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Seasonal incidence and effect of weather parameters on key insect pests in maize

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Abstract
Maize (*Zea mays* L.) belonging to the family Poaceae is the third most important cereal crop after rice and wheat. Major limiting factors are maize stem borer, pink stem borer, shoot fly, armyworm, maize cob borer and corn aphid, which cause economic yield losses during different seasons all over the country (Siddiqui and Marwaha, 1994). In addition to the above pests, currently Fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) causes a considerable damage to maize crop all over the world. The field experiment was conducted to see the Seasonal occurrence of major insect pests of maize with special reference to fall army worm at Goyeshpur, K.V.K farm, Nadia, West Bengal during Rabi 2020-21. The insect pests *viz*. Fall armyworm (*Spodoptera frugiperda*) and corn aphid (*Rhopalosiphum maidis*) were recorded as a major insect pest on maize crop. The highest number of fall armyworm larvae (1/plant) and corn aphid (2.61/plant) were seen during 10th SMW and 14th SMW respectively. During the study period natural enemies *viz*. spiders, coccinellids and rove beetles were also observed. The correlation study between fall armyworm, *Spodoptera frugiperda* and weather parameters during Rabi, 2020-21 exhibited a significant positive correlation with minimum temperature (r =0.508*). In case of aphid, the correlation with weather parameters showed a significant positive correlation with maximum temperature (r =0.772*) and minimum temperature (r =0.770*) and the total rainfall (r =0.531*), while it showed a significant negative correlation with morning relative humidity (r =0.636*).

Keywords: Maize, fall army worm, corn aphid, seasonal occurrence, correlation

Introduction
Maize (*Zea mays* L.) belonging to the family Poaceae is the third most important cereal crop after rice and wheat. It is also known as queen of cereals due to its highest yield potential among the cereals. In India, it is cultivated over an area of 9.63 million hectares with annual production of 25.90 million metric tonnes and average productivity of 2.69 metric tonnes per hectare. Maize crop is attacked by a large number of insect-pests from sowing to maturity causing damage to all plant parts (Root, stem, leaf, tassels, silk and grain). About 250 species of insect and mite pests have been reported damaging this crop out of which only half a dozen is of economic importance which threatens to limit the production of this crop (Mathur, 1991) [6]. Major limiting factors are maize stem borer, pink stem borer, shoot fly, armyworm, maize cob borer and corn aphid, which cause economic yield losses during different seasons all over the country (Siddiqui and Marwaha, 1994) [8]. In addition to the pests mentioned above, the fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith), is now causing significant damage to maize crops all over the world. It is a lepidopteran polyphagous pest which is originated from the tropical and subtropical America. The introduction of fall armyworm as an invasive pest into Asia was first reported from India on maize during May 2018 (Sharanabasappa *et al*. 2018) [7]. The agricultural sector in India faces a new challenge with the severe outbreak of S. frugiperda due to its wide host range and geographical distribution (Knipling, 1980) [4]. Its severe outbreak usually observed at the beginning of the wet season, that follows a long period of drought (Goergen *et al*., 2016) [3]. The life cycle of fall armyworm mainly depends on the seasons. According to the weather the whole life cycle varies from 30 days in summer whereas in winter it takes 90 days to complete its life cycle (Luginbill, 1928; Capinera, 2000) [5, 2]. The most destructive stage for maize crops is larval stage which can occur on over 80 host plants but mostly on Poaceae families (Ashley *et al*., 1989) [1]. Insect pests are one of the major factors limiting maize production reduction. In India, insect pests consume roughly 32.1 percent of the real production. Due to changes in the pest scenario and the intensity of pest infestation in the maize ecosystem, it is critical to do research on maize insect pests in order to

update our knowledge and also to provide relevant management strategies to farmers. The current inquiry was carried out in light of the circumstances stated above.

Materials and Methods

The experiment was carried out at central research farm of B.C. K.V. Gayeshpur, Nadia, West Bengal. The farm is located at 23° N latitude and 89° E longitudes at an elevation of 9.75 meter from the mean sea level. The land is topographically referred as a medium land.

