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Seasonal incidence of fall armyworm *Spodoptera frugiperda* (J. E. Smith) infesting maize in Konkan region of Maharashtra

JJ Dubale, BD Shinde, SK Mehendale, PS Bodake and SV Sawardekar

Abstract
A field experiment on seasonal incidence of fall armyworm in maize var. Sugar-75 was carried out at Tetawali block–B, Central Experiment Station, Wakawali, under Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during *Rabi* - 2019-20 and 2020-21 to know the status of the pest in Konkan region. The result revealed the, the incidence of fall armyworm population was ranged from 0.03 to 0.45 larvae per plant. The pest incidence was started on 2nd SMW (8th Jan to 14th Jan), however the outbreak was noticed during 8th SMW (19th Feb to 25th Feb) & 9th SMW (26th Feb. to 4th March) i.e. 0.45 larvae per plant while the minimum population was recorded at 13th SMW (26th March to 1st April). The correlation study during *Rabi* 2019-20 and 2020-21 indicated that, the fall armyworm in terms of larval population showed positively significant correlation with bright sunshine hours and negatively significant correlation with evening relative humidity.

Keywords: Maize, seasonal incidence, fall armyworm, weather parameter, correlation

Introduction
The fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) is an insect that is native to tropical and subtropical regions of the America. It is a serious pest of corn but also known to attack more than 100 hosts. In addition, it is reported to cause major damage to economically important cultivated crops (rice, sorghum and sugarcane) as well as horticultural crops (cabbage, beet, tomato, potato and onion) besides cotton, pasture grasses, peanut, soybean, alfalfa and millets (Pogue, 2018; Chapman *et al.*, 2000; Anon., 2016) [9, 2, 1]. Till 2015, FAW was not reported in countries other than the America. But a severe incidence of FAW was reported from African countries such as Sao Tome, Nigeria, Benin and Togo in 2016 (Goergen *et al.*, 2016*)* [5] and later in Ghana during 2017 (Cock *et al.*, 2017*)* [4]. Subsequently, it spread to most of the sub-Saharan Africa, causing extensive damage, especially to maize and to a less extent on sorghum and other crops. Within a short span of its introduction in Africa, presence of FAW was confirmed in over 43 African countries (Prasanna *et al.*, 2018). In India, it is reported for first time on maize from Shivamogga district of Karnataka during May- June, 2018 (Sharanabasappa *et al*., 2018b) [14], however, in Maharashtra it was noticed first time in the month of September 2018 feeding on two months old sugarcane crop, variety (Co 86032) at Ghogaon village of Sangli District (Maharashtra). Other than sugarcane, it was also reported on maize, sorghum and sweet corn in different districts of Maharashtra. (Chormule *et al*., 2019) [3]. Currently, FAW has spread to entire maize growing area of south India including Maharashtra. Further spreading may occur as the pest is migratory. The lack of information on the dynamics of the pest would affect the prediction of the population in other parts. The possibility of its spread across India cannot be ruled out. The pest has the ability to shift other hosts for survival in the absence of maize and maintain the population in India throughout the year. Thus the immediate focus of research should be on the reproductive biology, host preference and host plant resistance, diapause, strains, natural enemies and migration (Sharanbasappa *et al*., 2018b) [14].The present study on seasonal incidence of FAW on maize crop and their correlation with the weather parameters provides basic information about seasonal occurrence. This provides an opportunity for the development of management strategies significant for the control of this pest.

Material and Method
A field experiment on seasonal incidence of fall armyworm infesting maize var. Sugar-75 was

carried out at Tetawali block–B, Central Experiment Station, Wakawali, under Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. During *Rabi* - 2019-20 and 2020-21. The larval population of FAW was recorded at weekly interval on randomly selected 20 plants starting from emergence of seedlings to harvesting of the crop and was expressed in mean number of larvae per plant. The data on weather parameters *viz*., maximum and minimum temperature, morning and evening relative humidity, wind speed and sunshine hours were collected from Meteorological Observatory, Central Experiment Station, and Wakawali. This data was used for present study to work out correlation and regression between FAW and weather parameters.

