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Deciphering Abiotic Influences on the Seasonal Dynamics of Leaf Folder and Caseworm Infesting Rice in the Konkan Region of Maharashtra

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Abstract

Rice is an essential cereal crop and serves as the primary food source for the majority of people worldwide. It faces significant challenges from various abiotic and biotic stress factors, with insect pests being a major concern. An experiment was conducted during *kharif* (June–October), 2019 at Regional Agricultural Research Station (RARS), Karjat, Maharashtra, to study how abiotic factors affect the prevalence of leaf folders and caseworms in rice ecosystems. The results showed that the initial detection of rice leaf folders and caseworms occurred during the 31st Standard Meteorological Week (SMW). The highest incidence of rice leaf folders (1.04%) and caseworms (0.69%) was recorded in the 34th SMW. The minimum leaf folder infestation (0.11±0.38%) was recorded in the 40th SMW, while the minimum case worm infestation (0.09±0.25%) occurred during the 37th SMW. Correlation analysis revealed that minimum temperature significantly influenced the population of both the pests. Regression analysis demonstrated that maximum temperature and bright sunshine hours accounted for R^2=0.865 of the variability in the leaf folder population and R^2=0.798 of the variability in the caseworm population due to maximum temperature. The findings of this study hold significant implications, providing a valuable foundation for predicting pest populations and aiding in the formulation of management strategies in the Konkan region of Maharashtra.

Keywords: Rice, leaf folder, case worm, weather parameters

1. Introduction

Rice (*Oryza sativa* L.) is a staple food for a significant portion of the global population, particularly in Asia, where over 90% of its production and consumption takes place (Bin Rahman and Zhang, 2023; Muthayya et al., 2014). India is one of the world's leading rice-producing country, second only to China (Aslam et al., 2021). Nevertheless, rice cultivation in India faces ongoing challenges from a variety of biotic and abiotic factors that can significantly impact its yield (Iqbal et al., 2023). Among these challenges, insect pest infestations have remained a persistent threat, leading to substantial yield losses and economic implications for both smallholder farmers and large–scale agricultural operations. Over 100 insect species have been identified as potential threats to rice crops, with approximately 20 classified as significant pests. The extent of yield loss caused by these pests can vary depending on the specific agro-climatic conditions (Mahajan et al., 2017; Bhatt et al., 2018). In tropical Asia, it is estimated that rice pests can lead to yield reductions ranging from 25% to 43% (Chatterjee et al., 2021). In India, insect pests are responsible for approximately 25% of yield losses in rice cultivation (Chintalapati et al., 2023).

Over the past two decades, the rice leaf folder, *Cnaphalocrocis medinalis* (Guenee), has emerged as a significant pest in the Indian subcontinent (Chatterjee et al., 2023; Adhikari et al., 2023). This emergence can be attributed to shifts in crop management techniques, increased fertilizer and insecticides usage and changes in weather conditions (Hajjar et al., 2023; Chander, 2022). Leaf folder larvae roll leaves lengthwise, fasten the edges, and feed by scraping green tissue inside. Severe infestations give crops a sticky look with white patches (Gupta et al., 2021; Pal et al., 2023). Yield losses due to leaf folder infestation can exceed 50% (Singh et al., 2023; Preetha et al., 2023; Nayak et al., 2024). In severe conditions, losses can range from 63 to 80%, depending upon agro–climatic condition. (Sachin et al., 2023; Javvaji et al., 2021; Rizwan et al., 2021). Case worm is another important rice lepidopteran pest, which has transitioned from being a minor pest to pest of concern (Jena et al., 2018). The damaging stage is the larvae, which attack rice during seedling and tillering stages. The larva scrapes green leaf tissue, leaving white patches, and makes tubular cases by cutting leaf blades. These cases float, carrying larvae between plants which then climb plants to cut leaves for new cases (Belbase et al., 2021; Pandit et al., 2024).

The intricate interplay between weather parameters and incidence of rice pests has garnered increasing attention within the agricultural research community (Jasrotia et al., 2023). In recent years, climate change has brought about noticeable shifts in weather patterns, with alterations in temperature, precipitation, humidity, and other climatic variables becoming more pronounced. These changes have introduced a new dimension of complexity to the dynamics of pest populations and their interactions with rice crops (Wang et al., 2022). In light of this, effort has been made to investigate the impact of weather on the leaf folder and case worm of the rice crop by identifying potential associations between pest damage and meteorological parameters. Understanding the relationship between weather parameters and rice pest incidence is crucial for predicting pest outbreaks and devising effective and sustainable pest management strategies.

