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Seasonal occurrence of defoliators on soybean and their natural enemies in relation to weather conditions

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Abstract
A study was conducted in the kharif season of 2021 and 2022 at the Soyabean Research Farm of BAU, Ranchi, to investigate the seasonal occurrence of pre-dominant lepidopteran insect pests on soybean (Glycine max (L.) Merrill). At different phases of the soybean crop's growth, the tobacco caterpillar (*Spodoptera litura* Fab.) and green semilooper (*Chrysodeixis acuta* Walker) were identified as the main defoliator insects causing damage. The peak activity of tobacco caterpillar incidence during kharif, 2021 and 2022 (4.6 and 4.2 larva/mrl) was observed during 37th and 36th SMW respectively whereas the peak activity of green semilooper larva (2.2 and 1.7 larva/mrl) were recorded during 36th and 35th SMW. Correlation studies indicated that tobacco caterpillar has significant correlation with only minimum temperature during 2021 and for green semilooper only rainfall has significant correlation during 2022. The results of the multiple linear regression analysis showed that, for the years 2021 and 2022, respectively, the overall influence of weather parameters was 75.89% (R^2 = 0.7589) and 57.80% (R^2 = 0.578) on tobacco caterpillars. However, for green semiloopers, it was 75.03 percent (R^2 = 7.503) and 19.203 percent (R^2 = 0.192) in 2021 and 2022, respectively.

Keywords: Soybean, insect pests, seasonal occurrence, weather-related variables, correlation and regression

1. Introduction
Among the nation's oilseed crops, soybeans also referred to as "Golden Beans" are one of the most promising crops of the twenty-first century. It is part of pulse crops as well. Compared to other legumes, soybeans have a better potential for productivity. It is the best source of high-quality protein and can help treat malnutrition resulting from insufficient protein intake. With the exception of 18–20% oil, soybeans contain about 40% protein and all the necessary amino acids. Soybean oil alone accounts for roughly 28% of the nation's production of vegetable oil out of the nine oilseeds that are farmed.

The soft, succulent leaves and the abundant crop growth entice insects with abundance of food, space, and refuge. Approximately twelve of the more than 275 insect pests that infest soybean crops at different stages of growth have been found to be seriously damaging the crop from planting to harvesting (Jain *et al*., 2011) [4]. About 15–25% of soybean output is lost due to insect pest fauna (Biswas, 2013) [1]. Leaf miner (*Aproaerema modicella* Devanter), stem fly (*Melanagromyza sojae* Zehnter), tobacco caterpillar (*Spodoptera litura*), semiloopers (*Gastonia game*, *Achaea janata*, *Chrysodeixis acuta*), and sucking insect pests like white fly (*Bemisia tabaci*) and leaf hopper (*Amrasca biguttula biguttula*) are a few of them that are important. The primary defoliators of soybeans are the green semilooper, *Chrysodeixis acuta*, and the tobacco caterpillar, *Sopdoptera litura* (Fab.).

Both tobacco caterpillar and green semilooper in their immature phase (larva or caterpillar) harm crops during the vegetative stage; in extreme cases, they fully defoliate the crop and cause a significant loss in production. The relationship between abiotic factors and pest activity forms the basis of predictive models that assist in estimating the frequency of pests. This study sought to investigate the relationship between abiotic climate conditions and the abundance of pest insects that damage soybeans.

2. Material and Methods
In *Kharif* 2021 and 2022, field experiment was done at Birsa Agricultural University's Soybean Research Farm in Kanke, Ranchi, to investigate the seasonal occurrence of soybean

defoliator pests and their natural enemies and how they relate to abiotic meteorological conditions. The experiment was conducted on variety JS 335 in unprotected plot with spacing of 45 cm x 10 cm which was non-replicated and the plot size was 5 m x 4 m. The larval population of tobacco caterpillar and green semilooper were recorded at weekly interval from three randomly selected spots of one meter row length in each plot leaving border rows and mean was recorded in per meter. Natural enemies' population were recorded from five randomly selected plants per plot.

