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Incidence of leafhoppers in rice in relation to meteorological parameters

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Abstract
The present investigation was carried out at College of Agriculture, V. C. Farm, Mandya, University of Agricultural Sciences, Bangalore, during *Kharif* 2019. Occurrence of leafhoppers of rice was monitored by using yellow sticky trap on rice variety Jaya. The investigation revealed that, hoppers activity was first recorded during 36th standard meteorological week (SMW) on yellow sticky traps. Among the leafhopper complex observed during crop period only four species were abundant *viz*., *Nephottetix virescens, N. nigropictus, C. spectra* and *Maiestas dorsalis.* The peak incidence of *Nephottetix virescens* was observed during 45th SMW (25.00 hoppers/trap). The more number of *N. nigropictus* was recorded from 44th to 48th SMW (15.30 to 13.00 hoppers /trap). The highest number of trap catches was noticed at 45th SMW (19.8 hoppers/trap). *N. virescens and N. nigropictus* showed significant and positive association with sunshine hours and maximum temperature. Whereas, minimum temperature and morning relative humidity had found positive and non-significant association. Afternoon relative humidity, rainfall and number of rainy days were found negative association on leafhopper build up and found non-significant.

Keywords: Leafhopper, incidence, weather, parameters, correlation

Introduction
Rice (*Oryza sativa* Linn.), a member of the Gramineae group, evolved at least 130 million years ago. Rice is fundamental to the lives of billions across globe. Rice is the oldest domesticated cereal (~10,000 years) and evolved with man adopted under intense weather conditions. Paddy grains discovered around 1000-750 B.C during excavation at Hastinapur (India) and recognized as the world's oldest sample. *Oryza sativa*, though not a tropical species, is known to be associated with hot and humid climate (Ganesh *et al.,* 2007) [3]. It is the world's most important food crop providing food for about four billion peoples especially in Asia and Africa. As predicted, Asia contributes more than 92 per cent of the world's rice supply. In the world, rice occupies 13 per cent of the world's arable area and grown in 114 countries. Rice is the main staple food for more than 65 per cent of Indian population contributing approximately 46.6 per cent to overall food grain production, thereby, occupying a pivotal role in the food and nutritional security of people (Pathak *et al.,* 2018) [14]. Approximately 52 per cent of the overall global paddy production is affected annually due to biotic agents, out of which 21 per cent is due to insect pest attacks (Brookes and Barfoot, 2003) [2]. It has been estimated that the annual losses of insect pests in India ranges from 21 to 51 per cent (Krishnaiah and Varma, 2012) [6] and in the world, it varies between 26 to 34 per cent (Widowsky and O' Toole, 1996) [21]. Most common insect pests of rice considered to be of national economic importance are yellow stem borer, gall midge, brown plant hopper, green leafhoppers, white backed plant hopper, gundhi bug, leaf folder and case worm (Pasalu *et al*., 2008) [13]. In Rice, leafhopper complex are economically important insect pests attacking the rice crop including *N. virescens, N. nigropictus, N. malayanus, N. parvus, N. cincticeps, Cofana spectra, Recilia dorsalis, Empoascanara maculiforns* of which, the rice green leafhopper (GLH), *Nephotettix spp*. (Hemiptera, Cicadellidae) is one of the important destructive pests in the paddy growing regions of Asia (Razzaque *et al*., 1985; Heinrichs *et al*., 1986) [16, 4]. Climatic and weather factors are the key regulating causes for the insect pest populations by means of interfering their population dynamics, distribution, abundance, intensity and feeding behaviour (Hyslops, 1941) [5]. More than fifty per cent of rain fed rice in Karnataka is under traditional rice, thus sheltering a potential genetic diversity.

However, GLH is ecological important pests of rice, the ecology and seasonal abundance of GLH are little known. Therefore, considering the importance of climatic factors influencing the abundance of pest incidence present study has been done and correlated with weather parameters.

Materials and Methods

To study the incidence of leafhopper complex in relation to meteorological parameters, a field experiment was carried out at "A" block, College of Agriculture, V. C. Farm, Mandya, during *Kharif* 2019. A popular and susceptible rice variety Jaya (140-145 days) was sown and 25 day old seedlings were transplanted in a blocks of 8 × 9 m. In each block, seedlings were transplanted at 20 × 15 cm between rows and plants, respectively. Such three blocks were maintained and the crop was raised as per recommended package of practice, except the plant protection measures (Anon., 2017) [1].

To know the incidence of leafhoppers, the hoppers were recorded in blocks of 8 × 9 m by placing a yellow sticky trap at the top of canopy above half feet at the rate of 3 per block and the mean population of hoppers per week were worked out. The weekly data on meteorological variables during the study period especially maximum and minimum temperature, morning and afternoon relative humidity, rainfall, rainy days, sunshine hours were collected from agro-meteorological observatory unit, College of Agriculture, V. C. Farm Mandya. Further, to know the possible influence of meteorological variables on the incidence of leafhoppers, the weekly mean observations on trap count were correlated with weakly mean meteorological variables of previous week. Further, the pest population and weather parameter were subjected to Multiple Linear Regression Analysis Technique (Panse and Sukhatme, 1967) [12] by fitting different function.

