International Journal of Environment and Climate Change

Volume 14, Issue 3, Page 383-392, 2024; Article no.IJECC.114081
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Seasonal Incidence and Infestation Pattern of Sunflower Head Borer (*Helicoverpa armigera*) and Leaf Eating Caterpillar (*Spodoptera litura*) under the Influence of Climatic Factors

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2024/v14i34050

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/114081

Original Research Article

Received: 02/01/2024
Accepted: 07/03/2024
Published: 11/03/2024

ABSTRACT

Field experiments were conducted at Regional Research and Technology Transfer Station (RRTTS), Ranital, Bhadrak, OUAT during the summer seasons of 2019-20 and 2020-21 to study the seasonal incidence of sunflower head borer and leaf-eating caterpillar in sunflower in relation to the abiotic factor. The seasonal incidence of the target insects, *Spodoptera litura* and *Helicoverpa armigera,* was investigated using pheromone traps installed in the unprotected sunflower plots (10 m x 5 m) at the research block. The trap catches of male adults were expressed as a number of males trapped per trap per week. In the observation plots, the sunflower hybrid Aruna was cultivated with the approved agronomic package of techniques without any plant protection measures. Weekwise larval populations of *Spodoptera litura and Helicoverpa armigera* were

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counted from 10 randomly selected tagged plants starting from the initiation of damage and expressed as larval intensity i.e. average larval population per plant. Besides, weekwise incidence of the pest (leaf damage by *tobacco caterpillar* and head damage by head borer) were also recorded. The findings of the investigation indicated that tobacco caterpillars' adult activity commenced from the 5th to 6th standard weeks (1st and 2nd week of February) and peak activity in the 11th standard week (3rd week of March). Similarly, the larval population began to appear in the 6th to 7th standard weeks in 2020 and 2021, respectively with a peak population build-up stage during the 12th standard week and their activity steadily decreased as the cropping season progressed. The peak infestation stage coincided with the period of maximum larval activity and the pest caused sizable damage from the early vegetative stage to the peak flowering stage of the crop. The sunflower head borer (*Helicoverpa armigera*) infested sunflower crops throughout the reproductive stage of the plant with adult activity beginning in the 9th to 10th standard weeks (last week of February-first week of March) and attaining the peak in the 12th to 13th standard weeks (3rd-4th week of March). Similarly, the larval population began to appear in the 10th to 11th standard week and reached the peak in the 13th to 14th standard week (last week of March to first week of April).

Various environmental parameters *viz*. temperature, relative humidity and rainfall were collected from the automated weather station of Gramin Krishi Mausam Sewa (GKMS) located at RRTTS, Ranital., These abiotic factors were correlated with trap catch, larval intensity, leaf damage head damage to study the influence of ecological parameters on pest incidence and infestation. The findings of the investigation indicated that among the abiotic factors temperature had a positive influence and relative humidity exhibited a negative effect on the population and damage of *Spodoptera litura*. All the temperature variables and bright sunshine hour (BSH) exhibited a significant positive correlation and relative humidity (afternoon) had a significant negative correlation with the head damage *Helicoverpa armigera.*

Keywords: Sunflower; tobacco caterpillar; head borer; seasonal incidence; abiotic factors.

1. INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the principal and promising oilseeds crop next to groundnut, mustard and soybean in India and is making a rapid stride in the oil seed scenario of the country particularly after the inception of Technology Mission on Oil seed programme. Nutritional value of sunflower is quite promising as its seed contains 14–19% protein, 40–45% oil and 30– 35% carbohydrates and its oil is rich in oleic and linoleic acid which not only look after the cardiac health of human being but also is considered to be safe for the patients having heart problem. It contains sufficient amount of calcium, iron and vitamins like A, D, E and B complex [1]. The shortage of edible oils has become a chronic problem in India with increasing demographic pressure and sunflower can play an important role in meeting out the shortage of edible oils in the country by virtue of its shorter duration, low photo- and thermo-sensitivity and wider adaptability to different agro-ecological situations [2]. Though, sunflower has been proved to be as a highly promising crop under different agro-climatic regions of India, its productivity is quite low despite of the release of several hybrids and the development of an improved package of practices**.** The production and productivity of sunflowers is greatly constrained by various biotic factors and among them, insect pests cause substantial yield loss in this crop. Though about 251 insect pests are reported to infest the sunflower crop, defoliators, head borers, leafhoppers, thrips and whiteflies are considered the key pests [3]. Among these, the polyphagous insect pests like tobacco caterpillar (*Spodoptera litura*) and Head borer (*Helicoverpa armigera*) are assuming serious significance under the changing climatic scenario and are reported to cause heavy economic damage in sunflower [4]. One of the major reasons attributed to the decline in the cultivated area under sunflowers in different states is the widespread outbreak of these insect pests [5]. The productivity of sunflowers is limited mainly due to the heavy damage inflicted by the capitulum borer resulting in yield losses of 20-25 percent under normal conditions however, in certain cases; the damage is so severe that the loss can surpass 40-70 percent [6].

Conducting study on incidence of different insect pest and natural enemies may be the right research tool to investigate the existence of different insect pests, level of incidence at different stages of the crop during the growing season and their natural enemies abundance in sunflower ecosystem [7].

2. MATERIALS AND METHODS

The seasonal incidence of the target insects, *Spodoptera litura* and *Helicoverpa armigera,* was investigated using pheromone traps installed in the unprotected sunflower plots (10 m x 5 m) at RRTTS, Ranital, Bhadrak research block. The trap catches of male adults were expressed as number of males trapped per trap per week.In the observation plots, the sunflower hybrid Aruna was cultivated with the approved agronomic package of techniques without any plant protection measures. Three pheromone traps (funnel traps) were set at 5 m intervals in each plot, with the lure position at 45 cm above the crop canopy. The lures (Spodo lure and Heli lure manufactured by Pest Control India Ltd.) were changed at every three weeks interval. Week wise larval population of *Spodoptera litura and Helicoverpa armigera* were counted from 10 randomly selected tagged plants starting from the initiation of damage and expressed as larval intensity i.e. average larval population per plant. Besides, weekwise incidence of the pest (leaf damage by *tobacco caterpillar* and head damage by head borer) were also recorded.

Various environmental parameters viz. temperature, relative humidity and rainfall were collected from the automated weather station of Gramin Krishi Mausam Sewa (GKMS) located at RRTTS, Ranital., These abiotic factors were correlated with trap catch, larval intensity, leaf damage head damage to study the influence of ecological parameters on pest incidence and infestation. Regression analysis was taken to estimate the contribution of each abiotic factor on pest incidence and damage. In all the cases of analysis, the abiotic factors that prevailed during the previous standard week were correlated and regressed with the pheromone trap catch, larval intensity and damage recorded in the succeeding week.

3. RESULTS AND DISCUSSION

The seasonal activity of sunflower head borer and tobacco caterpillar was studied during the summer seasons of 2019-20 and 2020-21. The adult moth population trapped in the respective pheromone traps and the corresponding larval population and the extent of damage throughout the crop growth period have been reflected in the following sections.

3.1 Seasonal Incidence of Tobacco Caterpillar (*Spodoptera litura*)

A wide variation in the adult moth activity of tobacco caterpillar was noticed during both the years of investigation as evidenced from the Fig. 1. The pheromone trap catch data indicated that during the year 2019-20, the moths made their first appearance at 6th standard week (SW) (second week of February) i.e. 26 days after sowing. The trap catch showed an increasing trend till the 11th SW (third week of March), which was found to be the peak population build up stage of the pest with an average trap catch of as high as 104.33. Thereafter, the adult moth activity was gradually declining towards the end of the cropping season. However, during the subsequent year of experiment i.e. 2020-21, the moth activity was first observed at 5th SW (first week of February) i.e. 18 days after sowing and attained the peak during 11th SW (third week of March) with an average pheromone trap catch of 109.33. The moth activity thereafter declined with the minimum trap catch towards the end of the crop season. The pheromone trap catch data indicated that a higher adult activity was observed during 9th SW (last week of February) to 13th SW (last week of March).