3. Results and Discussion

Tables 1, 2, 3, and 4 provide data on the seasonal occurrence of key defoliators that infest soybeans and their natural enemies in connection to abiotic climatic conditions.

i) Tobacco caterpillar (*Spodoptera litura*)

In the years 2021 and 2022, respectively, the first week of August (the 31st SMW) marked the beginning of the tobacco caterpillar epidemic. In 2021 and 2022, the population increased gradually and reached its peak with 4.6 and 4.2 larva/mrl during the second and first weeks of September (the 37th and 36th SMW, respectively). The peak averages for 2021 and 2022 were 28.5 °C, 77.2%, 229.4 mm, and 26.2 hours for temperature, mean relative humidity, precipitation, and sunlight, and 28.85 °C, 78%, 145.6 mm, and 49.7 hours, respectively. The population gradually decreased and disappeared after the first week of October (Table 1). A peak population of *S. litura* was also observed by Chechani *et al*. (2002) [2] in early September, which somewhat corroborates the results of this study. According to Gaur *et al.* (2015) [3], the latter week of August was when *S. litura* was most active, which confirms the results of this study.

Larval population of tobacco caterpillar exhibited a non-significant negative correlation with maximum temperature, morning relative humidity and sunshine hours while significant positive correlation with minimum temperature during the year 2021. The pest exhibited non-significant positive correlation with maximum and minimum temperature, rainfall and sunshine however non-significant negative correlation with morning and afternoon relative humidity during 2022. Yeotikar *et al.* (2015) [6] found no significant correlation between *S. litura* population and meteorological conditions.

According to the results of the multiple linear regression analysis, the population of tobacco caterpillars in the years 2021 and 2022 was affected by all-weather parameters in a total of 75.89% (R^2 = 0.7589) and 57.80% (R^2 = 0.578), respectively (Table 3).

ii) Green semilooper (*Chrysodeixis acuta*)

Semilooper infestation observed in 2021 and 2022 during the first week of August (the 31st SMW). The population increased gradually and reached its peak with larval populations of 2.2 and 1.7 larva/mrl in the first week of September (36th SMW) and the last week of August (35th SMW) in 2021 and 2022, respectively. The mean relative humidity, sunshine, rainfall, and temperature at the peak of activity were 28.85 °C, 77.55 %, 68.8 mm, and 50.3 hours in 2021 and 29 °C, 78.5 %, 182.8 mm, and 41.2 hours in 2022, respectively (Tables 2).

In 2021, the semilooper population showed a non-significant positive correlation with afternoon humidity and rainfall and a non-significant negative correlation with maximum temperature, morning humidity, and sunshine hours. There was a negative correlation with afternoon humidity, but a nonsignificant positive correlation with temperature, morning humidity, and sunshine. Rainfall has significant positive correlation during 2022 (Tables 4). According to the results of the multiple linear regression analysis, the population of semiloopers in the years 2021 and 2022 was affected by all meteorological parameters in a total of 75.03 percent (R^2 = 7.503) and 19.203 percent (R^2 = 0.192), respectively (Table 3).

The current results closely match those of Netam *et al.* (2013) [5], who found that the last week of August is the peak activity of lepidopteron pest.

iii) Predators

The predatory stink bug, *Eocanthecona furcellata* (Hemiptera: Pentatomidae) initially emerged on crops in 2021 and 2022 during the first week of August, averaging between 0.2 and 0.1 bugs per plant. Its density gradually increased, peaking at 2.1 and 1.2 bugs in the latter week of September and August of 2021 and 2022, respectively (Table 1 and 2).

Oxyopes satticus (Araneae: Oxyopidae), a predatory spider known as a lynx spider, initially appeared on the crop during the first week of August in 2021 and 2022, respectively, with a mean population of 0.1 and 0.2 spiders per plant. From the beginning of the crop growing period until the final week of September, they were actively found. The spiders left the crop after losing their host insects (Table 1 and 2).

