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Population dynamics of major defoliator on soybean and their relation with abiotic factors

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Abstract

The present study on the effect of weather parameters on the population dynamics of defoliators *Spodoptera litura* and *Chrysodeixis acuta* in soybean was conducted during Kharif 2022-23 and 2023-24 at IGKV, Raipur. The population of *S. litura* ranged from 0.40-9.10 larvae/mrl (2022-23) and 0.10-8.20 larvae/mrl (2023-24), with peak incidence during the 36th-37th SMW (September). The pooled mean peak reached 8.65 larvae/mrl with a seasonal mean of 3.31 larvae/mrl. Correlation analysis revealed significant positive association between maximum temperature with *S. litura* in during the 2022-23 season ($r = 0.599^*$), 2023-24 season ($r = 0.584^*$) and pooled analysis ($r = 0.623^*$), while rainfall and sunshine hours had negative effects. Regression analysis confirmed temperature as a major factor influencing pest abundance.

Similarly, *C. acuta* population ranged from 0.70-7.17 larvae/mrl (2022-23) and 0.40-7.70 larvae/mrl (2023-24), peaking during the 36th SMW. The pooled mean peak was 7.44 larvae/mrl with a seasonal mean of 3.60 larvae/mrl. Correlation studies showed significant positive relationship between *C. acuta* with evening relative humidity ($r = 0.594^*$ in 2022-23; $r = 0.450$ in 2023-24) while minimum temperature $r = 0.568$, 0.579^* and pooled 0.589^* respectively. Whereas rainfall and sunshine hours were negatively correlated. Regression analysis indicated that minimum temperature and evening relative humidity played a key role in semilooper population buildup during Kharif.

Keywords: Population dynamics, defoliator, abiotic factors

Introduction

Soybean (*Glycine max* L. Merrill) is one of the most important oilseed and leguminous crops in the world, valued for its high protein (about 40%) and oil content (around 20%). In India, soybean plays a vital role in enhancing farmers' income and improving soil fertility through biological nitrogen fixation. Despite its economic importance, soybean productivity is considerably constrained by the attack of various insect pests throughout its growth period.

The soybean ecosystem harbors a wide range of insect pests, which defoliators the most destructive and occur regularly from the vegetative to reproductive stages of the crop. Defoliators such as the tobacco caterpillar *Spodoptera litura* (Fabricius), green semilooper *Chrysodeixis acuta* (Walker) and other lepidopteran larvae cause severe foliage damage, leading to reduced photosynthetic area and ultimately significant yield losses. Heavy infestation during early crop growth may even result in complete defoliation.

Material and Methods

The experiment was conducted at the Research cum Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya; Raipur, Chhattisgarh (India) with the soybean variety RSC 10-46. Record of population of major defoliators of soybean crop was done in the Control plot during the Kharif of 2022-2023 and Kharif of 2023-24.

Experimental details

Crop		Soybean
Variety	:	RSC 10-46
Field size	:	100m ²
Plot size	:	10 x 10 m.
Spacing	:	40 x 10 cm.

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Methodology of observation recorded

Observation of defoliators like tobacco caterpillar (*Spodoptera litura* Fabricius) and green semilooper (*Chrysodeixis acuta* Walker) were recorded by counting the number of larvae found in one meter row length to shaking the plant on muslin cloth from ten randomly selected spot at weekly interval and mean number of larvae per meter row length was calculated (Sundar *et al.* 2018).

The meteorological data with incidence of major defoliators obtained during the study period, *Kharif* of 2022-2023 to *Kharif* of 2023-24 was subjected to simple correlation analysis. The data was statistically analyzed by using the

Karl Pearson's coefficient of correlation formula: The calculated t-value obtained was compared with correlation coefficient table 2 at 5% level of significance.

Results and Discussions

In the present investigation, numbers of defoliators were recorded infesting the soybean crop. Among the lepidopteran defoliators were the tobacco caterpillar (*Spodoptera litura* Fab.) and the green semilooper (*Chrysodeixis acuta* Walker). Data on the population dynamics of the major insect pests were presented in tables no 1.

