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POPULATION DYNAMICS OF *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) IN PERAMBALUR DISTRICT OF TAMIL NADU

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This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The Fall Armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith), a migratory polyphagous pest with high feeding preference to maize, is native to American continent but detected in African continent in the year 2016 and reached the Indian sub-continent by 2018. Now the pest has been spread over the maize growing states in India and causing drastic economic loss. Studies on population dynamics of *Spodoptera frugiperda* was carried out in all the four blocks of Perambalur district of Tamil Nadu by conducting the season long survey with the aim to correlate the occurrence and weather variables. The number of egg masses and larval population were counted and percent infestation was worked out. Among the four blocks, Veppur block showed the heavy infestation of 85%. Thus, the climatologic conditions prevailing in the cropping season decides the fluctuation and abundance of FAW. So, abiotic factors must be taken into consideration in the IPM model for the management of FAW.

Keywords: *Spodoptera frugiperda;* population dynamics; fall armyworm.

1. INTRODUCTION

The Fall Armyworm (FAW), *Spodoptera frygiperda* (J.E. Smith) is a migratory polyphagous pest. It feeds on various crops such as maize, sorghum, forage grasses for livestock, turf grasses, rice, cotton, etc [1,2]. Two races of *S. frugiperda* namely a 'rice strain' (R strain) and a 'maize strain' (C strain). FAW is the most important corn pest and fluctuates the yield loss can reach upto 95% [3]. Because the larva feeds on young leaves, leaf whorls and tassels or cobs of corn [4]. The young larvae scrape nearer to the oviposition site [1] but the second and third instars feed by making holes. However the last three larval instars (L4 to L6) prefer reproductive structures of corn and affect its production [5].The 'R' strain

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preferentially feed on rice and various pasture grasses and the 'C' strain on maize, cotton and sorghum [6]. It is the most destructive pest and cause economic damage to many agricultural crops [1].

FAW has a wide distribution based on abiotic factors such as climatic diversity *ie.*, temperature, moisture and soil type. The optimal range of temperature for the normal development of *S. frugiperda* was determined to be between 26 and 32°C. For adapting suitable climate, *S.frugiperda* migrates over long distance on prevailing winds and breed continuously [7,8]. Westbrook *et al*. [9] recorded that FAW can travel several hundred kilometers over a single night by flying and maintaining an elevation of several hundred meters which lead them in a directional manner. In this line, the fall armyworm *Spodoptera frugiperda* (J. E. Smith); indigenous to the tropical regions of the western hemisphere from Argentina to the United States of America has been reported for the first time in India during July 2018, from the maize fields of Karnataka and severe damage was noticed in Chikkaballapur, Hassan, Shivamogga, Davanagere and Chitradurga districts [10, 11, 12 & 13]. Field surveys by a team from ICAR – NBAIR revealed that the damage in Chikkaballapur area was more than 70%.

Now the pest infestation has spread to most parts of the Indian subcontinent and has been reported from maize farms in 20 states. The spread of fall armyworm (FAW) through the subcontinent has been particularly fast. In 2019, the pest has spread as far as Mizoram in the northeast, Uttar Pradesh in the north, Gujarat in the west, Chhattisgarh in central India, and several states in the south. The biggest victims so far have been the farmers in northeastern states, where a cumulative of 10,772 hectares of maize crop has been affected. In 2018, maize production fell by 3.2% (27.8 million tonnes) in India. It is expected that the net production will decline further in subsequent years due to the attack of FAW [14].

In Tamil Nadu, Maize is cultivated in about 3.5 lakh hectares and around 1.2 lakh hectares have been covered against the menace of FAW. Perambalur, Virudhunagar, Salem, Tirunelvel, Erode, Dindigul and Trichy are the worst affected districts. In Perambalur alone, more than 31000 out of 60000 ha of maize crop were affected by FAW in 2018. In 2019, widespread occurrence of FAW was noticed in 50000 ha in the Perambalur district [15 & 16]. The state government allotted Rs.186.25 crore rupees as compensation to the farmers in 2019.

The study is mainly conducted to establish the relationship on weather parameters and the incidence of *S. frugiperda* in Perambalur district where maize is grown in large hectares in Tamil Nadu. The count on egg masses, larval population and percent infestation were taken on each blocks of Perambalur district during 2021 for thirteen standard weeks to find the correlation with abiotic factors and conclude with the factor which had influenced the population of FAW and its damage potential. There is no apparent idea about the proclivity of FAW to abiotic factors at regional level. Further; this knowledge will offer ample scope for better pest management.