2. Materials and Methods

The study was conducted during the *kharif* (June–October), 2019, at the Regional Agricultural Research Station, Karjat, Maharashtra, situated at a latitude of 18° 55′ N, longitude of 71° 18′ E and an altitude of 51 m above sea level. The rice variety Karjat 3, obtained from RARS, Karjat was used for this experiment. Seedlings were transplanted at a spacing of 20×15 cm^2, with a plot size of 6×4.5 m^2. All agricultural practices were carried out following the recommended package of practices, except for measures related to plant protection. Ten rice hills were randomly selected for observation. Data was collected weekly, following the Standard Meteorological

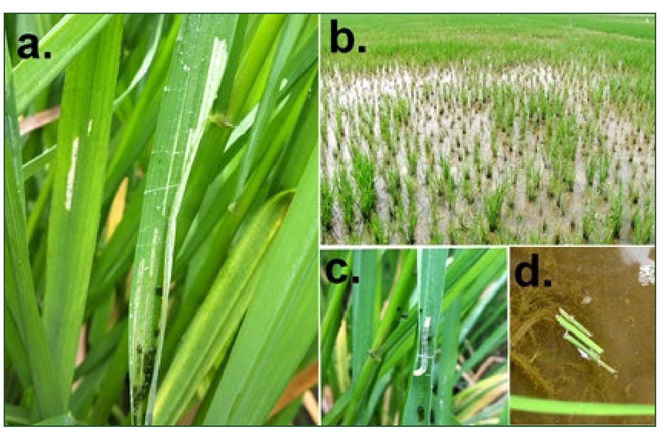

Figure 1: a) leaf folder damaging symptoms; b) Case worm infested rice field; c) leaf folder larva d) floating tubular cases constructed by case worm

Week. Observations were recorded by counting the total number of leaves and the number of damaged leaves (Figure 1). Meteorological data were obtained from RARS, Karjat. The following formula was used to calculate the percentage of damage:

Percent damage=Number of damaged leaves/Total number of leaves per hill×100

Analysis of variance (ANOVA) was used for statistical analysis to investigate data concerning damage caused by leaf folders and case worms. Correlation and regression analyses were performed to assess the impact of weather parameters on the incidence of rice leaf folders and case worms. A correlogram, visually representing the correlation matrix, was generated using R software. Additionally, multiple linear regression analysis was employed to determine the association between pest damage and weather parameters.

3. Results and Discussion

3.1. Effect of weather parameters on incidence of rice leaf folder and case worm

The onset of leaf folder infestation (0.44%) was recorded during the 31^{st} SMW. The minimum leaf folder infestation (0.11±0.38%) was observed in the 40^{th} SMW, while the maximum infestation (1.04±0.38%) occurred during the 34^{th} SMW. The results indicate that leaf folder infestation gradually increased from the 31^{st} to the 34^{th} SMW and then declined from the 35^{th} SMW until harvest.

High rainfall reduced the pterygotes insect population by damaging their wings and hindering their growth and development. Initially, leaf folder infestation was low when rainfall was high and minimum temperatures were low. However, as rainfall decreased and temperatures rose from the 32^{nd} to the 34^{th} SMW, the leaf folder populations increased. Subsequently, increased rainfall and decreased minimum temperatures led to a further decline in leaf folder incidence. Despite favourable weather conditions, leaf folder infestation continued to decrease as the crop matured. Raju et al. (2021) also reported that infestation of rice leaf folder started during the 31^{st} SMW. Similarly, Giri and Mohapatra (2024) reported that infestation of leaf folder began during the first week of august and peaked during the second week of September, while Kumar et al. (2023) noted that leaf folder activity started in the 29^{th} SMW and increase to a peak by the 35^{th} SMW (Table 1).

