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CORRELATION STUDIES BETWEEN MAIZE PLANTING DATES, WEATHER PARAMETERS AND THE INCIDENCE OF FALL ARMYWORM (*SPODOPTERA FRUGIPERDA*)

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ABSTRACT

In maize cultivation, the fall armyworm (FAW) emerged as a major insect pest, contributing to significant declines in crop yield. The study aimed to assess the influence of different planting dates and weather parameters on the incidence of FAW in the *kharif* and *rabi* seasons of 2021. A series of six plantings were undertaken, with the maize single-cross hybrid DHM 121 sown at fortnightly intervals starting from August. Correlations with weather parameters were made for the FAW larval population and its fecundity across different planting dates. Rainfall, relative humidity (RH-I & RH-II) and minimum temperature had detrimental effects on the FAW larva, whereas maximum temperature showed a positive correlation. Conversely, all the weather parameters studied negatively affected egg-laying by FAW female moths. Hence, the role of weather parameters on FAW incidence is fundamental, emphasising the necessity for the development of forecasting models and sustainable management approaches.

Key words : Planting, RH-I, RH-II, Rainfall and correlation, Maize, Fall armyworm.

Introduction

Maize (*Zea mays* L.), commonly known as the “Queen of Cereals,” holds the rank of being the third most important food crop, preceded by rice and wheat (Prasanna *et al*., 2001). It has the ability to thrive in diverse agroclimatic conditions across the globe, showing a promising yield potential among cereals (Singh and Jaglan, 2018). With cultivation spanning over 170 nations, maize occupies an extensive area of nearly 193.7 Mha worldwide. The total production amounts to 1147.7 Mts, boosting an average productivity of 5.75 t/ha (FAOSTAT, 2020a). In terms of maize cultivation, India holds the 4th position globally in area and the 7th position in production. This accounts for approximately 4.6% of the total global maize cultivation area and 2.4% of the overall production (FAOSTAT, 2020b). During the 2023-2024 time frame, India recorded a maize production of 33.5 Mts. (Statista, 2023).

Reddy and Trivedi (2008) reported that maize faces threats from as many as 141 insect pests, causing varying degrees of damage from sowing until harvest. The FAW, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) is of significant concern owing to its atrocious polyphagous nature. Nagoshi (2009) states that FAW is indigenous to the Western Hemisphere (North and South America). The initial report of FAW in India came from Karnataka in 2018 (Ganiger *et al*., 2018). Then, it swiftly spread across the country, invading maize fields in all regions, where they were grown (Rakshit *et al*., 2019). The rapid multiplication of FAW in Telangana is attributed to the favourable climatic conditions, making it one of the high-risk areas for FAW incidence on maize crop.

Becker (1974) observed that environmental factors exert a considerable impact on regulating population density and the extent of damage inflicted by a pest. Earlier, the influence of weather parameters on pest density in different crops was studied by several authors (Saminathan *et al*., 2001; Priyanka *et al*., 2018). FAW requires a minimum threshold temperature of 13.8°C, below which development ceases (Li *et al*., 2020). Also, FAW doesn't have a diapause stage and doesn't thrive in low temperatures. Because of the above facts, the present study was made to know the effect of different planting dates and weather parameters on the FAW incidence, which helps in preventing economic yield losses and enabling pesticide use to be reduced.

Materials and Methods

The present study was conducted at the Winter Nursery Centre-IIMR, Hyderabad. DHM 121, a maize single-cross hybrid was sown at fortnightly intervals, starting from August to December 2021. The planting dates were August 2nd and 17th, October 23rd, November 10th and 24th and December 4th. The plot measures 7.5

Table 1 : Weather data during the crop growth period (2/08/21 to 11/03/22).