Details of experiment

For the experiment maize variety DMRH-1301(Hybrid maize) was taken. Plot size of 15m x 10 m was made and the sowing was done on 2nd January, 2021. The seeds were sown at the rate of 15-20 kg/ha and taking row to row distance of 60 cm and plant to plant distance of 20 cm. Nutrient application ratio was maintained at 120:60:30 NPK kg/ha. Rest other interculture operations were followed.

List of pests to be observed:

1. Fall armyworm
2. Corn aphid

A. Study for the seasonal occurrence of major insect pests infesting maize along with natural enemies

The experimental plots were kept free from insecticidal spray throughout the crop season in order to record the incidence of insect pests. Five plants were selected randomly from three spot and tagged. The population of different insect-pests associated with the crop were recorded from the tagged plant from the plot at weekly interval during morning hours without disturbing the insect fauna of the plants from the time of appearing of the insect pests after sowing to till the availability of those insect pests or maturity of the crop. In the instance of fall army worm, counts were made based on the number of larvae per plant. In case of corn aphid three leaves were selected randomly from top, middle and bottom portion of each plant to count nymphs and adults of aphids. The aphid population expressed as number of aphids per plant

B. Correlation between the developments of pests with weather parameters

The population of insect pests, and natural enemies recorded from the plot were correlated with weather parameters namely maximum temperature, minimum temperature, relative humidity, sunshine hours, wind speed and total rainfall. Observations were scheduled at weekly intervals throughout the crop season. During the trial period, correlation coefficients between pest population densities and abundance of their natural enemies were calculated in the context of existing meteorological conditions.

Results and Discussion

A. Study for the seasonal occurrence of major insect pests infesting maize along with natural enemies

The occurrence of the major insect pests of maize, namely fall armyworm and corn aphid, was recorded at weekly intervals from the 5th standard week to the 16th standard week, with effect from the 1st February 2021 to the 19th April 2021, and is provided in tables (1-3). The abundance in the field of the natural enemy fauna associated with the maize pest complex, namely spiders, coccinellids, and rove beetles, was also assessed.

Seasonal occurrence of maize fall army worm (*Spodoptera frugiperda*)

The incidence of fall armyworm first appeared in 7th SMW and last up to 16th SMW during Rabi 2020-21 on maize. The incidence of fall armyworm initiated in 7th SMW with mean larval population with 0.13. The pest infestation increased gradually and reached its peak during 10th SMW with mean larval population 1 (Table 1). Thereafter, pest infestation reduced gradually from 11th SMW with mean larval population 0.87 and onwards the population started declining and reached to its minimum larval population 0.13 on 16th SMW. A review of the data on the abundance of the fall armyworm in terms of mean larval population revealed a clear pick during the 10th SMW (Fig 1). During the peak time of incidence, the maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind speed, sunshine hours, and total rainfall were 32.21 °C, 20.97 °C, 91.14%, 44.57%, 0.2 Km/h, 5.1hours, and 0mm, respectively.

Seasonal occurrence of corn aphid, *Rhopalosiphum maidis*

The incidence of aphid first appeared in 5th SMW and last up to 16th SMW during Rabi 2020-21 on maize. The population increased gradually and reached its 1st peak during 9th SMW or the 8th week after sowing with 1.2 per plant (Table 2). Thereafter, pest infestation reduced gradually from 10th SMW with 0.57 per plant. Again, the pest population increased and reached is 2nd peak during 13th week after sowing i.e., 14th SMW. A review of the data on the abundance of the aphid population in terms of the number of aphids per plant revealed a definite peak during the 14th SMW (Figure 2), which coincided with the tasseling and silking stages. During the peak time of incidence, the highest temperature, minimum temperature, morning relative humidity, evening relative humidity, sunlight hours, and total rainfall were 35.5 °C, 23.77 °C, 87%, 41.57%, 7.79 hours, and 1.51 mm, respectively.