Result and discussion

The data on seasonal incidence of fall armyworm infesting maize during *Rabi* 2019-20, *Rabi* 2020-21 and pooled are presented in Table 1, 2 and 3. The incidence of fall armyworm during *Rabi* 2019-20 ranged from 0.05 to 0.50 larvae per plant. The pest incidence was observed at 2nd SMW (8th Jan to 14th Jan), however the outbreak was noticed during 8th SMW (19th Feb to 25th Feb) when there was 0.50 larvae per plant. There after it had declined trend. The minimum population (0.05 larvae per plant) was recorded at 2nd SMW (8th Jan. to 14th Jan) and 12th SMW (19th March to 25th March). During *Rabi* 2020-21, the incidence of fall armyworm ranged from 0.05 to 0.55 larvae per plant. The pest incidence was started at 2nd SMW (8th Jan to 14th Jan). In contrast to the year 2019-20 the outbreak in 2020-21 was noticed during 9th SMW (26th Feb to 4th March) i.e. 0.55 larvae per plant, after which it declined. The minimum population (0.05 larvae per plant) was recorded at 2nd SMW (8th Jan to 14th Jan) and 13th SMW (26th March to 1st April). Incidence though occurred in 2nd SMW during both years but, during the 2020-21, it remained in the field till 13th SMW against 12th SMW in 2019-20. The two year pooled data (*Rabi* 2019-20 and 2020-21) revealed that the incidence of fall armyworm ranged from 0.03 to 0.45 larvae per plant. The pest incidence was started on 2nd SMW (8th Jan to 14th Jan), however the outbreak was noticed during 8th & 9th SMW (19th Feb to 25th Feb) & (26th Feb to 4th March) i.e. 0.45 larvae per plant while the minimum population was recorded at 13th SMW (26th March to 1st April). The present findings are in close agreement with the earlier research work of Pasay at, (2021) [8] resulted that the incidence of fall armyworm in terms of its population started during 2nd week of December (50th SMW) (0.03 larvae/plant) and gradually increased reaching a peak during 5th week of January (5th SMW) (3.90 larvae/plant). The period reach to peak activity was 7 weeks from the pest appearance. Thereafter its activity started declining gradually and remained active till 4th week of February (9th SMW) with a population ranging from 0.50/plant

Table 1: Seasonal incidence of *S. frugiperda* infesting maize during *Rabi* 2019-20

SMW	Period	Mean no. of larvae/plant	Tmax (^{0}C)	Tmin (^{0}C)	RH-I (%)	RH-II (%)	WS (km/hr)	BSS (hr)	EPAN (mm)
52	24.12.19 to 31.12.19	0.00	32.26	19.70	91.20	47.10	1.3	5.8	2.8
1	01.01.20 to 07.01.20	0.00	30.66	14.54	92.70	51.70	1.6	7.6	3.2
2	08.01.20 to 14.01.20	0.05	31.43	18.09	90.90	42.50	1.7	6.8	2.9
3	15.01.20 to 21.01.20	0.10	31.74	14.70	85.50	45.10	1.8	8.3	3.0
4	22.01.20 to 28.01.20	0.10	34.44	16.67	90.40	33.80	1.6	8.5	3.9
5	29.01.20 to 04.02.20	0.15	30.98	14.53	90.00	53.30	2.0	8.5	3.2
6	05.02.20 to 11.02.20	0.20	31.69	13.81	86.60	33.20	2.1	8.0	3.5
7	12.02.20 to 18.02.20	0.35	35.45	17.21	83.80	36.80	1.9	8.1	3.9
8	19.02.20 to 25.02.20	0.50	36.06	16.99	85.50	33.30	2.1	8.6	4.3
9	26.02.20 to 04.03.20	0.35	35.23	16.28	78.70	26.50	2.3	8.4	5.2
10	05.03.20 to 11.03.20	0.20	31.18	16.80	84.30	39.80	2.7	8.4	4.3
11	12.03.20 to 18.03.20	0.10	35.20	17.63	73.70	31.80	2.5	8.5	5.5
12	19.03.20 to 25.03.20	0.05	36.13	19.64	78.10	36.80	2.8	7.9	5.5
13	26.03.20 to 01.04.20	0.00	36.71	22.14	70.50	40.70	2.6	7.7	5.8
14	02.04.20 to 08.04.20	0.00	36.36	21.20	79.40	39.20	2.7	7.8	5.6
15	09.04.20 to 15.04.20	0.00	36.67	22.10	79.50	45.40	2.5	7.8	4.9
SD ±		0.15							

