Impact of abiotic factors on population dynamics of leaf miner, *Aproaerema modicella* D. and its natural enemies in groundnut

ABSTRACT: Groundnut leaf miner (*Aproaerema modicella*. D.) is an important leaf feeding insect in groundnut that significantly reduces the pod yield op to 50 per cent. The growth and development of this insect pest is closely associated with the abiotic weather parameters prevailing in a particular location. Due to paucity of information available on the population dynamics of groundnut leaf miner and weather parameters a study was undertaken in Erode district of Tamil Nadu during Summer, 2023. Groundnut leaf miner damages were recorded through the fixed plots survey and the adult moth activities were monitored through pheromone traps at weekly intervals. From this study it was observed that, the leaf miner incidences were observed from 30 days after sowing. The highest mean leaf miner mean damage (17.84%), pheromone adult catches (58.38 nos./5 traps), coccinellid beetle population (4.70 nos./10 plants) and spider population (5.17 nos./10 plants) were observed during 9th SMW. Whereas, the rove beetle population was maximum (4.62 nos./10 plants) during 10th SMW. The correlation study revealed that the maximum temperature had positive correlation and rainfall had negative correlation with the populations of groundnut leaf miner and its natural enemies. The multiple linear regression analysis indicated that the weather parameters together had 66.00 to 95.00 per cent influence on the groundnut leaf miner and its natural enemy population. The present study clearly indicated that, the population of groundnut leaf miner and its damage levels were closely related to the abiotic weather parameters prevailed in the study area during entire crop duration. Better understanding of the weather factors resulted in better leaf miner management and more net profit for the groundnut growers.

Key words: Groundnut, Leaf miner, Natural enemies, Population dynamics, Weather parameters, Correlation and regression.

1. INTRODUCTION

Groundnut (*Arachis hypogea* L.) is an important oilseed crop in India. It ranks first in area (85 lakh ha) and production (84 lakh metric tonnes) during 2022-2023 (https://agmarknet.gov.in). Tamil Nadu is one of the leading groundnut growing states in India with an area of 3.30 lakh hectare. Even though India ranks second in groundnut production in the World, the productivityis still low when compared to other

groundnutgrowing countries[1]. The lower productivity might be due to the infestation of various kinds of insect pests damage, of which the groundnut leaf miner (GLM), *Aproaerema modicella* (D) an important oligophagous insect pest, that itself caused up to 75 per cent leaf damage and up to 50 per cent yield reduction. The more leaf damage by GLM in groundnut is due to the faster growth and development of GLM under favourable conditions. Among the various factors responsible for GLM population, the influence of abiotic factorsplays a vital role [2]. The present-dayglobal weather changes leadto increase in the average temperature, erraticin rainfall pattern and atmospheric RH. These seasonal and long-term variations of abiotic factors would also influence the population dynamics of crop pests, particularly in groundnut. In addition to the abiotic factors, the occurrence of natural enemies also influences the population dynamics of GLM.Hence, understanding about the abiotic factors and theireffect on the population dynamics of pests and natural enemies is always a prerequisite for effective management programme. Thus, the present investigation was carried out with the objective to study the population dynamics of GLM and their natural enemies in correlation with theabiotic weather factors on groundnut grown in Tamil Nadu, India.

2. MATERIALS AND METHODS

Field experiments were conducted in Erode district of Tamil Nadu during *Summer*,2022. Three groundnut growing villages in Sathyamangalam taluk *viz.*,Pungar (11.487^{o} N; 77.114^{o} E), Bhavanisagar (11.483^{o} N; 77.132^{o} E) and Bagaduduari (11.479^{o} N; 77.117^{o} E)were selected for the study. Sowing of groundnut variety BSR 2 was taken on 04.01.2023 with the recommended spacing of 30x10 cm. All agronomical practices were followed as per the Crop Production Guide 2020 for Tamil Nadu. None of the pesticides were sprayed in the experimental fields throughout the study period. The leaf damage was recorded in 10 randomly selected plants at weekly intervals through the fixed plot survey. The per cent leaf damage was calculated by using the following formula [3].

$$\text{Per cent leaf damage} = \frac{\text{Number of leaves damaged per plant}}{\text{Total number of leaves per plant}} \times 100$$

