Research Article

First Record of Invasive Fall Armyworm (*Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae)) in Corn Fields of Sindh, Pakistan

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Abstract | The fall armyworm (FAW) *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae) is an invasive polyphagous pest, particularly damaging to corn. Although native to American continents, it has spread in various African and Asian countries. However, no confirmed report of its presence has been made from Pakistan as it has already been reported from its neighbors India and China. So, this study was conducted in 15 corn growing areas of Sindh, Pakistan to determine the presence and damage status of FAW on fodder and grain corn along with sorghum and millet. The presence of FAW was confirmed from all corn growing districts of Sindh except Jacobabad, Larkana and Shikarpur districts of upper Sindh. The identification of FAW was done based on its morphological characters. More damage was recorded in fodder corn than grain corn. The presence of FAW was also recorded from sorghum and millet. The 100% damage was recorded on fodder corn in Shaheed Benazirabad district. Although this is the first record of FAW from Sindh, Pakistan, but, a country wide study along with molecular identification of FAW should be conducted to confirm its presence in corn growing areas of Pakistan. This could be helpful to restrict its further spread with proper management.

Introduction

The fall armyworm (FAW) *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) is native to subtropical and tropical regions of the American continents (Sparks, 1979; Abrahams et al., 2017; FAO, 2018a; Prasanna et al., 2018). It has been reported to damage more than 80 crop species with maize, sorghum, rice, sugarcane, millet and cotton being the most important hosts (Sena et al., 2003; Prowell et al., 2004; Clark et al., 2007; Abrahams et al., 2017; Cock et al., 2017; FAO, 2018a; Montezano

et al., 2018). The FAW is an invasive pest which can cause severe economic losses because of its high reproductive potential and intensive migratory behavior with high dispersal capability as adults can fly up to 100 km in a night. Therefore, an early and integrated management approach is required to reduce the damage of FAW. Moreover, FAW has several generations in a year and temperature has significant role in its development (Belay, 2011). Its life cycle is as low as 30 days in summer but can be extended up to 60 days in winter. The eggs are laid in masses of 100-200 eggs on upper surface of leaves

which passes through six larval instars and pupate in soils (Sparks, 1979; Capinera, 2014). The larvae are the damaging stage of FAW as early first and second instars normally feed on one side of the leaves and skeletonized them, whereas, final instars feed on all parts of their hosts (Abrahams et al., 2017). In maize, the FAW cause most damage at stage 3 to 6, when it reaches to the protective regions of the whorls. The feeding in early stages kill the growing points, with no more leaf or cob development. Normally, one or two larvae feed in a whorl, as lager larvae can feed on younger larvae to reduce competition. Often, large quantities of frass are present at the feeding points of FAW, that dries to resemble sawdust. The attack of FAW after the development of cobs can devoid cobs of the grains (FAO, 2018a).

Recently, FAW has reached the African continent, with first reported appearance in Nigeria during 2016. Since then, it has spread to more than 28 countries of southern and eastern Africa (Rose et al., 2000; Goergen et al., 2016; Abrahams et al., 2017; Cock et al., 2017; FAO, 2018a). Most recent, it has been reported from many maize producing areas of India (Mahadeva et al., 2018; Ganiger et al., 2018; Kalleshwaraswamy et al., 2018; Chormule et al., 2019), Yemen (FAO, 2018b), Thailand (FAO, 2018c), Sri Lanka (FAO, 2019a), Bangladesh (FAO, 2019b), Myanmar (FAO, 2019c) and China (FAO, 2019d). Since their introduction in Africa, FAW has caused severe economic losses amounting millions of dollars (Day et al., 2017; Stokstad, 2017).

Although, no confirm reports of its presence in Pakistan have been made, but, due to the ability of FAW adults to fly long distance and confirmed reports of its presence in India, China and other neighboring countries, it is inevitable to conduct a survey on corn and other preferred hosts of FAW. Thus, objective of this study was to determine the presence and infestation rate of FAW in Sindh, Pakistan, so that appropriate steps should be taken for its better management.