It was evident from Fig. 2 that during the year 2019-20 the larval infestation started with a minimal 0.74 larvae/plant/week from the 7th SW (third week of February) and increased progressively thereafter. The maximum larval activity was noticed during 12thSW (fourth week of March) with a larval intensity of 15.56 and the larval activity declined steadily thereafter to attain a minimum level towards the end of the crop season. During 2020-21, the larvae of tobacco caterpillar made their first appearance during the 6th SW (second week of February) with a minimum larval load per plant (0.82) and continuously increased till the 12th SW (fourth week of March) with the maximum larval intensity of 16.38. The average larval population decreased towards the crop maturity stage. A higher larval population of tobacco caterpillar was observed during the 10th SW (second week of March to 15th SW (second week of April) during both years of the experiment.

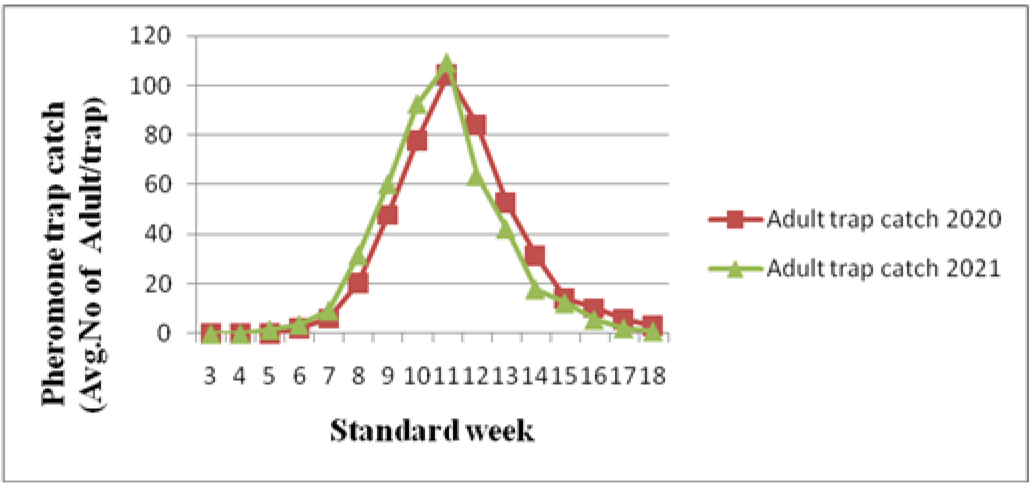

Fig. 1. Seasonal trend of pheromone trap catch of *Spodoptera litura* (Summer 2019-20 and 2020-21)

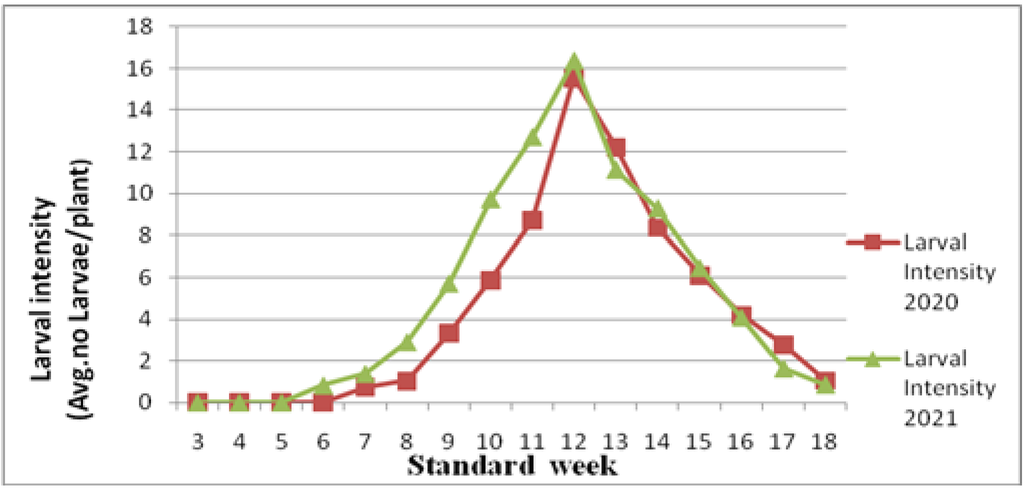

Fig. 2. Seasonal trend of Larval intensity of *Spodoptera litura* (Summer 2019-20 and 2020-21)