Delta-type pheromone traps with GLM lures @ 5/ac was used to monitor the leaf miner adult moths in the experimental fields. The pheromone traps were installed on 20 DAS as per the procedure and the adult catches were recorded in each location at weekly intervals. The lures were replaced once in 15 days to maintain the efficiency of the pheromone traps throughout

the study. The natural enemies like parasitoids and predators of the experimental fields were recorded in 10 randomly selected plants on visual basis and expressed in numbers per 10 plants. The weather parameters like maximum temperature (^{o}C), minimum temperature (^{o}C), relative humidity (%), wind speed (km/hr), sunshine hours (hrs) and rainfall (mm) were recorded on a daily basis from the meteorological observatory located near the experimental area and used for correlation studies. The correlation and regression analysis were done by using R software version 4.3.1 Windows 10. Groundnut leaf miner pheromone catches and natural enemies of the experimental fields were correlated with the weather parameters on Standard Mean Week (SMW) basis. Correlation coefficient (r) was calculated to assess the influence of weather factors on their population dynamics. Regression analysis which determines the strength and relationship between GLM population and abiotic factors were confirmed with the Rsquarevalue.

3. RESULTS AND DISCUSSION

3.1. Leaf miner damage

The groundnut leaf miner incidence was noticed from 6th SMW onwards. The mean GLM damage during the early period of the crop (30 DAS) was only 0.25 per cent. Thereafter, the damage was in increasing trend and reached its maximum during the 9th SMW (50 DAS) with the mean damage of 17.84 per cent. The damage of GLM was more or less static from 10th SMW to 16th SMW and the mean damages were in the ranges from 12.26 to 17.62 per cent. After 16th MSW, the mean damage was in decreasing trend and it reached the ever less of 0.03 per cent during the end of the crop period (Table 1). More GLM damage was noticed during March and April months and reached its peak during 9th MSW (17.84%), this might be due to the positive effect of weather factors prevailed during that period which favored for the growth and development of GLM. The weather parameters during the peak infestation of the GLM (9th SMW) were maximum temperature (33.3^{o}C), minimum temperature (15.2^{o}C), morning RH (85.6%), evening RH (62.4%), windspeed (3.10 km/hr) with no rainfall. The present study was in accordance with the previous research findings [4] who revealed that the GLM damage was more during February to March and reached its peak damage during 8th and 9th SMW in groundnut.

Among three locations of the study, the total leaf damage was more in Bhavanisagar followed by Pungar and Bagadudurai. In Bhavanisagar, the GLM damage was more (26.36%) during 9th SMW followed by 10th SMW (19.89%) and 12th SMW (18.42%). Up to

16th SMW the damage levels were static and decreased after 16th SMW. The same trend was observed in Bagadudurai village also. Whereas, in Pungar village the GLM leaf damage was maximum during 16th SMW (21.85%) followed by 12th SMW (21.45%) and 14thSMW (21.26%) and after 16thSMW the damage levels were in decreasing trend as that of other two locations (Table 1, Fig 1). These findings were corroborated with the other findings [5, 6] in groundnut ecosystem.

Table 1. Damage intensity of leaf miner on groundnut at three different locations

Standard Week	Month and Days	Leaf miner damage (%)			Mean Damage (%)
		Pungar	Bhavanisagar	Bagadudurai	
6	Feb. 05 - 11	0.30	0.00	0.45	0.25
7	Feb. 12-18	2.10	3.72	0.58	2.13
8	Feb. 19 - 25	1.36	2.32	1.95	1.88
9	Feb. 26-Mar. 04	10.30	26.36	16.85	17.84
10	Mar. 05 - 11	10.19	19.89	14.86	14.98
11	Mar. 12 - 18	15.61	18.00	16.76	16.79
12	Mar. 19 -25	21.45	18.42	11.20	17.02
13	Mar. 26-Apr. 01	20.52	14.54	18.15	17.74
14	Apr. 02 - 08	21.26	16.50	15.50	17.75
15	Apr. 09 - 15	15.36	9.78	11.65	12.26
16	Apr. 16 - 22	21.85	13.61	17.40	17.62
17	Apr. 23 - 29	7.05	8.87	7.27	7.73
18	Apr. 30-May 06	3.56	1.90	4.84	3.43
19	May 07 - 13	0.65	0.00	2.70	1.12
20	May 14 - 20	3.90	1.00	0.00	1.63
21	May 21 - 27	0.00	0.00	0.09	0.03
				SD (±)	***7.65***