Standard week	Date & Month	Temperature (°C)		R.H (%)		Rainfall (mm)
		Max.	Min.	I	II	
32	06 Aug – 12 Aug	32.50	24.00	94.00	66.00	0.30
33	13 Aug - 19 Aug	29.50	22.80	95.00	79.00	7.70
34	20 Aug - 26 Aug	30.50	25.50	95.00	66.00	1.50
35	27 Aug - 02 Sep	28.40	22.30	96.00	81.00	7.80
36	03 Sep - 09 Sep	27.60	22.30	96.00	83.00	11.80
37	10 Sep - 16 Sep	29.40	22.70	91.00	71.00	0.90
38	17 Sep - 23 Sep	30.00	22.60	93.00	76.00	5.90
39	24 Sep - 30 Sep	28.40	22.00	93.00	76.00	17.20
40	01 Oct - 07 Oct	31.60	22.60	94.00	62.00	0.60
41	08 Oct - 14 Oct	31.40	21.00	92.00	58.00	12.60
42	15 Oct - 21 Oct	30.70	21.20	88.00	59.00	1.10
43	22 Oct - 28 Oct	30.70	17.40	90.00	42.00	0.00
44	29 Oct - 04 Nov	29.20	20.90	85.00	63.00	0.00
45	05 Nov- 11 Nov	29.00	16.60	85.00	43.00	0.00
46	12 Nov- 18 Nov	28.70	21.60	86.00	73.00	0.30
47	19 Nov- 25 Nov	28.10	20.60	96.00	67.00	2.30
48	26 Nov- 02 Dec	28.10	17.10	83.00	52.00	0.00
49	03 Dec-09 Dec	29.40	16.40	89.00	46.00	0.00
50	10 Dec-16 Dec	27.70	16.90	91.00	55.00	0.00
51	17 Dec - 23 Dec	27.40	9.60	87.00	32.00	0.00
52	24 Dec - 31 Dec	29.20	14.10	91.00	48.00	0.00
1	1 Jan - 7 Jan	27.90	14.10	91.00	53.00	0.00
2	8 Jan - 14 Jan	28.60	18.50	91.00	56.00	0.70
3	15 Jan - 21 Jan	28.20	15.40	91.00	51.00	0.00
4	22 Jan - 28 Jan	29.20	14.30	81.00	42.00	0.00
5	29 Jan - 4 Feb	30.90	12.10	76.00	25.00	0.00
6	5 Feb - 11 Feb	30.10	14.70	87.00	37.00	0.00
7	12 Feb - 18 Feb	30.10	15.80	86.00	40.00	0.00
8	19 Feb - 25 Feb	32.40	14.90	83.00	38.00	0.00
9	26 Feb - 4 March	33.50	15.00	84.00	43.00	0.00
10	5 March – 11 March	33.30	17.40	82.00	51.00	0.00
Total		**921.70**	**572.40**	**2762.00**	**1734.00**	**70.70**
Mean		**29.73**	**18.46**	**89.10**	**55.94**	**2.28**

m in length and 3 m in width. A spacing of 75 cm × 20 cm was maintained. Except for the plant protection measures, the DHM 121 maize hybrid was raised according to recommended agronomic practices.

Agriculture Research Institute (PJTSAU), Rajendranagar's meteorological station furnished data on weather parameters, as outlined in Table 1. Observations were taken as per the standard week. For each planting, the entire DHM 121 field was split into three replications, each with three crop rows. The number of FAW larvae/ plant and the number of egg masses laid by it were calculated based on weekly recorded observations in each plot.

Using OPSTAT software, the FAW larval count per plant has been converted into square root values, and its egg masses per plant have been transformed into angular values. Next, the same software was used to make a regression analysis and to correlate the incidence of FAW with weather parameters.

Results and Discussion

FAW larval count on maize hybrid DHM 121

The mean number of FAW larvae per plant in the crop sown on the first fortnight of August and first fortnight of the December was found to be significantly lower, *i.e.*, 0.10 and 0.11, respectively (Table 2). The larvae per plant were moderately higher in crop sown during the second fortnight of November (0.14). The highest number of larvae per plant was observed in the crop sown on the first fortnight of November (0.25), followed by the crop sown on the second fortnight of August (0.20) and the second fortnight of October (0.18) respectively.

The fecundity of FAW on the maize hybrid DHM 121

The mean number of egg masses of FAW per plant was found to be the lowest in the first fortnight of August sown crop (0.03) and was followed by the first fortnight of December (0.04) and the second fortnight of November sown crop (0.04), respectively (Table 2). The maximum number of egg masses per plant was recorded on the second fortnight of the October sown crop (0.07), which was followed by the second fortnight of August (0.05) and the first fortnight of the November sown crop (0.05), respectively.

