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Seasonal dynamics and spatial distribution of fall armyworm *Spodoptera frugiperda* (J.E. Smith) on Maize (*Zea mays* L.) in Cauvery Delta Zone

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Abstract
Maize (*Zea mays*; Poaceae) is an important stable food (17%) and fodder crop (61%) next to rice and wheat. To study the seasonal variations and spatial distributions of fall armyworm *Spodoptera frugiperda* (J. E. Smith) on maize in Cauvery Delta Zone, random survey was made during 2019 -2020 at *kharif* and *rabi* seasons at six locations. The larval population was maximum during *kharif* (0.99 to 3.66 larvae per plant) compared to *rabi* (0.66 to 2.60 larvae per plant) in all the locations. Among six various locations, maximum population was recorded at Devanur (0.91 to 3.66 larvae per plant) during kharif and at Veppanthattai (0.90 to 2.60 larvae per plant) during *rabi* season.27th Standard Mean Week (3.13 to 3.66 larvae per plant) during *kharif* and 45th Standard Mean Week (2.01 to 2.60 larvae per plant) during *rabi* recorded the maximum larval population.

Keywords: Fall armyworm, maize, seasonal variation, fortnight, SMW

Introduction
Maize (*Zea mays* L.) is known as "queen of cereal" as it has the highest production among the cereals (Parihar *et al*., 2011) [11]. Fall armyworm (FAW) *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), is an invasive alien pest that attacks mainly maize crop (Andrews, 1980) [2]. This polyphagous pest damages around 80 species such as rice, maize, sorghum, beans and cotton (Abrahams *et al*., 2017; Day *et al*., 2017) [2, 4]. They can migrate over 500km before oviposition (Prasanna *et al*., 2018) [13]. They mainly feed on leaf whorls, tassels, ears and cobs of maize, resulting in total yield loss occasionally (Sarmento *et al*., 2002) [19]. According to the recent studies, fall armyworm can cause yield losses ranging from 8.3 to 20.6 million tonnes of maize per year in absence of management practices (Day *et al*., 2017) [4]. It is native to America and first reported in West Africa in late 2016 as invasive pest (Goergen *et al*., 2016) [6] and later in Sub-Saharan Africa. Recent reports confirmed the occurrence of fall armyworm in 44 countries in Africa (Rwomushna *et al*., 2018) [17]. In India, it was first reported on maize from Shivamogga district (Karnataka) during May-June, 2018 (Sharanabasappa *et al*., 2018) [19]. The first report of FAW in Tamilnadu was on August, 2018 in Karur district (The Hindu, 2018). In an area, the population size and the severity of damage caused is influenced mainly by the environmental factors (Becker, 1974) [3]. So understanding the seasonal variation of the pest in different locations is crucial in developing management techniques. Effect of weather factors and seasonal variations on the crop pests was earlier studied by many workers (Rote and Puri, 1991; Saminathan *et al*., 2001) [16, 18].As FAW is a new pest to Tamil Nadu, we must know the impact of seasons and locations on the population dynamics of this pest.

Materials and Methods
The quantitative pest data on seasonal abundance of *S. frugiperda* were collected from the farmer's holdings at the following six locations of Cauvery Delta Zone during *kharif*(July 2019 to September 2019) and *rabi* seasons (October 2019 to January 2020). Total larval population in the whole plant was recorded.
The incidence was recorded from 27th Standard Mean Week (SMW) to 39th SMW (July first fortnight to September second fortnight) for *kharif* and from 43rd SMW to 3rd SMW (October second fortnight to January second fortnight) for *rabi* seasons. In each location, random survey was made and observations were recorded at fortnightly intervals on 10 randomly selected plants in the field by following "W" pattern in zigzag manner (Prasanna *et al*., 2018) [13]. All the open leaves and whorls of selected plants were observed thoroughly and larvae found were

recorded. In all the locations, fields which were maintained free of chemical pesticide were selected for survey. Data on abiotic factors such as maximum and minimum temperature and rainfall were collected from NASA ARC POWER [9] website for the different locations of Cauvery delta zone and relationship between pest incidence weather parameters were analysed.

