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Effect of weather parameters on the seasonal incidence of maize stem borer (*Chilo partellus*) in the *kharif* season in the Gird region of Madhya Pradesh

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ABSTRACT

The present experiment was conducted during rainy (*kharif*) seasons of 2021–22 and 2022–23 at College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh to investigate the seasonal incidence of *Chilo partellus* and its correlation with weather parameters in the Gird region of Madhya Pradesh. The maize (*Zea mays* L.) variety RMH 1899 Super (Hybrid) was used for the experiment. The study revealed that the population of stem borer, *C. partellus,* larvae/plant was first recorded in early August during the 31st Standard Meteorological Week (SMW) and reached its peak in the third week of August during the 34th SMW. After the 41st SMW, no larvae were recorded in the crop during both years. From the 31st–36th SMW, the presence of dead hearts caused by *C. partellus* was noted, but no dead hearts were observed until the crops were harvested in both years. Additionally, plant damage due to *C. partellus* also began in the first week of August during the 31st SMW and reached a maximum in early September during the 36th SMW in both years. After the 41st SMW, no further plant damage occurred due to the reduced number of larvae in both consecutive years. During *kharif* 2021, the larval population of stem borer, dead heart % and plant damage % due to stem borer were significantly positively impacted by minimum temperature. During *kharif* 2022, the larval population of stem borer and plant damage % due to stem borer were significantly positively impacted by minimum temperature and evening relative humidity while none of the abiotic factors showed a significant correlation with the dead heart % in this year.

Keywords: *Chilo partellus*, Correlation, Dead hearts, Infestation, Regression, Stem borer

Maize (*Zea mays* L.) is also known as the "Queen of Cereals" because of its high genetic yield potential among cereals. It is more adaptable and flexible under various agro-climatic conditions because of its wide genetic base and high level of genotypic diversity. It belongs to Poaceae family. According to Kopsell *et al*. (2009), maize is a vital source of several phytochemicals that are crucial to human health. There are many health advantages to maize. Maize contains vitamin B-complex which is beneficial to the heart, brain, skin, hair, and digestive system. Because they are believed to increase joint mobility, they also prevent the symptoms of rheumatism. Several biotic and abiotic factors cause significant losses in the production of maize. It is the insect-pests that are the most prevalent among the biotic factors. When compared to aphids and grasshoppers, damage caused by maize stem borers exacerbates crop damage significantly (Neupane and Subedi 2019). The maize stem borer, *Chilo partellus* (Swinhoe) has been found to reduce grain yield by 7.0–35.7% in various agroclimatic regions of India (Anonymous 2013). In cases of severe infestation, the larvae have the ability to cut off the meristematic tissues in the stem or in the leaf whorl (Groote 2002). It causes the center leaves of the developing shoot to dry up shortly after the plant germination leading to "dead heart" symptom, which can kill the plant or stunt its growth. Damage caused by insect-pests poses serious challenges to maize cultivation resulting in potential economic losses for farmers. To take preventive and curative actions at the right time, farmers need to monitor pest populations throughout the growing season of crop which helps them in identifying critical periods of pest activity and understanding the life cycle of pests.

Correlation of pest incidence with weather parameters, such as temperature, rainfall, or humidity, provides valuable

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understanding into the causes of pest outbreaks. The study of correlation between pest population dynamics and these variables helps in the prediction and prevention of infestations. For example, if a particular pest species shows a correlation with temperature, farmers can anticipate pest population during specific temperature ranges and implement control measures accordingly. Therefore, the present study aimed to investigate the seasonal incidence of *Chilo partellus* and its correlation with weather parameters in the Gird region of Madhya Pradesh.