During the year 2019-20, the leaf infestation by *Spodoptera litura* was initiated at the 7th SW (third week of February) with minimum leaf damage of 3.26 %, which increased thereafter and attained the peak infestation stage at the 12th SW (fourth week of March) with 38.65 % damage. In the second year of the experiment, though the infestation commenced at the 6th SW (second week of February), the peak infestation period was observed on the 12th SW (41.45 % damage). It was evident from both years of investigation that damage by tobacco caterpillars was more from the vegetative stage to the maximum flowering stage and the extent of damage was declining towards the crop maturity stage.

The results of the present investigation were substantiated with the findings of Chalapathi Rao et al., [8] who revealed that the tobacco caterpillar *S. litura* has a high prevalence in December, January, and February sown crops. Topagi [9] also opined that the seasonal prevalence of *S. litura* on sunflower crop steadily increased from the second week of January to the second week of March a peak population documented in the first week of April for the February sown crop. Further Basit et al., [10] also reported that *Spodoptera litura* remained active from the early vegetative stage to the reproductive stage of the sunflower crop and its maximum population was recorded during the third week of March.

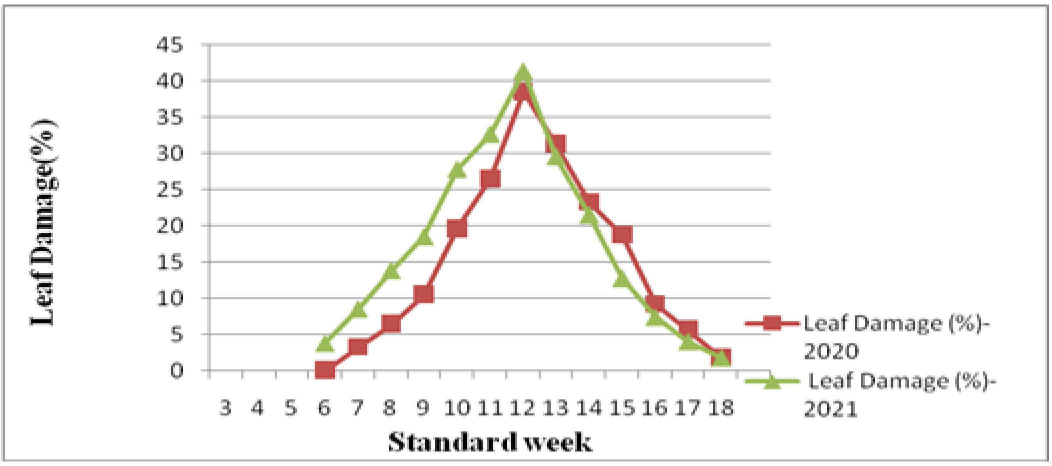

Fig. 3. Seasonal trend of leaf Damage by *Spodoptera litura* (Summer 2019-20 and 2020-21)

3.2 Seasonal Incidence of Sunflower Head Borer (*Helicoverpa armigera*)

As shown in the Fig. 4, there was a significant variation in the adult moth activity of *Helicoverpa armigera* over both the years of investigation. The pheromone trap catch data indicated that during the year 2019-20, the moths made their first appearance at 9th standard week (SW) (last week of February) i.e. 56 days after sowing. The trap catch showed an increasing trend till the 12th SW (third week of March), which was found to be the peak population build up stage of the pest with an average trap catch of 10.67. Following that, as the cropping season progressed, adult moth activity began to decline. During the following year of the experiment, 2020-21, moth activity was initially noticed at 10th SW (first week of March), 63 days after sowing, and peaked at 13th SW (last week of March), with an average pheromone trap catch of 8.33. The moth activity, thereafter decreased with the minimum trap catch towards the end of the crop season. The pheromone trap catch data indicated that a higher adult activity was observed during 13th SW (last week of March) to 16th SW (third week of April).