Village	Latitude	Longitude
Devanur	11.167^{0}N	79.193^{0}E
Kuvagam	11.282^{0}N	79.284^{0}E
Sendurai	11.143^{0}N	79.617^{0}E
Sengunam	11.164^{0}N	78.542^{0}E
Vallikandapuram	11.319^{0}N	78.919^{0}E
Veppanthattai	11.226^{0}N	78.226^{0}N

Results and Discussion

The results pertaining to seasonal dynamics of *S. frugiperda* indicates that incidence was mostly depends on weather parameters and not much variation in larval population was observed among different surveyed locations. Average larval population was higher during *kharif* (1.02 to 3.36 larvae per plant) compared to *rabi* (0.82 to 2.28 larvae per plant) in all the locations. This is in line with the findings of Rojas *et al.* (2004) [15] who reported that peak activity of *S. frugiperda* was observed during June to September.Increased temperature during *kharif* season might have favoured the higher photosynthetic rate of maize which in turn favoured the continuous and abundant food supply to *S. frugiperda*. During *kharif*, the FAW larval population was maximum during first fortnight of July 2019 *ie* 27th SMW (3.13 to 3.36 larvae per plant) and minimum during second fortnight of September 2019 *ie* 39th SMW (0.90 to 1.21 larvae per plant) in various locations (Table 1).During rabi, population was maximum during first fortnight ofNovember *ie* 45th SMW (2.10 to 2.60 larvae per plant) which gradually decreased and reached the minimum during second fortnight of January *ie* 3rd SMW (1.00 1.19 larvae per plant) in various locations (Table 2). Higher rainfall distribution during *rabi* has great influence on the *S. frugiperda* population. These results agree with those of Mitchell *et al*. (1991) [8] who reported that in the tropics, *S. frugiperda* populations have a tendency to vary with seasonal changes in rainfall. Pair *et al*. (1986) [10] reported that the availability and amounts of susceptible stages of maize as the most important reason decide the magnitude of *S. frugiperda* populations. As maize is a C4 plant, increased rain fall with reduced temperature might have led to slower crop growth and water saturation in soil. This might have resulted in unavailability of enough food continuously and unfavourable soil condition for pupation during *rabi* season. Waddill *et al*. (1981) [20] reported that heavy and light rainfall kill significant number of early instar of FAW which reduced the adult population.

Our study was conducted in a relatively small region and factors such as temperature and rainfall are expected to be quite similar and therefore not much differences in the population of *S. frugiperda* was observed among different locations. Considering the geographic quantitative variations, at Devanur, larval population ranged between 0.91 to 3.66 larvae per plant. The highest FAW population of 3.66 larva per plant was recorded on 27th SMW (July 1st fortnight) when average atmospheric maximum and minimum temperatures were 39.5^{0}C and 27.1^{0}C and gradually decreased to 0.91 larvae per plant on 43rd SWM (Oct 2nd fortnight), when average atmospheric maximum temperature and minimum temperature reached to 31.8^{0}C and 26.1^{0}C with maximum rainfall of 105.4mm (Fig. 1). But Priyanka *et al*. (2019) [14] reported the maximum trap catches of *Helicoverpa armigera* in redgram field during 2nd SMW and 52nd SMW. This is mainly because *H. armigera* attacks the reproductive phase of redgram which falls during above period. Similarly, peak occurrence of lepidopteran pest *Hendicasis duplifascialis* was noticed during first fortnight of November (Pirithiraj *et al*., 2020) [12].

At Kuvagam, the highest FAW larval population of 3.21 larva per plant was recorded on 27th SMW (July 1st fortnight) when average atmospheric maximum and minimum temperatures were 39.4^{0}C and 27.3^{0}C and declined to 0.91 larvae per plant during 43rd SMW (Oct 2nd fortnight), when average atmospheric maximum temperature and minimum temperature were 32.4 ^{0}C and 26.5^{0}C and 107.6 mm rainfall (Fig. 2). At Sendurai, the highest population of3.66 larva per plant was recorded on 27th SMW (July 1st fortnight) when mean atmospheric maximum and minimum temperature was 39.6^{0}c and 26.9^{0}c and declined to 0.60 larva per plant on 43rd SWM (Oct 1st fortnight), when avarage atmospheric maximum temperature and minimum temperature (35.4^{0}C and 25.6^{0}C) and rainfall was 134.4 mm (Fig. 3).

