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Seasonal occurrence of major insect pests of groundnut in Ariyalur District, Tamil Nadu, India

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Abstract
Field studies were conducted during *Kharif* 2020 and *Rabi* 2020–2021 at Hasthinapuram village, Ariyalur district, Tamil Nadu, India, to study the seasonal occurrence of major insect pests of groundnut in relation to weather parameters. The predominant pests recorded were the groundnut leaf miner, *Aproaerema modicella*, tobacco leaf caterpillar, *Spodoptera litura*, leafhopper, *Empoasca kerri*, and aphid, *Aphis craccivora*. During *Kharif* 2020, peak incidence of *A. modicella* and *S. litura* were recorded during the 35th standard week with 67 and 60 larvae per 50 plants, respectively, whereas *E. kerri* and *A. craccivora* reached maximum populations of 130 and 170 individuals per 50 plants during the 40th and 44th standard weeks, respectively. During *Rabi* 2020–2021, peak populations of *A. modicella, S. litura, E. kerri*, and *A. craccivora* were observed during the 11th, 10th, 7th, and 4th standard weeks, respectively.

Correlation analysis indicated significant positive association of *A. modicella* and *S. litura* with maximum and minimum temperatures, while *E. kerri* and *A. craccivora* exhibited negative correlation with temperature and positive association with relative humidity. Rainfall showed no significant influence on pest incidence during both seasons. These findings highlight the importance of temperature and relative humidity on the regulation of pest population in groundnut ecosystems and may aid in developing weather-based pest forecasting under integrated pest management.

Keywords: Groundnut, *aproaerema modicella, spodoptera litura, empoasca kerri, aphis craccivora*, seasonal incidence, population dynamics, meteorological parameters, correlation analysis, pest forecasting, integrated pest management

Introduction
Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed and food legume crops cultivated in tropical and subtropical regions of the world. India is among the major groundnut-producing countries, where the crop contributes significantly to edible oil production, nutritional security, and rural livelihoods (FAOSTAT, 2023). In Tamil Nadu, groundnut is cultivated extensively under rainfed and irrigated conditions and plays an important role in the agricultural economy of semi-arid regions. However, productivity of groundnut is considerably affected by several biotic and abiotic stresses, among which insect pests are major constraints limiting yield and quality (Amin *et al.*, 2011) [3]. More than 100 insect species have been reported to infest groundnut at different crop growth stages, causing substantial economic losses under favorable environmental conditions (Butani and Jotwani, 1984) [4]. Among them, the groundnut leaf miner, *Aproaerema modicella*, tobacco leaf caterpillar, *Spodoptera litura*, leafhopper, *Empoasca kerri*, and aphid, *Aphis craccivora*, are considered economically important pests in South Indian groundnut ecosystems (Ranga Rao *et al.*, 1993) [38]. These pests damage foliage through feeding, mining, sap sucking, and defoliation, resulting in reduced photosynthetic efficiency, stunted growth, and yield reduction.

The occurrence and population buildup of insect pests are strongly influenced by prevailing weather parameters such as temperature, relative humidity, and rainfall (Panda and Khush, 1995) [30]. Seasonal variation in climatic factors alters pest biology, survival, reproduction, and dispersal, thereby influencing pest incidence and severity in crop ecosystems. Understanding the relationship between weather variables and pest population dynamics is essential for developing effective pest forecasting models and integrated pest management (IPM) strategies (Dent, 2000) [6]. Several studies have reported that higher temperature favors the multiplication of defoliators such as *A. modicella* and *S. litura*, whereas sap feeders including *E. kerri* and *A. craccivora* are often associated with higher relative humidity conditions (Kandakoor *et al.*, 2014; Reddy and Wightman, 1988) [16, 41]. However, information on seasonal incidence and weather relationships of major groundnut pests under the agro-climatic conditions of Ariyalur district, Tamil Nadu, remains limited. Therefore, the present investigation was undertaken to study the seasonal incidence of major insect pests of groundnut and to determine the influence of weather parameters on their population dynamics under field conditions in Tamil Nadu, India.

Materials and Methods
Study area and crop establishment
Field investigations were carried out during *Kharif* 2020 and *Rabi* 2020–2021 at Hasthinapuram village, Ariyalur block, Ariyalur district, Tamil Nadu, India. The experimental field is situated in the semi-arid agro-climatic zone of Tamil Nadu and is characterized by tropical climatic conditions. The ruling groundnut variety, GJG 9 was raised following the recommended agronomic practices of Tamil Nadu Agricultural University, except plant protection measures against insect pests.

