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Seasonal Occurence of Major Insect Pests of Rice Grown in Krishna Delta Region of Andhra Pradesh

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Authors' contributions

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

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ABSTRACT

The investigation on seasonal occurrence of major insect pests of rice grown in Krishna Delta of Andhra Pradesh was conducted during *kharif* 2023-24. Weekly observations on pest population in relation with abiotic factors revealed that the initial and peak incidence of yellow stem borer (YSB) as dead hearts was observed at vegetative stage during SMW 30 and SMW 38 with 0.30% and 5.56% respectively, whereas at reproductive stage the highest and lowest incidence in the form of white ears was observed after panicle emergence at SMW 44 and SMW 42 *i.e.,* 0.33% and 2.20%, respectively. The highest rice leaf folder incidence was recorded at SMW 39 (9.21%) and lowest at SMW 44 (1.00%). The highest and lowest brown planthopper (BPH) mean population was recorded at SMW 39 and SMW 31 and it was 9.60 hoppers/hill and 0.20 hoppers/hill, respectively. On the other hand, highest and lowest white backed planthopper (WBPH) mean population was recorded during SMW 38 and SMW 32 and it was 3.70 and 0.40 hoppers/hill respectively. The YSB showed non-significant negative correlation with maximum temperature and rainfall, while showed non-significant positive correlation with minimum temperature, morning and evening relative humidity. The rice leaf folder population showed non-significant negative correlation with minimum temperature and non-significant positive correlation with maximum temperature, morning and evening relative humidity and rainfall. BPH population showed non-significant negative correlation with maximum and minimum temperature and rainfall, while it was non-significant positive correlation with morning and evening relative humidity. WBPH population showed significant positive correlation with morning relative humidity, non-significant positive correlation with maximum temperature and evening relative humidity and non-significant negative correlation with minimum temperature.

Keywords: Abiotic factors; brown planthopper; rice leaf folder; seasonal occurrence; yellow stem borer.

1. INTRODUCTION

Rice, *Oryza sativa* (Poaceae) is the most important crop of the world and second largest cultivated cereal crop after wheat which occupies foremost status in human food requirement. It is cultivated in almost all tropical, subtropical and temperate countries and is the staple food of over half of the world's population and 90 per cent of Asians [1]. Raw rice is a good source of nutrients, which contains 7-8% protein, 3% fat, 77-84% carbohydrate, 3% fibre and a good source of thiamine (Vitamin B_1) and riboflavin (Vitamin B_2) together with eight essential amino acids (Chaudhari *et al.,* 2018). India is amongst the top most rice producers in the world, second only to China. In AP, paddy cultivation in Krishna district is highly significant growing in an area of 0.31 Mha out of 2.35 Mha in AP. The significant contributions of Krishna rice farmers in food production are recognized by production and productivity of 1.89 MT and 6006 kg ha^{-1} respectively [2].

From seedling to maturity, rice crop is affected by number of various insect pests which causes the severe quantitative and qualitative loss in yield [3,4]. About 100 species of insects have been reported to attack on rice crop in India, out of which, yellow stem borer (YSB) (*Scirpophaga incerulas* Walker), brown planthopper (BPH) (*Nilaparvata lugens* Stal), white backed planthopper (WBPH) (*Sogatella furcifera* Horvath), leaf folder (*Cnaphalocrocis medinalis* Guenee) are very important and can cause 21 to 51 per cent yield loss in different rice agro ecosystems. (Nikhil *et al.,* 2021). The yield loss estimates due to yellow stem borer, leaf folder and brown plant hopper are 25, 10 and 30%, respectively. Among the insect pests, yellow stem borer (YSB), *S. incertulas* (Walker) is the most destructive pest of rice, causing yield losses to the tune of 10-60 per cent every year [5].

Weather conditions also play an important role for determining the geographical distribution and periodic abundance of major insect pests in rice [6,7]. The infestation of major insect pests of rice depends on the prevailing weather conditions in an area and it also depends on type of variety used. Among the weather factors; temperature, rainfall, relative humidity plays the crucial role in insect life [8]. Hence it is necessary to quantify and verify, by the critical experiments, the theoretical relationships, normally proposed in rice insects between the abiotic factors and the population dynamics [9]. The knowledge of

insect-pests population dynamics is essential for developing sustainable crop protection strategies. Hence, population dynamics of major pests of rice were studied and correlated with the different weather parameters.