Table 1: Population dynamics of major defoliator pests recorded on soybean during *Kharif*, 2022-23, 2023-24 and pooled mean data 2022-23 to 2023-2024

SMW	<i>S. litura</i>		Number of larvae/mrl			
			<i>C. acuta</i>			
	2022-23	2023-24	Pooled mean	2022-23	2023-24	Pooled mean
32	0.00	0.10	0.05	0.70	0.90	0.80
33	0.50	1.20	0.85	2.41	2.10	2.26
34	2.10	2.10	2.10	5.23	5.30	5.27
35	6.20	5.10	5.65	5.61	6.85	6.23
36	9.10	8.20	8.65	7.17	7.70	7.44
37	6.10	7.20	6.65	6.85	6.39	6.62
38	5.12	7.50	6.31	6.31	4.91	5.61
39	6.10	3.20	4.65	3.19	4.24	3.72
40	4.20	1.50	2.85	1.61	2.11	1.86
41	1.61	0.90	1.26	0.90	1.50	1.2
42	0.90	0.20	0.55	0.40	0.40	0.4
43	0.40	0.00	0.20	0.20	0.00	0.10
Seasonal mean	3.53	3.67	3.10	3.67	3.67	3.36

Table 2: Correlation coefficient (r) between insect pests infesting soybean with weather parameters during *Kharif*, 2022-23, 2023-24 and Pooled mean data 2022-23 to 2023-24

Weather parameters	Defoliators					
	<i>S. litura</i> <i>C. acuta</i>					
	2022-23	2023-24	Pooled mean	2022-23	2023-24	Pooled mean
Maximum temperature °C	0.599*	0.584*	0.623*	0.280	0.436	0.449
Minimum temperature °C	0.387	0.381	0.390	0.568	0.579*	0.589*
Rainfall mm	-0.306	-0.008	-0.176	-0.068	0.015	-0.033
Morning relative humidity%	0.154	0.185	0.161	-0.198	0.105	0.096
Evening relative humidity%	0.405	0.387	0.404	0.594*	0.450	0.458
Wind speed, Km/hr	0.042	0.272	0.199	0.528	0.37	0.444
Sunshine hrs	-0.342	-0.243	-0.200	-0.407	-0.198	-0.320

*Level of significant at 5%

Population dynamics of tobacco caterpillar, *Spodoptera litura* F. with abiotic factor

The population of *S. litura* ranged from 0.40 to 9.10 larvae per mrl, as presented in table 1. The incidence of the tobacco caterpillar was began during the third week of August (33rd SMW) with a mean population of 0.50 larvae per mrl. It was gradually increased and reached its highest peaked density at 9.10 larvae per mrl in the second week of September (36th SMW). During this period, the maximum temperature 33.25°C, minimum temperature 25.34°C, rainfall 9.57 mm, morning relative humidity 90.57 percent, evening relative humidity 68.42 percent, wind speed was 1.07 km/hr and sunshine hours 6.92 hrs were recorded. Later, the tobacco caterpillar population declined until the crop reached maturity recorded on the soybean crop during *Kharif* 2022-23.

During *Kharif* 2023-24, depicted in table 1 revealed that the population ranged from 0.10 to 8.20 larvae per mrl. The larvae of the tobacco caterpillar were first observed during

the second week of August (32nd SMW) with mean population of 0.10 larvae per mrl. The peaked population 8.20 larvae per mrl during the third week of September (37th SMW). The maximum temperature recorded 31.46°C, the minimum temperature 25.77°C, rainfall measured 5.63 mm, morning relative humidity 87.35 percent, evening relative humidity 70.35 percent, wind speed 5.53 km/hr and sunshine 6.79 hours were recorded during the 2023-24 season. Thereafter, the population declined until the end of the season.

The pooled mean population of the tobacco caterpillar during *Kharif* 2022-23 and 2023-24 ranged from 0.05 to 8.65 larvae per mrl. The population peaked at 8.65 larvae per mrl during the second week of September (36th SMW) and the seasonal mean population was 3.31 larvae per mrl depicted in table 1. During this period, the maximum temperature recorded 31.34°C, the minimum temperature 24.21°C, rainfall measured 7.41 mm, morning relative humidity reached 89.46 percent, evening relative humidity

reached 65.66 percent, wind speed 2.73 km/hr and sunshine 5.52 hours were recorded.

The present findings were in agreement with those of Sapekar *et al.* (2020), who reported that the incidence of tobacco caterpillar was recorded during the 31st standard week (0.66 larvae/mrl), with the highest population observed at 3.66 larvae/mrl during the 36th SMW. Munje *et al.* (2022) also supported these findings, stating that the presence of tobacco caterpillar was recorded at the 31st SMW and continued up to the 34th SMW, ranging from 0.40 larvae/mrl. The maximum population of the tobacco leaf-eating caterpillar was recorded between the 31st and 34th SMW at 0.40 larvae/mrl. Panwar *et al.* (2021) mentioned in their study that the peaked activity of semilooper (5 larvae/mrl) and tobacco caterpillar (1.33 larvae/mrl) was observed during the 37th and 38th SMW, respectively. Sunder *et al.* (2018) also reported the highest tobacco caterpillar infestation during the *Kharif* season, with a mean population of 4.30 larvae/mrl recorded in the last week of August. Subsequently, an abrupt decline in larval population was observed in the fourth week of September, with an average of 1.20 larvae/mrl.