The Correlation between weather factors and the incidence of FAW larvae on maize hybrid DHM 121 is presented in Table 3.

In the first date of sowing, only the maximum temperature had a positive influence on the FAW larval population (0.105), whereas rainfall had a negative effect on the larval density of the FAW (-0.406). However, a significant correlation was observed in the case of minimum temperature, RH II and rainfall, which showed a negative correlation (-0.811**, -0.638** and -0.686**). In the second sowing, the r values for the maximum temperature, minimum temperature, RH I, RH II, and rainfall were found to be 0.626*, -0.235, -0.149, -0.463, and -0.278, respectively (Fig. 1). There was no significant correlation observed for any parameters in the third sowing, with r values for the maximum temperature, minimum temperature, RH I, RH II and rainfall being 0.068, -0.034, 0.037, -0.103 and -0.299, respectively. The r values for the maximum temperature, minimum temperature, RH I, RH II and rainfall were 0.468, -0.348, -0.672*, -0.479 and -0.348 on the fourth date of sowing, whereas the r values were 0.169, -0.190, -0.633*, -0.562*, and -0.337 on the fifth date of sowing, and 0.007, -0.201, -0.430, -0.470 and -0.214, respectively, on the sixth date of sowing (Fig. 1).

The multiple regression analysis revealed that weather parameters contributed to 82, 48, 28, 54, 71 and 47% of the total variation in the FAW larval population on maize cultivar DHM 121 in 1st, 2nd, 3rd, 4th, 5th and 6th sowings, respectively.

The studies by Warkad *et al.* (2021) revealed a significant positive relationship (r = 0.694) between the larval population of FAW and maximum temperature. Conversely, significant negative correlations were observed with morning relative humidity (r = -0.799) and

Table 2 : Different planting dates as well as the FAW larval count and its egg masses per plant on DHM 121 maize single cross hybrid.

Dates of planting	C(A): Mean number of larva/plant	C(B): Mean number of egg masses/plant
D1 (02/08/21)	0.10(1.05)	0.03(1.04)
D2 (17/08/21)	0.20(1.09)	0.05(1.35)
D3 (23/10/21)	0.18(1.08)	0.07(1.55)
D4 (10/11/21)	0.25(1.11)	0.05(1.35)
D5 (24/11/21)	0.14(1.07)	0.04(1.19)
D6 (04/12/21)	0.11(1.05)	0.04(1.14)

Figures in the parenthesis of columns C (A) and C (B) are square root transformed values and angular transformed values, respectively.