SMW- Standard Meteorological Week

Table 2: Seasonal incidence of *S. frugiperda* infesting maize during *Rabi* 2020-21.

SMW	Period	Mean no. of larva/plant	Tmax (^{0}C)	Tmin (^{0}C)	RH-I (%)	RH-II (%)	WS (km/hr)	BSS (hr)	EPAN (mm)
52	24.12.20 to 31.12.20	0.00	33.14	15.54	89.40	47.10	0.9	7.5	2.7
1	01.01.21 to 07.01.21	0.00	32.53	19.59	92.66	52.06	1.0	5.1	2.6
2	08.01.21 to 14.01.21	0.05	33.40	20.64	93.82	52.10	1.1	5.8	2.6
3	15.01.21 to 21.01.21	0.10	33.87	15.95	88.84	47.20	1.2	7.6	3.0
4	22.01.21 to 28.01.21	0.15	33.52	15.33	88.95	39.86	1.2	7.9	3.4
5	29.01.21 to 04.02.21	0.20	34.14	14.09	86.54	31.25	1.1	7.8	3.4
6	05.02.21 to 11.02.21	0.30	34.04	12.82	81.22	24.51	1.4	8.6	4.2
7	12.02.21 to 18.02.21	0.35	33.66	15.57	93.02	40.53	1.6	7.9	3.7
8	19.02.21 to 25.02.21	0.40	34.35	17.30	87.86	29.65	1.6	7.8	4.3
9	26.02.21 to 04.03.21	0.55	38.02	24.77	80.83	27.60	1.8	8.1	5.3
10	05.03.21 to 11.03.21	0.45	37.09	17.10	79.98	32.67	1.9	7.4	4.3
11	12.03.21 to 18.03.21	0.25	37.41	17.97	84.14	37.07	1.8	7.1	4.6
12	19.03.21 to 25.03.21	0.10	37.03	19.42	72.93	33.39	2.0	6.6	4.7

13	26.03.21 to 01.04.21	0.05	38.51	19.86	77.67	41.62	2.0	7.4	6.0
14	02.04.21 to 08.04.21	0.00	36.56	20.59	80.37	40.77	2.4	6.3	5.4
15	09.04.21 to 15.04.21	0.00	37.38	22.98	80.33	44.03	2.0	7.4	5.4
SD ±		0.18							

SMW- Standard Meteorological Week

Table 3: Seasonal incidence of *S. frugiperda* infesting maize (pooled data *Rabi* 2019-20 and 2020-21)