Result and discussion

Population dynamics of major leafhopper in paddy ecosystem (Table 1)

1. Nephottetix virescens

The results revealed that the incidence of green leafhopper, *Nephottetix virescens* was first recorded during 36th standard meteorological week (SMW) on yellow sticky traps. The activity period of green leafhoppers was observed from first week of September to last week of December with two distinct peaks at 39th (19.30 hoppers/trap) and 45th (25.00 hoppers/trap) standard meteorological week (SMW), respectively. The population of leafhopper gradually increases up to 40th SMW and then decreased until 43rd SMW (1.25 hoppers/trap) which is lowest, and this might be due to unfavourable climate especially heavy rainfall in the respective SMW. However, the peak incidence of leafhoppers was observed during 45th SMW (25.00 hoppers/trap). The results of present findings corroborates with Sabale *et al.* (2010) [17], where, first peak of green leafhopper, *N. virescens* was observed during 38th to 41st SMW, the 2nd peak was observed during 45th SMW and the third peak was observed during 52nd to 2nd SMW, respectively at Kerala.

Table 1: Seasonal incidence of major leafhoppers in relation to meteorological variables, *Kharif* 2019

Month	SMW	N. *virescens*	*N. nigropictus*	*C. spectra*	*M. dorsalis*	Temperature(^{0}C)		Relative Humidity (%)		Sunshine hours	Rainfall (mm)	Rainy days (>2.5 mm)
						Max.	Min.	Morning	Afternoon			
September	36	4.00	3.30	0.66	5.50	30.10	18.50	91.00	80.00	2.50	6.00	1.00
	37	8.50	6.80	3.20	10.20	31.70	19.40	92.00	77.00	4.90	8.80	1.00
	38	14.30	11.00	4.80	15.00	32.40	19.30	94.00	88.00	5.40	109.40	3.00
	39	19.30	14.40	8.00	9.80	32.10	18.90	92.00	75.00	6.40	5.40	1.00
October	40	16.80	10.50	6.50	11.30	31.60	18.30	89.00	80.00	8.10	112.00	5.00
	41	13.00	9.10	4.00	6.40	30.60	17.50	88.00	69.00	7.10	7.40	1.00
	42	4.15	3.50	1.75	4.00	29.10	17.10	85.00	78.00	5.30	164.90	4.00
	43	1.25	1.00	0.00	0.00	32.30	19.30	91.00	80.00	5.50	34.50	3.00
	44	21.00	15.30	3.00	8.80	32.10	19.50	94.00	79.00	6.60	1.80	1.00
November	45	25.00	19.80	10.50	11.20	31.40	18.50	88.00	77.00	7.10	0.30	0.00
	46	19.10	12.30	12.00	12.00	31.30	19.40	91.00	75.00	8.10	0.00	0.00
	47	22.30	16.50	11.50	9.80	32.20	18.80	90.10	72.00	7.80	2.00	1.00
	48	20.15	13.00	9.00	6.30	30.70	18.50	88.50	75.00	3.90	0.10	0.00
December	49	14.80	8.40	8.20	6.00	29.20	17.90	86.80	77.00	6.60	0.30	0.00
	50	9.20	5.60	7.50	3.00	28.40	17.10	85.10	74.00	7.10	0.00	0.00
	51	6.00	4.20	2.20	3.20	28.10	16.90	83.30	76.00	6.80	0.00	0.00

SMW- Standard meteorological week; * - mean number of 3 yellow sticky traps; N = 17

2. Nephottetix nigropictus

The population fluctuation of green leafhopper, *N. nigropictus* on late *Kharif* rice was observed almost throughout the crop growth right from 36th to 51st SMW. The trap catches of leafhopper, *N. nigropictus* during *Kharif* 2019 was varied from 1.00 to 19.80 hoppers/trap. The incidence initiated from 36th SMW *i.e.*, first week of September with 3.30 hoppers/trap and was found increasing up to 39th SMW with 14.40 hoppers/trap. However, the lowest number of leafhoppers (1.00 hoppers /trap) were recorded during 43rd SMW mainly due to high rainfall in the respective SMW. The more number of *N. nigropictus* recorded from 44th to 48th SMW (15.30 to 13.00 hoppers /trap). The highest trap catches was noticed at 45th SMW (19.8 hoppers/trap). The results of present findings were in line with the reports done by Madhukar *et al.* (2014) [7], who observed that the population of leafhoppers was started from first week of September (36th SMW). Thereafter, the population gradually increases and the maximum population was recorded during first week of October (40th SMW). Similar results were also reported by Nirala *et al.* (2015) [11].

