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Consequences of Weather Parameters and their Correlation with the Sucking Pests and Gundhi Bug of Rice (*Oryza sativa* L.)

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ABSTRACT

The field experiments were carried out during kharif 2020 and 2021 at the Agriculture Research Station research farm, Sakoli, Dist. Bhandara (Maharashtra) under Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The findings of this study showed a considerable impact of climatic variables on the biology of sucking pests, notably the rice gundhi bug, brown plant hopper, white-backed plant hopper and green leaf hopper. In *kharif* 2020, the maximum population of green leaf hopper, brown plant hopper and white backed plant hopper was observed at 45th meteorological weak (2.53 nos/hill), 43rd MW (1.33 nos/hill) and 46th (3.53 nos/hill), respectively. In *kharif* 2021, the green leaf hopper reached its peak level during at 41st meteorological week (1.67 nos/hill), and the brown plant hopper attained its peak at the 44th meteorological week (9.60 nos/hill), while the maximum population of white backed plant hopper was observed at 43rd meteorological weak (1.33 nos./hill). In contrast, the incidence of the gundhi bug was the highest at 45th (0.27 nos./hill) and 41st meteorological week (0.23 nos./hill) in *kharif* 2021 and 2022, respectively. Additionally, there was a strong relationship between the investigated pest population and other environmental variables, including maximum temperature, minimum temperature, relative morning humidity, relative evening humidity, rainfall and the number of days with rain during both seasons.

Keywords Brown plant hopper, Correlation, Green leaf hopper, Gundhi bug, Seasonal incidence, Rice, Weather parameters.

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INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereals among the field crops, feeding more than 50% population of the world. It is an important staple food for most of the population. It is almost cultivated in tropical, subtropical and temperate countries worldwide. Regarding area and production, rice stands second after wheat in the world. To meet the increasing population demand, we must grow and increase rice production yearly. However, several biotic and abiotic constraints encounter in the production of rice. Insect pest is among them that occur throughout the growing period of rice. It is subjected that more than 100 species of insects attracted to the rice plant, mostly 20 of them pest species, causing a 30% yield loss (Atwal and Dhaliwal 2005).

Stem borers (*Scirpophaga incertulas*), gall midge (*Orseolia oryzae*), brown plant hoppers (*Nilaparvata lugens*), white-backed plant hopper (*Sogatella furcifera*), green plant hopper (*Nephotettix virescens*) and leaf folders (*Cnaphalocrocis medinalis*), are the most important and widely distributed pest species. Plant hoppers and gall midge usually create localized outbreaks, causing high-yield losses in relatively small areas. In India, the significant constraints of rice production are insect pests at various crop growth stages. The brown plant hopper (BPH) (*Nilaparvata lugens* Stal.) belongs to the order Homoptera, family Delphacidae with piercing and sucking mouth parts. They suck the plant sap from the phloem vessels through their proboscis, the plant starts wilting with outermost leaves drying first and then drying up. The green leaf hopper (GLH) (*Nephotettix virescens*) belongs to the order Hemiptera, family Cicadellidae, suck the cell sap from leaves and turns it brown. It transmits the tungro disease of rice. White-backed plant hopper (WBPH) (*Sogatella furcifera*) belongs to the order Homoptera, family Delphacidae, suck the cell sap at the base of rice plant and leaf surface.

Climate change, especially temperature, affects insect physiology, behavior, development, and species distribution and abundance, evidenced by changes in the number of generations a year, increasing survival rates in winter and the earlier appearance of some insects. Recently, emphasis has been given to ecological-based pest management strategies. The main components of any pest management program are to study the incidence period of the pest, population distribution of crops and regular monitoring or survey of the field. Seasonal incidence studies help plan the need-based application of insecticides as they reveal the insect's peak activity and insect-free periods during crop growth (Sulagitti *et al.* 2017).