Seasonal occurrence of maize fall army worm (*Spodoptera frugiperda*)

The incidence of fall armyworm first appeared in 7th SMW and last up to 16th SMW during Rabi 2020-21 on maize. The incidence of fall armyworm initiated in 7th SMW with mean larval population with 0.13. The pest infestation increased gradually and reached its peak during 10th SMW with mean larval population 1 (Table 1). Following that, pest infestation decreased progressively beginning on the 11th SMW with a mean larval population of 0.87 and continuing until the population reached its lowest larval population of 0.13 on the 16th SMW.

Table 1: Mean larval population of FAW on maize in relation to weather factors:

Sr. No	SMW	Month and week	Mean larval population/plant	Weather factors						
				Max. Temp. (°C)	Min. Temp. (°C)	Morn. RH (%)	Even. RH (%)	W.S. (Km/h)	Sunshine hours	Total Rainfall (mm)
1	5	Feb-I	0	24.1	8.36	87.71	39.71	0.3	6.46	0
2	6	Feb-II	0	28.06	12.17	88.57	38.71	0	7.81	0.16
3	7	Feb-III	0.13	29.13	15.09	91	45	0.2	5.83	0
4	8	Feb-IV	0.2	31	15.49	89.43	40	0.1	5.86	0
5	9	Mar-I	0.27	35.9	18.97	87.57	26.43	0.3	8.5	0
6	10	Mar-II	1	32.21	20.97	91.14	44.57	0.2	5.1	0
7	11	Mar-III	0.87	34.26	19.64	88.43	37	2.7	6.83	0
8	12	Mar-IV	0.47	37.54	21.36	85.14	28.14	1.3	7.44	0
9	13	Mar-V	0.33	37.81	23.26	86.43	34	0.3	6.86	0
10	14	Apr-I	0.53	35.5	23.77	87	41.57	0.1	7.79	1.51
11	15	Apr-II	0.27	37.86	25.51	83.71	41.57	1.3	7.36	0
12	16	Apr-III	0.13	35.81	24.61	83.29	48.14	1	7.1	2.19

Table 2: Seasonal incidence of corn aphids in relation to weather parameters:

Sl. No	SMW	Month and week	No. of aphids/plant	Weather factors					
				Max. Temp. (°C)	Min. Temp. (°C)	Morn. RH (%)	Even. RH (%)	Sunshine hours	Total Rainfall (mm)
1	5	Feb-I	0.3	24.1	8.36	87.71	39.71	6.46	0
2	6	Feb-II	0.47	28.06	12.17	88.57	38.71	7.81	0.16
3	7	Feb-III	0.53	29.13	15.09	91	45	5.83	0
4	8	Feb-IV	0.9	31	15.49	89.43	40	5.86	0
5	9	Mar-I	1.2	35.9	18.97	87.57	26.43	8.5	0
6	10	Mar-II	0.57	32.21	20.97	91.14	44.57	5.1	0
7	11	Mar-III	0.43	34.26	19.64	88.43	37	6.83	0
8	12	Mar-IV	1.2	37.54	21.36	85.14	28.14	7.44	0
9	13	Mar-V	1.7	37.81	23.26	86.43	34	6.86	0
10	14	Apr-I	2.61	35.5	23.77	87	41.57	7.79	1.51
11	15	Apr-II	2.04	37.86	25.51	83.71	41.57	7.36	0
12	16	Apr-III	1.58	35.81	24.61	83.29	48.14	7.1	2.19

