REPORT ON AN INVASIVE PEST, THE FALL ARMYWORM *Spodoptera frugiperda* (J. E. SMITH) (LEPIDOPTERA: NOCTUIDAE) ON MAIZE CULTIVATION IN BINTULU, SARAWAK

Muhamad Azmi Mohammed*, Ameyra Aman-Zuki & Wan Asrina Wan Yahaya
Department of Crop Science,
Faculty of Agricultural Science and Forestry,
Universiti Putra Malaysia Bintulu Sarawak Campus,
Nyabau Road, 97008 Bintulu, Sarawak, Malaysia.
*Corresponding author: *mm_azmi@upm.edu.my*

ABSTRACT

The fall armyworm (FAW), *Spodoptera frugiperda* is a polyphagous pest for the family of Poaceae crops such as maize, sugarcane, sorghum, and rice by feeding on the leaves, stems, and reproductive plant's parts. Natives from America, this invasive pest has been reported to spread rapidly to Europe, Africa, India, and Sri Lanka. Currently, this pest was reported in the Southeast Asia region, such as Myanmar, Thailand, and Indonesia. In this study, an occurrence of FAW infesting maize cultivation in Bintulu, Sarawak were reported. This pest species was identified by its larval morphological features such as an inverted "Y" shape on the head and four dotted black spots arranged in a square shape on their 8th abdominal segment. The FAW larvae were found as early as the vegetative growth stage 3 (V3) and continue up to the reproductive phase 1 (R1) of the crop. The damages of FAW are serious on the shoots and bore the stalk causing the crop to stunt and died. The larvae were also causing economic injuries to the farmers by feeding on the newly formed cobs. This study served as an early report on FAW infestation on maize in East Malaysia from mid-2019. The immediate and proper monitoring and management of this pest could prevent further damages to other crops in Malaysia.

Keywords: Fall armyworm, *Spodoptera frugiperda*, maize, Sarawak, Malaysia.

ABSTRAK

Ulat ratus (FAW), *Spodoptera frugiperda* merupakan serangga perosak polifagus untuk tanaman daripada famili Poaceae seperti jagung, tebu, sekoi dan padi dengan memakan daun, batang dan bahagian pembiakan tumbuhan. Berasal dari Amerika, perosak invasif ini telah dilaporkan merebak dengan cepat di Eropah, Afrika, India dan Sri Lanka. Pada masa ini, perosak ini telah dilaporkan di kawasan Asia Tenggara seperti Myanmar, Thailand dan Indonesia. Dalam kajian ini, kejadian FAW dilaporkan menjangkiti penanaman jagung di Bintulu, Sarawak. Spesies perosak ini telah dikenal pasti melalui ciri-ciri morfologi larva, seperti bentuk "Y" terbalik di kepala dan empat titik hitam berbintik tersusun dalam bentuk empat segi sama pada segmen abdomen ke-8. Larva FAW dijumpai seawal peringkat pertumbuhan vegetatif 3 (V3) sehingga fasa pembiakan 1 (R1) jagung. Kerosakan oleh FAW adalah serius pada pucuk dan menebuk batang menyebabkan tumbuhan terbantut dan mati.

Larva tersebut juga menyebabkan kerosakan ekonomi kepada petani dengan memakan tongkol jagung baru. Kajian ini bertindak sebagai laporan awalan untuk serangan FAW di penanaman jagung di timur Malaysia bermula pertengahan tahun 2019. Pemantauan serta pengurusan yang segera dan sesuai terhadap perosak ini dapat mengelakkan kerosakan yang lebih teruk kepada tanaman lain di Malaysia.

Kata kunci: Ulat ratus, *Spodoptera frugiperda*, jagung, Sarawak, Malaysia

INTRODUCTION

Spodoptera frugiperda (Lepidoptera: Noctuidae) or the fall armyworm (FAW) is an economically important insect pest that attacking a wide range of Poaceae crops such as paddy, sugarcane, sorghum, and maize (Casmuz et al. 2017). This pest is native to America and has been spread widely to Europe, Africa, India, and Sri Lanka (Baloch et al. 2020). Later on, Southeast Asia regions such as Thailand, Myanmar, and Indonesia reported on the FAW infestation in 2018 (Ginting et al. 2020; Ginting et al. 2021; Li et al. 2020). In early 2019, maize cultivations of several states in Peninsular Malaysia, such as Perlis, Kedah, Perak, and Johor, were reported to be infested by FAW (Nor Fazlina Abdul Rahim 2019).