2. MATERIALS AND METHODS

2.1 Sampling Procedure

The study was carried out in Krishna Delta area of Krishna district of Andhra Pradesh during *kharif* 2023-2024. Krishna district is located between 15°-43' and 17°-10' of the Northern Latitude and 80°-0' and 81°-33' of the Eastern Longitude, which occupies first position in the rice growing area across the state (2.45 lakh hectares out of 22 lakh hectares in AP). The data was collected at weekly intervals from sowing to harvesting in 30 farmer fields from five mandals *viz.,* Kankipadu, Penamaluru, Vuyyuru, Thotlavalluru, Gannavaram (Table 1 and Fig. 1). Random sampling was done in fixed plots to record the occurrence of various pests in rice ecosystem for the entire crop growth period. For this, each field was hypothetically assumed and marked with X path for collection of data from ten random sampling spots (1 square metre each) using quadrant, and leaving 3 metres distance from the field borders. From each spot all the hills were observed for recording infestation level.

Table 1. Details of the farmers selected during *kharif* 2023-2024 in Krishna Delta of Andhra Pradesh

S. No.	Mandal	Village	Name of the Farmer	GPS Coordinates of the Field
1	Kankipadu	Kankipadu	Srinivasa Rao T	16.44N, 80.77E
2			Arun Kumar T	16.43N, 80.77E
3		Edupugallu	Srinivasa Rao V	16.44N, 80.76E
4			Rama Krishna T	16.45N, 80.77E
5		Kolavennu	Ramesh P	16.45N, 80.77E
6			Sai Babu N	16.44N, 80.76E
7	Penamaluru	Tadigadapa	Azez Sk	16.45N, 80.70E
8			Yasin Sk	16.45N, 80.69E
9		Pedapulipaka	Venkat Ramayya B	16.45N, 80.70E
10			Srinivas Reddy V	16.45N, 80.71E
11		Yanamalakuduru	Ragavayya N	16.45N, 80.70E
12			Imran Md	16.45N, 80.71E
13	Vuyyuru	Gandigunta	Yugendra Prasad N	16.37N, 80.99E
14			Kishore D	16.37N, 80.84E
15		Pedaogirala	Sathish N	16.37N, 80.82E
16			Somasekhar N	16.37N, 80.84E
17		Chinaogirala	Bhupal Reddy R	16.37N, 80.84E
18			Murali P	16.37N, 80.84E
19	Thotlavalluru	Thotlavalluru	Venkat Reddy B	16.35N, 80.79E
20			Prabakhar Reddy B	16.35N, 80.79E
21		Boddapadu	Venkatappa Reddy B	16.36N, 80.77E
22			Koti Reddy k	16.36N, 80.76E
23		Chalivendrapalem	Sagar P	16.34N, 80.79E
24			Shiva Reddy R	16.34N, 80.79E
25	Gannavaram	Mustabada	Karimulla Sk	16.52N, 80.76E
26			Kalil Rahman Sk	16.53N, 80.77E
27		Kesarapalli	Sambasiva Rao K	16.51N, 80.77E
28			Raja Ramesh U	16.50N, 80.74E
29		Purushothapatnam	Chakradhar Rao M	16.52N, 80.76E
30			Madhina saheb Sk	16.52N, 80.76E