During 2019-20, the larval infestation began with a minimum of 0.48 larvae/plant/week on the 10th SW (first week of March) and gradually increased thereafter (Fig. 5). The highest larval activity was seen during the 13th SW (last week of March) with a larval intensity of 5.45 and the activity gradually decreased thereafter, reaching a minimum towards the end of the crop season. The larvae of the sunflower head borer first appeared in 2020-21 during the 11th SW (second week of March) with a low larval load per plant (0.36) and gradually rose until the 14th SW (first week of April) with a maximum larval intensity of 4.86. As the crop reached maturity, the average larval population declined. During both years of the experiment, a higher larval population of head borer was observed from the 13th SW (last week of March) to the 16th SW (third week of April).

During 2019-20, *Helicoverpa armigera* began infesting sunflower crop at the 10th SW (first week of March) with minimal damage of 3.08 %, then progressed to attain the peak infestation stage at 13th SW (fourth week of March) with 21.34 per cent damage (Fig. 6). During the second year of the experiment, the infestation began on the 11th SW (second week of March), and the peak infestation stage was noted on the 14th SW (18.56 per cent damage). It was evident from both the years of investigation that damage by sunflower head borer was more from the flowering stage to the heading stage and the extent of damage was declining towards the crop maturity stage.

The results of the present investigation are in close conformity with the findings of Visalakshmi et al., [11] who opined that, the major activity of *Helicoverpa armiigera* in the summer crop was during March-April and at Hyderabad situation the peak adult activity in sunflower crop was during the 2nd week of February (55 moths/trap) and the maximum larval activity was at 3rd week of February (19 larvae/plant) in Sunflower. According to Bajya and Monga [12], the *Helicoverpa armigera* started infesting the summer sunflower crop in March and remained active until the beginning of June. Zafaret al., (2013) also observed that the egg count of sunflower head borer was in an increasing trend from 12th April to 27th April and thereafter decreased in the subsequent dates of observation. Further Basit et al., [10], who informed that the maximum population of *H. armigera* (4.20 larvae/ plant) was recorded during fourth week of March and infested the sunflower crop for 2 -3 weeks only during the month of March and afterward it was disappeared.

3.3 Influence of Abiotic Factors on the Population Dynamics and Damage of Tobacco Caterpillar and Sunflower Head Borer

Various weather parameters like temperature (maximum, minimum, average temperature and temperature gradient), relative humidity (morning and afternoon), rainfall, Bright Sunshine Hour (BSH) and Wind Velocity as prevailed during the crop growth periods in the summer seasons of 2019-20 and 2020-21 were subjected to correlation analysis with the adult trap catch, larval intensity and the damage of insect pests under study and the correlation coefficient values thus obtained have been presented in Tables 1 and 2. For the correlation studies, the weather parameters that prevailed one week ahead of the pest appearance and initiation of damage were taken into consideration as the environmental factors in the preceding week normally influence the prevalence and biology of the insect pests and damage caused by them. The results so obtained are discussed in detail in the following subheads.

3.3.1 Influence of abiotic factors on the incidence and infestation of *Spodoptera litura*

The influence of different weather parameters on the adult moth activity, larval intensity and damage by tobacco caterpillars was assessed by correlating these variables and the results are presented in Table 1. It was evident from Table 2 that during the summer season of both the years of the experiment, all the temperature variables and bright sunshine hour (BSH) exhibited a non-significant positive correlation and rainfall, wind velocity and relative humidity (morning and afternoon) had a non-significant negative correlation with the moth activity. Hence, none of the abiotic factors could influence the adult trap catch significantly during both the years of experiment.