Table 3: Activity of natural enemies in relation to weather factors in Maize

Sr. No.	SMW	Month and week	Predators			Weather factors					
			No. of spiders/plant	No. of grubs and adults of coccinellids/plant	No. Of rove beetles/ plant	Max. Temp. (°C)	Min. Temp. (°C)	Max. R.H. (%)	Min R.H. (%)	Sunshine hours	Total rainfall (mm)
1	5	Feb-I	0	0	0	24.2	9.2	90	45	6.46	0
2	6	Feb-II	0.1	0	0	20.5	14.8	93	71	7.81	0
3	7	Feb-III	0.25	0.2	0	28.6	12.6	86	36	5.83	0
4	8	Feb-IV	0.15	0.5	0	30.2	14.5	89	43	5.86	0
5	9	Mar-I	0.6	0.52	0	30.5	15.0	87	46	8.5	0
6	10	Mar-II	0.89	0.65	0.24	29.5	19.5	94	59	5.1	0.4
7	11	Mar-III	0.8	0.7	0.36	30.0	17.5	85	58	6.83	0
8	12	Mar-IV	0.97	0.85	0.5	28.8	17.0	100	63	7.44	18.7
9	13	Mar-V	0.94	0.9	1.9	35.4	21.2	88	39	6.86	0
10	14	Apr-I	0.83	1	4.38	36.5	25.5	86	32	7.79	0
11	15	Apr-II	0.74	0.65	3.37	35.0	21.5	78	51	7.36	0
12	16	Apr-III	0.7	0.6	0	36.4	23.0	76	44	7.1	22.5

