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Influence of Abiotic Factors on Trap Catch of Gram Pod Borer, *Helicoverpa armigera* (Hubner) in Redgram, *Cajanus cajan* (L.) Millsp. Ecosystem

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Abstract

An experiment was conducted to study the influence of weather parameters on trap catches of *Helicoverpa armigera* (Hubner) in redgram *Cajanus cajan* (L.) ecosystem during *kharif* 2017 at experimental farm of NPRC, Vamban and farmer's field at Vadakaddu with green colour funnel pheromone traps containing Heli lure. The highest catch (98 moths/ 5 traps) was recorded on January 2nd SMW at Vamban and on 52nd SMW of December at Vadakaddu. In both the locations lowest catch of 20 moths/ 5 traps and 30 moths/ 5 traps were recorded on 35th SMW. The moth catches had highly significant negative correlation with maximum temperature ($r = -0.79^{**}$), ($r = -0.79^{**}$), minimum temperature ($r = -0.66^{**}$), ($r = -0.68^{**}$), wind speed ($r = -0.71^{**}$), ($r = -0.73^{**}$), rainfall ($r = -0.54^{**}$), ($r = -0.51^{**}$), rainy days ($r = -0.54^{**}$), ($r = -0.52^{**}$) and sunshine hours ($r = -0.44^{**}$), ($r = -0.42^{**}$) at Vamban and Vadakaddu, respectively. But there was highly significant positive correlation with relative humidity ($r = 0.78^{**}$) and ($r = 0.76^{**}$) at Vamban and Vadakaddu, respectively. The regression analysis resulted with an R^2 value of 0.791, which indicates that 79.1% catches depends on all the weather parameters at Vamban and R^2 value of 0.829 indicating that 82.9% of catches depends on all the weather parameters at Vadakaddu.

Keywords: Gram Pod Borer, *H. armigera*, Redgram, Trap catches, Weather parameters

Introduction

Pulses hold significant significance in a balanced diet due to their exceptional nutritional content. In recognition of their nutritional importance, the FAO declared the year 2016 as "The International Year of Pulses," emphasizing the crucial role that pulses play in a healthy diet. India stands as a prominent global hub for pulse cultivation, contributing to approximately 35-36% of the total pulse-growing area and 27-28% of pulse crop production worldwide (Swathi *et al.*, 2018). In India, an impressive 12-14 million tons of pulses are produced annually, utilizing approximately 22-24 million ha of agricultural land for this purpose (Cherif and Grissa-Lebdi, 2017; Swathi *et al.*, 2018). The global production of Redgram is 36.81 lakh tonnes in an area of 4.75 million ha and the productivity is 775 kg ha^{-1} in 2010-2011. In India the production is 4.23 million tonnes in an area of 5.13 million ha and the productivity is 824 kg ha^{-1} in 2016-2017. Tamil Nadu produces 60.4 million tonnes of pulses in an area of 60.9 million ha and productivity is 992 kg ha^{-1} (Lakshmi Narayanan *et al.*, 2018).

Pulse crops are susceptible to infestation by over 40 different species of insect pests (Sharma *et al.*, 2005). Among these, the Gram pod borer, scientifically known as *Helicoverpa armigera* (Hubner), poses a significant threat to pulse crops. Its elevated levels of polyphagy,

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mobility, rapid reproduction rate and the ability to enter diapause are key factors that contribute to its status as a major pest of pulses (Fitt, 1989; Lekha Priyanka *et al.*, 2020). This pest initiates its infestation during the seedling stage and subsequently consumes flowers and developing seeds within pods until the crop reaches maturity (Lekha Priyanka *et al.*, 2020; Mandal and Roy, 2012). This pest causes 30-40% pod damage and 400 kg ha^{-1} grain loss. Under favourable conditions, pod damage goes even up to 90%. Farmers heavily depend on chemical pesticides to manage this pest in pulse crops. However, the intensive and indiscriminate application of these pesticides can result in detrimental consequences for the ecosystem. These include the development of resistance to insecticides, environmental degradation, negative impacts on beneficial plant and animal species, and the resurgence of secondary pests (Lekha Priyanka *et al.*, 2020; Phokela *et al.*, 1990). Managing pod borers with chemical insecticides is complicated due to the cryptic behavior of the larvae. Consequently, there is a growing imperative to address this pest using eco-friendly methods. Utilizing pheromone traps for pest control offers an environmentally benign and cost-effective approach. Behavioral control through pheromone traps represents a recent advancement in pest management and serves as an excellent tool, not only for monitoring and forecasting (Lekha Priyanka *et al.*, 2020), but also for effective pest management.

