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Seasonal Fluctuation of Rice Brown Planthopper (Homoptera: Delphacidae), *Nilaparvata lugens* (Stal) - A Major Paddy Pest in Central India

Madhukar F. Jadhao*[1] and Arti A. Salwe[2]
[* 1 & 2]Department of Zoology, S. N. Mor College, Tumsar- 441912, Dist- Bhandara (Maharashtra), India
mfjadhao@gmail.com, aaszoology@gmail.com

***Abstract*: Among the 5 species of sap feeders belonging to order Homoptera identified in the present investigation in both *rabi* and *kharif* seasons, *Nilaparvata lugens* was infesting rice crop very commonly and thus representing major pest status in Bhandara district (a rice bowl of state) of Maharashtra (central India). The overall population growth rate and peak density of *N. lugens* during *rabi* season was much lower as compared to the *kharif* season. The peak population of *N. lugens* was observed during the late *kharif* seasons from October to November. Another peak appeared during the *rabi* season from April to May. The infestation of *N. lugens* appeared in appreciable number at the grain filling stage of crop. The correlation analysis study showed that in *rabi* season, *N. lugens* exhibited highly positive correlation with relative humidity and significant negative correlation with maximum temperature whereas it showed highly significant negative correlation with relative humidity and minimum temperature during *kharif* season. The linear regression equations derived from the data may help in predicting the occurrence of these major pests in rice ecosystem of this region.**

***Keywords*: Rabi, Central India, Correlation, Kharif, *Nilaparvata lugens*, Paddy pest, Regression.**

I. Introduction

In India, rice (paddy), *Oryza sativa* L. is a staple food for over 55% population and is grown in almost all the states. Despite having the largest area under rice, its yield is among the lowest in the world (Rangi, 1993). The insect pests constitute one of the major yields limiting biotic stresses for rice crop throughout the world. About 300 species of insects have been reported to attack rice crop in India, of which 20 have been found to be the major pests (Pathak, 1967) causing 21 to 51 percent yield losses (Singh and Dhaliwal, 1994). The present paper describes the seasonal incidence and correlation between weather parameters and population of a major pest, *Nilaparvata lugens* in the rice ecosystem of Bhandara district of eastern Maharashtra (central India) in relation to climatic conditions of this region.

extensively in the oil, gas and chemical industries because of its outstanding mechanical properties. The use of steel is also one of the effective strategies to maximize profit and reduce cost as compared to expensive corrosion resistant alloys. In many industrial applications related to oil and gas processing such as pipeline cleaning, pipeline/acid descaling and oil well acidizing, the use of mineral acids (usually hydrochloric acid) is still an effective method for improving productivity. This process however endangers the life of steel structures as a result of acid driven corrosion. In order to prevent this undesirable reaction, corrosion inhibitors are often added to the acid solution during acidification process (Hassan AR., and Gbadeyan JA.,2015; Ferdows M., et al.2009). Organic compounds, containing functional electronegative groups and π-electron in triple or conjugated double bonds are usually good inhibitors (Cano E., et al 2004; Ghailane T., et al.2013). Heteroatoms, such as sulphur, phosphorus, nitrogen and oxygen, together with aromatic rings in their structure are the major adsorption centres (Goulart CM., et al.2013; Bentiss F., et al 2005). The planarity (g) and the lonely electron pairs in the heteroatoms are important features that determine the adsorption of these molecules on the metallic surface (Hegazy MA., et al.2013; Hu SQ., et al.2010). The use of corrosion inhibitors is one of the most effective measures for protecting metal surfaces against corrosion in acid environments (Issa RM., et al.2008; Khamis A., et al.2013).

