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Correlation of Fall Armyworm *Spodoptera frugiperda* (J.E. Smith) with Weather Parameters in Maize Ecosystem

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A B S T R A C T

Fall armyworm *Spodoptera frugiperda* is an invasive alien pest that attacks mainly maize crop. Influence of weather parameter on the incidence of *S. frugiperda* larva on maize was studied during 2019-2020 at Cauvery Delta Zone, Tamilnadu, India. Random survey was conducted in six maize growing areas and correlation between larval population and weather parameters like maximum temperature, minimum temperature and rainfall was worked out. The larva population had significant positive correlation of both same (r = 0.32 to 0.45) and previous week (r = 0.21 to 0.52) at all the locations. Same week and previous week minimum temperature had no significant correlation at location. The rainfall of same week (r = -0.36 to -0.47) and previous week (-0.19 to -0.24) were significantly and negatively correlated.

Introduction

Environmental factors play a major role in deciding the population size and damage severity of a pest in particular locality (Becker, 1974). Hence understanding the influence of environmental factors on the occurrence of pest is crucial in developing management strategies. Though the impact of weather parameters on insect pest is confounded, temperature and rainfall are the chief factors which decide the occurrence, development and survival of the insect pest. Many authors earlier reported the relation between pests and weather factors on various crops (Saminathan *et al.*, 2001; Prianka *et al.*, 2018). The environmental factors vary from region to region even place to place within the region. In Cauvery Delta Region of Tamil Nadu, maize (*Zea mays* L., Poaceae; Graminae), is gaining importance as alternate crop to paddy in recent days. It is the third

most important cereal crop after rice and wheat and one of the stable food crops in many developing countries and quality feed for livestock. It is main raw material for corn floor industry, baby corn, corn oil production, sweetener, alcohol, starch and bio-fuel production (Martin *et al.*, 2006) which shows its continuous demand. Maize becomes unique crop because of its versatile use and low per unit cost of production (Tariq, 2010). Over 250 insect species are associated with maize in field and storage conditions (Mathur, 1992). Fall armyworm, *Spodoptera frugiperda* (Lepidoptera=Noctuidae) is a destructive, highly mobile, invasive pest, native to the Americas (Prasanna *et al.*, 2018; Midega *et al.*, 2018). FAW has invaded into Africa in 2016 (Goergen *et al.*, 2016) and many Asian countries in 2018 (Liu *et al.*, 2019). In India, it was first observed on maize in Karnataka during 2018 (Sharanabasappa *et al.*, 2018; Ganiger *et al.*, 2018; Shylesha *et al.*, 2018). It is highly mobile and polyphagous causing economic damage in various crops such as rice, maize, sorghum, beans and cotton (Abrahams *et al.*, 2017; Day *et al.*, 2017). The estimated yield lose in maize ranged from 8.3 million tonnes to 20.6 million tonnes per year (Day *et al.*, 2017). As FAW is a well-known long-distance migratory pest and can fly over 100 km per night (Liu *et al.*, 2019), influence of weather factors on the bevaviour of FAW is very important. But availability of documented data in this aspect in Indian condition is very scarce as *S. frugiperda* is a new pest to India. Hence this study will help to evolve suitable integrated pest management (IPM) packages for *S. frugiperda* on maize that are cost effective.

Materials and Methods

The quantitative pest data on the incidence of *S. frugiperda* were collected from the farmer's holdings from the following six locations of Cauvery Delta Zone during 2019-2020. Total larval population in the whole plant was recorded.

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	76.617^{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	78.243^{0}E

The incidence was recorded from 27th Standard Mean Week (SMW) (July first fortnight) to 3rd SMW (January second fortnight) during 2019-2020. 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). All the open leaves and whorls of selected plants were observed thoroughly for FAW larvae and 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 website for the different locations of Cauvery Delta Zone. The quantitative relationship between the fortnightly mean population and weather parameters *viz*. maximum and minimum temperatures and rain fall were worked out by using correlation and regression analysis, and were expressed in the form of mathematical equations. The correlation coefficient (r) values were subjected to the test of significance using student t-test (Fisher and Yates, 1938). The calculated t-value obtained was compared with tabulated t-value at 5 % level of significance.

$$t = \frac{r}{\sqrt{1-r2}}(n-2)df$$

The quantitative influence of each weather parameter prevailing during experimentation as well as one week prior to the corresponding period of infestation for all locations separately was worked out.