Maize is the third-largest crop in the world after wheat and rice. Maize production in Malaysia is still lacking due to the low number of farmers involving in the plantation (Wong 1992), despite the high demand for this crop. Three major maize-producing states in Malaysia are Perak, Johor and Sarawak with total produced of 41, 925 million tons for 2018 (DOA 2019). There are 24 and three varieties of sweet corn and grain corn were planted in Malaysia (DOA 2015). In 2018, Malaysia reported importing 4,000 million tons of grain maize mainly from Argentina, Brazil, and the USA (USDA 2017). Due to the high demand for this crop, the Ministry of Finance has developed a Grain Maize Development Master Plan in 2017, prior to promote and enable farmers to produce at least 30% requirement of domestic consumption. Through the plan, it targeted to produce 1.44 metric tonnes of grain maize and cover 80,000 ha by 2032.

The infestation of FAW was responsible for the yield losses of 8.3-20.6 million metric tons per year (21-53% of production) in 12-maize producing countries in Africa (Huesing et al. 2018). A study by Kumela et al. (2018) reported a maize yield reduction of 934 kg/ha (32% of production) in Ethiopia and 1381 kg/ha (47% of production) in Kenya based on farmers' estimates. In 2018, 11.57% yield loss in Chipinge and Makoni, two districts in Zimbabwe, was estimated (Baudron et al. 2019). Yield loss in Benin of West Africa amounted to 797.2 kg/ha (49% of production) (Houngbo et al. 2020). A study by De Groote et al. (2020) estimated 1 million tons of losses in 2018 in Kenya based on surveys on farmers' estimates.

The rapid spreading of FAW contributed by its ability to produce many eggs, from 160 to 1000 eggs per egg mass (Barros et al. 2010; Deole & Paul 2018; Kumela et al. 2019), a wide range of crop hosts, for example, maize, cotton, millet, soybean, alfalfa and wheat (Barros et al. 2010; Casmuz et al. 2017; Murua et al. 2008), and ability to migrate over long distances with hundreds of kilometres per night and up to thousands of kilometres per annually migration (Nagoshi et al. 2012; Rose et al. 2012; Westbrook 2008). The damages caused by FAW include heavy feeding on leaves and shoots, boring the stems, and feeding on new cobs. The feeding behaviour of the larvae causing the plants stunted and died if no immediate action is taken (Kumela et al. 2019). The infestation of larvae will show heavily damaged shoots and wet frass on the leaves and whorl, thus provided a distinct symptom mark for farmers to detect the

infested plant (Deole & Paul 2018). The spreading of FAW is becoming a concern because it can infest other crop plantations due to its wide range of hosts. Thus, the objective of this study is to report on the occurrences of FAW in maize cultivation of Bintulu, Sarawak.

MATERIALS AND METHODS

Sampling Locality

The study site location is adjacent to the vegetable's plantation such as mustards, spinach, groundnuts, water spinach and terung asam. There is Napier cultivation for cattle farm in the vicinity. There are smallholder maize, sugarcane, pepper, tapioca and Cruciferous vegetable farmers in the neighbouring areas (20-50 km). There are also secondary and rehabilitated forests as well as perennial plantations such as oil palm and coconut plantations in the proximate areas.

Insect Sampling and Observation on Plant Damage

A total of 247 FAW larvae were collected using active sampling by handpicking from June 2019 to January 2020 at maize cultivation in Bintulu, Sarawak. The infestation of the FAW damaging almost half of the maize plants in the cultivation area. The damaged maize plants were left with holes leaves and disappearing shoots due to FAW bored the maize plant (Baudron et al. 2019). Monitoring was done during field observation for visual symptoms assessment of the maize plant. The monitoring was employed once a week for one hour (either 7.30 am – 8.30 am or 5.30 pm - 6.30 pm).

The larvae were brought to the lab for rearing. The collected specimens were kept in the rearing cage (24.5 cm x 13.5 cm x 13.0 cm) with young shoots of maize as feeds. The rearing condition was set as 25 ± 1°C of temperature, 70 ± 10% of relative humidity, and 12 h (L:D) following Bueno et al. (2010a, 2010b). In the laboratories, the observation of cannibalism behaviour was also recorded. The larvae were identified morphologically following keys to species by Oliver (1981) and Polaszek and Kimani (1990). The identified specimens photographed using a digital microscope. The larvae reared until the adult stage for photograph and identification on adult samples. The rearing of the larvae to emerge into adult took 30-40 days. The larvae instar stages were determined following Kalleshwaraswamy et al. (2018). The collected specimens were then kept in the repository of Entomology Laboratory, Department of Crop Science, Faculty of Agricultural Science and Forestry, Universiti Putra Malaysia Bintulu Sarawak Campus for future references.

RESULTS AND DISCUSSION

Possible Port of Entry of FAW in Sarawak

The port of entry for FAW into Bintulu is not yet determined but could be unravelled through further study based on haplotype analysis. The closest record of occurrence of FAW from Bintulu was at North and East Kalimantan, Indonesia (IPPC 2019). The entry could be through import of agricultural commodities or natural dispersal of this pest, as FAW is known to have a terrific dispersal capacity (Nagoshi et al. 2012).