Correlation of tobacco caterpillar population with weather parameters

The data presented in Table no 2 indicated that, in *Kharif* 2022-23, the larval population of the tobacco caterpillar showed with maximum temperature ($r = 0.599^*$) significant positive correlation, minimum temperature ($r = 0.387$), evening relative humidity ($r = 0.407$), morning relative humidity ($r = 0.154$) and wind speed ($r = 0.042$) non-significant positive correlation. However, non-significant negative correlation was observed with rainfall ($r = -0.306$) and sunshine hours ($r = -0.342$).

Furthermore, the data presented in Table 2 demonstrated that, in *Kharif* 2023-24, the larval population of the tobacco caterpillar exhibited a non-significant positive correlation with maximum temperature ($r = 0.584^*$), evening relative humidity ($r = 0.387$), minimum temperature ($r = 0.381$), morning relative humidity ($r = 0.185$) and wind speed ($r = 0.272$). In contrast, negative non-significant correlation were observed with sunshine hours ($r = -0.243$) and rainfall ($r = -0.008$).

Pooled mean of during *Kharif* 2022-23 and 2023-24, the larval population of the tobacco caterpillar showed with maximum temperature ($r = 0.623^*$) significant positive correlation, minimum temperature ($r = 0.390$), evening relative humidity ($r = 0.404$), morning relative humidity ($r = 0.164$) and wind speed ($r = 0.199$) non-significant positive correlation. However, non-significant negative correlation was observed with rainfall ($r = -0.176$) and sunshine hours ($r = -0.200$) depicted in table 2.

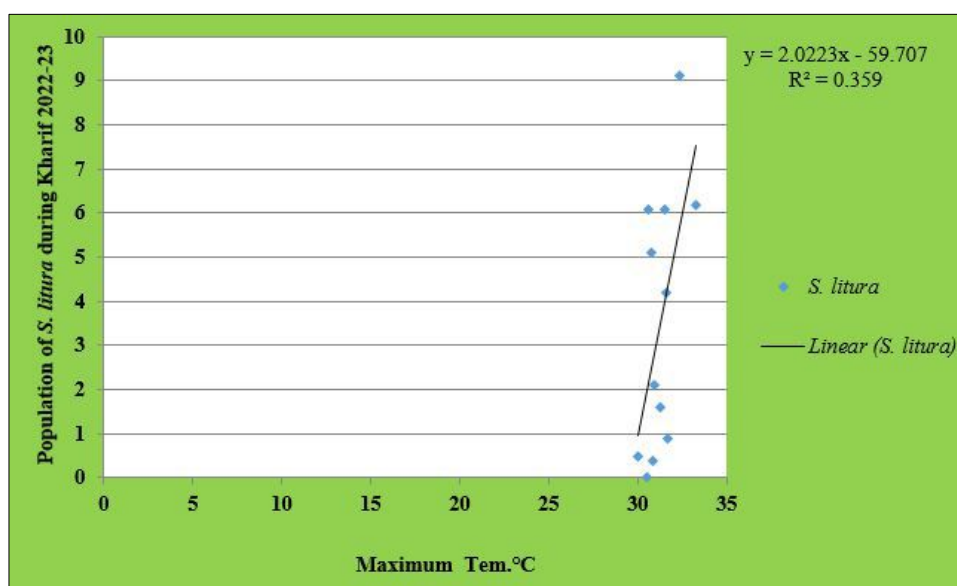
The present findings agree with earlier studies on *S. litura* population dynamics. Bramhan *et al.* (2018) reported a significant positive correlation with maximum temperature ($r = 0.663$) and a significant negative correlation with rainfall ($r = -0.570$). Sapekar *et al.* (2020) observed non-significant relationships between abiotic factors and *S. litura*, though morning ($r = 0.052$) and evening relative humidity ($r = 0.289$) showed weak positive associations.

Similarly, Panwar *et al.* (2021) found a significant positive correlation between larval population and maximum temperature ($r = 0.55$). Patidar (2020) reported a strong negative correlation of rainfall ($r = -0.71$) with larval incidence. Other studies also showed that maximum and minimum temperatures had positive correlations ($r = 0.46$ and $r = 0.01$), while morning relative humidity showed a negative correlation ($r = -0.23$) with pest population.