MATERIALS AND METHODS

Experimental site and methods

At the Agriculture Research Station research farm in Sakoli District, the field experiment was conducted during the *kharif* seasons of 2020 and 2021. Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Bhandara (MH). The investigation was laid out on a 400 m^2 experimental plot. Before being planted in raised beds, rice seeds (var PKV HMT) were treated with a 3% brine solution. Before planting, the earth was flooded, and then rice seedlings were transplanted 20 x 15 cm^2 apart. Typically, 1-2 rice seedlings were transplanted into puddled soil per hill. The data on pest infestation was recorded weekly after transplanting and continued to crop harvesting. The observation of the population of GLH, WBPH and BPH was recorded by counting the total number of GLH, WBPH and BPH present on the hill. The population of the gundhi bug was recorded by counting the total number of gundhi bugs per hill.

Statistical analysis

The data obtained from the experiment were subjected to correlation analysis using OPSTAT.

RESULTS AND DISCUSSION

Seasonal incidence of green leaf hopper

The incidence of the green leaf hopper (Table 1) was seen in the first week of September (35^{th} MW) with a population of 0.36 nos/hill and it attained its peak during the third week of November (46^{th} MW) with a population of 3.53 nos/hill in *kharif* 2020. Whereas, in *kharif* 2021, the population of GLH reaches its maximum infestation at 41^{st} MW, i.e., the second week of October, with a population of 1.67 nos/hill. The seasonal pooled incidence of GLH revealed the highest population at 43^{rd} MW i.e., with a population of 2.12 nos/hill. A similar result was recorded by Kathirvelu and Manickavasgam (2007), they reported that green leaf hopper (GLH) had the highest population at the 35^{th} standard week. Likewise, Kalita *et al.* (2020) recorded that the green leaf hoppers' peak population appeared in 38^{th} -39^{th} SMW.

Table 1. Seasonal incidence of pests of rice during *kharif* 2020.

Date	MW	Green leaf hopper (No./hill)	White-backed plant hopper (No./hill)	Brown plant hopper (No./hill)	Gundhi bug (No./hill)
2.7.2020	26	0.00	0.00	0.00	0.00
7.7.2020	27	0.00	0.00	0.00	0.00
14.7.2020	28	0.00	0.00	0.00	0.00
21.7.2020	29	0.00	0.00	0.00	0.00
27.7.2020	30	0.00	0.00	0.00	0.00
1.8.2020	31	0.00	0.00	0.00	0.00
11.8.2020	32	0.00	0.00	0.00	0.00
17.8.2020	33	0.00	0.00	0.00	0.00
24.8.2020	34	0.00	0.00	0.00	0.00
1.9.2020	35	0.36	0.03	0.00	0.00
7.9.2020	36	0.43	0.13	0.00	0.00
14.9.2020	37	1.03	0.76	2.30	0.00
21.9.2020	38	2.13	1.46	3.00	0.00
29.9.2020	39	1.26	1.11	5.90	0.00
6.10.2020	40	1.90	2.00	10.73	0.00
12.10.2020	41	2.40	2.03	9.06	0.06
19.10.2020	42	2.23	1.80	7.73	0.13
27.10.2020	43	2.63	2.23	9.70	0.26
2.11.2020	44	2.66	2.03	10.73	0.20
9.11.2020	45	2.63	2.53	17.26	0.27
17.11.2020	46	3.53	2.30	10.50	0.16
24.11.2020	47	2.20	2.13	8.56	0.20

MW: Meteorological week.

Seasonal incidence of brown plant hopper

The seasonal incidence of brown plant hopper was presented in Table 1, and it revealed that the population was initiated from 37th MW and attained its peak during the first week of October (45th MW) with a population of 17.26 nos/hill in *kharif* 2020. In *kharif* 2021, the population of BPH in Table 2 was seen in the first week of September (35th MW) and reached the maximum infestation level in the first week of November (44th MW) with a population of 9.60 nos/hill. The pooled population of BPH presented in Table 3 shows that in the first week of September (35th MW) and attained its peak in the second week of November (45th MW) with a population of 12.88 nos/hill. A similar result was found by Sulagitti *et al.* (2017), that BPH appeared in rice crops during the first week of August and reached the highest level of infestation during 2nd week of October. Kumar *et al.* (2020) revealed that the rice brown plant hopper reaches the peak level during the 41st SMW.