Species Identification of FAW

The FAW lays their eggs underneath the leaves as early as the vegetative growth stage 3 (V3) of the maize (Figure 1A), and the hatched larvae climb upward to the shoot/tiller and start to eat and bore the crop. Adult females of *S. frugiperda* can lay eggs for 1,500 to 2,000 per cycle (Prasanna et al. 2018). The size of young larvae is ranging from 6-9 mm (Figure 1B), and

mature larvae are around 30-36 mm (Figure 2). The larvae collected from the field were identified as FAW by its distinguished inverted "Y" shape on the head and four dotted black spots arranged in a square shape on their 8th abdominal segment (Figure 2). The brown to darker brown pupae with size 13-17 mm were found in the soil or the cob of the maize (Figure 1C-D). The rearing of the specimens further confirmed the identification of the invasive pest based on the male and female adult morphological characteristics on the wing. The adult male of FAW has white-spotted at the tip and near the center of the forewings (Figure 1E-F), while the female lacks the variation (Sidana et al. 2018).

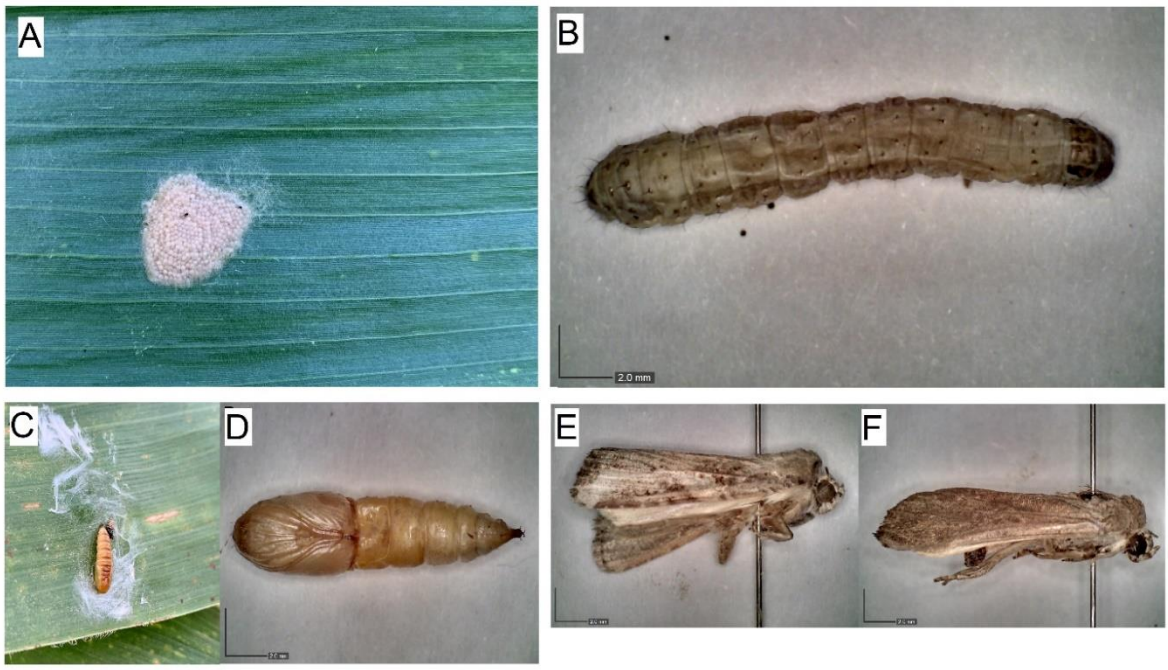

Figure 1. A) Eggs of *Spodoptera frugiperda* on the maize's leaf; B) Third instar larva of *S. frugiperda* with scale for reference; C) Pupa of *S. frugiperda* found on the leaf of maize during field observation; D) Pupa from rearing process in the lab with scale for reference; E) Adult male of *Spodoptera frugiperda* and F) adult female of *S. frugiperda*

Figure 2. Mature larva (fifth instar) of *Spodoptera frugiperda* with morphological characteristics marked on the larvae. A) The inverted "Y" shape on the head and B) four dotted spots on the 8th abdominal segment

The FAW exhibit cannibalism behaviour during laboratory rearing (Figure 3). The larvae ate others on several occasions, such as lack of food and high density of larvae. Cannibalism is a normal behaviour of Lepidopteran larvae when food is a limiting factor (Valicente et al. 2013). Cannibals had the same growth characteristics as non-cannibal larvae; however, they were smaller and suffered higher mortality than non-cannibals (Andow et al. 2015). Cannibalism in the larvae of *S. frugiperda* influences population dynamics and community structure of the species (Chapman et al. 2000). This behaviour influenced the effectiveness of predation (Chapman et al. 2000) and virus production with *Baculovirus spodoptera* (Valicente et al. 2013) for management control of this pest.