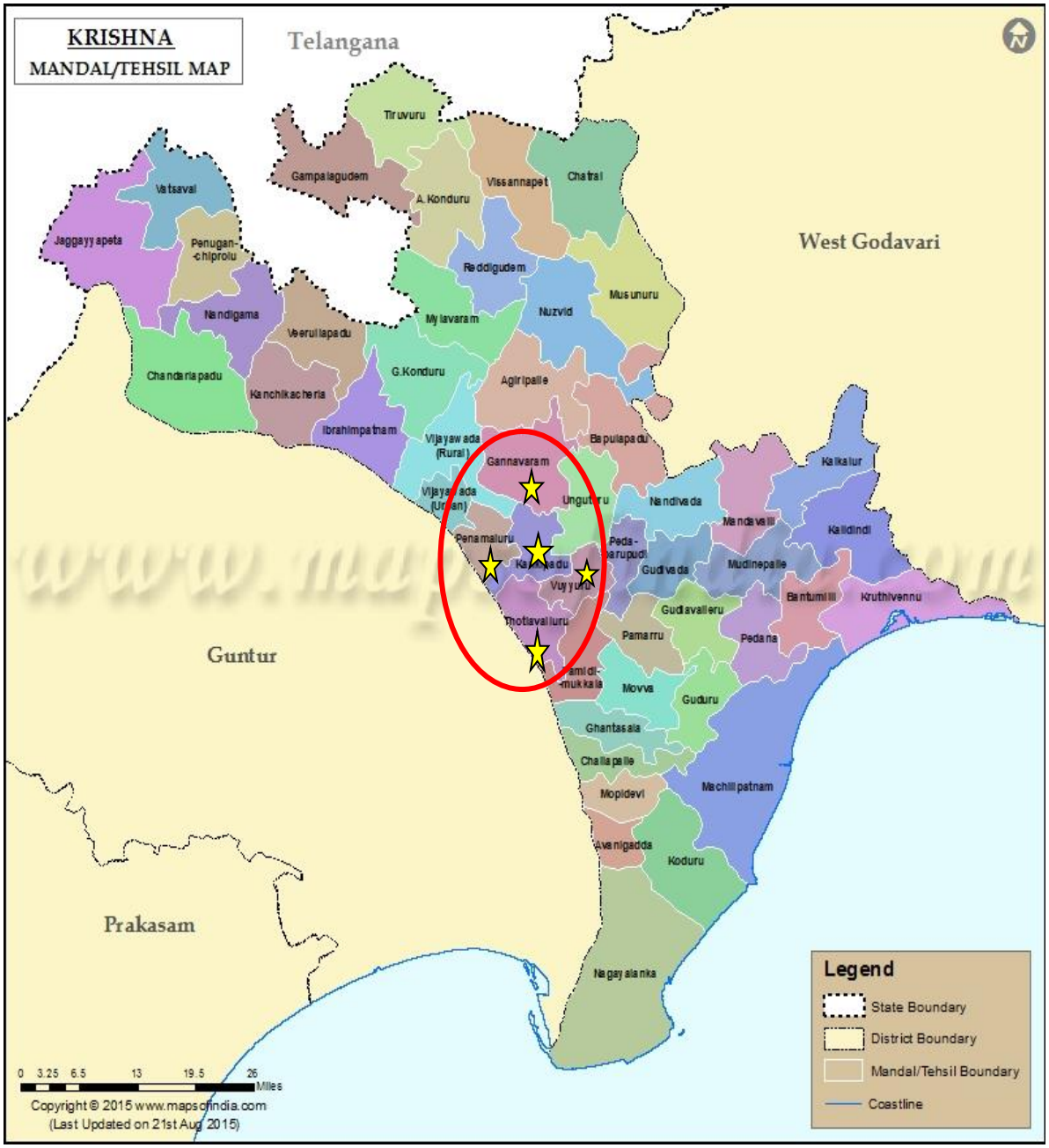

Fig. 1. Mandals selected for the study in Krishna district of Andhra Pradesh

Recording of Observations: In terms of standard meterological weeks (SMWs), the observations on pest data was recorded from 30-45 SMWs (July to November) of 2023 during the crop season and expressed as per cent or number per hill (mean) of all 30 farmer fields. As the farmers have applied pesticides continuously, the correlation of insect pest populations with weather parameters does not yield any clear-cut correlation. But, for general comprehension, the pest data was analysed for their incidence at weekly intervals throughout the season and was correlated with weather parameters. The effect of various weather parameters such as maximum temperature, minimum temperature, morning relative humidity, evening relative humidity and rainfall on the incidence of various insect pests was correlated and presented below. For the combined data, multiple linear regression models were also carried out. The weather data during *kharif* 2023-24 was obtained from Agricultural Research Station, Vuyyuru (Table 5).