Regression equation tobacco caterpillar, *S. litura* Fab. with weather parameters

During *Kharif* 2022-23, regression analysis between tobacco caterpillar population and minimum temperature showed the equation $y = 2.0677x - 50.707$ ($R^2 = 0.359$), indicating that infestation increased by 2.0677 units with every unit rise in minimum temperature. Similarly, another analysis for the same season gave $y = 1.9177x - 57.132$ ($R^2 = 0.3412$), showing an increase of 1.9177 units in infestation per unit rise in minimum temperature.

When pooled data from *Kharif* 2022-23 and 2023-24 were analyzed, the regression between tobacco caterpillar population and maximum temperature produced the equation $y = 2.0911x - 62.033$ ($R^2 = 0.361$). This indicated that for every unit increase in temperature, the infestation level increased by 2.091 units, confirming temperature as an important factor influencing pest buildup. (Fig. 1.1)



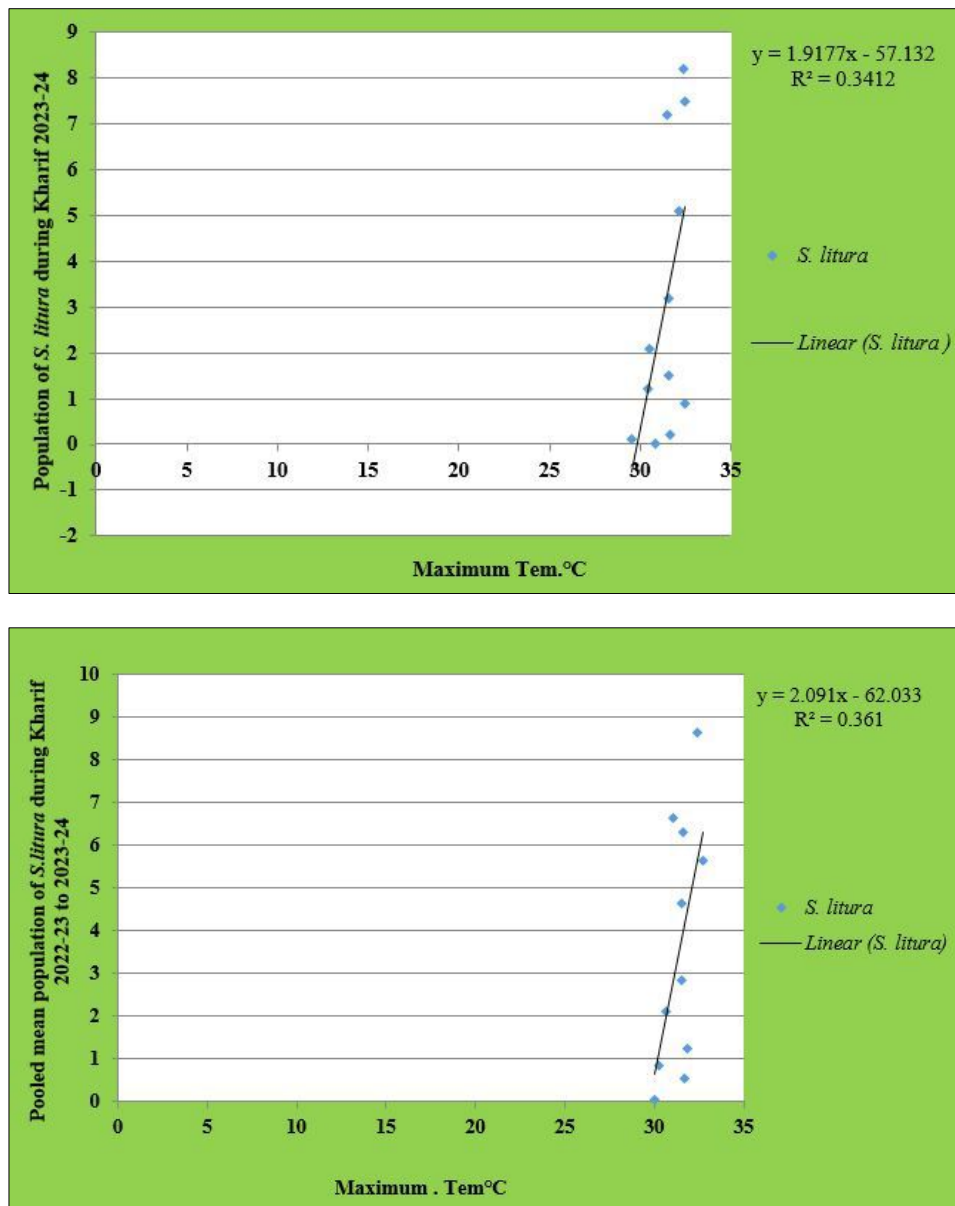


Fig 1.1: Regression equation between tobacco caterpillar populations with weather parameters during *Kharif* 2022-23, 2023-24 and pooled mean

These results consistently highlight that minimum temperatures created favorable conditions for the buildup of *S. litura*. This finding corroborates earlier reports by Patel *et al.* (2017), who also found positive associations between temperatures and tobacco caterpillar population dynamics in soybean ecosystems.