2. MATERIALS AND METHODS

2.1 Survey Locations

Fixed plot surveys were conducted to document the occurrences of *S. frugiperda* in the maize fields of Perambalur district, one of the major maize growing districts of Tamil Nadu from September to December during 2021. **Perambalur, Tamil Nadu, India** is located with the GPS coordinates of 11° 13' 48.0000" N and 78° 52' 47.9892" E. All the four blocks of Perambalur district were subjected to the survey and in each block maximum maize cultivating villages (two) were marked. The average of two villages per block were taken into the account.

2.2 Cropping Details

In each location, one acre field was earmarked for the survey with the consent of the farmer not to spray any

Chart 1. Survey location in Perambalur district of Tamil Nadu

Name of the block	Name of the villages	Cultivar	Duration (Days)
Veppanthattai	1. Veppanthattai	NK 6240	115-120
	2. Mettupalayam	Pioneer 3302	120-135
Veppur	3. Aaduthurai	NK 7328	120-135
	4. Keelapuliyur	NK 6668	120-135
Perambalur	5. Kurumbalur	DMH 8255	115-120
	6. Velur	S-6668	125-130
Alathur	7. Sillakudi	NK 6240	115-120
	8. Chettikulam	CP 818	125-130

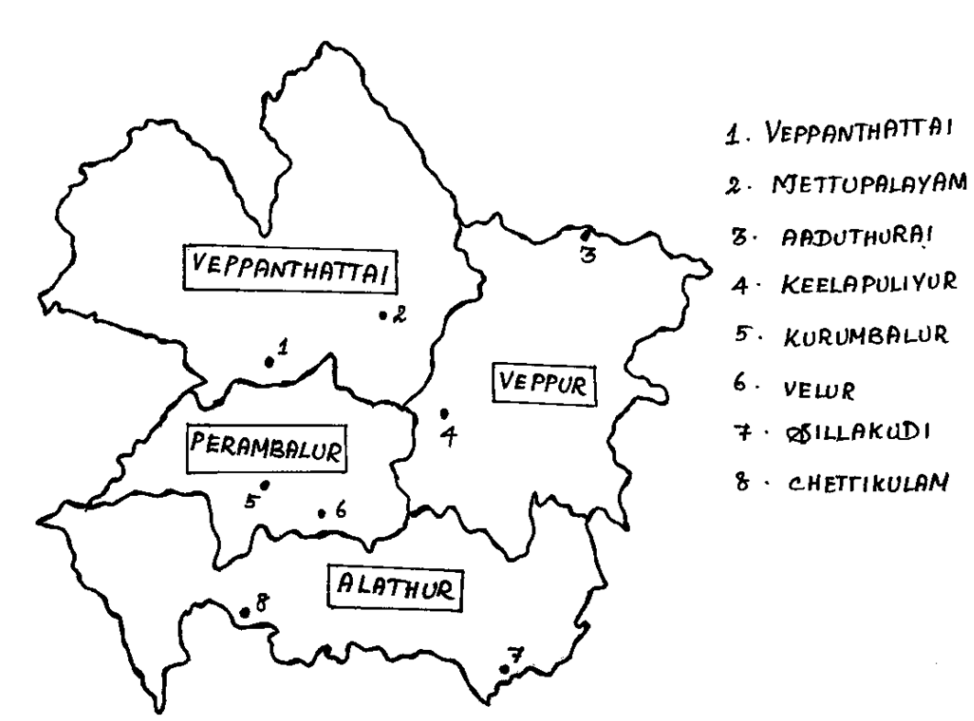

Fig. 1. Map of Perambalur district showing survey locations

insecticide in raising the crop but by following prescribed crop production practices. Spacing of 60 × 25 cm was followed. Surface irrigation was adapted. The details of variety and duration of the maize crop are mentioned in the above table.

2.3 Scouting

In each field five spots were randomly selected for scouting. In each spot, 5 rows of 5m length were marked. From the marked area, 20 randomly selected plants were counted for infestation, egg masses and larvae. In total 100 plants/field were considered as sample size. Then the percent infestation and mean numbers of egg masses and larvae per plant were worked for thirteen standard weeks (38 to 50) after third week of planting and till it reaches the maturity.

Per cent infestation = Number of infested plants/Total number of plants observed X 100
Number of egg masses per plant = Total number of egg masses/Total number of plants observed
Number of larvae per plant = Total number of larvae/Total number of plants observed

2.4 Statistical Analysis

The worked data was correlated with the abiotic factors such as maximum and minimum temperature, RH, Rainfall and wind velocity in Microsoft excel.