At Sengunam highest FAW population of 3.66 larva per plant was recorded on 27th SMW (July 1st fortnight) when mean atmospheric maximum and minimum temperatures were 39.5^{0}C and 27.1^{0}C and declined and reached minimum of 0.80 larva per plant during 43rd SMW (Oct second fortnight), when average atmospheric maximum temperature and minimum temperatures were 34.5^{0}C and 25.6^{0}C with 124.3 mm rainfall (Fig. 4). Pair *et al*. (1986) [10] attributed the lower temperature as reason for less incidence of *S. frugiperda*. Larval population at Vallikandapuram was highest (3.66 larva per plant) during 27th SMW (July first fortnight) when mean atmospheric maximum and minimum temperatures were 39.5^{0}C and 27.1 ^{0}C) and reached the minimum of 0.84 larva per plant during 43rd SWM (Oct second fort night), when average atmospheric maximum temperature and minimum temperature were 34.5 ^{0}C and 25.6.1^{0}C with 128.3 mm rainfall (Fig. 5). At Veppanthattai, highest FAW population of 3.35 larva per plant was recorded during 27th SMW (July first fortnight) when mean atmospheric maximum and minimum temperatures were 39.5^{0}C and 26.9^{0}C and declined continuously and reached the minimum of 0.90 larvae per plant during 43rd SMW (Oct second fortnight), when average atmospheric maximum and minimum temperatures were 30.2^{0}C and 26.1^{0}C with 110.4 mm rainfall (Fig. 6). Slight variation in the *S. frugiperda* larval population among the different locations was observed which can be attributed to the variation in weather factors like temperatures and rainfall among the locations. Mahalingam *et al*. (2003) [7] found that change in temperature as reason for variation in trap catches of *Spodoptera litura*. It is concluded that understanding the population variation due to season and climate will be much helpful in formulating management strategies for the invasive pest like *S. frugiperda*.

Table 1: Seasonal incidence of *S. frugiferda* on Maize during kharif 2019-2020 in Cauvery Delta Zone

S. N	Fort night	SMW	Larval population (No. per plant*)						
			Devanur	Kuvagam	Sendurai	Sengunam	Valliankandaputram	Veppanthattai	Average
1	July I	27th	3.66	3.21	3.13	3.26	3.54	3.35	3.36
2	July II	29th	2.11	2.43	2.32	2.17	2.43	2.39	2.31
3	Aug 1	33rd	1.22	1.43	1.31	1.26	1.43	1.21	1.31
4	Aug II	35th	1.45	1.29	1.61	1.04	1.21	1.32	1.32
5	Sep I	37th	1.23	1.21	1.39	1.23	1.04	1.04	1.19
6	Sep II	39th	1.01	0.99	0.91	1.21	1.00	1.00	1.02

*Mean of 10 plants

Table 2: Seasonal incidence of *S. frugiferda* in Maize during rabi 2019-2020 in Cauvery Delta Zone

S. N	Fort night	SMW	Larval population (No. per plant*)						
			Devanur	Kuvagam	Sendurai	Sengunam	Valliankandapuram	Veppanthattai	Average
1.	Oct II	43rd	0.91	0.89	0.60	0.83	0.81	0.90	0.82
2.	Nov I	45th	2.12	2.10	2.30	2.54	2.01	2.60	2.28
3.	Nov II	47th	1.73	1.82	1.72	1.53	1.72	1.74	1.71
4.	Dec I	49th	1.54	1.52	1.94	1.82	1.51	1.85	1.70
5.	Dec II	51rd	1.90	1.92	1.50	1.61	1.84	1.58	1.73
6.	Jan 1	1rd	1.21	1.21	1.16	1.00	1.1	1.10	1.13
7.	Jan II	3rd	1.19	1.1	1.00	1.00	1.1	1.00	1.07