Green semilooper, *Chrysodeixis acuta* Walker **Population dynamics of green semilooper, *Chrysodeixis acuta* Walker with weather parameters**

The mean larval counts per meter row length (mrl) of the green semilooper, *C. acuta*, on soybean crops were recorded during *Kharif* 2022-23. According to table 1, the population ranged from 0.70 to 7.17 larvae per mrl. The incidence of *C. acuta* started in the second week of August (32nd SMW) with a mean number 0.70 larvae per mrl and reached a peak of 7.17 larvae per mrl in the second week of September (36th SMW). During this period, the maximum temperature 33.36°C, the minimum temperature 25.54°C, rainfall 4.63 mm, morning relative humidity 91.14 percent, evening relative humidity 68.42 percent, wind speed 2.83 km/hr and

sunshine 6.79 hours. The green semilooper population declined until the crop reached maturity.

In *Kharif* 2023-24, the population of *C. acuta* varied from 0.40 to 7.70 larvae per mrl, as documented in table 1. Activity commenced in the second week of August (32nd SMW) with a mean population of 0.90 larvae per mrl, peaked at 7.70 larvae per mrl in the second week of September (36th SMW). During this period the maximum temperature 32.41°C, the minimum temperature 24.54°C, rainfall remained at 4.63 mm, the morning relative humidity 91.14 percent, the evening relative humidity 66.42 percent, wind speed 2.85 km/hr and sunshine 6.79 hours. Subsequently, the semilooper population decreased until the crop matured.

The pooled mean population for *Kharif* 2022-23 and 2023-24 was presented in table 1. and ranged from 0.10 to 7.44 larvae per mrl. The peak population reached 7.44 larvae per mrl in the second week of September (36th SMW), while the seasonal mean population was 3.60 larvae per mrl. During the period of maximum population density, the recorded weather parameters were as follows: a maximum temperature of 31.34°C, minimum temperature of 24.21°C,

rainfall of 7.41 mm, morning relative humidity of 89.46 percent, an evening relative humidity of 65.66 percent, wind speed of 2.73 km/hr and sunshine duration of 5.52 hours.

The results of the present investigations were consistent with earlier studies. Sapekar *et al.* (2020) reported that the incidence of green semilooper during the 33rd and 34th standard meteorological weeks (SMW) produced populations of 4.33 and 4.66 larvae per meter row length (mrl) respectively, with the highest population of 7.66 larvae per mrl recorded during the 35th SMW (27 Aug-02 Sep). Chaudhari *et al.* (2020) observed a peak population of 8.67 larvae per mrl in the third week of September, while Parmar *et al.* (2020) documented that the green semilooper initiated in the first week of August (31st SMW) and increased thereafter, reaching a maximum population of 3.2 larvae per mrl during the 36th SMW (first week of September). Additionally, Munje *et al.* (2022) also reported that the incidence of semilooper, *C. acuta* (Walker), was observed from the 31st to the 34th SMW, with populations ranged from 0.2 to 0.22 larvae per mrl and the highest count of 0.22 larvae per mrl recorded during the 34th SMW.

Our study produced similar results. semilooper activity began in early August, increased over time, reached its peak in mid-September and then declined as the crop matured. These findings match earlier studies and support the seasonal trend of semilooper populations during the *Kharif* season.

Correlation of green semilooper, *Chrysodeixis acuta* Walker with weather parameters

During *Kharif* 2022-23, the analysis revealed that the semilooper population was significantly and positively correlated with evening relative humidity ($r = 0.594^*$). In contrast, minimum temperature ($r = 0.568$), maximum temperature ($r = 0.280$) and wind speed ($r = 0.528$) were positively correlated, although these relationships were not statistically significant. Moreover, the correlations with morning relative humidity ($r = -0.198$), bright sunshine ($r = -0.407$) and rainfall ($r = -0.068$) were negative and also not significant depicted in table 2.