Results and Discussion

The results revealed that *S. frugiperda* larval population fluctuates depending upon the weather parameters prevailing in the locality. *S. frugiperda* incidence was significant and positively correlated with maximum temperature at all locations (r = 0.39, 0.44, 0.41, 0.32, 0.45 and 0.40). The Correlation was significant at 5 % level. The regression equation indicated that for every 1°C increase in maximum temperature during same week increased the larval population of *S. frugiperda* by 1.56 per plant at Devanur, 1.84 at Kuvagam, 1.6 per plant at Sendurai, 1.99 per plant at Sengunam, 1.66 per plant at Vallikandapuram and 1.82 at Veppanthattai (Table 1). Similar type of significant and positive relation was observed between maximum temperature of previous week and *S. frugiperda* larval population at all locations (r = 0.21 to 0.52) (Table 4). Overall, the rate of increase was maximum at Sengunam (1.19 and 2.09 larvae per plant and minimum at Devanur (1.56 and 0.89 larvae per plant) in relation to increase of maximum temperature prevailing during same week and one previous week. Earlier, the positive correlation of lepidopteran pests *Earias vittella* on bhendi (Archunan *et al.,* 2018), *Helicoverpa armigera* on tomato (Vijaya Kumar *et al.,* 2017) and *Spodoptera litura* on groundnut (Mahalingam *et al.,* 2003) with maximum temperature was reported.

Table.1 Influence of maximum temperature prevailing during the same week on the incidence of *S. frugiperda* larva during 2019 -20 at Cauvery Delta Zone

Village	r value	R^2 value	Regression equation	t value
Devanur	(0.39)*	0.156	Y = 1.56x + 32.47	(1.429)*
Kuvagam	(0.44)*	0.196	Y=1.84x + 31.55	(1.641)*
Sendurai	(0.41)*	0.175	Y = 1.60x + 32.22	(1.528)*
Sengunam	(0.32)*	0.107	Y=1.199x + 32.77	(1.149)*
Vallikandapuram	(0.45)*	0.210	Y=1.662x + 31.95	(1.713)*
Veppanthattai	(0.40)*	0.166	Y=1.826x + 33.46	(1.543)*

*Significant at 5% probability level

Table.2 Influence of minimum temperature prevailing during the same week on the incidence of *S. frugiperda* larva during 2019 -20 at Cauvery Delta Zone

Village	r value	R^2 value	Regression equation	t value
Devanur	(-0.10)ns	0.011	Y = -0.44x + 26.56	(-0.351)ns
Kuvagam	(-0.07)ns	0.006	Y = -0.30x + 26.29	(-0.258)ns
Sendurai	(-0.02)ns	0.001	Y= -0.106x +25.35	(-0.078)ns
Sengunam	(-0.04)ns	0.015	Y=-0.42x + 22.34	(0.284)ns
Vallikandapuram	(-0.01)ns	0.003	Y=-0.060x + 24.89	(0.044)ns
Veppanthattai	(-0.04)ns	0.001	Y=-0.192x + 24.07	(0.207)ns

Table.3 Influence of rain fall prevailing during the same week on the incidence of *S. frugiperda* larva during 2019 -20 at Cauvery Delta Zone

Village	r value	R^2 value	Regression equation	t value
Devanur	(-0.38)*	0.146	Y=-19.79x + 67.14	(-1.376)*
Kuvagam	(-0.42)*	0.178	Y= -24.47x + 74.72	(-1.545)*
Sendurai	(-0.47)*	0.229	Y= -30.54x + 87.30	(-1.801)*
Sengunam	(-0.36)*	0.132	Y=-21.44x + 70.20	(-1.294)*
Vallikandapuram	(-0.42)*	0.178	Y=-23.91x + 75.13	(-1.546)*
Veppanthattai	(-0.41)*	0.171	Y=-20.52x + 66.93	(-2.05)*

*Significant at 5% probability level

Table.4 Influence of maximum temperature prevailing during the one previous week on the incidence of *S. frugiperda* larva during 2019 -20 at Cauvery Delta Zone

