Indian Journal of Agricultural Sciences **94** (9): 996–1000, September 2024/Article
https://doi.org/10.56093/ijas.v94i9.147332

Influence of weather parameters on the seasonal occurrence of paddy yellow stem borer (*Scirpophaga incertulas*)

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Received: 10 January 2024; Accepted: 16 July 2024

ABSTRACT

The experiment was conducted during the rainy (*kharif*), winter (*rabi*) and summer seasons of 2022–23 at College of Agriculture, V C Farm, Mandya, Karnataka to study the influence of weather conditions on the occurrence of paddy yellow stem borer [*Scirpophaga incertulas* (Walker)]. Rice (*Oryza sativa* L.) variety Jaya was selected for the experiment. Results found that the 37th and 39th Standard Meteorological Weeks (SMW) exhibited the highest infestation of dead heart (14.22%) and white ears (8.91%), respectively. This was associated with a noteworthy positive correlation with maximum temperature and a significant negative correlation with minimum temperature. Similarly, in *rabi* 2022, the 50th and 3rd SMW recorded the peak infestation of the dead heart (8.92%) and white ears (7.64%), respectively. These instances were linked to a significant positive association with morning relative humidity and bright sunshine hours, along with a significant negative association with minimum temperature and afternoon relative humidity. During summer 2023, the highest incidence of dead heart (29.26%) and white ears (21.74%) occurred in the 16th and 20th SMW, respectively. This was accompanied by a significant positive correlation with minimum temperature, rainy days, rainfall, and afternoon relative humidity. The peak infestation of dead heart and white ears was observed between 30–50 days after transplanting (DAT) and 80–100 DAT, respectively. To effectively manage this pest, it is recommended to adopt early sowing and timely interventions before reaching the peak, employing appropriate management practices. Therefore, continuous monitoring of the pest, utilizing future prediction models, and staying attentive to evolving weather conditions are essential components of effective pest management strategies.

Keywords: Climate change, Seasonal incidence, *Scirpophaga incertulas*, Weather parameters

Rice (*Oryza sativa* L.) a staple for over 50% of the world's population, plays a crucial and stable role in this context (Anonymous 2022). However numerous biotic and abiotic factors have been identified as significant constraints that limit the potential yield of rice and led to substantial reductions in both quality and quantity. Insect pests are among the prime challenges confronting the global rice economy. All the plant parts are accessible to insect-feeding throughout its growing season, thereby hampering its yield potential (Ali *et al*. 2021). Stem borers (40%), planthoppers (25%), gall midges (10%), and other pests (25%) collectively contribute to significant losses (Reddy *et al*. 2010). Among the stem borers affecting rice crops, the yellow stem borer (YSB), scientifically known as *Scirpophaga incertulas* (Walker), emerges as the most destructive, causing a substantial reduction in yield ranging from 25–70% (Catling *et al*. 1987). Stem borer attacks during the vegetative stage result in symptoms referred to as dead hearts (DHs), while attacks during the reproductive stage lead to the manifestation of white ear heads (WEs). The significance of addressing these challenges becomes evident in the context of the crucial role rice plays in global food security, necessitating effective strategies for pest management to ensure sustainable and enhanced rice production.

The recent climate changes have been attributed to affect physiology, abundance, phenology, behaviour and development of YSB. In India, there is documented evidence showing how changing weather conditions affect the timing, intensity, and severity of insect pests on various crops. Given these findings, it becomes crucial to evaluate the future outlook for YSB by employing developed models and climatic projections. Such an assessment will aid in strategic planning for the effective management of YSB in the face of climate change (Reji *et al*. 2014, Nurhayati and Koesmaryono 2017). Therefore, research into the effects of diverse abiotic variables is crucial and it is worth noting that knowledge of population dynamics in contrast to meteorological parameters is a prerequisite for developing

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weather-based forecasting systems. Furthermore, the studies concerning seasonal incidence and population fluctuations will also aid in formulating the right time for transplanting and efficient management approaches to control this pest (Schurr *et al*. 2012). With this significance, the present study was undertaken to study the the influence of weather conditions on the seasonal occurrence of paddy yellow stem borer.