The GLM damage data were correlated with the weather parameters and the results were statistically significant for many factors. The GLM damages showed significant negative correlation with evening RH (r = - 0.458*) and are positively correlated with maximum temperature (r = 0.298), minimum temperature (r = 0.052), morning RH (r = 0.210) and windspeed (r = 0.092). Whereas, the sunshine hours (r = - 0.154) and rainfall (r = - 0.321) showed non-significant negative correlation with leaf damage (Table 4). It clearly indicated

that the GLM requires elevated temperatures with minimum sunshine and humidity for their increased growth and development. The present result was in accordance with the earlier findings [7] where the GLM damage was increased with increasing maximum temperature and decreased with evening relative humidity and showed negative correlation with sunshine hours [8]. The regression equation fitted with weather parameters was $Y = 321.949 + 7.310\ X_1 + 3.169\ X_2 + 2.784\ X_3 + 0.865\ X_4 + 3.634\ X_5 + 5.134\ X_6 + 0.100\ X_7$. This indicated that one unit increase in maximum temperature resulted in 7.31 unit increase in leaf damage. The multiple linear regression analysis revealed that all the weather parameters together contributed about 93.07 per cent variability in leaf miner damage (Table 5). The present investigations were supported by previous studies [9] which revealed that the coefficient of multiple regression (R^2) between leaf miner damage and weather parameters were highly significant. The results were also in accordance with the other findings [10] which asserted that every degree rise in temperature shorten the life cycle of insects which resulted in higher pest population and damage.

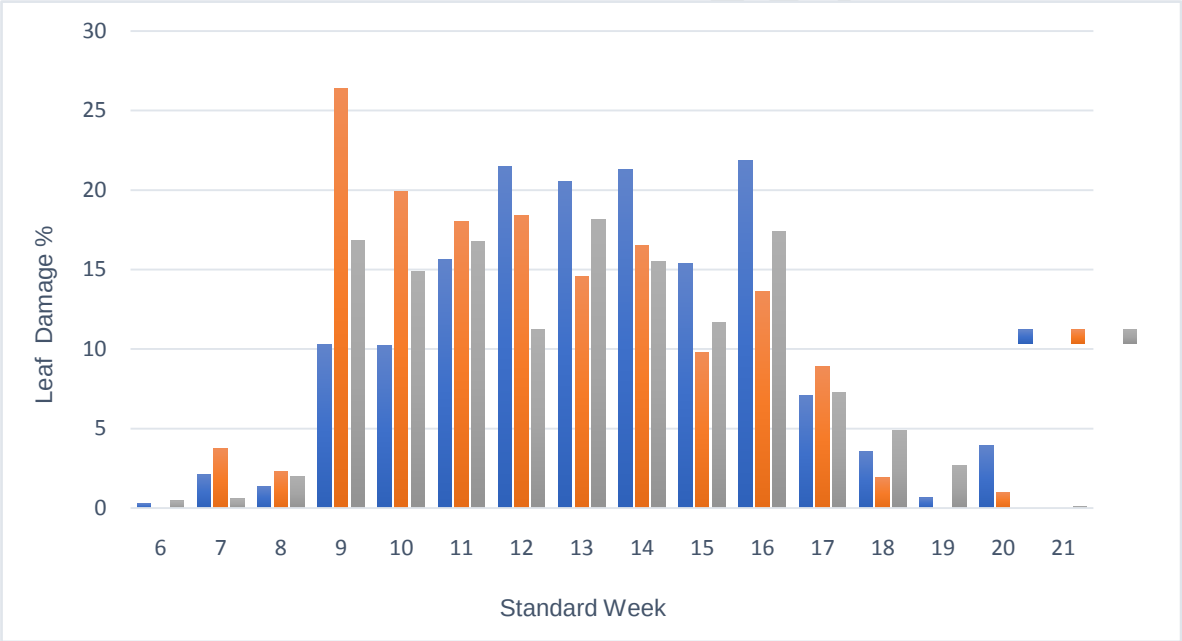

Fig 1. Leaf miner damage intensity on groundnut in three locations

3.2. Pheromone trap adult catches

Among three locations, the maximum adult catches were observed in Bhavanisagar (61.05 nos./5 traps) during 15th SMW, followed by Pungar (60.10 nos./5 traps) during 9th SMW and Bagadudurai (60.05 nos./5traps) during 16th SMW (Fig 2). The mean adult moth catches were also reached its peak during 9th SMW with mean value of 58.38 nos. / trap. Thereafter,

the adult moth catches were in declining trend but again it over-shooted at the 16th SMW and the numbers ranged from 4.9 to 58.3 adults/5 traps (Table 2, Fig 4). This might be due to the prevalence of favorable weather parameters for the growth and development of GLM during 8th and 9th SMW and during that period, the weekly mean maximum temperature (33.3°C), minimum temperature (15.2°C), morning RH (85.6%), evening RH (62.4%), wind speed (3.10 km/hr) and no rainfall was observed.

