host range shown by *S. frugiperda* which increases the long-term evolutionary survival of this species. When given no choice condition *S. frugiperda* preferred to oviposit on all crops except chickpeaand tomato. Whereas, in the free choice condition it preferred to oviposit on maize and sorghum. Thus, ratifying wider host flexibility (Sivaranjani et al. 2021).The ovipositional choice of fall armyworm can be used to decide its preference level and that plant can be utilized as a trap crop in IPM.

Conclusions

The results of the current research revealed that the maize was highly preferred host compared to other hostplants. But, the sorghum, groundnut, cabbage and cotton can also act as preferable hosts when preferred hosts are absent. The ovipositional preference of fall armyworm can be used to decide its preference level and that plant can be utilized as a trap crop in IPM.

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Data availability

All data and materials are available if requested with the corresponding author

Declarations

We confirm that this work is original and has not beenpublished elsewhere and is not currently under consideration for publicationelsewhere.

We confirm that the results presented clearly, honestly, and without fabrication, falsification or inappropriate data manipulation. Additionally, no data, text, or theories by others are presented.