The role of ecological parameters on the larval activity of *Spodoptera litura* (Table 1) indicated that during the year 2019-20, only average temperature exerted a significant positive influence (r = 0.450) and the influence of other abiotic factors was not much pronounced. However, maximum temperature, minimum temperature, temperature gradient and BSH had non-significant positive and rainfall, wind velocity

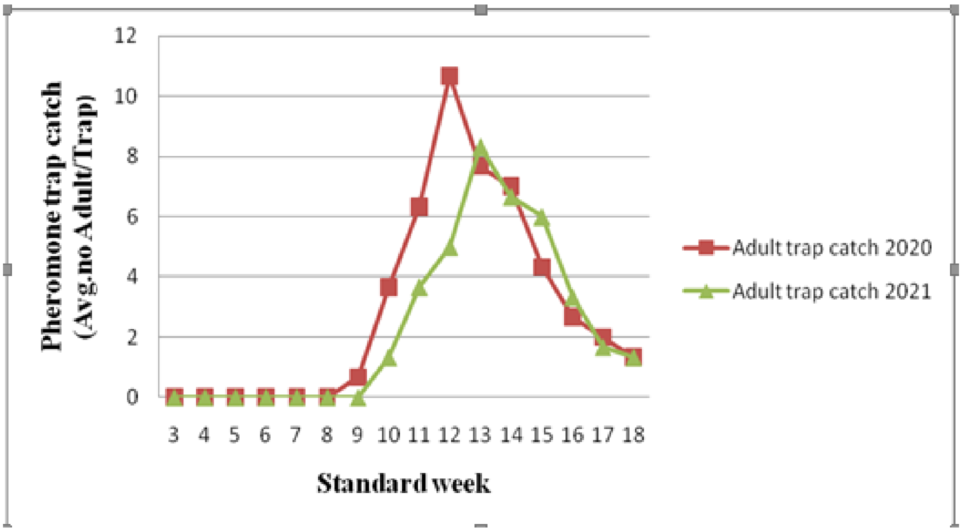

Fig. 4. Seasonal trend of pheromone trap catch of *Helicoverpa armigera* (Summer 2019-20 and 2020-21)

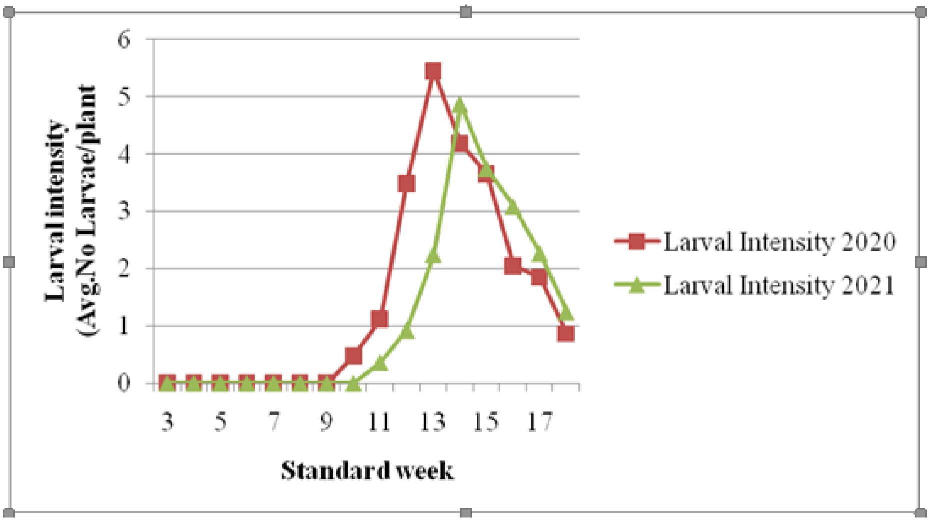

Fig. 5. Seasonal trend of Larval intensity of *Helicoverpa armigera* (Summer 2019-20 and 2020-21)