Table 2. Leaf miner adult catches through pheromone traps during summer, 2023

Standard Week	Month and Days	GLM adult moth catches (nos./5 traps)			Mean catches (nos./5 traps)
		Pungar	Bhavanisagar	Bagadudurai	
6	Feb. 05 - 11	4.20	7.80	9.60	7.20
7	Feb. 12-18	21.80	27.30	23.10	24.07
8	Feb. 19 - 25	53.10	49.00	36.80	46.30
9	Feb. 26-Mar. 04	60.10	58.00	57.05	58.38
10	Mar. 05 - 11	43.05	40.10	36.30	39.82
11	Mar. 12 - 18	39.60	37.60	43.00	40.07
12	Mar. 19 -25	45.80	39.20	41.35	42.12
13	Mar. 26-Apr. 01	49.10	56.60	51.00	52.23
14	Apr. 02 - 08	53.20	56.00	58.70	55.97
15	Apr. 09 - 15	57.90	61.05	52.90	57.28
16	Apr. 16 - 22	57.20	55.80	60.05	57.68
17	Apr. 23 - 29	21.61	36.80	24.20	27.54
18	Apr. 30-May 06	16.80	11.40	8.80	12.33
19	May 07 - 13	13.90	13.00	7.45	11.45
20	May 14 - 20	11.60	8.20	4.40	8.07
21	May 21 - 27	7.40	6.20	1.10	4.90
				SD (±)	***20.25***

The adult moth catches through pheromone traps showed a significant negative correlation with rainfall (r = -0.477*) and positive correlation with maximum temperature (r = 0.048), morning RH (r = 0.049) and sunshine hours (r = 0.006) and non-significant negative correlation with minimum temperature (r = -0.311), evening RH (r = -0.249) and wind speed (r = -0.109) (Table 4). This might be due to the effect of favorable weather parameters for the growth and development of GLM adults [11]. This result was in accordance with the earlier studies [12] whofound that the adult trap catches showed positive correlation with

maximum temperature, morning RH, and sunshine hours and negative correlation with minimum temperature and evening RH. The increased leaf miner infestation was found during droughtstressed field condition with increased leaf surface temperature. Another studies [8] also supported this finding, where the RH and rainfall had showed negative influence on the adult trap catches.