Seasonal incidence of white-backed plant hopper

The data of seasonal incidence of *kharif* 2020 was presented in Table 1 and it revealed that the population WBPH was initiated from (35th MW) with a very less population (0.03 nos/hill) in the first week of September, and then it gradually rose to the maximum during the second week of November (45th MW) with a population of 2.53 nos/hill. In *kharif* 2021, the population of WBPH in Table 2 and depicted in was seen in the first week of September (35th MW) and continued up to harvesting (47th MW). At 35th MW, the population of WBPH was 0.16 nos./hill, and it reached its maximum level of infestation at 43rd MW, i.e., the last week of October (1.33 nos/hill). The pooled population of WBPH (Table 3) was seen in the first week of September (35th MW) with a population of 0.10 nos/hill. After the initiation of the white-backed plant hopper, it gradually increased and attained the peak at 41st MW, i.e., the second week of October (1.82 nos./hill). A similar type of result was recorded by Prasad *et al* (2010). They reported that the white-backed plant hopper was maximum during November. Seni and Naik (2018), concluded that the number of white-backed plant hoppers per hill was found to initially low (0.4/hill) during 2nd week of

Table 2. Seasonal incidence of pests of rice during *kharif* 2021.

Date	MW	Green leaf hopper (No./hill)	White-backed plant hopper (No./hill)	Brown plant hopper (No./hill)	Gundhi bug (No./hill)
1.7.2021	26	0	0	0	0
7.7.2021	27	0	0	0	0
14.7.2021	28	0	0	0	0
22.7.2021	29	0	0	0	0
26.7.2021	30	0	0	0	0
2.8.2021	31	0	0	0	0
9.8.2021	32	0	0	0	0
17.8.2021	33	0	0	0	0
23.8.2021	34	0	0	0	0
30.8.2021	35	0.13	0.16	0.03	0
6.9.2021	36	0.24	0.15	2.14	0
15.9.2021	37	0.4	0.03	3.56	0
22.9.2021	38	0.46	0.26	4.97	0.4
28.9.2021	39	0.7	0.5	7.33	0.23
5.10.2021	40	1.13	0.9	8.86	0.13
12.10.2021	41	1.67	1.6	8.66	0.23
21.10.2021	42	0.97	0.73	8.3	0
26.10.2021	43	1.6	1.33	9.36	0.16
1.11.2021	44	1.1	0.96	9.6	0.13
8.11.2021	45	1.23	1.1	8.5	0.07
15.11.2021	46	0.8	0.83	4.03	0.43

MW: Meteorological week.

September (36th SMW) and reached the peak during the 1st week of November (44th SMW).

Seasonal incidence of gundhi bug

The data of seasonal incidence of gundhi bug in *kharif* 2020 was presented in Table 1 and concluded that the population was initiated from the week of October (41st MW) with the population 0.06 nos/hill and then gradually rising to reach the maximum level at the second week of November (45th MW) with a population of 0.27 nos/hill. In *kharif* 2021, the population of the gundhi bug (Table 2) was seen in the third week of September (38th MW) with a population of 0.40 nos/hill. Afterward, it gradually increased in the last week of November (46th MW) with a population of 0.43 nos/hill. The pooled population of the gundhi bug (Table 3) was seen in 38th MW and continued up to harvesting (46th MW). At 38th MW, the gundhi bug population was very low, with a population of 0.20 nos/hill. Afterward, it gradually increased and reached its maximum level in the third week of November with a population of 0.23 nos/hill. A similar result was recorded by Kalita *et al.* (2015), found maximum when the crop attained the milky stage in the first fortnight of October. Gupta *et al.* (2018), found that the initial incidence of the rice gundhi bug was noticed on the 38th (third week of September) standard week and reached the peak in the 43rd (fourth week of October) standard week.