MATERIALS AND METHODS

The present experiment was conducted during rainy (*kharif*) seasons of 2021–22 and 2022–23 at College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (26°14'N, 78°15'E; at an elevation of 211.52 m amsl), Madhya Pradesh. RMH 1899 Super (Hybrid) maize variety was sown on 17 July 2021, and 17 July 2022, respectively, maintaining a distance of 20 cm between rows and 60 cm between plants with plot size 10.0 m × 3.0 m. Observations on the larval population of stem borer were recorded on ten randomly selected plants at weekly intervals starting from the germination till harvest of the crop. For the observations of stem borer, per cent plant damage or dead heart was recorded on the total number of plants from the plot in the morning hours at weekly intervals. Observations were recorded based on the number of dead hearts from the plot and converted into per cent dead hearts. Plants damaged by stem borer were recorded based on the number of damaged plants out of observed plants from the plot and converted into per cent infestation. Data on the meteorological parameters i.e. temperature (maximum and minimum), relative humidity (morning and evening) and rainfall were obtained from the Meteorological Observatory, College of Agriculture, Gwalior, Madhya Pradesh during *kharif* 2021 and *kharif* 2022. Meteorological data were utilized for statistical analysis of the influence of weather parameters on the occurrence of stem borer infesting maize by subjecting weather data and the number of larvae, dead heart per cent and plant damage per cent due to stem borer to simple correlation (Gomez and Gomez 1984) by using JMP 18.0.1 software.

RESULTS AND DISCUSSION

During the *kharif* seasons of both the years 2021 and 2022, data on the infestation of *Chilo partellus* in maize crops is presented in Table 1. The observations revealed that the population of *C. partellus* larvae/plant was minimal, with 0.3 and 1.5 larvae/plant, respectively in early August during the 31st Standard Meteorological Week (SMW) when the crop was 15 days old (Fig. 1). However, the peak population of *C. partellus* larvae was observed in the third week of August during the 34th SMW, with 3.2 and 3.0 larvae/plant in the consecutive years. Following the peak, the population gradually declined, reaching its minimum in the second week of October during the 41st SMW, with a mean population of 0.6 and 0.3 larvae/plant in the consecutive years. After the 41st SMW, no larvae were found in both years. These findings are in harmony with those of Mohan *et al*. (1990) who recorded the highest larval population in *kharif* sorghum in Haryana from the third week of August to the second week of September. Also, from the third week of July to the third week of September, the pest population was active, peaking in August (34th SMW) with 1.12 larvae/ plant (Patel *et al*. 2016). However, *C. partellus* continue to remain active from March to November (Panwar 2005), but it mostly infests *kharif* maize from the first week of July to the second week of September, with the peak activity during August (Patel *et al.* 2005). The present results were somehow compatible with the findings of Kumar and Arivudainambi (2018) who reported that the peak larval population of stem borer on maize occurred in July of *kharif* and declined during *rabi* season. Kumar *et al*. (2017) concluded that *C. partellus* on maize appeared in the second week of August and

Table 1 Seasonal incidence of *C. partellus* in maize during the *kharif* season

SMW	Dates	Stem borer					
		Kharif 2021			*Kharif* 2022		
		No. of Larvae/ plant	Dead heart (%)	Plant damage (%)	No. of larvae/plant	Dead heart (%)	Plant damage (%)
31	July 30–Aug 5	0.3	3.40	6.40	1.5	3.40	6.67
32	Aug 6–12	1.6	5.28	11.50	2.5	5.50	10.40
33	Aug 13–19	2.4	10.44	14.86	2.8	8.78	14.84
34	Aug 20–26	3.2	12.80	16.62	3.0	10.29	24.35
35	Aug 27–Sept 2	3.0	15.66	25.53	2.4	15.08	28.70
36	Sept 3–9	2.7	25.60	32.45	2.0	22.6	30.40
37	Sept 10–16	2.0	0.00	31.44	1.7	0.00	26.45
38	Sept 17–23	1.5	0.00	28.87	1.7	0.00	25.00
39	Sept 24–30	1.2	0.00	26.77	0.8	0.00	20.65
40	Oct 1–7	0.9	0.00	22.40	0.6	0.00	19.68
41	Oct 8–14	0.6	0.00	21.18	0.3	0.00	14.24

SMW, Standard Meteorological Week.