Materials and Methods

The field experiments were carried out at the farmland of National Pulses Research Centre (NPRC) Vamban (10°36′ N and 78°90′ E) and farmer's field at Vadakaddu (10°34′ N and 79°06′ E), Pudukottai, Tamil Nadu. Pudukottai experiences a semi-arid climate characterized by consistently high temperatures round the year and relatively limited rainfall. In both of these areas, the average maximum temperature hovers around 35.4 °C, while the minimum temperature is approximately 23.2 °C. Over the past decade, the mean annual rainfall has measured 881 mm, occurring over 45 rainy days, as reported by the NPRC weather station. The soil in these regions is primarily red laterite with an acidic pH ranging from 3.9 to 6.5. Due to Pudukottai's status as a prominent pulse cultivation region, it was chosen as the research site.

A total of ten green-colored funnel traps were set up in the field where VBN-2 (long duration) Redgram was raised. The traps were fixed in an erect stick of four feet height. Polythene cover of the trap was secured at the bottom by folding it and affixing it with a stick to prevent the insects from escaping (Lekha Priyanka *et al.*, 2020). In order to count the insects, the thread at the bottom was removed. Hexadecanol lures (Heli lures) made up of rubber septum was placed in the provision at the centre of the lid. The lures were replaced in every 15 days. The traps were positioned at a distance of 2 m from one another for monitoring purposes in the Redgram field (Ugale *et al.*, 2011). The similar procedure was adopted in Vadakaddu. The adults of *H. armigera* were collected and counted once in a week at evening hours to work out the weekly moth catches.

Statistical Analysis

Data on weekly trap catches of adults were recorded from Vamban and Vadakaddu. Weather parameters from August (32nd standard week) to February (9th standard week) were collected from NPRC weather station. We performed correlation and regression analyses using IBM SPSS software to assess the relationship between the weekly average weather parameter values and the catches of *H. armigera* in pheromone traps.

Results and Discussion

Study was conducted for a period of 28 standard weeks from 2017 August month 32nd standard week to 2018 February month 9th standard week. The catches were obtained all over the study duration with fluctuating population in Vamban as well as in Vadakkaddu. However in both the locations the minimum number of catches of *H. armigera* was noticed in the month of August. Whereas the maximum catches was in the month of January in Vamban and December in Vadakkaddu. The obtained results were interpreted as follows.

Correlation of Weather Parameters with Weekly Moth Catches in Vamban

The maximum number of moths recorded throughout the study period was 98 moths/ 5 traps in January 2nd standard week. Next in rank was 97.6 moths/ 5 traps in the month of December (51st standard week). Minimum catch was recorded in August month 35th standard week (20 moths/ 5 traps) which was followed by 28 moths/ 5 traps noticed in the month of august (34th standard week), as represented in table 1 and figure 1. The trap catches exhibited a highly significant positive correlation with relative humidity ($r = 0.78^{**}$). Conversely, highly significant negative correlations were observed with Maximum temperature ($r = -0.79^{**}$), Minimum temperature ($r = -0.66^{**}$), Wind speed ($r = -0.71^{**}$), Rainfall ($r = -0.54^{**}$), Rainy days ($r = -0.54^{**}$) and Sunshine hours ($r = -0.44^{**}$) (Table 3). The present results align with previous research by Chatar *et al.* (2010), who reported a highly significant negative correlation between the larval population of *H. armigera* and maximum temperature, as well as a significant negative correlation with minimum temperature. They also found a highly significant positive correlation between pest population and relative humidity. Likewise, Ugale *et al.* (2011) discovered a negative and significant correlation between the *H. armigera* population and mean atmospheric temperature, consistent with our findings. Additionally, Dajya *et al.* (2010) observed a positive correlation between relative humidity and the population of *H. armigera*.