Impact of predators on the incidence of caterpillars infesting soybean during, *Kharif*, 2021 and 2022

The population of lepidopterous caterpillars shown in Table 4 was correlated with the population of predators, such as predatory stink bugs and spiders. The correlation between spiders and all lepidopterous pests (*S. litura* and *C. acuta*) was found to be positive and non-significant in 2021 with "r" values of 0.529, and significant at 1% and positive with "r" values of 0.749 in 2022. Further correlation between predatory stink bug and lepidopterous pests was found to be positive but and significant at 1 percent with "r" values 0.904 and 0.791 in 2021 and 2022 respectively.

4. Conflict of interests

The authors have stated that there are no conflicting interests.

Table 1: Seasonal incidence of major insect pest and predators in soybean var. JS 335 during *Kharif* 2021

Std. Met. Week	Period	Abiotic factors						Mean larval population/mrl		No. of predators/plant	
		Temperature (^{0}C)		RH (%)		Rain fall (mm)	Sun shine (hr)	*S. litura*	*C. acuta*	Spiders	Predatory stink bug
		Max.	Min.	Morn.	Even.						
30	July23-29	33.8	24.2	85.3	69.0	74.8	30.7	0	0	0	0
31	Jul 30-Aug 5	31.2	23.0	84.9	68.7	302	23.9	1.3	0.7	0.1	0.2
32	Aug 6-12	33.6	24.3	85.0	69.9	133.4	59.9	1.8	1.1	0.3	0.5
33	Aug13-19	33.5	24.9	84.6	68.6	60.8	49.9	2.4	0.9	0.5	1.1
34	Aug20-26	33.6	24.6	85.6	69.4	54.8	49.5	2.7	1.4	1.6	0.8
35	Aug.27-Sept.2	31.5	25.2	84.4	70.0	27.4	39.1	3.1	1.6	1.2	1.4
36	Sept.3-9	33.0	24.7	85.4	69.7	68.8	50.3	3.7	2.2	0.8	2.1
37	Sep10-16	32.3	24.7	85.0	69.4	229.4	26.2	4.6	1.9	0.2	1.7
38	Sep17-23	32.3	23.6	84.4	69.0	114.6	41.7	2.3	1.2	0.3	1.2
39	Sept.24-30	32.7	24.3	86.7	69.6	33.4	53.1	2.1	0.4	0.1	0
40	Oct. 1-7	31.9	23.8	85.9	69.1	49.6	55.9	0	0	0	0
41	Oct 8-14	32.0	22.5	85.4	69.1	0	61.8	0	0	0	0

Table 2: Seasonal incidence of major insect pest and predators in soybean var. JS 335 during *Kharif* 2022

Std. Met. Week	Period	Abiotic factors						Mean larval population/mrl		No. of predators/plan	
		Temperature (^{0}C)		RH (%)		Rain fall (mm)	Sun-shine (hr)	*S. litura*	*C. acuta*	spiders	Predatory stink bug
		Max.	Min.	Morn.	Even.						
30	July23-29	32.5	24.1	86	70	133.2	18.9	0	0	0	0
31	Jul 30-Aug 5	32.0	24.6	85	70	148.8	28.8	1.2	0.2	0.2	0.1
32	Aug 6-12	33.7	23.9	86	70	180.4	26.7	1.8	0.6	0.4	0.3
33	Aug13-19	31.4	23.9	84	70	149.6	16.8	3.3	1.4	0.7	0.6
34	Aug20-26	32.8	23.5	87	70	209.6	39.6	2.9	1.5	1.3	1.2
35	Aug.27-Sept.2	33.5	24.6	87	70	182.8	41.2	3.8	1.7	0.8	0.7
36	Sept.3-9	34.3	25.4	86	70	145.6	49.7	4.2	1.3	0.6	1.1
37	Sep10-16	33.6	25.1	84	70	115.0	58	3.4	0.7	0.3	0.5
38	Sep17-23	33.5	24.0	86	70	58.8	33.1	2.8	1.1	0.2	0
39	Sept.24-30	31.9	24.3	88	70	149.0	52.6	0	0.3	0.1	0
40	Oct. 1-7	32.2	24.0	86	71	77.0	26.9	0	0	0	0
41	Oct 8-14	31.5	23.0	86	70	6.0	50	0	0	0	0