MATERIALS AND METHODS

The experiment was conducted during the rainy (*kharif*), winter (*rabi*) and summer seasons of 2022–23 at College of Agriculture, V C Farm, Mandya, Karnataka. The popular and susceptible rice variety Jaya, was planted in an area of 25 m^2. The 25-day-old seedlings were transplanted into an 8 m × 9 m block, with a spacing of 20 cm × 15 cm between rows and plants. Three such blocks were maintained. The cultivation followed the recommended package of practices, except for plant protection measures (Anonymous 2017). In each block, the number of dead hearts in the vegetative stage and the total count of healthy tillers were recorded weekly on 10 hills. The dead heart percentage was calculated using the Standard Evaluation System for Rice (SES) as (IRRI 2013):

$$\text{Dead heart percentage} = \frac{\text{Total no. of dead heart/10 hill}}{\text{Total no. of tillers}} \times 100$$

Likewise, during the flowering and reproductive stage (80–90 days) the number of white ears and the total number of panicles was recorded in 10 hills and the percentage of white ears was computed as:

$$\text{White ears percentage} = \frac{\text{Total no. of white ears/10 hill}}{\text{Total no. of panicles}} \times 100$$

The weekly meteorological data, particularly maximum and minimum temperature, morning and afternoon relative humidity, rainfall, rainy days, and bright sunshine hours (BSS), were gathered from the agro-meteorological observatory unit at V C Farm, Mandya, Karnataka throughout the study. To explore the existing correlation between YSB incidence and prevailing meteorological conditions, weekly mean observations of dead hearts and white ears were correlated with the weather parameters of the preceding week (Panse and Sukhatme 1967). The percentage of dead hearts (DHs) and white ears (WEs) were recorded at weekly intervals.

Statistical analysis: Further, the data of all three seasons was subjected to correlation and regression analysis using SPSS 21 statistical software and the graphs were plotted in GraphPad Prism 8.0.2 for a better understanding of DH and WE occurrence.

RESULTS AND DISCUSSION

During *kharif* 2022, the infestation due to yellow stem borer was initiated from 31st SMW with 1.50% dead heart (DH). The peak infestation of 14.22% DHs was observed at 37th SMW (Table 1). Further, the white ears (WEs) infestation started from 36th SMW with 3.50% WEs. Similarly, the peak infestation due to WEs was recorded during the 39th SMW, but the infestation continued till the harvest (Table 2). Correlation analyses between DH and weather parameters revealed a non-significant association. Whereas, maximum temperature (r = 0.218), BSS (r = 0.025) and morning relative humidity (r = 0.007) showed a non-significant positive correlation. The rainfall (r = -0.217), rainy days (r = -0.054), afternoon relative humidity (r = -0.021) and minimum temperature (r = -0.006). Similarly, Madhuri *et al*. (2017) reported a positive significant association with maximum temperature, minimum temperature and morning relative humidity and a negative significant association between sunshine hours and pest infestation. In the years 2018 and 2019, the highest dead heart incidence (5.32 and 5.64%) was observed during the 33rd and 34th SMW, respectively. Additionally, the maximum occurrence of white ears (4.96 and 5.28%) was noted during the 40th SMW. Notably, Sharma and Sharma (2023) recorded a significant positive correlation between minimum temperature and evening relative humidity with dead heart incidence. Conversely, the correlation between WEs and weather parameters varied significantly. Maximum temperature (r = 0.531*) indicated a positive association with the WEs infestation. The BSS (r = 0.246), morning relative humidity (r = 0.060) and afternoon relative humidity (r = 0.010) showed non-significant correlations. Further, minimum temperature (r = -0.606*) showed a significant negative correlation with WEs; while rainfall and rainy days exhibited a non-significant negative association with WEs infestation (Table 3). Whereas, the mean temperature was found to be negatively associated with the per cent DH and per cent WEs, and positively associated with rainfall and relative humidity (Zainab *et al.* 2017). Hatwar *et al*. (2021), reported the onset of infestation with DH at 3.06% and WEs at 1.72% during the 31st SMW (30 July–5 Aug) and 40th SMW (1 Oct–7 Oct), respectively. The peak DH incidence, recorded at 6.31±2.57%, occurred during the 37th SMW (10 Sept–16 Sept), while the highest WE incidence, at 6.81±2.38%, was observed during the 42nd SMW (15 Oct–21 Oct). Additionally, correlation studies between YSB incidence and weather parameters indicated that morning relative humidity and evening relative humidity were positively significant. In contrast, maximum temperature and bright sunshine hours exhibited negative significance, while all other weather parameters were deemed non-significant (Dalvi *et al*. 2021).