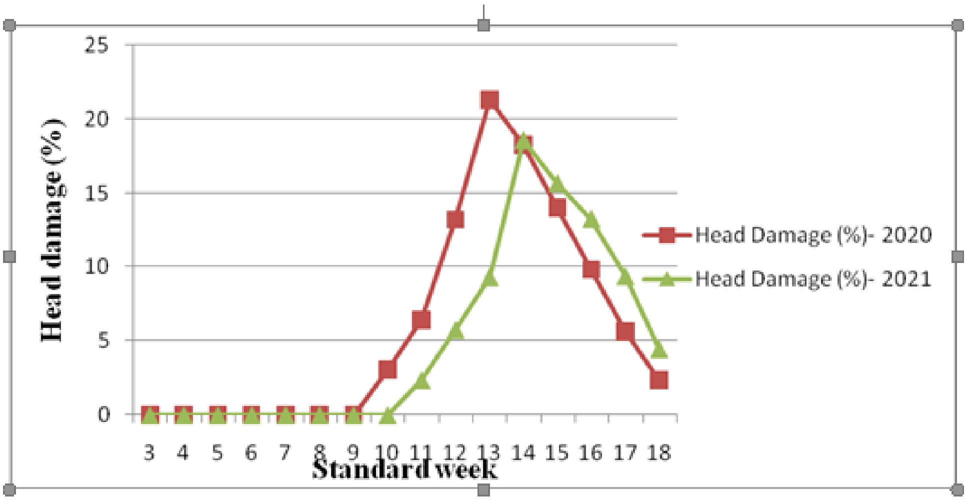

Fig. 6. Seasonal trend of head damage by *Helicoverpa armigera* (Summer 2019-20 and 2020-21)

and relative humidity (morning and afternoon) had non-significant negative correlations with the fluctuation in larval population. During 2020-21, both temperature and average temperature showed a significant positive relationship (r =0.515 and 0.454, respectively) and relative humidity (morning) had significant negative correlation with the seasonal variation in the larval population of *Spodoptera litura*.

It was evident from Table 1 that during 2019-20 though all the temperature variables and bright sunshine hour (BSH) exerted a positive correlation and rainfall, wind velocity and relative humidity (morning and afternoon) had a negative correlation with the fluctuation in leaf damage, none of the abiotic factor could not produce any significant effect. During 2020-21, a similar result obtained but a significant negative correlation was visualized between the relative humidity and leaf infestation (r = -0.460 and -0.476 for morning and evening R H, respectively).

The results of the present investigation are in close conformity with the findings of Chalapathi Rao et al*.* [8] who also opined that the maximum and minimum temperatures had a considerably favourable effect on the larval population of *Spodoptera litura* in January and February sown sunflower crops. Topagi [9] also partially support the present findings as he revealed that, the larval population of *S. litura* in sunflowers was found to have a positive and significant relationship with minimum temperature, and evening relative humidity.

3.3.2 Influence of abiotic factors on the incidence and infestation of *Helicoverpa armigera*

The finding of the correlation study between the weather factors and the incidence and infestation of *H.armigera* has been presented in Table 2. It was evident from Table 2 that during 2019-20 all the temperature variables and bright sunshine hour (BSH) exhibited a non-significant positive correlation and rainfall, wind velocity and relative humidity (morning and afternoon) had a non-significant negative correlation with the variation in the moth activity. However, during 2020-21 only temperature gradient and BSH had a positive correlation (r = 0.566 and 0.534, respectively) with the pheromone trap catch and the rest of the weather parameters did not produce any significant influence on adult activity.

The influence of different weather parameters on the larval intensity of *H. armigera* was studied and the findings are presented in Table 2. It was evident from Table 2 that during the year 2019-20 only maximum temperature had a significant influence (r = 0.476) on the fluctuation of larval population during the crop growth period and the role of weather variables was not so much pronounced. However, the rest of the temperature variables and bright sunshine hour (BSH) exhibited a non-significant positive correlation and rainfall, wind velocity and relative humidity (morning and afternoon) had a non-significant negative correlation on the larval activity. In the second year of the experiment, all the temperature variables (maximum, minimum, average temperature and temperature gradient) and Bright Sunshine Hour (BSH) had significant positive influence, whereas, relative humidity (afternoon) exhibited significant negative effect (r = -0.634) on the larval activity.