Village	r value	R2 value	Regression equation	t value
Devanur	(0.21)*	0.044	Y=0.892x + 33.83	(0.174)*
Kuvagam	(0.35)*	0.123	Y=1.638x + 32.28	(1.24)*
Sendurai	(0.48)*	0.233	Y=1.999x + 32.09	(1.832)*
Sengunam	(0.52)*	0.280	Y=2.095x + 31.86	(2.07)*
Vallikandapuram	(0.42)*	0.178	Y=1.645x + 32.46	(1.544)*
Veppanthattai	(0.44)*	0.195	Y=1.530x + 32.81	(1.636)*

*Significant at 5% probability level

Table.5 Influence of minimum temperature prevailing during the one previous week on the incidence of *S. frugiperda* larva during 2019 -20 at Cauvery Delta Zone

Village	r value	R^2 value	Regression equation	t value
Devanur	$(-0.07)^{ns}$	0.017	Y=-0.542x + 26.58	$(-0.438)^{ns}$
Kuvagam	$(-0.03)^{ns}$	0.001	Y=-0.126x + 26.31	$(-0.111)^{ns}$
Sendurai	$(-0.08)^{ns}$	0.005	Y=0.323x + 24.88	$(0.236)^{ns}$
Sengunam	$(0.06)^{ns}$	0.004	Y=0.249x + 25.42	$(0.219)^{ns}$
Vallikandapuram	$(0.05)^{ns}$	0.003	Y=0.265x + 24.81	$(0.197)^{ns}$
Veppanthattai	$(-0.03)^{ns}$	0.019	Y=0.600x + 23.75	$(0.469)^{ns}$

Table.6 Influence of rainfall prevailing during the one previous week on the incidence of *S. frugiperda* larva during 2019 -20 at Cauvery Delta Zone

Village	r value	R^2 value	Regression equation	t value
Devanur	(-0.20) *	0.043	Y=-10.74x + 52.32	(-0.705)*
Kuvagam	(-0.20)*	0.042	Y=-11.92x + 54.33	(-0.697)*
Sendurai	(-0.21)*	0.043	Y=-13.26x + 59.54	(-0.704)*
Sengunam	(-0.19) *	0.051	Y=-15.846x+ 40.87	(-0.926)*
Vallikandapuram	(-0.22)*	0.042	Y=-12.89x + 57.55	(-0.776)*
Veppanthattai	(-0.24) *	0.061	Y=-18.272x+ 43.83	(-1.102)*

*Significant at 5% probability level

The relation of *S. frugiperda* with minimum temperature prevailing during same week was negative and non significant at all locations (r = -0.01 to -0.10) (Table 2) and with minimum temperature prevailing during one previous week was negative and

non significant at Devanur (-0.07), Kuvagam (-0.03), Sendurai (-0.08) and Veppanthattai (-0.03) and positive and non significant at Sengunam (-0.06) and Vallikandapuram (-0.05) (Table 5). This agreed with the findings of Khan and Talukdar (2017) who found that the minimum temperature negatively influenced the *Pieris brassicae* larval population on cabbage. This might be due to the fact that lowering of minimum temperature created the favourable micro climate for the natural enemies activities which in turn reduced the larval population. Rain fall of the same week and of one previous week had significant and negative correlation with *S. frugiperda* larval population at all locations (Table 3 and Table 6). The correlation was strong with same week total rain fall (r = -0.38, -0.42, -0.47, -0.36,-0.42 and -0.41) compared to previous week total rain fall (r = -0.20, -0.20, -0.21, -0.19, -0.22 and -0.24). Increase in 1 mm of same week total rainfall decreased the larval population to the level of 19.79, 24.47, 30.54, 21.44, 23.91 and 20.52 larvae per plant at Devanur, Kuvagam, Sendurai, Sungunam, Vallikandapuram and Veppanthattai respectively. The level of decrease due to increase in 1^{o}C of previous week total rain fall was 10.74 to 18.70 larvae per plant at different locations. Heavy rainfall might have washed out the first and second instar larvae and the longer developmental period during rainy seasons might have pre disposed the larvae to natural enemies and insect pathogens. Waddill *et al.*, (1981) reported that heavy and light rainfall killed significant number of early instar of *S. frugiperda*. These results agreed with those of Mitchell *et al.*, (1991) who reported that in the tropics, *S. frugiperda* populations have a tendency to vary with changes in rainfall. Khan and Talukder (2017) reported a significant negative correlation between larval population of diamondback moth and rainfall.

As the weather parameters of the region have great influence on the incidence of *S. frugiperda*, we have to consider the local climatic factors while formulating the integrated pest management strategies.

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