SMW	Period	Mean no. of larva/plant	Tmax (^{0}C)	Tmin (^{0}C)	RH-I (%)	RH-II (%)	WS (km/hr)	BSS (hr)	EPAN (mm)
52	24.12.20 to 31.12.20	0.00	32.70	17.62	90.30	47.10	1.1	6.7	2.8
1	01.01.21 to 07.01.21	0.00	31.60	17.07	92.68	51.88	1.3	6.3	2.9
2	08.01.21 to 14.01.21	0.05	32.42	19.37	92.36	47.30	1.4	6.3	2.8
3	15.01.21 to 21.01.21	0.10	32.81	15.33	87.17	46.15	1.5	7.9	3.0
4	22.01.21 to 28.01.21	0.13	33.98	16.00	89.68	36.83	1.4	8.2	3.7
5	29.01.21 to 04.02.21	0.18	32.56	14.31	88.27	42.28	1.5	8.1	3.3
6	05.02.21 to 11.02.21	0.25	32.86	13.32	83.91	28.86	1.8	8.3	3.9
7	12.02.21 to 18.02.21	0.35	34.55	16.39	88.41	38.67	1.8	8.0	3.8
8	19.02.21 to 25.02.21	0.45	35.20	17.15	86.68	31.48	1.8	8.2	4.3
9	26.02.21 to 04.03.21	0.45	36.63	20.53	79.77	27.05	2.0	8.3	5.2
10	05.03.21 to 11.03.21	0.33	34.13	16.95	82.14	36.24	2.3	7.9	4.3
11	12.03.21 to 18.03.21	0.18	36.31	17.80	78.92	34.44	2.2	7.8	5.0
12	19.03.21 to 25.03.21	0.08	36.58	19.53	75.52	35.10	2.4	7.3	5.1
13	26.03.21 to 01.04.21	0.03	37.61	21.00	74.09	41.16	2.3	7.5	5.9
14	02.04.21 to 08.04.21	0.00	36.46	20.90	79.89	39.99	2.5	7.1	5.5
15	09.04.21 to 15.04.21	0.00	37.02	22.54	79.92	44.72	2.2	7.6	5.1
SD ±		0.16							

SMW- Standard Meteorological Week

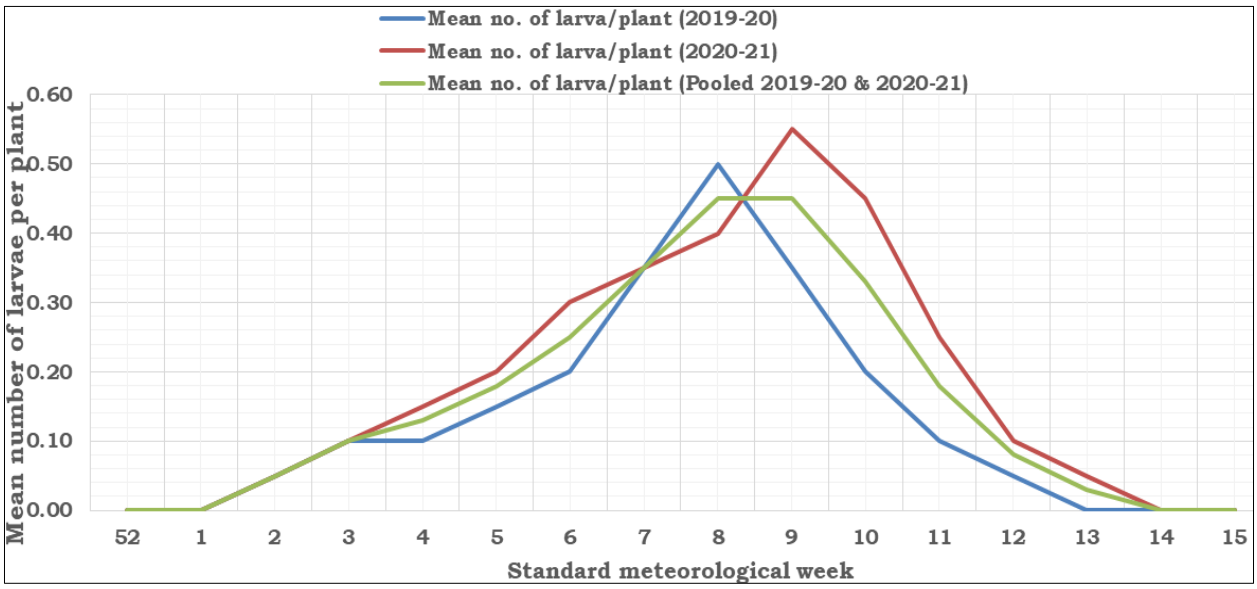

Fig 1: Seasonal incidence of *S. frugiperda* on maize (*Rabi* 2019-20, *Rabi* 2020-21 and pooled)