Observation on insect pests
Seasonal incidence of major insect pests *viz*., groundnut leaf miner, *Aproaerema modicella*, tobacco leaf caterpillar, *Spodoptera litura*, leafhopper, *Empoasca kerri*, and aphid, *Aphis craccivora* were recorded at weekly intervals from

crop germination to harvest. Observations were made on 50 randomly selected plants in the untreated field following the standard sampling procedure described by Ranga Rao and Wightman (1993) [39]. The number of larvae or nymphs/adults present on selected plants was counted and expressed as population per 50 plants.

Meteorological observations

Meteorological data including maximum temperature (°C), minimum temperature (°C), morning relative humidity (%), evening relative humidity (%), and rainfall (mm) were collected from the nearest agro-meteorological observatory located at Ariyalur district. Standard meteorological week (SMW)-wise weather data corresponding to pest observation periods were utilized for analysis.

Correlation analysis

The relationship between pest incidence and weather parameters was determined using Pearson's correlation coefficient method as described by Gomez and Gomez (1984) [11]. Correlation coefficients (r) were computed between pest population and abiotic factors to assess the influence of climatic variables on seasonal pest dynamics.

Results and Discussion

Seasonal Incidence and Influence of Abiotic Factors on the Population Dynamics

1. Groundnut leaf miner, *Aproaerema modicella*

The larval incidence of *A. modicella* appeared during the 32nd standard week (SW) (20 larvae/50 plants) and continued up to the 38th SW during *Kharif* 2020 (Table 1; Fig. 1). The peak population was recorded during the 35th SW with 67 larvae/50 plants, after which the population gradually declined. During *Rabi* 2020 [43]–2021, infestation commenced during the 5th SW (10 larvae/50 plants) and persisted up to the 14th SW with populations ranging from 10 to 40 larvae/50 plants (Table 2; Fig. 2). The maximum larval population was observed during the 11th SW (40 larvae/50 plants), followed by a gradual decline towards crop maturity. Similar observations on seasonal incidence of *A. modicella* were reported by Khan and Raodeo (1987), Rathod (2006), Dabhade (2009), Hussain *et al.* (2012) [5, 13, 20, 40], and Nigude *et al.* (2018a), who recorded peak incidence during August–September under *Kharif* conditions. Pazhanisamy and Hariprasad (2014) [32] also observed maximum population during the 39th SW. During *Rabi* season, the present findings are in agreement with Gadad *et al.* (2013) [9], who reported incidence from February to April with peak activity during 8th–9th SW. However, the present results differ from the findings of Satyanarayana (2006) [44], who reported peak incidence during the second week of February.

Correlation analysis revealed that the incidence of *A. modicella* had significant positive association with maximum (r = 0.73) and minimum temperature (r = 0.61), whereas non-significant negative correlation was observed with morning (r = -0.29) and evening relative humidity (r = -0.37) during *Kharif* 2020. Rainfall showed a non-significant positive correlation (r = 0.34). During *Rabi* 2020–2021, significant positive correlation was observed with maximum temperature (r = 0.66), while minimum temperature showed non-significant positive association (r = 0.56). Morning relative humidity (r = -0.36), evening relative humidity (r = -0.70), and rainfall (r = -0.40) exhibited non-significant negative correlation with pest incidence. Multiple linear regression analysis indicated that the combined effect of weather parameters contributed 66 and 78% variation in leaf miner incidence during Kharif 2020 and Rabi 2020–2021, respectively (Tables 3 and 4). The present findings are partly in agreement with Radhika (2013) and Ibanda *et al.* (2018) [14, 35], who reported positive association of temperature and negative association of relative humidity with leaf miner incidence. Similar results were also reported by Naresh *et al.* (2017a), who observed positive correlation of temperature and negative correlation of relative humidity with *A. modicella* incidence under *Rabi* conditions.