Table 2. Incidence of insect pests of rice during *kharif* 2022-2023 (Mean of all 30 farmer fields)

Standard meteorological week (SMW)	Duration	Yellow stem borer		Leaf folder (% leaf damage)	Brown planthopper (hoppers/hill)	White backed planthopper (hoppers/hill)
		% Dead hearts	% White Ears			
SMW30	23 Jul - 29 Jul 2023	0.30	0.00	1.10	0.00	0.00
SMW31	30 Jul - 05 Aug 2023	0.70	0.00	1.31	0.20	0.00
SMW32	06 Aug - 12 Aug 2023	1.00	0.00	2.50	0.70	0.40
SMW33	13 Aug - 19 Aug 2023	2.15	0.00	2.20	2.45	0.90
SMW34	20 Aug - 26 Aug 2023	3.20	0.00	3.15	3.80	1.20
SMW35	27 Aug - 02 Sep 2023	3.93	0.00	3.94	5.40	1.50
SMW36	03 Sep - 09 Sep 2023	4.70	0.00	7.16	8.95	1.96
SMW37	10 Sep - 16 Sep 2023	4.30	0.70	8.02	7.45	2.35
SMW38	17 Sep - 23 Sep 2023	5.56	1.10	8.58	9.20	3.70
SMW39	24 Sep - 30 Sep 2023	0.50	1.23	9.21	9.60	3.15
SMW40	01 Oct - 07 Oct 2023	0.35	0.90	7.02	4.50	1.33
SMW41	08 Oct - 14 Oct 2023	0.00	1.80	4.60	1.80	0.96
SMW42	15 Oct - 21 Oct 2023	0.00	2.20	2.26	1.33	0.80
SMW43	22 Oct - 28 Oct 2023	0.00	0.50	1.24	0.00	0.00
SMW44	29 Oct - 04 Nov 2023	0.00	0.33	1.00	0.00	0.00
SMW45	05 Nov - 11 Nov 2023	0.00	0.00	0.36	0.00	0.00

Rice transplantations was carried out by all farmers in the study area at almost the same time (SMW-28) during *kharif* 2023-24 within a gap of 2-3 days.

Paddy Yellow Stem Borer (YSB): The incidence of YSB was recorded in terms of per cent damage by counting the damage done *i.e.,* dead hearts and white ears to total number of tillers and panicles per hill in vegetative and reproductive stages, respectively. The per cent damage was calculated using the below mentioned formula [10].

> Per cent damage (%) = Number of dead hearts or white ears per hill / Total number of tillers or panicles per hill X 100

Leaf Folder: The leaves that had damage symptoms like folded leaves and scratching of chlorophyll by larva were considered to record per cent damage infestation. The extent of damage caused by leaf folder was calculated using the formula presented below [11].

> Per cent damage (%) = Number of damaged leaves per hill / Total number of leaves per hill X 100

Planthoppers (Brown Planthoppers (BPH) and White Backed Planthoppers (WBPH): The number of nymphs and adults per hill were counted to record the abundance of BPH and WBPH in the field and expressed as population per hill [10].

3. RESULTS AND DISCUSSION

3.1 Incidence of Yellow Stem Borer

The incidence of YSB started at tillering stage of the crop and continued till harvest.

3.2 Per cent Dead Hearts during Kharif 2023-24

The dead hearts caused due to YSB incidence presented in (Table 2) revealed that, the initial record of dead hearts (0.30 %) was noticed during SMW 30 (23 Jul - 29 Jul 2023) and gradually increased reaching highest per cent of damage (5.56%) during SMW 38 (17 Sep - 23 Sep 2023), during which maximum and minimum temperature ranged from 34.00^{0}C and 23.90^{0}C, morning and evening relative humidity ranged from 91.43% and 74.00% and rainfall 71.5mm (Table 5). Studies conducted by Kumar et al., (2013), Patel and Singh [12]. Tandon and Srivastava (2018), Pallavi et al., (2018), Jasrotia et al., [13], Patil et al., [3] Sreelatha et al., [14], Varsha *et al.,* [6] also reported the peak infestation of YSB (dead hearts) during SMW 38.