*Mean of 10 plants

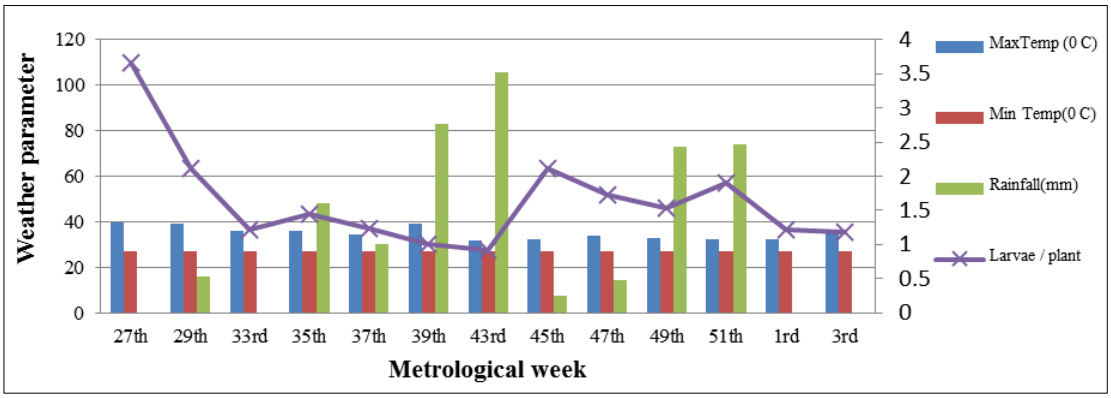

Fig 1: Seasonal dynamics of *S. frugiperda* in Devanur village

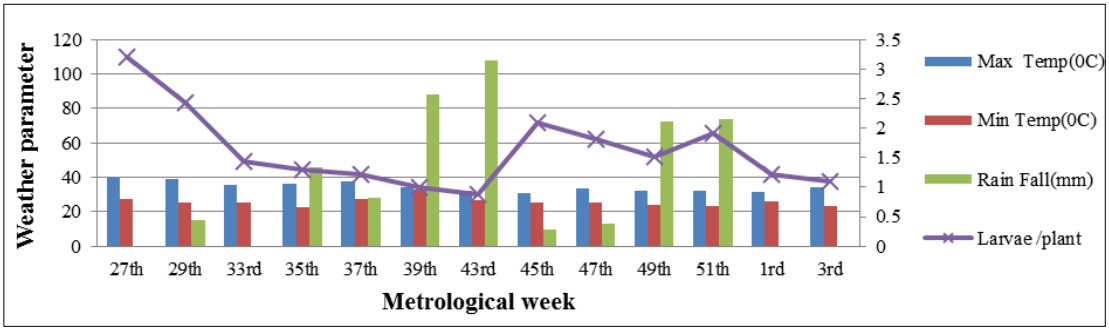

Fig 2: Seasonal dynamics of S. frugiperda in Kuvagam village

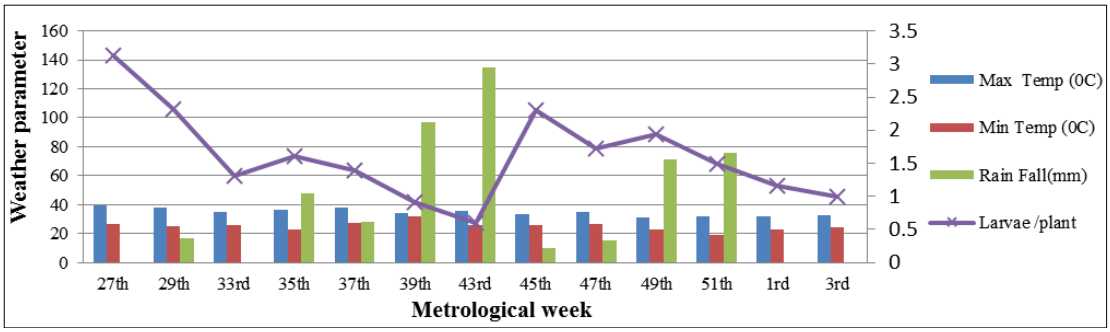

Fig 3: Seasonal dynamics of *S. frugiperda* in Sendurai village

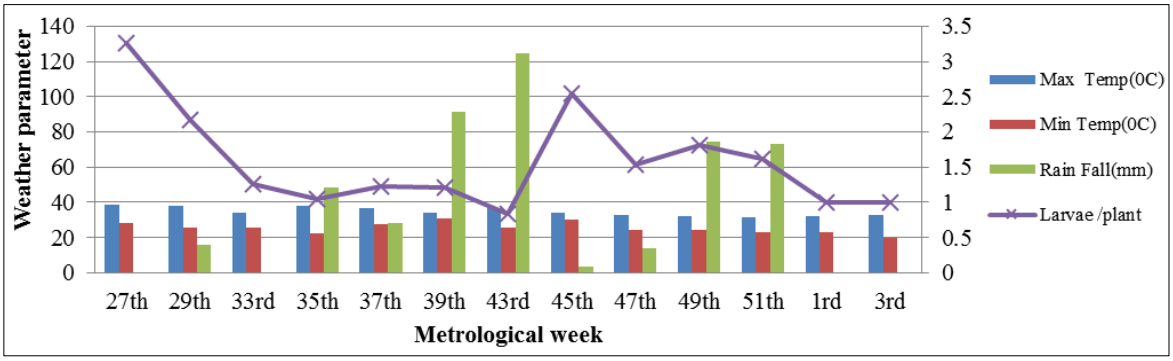