Correlation and regression between fall armyworm population and weather parameters

Correlation studies

The data on correlation between weather parameters and fall armyworm population during *Rabi* 2019-20 and 2020-21 are presented in Table 4.

During *Rabi* 2019-20 the fall armyworm population showed positively significant correlation with bright sunshine hours (r=0.531*) and negatively significant correlation with evening relative humidity (r=-544*).

During *Rabi* 2020-21 the fall armyworm population showed positively significant correlation with bright sunshine hours (r=0.572*) and negatively highly significant correlation with evening relative humidity (r=-748**).

The present findings are in close agreement with the earlier research work of Madhu Kumari, (2020) [6] reported that the population of fall armyworm larva showed significant positive correlation with Sunshine hour (r = 0.775**) and significant but negative correlation with the evening relative humidity (r = -0.519*). Nimbekar, (2020) [7] reported that FAW infestation had positively significant correlation sunshine hours (r = 0.701). Reddi *et al.*, (2020) reported during *Rabi* 2019-20 that relative humidity was negatively significantly correlated with fall armyworm infestation. Vijayakshaya kumar *et al.*, (2020) [15] reported that the relative humidity (r= -0.6739) had negatively correlated with the *S. frugiperda* incidence in maize. Rajisha *et al.*, (2022) [11] reported that the evening relative humidity had significant negative correlated with fall armyworm population.

Table 4: Correlation coefficient of mean population of fall armyworm in relation to weather parameters during *Rabi* 2019-20 and 2020-21

Weather parameters	Correlation coefficient (r)	
	2019-20	2020-21
Temperature Maximum (ºC)	0.122	0.204
Temperature Minimum (ºC)	-0.426	-0.077
Relative humidity- morning (%)	0.036	-0.093
Relative humidity- afternoon (%)	-0.544*	-0.748**
Wind speed (Km/hr)	0.001	0.146
Bright sunshine	0.531*	0.572*
Evaporation (mm)	-0.028	0.188

N=14
** Correlation is significant at the 0.01 level r value = 0.623
* Correlation is significant at the 0.05 level r value = 0.497

Simple linear regression studies

The simple linear regression worked out between weather parameters and the fall armyworm population along the regression coefficient 'b' and constant 'a' are presented in Table 5 and their equations were setup and presented below.

Rabi 2019-20

$Y= 0.576-0.011(X_4)$ which indicated that for every unit increase in evening RH fall armyworm population decreased by 0.011

$Y= -0.742+0.111(X_6)$ which indicated that for every unit increase in bright sunshine fall armyworm population increased by 0.111

Rabi 2020-21

$Y= 0.800-0.016(X_4)$ which indicated that for every unit increase in evening RH fall armyworm population decreased by 0.016 $Y= -0.627+0.112(X_6)$ which indicated that for every unit increase in bright sunshine fall armyworm population increased by 0.112

Table 5: Simple linear regression between weather parameters and fall armyworm during *Rabi* 2019-20 and 2020-21

Weather parameters		FAW larvae	
		2019-20	2020-21
Tem. Max. (X_1)	Intercept (a)	-0.133	-0.453
	Slope (b)	0.008	0.018
Tem. Min. (X_2)	Intercept (a)	0.558	0.261
	Slope (b)	-0.024	-0.004
RH-I (X_3)	Intercept (a)	0.065	0.416
	Slope (b)	0.001	-0.003
RH-II (X_4)	Intercept (a)	0.576	0.800
	Slope (b)	-0.011	-0.016
WS (X_5)	Intercept (a)	0.134	0.091
	Slope (b)	0.000	0.060
BSS (X_6)	Intercept (a)	-0.742	-0.627
	Slope (b)	0.111	0.112
EVP (X_7)	Intercept (a)	0.151	0.057
	Slope (b)	-0.004	0.031