The correlation results of dead hearts caused due to YSB with abiotic factors (Table 3) revealed non-significant positive correlation with minimum temperature (0.264), morning relative humidity (0.227) and evening relative humidity (0.449), while showed non-significant negative correlation maximum temperature (-0.084), and rainfall (-0.100). The incidence of dead hearts and abiotic factors were subjected to MLR analysis and the results revealed coefficient of determination (R^2) value of 0.715, which indicates that the weather parameters could cause 71.5 % variation in occurrence of dead hearts (Table 4). The above discussed results were in agreement with the findings of Rana et al., (2017), Sreelatha et al., [14] and Kumar et al., [1] who reported that minimum temperature, morning and evening relative humidity showed non-significant positive correlation. Similar findings were also reported by Nikhil et al., [15] and Devi and Varma [16] who stated that maximum temperature and rainfall showed non-significant negative correlation.

3.3 Per Cent White Ears

The incidence of white ears (0.70 %) was first noticed after emergence of panicles during SMW 37 (10 Sep - 16 Sep 2023) and reached the peak incidence (2.20 %) during SMW 42 (15 Oct - 21 Oct 2023) (Table 2), during which maximum and minimum temperature ranged from 34.71^{0}C and 25.57^{0}C, morning and evening relative humidity ranged from 86.86% and 54.86% and rainfall 4.6mm (Table 5). The present results were conferred by Das [17], Paramasiva et al., [18] Sreelatha et al., [14] and Yadav et al., [8] who also reported the peak infestation of YSB (white ears) during SMW 42.

The correlation results of per cent white ears caused by YSB with abiotic factors (Table 3) revealed non-significant negative correlation with minimum temperature (-0.253), evening relative humidity (-0.150) and rainfall (-0.112), while maximum temperature (0.325) and morning relative humidity (0.329) showed positive non-significant correlation. The incidence of white ears and abiotic factors were subjected to MLR analysis and the results revealed coefficient of

determination (R^2) value of 0.539, which indicates that the weather parameters could cause 53.9 % variation in occurrence of white ears (Table 4). The findings related to correlation of per cent white ears with abiotic factors were in line with the findings of Appalanaidu et al., [19] and Morshed et al., [20] who reported non-significant positive correlation with maximum temperature and non-significant negative correlation with minimum temperature and evening relative humidity. Ashrith et al., [21], Sulagitti et al., [22] Varsha et al., [6] and Amandeep et al., [23] who reported non-significant positive correlation with morning relative humidity and non-significant negative correlation with rainfall also support the present findings.

3.4 Incidence of Leaf Folder

The mean data on leaf folder incidence presented in (Table 2) revealed that, the initial incidence (1.10%) was noticed during SMW 30 (23 Jul - 29 Jul 2023) and gradually increased causing highest per cent leaf damage during SMW 39 (24 Sep - 30 Sep 2023) causing 9.21% leaf damage (Table 2), during which maximum and minimum temperature ranged from 33.43^{0}C and 22.00^{0}C, morning and evening relative humidity ranged from 88.29% and 66.43% and rainfall 38.20mm (Table 5). The present findings are in accordance with the findings of Kakde and Patel [24], Netam and Gupta [25], Gajjar et al., [26] Thokchom et al., [27] Rautaray et al., [28], Das [17], Seni et al., (2022) and Das et al., [17] who reported peak infestation of leaf folder during SMW 39.