The regression equation fitted with weather parameter was,

$$Y = 53.36 - 3.27X_1 - 1.38X_2 + 2.10X_3 - 6.81X_4 - 0.41X_5 + 5.37X_6 - 3.06X_7$$

The R^2 value obtained in regression analysis was 0.791 which indicates the 79.1% catches depends on all the weather parameters. The regression analysis indicated that 1 °C increase in maximum and minimum temperature would tend to decrease the catches by 3.27% and 1.38% respectively.

Table 1: Seasonal incidence of *H. armigera* in Vamban during *kharif* 2017

SW No.	Moth catch/ 5 traps	Max tem (°C)	Min temp (°C)	RH (%)	Wind speed (km hr^{-1})	Rainfall (mm)	Rainy day	Sunshine hours (hrs day^{-1})
Aug 32	29	34.6	26.2	84.7	3.09	39.8	2	7.65
33	32	33.1	25	86	3.8	95.9	4	5.22
34	28	34.1	24.5	86.1	3.8	46.6	4	5.21
35	20	34.6	20.2	83.4	3.04	0	0	6.99
Sep 36	35	33.9	24.1	81.1	2.87	18.8	1	6.12
37	37	33.5	23.5	80.9	2.67	21.4	1	7.74
38	33	35.4	23.5	80.1	3.74	0	0	7.70
39	40	35.6	24.8	81.8	4.46	10.4	2	7.05
Oct 40	42	34	23.4	82	1.6	63	2	6.87
41	46	33.4	22.6	82.8	1.69	43.4	2	5.52
42	32	33.1	22.8	82.5	2.02	0	0	5.62
43	48	32.8	22.7	83.4	3.09	5.2	1	6.50
44	60	32.7	21.7	82.3	3.03	15.6	2	7.15
Nov 45	58	31.1	21	83.1	2.97	16.6	2	4.30
46	66	31.8	21.7	83.1	3.18	0	0	5.50
47	78	31.8	21.8	85	3.27	6.6	1	4.50
48	85	32.1	21.9	85.4	3.16	52.8	4	1.66
Dec 49	95.8	32	22.1	86	1.02	0	0	1.64
50	97.2	32.7	21.7	90	0.61	0	0	6.41
51	97.6	28.8	21.5	91.4	1.01	0	0	4.45
52	96.2	29.7	21.7	92.5	1.33	0	0	1.93
Jan 1	96.8	30.4	20.6	92	1.43	0	0	6.92
2	98	30.6	20.4	91	1.26	3.9	1	6.47
3	63.8	29	21	88	1.77	0	0	8.11
4	62.8	30.9	20.3	86	2.76	0	0	8.00
5	57.6	30.5	20.9	86	3.08	0	0	7.13
Feb 6	56.6	32.1	22.1	86	2.84	0	0	7.37
7	59	31.7	21.7	83	3.22	0	0	7.62
8	56	32	22.1	84	2.28	0	0	8.35
9	56.8	32.1	22.3	84	3.13	0	0	8.23

One unit increase in relative humidity may increase the number of catches by 2.10%. Whereas the regression equation notifies that one unit increase in wind speed, rainfall and sunshine hours will decrease the total number of catches by 6.81%, 0.41% and 3.06%, respectively. However, in contrast to rainfall, it is noteworthy that an increase in the number of rainy days is associated with a 5.37% increase in the total catch (as shown in Table 4). In a related study, the R^2 value for the lepidopteran caterpillar (*Nausinoe geometralis*) was calculated at 0.898, indicating that 89.8% of the pest's behavior was influenced by the various weather parameters (Pirithiraj *et al.*, 2020).