During *Kharif* 2023-24, the semilooper population exhibited a significant positive correlation with minimum temperature ($r = 0.579^*$). Meanwhile, the correlations with evening relative humidity ($r = 0.450$), maximum temperature ($r = 0.436$), wind speed ($r = 0.370$), morning relative humidity ($r = 0.105$) and rainfall ($r = 0.015$) were positive yet not significant. Furthermore, sunshine hrs ($r = -0.198$) showed negative and non-significant correlations depicted in table 2. When pooled data for *Kharif* 2022-23 and 2023-24, the average weather parameters demonstrated significant positive correlation of the semilooper population with minimum temperature ($r = 0.589^*$). In contrast, evening relative humidity ($r = 0.458$), maximum temperature ($r = 0.449$), wind speed ($r = 0.444$), and morning relative humidity ($r = 0.096$) positive correlated but non-significant. While sunshine hrs ($r = -0.320$) and rainfall ($r = -0.033$) exhibited non-significant negative correlations showed in table 2. This pattern shows that weather conditions have a complex effect on pest occurrence during the *Kharif* season. These results were consistent with previous studies. Sapekar *et al.* (2020) reported that the correlation between weather factors and green semilooper populations was non-

significant overall, with the correlations for morning relative humidity ($r = 0.113$) and evening relative humidity ($r = 0.226$) being positive but not statistically significant. Chaudhari *et al.* (2020) supported these findings by demonstrating that the correlations between green semilooper counts and maximum temperature, as well as morning and evening relative humidity, were positive yet non-significant. In addition, Panwar *et al.* (2021) observed a significant positive correlation between the semilooper larva population and maximum temperature and evaporation ($r = 0.31$). Similarly, Parmar *et al.* (2020) also found that the correlations between green semilooper infestation and temperature ($r = 0.21$) and relative humidity ($r = 0.22$) were positive but non-significant. Overall these studies suggested that while there was a slight tendency toward increased semilooper populations with higher temperatures and relative humidity the relationships were weak indicating that factors likely influenced semilooper dynamics during the *Kharif* season.

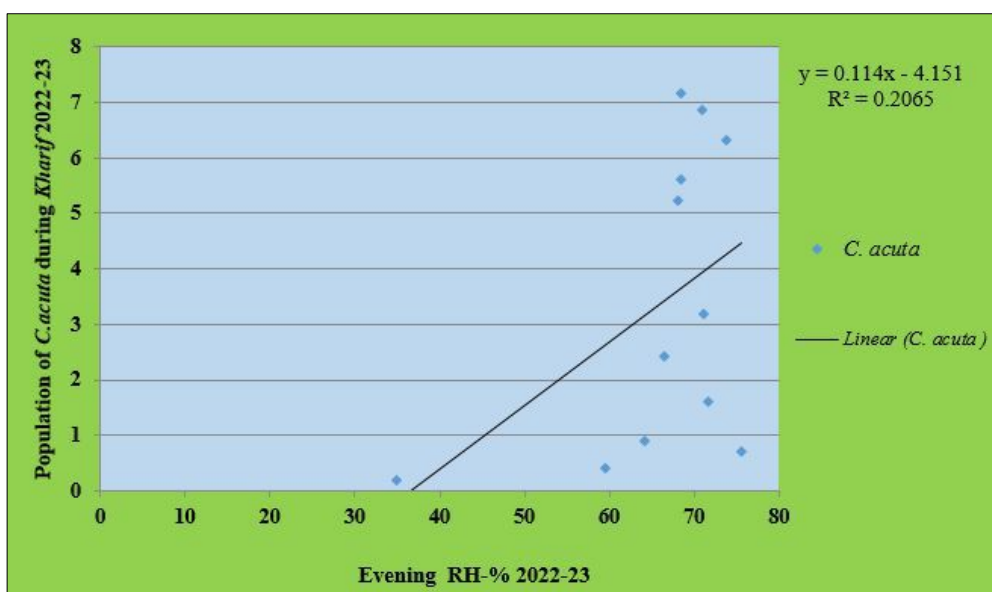
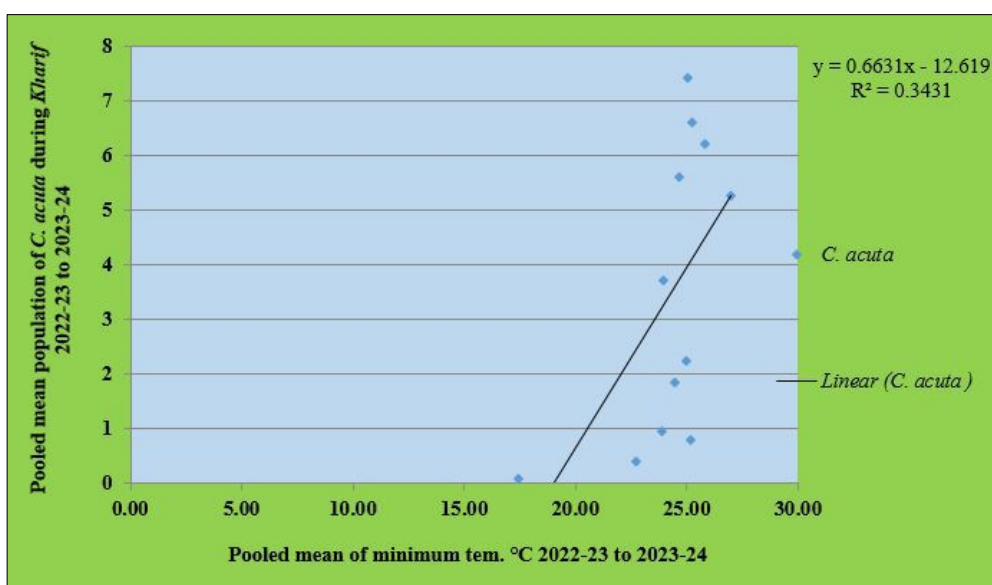
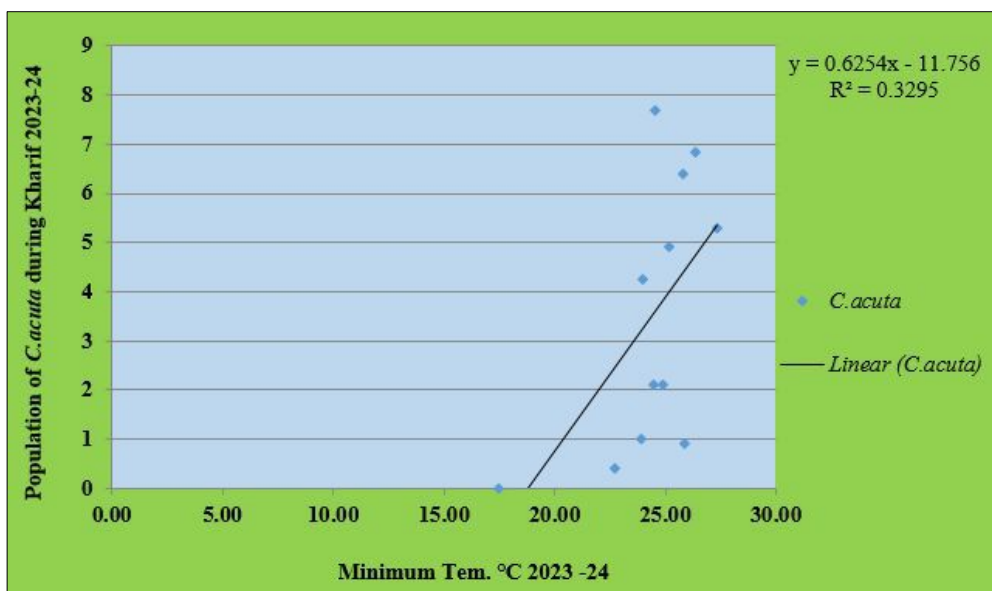
Regression equation green semilooper, *Chrysodeixis acuta* Walker with weather parameters