2. Tobacco leaf caterpillar, *Spodoptera litura*

The larval incidence of *S. litura* appeared during the 32nd standard week (SW) (35 larvae/50 plants) and continued up to the 40th SW during *Kharif* 2020 (Table 1; Fig. 1). The highest larval population was recorded during the 35th SW with 60 larvae/50 plants, followed by a gradual decline. During *Rabi* 2020–2021, infestation commenced during the 5th SW (5 larvae/50 plants) and continued up to the 14th SW with populations ranging from 5 to 49 larvae/50 plants (Table 2; Fig. 2). Peak larval population was observed during the 10th SW with 49 larvae/50 plants, after which the population gradually declined towards crop maturity. The present findings are in agreement with Patel (2010), Raghvani (2012) [31, 36], Nigude *et al.* (2018a), and Mishra *et al.* (2021) [24], who reported peak incidence of *S. litura* during August–September under *Kharif* conditions. Similar observations during *Rabi* season were also reported by Kolkur (2017) and Pazhanisamy *et al.* (2019) [22, 33], who observed maximum larval population during the 6th to 13th standard weeks.

Correlation analysis revealed that the incidence of *S. litura* exhibited significant positive association with maximum (r = 0.70) and minimum temperature (r = 0.63), whereas morning (r = -0.36) and evening relative humidity (r = -0.39) showed non-significant negative association during *Kharif* 2020. Rainfall exhibited non-significant positive correlation (r = 0.37). During *Rabi* 2020–2021, a significant positive correlation was observed with maximum temperature (r = 0.74), while minimum temperature showed non-significant positive association (r = 0.64). Relative humidity and rainfall exhibited non-significant negative association with larval incidence. Multiple linear regression analysis indicated that weather parameters collectively contributed 62 and 76% variation in larval incidence during *Kharif* 2020 and *Rabi* 2020–2021, respectively (Tables 3 and 4). The present findings are in agreement with Radhika (2013), Patel (2010), Mishra *et al.* (2021) [24, 31, 35], Ahir *et al.* (2017a), and Naresh *et al.* (2017b), who reported positive association of temperature and negative association of relative humidity with *S. litura* incidence. Similar observations under *Rabi* conditions were also reported by Khan and Talukder (2017) and Pazhanisamy *et al.* (2019) [19, 33].

3. Leafhopper, *Empoasca kerri*

The incidence of *E. kerri* appeared during the 32nd standard week (SW) (30 hoppers/50 plants) and continued up to the 46th SW during *Kharif* 2020 (Table 1; Fig. 1). The highest population was recorded during the 40th SW with 130 hoppers/50 plants, after which the population gradually declined. During *Rabi* 2020 [43]–2021, infestation commenced during the 53rd SW (17 hoppers/50 plants) and persisted up to the 12th SW with populations ranging from 17 to 90 hoppers/50 plants (Table 2; Fig. 2). The peak population was observed during the 7th SW with 90 hoppers/50 plants, followed by a gradual decline towards crop maturity. The present findings are in agreement with Karena (2012), Raghvani (2012), and Harish *et al.* (2020) [12, 18, 36], who reported peak incidence of leafhoppers during September–October under *Kharif* conditions. However, the present results differ from the observations of Satyanarayana (2006) and Mer *et al.* (2016) [23, 44], who reported peak incidence during January and April, respectively, under *Rabi* conditions.

Correlation analysis revealed that the incidence of *E. kerri* exhibited negative association with maximum (r = -0.59) and minimum temperature (r = -0.71), whereas morning (r = 0.67) and evening relative humidity (r = 0.61) showed significant positive association during *Kharif* 2020 (Table 9). Rainfall exhibited non-significant positive correlation (r = 0.06). During *Rabi* 2020–2021, maximum (r = -0.61) and minimum temperature (r = -0.71) showed negative correlation, while morning relative humidity (r = 0.61) exhibited significant positive association with leafhopper incidence. Evening relative humidity and rainfall showed non-significant positive association. Multiple linear regression analysis indicated that weather parameters collectively contributed 66 and 69% variation in leafhopper population during *Kharif* 2020 and *Rabi* 2020 [43]–2021, respectively. The present findings are in agreement with Saradava (2010), Yadav *et al.* (2012) [42, 45], Nigude *et al.* (2018b), Gocher and Ahmad (2019), and Khanpara and Acharya (2012) [10, 21], who reported negative association of temperature and positive association of relative humidity with leafhopper incidence in groundnut ecosystems. Similar observations under *Rabi* conditions were also reported by Kantilal (1993) [17] (Tables 3 and 4).