Correlation of Weather Parameters with Weekly Moth Catches in Vadakaddu

The maximum number of catches was obtained in the month of December (52nd standard week) with 98 moths/ 5 traps. It was followed by 97.4 moths/ 5 traps observed in the same month December (49th standard week). Minimum number of catches was recorded in August month (35th standard week) which was 30 moths/ 5 traps. Next was 32 moths/ 5 traps noticed in the month of August (32nd standard week), as represented in table 2 and figure 2. The catches were highly significant and positively correlated with relative humidity ($r = 0.76^{**}$). Highly Significant and negatively correlated with maximum temperature ($r = -0.79^{**}$), minimum temperature ($r = -0.68^{**}$), Wind speed ($r = -0.73^{**}$), Rainfall ($r = -0.51^{**}$), Rainy days ($r = -0.52^{**}$) and Sunshine hours ($r = -0.42^{**}$) as given in table 3. Our research outcomes differ from those of Rawat *et al.* (2017), who found that the *H. armigera* population had a positive correlation with maximum temperature and minimum temperature, along with a significant negative correlation with relative humidity. Keval *et al.* (2017) similarly noted a significant positive correlation between the *H. armigera* population and maximum temperature, coupled with a significant negative correlation with relative humidity. In contrast, Ojha *et al.* (2017) reported positive correlations between mean atmospheric temperature and wind speed, while they found a negative correlation with relative humidity in relation to pest population. These variations could be attributed to the specific weather conditions prevailing in our research location.

The regression equation fitted with the weather parameter was,

$$Y = 44.34 - 2.41X_1 - 0.73X_2 + 1.73X_3 - 7.02X_4 - 0.39X_5 + 4.13X_6 - 2.42X_7$$

The regression analysis resulted with an R^2 value of 0.829 indicating that the 82.9% of catches depends on all the weather parameters. The regression analysis indicates that 1 °C increase in maximum and minimum temperature would decrease the catches by 2.41% and 0.73%, respectively. Whereas one unit increase in relative humidity and rainy days tend to increase the catches by 1.73% and 4.13%. However increase in one unit of wind speed, rainfall and sunshine hours will decrease the number of catches by 7.024%, 0.39% and 2.42%, as indicated in table 4. In a similar study, the 1 °C increase of minimum temperature decreased the shoot damage and fruit damage due to *Earias vittella* by 1.53% and 1.47% per five plants week^{-1} (Archunan *et al.*, 2018).

Table 2: Seasonal incidence of H. *armigera* in Vadakaddu during *kharif* 2017

SW No.	Moth catch/ 5 traps	Max tem (°C)	Min temp (°C)	RH (%)	Wind speed (km hr^{-1})	Rainfall (mm)	Rainy day	Sunshine hours (hrs day^{-1})
Aug 32	32	34.6	26.2	84.7	3.09	39.8	2	7.65
33	36	33.1	25	86	3.8	95.9	4	5.22
34	39	34.1	24.5	86.1	3.8	46.6	4	5.21
35	30	34.6	20.2	83.4	3.04	0	0	6.99
Sep 36	44	33.9	24.1	81.1	2.87	18.8	1	6.12
37	42	33.5	23.5	80.9	2.67	21.4	1	7.74
38	40	35.4	23.5	80.1	3.74	0	0	7.70
39	48	35.6	24.8	81.8	4.46	10.4	2	7.05
Oct 40	50	34	23.4	82	1.6	63	2	6.87
41	54	33.4	22.6	82.8	1.69	43.4	2	5.52
42	46	33.1	22.8	82.5	2.02	0	0	5.62
43	58	32.8	22.7	83.4	3.09	5.2	1	6.50
44	60	32.7	21.7	82.3	3.03	15.6	2	7.15
Nov 45	64	31.1	21	83.1	2.97	16.6	2	4.30
46	62	31.8	21.7	83.1	3.18	0	0	5.50
47	68	31.8	21.8	85	3.27	6.6	1	4.50
48	75	32.1	21.9	85.4	3.16	52.8	4	1.66
Dec 49	97.4	32	22.1	86	1.02	0	0	1.64
50	95.2	32.7	21.7	90	0.61	0	0	6.41
51	93.2	28.8	21.5	91.4	1.01	0	0	4.45
52	98	29.7	21.7	92.5	1.33	0	0	1.93
Jan 1	95.8	30.4	20.6	92	1.43	0	0	6.92
2	96	30.6	20.4	91	1.26	3.9	1	6.47
3	64.2	29	21	88	1.77	0	0	8.11
4	63.2	30.9	20.3	86	2.76	0	0	8.00
5	67.8	30.5	20.9	86	3.08	0	0	7.13
Feb 6	65.2	32.1	22.1	86	2.84	0	0	7.37
7	64.8	31.7	21.7	83	3.22	0	0	7.62
8	62	32	22.1	84	2.28	0	0	8.35
9	63.8	32.1	22.3	84	3.13	0	0	8.23