Correlation analysis of green leaf hopper with weather parameters during *kharif* 2020 and 2021

The data analysis of the correlation coefficient of *kharif* 2020 and *kharif* 2021 showed that rainfall (r= -0.922**) and rainy days (r= -0.687**) had a negative and highly significant relationship with the GLH population. While, wind speed (r= -0.330), minimum temperature (r= -0.456), morning relative humidity (r= -0.478) and evening relative humidity (r= -0.127) had a negative and maximum temperature (r= 0.127) showed positive but non-significant correlation with it. While green mirid bug (r= 0.898**) and brown mirid bug (r= 0.805**) had positive and significant

Table 3. Pooled seasonal incidence of pests of rice during *kharif* 2020 and 2021.

Date	MW	Green leaf hopper (No./hill)	White-backed plant hopper (No./hill)	Brown plant hopper (No./hill)	Gundhi bug (No./hill)
1.7.2021	26	0.00	0.00	0.00	0.00
7.7.2021	27	0.00	0.00	0.00	0.00
14.7.2021	28	0.00	0.00	0.00	0.00
22.7.2021	29	0.00	0.00	0.00	0.00
26.7.2021	30	0.00	0.00	0.00	0.00
2.8.2021	31	0.00	0.00	0.00	0.00
9.8.2021	32	0.00	0.00	0.00	0.00
17.8.2021	33	0.00	0.00	0.00	0.00
23.8.2021	34	0.00	0.00	0.00	0.00
30.8.2021	35	0.25	0.10	0.02	0.00
6.9.2021	36	0.34	0.14	1.07	0.00
15.9.2021	37	0.72	0.40	2.93	0.00
22.9.2021	38	1.30	0.86	3.99	0.20
28.9.2021	39	0.98	0.81	6.62	0.12
5.10.2021	40	1.52	1.45	9.80	0.07
12.10.2021	41	2.04	1.82	8.86	0.15
21.10.2021	42	1.60	1.27	8.02	0.07
26.10.2021	43	2.12	1.78	9.53	0.21
1.11.2021	44	1.88	1.50	10.17	0.17
8.11.2021	45	1.93	1.82	12.88	0.17
15.11.2021	46	1.67	1.57	7.27	0.30
21.11.2021	47	1.60	1.07	4.28	0.10

MW: Meteorological week.

correlation at a 1% level. However, ladybird beetle (r= 0.576*) represents a positive correlation at a 5% level and spider (r= 0.401) showed a positive but non-significant correlation with the population of green leaf hoppers. Sawai *et al.* (2019). Concluded that evening relative humidity, rainfall, and rainy days had a significant negative correlation with the population of green leaf hoppers. Singh *et al.* (2020) found the negative correlation of green leaf hopper with rainfall maximum temperature minimum temperature, relative humidity, spiders and natural enemies.

Correlation analysis of brown plant hopper with weather parameters during *kharif* 2020 and 2021

The correlation analysis of *kharif* 2020 and *kharif* 2021 (Table 4) revealed that rainy days (r= -0.657*) showed a negative and significant correlation with the brown plant hopper population. Then rainfall (r= -0.841**) showed a negative but highly significant correlation with the population of brown plant hoppers. While wind speed (r= -0.142), minimum temperature (r= -0.172) and evening relative humidity (r= -0.206) had a negative but non-significant relationship with it. However, maximum temperature (r= 0.0588*) had a positive and significant correlation at 5%. While green mirid bug (r= 0.934**) and brown mirid bug (r= 0.817**) showed positive and significant correlation at a 1% level. Whereas morning relative humidity (r= 0.115), spider (r= 0.443) and ladybird beetle (r= 0.468) represent positive but non-significant correlations with the brown plant hopper population.

These findings are similar to Seni and Naik (2018), reporting that rice crops' brown plant hop population was significantly and negatively correlated with minimum temperature, evening relative humidity, and rainfall. Whereas negatively non-significantly correlated with morning relative humidity (r= 0.015) Sawai *et al.* (2019). Concluded that evening relative humidity, rainfall and rainy days had a significant negative correlation with the population of brown

Table 4. Pooled correlation coefficient of pests of rice during *kharif* 2020 and 2021.