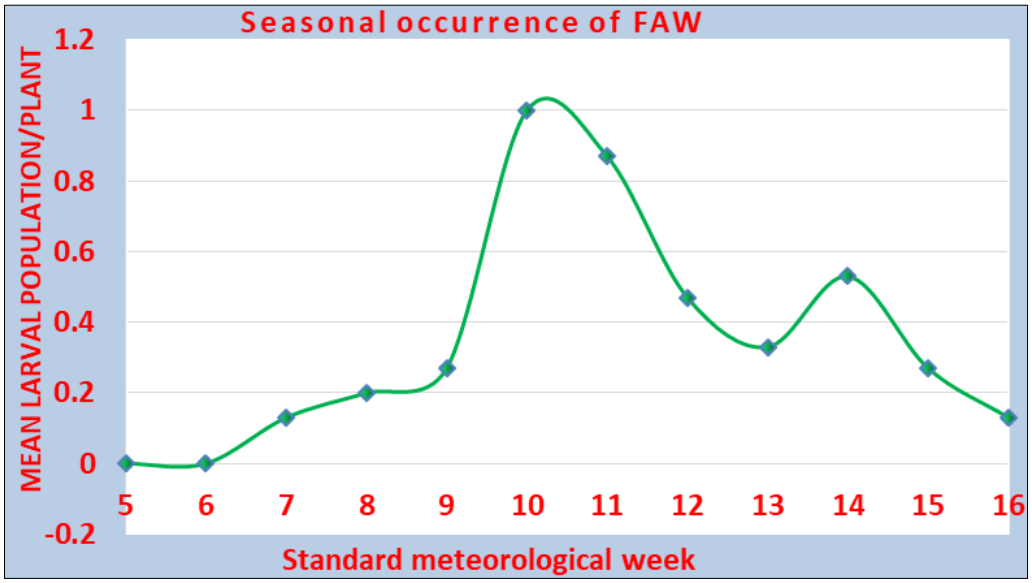

Fig 1: Seasonal occurrence of fall armyworm

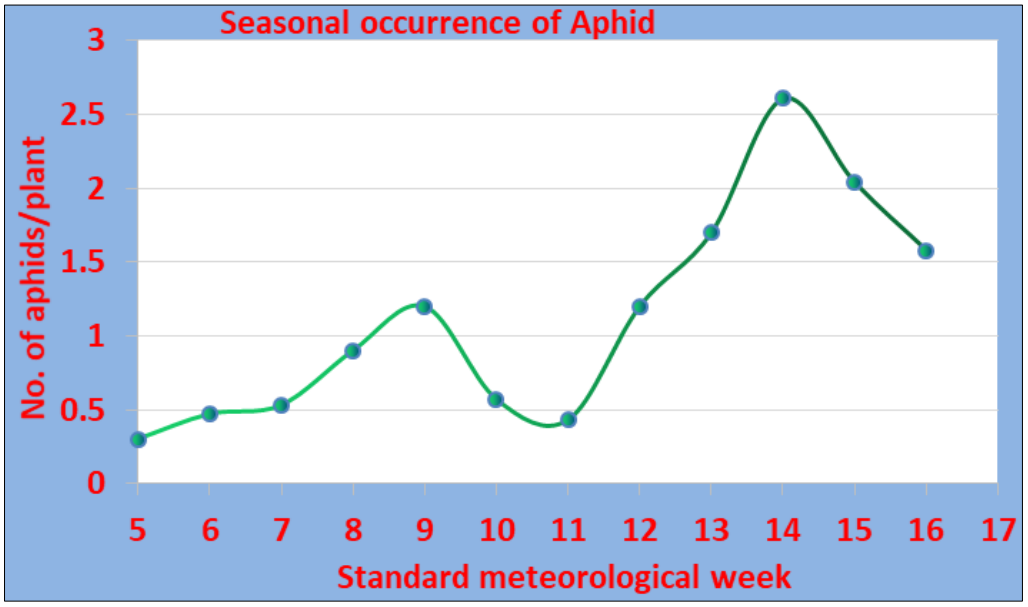

Fig 2: Seasonal occurrence of Corn aphid

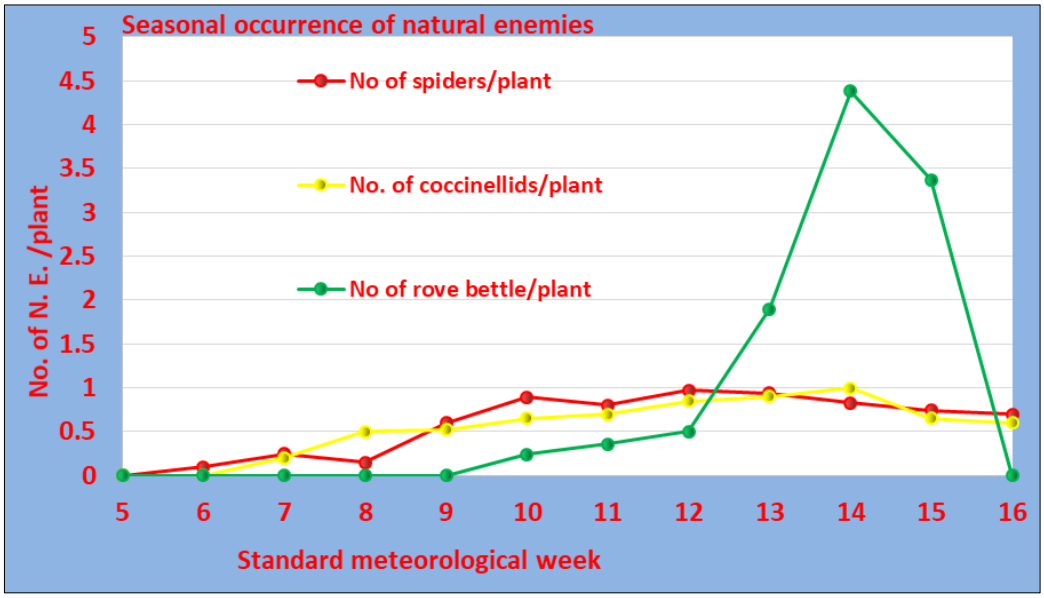

Fig 3: Seasonal occurrence of Natural enemies