3. RESULT AND DISCUSSION

3.1 Veppanthattai Block

During 2021, in Veppanthattai block, 83.5% plant infested by *S. frugiperda* and was the maximum. During the high infestation, the maximum and minimum temperature recorded were 33.4°C and 25.1°C respectively with RH of 77%. The percent infestation ranges between 83.5 to 20%. Percent infestation in this block crossed 50% for five standard weeks. The egg mass count was between 0 to 0.11 egg masses/plant. The maximum of 0.11 egg masses/plant was observed during two consecutive standard weeks (45^{th} and 46^{th}) and no rainfall was observed in that particular weeks. Nil egg masses was observed on 44^{th} standard week and egg masses was found below 0.1 in ten standard weeks. The larval population fluctuates between 0.17 and 3.19 larvae/plant. The larval population was delined below 1 in seven standard weeks and in the remaining six standard weeks, it crossed above 1. There was positive correlation with maximum and minimum temperature and other abiotic factors such as RH, rainfall and wind velocity showed negative correlation. The correlation was found to be highly significant with RH and rainfall at 0.01% significance level (Table 1).

3.2 Veppur Block

The egg mass count was maximum during 45^{th} standard week (0.13 egg mass/plant). The count was

declined to 0.12 in two standard weeks (41st and 46th). The remaining ten weeks showed below 0.1 egg mass/plant. The maximum larval incidence was documented on 45th standard week (3.26 larvae/plant) and this week showed the peak infestation of 85% among all the four blocks. The percent plant infestation was recorded between 21 and 85%. While the larval population was in the range from 0.23 to 3.26 larvae/plant. The highest larval population of 1 to 3 larvae/plant was observed in six standard week and the least larval population of less than one was found in the remaining seven standard week. During the maximum infestation, there was no rainfall and maximum and minimum temperature recorded were 33.4°C and 25.1°C respectively. The correlation between RH and rainfall with egg mass, larval population and percent infestation were significant. They were -0.68, -0.51 and -0.48 in case of RH and 0.73, -.0.68 and -0.60 respectively with rainfall. The correlation was found non-significant with temperature and wind velocity (Table 2).

3.3 Perambalur Block

In this block, the maximum of 0.10 egg mass/plant, 3.01 larvae/plant and 82% plant infestation were recorded on 41st standard week. The 40th and 41st standard week showed zero rainfall but the infestation percentage was observed to be the maximum of above 80%. During the survey period, the first two and last three standard weeks showed the minimum level of infestation (< 40%), least larval population (<0.45 larvae/plant) and least egg mass count (<0.03 egg mass/plant). The larval occurrence in this block ranges between 0.26 and 3.01 larvae/plant while egg mass count recorded was between 0 and 0.10. The percent plant infestation crossed more than 50% for seven standard weeks and the remaining six standard weeks showed the infestation of between 27 and 39.5%. The egg mass, larval population and percent infestation was positively correlated with maximum and minimum temperature and negatively correlated with RH, rainfall and wind velocity. In this case, the maximum temperature and egg mass count was found positively (0.52) significant. High negative significance was noted with RH and rainfall (Table 3).

3.4 Alathur Block

The high larval population (3.08 larvae/plant) was found during active growth stage (41st standard week) of maize plant and become lower (0.26 larvae/plant) during the maturity stage of the crop. The larval population was within two per plant in twelve standard weeks except that 41st standard week. As there was no rainfall recorded on this 41st standard week, the egg mass/plant (0.13) and percent infestation (83.5%) was found to be the maximum. The egg mass count was found less than 0.1 in twelve standard weeks as similar to larval population. The plant infestation recorded for the thirteen standard weeks were found between 83.5%.

The correlation was found highly significant (-0.68) between RH and egg mass count and significant with rainfall (-0.52) and wind velocity (-0.51). Maximum and minimum temperature was positively correlated (Table 4).

In our study, the maximum of 85% infestation was recorded and Midega *et al.* [3] recorded the infestation even upto 95%. A positive correlation was found between the infestations, egg masses and larval population and temperature (maximum and minimum temperature) in all the four blocks while negative correlation with rainfall, RH and wind velocity. Thus, whenever the rainfall received above 3mm, there is decline in the larval population and percent infestation. . The average RH recorded was high during 2021, it indicates that RH also has influence on the population of *S. frugiperda.* This result is in accordance with Clavijo and Notz [17] who reported a correlation coefficient -0.56 in case of RH and larval population and he indicated that whenever there is increase of humidity, it matches the upward trend of this pest. The favourable wind velocity will be attributed to the distribution of population and agreed with the report of Mitchell *et al.* [18]. Thus the rainfall, RH and wind velocity played significant role in the reduction of FAW.