During *Kharif* 2022-23, the regression analysis between the semilooper population and minimum temperature yielded the equation $y = 0.6677x - 12.672$ ($R^2 = 0.3223$), which indicated that for every unit increase in minimum temperature, the infestation level increased by 0.6677 units (Fig. 1.2). Similarly, the regression equation for evening relative humidity was $y = 0.114x - 4.1451$ ($R^2 = 0.2065$), demonstrating that for every unit increase in evening relative humidity, the infestation level increased by 0.114 units (Fig. 1.2).

During *Kharif* 2023-24, the regression equation between the semilooper population and minimum temperature was $y = 0.6254x - 11.756$ ($R^2 = 0.3295$), which showed that for every unit increase in minimum temperature, the infestation level increased by 0.6254 units (Fig. 1.2). In addition, the regression equation for evening relative humidity was $y = 0.112x - 3.8155$ ($R^2 = 0.1977$), indicating that for each unit increase in evening relative humidity, the infestation level increased by 0.112 units (Fig. 1.2).

When data from *Kharif* 2022-23 and 2023-24 were combined, the regression analysis between the semilooper population and minimum temperature produced the equation $y = 0.6631x - 12.619$ ($R^2 = 0.3431$), which demonstrated that each unit increase in minimum temperature was associated with a 0.6631 unit increase in the infestation level (Fig. 1.2). Correspondingly, the regression equation for evening relative humidity was $y = 0.1135x - 4.0164$ ($R^2 = 0.207$), indicating that for every unit increased in evening relative humidity, the infestation level increased by 0.1135 units (Fig. 1.2). This analysis clearly supported that higher minimum temperatures and increased evening relative humidity were associated with elevated semilooper infestation levels during the *Kharif* season.