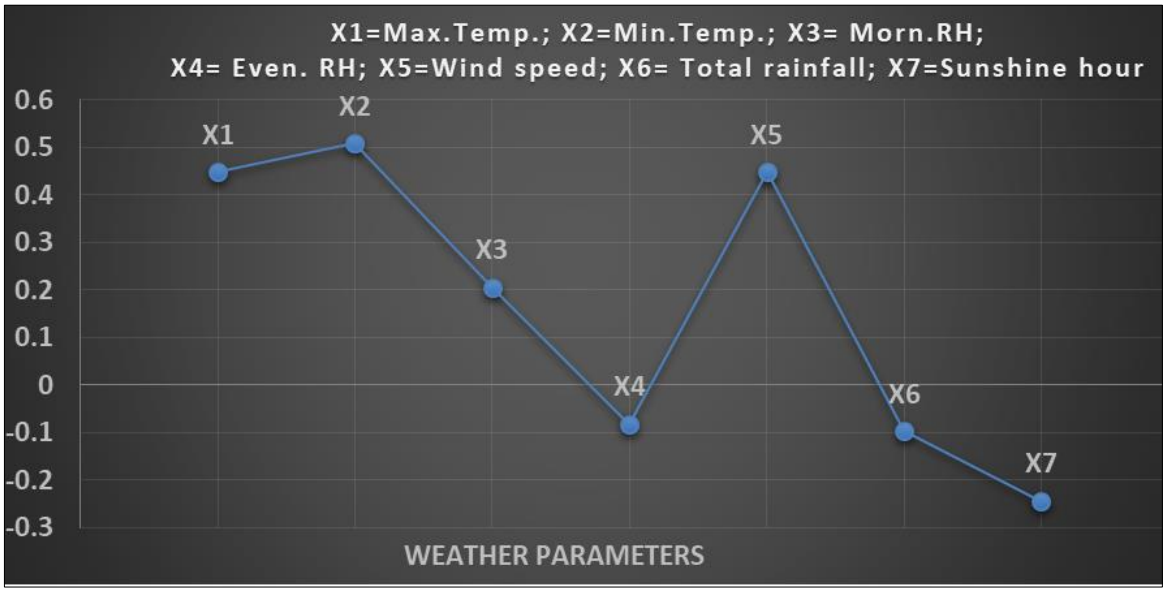

Fig 4: Correlation coefficient between fall armyworm, *Spodoptera frugiperda* and weather parameters (X)

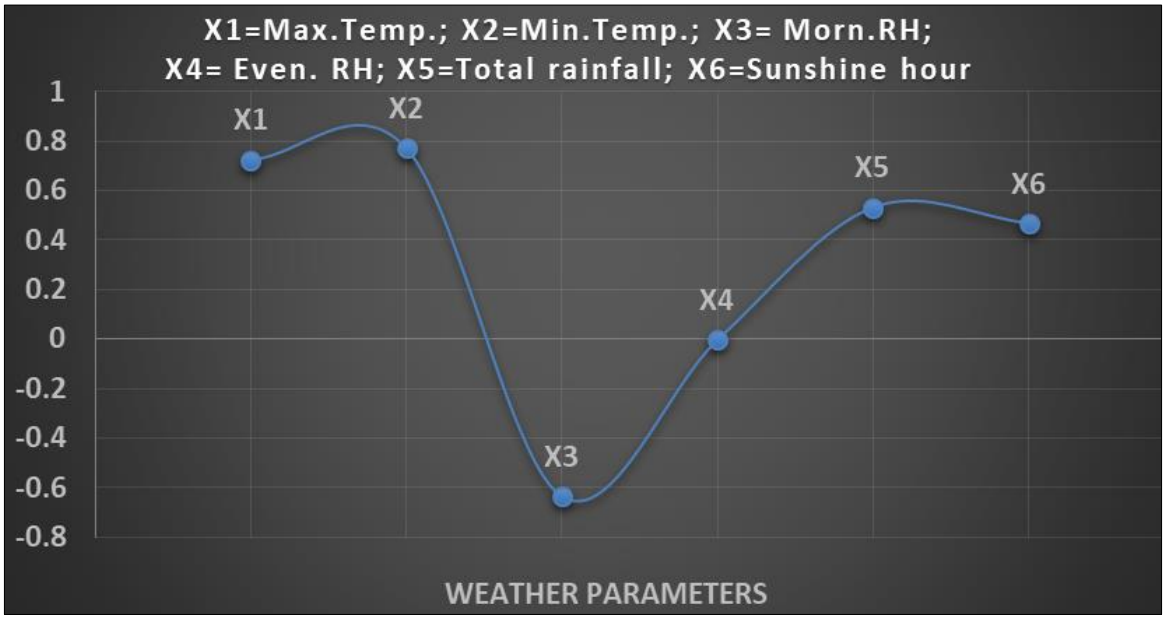

Fig 5: Correlation coefficient between corn aphid, *R. maidis* and weather parameters (X)