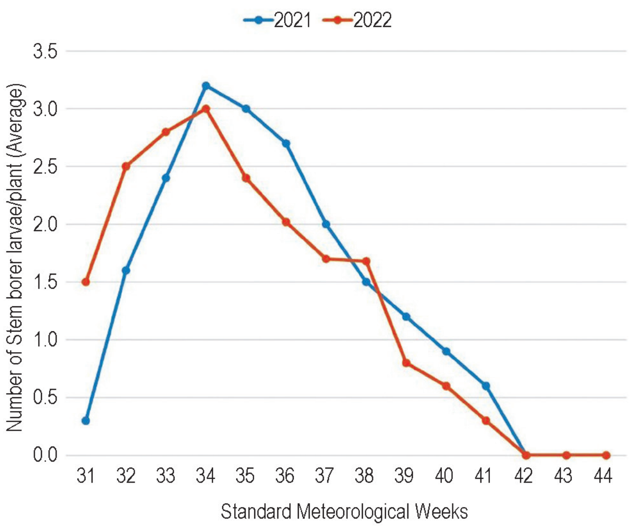

Fig. 1 Larval population of stem borer, *C. partellus*, infesting maize crop during *kharif* season 2021 and 2022 at different Standard Meteorological Week.

reached its peak (2.4 larvae/plant) in the 38th SMW (3rd week of September 2016). Singh *et al*. (2020) also initially recorded the larval population of *C. partellus* in the 28th SMW (second week of July), and it continued until the 31st SMW (last week of July). This showed a decreasing trend that remained up to the 35th SMW (last week of August), after which no larval population was seen.

In terms of damage caused by *C. partellus*, the data (Fig. 2) indicated that 3.40% dead heart were observed in early August during the 31st SMW in both years. The percentage of dead hearts increased during the 32nd and 33rd SMW, and reached its peak in early September during the 36th SMW, with 25.60% and 22.60% dead hearts, respectively. Following that, no dead hearts were found until the crops were harvested in both years (Table 1). Similar to our findings, Kumar (2017) concluded that *C. partellus* was first observed in the second week of July at 15 days of crop age (1.67% dead heart) and reached its peak in the last week of August at 57 days of crop age (16.67% dead heart). In another study, Kishore (2019) also discovered that the first known cases of *C. partellus* during *kharif* in 2016 and 2017 resulted in 4.20 and 2.80% mean numbers of dead hearts, respectively during the 30th SMW, or 33 DAS. The pest population increased significantly and peaked on the 33rd SMW, or 53 DAS, with a mean percentage of dead hearts of 28.10 and 27.80%, respectively. According to Biradar *et al*. (2011), the maximum dead hearts were caused by stem borer during the month of July, and the highest number of pin holes were found in August. These findings contrast with those of Kore *et al*. (2013), who found that the dead hearts caused by the stem borer *C. partellus* were observed between the third week of August (33rd SMW) and the third week of October (42nd SMW).

Additionally, plant infestation by neonate larvae of *C. partellus* began in the first week of August, with an average plant damage of 6.40% and 6.67% during the 31st SMW in both years of study. The infestation increased over time, reaching a maximum of 32.45% and 30.40% plant damage in early September during the 36th SMW. However, the infestation gradually declined thereafter, with the lowest mean plant damage of 21.18% and 14.24% recorded in the second week of October during the 41st SMW. After the 41st SMW, no further plant infestations occurred due to the reduced number of larvae in both consecutive years (Table 1). The current results are somehow consistent with those of Jeengar (2005), who discovered that the *C. partellus* infestation peaked in the second week of August during the 32nd SMW after starting in the last week of July 30th. War *et al*. (2022) also reported that *C. partellus* caused leaf damage between 24th SMW and 40th standard weeks. Although, the peak leaf infestation was recorded in the 32nd SMW at 48.05%, but it started to decline afterward, reaching its lowest point in the 40th SMW (13.05%). Similarly, Mallapur *et al*. (2012) also observed that the maximum per cent infestation of stem borers varied by month, with the maximum infestation (19.22%) recorded in August, followed by July (15.80%) and September (15.10%). The findings of Divya *et al*. (2009) showed that the highest plant damage (38%) caused by *C. partellus* was recorded