Similar findings were reported by Patel *et al.* (2018), who observed that *Chrysodeixis acuta* and other lepidopteran defoliators showed positive correlations with minimum temperature and relative humidity in soybean. Likewise, Srivastava *et al.* (2017) noted that high humidity coupled with moderate night temperatures favoured the multiplication of semilooper populations in central India.



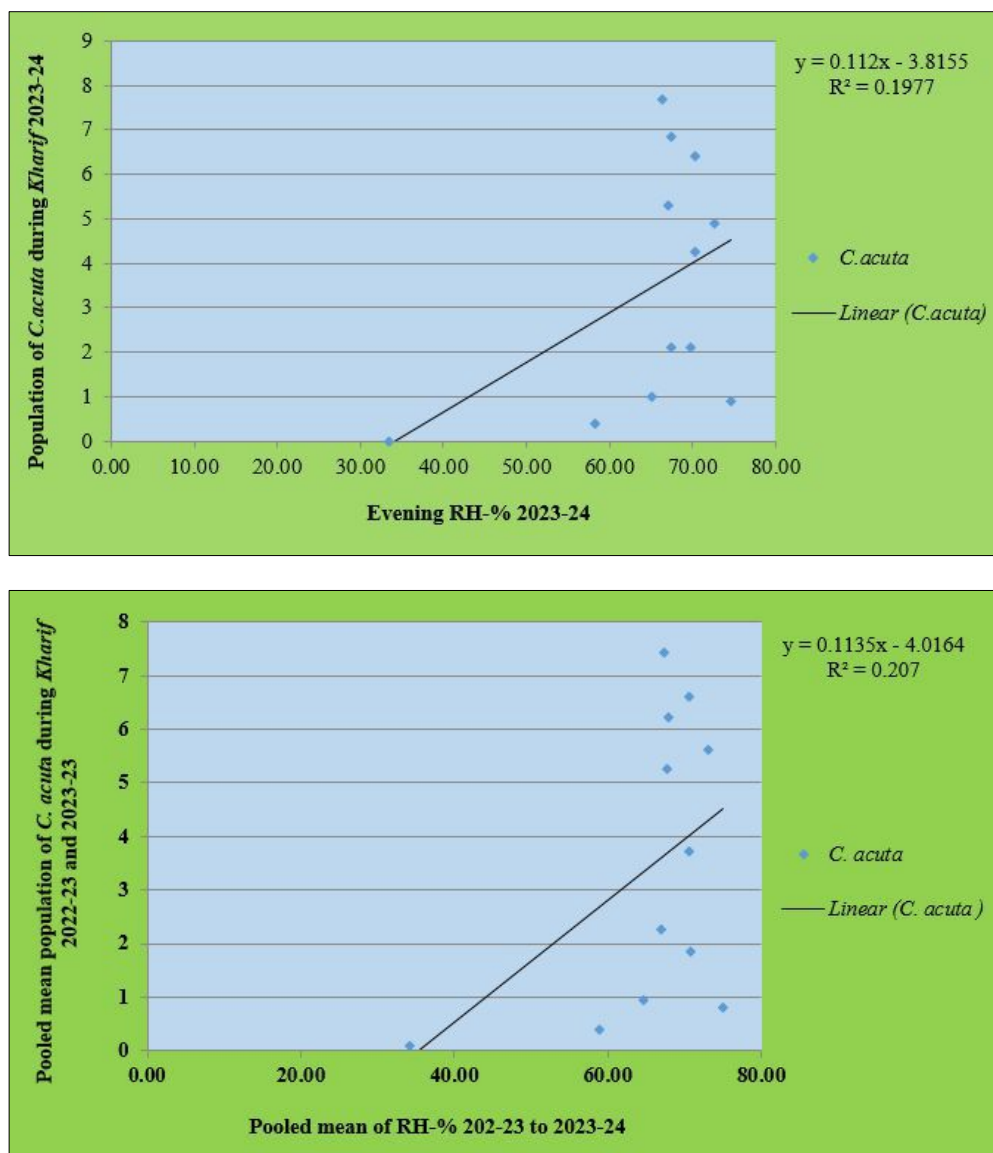


Fig 1.2: Regression equation between green semilooper populations and weather parameters during Kharif 2022-23, 2023-24 and pooled mean

Conclusion

The study showed a clear seasonal pattern of *S. litura* and *C. acuta* on soybean during Kharif 2022-23 and 2023-24, with incidence starting in August, peaking in September (36th-37th SMW), and declining at crop maturity. *S. litura* was positively associated with maximum temperature, while *C. acuta* was mainly influenced by minimum temperature and evening relative humidity. Regression analysis confirmed a positive linear effect of temperature on both pests, identifying minimum temperature as the key abiotic factor governing their seasonal buildup.

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