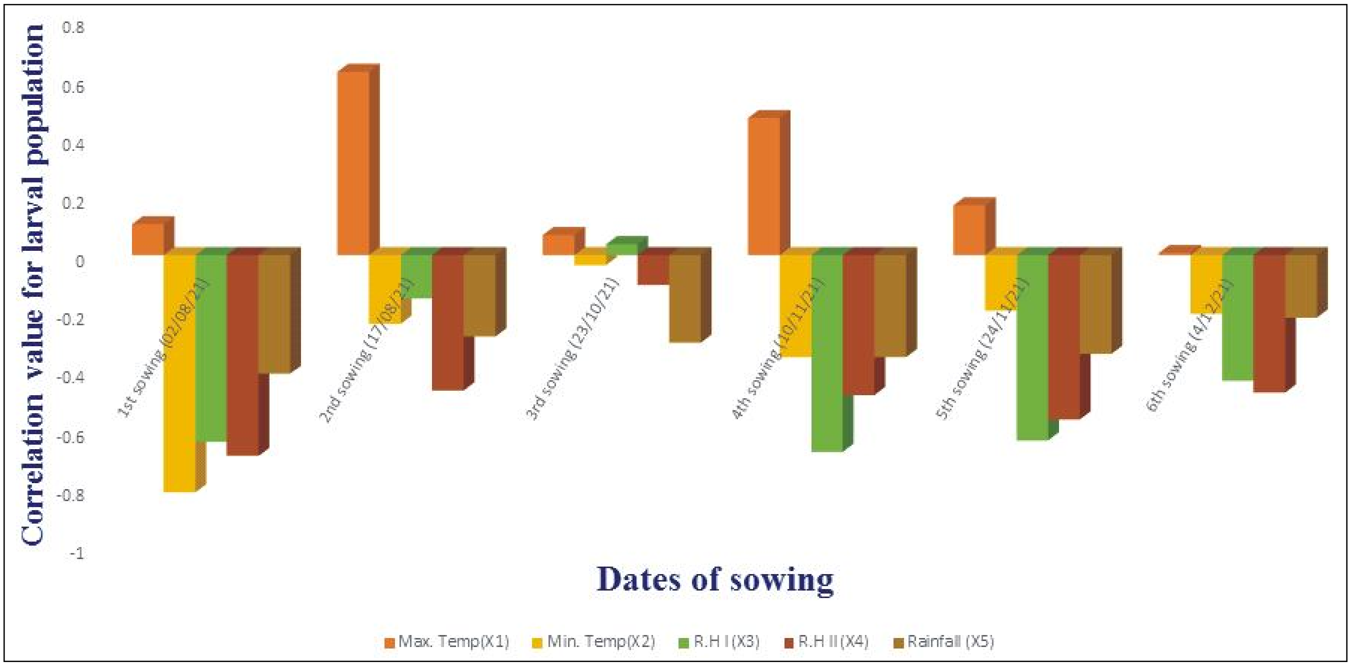

Fig. 1 : Correlation between larval population of FAW per plant on maize cultivar DHM 121 and weather parameters at different dates of sowing.