Weather parameter		Brown plant hopper (No./hill)	White-backed plant hopper (No./hill)	Green leaf hopper (No./hill)	Gundhi bug (No./hill)
Rainfall (mm)		-0.841**	-0.906**	-0.922**	-0.019
Rainy days		-0.657*	-0.719**	-0.687**	-0.005
Wind speed		-0.142	-0.251	-0.330	0.009
Temperature	Min (^{0}C)	-0.172	-0.329	-0.456	0.179
	Max (^{0}C)	0.588*	0.414	0.127	0.187
Humidity	Min (%)	-0.206	-0.360	-0.478	0.051
	Max (%)	0.115	0.595*	-0.324	0.192
Table 'r' value at 1% significance level		0.684	0.684	0.684	0.765
Table 'r' value at 5% significance level		0.553	0.553	0.553	0.632

** at 1% significance level, * at 5% significance level.

plant hoppers.

Correlation analysis of white-backed plant hopper with weather parameters during *kharif* 2020 and 2021

The pooled correlation analysis of *kharif* 2020 and *kharif* 2021 (Table 4) revealed that rainfall (r= -0.906**) and rainy days (r= -0.719**) showed negative and highly significant correlation with the population of white-backed plant hoppers. However, morning relative humidity (r= -0.595*) had a negative but non-significant correlation, whereas wind speed (r= -0.251), minimum temperature (r= -0.329) and evening relative humidity (r= -0.360) represented negative and non-significant correlation with a population of white backed plant hopper. Maximum temperature (r= 0.414) had a positive but non-significant correlation, while ladybird beetle (r= 0.619*) also had a significant positive correlation at a 5% level with the white-backed plant hopper population. Likewise, the green mirid bug (r= 0.940**) and the brown mirid bug (r= 0.844**) had a positive and significant correlation at the 1% level. This present study is in line with the findings of Win *et al.* (2011), that maximum temperature and relative humidity had a significant positive correlation with the white-backed plant hopper population. Sawai *et al.* (2019) observed the positive correlation of the white-backed plant hopper population with morning relative humidity. They concluded that evening relative humidity, rainfall and rainy days negatively correlate significantly with the white-backed plant hopper population.

Correlation analysis of gundhi bug with weather parameters during *kharif* 2020 and 2021

The pooled correlation analysis of *kharif* 2020 and *kharif* 2021 (Table 4) revealed that rainfall (r= -0.019) and rainy days (r= -0.005) had a negative non-significant correlation with the population of the gundhi bug. Whereas morning relative humidity (r= 0.192), wind speed (r= 0.009), maximum temperature (r= 0.187), minimum temperature (r= 0.179) and evening relative humidity (r= 0.051) showed positive but non-significant correlation with gundhi bug population. A similar result was observed by Parwez *et al.* (2012), which reported that the maximum temperature and wind velocity showed negative effect, whereas minimum temperature and relative humidity positively influenced the gundhi bug infestation. Likewise, Das *et al.* (2021) revealed that only rainfall (r= -0.606) showed a significant negative correlation, whereas other parameters showed a non-significant correlation with the gundhi bug population.

CONCLUSION

The present investigation concluded that the infestation of green leaf hopper, brown plant hopper, white backed plant hopper and gundhi bug was seen after one month of transplanting rice and continued till the harvesting; therefore, it becomes crucial to take timely pest management operations to reduce the infestation of these pests of rice. Additionally, the presence of these pests demonstrated a strong correlation with various weather variables. The results of the current study showed that studying the population dynamics of the four pests, i.e., green leaf hopper, brown plant hopper, white backed plant hopper and gundhi bug, helps for the identification of the peak pest activity periods and their correlation with various weather factors, including rainfall, the presence of rainy days, minimum and maximum temperatures, wind speed, morning and evening relative humidity. It is also helpful to develop the IPM program to integrate new management tactics.

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