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PREVALENCE OF INVASIVE FALL ARMY WORM *SPODOPTERA FRUGIPERDA* (J E SMITH) ON ORGANIC MAIZE IN SIKKIM

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ABSTRACT

Fall army worm (FAW) *Spodoptera frugiperda* (J E Smith) has been observed invading the north eastern region of India during April 2019 in Mizoram and on maize crop of Namphing GPU, South Sikkim, during May 2019. The detailed survey in the maize growing areas of state revealed the presence of early to fourth instar larvae feeding on the leaves and whorls. The identification was confirmed by morphological characters and DNA barcoding with mtCO1. The study indicated range (8.8 to 71.4%) of FAW infestations on maize. During survey, microbial infection in few larvae, and predatory wasps and spiders as predators were found. This is the first record of FAW on organic maize of Sikkim.

Key words: *Spodoptera frugiperda*, Sikkim, organic maize, first record, field survey, diagnosis, mtCO1, DNA barcoding, wasps, spiders, microbial infection, Mizoram

Sikkim, the first organic state of India, cultivates cereals, pulses, vegetables, tuber crops and oilseeds in organic manner on an area of about 75 thousand ha **(**Bhutia et al., 2014) of which maize, a staple food crop of Sikkim, is grown in all four districts during February to November (Rahman and Karuppaiyan, 2011) over an area of 38 thousand ha from altitude 300- ≥2200 m (Avasthe et al., 2018). Many insect pests attack maize viz., maize stem borer (*Chilo zonellus* Swinhoe and *Sesamia inferens* Walker), aphid (*Rhopalosiphum maidis* Fitch), grasshoppers (*Chrotogonus robertison* Blanchard and *Oxya chinensis* Thunberg), semilooper (*Trichoplusia orichalcea* Martyn), army worm (*Mythimna separate* Walker) and defoliating beetles (*Centrocorynus scutellaris* Gyllenhal) (Azad Thakur, 1998). In May 2018, the invasive fall army worm (FAW) *Spodoptera frugiperda* (J E Smith) was observed on maize for the first time from Karnataka (Sharanabasappa et al., 2018a) and later spread to many southern states (Mahadevaswamy et al., 2018). Later it has been spread to north eastern states of India since March 2019 (Firake et al., 2019). The FAW incidence appeared for the first time during first week of May, 2019 in maize fields of Sikkim. In this preliminary study, the level of FAW infestation in organic maize fields at Sikkim is reported and efforts made to provide details of its natural enemies.

MATERIALS AND METHODS

Maize fields were surveyed during May 2019 to April 2020 to know the level of FAW infestation in different parts of Sikkim. The observations were made by adopting standard scouting methods for FAW (FAO and CABI, 2019). The numbers of plants damaged were counted based on the characteristics damage symptoms like skeletonising the upper epidermis of maize leaves, windows and ragged holes on leaves, faecal matter in the whorls and damaged cobs. The field collected larvae were brought to the ICAR Research Complex for NEH Region, Sikkim Centre, Tadong laboratory for detailed observation on lifestages. Its larvae were reared on maize leaves until these complete development. The characteristics morphological characters like presence of inverted "Y" on head with distinct black dots on the body with four black dots in a square pattern on the 8th abdominal segment were found on the larvae and the observed specimen were also matched with the identification keys of *S. frugiperda* (Passoa, 1991; Sharanabasappa et al., 2018b). The damage symptoms and lifestages were captured with a Canon EOS 200D 24.2MP Digital SLR Camera, 18-55 mm macrolens and Leica S8 APO stereozoom microscope with Leica MC120 HD inbuilt camera, respectively. The larvae collected from five locations of Sikkim were reared on maize leaves until complete development. Mitochondrial DNA from two individuals (adult moths) was extracted by the procedure described by Firake and Behere (2020a,b). Overall procedure for amplification of mtCOI, sequencing and further analysis was adopted from Behere et al. (2016).

RESULTS AND DISCUSSION

The FAW *S. frugiperda* being a highly destructive pest, causes significant yield loss in maize and other economic crops (Maruthadurai and Ramesh, 2020; Montezano et al., 2018). In India, its incidence ranged from 2.0 to 100% in maize growing areas (Sharanabasappa et al., 2018a; Shylesha et al., 2018; Mallapur et al., 2018; Chormule et al., 2019; Padhee and Prasanna 2019; Srikanth et al., 2018). In the present study, the survey conducted in districts of Sikkim revealed the presence of early to fourth instar larvae feeding on the leaves and whorls of maize plants. The infested plant exhibited characteristic symptom of papery windows, pin or shot holes and ragged appearance of whorl along with moist saw dust-like faecal matter in the form of lumps either on leaves or inside the whorl. Scrapping of leaves by early instar larvae, stem scrapping, presence of bore holes along with whorl toppling by matured larvae were noticed. The incidence was from 8.8 % on RCM 1-1 (a composite germplasm of maize from Meghalaya) to 71.4% on C.P. 333 (hybrid variety from Charoen Pokphand India Private limited, India) in East district of Sikkim. For the first time FAW infestation was noticed in Namphing village of South Sikkim during kharif season (May 2019) which acted as an epicenter for other maize growing areas of maize in the South and other district of Sikkim. The maximum incidence (56.4± 2.51%) at same place was observed during rabi season in September, 2019, compared to that of kharif season (41.6± 2.28%) and early infestation (55.4± 1.60%) during this year in April 2020 (Table 1).