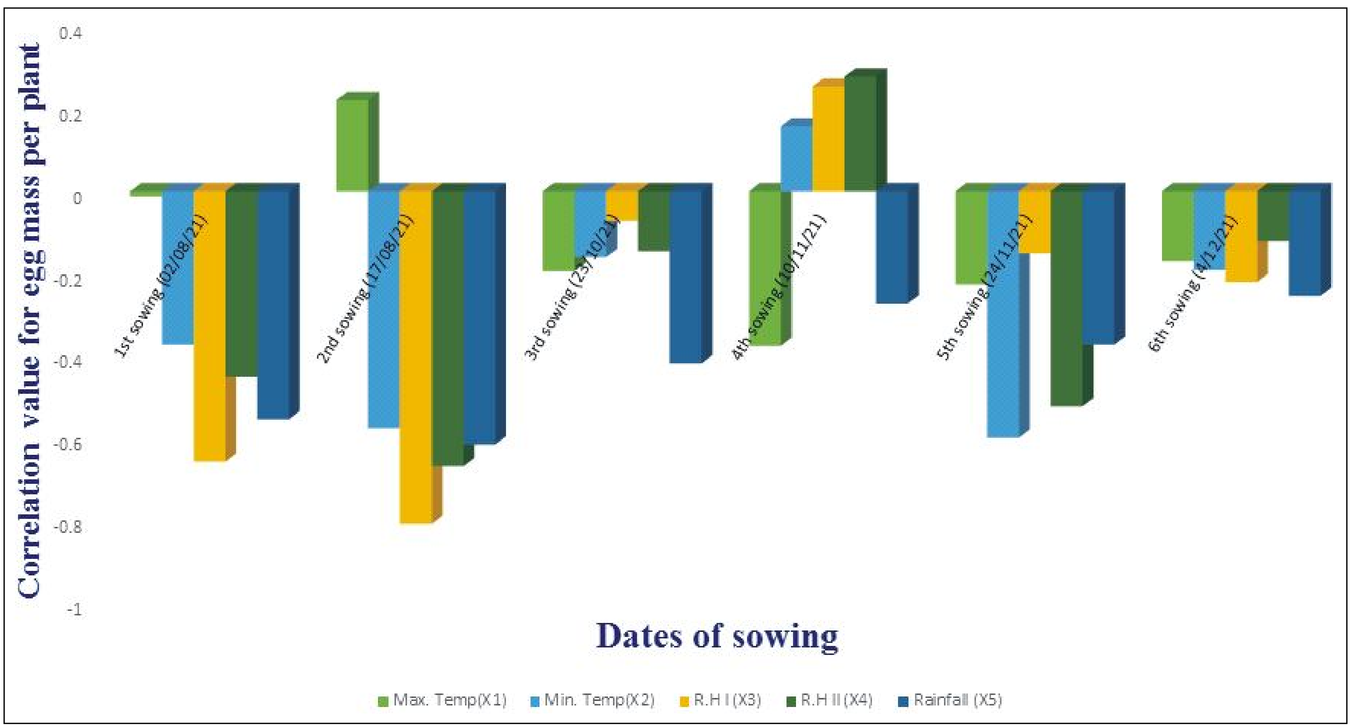

Fig. 2 : Correlation between number of FAW egg mass per plant on maize cultivar DHM 121 and weather parameters at different dates of sowing.

evening relative humidity (r = -0.664). Similar outcomes were observed in Madhubhasini's (2021) study, where a significant negative correlation was identified between the FAW larval population and minimum temperature (r = -0.549) as well as total rainfall (r = -0.548). Nandita Paul (2020) found that the FAW larval population had a negative correlation with evening relative humidity (r = -0.233) and total rainfall (r = -0.320). While the maximum temperature exhibited a significant positive correlation (r = 0.586). In accordance with the present research, Kumar *et al.* (2020) reported significant negative associations with relative humidity (r = -0.673) and rainfall (r = -0.829), along with a significant positive correlation (r = 0.720) between larval population and maximum temperature.

Table 3 : Correlation and regression equation between the FAW larval count per plant on the DHM 121 and weather factors across different sowing dates.

Different dates of sowing	r values					Regression equation	Coefficient of determination (R^2)
	Max. Temp(X_1)	Min. Temp(X_2)	R.H I (X_3)	R.H II (X_4)	Rainfall (X_5)		
1st sowing (02/08/21)	0.105	-0.811**	-0.638*	-0.686**	-0.406	$Y= 1.542 -0.016X_1 -0.033X_2 -0.001X_3 -0.002X_4 -0.006X_5$	0.82
2nd sowing (17/08/21)	0.626*	-0.235	-0.149	-0.463	-0.278	$Y= -2.255 +0.097X_1 -0.037X_2 -0.0004X_3 +0.006X_4 -0.003X_5$	0.48
3rd sowing (23/10/21)	0.068	-0.034	0.037	-0.103	-0.299	$Y= -1.116 -0.039 X_1 +0.060X_2 +0.025 X_3 -0.015 X_4 -0.207X_5$	0.28
4th sowing (10/11/21)	0.468	-0.348	-0.672*	-0.479	-0.348	$Y= 0.080 +0.102X_1 -0.058X_2 -0.032X_3 +0.021X_4 +0.010X_5$	0.54
5th sowing (24/11/21)	0.169	-0.190	-0.633*	-0.562*	-0.337	$Y= 2.519 -0.041X_1 +0.047X_2 -0.016X_3 -0.010X_4 -0.243 X_5$	0.71
6th sowing (4/12/21)	0.007	-0.201	-0.430	-0.470	-0.214	$Y= 1.200 -0.023X_1 +0.026X_2 -0.006X_3 -0.006X_4 -0.108X_5$	0.47

* Indicates correlation is significant at 5% (p=0.05)

** Indicates correlation is significant at 1% (p=0.01); r = correlation coefficient.

Table 4 : Correlation and regression equation between the FAW egg masses per plant on the DHM 121 and weather factors across different sowing dates.

Different dates of sowing	r values					Regression equation	Coefficient of determination (R^2)
	Max. Temp(X_1)	Min. Temp(X_2)	R.H I (X_3)	R.H II (X_4)	Rainfall (X_5)		
1st sowing (02/08/21)	-0.012	-0.372	-0.656*	-0.450	-0.553*	$Y= 0.860 -0.016X_1 +0.003X_2 -0.003X_3 -0.002X_4 -0.003X_5$	0.66
2nd sowing (17/08/21)	0.221	-0.575*	-0.807**	-0.667*	-0.614*	$Y= 0.910 +0.002X_1 -0.0003X_2 -0.009X_3 -0.001X_4 -0.002 X_5$	0.73
3rd sowing (23/10/21)	-0.194	-0.159	-0.071	-0.145	-0.417	$Y= 0.423 -0.022X_1 +0.008X_2 +0.003X_3 -0.002X_4 -0.042X_5$	0.33
4th sowing (10/11/21)	-0.375	0.157	0.254	0.278	-0.272	$Y= 0.376 -0.022X_1 +0.013X_2 +0.002X_3 -0.002X_4 -0.052X_5$	0.49
5th sowing (24/11/21)	-0.226	-0.598*	-0.150	-0.522	-0.372	$Y= 0.081 -0.006X_1 +0.001X_2 +0.003X_3 -0.003X_4 -0.023X_5$	0.60
6th sowing (4/12/21)	-0.169	-0.191	-0.220	-0.121	-0.254	$Y= 0.626 -0.008X_1 +0.0002X_2 -0.005X_3 +0.001X_4 -0.040X_5$	0.32