The correlation results of leaf folder damage with abiotic factors (Table 3) revealed non-significant positive correlation with maximum temperature (0.054), morning relative humidity (0.482), evening relative humidity (0.355) and rainfall (0.003) unlike minimum temperature (-0.331), which showed non-significant negative correlation. The incidence of leaf folder and abiotic factors were subjected to MLR analysis and the results revealed coefficient of determination (R^2) value of 0.475, which indicates that the weather parameters could cause 47.5 % variation in leaf folder incidence (Table 4). The above findings with respect to

Table 3. Correlation between incidence of insect pests of rice and weather parameters during *kharif* 2023-24 in in Krishna Delata area of Krishna district of Andhra Pradesh

Insect pest	Correlation coefficient (r)				
	Temperature (^{0}C)		Relative humidity (%)		Rainfall (mm)
	Maximum	Minimum	Morning	Evening	
Yellow stem borer (Dead hearts)	-0.084	0.264	0.227	0.449	-0.100
Yellow stem borer (White ears)	0.325	-0.253	0.329	-0.150	-0.122
Leaf folder	0.054	-0.331	0.482	0.355	0.003
Brown planthopper	-0.020	-0.179	0.490	0.484	-0.018
White backed planthopper	0.089	-0.358	0.507*	0.455	-0.009

*** Correlation is significant at 0.01 level (2-tailed); * Correlation is significant at 0.05 level (2-tailed)*

Table 4. Regression equations for insect pest complex of rice with weather parameters during *kharif* 2023-24 in Krishna Delata area of Krishna district of Andhra Pradesh

Insect pests	Regression equation	R^2
Yellow stem borer (Dead hearts)	Y = -17.265 - 0.271 X1 + 0.460 X2 - 0.004 X3 + 0.285 X4 - 0.036 X5	0.715
Yellow stem borer (White ears)	Y = -16.040 + 0.282 X1 - 0.092 X2 + 0.148 X3 - 0.055 X4 + 0.033 X5	0.539
Leaf folder	Y = -50.593 + 0.747 X1 - 0.643 X2 + 0.369 X3 + 0.244 X4 - 0.031 X5	0.475
Brown planthopper	Y = -53.209 + 0.332 X1 - 0.219 X2 + 0.301 X3 + 0.430 - 0.054 X5	0.608
White backed planthopper	Y = -19.630 + 0.348 X1 - 0.244 X2 + 0.089 X3 - 0.127 X4 - 0.012 X5	0.678

Note: X_1 = Maximum temperature (Mean), X_2 = Minimum temperature (Mean), X_3 = Morning relative humidity (Mean), X_4 = Evening relative humidity (Mean), X_5 = Rainfall (Mean)

Table 5. Weather data during *kharif* 2023-24

SMW	Date	Maximum Temp. (ºC)	Minimum Temp. (ºC)	Morning RH (%)	Evening RH (%)	Rainfall (mm)
27	July 02 - Jul 08	33.57	25.57	85.85	60.14	24.00
28	July 09 - Jul 15	32.71	25.42	86.00	65.14	24.9
29	July 16 - Jul 22	30.87	25.57	87.28	74.85	67.4
30	July 23 - Jul 29	30.14	25.00	91.00	78.57	216.5
31	July 30 - Aug 05	34.00	26.70	78.14	59.00	2.0
32	Aug 06 - Aug 12	34.28	26.42	81.85	56.28	4.20
33	Aug 13 - Aug 19	34.00	26.28	83.14	58.42	4.00
34	Aug 20 - Aug 26	34.28	25.85	87.14	67.71	2.20
35	Aug 27 - Sep 02	35.57	26.42	83.42	60.14	0.3
36	Sep 03 - Sep 09	32.42	26.28	89.14	68.71	35.5
37	Sep 10 - Sep 16	32.00	25.86	89.14	68.29	18.00
38	Sep 17 - Sep 23	34.00	23.29	91.43	74.00	71.5
39	Sep 24 - Sep 30	33.43	22.00	88.29	66.43	38.2
40	Oct 01 - Oct 07	34.57	26.29	86.29	52.71	10.9
41	Oct 08 - Oct 14	35.00	26.14	88.86	60.57	13.4
42	Oct 15 - Oct 21	34.71	25.57	86.86	54.86	4.6
43	Oct 22 - Oct 28	34.00	24.14	80.00	50.71	0
44	Oct 29 - Nov 04	33.14	24.43	86.57	58.86	28.1
45	Nov 05 - Nov 11	32.71	24.00	88.14	60.57	27.9
46	Nov 12 - Nov 18	32.71	23.57	83.14	51.57	0.1
47	Nov 19 - Nov 25	32.42	23.85	80.14	61.85	34.8
48	Nov 26 - Dec 02	33.00	22.57	82.28	60.00	0