In Veppanthattai and Veppur block, the infestation was found maximum during 45th standard week of early reproductive stage of the crop while the remaining two blocks, Perambalur and Alathur block, the infestation level was peak during 41st standard week of the vegetative stage. Thus the infestation was observed at both vegetative and reproductive stages of the crop. It is interrupted that the larvae may infest on both vegetative and reproductive stages as indicated by Capinera [19]. In agreeing with Georgen *et al.* [4] and Deole *et al.* [20], the fall armyworm cause damage in all growth stage of the crop. But the infestaion during reproductive stage alter the structure of the cob as supported by Midega *et al.* [3]. The infestation of *S. frugipetda* seen throughout the cropping season but severe infestations are influenced by crop stage and abiotic factors.

Table 1. Population dynamics of *Spodoptera frugiperda* in Veppanthattai Block (2021)

Standard Week	Stage of the crop	Temperature (° C)		RH (%)	Rainfall (mm)	Wind Velocity (Km/ h)	*Mean No. of Egg Mass/ Plant	*Mean No. of Larvae/ Plant	Percent Infestation
		Max.	Min.						
38	**V5**	33.80	25.10	76	11.40	10.10	0.01	0.25	23.5
39	**V5**	32.40	25.00	77	10.00	9.50	0.03	0.33	34.0
40	**V9**	34.50	26.30	72	2.80	7.90	0.06	1.35	56.5
41	**V9**	34.70	26.40	72	0.00	8.20	0.10	1.89	79.0
42	**V15**	30.50	25.10	83	8.50	9.30	0.02	1.80	32.0
43	**V15**	31.00	24.50	82	7.10	9.40	0.04	0.95	37.5
44	**VT**	35.80	28.30	84	14.30	9.80	0.00	0.33	22.0
45	**R1**	33.40	25.10	77	0.00	6.90	0.11	3.19	83.5
46	**R2**	31.40	24.50	76	0.00	13.30	0.11	2.89	77.5
47	**R3**	30.00	24.30	79	2.80	13.60	0.04	1.71	55.0
48	**R4**	28.00	24.00	85	11.40	12.60	0.01	0.35	31.5
49	**R5**	29.10	23.20	80	7.20	13.50	0.01	0.19	26.5
50	**R6**	29.50	22.70	82	0.00	12.30	0.02	0.17	20.0
*Mean of 100 plants									
Correlation coefficient									
Max. Temp.							0.30	0.19	0.29
Min. Temp.							0.11	0.13	0.17
RH							**-0.65****	-0.41	**-0.65****
Rainfall							**-0.78****	**-0.65****	**-0.72****
Wind velocity							-0.32	-0.27	-0.30

**0.05% significance*
***0.01% significance*

Table 2. Population dynamics of *Spodoptera frugiperda* in Veppur Block (2021)

Standard Week	Stage of the crop	Temp erature (˚ C)		RH (%)	Rainfall (mm)	Wind Velocity (Km/ h)	*Mean No. of Egg Mass/ Plant	*Mean No. of Larvae/ Plant	Percent Infestation
		Max.	Min.						
38	**V5**	33.80	25.10	76	11.40	10.10	0.02	0.31	33.0
39	**V5**	32.40	25.00	77	10.00	9.50	0.02	0.38	42.5
40	**V9**	34.50	26.30	72	2.80	7.90	0.06	1.41	58.0
41	**V9**	34.70	26.40	72	0.00	8.20	0.12	2.85	78.5
42	**V15**	30.50	25.10	83	8.50	9.30	0.02	0.97	39.5
43	**V15**	31.00	24.50	82	7.10	9.40	0.03	1.11	44.5
44	**VT**	35.80	28.30	84	14.30	9.80	0.01	0.47	31.5
45	**R1**	33.40	25.10	77	0.00	6.90	0.13	3.26	85.0
46	**R2**	31.40	24.50	76	0.00	13.30	0.12	2.49	81.0
47	**R3**	30.00	24.30	79	2.80	13.60	0.04	1.73	62.0
48	**R4**	28.00	24.00	85	11.40	12.60	0.00	0.56	31.0
49	**R5**	29.10	23.20	80	7.20	13.50	0.01	0.32	23.0
50	**R6**	29.50	22.70	82	0.00	12.30	0.01	0.23	21.0
*Mean of 100 plants									
Correlation coefficient									
Max. Temp.							0.37	0.27	0.15
Min. -Temp.							0.20	0.20	0.13
RH							**-0.68****	**-0.51***	-0.48
Rainfall							**-0.73****	**-0.68****	**-0.60***
Wind velocity							-0.40	-0.48	-0.28