* Indicates correlation is significant at 5% (p=0.05)

** Indicates correlation is significant at 1% (p=0.01); r = correlation coefficient.

The correlation between weather factors and FAW fecundity on maize hybrid DHM 121 is presented in Table 4.

In the first sowing date, maximum temperature, minimum temperature, and RH II were having a negative influence on the fecundity of FAW (r = -0.012, r = -0.372 and r = -0.450). However, a significant correlation was observed in the case of RH I and rainfall, which showed a negative correlation (r = -0.656* and r = -0.553**). In the second sowing, only the maximum temperature had a positive influence on fecundity (r = 0.221), whereas the minimum temperature, RH I, RH II and rainfall were having a significant negative effect on the larval population of FAW (r = -0.575*, r = -0.807**, r = -0.667* and r = -0.614*, respectively). There was no significant correlation for any parameters in the third, fourth, and sixth sowings, with r values for maximum temperature, minimum temperature, RH I, RH II, and rainfall being -0.194, -0.159, -0.071, -0.145 and -0.417 on the third date of sowing, whereas the values for the fourth date of sowing were -0.375, 0.157, 0.254,0.278 and -0.272; the r values were -0.169, -0.191, -0.220, -0.121 and -0.254; in the sixth date of sowing. In the fifth sowing, only the minimum temperature was having a significant negative influence on the fecundity of FAW (-0.598*), whereas the minimum temperature, RH I, RH II and rainfall were negatively correlated (r = -0.226, r = -0.150, r = -0.522, and r = -0.372, respectively) (Fig. 2). Here also during each different sowing date t all the weather variables were negatively correlated with the fecundity of FAW.

The multiple regression analysis revealed that weather parameters contributed for 66, 73, 33, 49, 60 and 32% of the total variation in the FAW egg mass per plant on maize cultivar DHM 121 in 1st, 2nd, 3rd, 4th, 5th and 6th sowings, respectively.

The current findings are in line with Gedia *et al.* (2007), who found a significant inverse relation between *S. litura* egg masses and rainfall (r = -0.482 and r = -0.468, respectively) during 2003 and 2004. Perhaps the heavy rainfall wiped away the egg masses. Also, the vulnerability of the egg stage to heat shock and temperature fluctuations leads to a diminished hatching rate. Furthermore, he observed a negative association between *S. litura* fecundity and both minimum temperature (r = -0.026 and r = -0.237) and RH-II (r = -0.102 and r = -0.048) for the years 2003 to 2004. The present results are comparable with those of Sunitha *et al.* (2021), who reported that RH I (r = -0.081) was negatively correlated with the fecundity of FAW. Elevated humidity levels may increase the risk of eggs drowning or being more susceptible to pathogenic infections.

Conclusion

Correlation and regression analysis highlighted the importance of weather parameters in influencing both the larval density and the fecundity of FAW in maize. FAW larval count and egg masses per plant in the crop planted during the first fortnight of August 2021 were minimal. This might be due to significant fluctuations in the weather parameters that prevailed on the crop sown on August 2, 2021. Hence, the adoption of an optimal planting period stands out as a low-input cultural approach essential for the sustainable management of FAW.

Future scope

The information obtained from the present study helps to develop models and predictive tools that incorporate planting dates, weather data and other relevant factors to forecast FAW outbreaks. This can assist farmers and policymakers in making informed decisions and implementing timely preventive measures.

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Conflict of interest : None.

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