Table 3: Correlation of weather parameters with weekly moth catches in Vamban and Vadakaddu

Location/ weather parameters	Max tem	Min temp	RH	Wind speed	Rainfall	Rainy days	Sunshine hours
Vamban	-0.79**	-0.66**	0.78**	-0.71**	-0.54**	-0.54**	-0.44**
Vadakaddu	-0.79**	-0.68**	0.76**	-0.73**	-0.51**	-0.52**	-0.42**

**Significant at 5% level

Table 4: Multiple linear regression analysis number of catches (y) and weather parameters (x)

Variables	Partial regression coefficient	Standard error	t-value	R^2
Vamban				
X_1: Maximum temperature	-3.274	2.489	-1.315*	
X_2: Minimum temperature	-1.387	2.586	-0.536NS	
X_3: Relative humidity	2.109	1.158	1.820*	
X_4: Wind speed	-6.812	3.840	-1.774*	0.791
X_5: Rainfall	-0.417	0.239	-1.739*	
X_6: Rainy days	5.372	4.775	1.124*	
X_7: Sunshine hours	-3.066	1.537	-1.993*	
Vadakaddu				
X_1: Maximum temperature	-2.414	1.887	-1.279*	
X_2: Minimum temperature	-0.730	1.960	-0.372NS	
X_3: Relative humidity	1.730	0.878	1.969*	
X_4: Wind speed	-7.024	2.911	-2.412*	0.829
X_5: Rainfall	-0.394	0.181	-2.170*	
X_6: Rainy days	4.134	3.620	1.141*	
X_7: Sunshine hours	-2.422	1.166	-2.077*	

*Significant at 5% level

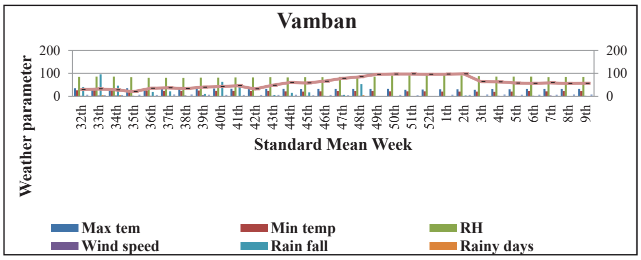

Figure 1: Seasonal incidence of *H. armigera* in Vamban during *kharif* 2017

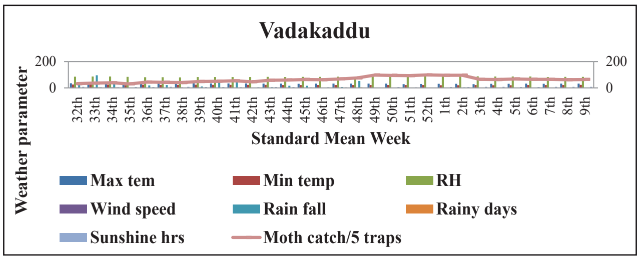

Figure 2: Seasonal incidence of *H. armigera* in Vadakaddu during *kharif* 2017

Conclusion

The pest population was prevalent throughout the study period (from August month 32nd standard week to February month 9th standard week). In Vamban, the population ranged from 20-98 moths/ 5 traps, whereas, in Vadakkaddu, it ranged from 30-98 moths/ 5 traps. The current research indicates that the pest occurrence of *H. armigera* was positively correlated with relative humidity and negatively correlated with other weather parameters. Hence appropriate crop protection practises are to be implemented when relative humidity is higher and in winter season. There was a considerable fluctuation in the population of *H. armigera* during the study period. Hence integrated management practices can be followed during the peak occurrence of the pest for effective management.

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