4. Groundnut aphid, *Aphis craccivora*

The incidence of *A. craccivora* appeared during the 32nd standard week (SW) (35 aphids/50 plants) and continued up to the 46th SW during *Kharif* 2020 (Table 1; Fig. 1). The highest population was recorded during the 44th SW with 170 aphids/50 plants, after which the population gradually declined towards crop maturity. During *Rabi* 2020 [43]–2021, infestation commenced during the 53rd SW (45 aphids/50 plants) and persisted up to the 11th SW with populations ranging from 10 to 100 aphids/50 plants (Table 2; Fig. 2). Peak population was observed during the 4th SW with 100 aphids/50 plants, followed by a gradual decline. The present findings are in agreement with Rana (2003), Amarshibhai (2004), Rathod (2006), Saradava (2010), Yadav *et al.* (2012), and Saritha *et al.* (2020) [2, 37, 40, 42, 43, 45], who reported peak aphid incidence during August–September under *Kharif* conditions. Similar observations during *Rabi* season were also reported by Dhirajlal (2018) [7], who observed peak aphid population during April in groundnut ecosystems.

Aphid incidence was negatively correlated with maximum and minimum temperature, whereas morning and evening relative humidity showed positive association during both *Kharif* 2020 and *Rabi* 2020–21. During *Kharif* 2020, rainfall exhibited a non-significant negative correlation, while in *Rabi* 2020–21, it showed a non-significant positive correlation with aphid population. Multiple linear regression analysis indicated that the combined effect of weather parameters contributed to 63% and 74% variation in aphid incidence during *Kharif* 2020 and *Rabi* 2020–21, respectively, suggesting a strong influence of climatic factors on aphid population dynamics. The present findings are in agreement with the reports of Kandakoor *et al.* (2012) and Yadav *et al.* (2012) [15, 45], who reported negative association of aphid population with temperature and rainfall in groundnut. Similarly, Nayak *et al.* (2019) [27] observed negative correlation with temperature and rainfall, and positive association with relative humidity during *Kharif* season. Further, the positive influence of relative humidity and negative association of temperature during *Rabi* 2020–21 corroborate the findings of Prasad *et al.* (2008) and Dhirajlal (2018) [7, 34]. Overall, the study indicates that lower temperature and higher relative humidity favoured aphid multiplication in groundnut ecosystems.

Conclusion

The present investigation on seasonal incidence and influence of abiotic factors on major insect pests of groundnut revealed distinct population dynamics under *Kharif* 2020 and *Rabi* 2020 [43]–21 conditions. Among defoliators, *Aproaerema modicella* and *Spodoptera litura* attained peak incidence during the 35th standard week in *Kharif* and during the 10th–11th standard weeks in *Rabi*. Both pests showed positive association with temperature and negative association with relative humidity, indicating that warm and comparatively dry weather favoured their multiplication. The sucking pests, *Empoasca kerri* and *Aphis craccivora*, exhibited peak activity during later crop stages and showed negative association with temperature but positive association with relative humidity, suggesting that cooler and humid conditions were conducive for their population build-up. Rainfall generally exhibited non-significant influence on pest incidence across seasons. Multiple linear regression analysis indicated that weather parameters collectively explained a substantial proportion of variation in pest populations, emphasizing the important role of climatic factors in regulating pest dynamics in groundnut ecosystems. The findings of the present study provide useful information for forecasting pest outbreaks and developing weather-based integrated pest management strategies for sustainable groundnut cultivation.

Table 1: Seasonal incidence of groundnut pests on the groundnut variety GJG 9 during *Kharif* 2020

Standard week	Defoliators		Sucking pests	
	A. modicella **population/50 plants**	***S. litura*** **population/50 plants**	***E. kerri*** **population/50 plants**	***A. craccivora*** **population/50 plants**
32	20	35	30	35
33	43	40	32	49
34	55	55	33	50
35	67	60	90	95
36	19	30	94	107
37	5	22	95	108
38	2	20	100	109
39	-	19	111	112
40	-	15	130	140

41	-	-	127	150
42	-	-	125	157
43	-	-	123	160
44	-	-	121	170
45	-	-	119	169
46	-	-	115	168

Table 2: Seasonal incidence of groundnut pests on the groundnut variety GJG 9 during *Rabi* 2020 – 2021