The initiation of caseworm infestation (0.22%) was observed during the 31^{st} SMW. The minimum caseworm infestation (0.09±0.25%) was recorded during the 37^{th} SMW, while the maximum infestation (0.69±0.25%) occurred during the 34^{th} SMW. The results indicate a gradual increase in caseworm infestation up to the 34^{th} SMW, followed by a decline from the 35^{th} SMW onwards, which continued until harvest. During the initial phase of crop growth, high rainfall coincided with a high population of caseworms. Rainfall facilitates the movement

Table 1: Weather data and incidence of rice leaf folder and case worm during cropping season 2019

SMW	T (°C)		RH (%)		WS (km/hr)	BSS	Rainfall (mm)	Incidence of LF (%)	Incidence of CW (%)
	T_{max}	T_{min}	RH-1	RH-2					
30	29.1	23.9	93.7	91.4	5.3	0.7	737.2	0	0
31	27.7	23.6	90.3	92.6	6.2	0	978.8	0.44	0.22
32	28.2	24.9	89.9	89.7	7.2	0.1	253.6	0.77	0.45
33	30	24.6	92	76.3	4.3	2.2	54.9	1.01	0.67
34	30.2	24.2	92.6	77	3.1	5.6	72.7	1.04	0.69
35	30.1	24.4	89	81.9	3.9	4.3	128.9	0.81	0.40
36	28.4	23.7	91.9	90.1	5.3	0.4	546.5	0.68	0.20
37	28.1	23.5	94.6	89.1	3.5	0.3	345.7	0.46	0.09
38	29.2	23.3	91.3	85.3	2.6	3.1	182.4	0.33	0
39	31.3	23.8	91	77	3.3	4.7	104.2	0.17	0
40	32.2	23	91.9	70	2.5	6.7	77.4	0.11	0
41	33.3	22.8	93.4	60.4	2.2	6.7	90.4	0	0
42	31.9	21.7	86.4	74.3	1.8	5.7	33.7	0	0
43	30.6	23.2	91.1	71.1	2.1	0.7	92.2	0	0
SD(±)								0.38	0.25

SMW: Standard meteorological week; T: Temperature; RH: Relative humidity; WS: Wind speed; BSS: Bright sunshine hours; LF: Leaf folder; CW: Case worm, SD: Standard deviation

of rice caseworm larvae from one plant to another through standing water in the rice field. These findings are consistent with previous research by Haq et al. (2006) who observed that maximum infestation occurs 2 to 4 week after transplanting, with a peak during the month of August and October (Table 1).

3.2. *Correlation analysis*

3.2.1. *Rice leaf folder infestation and weather parameters*

Insects tend to thrive in warmer temperatures but are often hindered by rainfall. Temperature plays a crucial role in influencing various aspects of insect life cycles, such as development, birth rate, and death rate, collectively impacting insect populations. The minimum temperature showed significant positive impact on leaf folder. Morning relative humidity (RH I), evening relative humidity (RH II), and wind speed exhibited insignificant positive relationships, while maximum temperature, bright sunshine hours, and rainfall showed negative correlation. These results are supported by

Table 2: Correlation and regression analysis of incidence of rice leaf folder and case worm in relation to different weather parameters

Weather parameters		Correlation coefficient (r)		Regression coefficient	
		Leaf folder	Case worm	Leaf folder	Case worm
Maximum temperature (T_{max})		-0.467	-0.297	-0.494*	-0.299*
Minimum temperature (T_{min})		0.750*	0.718*	0.188	0.163
Morning relative humidity (RH I)		0.023	-0.023	-0.021	-0.026
Evening relative humidity (RH II)		0.333	0.153	-0.045	-0.038
Wind Speed		0.450	0.399	0.061	0.048
Bright Sun Shine Hours (BSS)		-0.194	-0.091	0.148*	0.086
Rainfall		-0.040	-0.113	-0.000	-0.000
r= 0.532, *Significant at (p=0.05) level	Intercept			15.835	10.388
	R square			0.865	0.798
	Standard error			0.208	0.169

Seni et al. (2022), who demonstrated the significant positive impact of minimum temperature on *C. medinalis* population. Ram et al. (2014) observed that the leaf folder population exhibited a negative correlation with maximum temperature and rainfall. (Table 2 and Figure 2a).

3.2.2. *Rice case worm infestation and weather parameters*

The mean infestation of case worm and minimum temperature showed a significant positive association. However, RH II and wind speed exhibited non-significant but positive relationship. On the other hand, maximum temperature, RH I, bright sunshine hours, and rainfall showed inverse, non-significant relationships. The results are partially supported by Nirala et al. (2015), who reported that case worm exhibited non-significant negative relationship with relative humidity and rainfall, and a non-significant positive correlation with maximum temperature and minimum temperature (Table 2 and Figure 2b).