The influence of abiotic factors on the head damage by *H. armigera* was presented in Table 2 which indicated that maximum temperature was positively correlated (r =0.454) and R.H (both morning and afternoon) imparted a negative influence (r = -0.453 and -0.451 for morning and evening R H, respectively) on the pest infestation pattern. The relationship between rest of the weather parameters with flower head infestation was not very much pronounced. During 2020-21, all the temperature variables and bright sunshine hour (BSH) exhibited a significant positive correlation and relative humidity (afternoon) had significant negative correlation with the head damage.

The results of the present investigation were substantiated by the findings of Zafar et al., [13] who also reported that among the different ecological parameters, maximum temperature exerted a significant positive influence and relative humidity had a significant negative effect on the larval population of sunflower head borer. Kumar et al., [14] further revealed that the larval population of *Helicoverpa armigera* in chick pea

Table 1. Correlation between the abiotic factors and damage by incidence and damage by *Spodoptera litura*

Abiotic factors	Correlation value (r)					
	Pheromone trap catch		Larval intensity		Damage (%)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Maximum Temperature (ºC)	0.032	0.180	0.415	0.515*	0.350	0.410
Minimum Temperature (ºC)	0.070	0.033	0.430	0.350	0.364	0.236
Average Temperature (ºC)	0.146	0.194	0.450*	0.454*	0.432	0.394
Temperature gradient (ºC)	0.182	0.276	0.030	0.086	0.067	0.222
RH (%) (Morning)	-0.034	-0.170	-0.373	-0.462*	-0.315	-0.460*
RH (%) (After noon)	-0.030	-0.286	-0.110	-0.360	-0.174	-0.476*
Rainfall (mm)	-0.420	-0.294	-0.296	-0.280	-0.414	-0.338
Bright Sunshine Hour (BSH)	0.120	0.086	0.313	0.210	0.370	0.180
Wind Velocity	-0.290	-0.188	-0.016	-0.166	-0.125	-0.085

* *Significant at 0.05 level*

Table 2. Correlation between the abiotic factors and damage by incidence and damage by *Helicoverpa armigera*

Abiotic factors	Correlation value (r)					
	Pheromone trap catch		Larval intensity		Damage (%)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Maximum Temperature (ºC)	0.064	0.31	0.476*	0.824*	0.454*	0.863*
Minimum Temperature (ºC)	0.152	0.074	0.314	0.713*	0.257	0.722*
Average Temperature (ºC)	0.036	0.237	0.437	0.817*	0.408	0.857*
Temperature gradient (ºC)	0.287	0.566*	0.018	0.664*	0.093	0.724*
RH (%) (Morning)	-0.160	-0.252	-0.417	-0.091	-0.453*	-0.152
RH (%) (After noon)	-0.368	-0.363	-0.394	-0.634*	-0.451*	-0.673*
Rainfall (mm)	-0.345	-0.256	-0.116	-0.176	-0.196	-0.225
Bright Sunshine Hour (BSH)	0.116	0.534*	-0.313	0.522*	0.393	0.513*
Wind Velocity	-0.324	-0.317	-0.052	-0.083	-0.062	-0.094

** Significant at 0.05 level*

crops was found to have a positive association with mean temperature and a negative relationship with mean relative humidity. The present findings are in partial agreement with the findings of Hegde [15], who reported that *Helicoverpa armigera* has a non-significant positive correlation with maximum temperature, morning relative humidity, and sunshine hours, as well as a negative relationship with rainfall, minimum temperature, and evening relative humidity in sunflower.

4. CONCLUSION

From the entire investigation, it can be concluded that higher larval infestation and leaf damage by *S.litura* was observed during March with the maximum incidence and infestation during the last week of March. Among the abiotic factors temperature had a positive influence and relative humidity exhibited a negative effect on the population and damage of *Spodoptera litura*. In the case of *Helicoverpa armigera* the higher larval intensity and head damage was noticed in April and maximum population build-up and infestation during the first fortnight of April. All the temperature variables and bright sunshine hour (BSH) exhibited a significant positive correlation and relative humidity (afternoon) had a significant negative correlation with the head damage.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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