Materials and Methods

This study was conducted in 289 fields across the corn growing districts of upper and lower Sindh, Pakistan i.e., lower Sindh (Hyderabad, Matiari, Tando Allah Yar, Mirpurkhas, Umarkot, Thatta, Jamshoro), and upper Sindh (Shaheed Benazirabad, Naushaharo Feroze, Larkana, Khairpur, Jacobabad, Shikarpur, Sukkur and Ghotki) (Figure 1). The selection of sampling fields was based from the locally available data from the extension departments on the corn cultivation and infestation reports of FAW. The visited fields were mostly cultivated with corn along with sorghum and millet, either for grains or fodder purposes. In an individual field, 20 plants of 45 to 60 days old were randomly selected to observe the presence or damage caused by FAW showing characteristic symptoms of shoot hole with ragged leaf infestations (window-paning), ragged whorl leaves, holes in stems and growing cobs along with sawdust-like larval feaces (FAO and CABI, 2019). The collected specimen of different stages of FAW (eggs, larva and pupae) from various visited fields were brought to the Insect Systematic and Stored Grain Laboratories, Department of Entomology Department, Faculty of Crop Protection Sindh Agriculture University Tandojam for their further rearing till adult emergence and identification. The genitalia of adult male were separated as per Pogue (2002) and observed using 350 k pixel USB camera fitted on magnifying instruments Labomed CSM2 (20X and 40X) and Kyowa Medilux 20. The high pixel mobile camera (OPPO F5) was used for habitus images of immatures and adults of FAW. The identification of collected specimen was done using keys given by Pogue (2002), EPPO (2015) and Ganiger et al. (2018). Moreover, percentage damage infestation of FAW from visited fields was calculated using following formula and presented as mean percentage infestation:

$$\% \ Infestation = Infested \ plants \ / \ total \ plants \ observed \ X \ 100$$
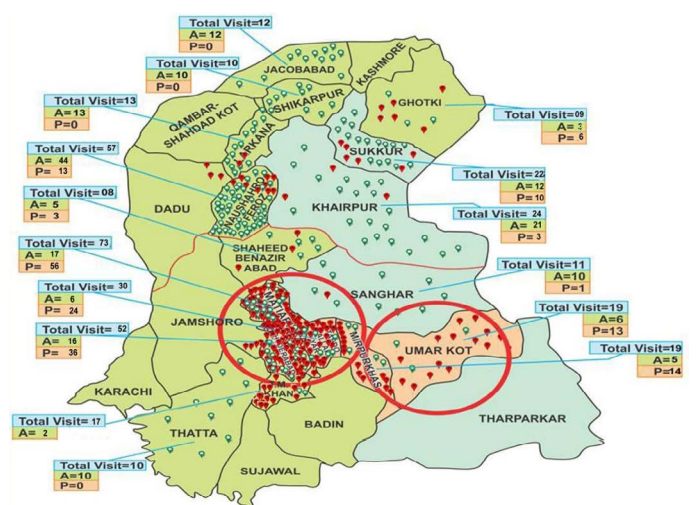

Figure 1: *Sampling locations of Spodoptera frugiperda from Sindh province, Pakistan.*

Results and Discussion

The study confirmed the presence of FAW from all the corn growing districts of Sindh except Jacobabad, Larkana, Shikarpur districts of upper Sindh. A great variation in damage percentage of FAW was also observed at different visiting crops as comparatively more damage was recorded in corn, sorghum and millet grown for fodder purpose than when these crops were grown for grain purpose. The highest damage percentage (100%) of FAW was observed from corn fodder crop at district Shaheed Benazirabad, followed 70% and 60% damage recorded at Tando Allahyar (fodder corn) and Hyderabad (grain corn) districts, respectively (Table 1). The variation in percentage damage at various locations was mainly attributed to management practices used by the growers as mostly they did not apply management practices in fodder corn. The fall armyworm is a voracious and polyphagous pest of many important crops and their level of damage varies with crop and developmental stage of the particular crop (Goergen et al., 2016; FAO and CABI, 2019). However, in maize, its most preferred host, the adult larvae may become cutworms owing to their much stronger mandibles having serrated cutting edges, enabling them to feed even on stronger portions of the crop (Goergen et al., 2016). Moreover, varietal preference and geographical conditions of the crop may also have contributed towards varying level of infestation by FAW at different study locations.