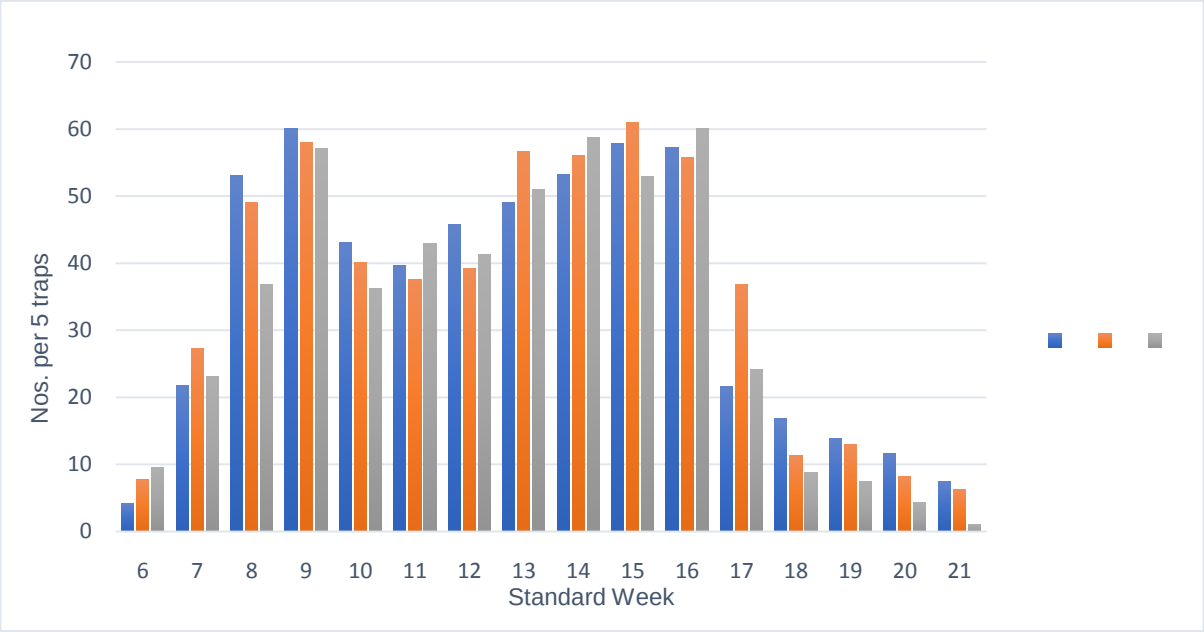

Fig 2. Groundnut leaf miner adult catches through pheromone traps

The multiple linear regression analysis resulted in the regression equation as follows: Y = 248.181 + 2.808 X_1 + 3.627 X_2 + 1.084 X_3 + 2.779 X_4 + 14.501 X_5 + 16.023 X_6 + 0.504 X_7,which indicates that one unit increase in wind speed (km/hr) resulted in 16.02 units in the adult catchesand the R^2 value obtained is 0.725, which revealed that the weather parameters influence the adult moth catches by 72.57 % (Table 5).

3.3. Natural enemies'population

3.3.1. Coccinellid beetles

The predatory coccinellid beetles were observed from the 6th SMW (30 DAS) onwards and the mean population was 0.80 nos./10 plants. The coccinellid beetle species recorded in the experimental fields were *Coccinella septempuctata* (L.), *Coccinella transversalis* (F.), *Chelomenes sexmaculata* (F.) and *Menochilus sexmaculatus* (F.). The same group of coccinellid species were also recorded in groundnut fields in previous studies [13,14]. Among the coccinellids, *Chelomenes sexmaculata* was predominant one and accounted for

70 per cent of the GLM population reduction [15].The coccinellid beetle population in three locations ranged from 0.03 and 4.70 nos. /10 plants. Among them, the mean coccinellid beetle population was maximum in Bagadudurai (2.56 nos. /10 plants) followed by Pungar (2.50 nos./10 plants) and Bhavanisagar (2.17 nos./10 plants) (Table 3). The population of coccinellids were increased gradually and reached its maximum during the 9th SMW (4.70 nos. /10 plants) (Fig 3). This might be due to the positive effect of weather factors prevailed during that period which favored for the growth and development of coccinellids. The weekly mean maximum temperature (33.3 ^{o}C), minimum temperature (15.2 ^{o}C), morning RH (85.6%), evening RH (62.4%), windspeed (3.10 Km/hr), and rainfall (0.00 mm) were observed during peak population of the coccinellid beetles (Table 3, Fig 4).

Table 3. Natural enemies' population in the experimental fields

Standard Week	Month and Days	Population (nos. / 10 plants) (Mean of three locations)		
		Coccinellid beetles	**Spiders**	**Rove beetles**
6	Feb. 05 - 11	0.80	0.40	0.02
7	Feb. 12-18	1.17	0.83	0.10
8	Feb. 19 - 25	2.10	1.53	0.53
9	Feb. 26-Mar. 04	4.70	5.17	4.00
10	Mar. 05 - 11	2.23	2.87	4.63
11	Mar. 12 - 18	2.60	2.92	3.50
12	Mar. 19 -25	3.03	3.72	3.00
13	Mar. 26-Apr. 01	3.83	3.37	3.77
14	Apr. 02 - 08	4.00	4.03	4.05
15	Apr. 09 - 15	4.03	4.97	4.47
16	Apr. 16 - 22	4.65	5.07	4.60
17	Apr. 23 - 29	2.47	2.37	2.88
18	Apr. 30-May 06	1.78	1.13	1.15
19	May 07 - 13	0.32	0.10	0.03
20	May 14 - 20	0.79	1.03	0.78
21	May 21 - 27	0.03	0.00	0.00
	SD (±)	***1.53***	***1.80***	***1.88***

The correlation studies revealed that the evening RH (r = -0.566*) showed significant negative correlation with coccinellids population and the maximum temperature (r = 0.346)

and sunshine hours (r = 0.044) were positively correlated. However, a non-significant negative correlation was observed in the case of minimum temperature (r = -0.011), morning RH (r = -0.117), windspeed (r = -0.273), and rainfall (r = -0.117) (Table 4). The multiple linear regression analysis revealed that, one unit increase in wind speed resulted in a 1.446 unit decrease in coccinellid population. This finding was corroborated with the findings of [15] who also revealed that increased wind speed affected the abundance of coccinellids. Another study [16] also showed that windspeed has significant effect on both natural enemies and leaf miner population. The regression coefficient (R^2 value) concluded that all the weather parameters together contributed about 82.25 per cent variability in the population of coccinellids (Table 5).