(Source: ARS, Vuyyuru)

abiotic factors and leaf folder infestation were in line with the reports of Varsha et al., [6] who stated that maximum temperature, morning relative humidity, evening relative humidity and rainfall showed non-significant positive correlation. Studies conducted by Ashrith et al.,[21] Bumireddy et al., [29] and Rautaray et al., [28] reported that correlation of leaf folder incidence with minimum temperature showed non-significant negative correlation.

3.5 Incidence of Brown Planthopper

The initial incidence of BPH was noticed at early tillering stage of the crop during SMW 31 (30 Jul - 05 Aug 2023) with 0.20 hoppers/hill and gradually increased where the highest number of hoppers/hill were observed during SMW 39 (24 Sep - 30 Sep 2023) with 9.60 hoppers/hill (Table 2), during which maximum and minimum temperature ranged from 33.43^{0}C and 22.00^{0}C, morning and evening relative humidity ranged from 88.29% and 66.43% and rainfall 38.20mm (Table 5). Studies carried out by Tetarwal et al., [30] , Das [17] Mohanta et al., [31], Yadav et al., [8] also reported peak incidence of BPH during SMW 39 which confirms the above findings of the present study.

The results of correlation between BPH and abiotic factors (Table 3) revealed negative non-significant correlation with maximum temperature (0.422), minimum temperature (0.450) and rainfall (0.123), while showed positive non-significant correlation with morning relative humidity (0.184), evening relative humidity (0.323). The incidence of BPH and abiotic factors were subjected to MLR analysis and the results revealed coefficient of determination (R^2) value of 0.549, which indicates that the weather parameters could cause 60.8 % variation in leaf folder incidence (Table 4). Verma et al., [32] and Kumar et al., [1] had also almost similar findings, that morning relative humidity, evening relative humidity showed positive non-significant correlation and rainfall showed positive non-significant correlation. On the other hand, study conducted by Kumar et al., (2020) that showed negative non-significant correlation with maximum temperature and minimum temperature is in agreement with the present study.

3.6 Incidence of White Backed Planthopper

The initial incidence of WBPH started in early tillering stage of the crop during SMW 32 (06 Aug - 12 Aug 2023) with 0.40 hoppers/hill and and

gradually increased where the highest number of hoppers/hill were observed during SMW 38 (17 Sep - 23 Sep 2023) with 3.70 hoppers/hill (Table 2), during which maximum and minimum temperature ranged from 34.00^{0}C and 23.90^{0}C, morning and evening relative humidity ranged from 91.43% and 74.00% and rainfall 71.5mm (Table 5). The above finding was similar to the findings of Krishnaiah et al., [33,34] at Maruteru, Andhra Pradesh, who reported maximum incidence of WBPH at panicle initiation stage. The results of correlation between WBPH and abiotic factors (Table 3) revealed non-significant positive correlation with maximum temperature (0.089) and evening relative humidity (0.455), while showed non-significant negative correlation minimum temperature (-0.358), rainfall (-0.009) and significant positive correlation with morning relative humidity (0.507*).

4. CONCLUSION

The research revealed that, the initial occurrence of YSB (0.30%) was observed during SMW 30 and gradually increased reaching highest per cent of damage (5.56%) during SMW 38 and during reproductive stage of the crop white ear head was maximum during SMW 42. The initial occurrence of leaf folder was observed during SMW 30 and gradually increased causing highest per cent leaf damage during SMW 39 with 9.21% leaf damage. The initial incidence of brown planthopper (*Nilaparvata lugens*) was observed at early tillering stage of the crop during SMW 31 with 0.20 hoppers/hill and gradually increased where the highest number of hoppers/hill were observed during SMW 39 with 9.60 hoppers/hill. The results are benefitting to promote Economic Threshold Level (ETL) among farmers as a result of which unnecessary and irrational usage of pesticides can be reduced.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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