A review of the data on the abundance of the fall armyworm in terms of mean larval population revealed a clear pick during the 10th SMW (Fig 1). The highest temperature, minimum temperature, morning relative humidity, evening relative humidity, wind speed, daylight hours, and total rainfall during the peak time of incidence were 32.21 °C, 20.97 °C, 91.14%, 44.57%, 0.2 Km/h, 5.1 hours, and 0 mm, respectively.

Seasonal occurrence of corn aphid, *Rhopalosiphum maidis*

The incidence of aphid first appeared in 5th SMW and last up to 16th SMW during Rabi 2020-21 on maize. The population increased gradually and reached its 1st peak during 9th SMW or the 8th week after sowing with 1.2 per plant (Table 2). Thereafter, pest infestation reduced gradually from 10th SMW with 0.57 per plant. Again, the pest population rose and reached its second peak during the 13th week after sowing, i.e., the 14th SMW. A review of the data gathered on the abundance of the aphid population in terms of the number of aphids per plant revealed a definite peak during the 14th SMW (Figure 2), which coincided with the tasseling and silking stages. During the peak time of incidence, the highest temperature, minimum temperature, morning relative humidity, evening relative humidity, sunlight hours, and total rainfall were 35.5 °C, 23.77 °C, 87%, 41.57%, 7.79 hours, and 1.51 mm, respectively.

Seasonal occurrence of natural enemies

The data obtained on the natural enemy populations on maize indicated that no spider was found during 5th SMW and started increasing in numbers with 0.1 numbers of spiders per plant during 6th SMW followed by 0.25 numbers of spiders per plant at 7th SMW (Table 3). The abundance of these predators increased with the crop age along with corresponding increase in pest population. The natural enemy population of spider reached its peak during 12th SMW with 0.97 number of spiders pet plant. However, on 13th SMW population decreased with 0.94 numbers of spiders per plant. A review of the data on spider abundance in terms of average number of spiders per plant revealed a distinct increase during

the 12th SMW (Figure 3). During the peak time of incidence, the maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, total rainfall, and sunlight hours were 28.8 °C, 17.0 °C, 100%, 63%, 18.7, and 7.44 hours, respectively.

The results obtained on the natural enemy populations on maize revealed that no coccinellids were identified during the 5th to 6th SMW and that numbers began to increase with 0.2 coccinellids per plant during the 7th SMW, followed by 0.5 coccinellids per plant during the 8th SMW ((Table 3). The abundance of these predators increased with the crop age along with corresponding increase in pest population. The population of coccinellids reached its peak during 14th SMW with 1.00 numbers of coccinellids pet plant. However, on 15th SMW population decreased with 0.65 numbers of coccinellids per plant. The data acquired on coccinellid abundance in terms of average number of coccinellids per plant revealed a definite peak during the 14th SMW (Figure 3). During the peak time of incidence, the highest temperature, minimum temperature, morning relative humidity, evening relative humidity, total rainfall, and sunlight hours were 36.5 °C, 25.5 °C, 86%, 32%, 0mm, and 7.79 hours, respectively.

The data obtained on the natural enemy populations on maize indicated that no rove beetles was found during 5th SMW to 9th SMW and started increasing in numbers with 0.24 number of rove beetles per plant during 10th SMW followed by 11th SMW with 0.36 number of rove beetles per plant (Table 3). The abundance of these predators increased with the crop age along with corresponding increase in pest population. The natural enemy population of rove beetles reached its peak during 14th SMW with (4.38) number of rove beetles per plant. However, on 15th SMW population decreased with (3.37) numbers of rove beetles per plant. On perusal of the data obtained on abundance of the rove beetles in terms of average number of rove beetles per plant indicated a clear peak during 14th SMW (Figure 3). During the peak period of incidence, the highest temperature, minimum temperature, morning relative humidity, evening relative humidity, total rainfall, and sunlight hours were 36.5 °C, 25.5 °C, 86%, 32%, 0mm, and 7.79 hours, respectively.