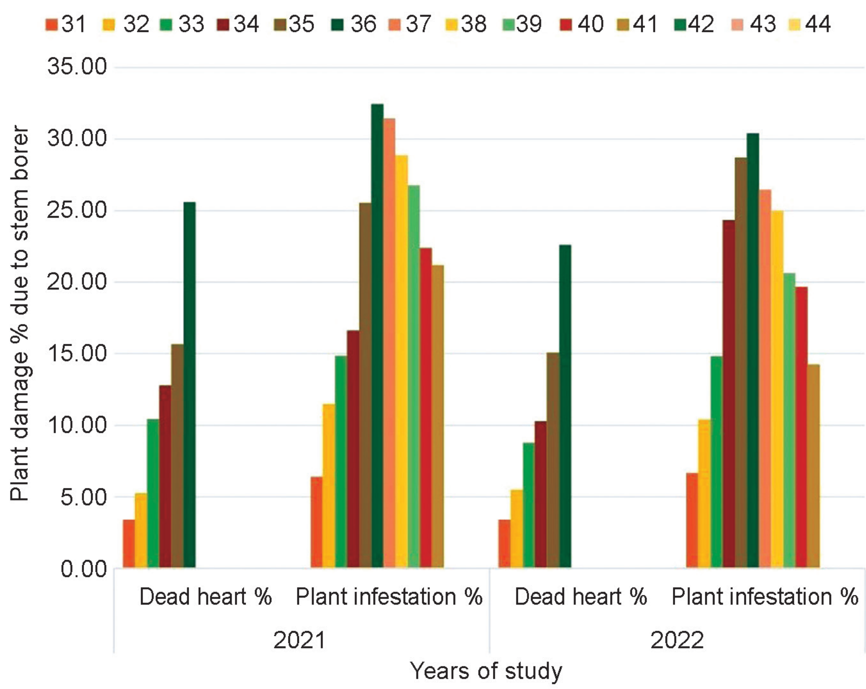

Fig. 2 Plant damage % due to stem borer, *C. partellus* infesting maize crop during *kharif* season 2021 and 2022 at different Standard Meteorological Week.

in 40th SMW during the *kharif* season. Kandalkar *et al.* (1996) also recorded that the peak infestation of *C. partellus* occurred between 31 and 68 days after sowing which is an important time that comprises both the vegetative and reproductive phases of crop. According to these results, precise monitoring during these critical periods is essential as well as the implementation of certain management strategies.

Correlation studies: According to the correlation studies during *kharif* 2021, the larval population of the *Chilo partellus* was significantly positively impacted by minimum temperature (r= 0.736) at a 1% level of significance (Table 2 and Fig. 3), while the maximum temperature and evening relative humidity exhibited non-significantly positive effects on the number of larvae of *C. partellus* (r= 0.359 and 0.171, respectively). However, the morning relative humidity, rainfall and evaporation also had non-significant correlations but negative effects on the number of larvae of *C. partellus* (r= -0.011, -0.057 and -0.222, respectively). Following the current findings, Kumar (2016) through correlation analysis revealed that the incidence of stem borer was positively correlated with the maximum and minimum temperatures, while the morning relative humidity and rainfall were negatively correlated. In contrast to the current findings, Achiri *et al.* (2020) found that the correlations between temperature and humidity and the mean number of *C. partellus* larvae were not significant for the first and second maize crops. During *kharif* 2022, it can be referred that the larval population of *C. partellus* was significantly positively impacted by evening relative humidity (r= 0.630) at the 5% level of significance (Table 2 and Fig. 4) and minimum temperature also indicated significant positive effects on the number of larvae (r= 0.714) but at 1% level of significance (Table 2 and Supplementary Fig. 1). Maximum temperature, morning relative humidity, and rainfall (r= 0.020, 0.094 and 0.532, respectively) exhibited non-significant positive relations whereas, evaporation (r= -0.259) showed a negative correlation with stem borer populations. The current finding is somewhat compatible with that of Sahito *et al.* (2012) who found that the population of stem borer was positively (0.1908) and non-significantly correlated with temperature and insect population increased with increasing temperature whereas the borer population was negatively (-0.4030) correlated with relative humidity in a way that suggested the population of stem borer decreased with increasing relative humidity. Arshad *et al.* (2021) also found that when relative humidity increased, the population dynamics of *C. partellus* on maize fluctuated significantly.