Table 1: *Infestation percentage of Spodoptera frugiperda at various sampling districts of Sindh, Pakistan.*

District	Fields surveyed	Infestation range (%)	Mean infestation (%)
Ghotki	5	0-12	4.80±2.33
Hyderabad	47	0-60	12.49±1.69
Jacobabad	12	0	0
Jamshoro	1	20	20.00±0.00
Khairpur	20	0-9	0.90±0.54
Larkana	13	0	0
Matiari	53	0-35	11.85±1.32
Mirpur Khas	19	0-50	8.05±2.51
Naushaharo Feroze	38	0-5	0.87±0.28
Shaheed Benazirabad	9	0-100	13.33±11.06
Shikarpur	10	0	0
Sukkur	15	0-11	1.93±0.91
Tando Allahyar	18	0-70	15.17±4.09
Thatta	10	0-10	1.70±1.05
Umer Kot	19	0-40	8.47±2.74

It has been observed that females lay eggs in clusters, brownish yellow in color on the underside of the leaves and close to the stem (Figure 2a) and same has been confirmed by the Shylesha et al. (2018). After emergence, young larvae are light greenish in color with dark black head (Figure 2b). The full-grown larvae (Figure 2c) are dark brownish having characteristic inverted 'Y' shaped marking in front of head, the elevated dim shaded dark spots (pinacula) all over its body along with spines and significant trapezoidal pattern of prominent four pinacula on 9th abdominal segment. The pupae of *S. frugiperda* is ruddy dark colored having a normal cremaster with two spines at the end (Figure 2d). The adults are greyish brown. The forewings of males are greyish brown, covered with oval or oblique orbital spots (marked with red) with a small distinct sideways v-shaped marking (marked with green) along with white patches at outer margins, whereas, hind wings are white with dark trimmings at edges (marked with blue) (Figure 2e). The forewings of females are uniformly greyish brown lacking distinct markings. The examination of male genitalia showed quadrate and broad valve; short clavus; costal process elongated, narrow, straight with hair like structure at its tip, juxta concave at base with a dorsal process; ampulla slightly curved; a single lobed coremata and a well-developed aedeagus (Figure 2f).
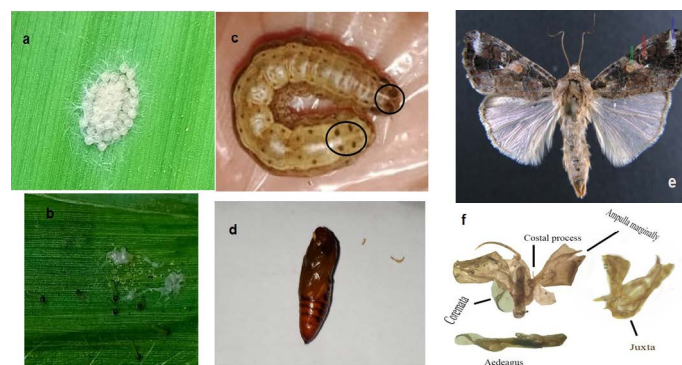

Figure 2: *The distinctive features of Spodoptera frugiperda a) eggs; b) early instar larvae; c) matured larva; d; pupa; e) adult male and f) male genitalia.*

Previous studies on identification and morphology of *S. frugiperda* also confirmed the above-mentioned key characteristics of the immature and adult stages of fall armyworm (Passoa, 1991; Pogue, 2002; Gilligan and Passoa, 2014; EPPO, 2015; Ganiger et al., 2018). Thus, the uniform characters of the immature and adult stages of the collected specimen from various corn fields of Sindh, Pakistan indicated introduction of FAW here may be through a single source.

Conclusions and Recommendations

The study confirmed the first record of *S. frugiperda* based on its morphological characters from various corn field of Sindh, Pakistan as comparatively more damage was recorded on fodder than grain corn crop. However, further studies and molecular identification should be done throughout corn growing areas of Pakistan to ensure its proper identification and possible routes of entry in Pakistan. The obtained information could be helpful in restricting the further spread and damage of *S. frugiperda*.

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Author's Contribution

Arfan Ahmed Gilal: Develop the idea, designed study and finalized manuscript.
Lubna Bashir: Develop idea, designed study and made rough draft.
Muhammad Faheem, Asad Rajput, Saifullah Kunbhar, Junaid Ahmed Soomro, Abdul Samad Mirwani and Ghulam Sarwar Mastoi: Conducted the study at various locations.
Tanzeela-ul-Zahra: Data analysis and presentation Conducted the study at various locations.
Jam Ghulam Mustafa Sahito: Finalize the manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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