Likewise, in *rabi* 2022, the dead heart (1.24%) infestation due to YSB was started at the 45th SMW during the *rabi* season. The peak DH infestation was noticed at 50th SMW with 8.92% DHs. Similarly, the white ear infestation started at 50th SMW 2.00% WEs and the peak was observed at 3rd SMW (7.64% WEs) (Table 1, 2). The correlation analysis between stem borer infestation and weather parameters had significant results. The afternoon relative humidity (r = 0.320), rainfall (r = 0.268), rainy days (r = 0.055) and maximum temperature (r = 0.015)

Table 1 Infestation by *Scirpophaga incertulas* in *kharif*, *rabi* and summer seasons of 2022–23

Kharif			*Rabi*			Summer		
SMW	Dead heart (%)	White ear (%)	SMW	Dead heart (%)	White ear (%)	SMW	Dead heart (%)	White ear (%)
29	0.00	0.00	44	0.00	0.00	10	2.04	0.00
30	0.00	0.00	45	1.24	0.00	11	4.82	0.00
31	1.50	0.00	46	1.50	0.00	12	7.82	0.00
32	2.40	0.00	47	2.02	0.00	13	12.03	0.00
33	5.24	0.00	48	3.05	0.00	14	15.56	0.00
34	10.39	0.00	49	7.24	0.00	15	26.15	0.00
35	13.26	0.00	50	8.92	2.00	16	29.26	4.72
36	12.51	3.50	51	7.94	3.72	17	27.54	8.43
37	14.22	5.35	52	6.01	4.62	18	15.63	12.94
38	9.32	6.28	1	5.45	5.35	19	10.02	18.25
39	7.83	8.91	2	3.81	6.83	20	9.13	21.74
40	5.14	7.24	3	2.19	7.64	21	7.07	15.62
41	1.24	6.92	4	0.00	5.35	22	1.03	8.83
42	0.00	4.29	5	0.00	2.54	23	0.63	7.43
43	0.00	3.28	6	0.00	2.20	24	0.00	5.62

SMW, Standard meteorological week.

showed a positive association with the DH infestation. Similarly, morning relative humidity (r = -0.380), BSS (r = -0.261) and minimum temperature (r = -0.085) had a non-significant association with DH. On the contrary, the white ear infestation showed a significant positive correlation with morning relative humidity (r = 0.706**) and BSS (r = 0.645**). Whereas maximum temperature showed a non-significant positive association. On the other hand, minimum temperature (r = -0.856**) and afternoon relative humidity (r = -0.727**) exhibited a significant negative association with WE infestation. Following, rainfall (r = -0.305) and rainy days (r = -0.423) showed a negative correlation (Table 3). Arya *et al*. (2017) recorded the DH symptoms from the 32nd SMW which peaked during the 39th SMW and WE infestation started from the 36th SMW and was found to peak during the 46th SMW. Similarly, DH infestation started from the 32nd SMW and continued up to the 38th standard week, whereas WEs were recorded from the 35th SMW and reached their peak in the 45th SMW. The relationship among weather parameters suggested a significant role in influencing the variation in YSB prevalence. Notably, elevated rainfall in August, coupled with reduced sunshine hours in September, followed by a gradual decline in rainfall and an increase in sunshine hours towards October, contributed to a higher incidence of *S. incertulas* (Patel and Singh 2017). Furthermore, the rice YSB incidence started from the 35th SMW till the 49th SMW. The highest percentage of DH was found in mid-September and abiotic factors like maximum temperature, minimum temperature, relative humidity and rainfall were found negatively correlated but sunshine hours had a positive effect on the incidence of YSB (Devendra *et al*. 2018). Conversely, the pooled data (2011–2016) analysis showed that the weather parameters except maximum temperature were significantly correlated with DHs and WEs caused by stem borer with varying degrees of correlation coefficients (Shekhar *et al*. 2018). The studies on factors influencing the infestation of YSB indicated a significant role of rainfall, change in rainfall, temperature fluctuations and limited variations in relative humidity, wind speed and sunshine hours (Mandal and Mondal 2018).