While dead heart percentage caused by stem borer during *kharif* 2021 showed a significant positive correlation by minimum temperature (r= 0.547) at the 5% level of significance (Table 2 and Fig. 3). The maximum temperature and evening relative humidity indicated that they had non-significant positive effects on the dead heart percentage (r= 0.400 and 0.052, respectively). However, the morning relative humidity, rainfall and evaporation also had non-significant correlations but negative effects on the number of larvae of stem borer (r= -0.068, -0.083 and -0.098, respectively). In the succeeding year, none of the abiotic factors showed a significant correlation with

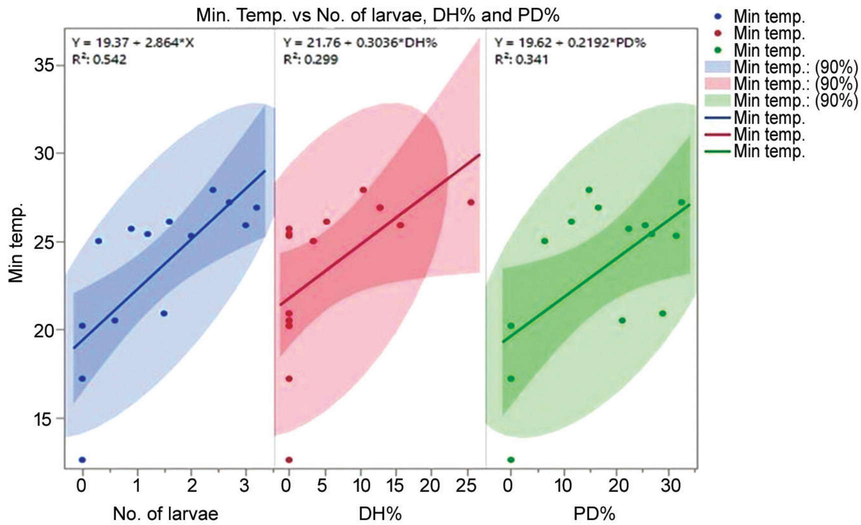

Fig. 3 Regression graph between minimum temperature and stem borer (no. of larvae, dead heart % and plant damage %) during *kharif* 2021.
DH, Dead hearts; PD, Plant damage.

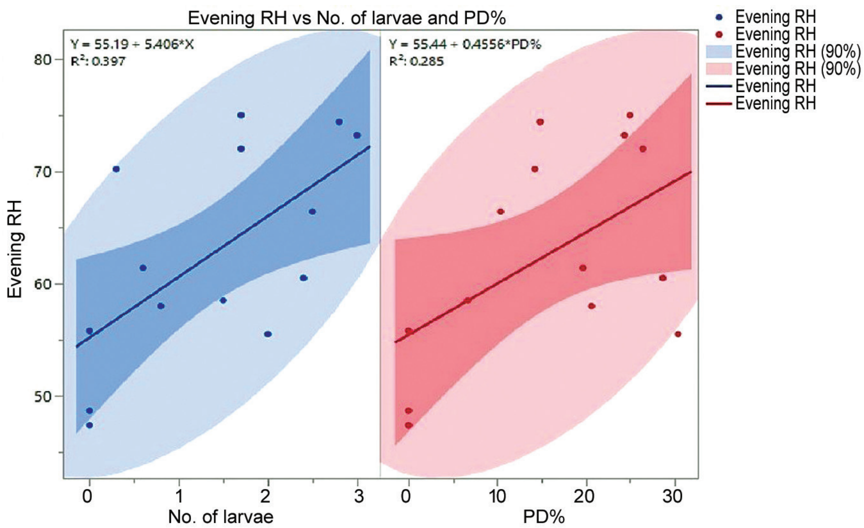

Fig. 4 Regression between evening relative humidity (RH) and no. of larvae and plant damage % (PD %) due to stem borer during *kharif* 2022.

Table 2 Correlation coefficient of stem borer with weather parameters in maize during *kharif* season

Weather Parameters	Stem borer					
	Larvae/plant		Dead heart %		Plant damage %	
	Kharif 2021	*Kharif* 2022	*Kharif* 2021	*Kharif* 2022	*Kharif* 2021	*Kharif* 2022
Maximum temperature (ºC)	0.359	0.020	0.400	0.504	0.127	0.148
Minimum temperature (ºC)	0.736**	0.714**	0.547*	0.468	0.584*	0.747**
Morning Relative Humidity (%)	-0.011	0.094	-0.068	-0.512	0.317	0.161
Evening Relative Humidity (%)	0.171	0.630*	0.052	0.029	0.301	0.534*
Rainfall (mm)	-0.057	0.532	-0.083	0.001	-0.144	0.258
Evaporation	-0.222	-0.259	-0.098	0.369	-0.131	-0.380