Subsequently, the damage was detected in other maize growing areas of Sikkim. The initial outbreak in maize field of South district of Sikkim could be reasoned due to two-season cropping of maize (kharif and rabi season) in the area and prevalence of hot and humid condition well in season than other parts of Sikkim. Heavy infestations in late planted maize of double-cropping systems had been reported (Robert and All, 1993). Favourable environment like warm and humid season along with rainfall favour the population buildup and spread (Stokstad, 2017). The

Table 1. Fall army worm *S. frugiperda* infestation on maize in Sikkim

Place	Latitude	Longitude	Altitude (feet)	Infestation (%)	Date of observation	Cultivar/ variety
Namphing, South Sikkim	27.228	88.483	2273	41.6± 2.28	10.5.2019	Setimakai
Namphing, South Sikkim	27.228	88.483	2273	56.4± 2.51	28.9.2019	Setimakai
Passi, South Sikkim	27.131	88.451	1943	69.8± 2.14	18.07.2019	Setimakai
Phensang-Kabi, North Sikkim	27.425	88.678	4189	43.8± 1.27	13.06.2019	Setimakai
Lingthem-Passindang, North Sikkim	27.510	88.438	3000	44± 1.14	30.05.2019	Setimakai
Ringhim-Mangan, North Sikkim	27.498	88.535	3136	17.6± 1.91	23.05.2019	Setimakai
ICAR-NOFRI, East Sikkim	27.324	88.601	3882	8.8± 1.15	21.06.2019	RCM 1-1
ICAR NOFRI, East Sikkim	27.323	88.601	3901	33.8± 2.77	25.04.2020	MS 4-1
Zijtlang, Rangpo, East Sikkim	27.181	88.524	1483	44.2± 2.74	2.5.2020	Setimakai
Namphing, South Sikkim	27.228	88.483	2273	55.4± 1.60	5.4.2020	Setimakai and CP 333 (hybrid)
Radong, East Sikkim	27.269	88.580	3364	26.6± 2.46	19.04.2020	JKMH 1701
Passi, South Sikkim	27.13	88.451	1975	52.8± 2.06	12.04.2020	Setimakai
Passi, South Sikkim	27.128	88.452	1942	14.6± 1.71	19.04.2020	Bio-9544
Passi, South Sikkim	27.131	88.451	1944	54.2± 2.18	19.04.2020	CP 333
Amba, East Sikkim	27.209	88.625	3056	68.2± 1.60	23.04.2020	Setimakai and 33M66
Namchebong, East Sikkim	27.260	88.591	3522	71.4± 0.85	10.4.2020	C.P. 333
Naibutar, East Sikkim	27.246	88.591	4826	16.6± 1.68	30.4.2020	Setimakai
ICAR-NOFRI, East Sikkim	27.326	88.598	3669	28.6± 1.94	25.04.2020	RCM-76
Krishi Vigyan Kendra, Ranipool, East Sikkim	27.285	88.591	2629	69.8± 1.41	8.6.2020	MS 8-1
Lower Sajong, East Sikkim	27.314	88.571	3862	26.6± 1.04	4.6.2020	Pehnlo Makai
ICAR NOFRI, East Sikkim	27.323	88.603	3897	52.6± 0.97	3.6.2020	Murali Makai

species identity was confirmed at molecular level by sequencing standard barcoding region of mtCOI gene. After trimming the ambiguous ends (5' and 3'), a final 626bp good quality sequence was obtained for both the individuals. BlastN search of our FAW 626bp sequences shown 100% similarities with FAW reported from China (MK860942), South Africa (MK493021), Kenya (MK492973) and others regions of India (MT644266) including North Eastern region of India (MN640599 and MN640598). The two sequences of FAW sequenced in the study showed 100% similarities, and a representative sequence submitted to the NCBI vide accession number 'MT621018'. The nucleotide composition of sequence reported in this study has A-29.1%, T-40.4%, G- 14.9% and C-15.7%.

Although the FAW has invaded and spread to different parts of Sikkim, the organic ecosystem has potential to restrict the pest below economic threshold level (Wyss et al., 2005; Zehnder et al., 2007). The native biocontrol agents against other *Spodoptera* spp., could possibly manage this invasive species as related indigenous pest species have been considered as first line of defense (Firake and Behere, 2020a). For instance, >26 species of natural enemies of FAW have been reported in similar agroecosystem of Meghalaya (Firake and Behere, 2020a; Firake and Behere, 2020b; Firake et al., 2020). In this study, predatory wasps (Hymenoptera: Vespidae) and different species spiders (unidentified) were found predating on FAW larvae during survey. Besides, microbial infection was also noticed in few larvae in organic maize fields. Therefore, there is huge scope for availability of several potential biocontrol agents of FAW in Sikkim which could be instrumental in managing the spread of FAW infestation.

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