The peak dead heart infestation during the summer of 2023 was recorded at 26th SMW with 29.26%. Likewise, the peak white ears were observed on the 20th SMW with 21.74% WEs (Table 1, 2). The correlation between YSB infestation and climatic factors showed a significant difference. The rainfall (r = 0.556*) and rainy

Table 2 Correlation between per cent dead heart and weather parameters

Weather parameter	Correlation (Dead heart)		
	Kharif	*Rabi*	Summer
Maximum temperature	0.218	0.015	0.332
Minimum temperature	-0.006	-0.085	0.161
Morning relative humidity	0.007	-0.380	-0.121
Afternoon relative humidity	-0.021	0.320	-0.064
Rainfall	-0.217	0.268	0.556*
Rainy days	-0.054	0.055	0.546*
Bright sunshine hours	0.025	-0.261	-0.062
Regression	0.544	0.770	0.776

*Significant at $P \leq 0.05$.

Table 3 Correlation between per cent white ear head and weather parameters

Weather parameter	Correlation (White ear)		
	Kharif	*Rabi*	Summer
Maximum temperature	0.531*	0.423	-0.046
Minimum temperature	-0.606*	-0.856**	0.699**
Morning relative humidity	0.060	0.706**	0.259
Afternoon relative humidity	0.010	-0.727**	0.625*
Rainfall	-0.242	-0.305	0.157
Rainy days	-0.296	-0.423	0.382
Bright sunshine hours	0.246	0.645**	-0.211
Regression	0.678	0.779	0.745

**Significant at $P \leq 0.01$; *Significant at $P \leq 0.05$.

days (r = 0.546*) exhibited a positive significance with DH infestation. Maximum (r = 0.332) and minimum (r = 0.161) temperatures showed a non-significant positive association. The remaining factors such as morning (r = -0.121) and afternoon (r = -0.064) relative humidity, BSS (r = -0.062) showed a non-significant association with the WEs infestation. Further, a positive association was observed with minimum temperature (r = 0.699**), afternoon relative humidity (r = 0.625*) and WEs infestation. Morning relative humidity (r = 0.259), rainfall (r = 0.157) and rainy days (r = 0.382) exhibited a positive association. Only BSS (r = -0.211) and maximum temperature (r = -0.046) had a negative association with WEs (Table 3). The current findings align closely with the results of Pallavi *et al.* (2018) who reported that maximum per cent infestation during 15th and 16th MSW with 43.20 and 46.40% DH and 22% WE in 20th MSW with positive correlation to maximum temperature, minimum temperature, afternoon humidity and sunshine hours. Meanwhile, Prasad *et al.* (2022) observed that maximum and minimum temperatures have a positive significant effect on the incidence of DH at a range of 25.7–39.5°C and 13.8–25.9°C, respectively. Whereas, WE showed a positive significant correlation with