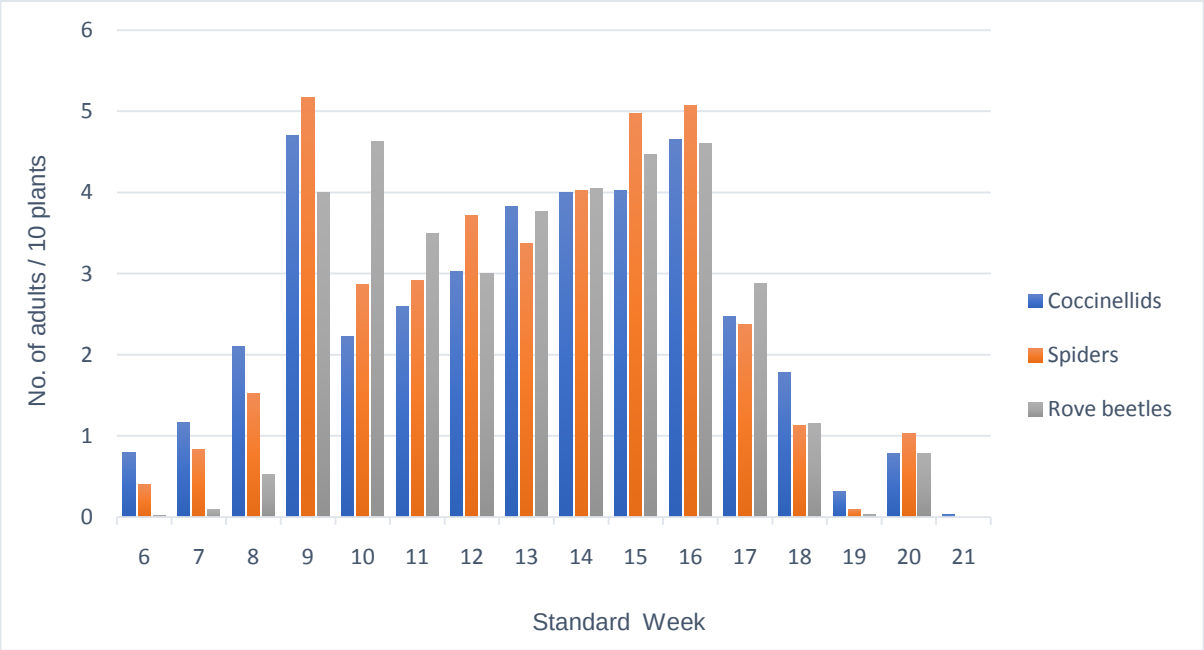

Fig 3. Natural enemies population in the experimental fields

3.3.2 Spiders

The spiders were noticed from the 6th SMW (30 DAS) onwards and the spider genera recorded were *Oxyopes* sp., *Clubiona* sp. and *Lycosidae* sp. and among them, the *Lycosidae* sp. was predominant one. This result was in accordance with other studies [14, 15] reported that the spiders belonging to Lycosidae family was found predominant in groundnut ecosystem. The population of spiders was gradually increased and reached its peak during the 9th SMW with an average population of 5.17 nos./10 plants (Table 3, Fig 3). The weekly averaged maximum temperature (33.3^{o}C), minimum temperature (15.2^{o}C), morning RH (85.6%), evening RH (62.4%), windspeed (3.10 km/hr), and rainfall (0.00 mm) were

observed during peak population (9th SMW). The range of spider populations throughout the study period ranged from 0.00 to 5.17 nos./10 plants (Table 3). In Bagadudurai, the maximum spider population was recorded with a mean population (2.77nos./10 plants), followed by Bhavanisagar (2.58 nos./10 plants). The weather parameters were correlated with the spider population and the results revealed that there was a significant negative correlation with evening RH (r = - 0.617*). Whereas, the maximum temperature (r = 0.407), minimum temperature (r = 0.014), and sunshine hours (r = 0.103) showed a positive influence on the spider population and a non-significant negative correlation was observed in the case of morning RH (r = -0.123), windspeed (r = -0.025), rainfall (r = -0.331) (Table 4). The multiple linear regression analysis resulted that all the weather parameters together contributed about 88.50 per cent variability to the spider population. From the regression equation obtained, it was revealed that one unit increase in windspeed (km/hr) resulted in a decrease of 0.96 units in the spider population (Table 5).