Table 3: Correlation coefficient and regression equation between insect pest population and weather parameters during *Kharif* 2021 and 2022

Sl.	Pest	Temperature (°C)		R. H. (%)		SS (hr.)	Rainfall (mm)	Regression equation
		Max.	Min.	7:00 AM	2:00 PM			
1	Tobacco caterpillar							
	2021	-0.13NS	0.62*	-0.38NS	0.32 NS	0.26 NS	-0.29NS	$Y = - 17.133 – 0.495(X_1) + 1.544(X_2) -0.322(X_3) +0.338(X_4) + 0.008 (X_5) + 0.027(X_6)$ $R^2 = 0.7589$
	2022	0.51 NS	0.47NS	-0.18NS	-0.32NS	0.48NS	0.19NS	$Y = 53.302 + 0.670(X_1) – 0.248(X_2) - 0.632(X_3) -0.237(X_4) + 0.016(X_5) + 0.037(X_6)$ $R^2 = 0.578$
2	Green semilooper							
	2021	-0.12NS	0.57*	-0.48NS	0.37NS	0.26NS	-0.24NS	$Y = -7.503 - 0.149(X_1) + 0.570(X_2) - 0.405(X_3) +0.476(X_4) + 0.004(X_5) + 0.014(X_6)$ $R^2 = 0.578$
	2022	0.35NS	0.22NS	0.08NS	-0.31NS	0.57*	0.09NS	$Y = 19.209 + 0.217(X_1) – 0.250(X_2) - 0.099(X_3) -0.175(X_4) + 0.007(X_5) + 0.009(X_6)$ $R^2 = 0.445$

*Significant at 5%, **Significant at 1%, NS- Non significant, Y=Dependent variable, R^2 – Coefficient of determination, X_1& X_2 - Max. and Min. temp.(°C), X_3 & X_4 - R.H. (%) at 7:00 AM and 2:00 PM, X_5 - Sun shine (hours), X_6 - Rainfall **(mm)**

Table 4: Influence of predators on the incidence of caterpillars infesting soybean during, *Kharif*, 2021 and 2022

Std. Met. Week	Period	2021			2022		
		No. of predators/plant		Incidence of insect pests	No. of predators/plant		Incidence of insect pests
		Spider	Predatory stink bug	No. of caterpillar/mrl	Spider	Predatory stink bug	No. of caterpillar/mrl
31	Jul 30-Aug 5	0.1	0.2	1	0.2	0.1	0.70
32	Aug 6-12	0.3	0.5	1.45	0.4	0.3	1.20
33	Aug13-19	0.5	1.1	1.65	0.7	0.6	2.35
34	Aug20-26	1.6	0.8	2.05	1.3	1.2	2.20
35	Aug.27-Sept.2	1.2	1.4	2.35	0.8	0.7	2.75
36	Sept.3-9	0.8	2.1	2.95	0.6	1.1	2.75
37	Sep10-16	0.2	1.7	3.25	0.3	0.5	2.05
38	Sep17-23	0.3	1.2	1.75	0.2	0	1.95
39	Sept.24-30	0.1	0	1.25	0.1	0	0.15
40	Oct. 1-7	0	0	0	0	0	0.00
41	Oct 8-14	0	0	0	0	0	0
Correlation co- efficient (r)		Spider		0.529	Spider		0.749**
		Predatory stink bug		0.904**	Predatory stink bug		0.791**

5. Conclusions

Basic knowledge regarding the seasonal presence of insect pests and their predators' peak activity is provided by studies on the incidence of insect pests and their natural enemies of the soybean crop. Weather influences on insect pest populations are also revealed by correlation studies of insect pests with pest populations. The data gathered for this study is helpful in managing insect pests.

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