B. Correlation between the developments of pests with weather parameters

The effect of weather conditions on the appearance and population dynamics of major insect pests of maize and their natural enemies was estimated by calculating simple correlation coefficients between pest and natural enemy populations and current weather elements. Simple correlation coefficients were calculated using this data.

Correlation coefficients between fall armyworm with weather factors on maize during Rabi, 2021

The data (Table 4) obtained by correlation study between fall armyworm larval population with abiotic factors *viz* maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, total rainfall, wind speed and sunshine hours, it was found that the larval population was positively significantly correlated with minimum temperature (r = 0.508) and positively non-significantly correlated with maximum temperature (r = 0.448), morning relative humidity (r = 0.452), and wind speed (r = 0.448). It indicated that as the maximum temperature, minimum temperature and wind speed and morning RH increases, the pest population also increased (Fig 4). However larval population of pest had non-significant negative correlation with evening relative humidity (r = -0.082), sunshine hours (r = -0.243), and total rainfall (r = -0.097).

Correlation coefficients between corn aphids with weather factors on maize during Rabi, 2021

The data (Table 5) obtained from correlation study between corn aphid population with abiotic factors *viz* maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, total rainfall, and sunshine hours revealed that the aphid population was positively significantly correlated with maximum temperature (r = 0.722), minimum temperature (r = 0.770), and total rainfall (r = 0.531). It indicated that as the maximum temperature, minimum temperature total rainfall increases, the pest population also increased (Fig 5). However, aphid population had significant negative correlation with morning relative humidity (r = -0.636). The pest population shows non-significantly positively correlation between total rainfall and sunshine hours and negative correlation between evening relative humidity (r = -0.003).

Table 4: Correlation coefficient of fall armyworm, *Spodoptera frugiperda* with weather factors on maize during *Rabi*, 2021:

Weather factors	larval population/plant
Maximum Temperature (°C)	0.448
Minimum Temperature (°C)	0.508*
Morning RH (%)	0.205
Evening RH (%)	-0.082
Total Rainfall (mm)	-0.097
Wind Speed (Km/h)	0.448
Sunshine hours	-0.243

***:** Significant at P= 0.05

Table 5: Correlation coefficient of corn aphid, *R. maidis* with weather factors:

Weather factors	Number of aphid/plants
Maximum Temperature (°C)	0.722*
Minimum Temperature (°C)	0.770*
Morning RH (%)	-0.636*
Evening RH (%)	-0.003
Total Rainfall (mm)	0.531*
Sunshine hours	0.467

*: Significant at P= 0.05

Conclusion

Investigations were conducted to analyze the seasonal prevalence of major insect pests, such as fall armyworm and corn aphid, and their natural enemies, such as spiders, coccinellids, and rove beetles on maize, as well as the relationship between the pest and their natural enemy and current climatic conditions. Seasonal occurrence of major insect pests *viz*. falls armyworm and corn aphid on maize revealed that, on rabi crop, fall armyworm incidence reached its peak during second week of March 2021 (1larvae/plant). Peak of corn aphid populations were recorded during first week of March 2021, first week of April, 2021 respectively.

Seasonal occurrence of natural enemies *viz*. spider, coccinellid, rove beetle on maize revealed that, on rabi crop, incidence of spider population reached its peak during second last week of March. Peak of coccinellids and rove beetles were recorded during first week of April.

Correlation coefficient between different weather parameters and population of insect pests revealed that, minimum temperature recorded significant positive correlation with

population of fall armyworm (Larval) and corn aphid (nymph and adult). Maximum temperature had a substantial positive correlation with the population of all pests except fall armyworm, which had a positive but non-significant correlation with maximum temperature. Morning relative humidity had significant negative correlation with corn aphid (Adult and nymph). Total rainfall had a significant positive correlation with aphid population.

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