Standard week	Defoliators		Sucking pests	
	A. modicella **population/50 plants**	***S. litura*** **population/50 plants**	***E. kerri*** **population/50 plants**	***A. craccivora*** **population/50 plants**
53	-	-	17	45
1	-	-	54	60
2	-	-	69	80
3	-	-	70	90
4	-	-	72	100
5	10	5	74	60
6	12	6	75	55
7	14	29	90	42
8	15	37	69	37
9	25	45	64	21
10	37	49	63	12
11	40	38	44	10
12	35	33	42	-
13	20	32	-	-
14	15	31	-	-

Fig 1. Seasonal incidence of major groundnut pests in the variety, GJG 9 during *Kharif* 2020 on the basis of meteorological parameters

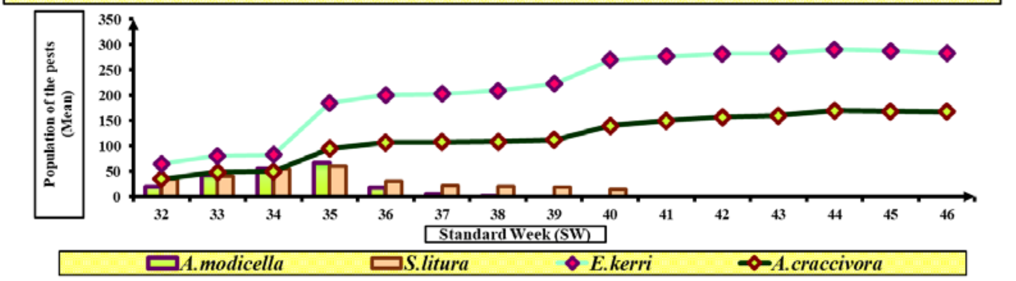

Fig 2. Seasonal incidence of major groundnut pests in the variety, GJG 9 during *Rabi* 2020 -2021 on the basis of meteorological parameters

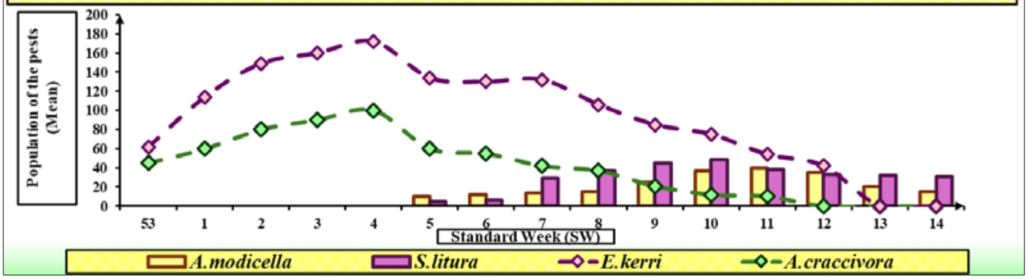

Table 3: Correlation between meteorological parameters and population of defoliators during *Kharif* 2020 and *Rabi* 2020 – 2021

Insects	*Kharif* 2020					*Rabi* 2020 – 2021				
	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
	Maximum	Minimum	Morning	Evening		Maximum	Minimum	Morning	Evening	
A. modicella	0.73*	0.61*	-0.29	-0.37	0.34	0.66*	0.56	-0.36	-0.70	-0.40
S. litura	0.70*	0.63*	-0.36	-0.39	0.37	0.74*	0.64*	-0.44	-0.68	-0.43

* Significance at 5 per cent level

Table 4: Multiple linear regression between meteorological parameters and defoliators during *Kharif* 2020 and *Rabi* 2020 – 2021

Variable (Y)	*Kharif* 2020		*Rabi* 2020 – 2021	
	Regression equation	R^2 value	Regression equation	R^2 value
A. modicella (larvae/ 50 plants)	Y=-662.45+17.87X1+1.62X2+1.43X3-0.7X4+1.99X5	0.66*	Y=-200-1.01X1+5.52X2+2.29X3-1.33X4+0.99X5	0.78*
S. litura (larvae/ 50 plants)	Y=-710.52+3.97X1+19.44X2+0.72X3-0.06X4+2.60X5	0.62*	Y=-350.06+8.39X1-2.20X2+2.61X3-0.69X4+0.19X5	0.76*

* Significance at 5 per cent level X1- Maximum temperature (°C) X2- Minimum temperature (°C) X3- Morning Relative Humidity (%) X4-Evening Relative Humidity (%) X5-Rainfall (mm)

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