Figure 3. Larvae of *Spodoptera frugiperda* eat its same-age cohort sibling larvae. The cannibalism behaviour observed in the lack of food and high-density cage rearing

FAW Damages to Maize Crop

The FAW caused damages to the maize cultivation in many parts of the maize plants. Larvae have a continuous feeding behaviour while producing the wet frass on the leaves and inside whorl. The constant feeding will eventually result in windowed whorls and skeletonized leaves (Figure 4). The larvae continue to bore the maize plant, causing the plant stunted and unable to produce flowering tassel (Figure 5). The infestation eventually continued to the reproductive phase 1 (R1) of the maize. Later on, the stunted plant eventually dies, and the non-flowering tiller plant unable to yield any maize cob. The damages by the FAW are not limited to the shoots, tiller, and whorls; the larvae also feed on newly formed cob (Figure 6). This situation causes economic loss to the farmers, such as dead plants, not producing maize cobs plants, and cobs damages by FAW larvae.

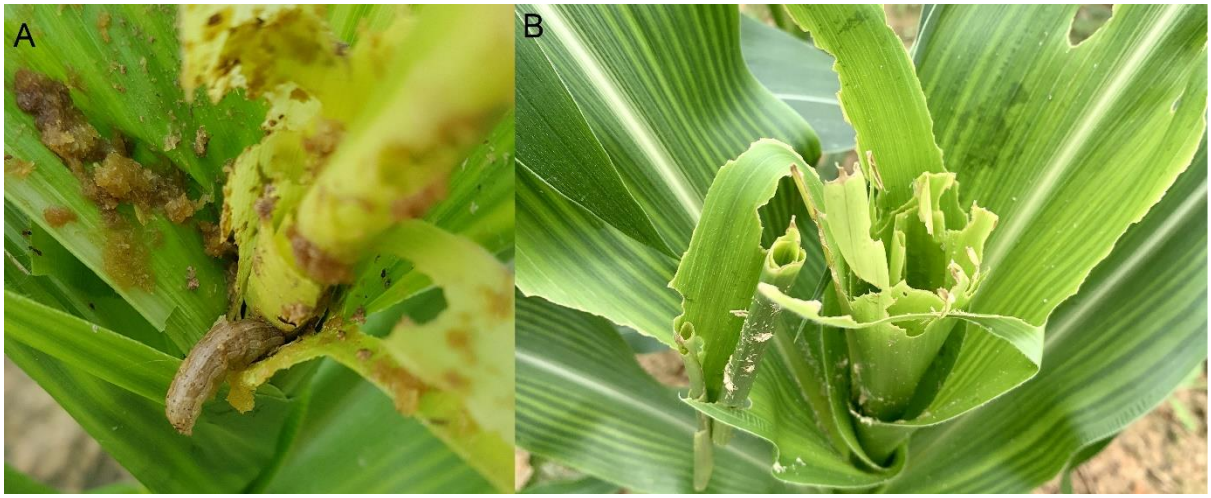

Figure 4. Damages caused by constant feeding by larvae of *Spodoptera frugiperda* on maize plants. A) Wet frass produced by larvae on the leaves and in the whorl of the plants and B) skeletonized leaves and windowed whorl results from heavy feeding of larvae

Figure 5. The bored maize plants by *Spodoptera frugiperda* larvae show symptoms of stunted plants and unable to produce flowering tassel (in red circle)

Figure 6. The sighting of young larvae of *Spodoptera frugiperda* on the newly formed cob of maize causing economic losses to the farmer due to the damages on the cob

The FAW caused damages in many parts of the plants. Another factor contributing to the widespread of this invasive pest species is their flying ability. This species is known to be a strong flyer and can travel up to 100 km in one night (Wu et al. 2019). The larvae stage is known to be the destructive stage of the FAW. The life cycle of this species is around 30–90 days to complete. The longest stage is in larva form that takes 14–38 days. FAW will go through a total of sixth instar larvae before moulting into pupa (Kalleshwaraswamy et al. 2018). The adult of *S. frugiperda* is in moulted grey, and the wingspan is around 40 mm (Capinera 2000). The larvae will reside and growing inside the stalk until pupation and emergence as an adult.

CONCLUSION

This study served as the first report of FAW infestation in maize cultivation in Bintulu, Sarawak. The FAW caused severe damages to the maize plants by boring the stalk leading the crop to stunt and died. The pathway spreading of this species from America to Africa, Middle Asia, and later to Southeast Asia is open for debate as this species has been reported infesting maize in Peninsular and East Malaysia concurrently. Immediate measures may prevent the infestation and losses towards the farmers by considering the rapid spreading of this species in recent years. The migration pathways, natural enemies, and host preferences are among areas that need to be further studied to prevent this invasive species from spreading.

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