Multiple regression studies (2019-20)

The multiple regression was worked out between weather parameters and fall armyworm population during 2019-20 and regression coefficient (b) and intercept (a) are presented in Table 6. The regression equation during *Rabi* 2019-20 is as follows $Y=-1.202+0.068 (X_1)-0.037(X_2) +0.003(X_3)-0.009(X_4) +0.231(X_5) +0.005 (X_6)–0.173(X_7)$

The coefficient of determination (R^2) represents the proportion of common variation in the two variables. The investigation revealed that the weather parameters contributed for 70.00 percent of total variation in the population of fall armyworm on maize.

Table 6: Multiple linear regression between weather parameters and mean larval population of FAW on maize during *Rabi* 2019-20

Sr. No	Weather parameters	Regression coefficient (b)	S.E. (b)	't' values
(X_1)	Temp. Max.	0.068	0.040	1.696
(X_2)	Temp. Min.	-0.037	0.037	-1.019
(X_3)	RH-I	0.003	0.011	0.279
(X_4)	RH-II	-0.009	0.006	-1.480
(X_5)	WS	0.231	0.184	1.258
(X_6)	BSS	0.005	0.096	0.051
(X_7)	EVP	-0.173	0.103	-1.680
Intercept (a) = -1.202, N=14, F value =2.69, R^2 = 0.70				

Multiple regression studies (2020-21)

The multiple regression was worked out between weather parameters and fall armyworm population during 2020-21 and regression coefficient (b) and intercept (a) are presented in Table 7.

The regression equation during *Rabi* 2020-21 is as follows
$Y=-3.921+0.075(X_1)$ $+0.014(X_2)$ $+0.025(X_3)-0.023(X_4)$ $+0.220(X_5)$ $+0.048$ $(X_6)–0.175(X_7)$
The coefficient of determination (R^2) represents the proportion of common variation in the two variables. The investigation revealed that the weather parameters contributed for 91.00 percent of total variation in the population of fall armyworm on maize.

Table 7: Multiple linear regression between weather parameters and mean larval population of FAW on maize during *Rabi* 2020-21

Sr. No	Weather parameters	Regression coefficient (b)	S.E. (b)	't' values
(X_1)	Temp. Max.	0.075	0.027	2.756
(X_2)	Temp. Min.	0.014	0.010	1.389
(X_3)	RH-I	0.025	0.007	3.664
(X_4)	RH-II	-0.023	0.004	-6.375
(X_5)	WS	0.220	0.112	1.961
(X_6)	BSS	0.048	0.036	1.327
(X_7)	EVP	-0.175	0.063	-2.760
Intercept (a) = -3.921, N=14, F value =12.03, R^2 = 0.91				

The present findings are in close agreement with the earlier research work of Madhu Kumari, (2020) [6] reported FAW had positive correlation with sunshine hour (r = 0.775**), the regression equation being Y= 0.2874× -0.3403 indicating that, with an increase in 1 hour of sunshine, there will be increase in population by 0.287. While FAW had significant but negative correlation with the evening relative humidity (r = -0.519*), the regression equation being Y =0.0485× 4.265 indicating 1 percent increase in RH, there will be decrease in population by 0.048.

Conclusion
The overall results of present study revealed that, the population of fall armyworm was observed in declining condition after peak incidence till maturity of maize crop. The correlation study during *Rabi* 2019-20 and 2020-21 indicated that, the fall armyworm in terms of larval population showed positively significant correlation with bright sunshine hours and negatively significant correlation with evening relative humidity.

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