*significant at $p \leq 0.05$; **significant at $p \leq 0.01$; NS, Non-significant.

the dead heart percentage. During *kharif* 2022, correlation studies with dead heart % showed a non-significant positive correlation with all the abiotic factors, viz. maximum temperature, minimum temperature, evening relative humidity, rainfall and evaporation (r= 0.504, 0.468, 0.029, 0.001 and 0.369, respectively) except morning relative humidity which showed negative correlation (r= -0.512). The results of Shivhare *et al*. (2022) partially supported the present findings. Study concluded that morning and evening relative humidity and rainfall showed a significant positive correlation (r = 0.631, 0.544 and 0.645, respectively) with dead heart percentage due to *C. partellus*. The present results somewhat supported the findings of Kishore (2019) who reported that % dead heart incidence indicated a significant positive correlation with the minimum temperature during the first year of study (2017) and a non-significant negative correlation with maximum temperature for both years (2017 and 2018). Contrary to the findings, Kumar *et al*. (2020) observed that maximum and minimum temperatures were negatively correlated to the dead hearts % in stem borer. The percentage of dead hearts was positively connected with rainfall. Against the current findings, Meti *et al*. (2014) also found a highly significant positive correlation between rainfall and the dead hearts percentage caused by stem borers, although relative humidity indicated a positive correlation.

Further, the correlation studies between abiotic factors and plant damage % due to *C. partellus* showed that during *kharif* 2021, plant damage percentage was significantly positively impacted by minimum temperature (r= 0.584) at a 5% level of significance (Table 2 and Fig. 3). Maximum temperature, morning and evening relative humidity had non-significantly positive effects on the plant damage percentage (r= 0.127, 0.317 and 0.301, respectively). Whereas, rainfall and evaporation also had a non-significant correlation but negative effects on plant damage % due to *C. partellus* (r= -0.144 and -0.131, respectively). Meti *et al*. (2014) partially supported the current findings who found that the leaf damage percentage produced by the stem borer complex was positively correlated with minimum temperature, rainfall, and relative humidity. Further, the studies revealed that plant damage percentage due to *C. partellus* during *kharif* 2022 was significantly positively impacted by evening relative humidity (r= 0.534) at the 5% level of significance (Table 2 and Fig. 4). While the minimum temperature had a highly significant positive correlation with the plant damage percentage (r = 0.747) at a 1% level of significance (Table 2 and Supplementary Fig. 1). Maximum temperature, morning relative humidity, and rainfall (r = 0.148, 0.161 and 0.258, respectively) exhibited non-significant positive relation whereas, evaporation (r = -0.380) showed a negative correlation with plant damage percentage due to *C. partellus*. Following the present results, Kumar *et al*. (2017) reported that relative humidity (14 h) showed a positive significant effect (r = 0.754**) and rainfall (r = 0.241) showed a positive but non-significant effect on per cent plant infestation due to stem borer. In contrast, Zulfiqar *et al*. (2010) found that the *Chilo partellus* infestation in the experiment grew as the temperature and relative humidity decreased. These results also disagreed with those of Panwar (1979), who reported that *Chilo partellus* infestation increased with a drop in temperature and relative humidity. According to the current research, there is an indication for pest populations to increase when the evening relative humidity and minimum temperature increase. Singh and Singh (2013) reported that the temperature and relative humidity were very responsible factors for the infestation of the insect-pest population in maize crops during the *kharif* season.

This two-year study concluded that the population of *C. partellus* was first recorded during the 31^{st} SMW and attained a peak in the third week of August during the 34^{th} SMW. From the 31^{st} to the 36^{th} SMW, the dead hearts of *C. partellus* were recorded, but no dead hearts were observed until the crops were harvested in both years. Plant damage due to *C. partellus* began in early August during the 31^{st} SMW and reached a maximum in late August during the 36^{th} SMW in both years. Correlation studies revealed that larval population and plant damage caused by stem borer were significantly positively impacted by minimum temperature and evening relative humidity. These two factors have an impact on the dynamics of the stem borer population in the Gird region. Since it ensures enough moisture for their life cycles, higher evening relative humidity conditions provide more favourable conditions for insect survival and reproduction.

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