Table 4. Correlation analysis of GLM and its natural enemies with weather parameters

Weather parameters	Correlation coefficient (r value)				
	Leaf damage	Pheromone trap catches	Spiders	Coccinellid beetles	Rove beetles
Max. Temp. (^{o}C)	0.298	0.048	0.407	0.346	0.318
Min. Temp. (^{o}C)	0.052	-0.311	0.014	-0.011	0.038
Mor. RH (%)	0.210	0.049	-0.123	-0.117	0.106
Eve. RH (%)	-0.458*	-0.249	-0.617*	-0.566*	-0.520*
RF (mm)	-0.321	-0.477*	-0.331	-0.273	-0.307
SSH (hrs)	-0.154	0.006	0.103	0.044	-0.075
WS (km/hr)	0.092	-0.109	-0.025	-0.117	0.088

*. Correlation is significant at the 0.05 level

RH - Relative Humidity, RF - Rainfall, SSH - Sunshine hours, WS - Windspeed

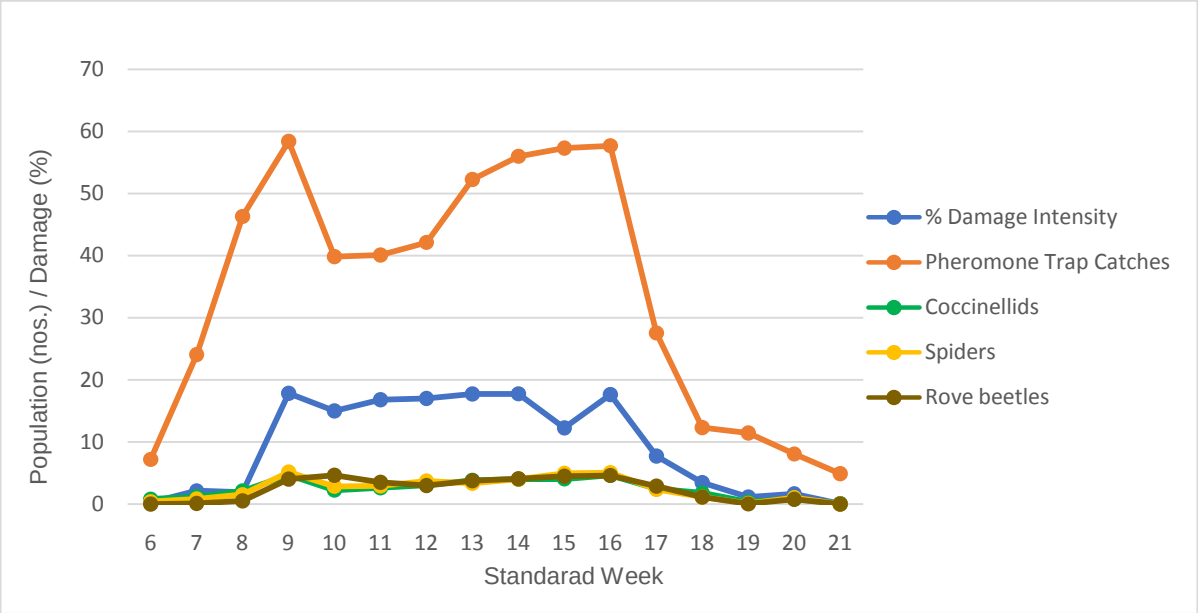

Fig 4. Mean GLM and its natural enemies population

3.3.3 Rove beetles

The rove beetle incidence was occurred 30 DAS onwards and their population were increased over the period of study. Among the three locations, the maximum rove beetle population was observed in Bagadudurai with a population of (2.55 nos. / 10 plants), followed by Pungar (2.25 nos. / 10 plants). The mean population was 1.88nos./10 plant (Fig 4). In a previous study [17] also revealed that, these predators were recorded on lepidopteran larvae at various stages and found increased over the crop period. The gradual increase in rove beetle population was observed and reached its maximum during the 10th SMW (4.63 nos. /10 plants) (Table 3, Fig 3). The weekly mean weather parameters coincided with the peak rove beetle incidence were the maximum temperature (33^{o}C), minimum temperature (16.5^{o}C), morning RH (88.9%), evening RH (65.9%), windspeed (3.00 km/hr) and no rainfall. The previous studies reported that the mean temperature of 25.3°C [18] and the relative humidity of 67.5 per cent [19, 20] supports better growth and development of rove beetles in groundnut ecosystem.

Table 5. Regression analysis of GLM and its natural enemies with weather parameters

Parameters	Regression equation	R^2 Value
Leaf miner damage intensity	$Y = - 321.949 + 7.310 X_1 - 3.169 X_2 + 2.784 X_3 - 0.865 X_4 - 3.634 X_5 - 5.134 X_6 - 0.100 X_7$	0.930
GLM adult moth catches	$Y = 248.181 + 2.808 X_1 - 3.627 X_2 + 1.084 X_3 - 2.779 X_4 - 14.501 X_5 - 16.023 X_6 - 0.504 X_7$	0.725
Coccinellids	$Y = 16.34 + 0.311 X_1 - 0.301 X_2 + 0.114 X_3 - 0.250 X_4 - 1.146 X_5 - 1.446 X_6 - 0.026 X_7$	0.885
Spiders	$Y = -56.509 + 1.438 X_1 - 0.721 X_2 + 0.542 X_3 - 0.258 X_4 - 0.504 X_5 - 0.960 X_6 - 0.006 X_7$	0.825
Rove beetles	$Y = -107.341 + 2.198 X_1 - 0.932 X_2 + 0.844 X_3 - 0.229 X_4 - 0.376 X_5 - 0.970 X_6 - 0.002 X_7$	0.945
X_1 - Maximum temperature, X_2 - Minimum temperature, X_3 - RH Morning, X_4 - RH Evening, X_5 - Sunshine hours, X_6 - Windspeed, X_7 – Rainfall		