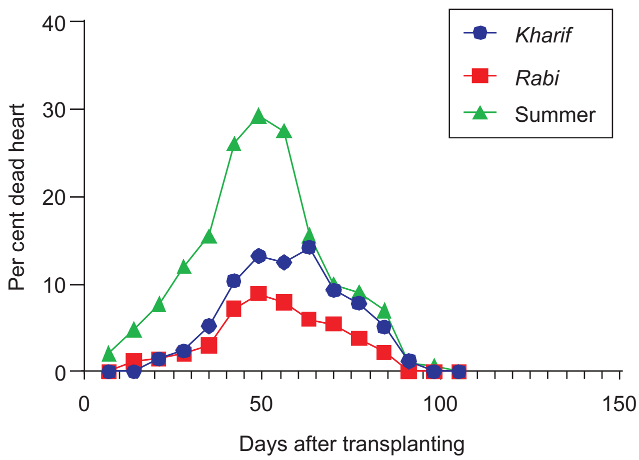

Fig. 1 Incidence of dead heart at weekly intervals across the seasons.

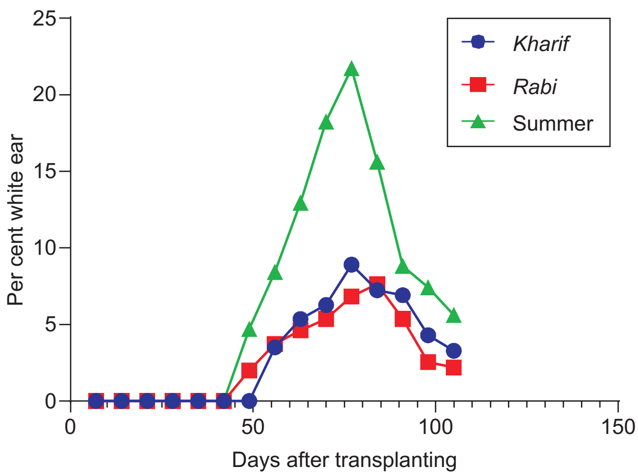

Fig. 2 Incidence of white ear at weekly intervals across the seasons.

minimum temperature (21.6–28.2°C) and evening relative humidity (62–95%). The rest of the abiotic factors, viz. rainfall, sunshine hours and relative humidity concurrently influenced the incidence of YSB.

Peak incidence of dead heart and white ear: In each of the seasons, the dead heart infestation started one week after transplanting. The peak dead heart infestation was observed between 30 and 50 DAT across all seasons, with the highest incidence of dead heart recorded in the summer season at 29.26% (Fig. 1). Likewise, the white ear infestation usually started at 50–60 DAT and the highest infestation was noticed in the summer season (21.74% WEs). Whereas the peak infestation of WEs was seen between 80–90 DAT (Fig. 2). Overall, the pest infestation was highest in the summer season followed by the *kharif* and *rabi* seasons. Similarly, Hugar *et al*. (2009) indicated the peak infestation of stem borer at 60 and 75 DAT. The peak incidence of YSB during summer was recorded when monitored with light and pheromone traps in lowland rice (Baskaran *et al*. 2019). Similarly, Shilpa *et al*. (2020) recorded the peak YSB infestation during *kharif* and summer.

Based on the findings, the least infestation occurred during July and January. To mitigate pest infestation effectively, it is recommended to implement early transplanting during both the *kharif* and summer season. In the case of *rabi*, infestation rates were lower compared to *kharif* and summer which is also consistent with previous studies. Besides early transplanting, timely intervention in pest management during the *rabi* season is crucial. Notably, peak infestation typically occurs between 30–40 DAT, necessitating management practices to commence between 20–25 DAT to prevent significant yield loss. It is important to acknowledge that climate change is real and is happening, these changing global warming patterns may influence variables such as temperature, rainfall frequency and relative humidity. These changes could potentially impact the severity of yellow stem borer infestation in the future. Therefore, it is recommended to maintain continuous monitoring of the pest, employ future prediction models and remain attentive to evolving weather conditions for effective pest management strategies.

ACKNOWLEDGMENT

Authors sincerely acknowledge the support of the KSTePS, Department of Science and Technology, Govt. of Karnataka for the financial assistance.

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