**0.05% significance*
***0.01% significance*

Table 3. Population dynamics of *Spodoptera frugiperda* in Perambalur Block (2021)

Standard Week	Stage of the crop	Temperature (° C)		RH (%)	Rainfall (mm)	Wind Velocity (Km/ h)	*Mean No. of Egg Mass/ Plant	*Mean No. of Larvae/ Plant	Percent Infestation
		Max.	Min.						
38	**V5**	33.80	25.10	76	8.50	10.10	0.03	0.40	33.5
39	**V5**	32.40	25.00	77	8.60	9.50	0.02	0.45	29.0
40	**V9**	34.50	26.30	72	0.00	7.90	0.09	2.52	81.5
41	**V9**	34.70	26.40	72	0.00	8.20	0.10	3.01	82.0
42	**V15**	30.50	25.10	83	8.20	9.30	0.02	0.55	57.0
43	**V15**	31.00	24.50	82	7.10	9.40	0.03	0.56	62.5
44	**VT**	35.80	28.30	84	10.50	9.80	0.02	0.38	39.5
45	**R1**	33.40	25.10	77	1.50	6.90	0.07	2.05	63.0
46	**R2**	31.40	24.50	76	1.70	13.30	0.06	1.82	63.5
47	**R3**	30.00	24.30	79	2.90	13.60	0.07	1.52	53.5
48	**R4**	28.00	24.00	85	8.60	12.60	0.01	0.82	37.5
49	**R5**	29.10	23.20	80	4.30	13.50	0.01	0.26	30.5
50	**R6**	29.50	22.70	82	1.40	12.30	0.00	0.30	27.0
*Mean of 100 plants									
Correlation coefficient									
Max. Temp.							0.52	0.41	0.41
Min. Temp.							0.40	0.32	0.40
RH							**-0.80****	**-0.74****	**-0.57***
Rainfall							**-0.68****	**-0.75****	**-0.53***
Wind Velocity							-0.41	-0.38	0.50

**0.05% significance*
***0.01% significance*

Table 4. Population dynamics of *Spodoptera frugiperda* in Alathur Block (2021)

Standard Week	Stage of the crop	Temperature (° C)		RH (%)	Rainfall (mm)	Wind Velocity (Km/ h)	*Mean No. of Egg Mass/ Plant	Mean No. of Larvae/ Plant	Percent Infestation
		Max.	Min.						
38	**V5**	33.80	25.10	76	8.60	10.10	0.02	0.30	30.0
39	**V5**	32.40	25.00	77	1.40	9.50	0.05	1.35	63.0
40	**V9**	34.50	26.30	72	1.60	7.90	0.06	1.22	63.0
41	**V9**	34.70	26.40	72	0.00	8.20	0.13	3.08	83.5
42	**V15**	30.50	25.10	83	8.70	9.30	0.02	0.37	54.0
43	**V15**	31.00	24.50	82	2.80	9.40	0.07	1.79	61.0
44	**VT**	35.80	28.30	84	7.10	9.80	0.02	0.69	45.0
45	**R1**	33.40	25.10	77	4.30	6.90	0.06	1.77	54.0
46	**R2**	31.40	24.50	76	2.80	13.30	0.05	1.97	62.0
47	**R3**	30.00	24.30	79	4.20	13.60	0.04	0.92	54.5
48	**R4**	28.00	24.00	85	8.50	12.60	0.01	0.86	37.0
49	**R5**	29.10	23.20	80	0.00	13.50	0.02	0.47	31.5
50	**R6**	29.50	22.70	82	0.00	12.30	0.02	0.26	23.5
*Mean of 100 plants									
Correlation coefficient									
Max. Temp.							0.46	0.36	0.44
Min. Temp.							0.31	0.29	0.47
RH							**-0.68****	**-0.56***	**-0.56***
Rainfall							**-0.52***	-0.42	-0.27
Wind velocity							**-0.51***	-0.38	-0.48

**0.05% significance*
***0.01% significance*

4. CONCLUSION

Hence, it is concluded that number of egg masses, larval population and FAW infestation levels are influenced by the climatic conditions of the location. Thus the climatologic conditions prevailing in the cropping season decides the fluctuation and abundance of the FAW. As it is a polyphagous insect, host plants grown in the area and cropping pattern are equally important as abiotic factors. During the survey, observation of biotic factors such as parasitoid and predators may also be included for further precision of FAW in the field condition. While preparing IPM model to manage FAW, temperature, rainfall and other abiotic factors and biotic factors along with the stage of the crop must to be taken into consideration.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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