The correlation studies revealed that a significant negative correlation was observed with evening RH (r = -0.520*), whereas the maximum temperature (r = 0.318), minimum temperature (r = 0.038), morning RH (r = 0.106) and windspeed (r = 0.088) showed a non-significant positive influence on the rove beetle population. Non-significant negative correlation was observed in the case of sunshine hours (r = -0.075) and rainfall (r = -0.307) (Table 4). The multiple linear regression analysis revealed that all the weather parameters influenced the rove beetle population by 94.54 per cent and the regression equation obtained showed that one unit increase in windspeed (km/hr) resulted in a reduction of 0.970 units in the rove beetle population (Table 5).

4. CONCLUSION

The groundnut leaf miner damage was more during 9th SMW which ranges from 0.25 to 18.00 per cent. The adult moth activity was also more during 9th SMW(4.00 to 60.00 nos./5 traps). Among the natural enemies, the spider population was more (0.00 to 5.17 nos. /10 plants) followed by the coccinellids (0.03 and 4.70 nos./10 plants) and rove beetles (0.00 and 4.63 nos./10 plants). The correlation studies clearly showed the significant influence of weather parameters the growth and development and population build-up of groundnut leaf miner and its natural enemies. The research findings also narrated that the evening RH had a

significantly negative impact on leaf miner damage (-0.458*) and its natural enemies *viz.*,coccinellids (-0.566*), spiders (-0.617*) androve beetles (-0.520*). The rainfall showed a significant negative influence on leaf miner adult catches (-0.477*).Whereas, the maximum temperature had a positive influence on both groundnut leaf miners and its natural enemies. The morning RH showed a positive influence on GLM populationbut had negative influence on the natural enemies of GLM. From the results, it could be concluded that abiotic factors influence the seasonal activity and population dynamics of GLM and its natural enemies. The present study also showed that the groundnut fields with an increased natural enemy population showed reduced GLM damage. This clearly indicated that besides abiotic factors, the biotic factors might also influence the population of GLM to some extent. A better understanding of the biotic and abiotic factors is essential to formulate an effective management strategy for GLM which in turn it enhances the net income of the groundnut farmers by avoiding application of toxic chemical insecticide during peak activity of the natural enemies of groundnut leaf miner.

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