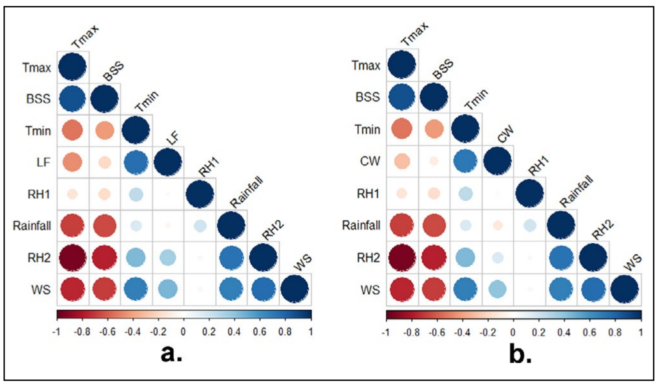

Figure 2: Correlogram explaining the relationship between a) rice leaf folder, b) rice case worm and weather parameters

3.3. Regression analysis between mean infestation of leaf folder, case worm infesting rice, and weather parameters

To determine the set of independent weather parameters significantly affecting the population of leaf folder and case worm (dependent variable Y), we conducted a multiple linear regression analysis. The independent variables included in the analysis were maximum temperature (X1), minimum temperature (X2), relative humidity I (X3), relative humidity II (X4), wind speed (X5), bright sunshine hour (X6), and rainfall (X7). During the growing season, the most influential parameters contributing to the variance in the leaf folder population were maximum temperature and bright sunshine hours, with an R^2 value of 0.865. The maximum temperature exhibited a significant negative regression coefficient, while bright sunshine hours showed a significant positive regression coefficient. Together,these two parameters explained 86.5% of the variation in the leaf folder population during the crop growing period. The results are supported by Kumar et al. (2023), who reported a non-significant positive relationship between minimum temperature and the leaf folder population. Shekhar et al. (2018) also noticed a significant positive correlation with sunshine hours and leaf folder population. For the case worm, the maximum temperature was identified as the primary factor influencing its population variation, with an R^2 value of 0.798. The influence of maximum temperature on the case worm population was found to be significantly negative. Throughout the crop growth period, this variable explained 79.8% of the overall variation in the case worm population. Consequently, our research highlights the crucial role of maximum temperature in determining the presence of both leaf folder and case worm populations, with bright sunshine hours exerting a significant influence on the occurrence of the leaf folder as well (Table 2 and Figure 3).The regression equation model developed for the prediction of leaf folder and case worm population is as follow:

Leaf folder: $Y=15.83-0.4^{*}X_1+0.18X_2-0.02X_3-0.04X_4+0.06X_5+0.14^{*}X_6-X_7+0.20$. Case worm: $Y=10.38-0.29^{*}X_1+0.16X_2-0.02X_3-0.03X_4+0.04X_5+0.08X_6-X_7+0.16$

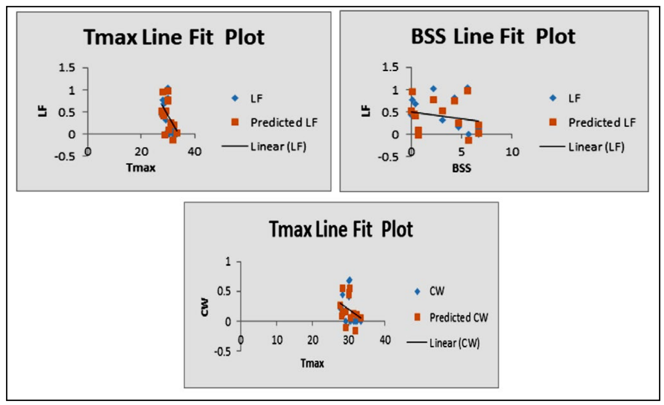

Figure 3: Multiple Linear regression analysis between leaf folder (LF), rice case worm (CW) infesting rice and weather parameters

4. Conclusion

Rice leaf folder and case worm populations remained low throughout the crop season, with peaks observed during the 34th SMW. Minimum temperature had a significant impact on both pests. Multiple linear regression analysis revealed that maximum temperature and sunshine hours influenced leaf folder populations, while maximum temperature was the main factor affecting case worm populations. These findings aid in creating area-specific models to forecast pest build-up, providing timely guidance for effective pest management in rice cultivation.

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