3. Cofana spectra

In the present study, population of white leafhoppers was very low in the initial stage of crop compared to green leafhoppers. Appearance of *C. spectra* was observed in 36th SMW with 0.66 hoppers (mean of 3 yellow sticky trap per week). Further, there was a gradual increase in the population from 37th to 41th SMW (3.20 to 8.00 hoppers/trap) with first peak was noticed during 39th SMW (8.00 hoppers/trap). Lowest number of white leafhoppers population was recorded at 43rd SMW. The peak incidence was found at 46th SMW, which

recorded 12.00 hoppers/trap. The results of present investigation are contradicted by the report of Sharma *et al.* (2011) [18], who observed maximum population of *C. spectra* during second and third weeks of October. But, Prasad and Prasad (2006) [15], who noticed leafhoppers attack with its peak during the months of October and November, and this was in line with present results.

4. Maiestas dorsalis

Among the different leafhoppers observed in paddy ecosystem, the activity of zigzag leafhoppers, *Maiestas dorsalis* was found more in the initial stage of the crop growth. During 36th standard meteorological week, the initial activity of its population was observed in yellow sticky trap with 5.5 hoppers/trap. Zigzag leafhoppers reached its peak incidence with two distinct period *i.e.*, first peak at 38th SMW with 15.00 hoppers/trap (3rd week of September) and second peak at 46th SMW with 12.00 hoppers/trap (2nd week of November). There was no occurrence of zigzag leafhoppers during 43rd SMW, but after reaching to its maximum number (46th SMW), leafhopper population declines gradually until the harvest of crop. The results of the present investigations are in accordance with Mallick and Chowdhury (2000) [9], who reported peak occurrence of zigzag leafhoppers from October to November. Likewise, Mondal *et al.* (2004) [10] also observed that leafhoppers population density in seedbeds was highest in the 2nd week of September.

Correlation between weather parameters and paddy leafhoppers (Table 2)

The correlation studies revealed that green leafhopper *N. virescens and N. nigropictus* exerted a significant positive association with sunshine hours and maximum temperature. Whereas, minimum temperature and morning relative humidity had found positive and non-significant association. On the other hand, the afternoon relative humidity, rainfall and number of rainy days were found negative association on leafhopper build up and found non-significant. Madhuri *et al.* (2017) [8] observed that the population of leafhoppers was positively correlated with maximum temperature, minimum temperature, relative humidity at morning and negatively correlated with rainfall but contradicted with the bright sunshine with present results. Similarly, Mishra *et al.* (2019) reported a significant and positive association between leafhopper population with maximum temperature, minimum temperature while rainfall, evening relative humidity and number of rainy days exhibited negative correlation and were statistically non-significant.

Table 2: Correlation coefficient between incidence of hoppers and weather parameter

Meteorological parameter	Major leafhopper species			
	N. virescens	***N. nigropictus***	***C. spectra***	***M. dorsalis***
Maximum temperature	0.52*	0.57*	0.36	0.51*
Minimum temperature	0.42	0.39	0.33	0.37
Morning RH	0.30	0.41	0.37	0.56*
Afternoon RH	-0.23	-0.19	-0.38	-0.20
Sunshine hours	0.49*	0.48*	0.52*	0.30
Rain fall	-0.22	-0.21	-0.46*	-0.17
Rainy days	-0.21	-0.20	-0.45*	-0.20
R^2 value	0.51	0.49	0.42	0.46

N = 17; * Significant at P ≤ 0.05

Correlation studies between population of *Cofana spectra* and weather parameters revealed that the sunshine hours had significant positive relation with population of white leafhoppers. Whereas, rainfall and number of rainy days had significantly negative effect on the population build up of white leafhoppers. But, maximum temperature, minimum temperature, morning relative humidity had influenced positively and were non-significant while, afternoon relative humidity was found negatively associated with the incidence of WLH and found non-significant. The present results are in close agreement with Sharma *et al.* (2004) [19], who reported afternoon relative humidity and rainfall playing negative role in the population build up of leafhopper, *C. spectra* during August and October. Whereas minimum temperature expressed a significant contribution to the increase of hopper populations.

The correlation analysis between incidence of zigzag leafhoppers and weather parameters were presented here under. The data presented clearly indicated that maximum temperature and morning relative humidity had significant positive role in population build up of *M. dorsalis.* Similarly, bright sunshine hours and minimum temperature had showed a positive correlation with incidence of zigzag leafhoppers but it was non-significant. However, Afternoon relative humidity, rainfall and number of rainy days showed non-significant and negative correlation with incidence of *M. dorsalis.* Similar results were reported by Valarmathi and Ladhalaksh (2019) [21], where they recorded lower population of zigzag leafhoppers during last weeks of November and December because of lowest maximum temperature recorded in these months.

Conclusion

The abundance of four leafhopper species in the order of *N. virescens* > *N. nigropictus* > *C. spectra* > *M. dorsalis*. The first two species *viz., N. virescens* and *N. nigropictus* were most important as their presence were higher and the number of other two species of leafhopper was comparatively low in the present season and habitats. The population of leafhoppers trapped on yellow sticky trap showed that the hoppers were active throughout the season and it was more during September and November but low in October due to unfavourable environmental conditions with respect to previous week SWM. Thus, weather parameters has greatly influenced on the incidence of leafhoppers in the paddy ecosystem.

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