Fig 4: Seasonal dynamics of *S. frugiperda* in Sengunam village

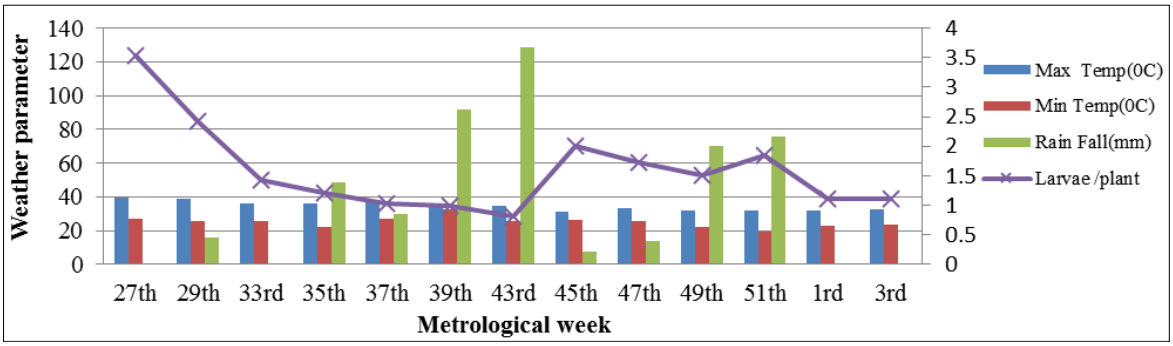

Fig 5: Seasonal dynamics of *S. frugiperda* in Vallikandapuram village

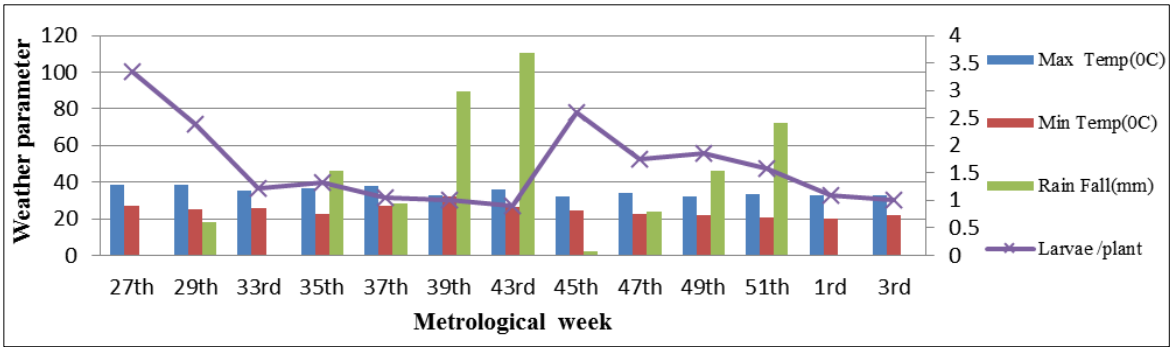

Fig 6: Seasonal dynamics of *S. frugiperda* in Veppanthattai block

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