Tetrazoles are one of the most stable nitrogen rich heterocyclic compounds among other heterocyclic systems. Due to their higher nitrogen content they show the exciting acidity, basicity, and complex formation constants. They have provided a platform for the rapid exchange of research in the area of organic, pharmaceutical, analytical,Material science and medicinal chemistry.Literature study revealed that the tetrazole ring, particularly, the 5-substituted-1H-tetrazole, that is, commonly referred as tetrazolic acid, has been widely employed in corrosion science as a corrosion inhibitors for protection of metals.

The present study was undertaken to investigate the inhibition of corrosion of mild steel in 1M hydrochloric acid by 5-(4-chlorophenyl) tetrazole. The study was conducted by using gravimetric analysis, electrochemical technique such as Open circuit potential, potentiodynamic polarization and surface analytical techniques such as Scanning electron microscope (SEM) and Energy Dispersive X-ray spectroscopy (EDX) studies.

II. MATERIALS AND METHODS

The study on population fluctuation of Brown Plant Hopper (BPH), *Nilaparvata lugens* was carried out in the farmer's fields of Bhandara district of Eastern Vidarbha (Maharashtra) during both *kharif* (monsoon crop) and *rabi* (summer crop) rice seasons during 2017 to 2018. Regular monitoring of the occurrence and abundance of BPH in rice fields was made visually as well as by insect collecting net.

The population of BPH was assessed by counting the number of adults on a hill at weekly interval from five randomly selected spots in each field site under study. Simultaneously information on weather parameters was also collected from nearby meteorological department. The statistical analysis of the data and weather parameters were carried out by Pearson correlation and bilinear regression by using software SPSS 7.0 version.

III .RESULTS AND DISCUSSION

Among the 5 species of sap feeders belonging to order Homoptera identified in the present study, population of Brown Plant Hopper (BPH), Nilaparvata *lugens* was always high during *kharif* season as compared to the other 4 species of leafhoppers, *Nephotettix* spp., *Recilia dorsalis* and *Pyrilla perpusilla* and *S. furcifera* hence considered it as major pest. Remaining species were considered as minor pests due to less incidence of infestation. Rajendran and Devarajah, (1990) also recorded *Nilaparvata lugens* as major pest in rice fields in three districts of Sri Lanka and other species described as minor pests. In India, pest status also varies considerably in different states. Sharma *et al.*, (1996), Vijay Kumar and Patil (2004) in Karnataka and Punjab, recorded *N. lugens, S. incertulus*, and *S. furcifera* as the dominant pests of rice.

A. Nature and symptoms of damage:

BPH, *N. lugens* (Fig. 1) inhibited the plant growth and destroyed the crop by sucking the sap and by damaging the plant by its exploratory feeding behavior and oviposition. As a result of feeding by both nymphs and adults at the base of the tillers, plants turned yellow and dried up rapidly. At an early infestation, round yellow patches appeared in the fields which soon turned brownish due to drying up of the plants. This condition (dried-out plants) is referred as **'hopper burn' (Fig. 2)**. The patches of infestation then spread out and covered the entire field. Heavy infestation of *N. lugens* during *kharif* 2018 destroyed the rice crop of various fields in Bhandara district causing 70-100 per cent loss. In addition, the honeydew excreted by the nymphs and adults at the base of the plants is covered with sooty mold. *N. lugens* is also a vector of ragged-stunt; grassy-stunt and wilted stunt virus diseases (Heinrichs and Mendrano, 1984; Pathak and Khush, 1979). In Indonesia about 5263 ha of rice were reported to be destroyed by a mixed population of the BPH, *N. lugens* and WBPH, *Sogatella furcifera* (Van Vreden and Abdul Latif, 1986).

Fig.1 BPH, *Nilaparvata lugens*

Fig.2 Damage ('hoppers burn') caused by BPH, *N. lugens*

2. Population dynamics and correlation regression analysis on weather parameters:

In the present study BPH, *N. lugens* in the rice field infested the crop at its late stage. Although its populations persisted in both *kharif* and *rabi* seasons throughout the year, the population density was high in any given season (Table 1, 2, 3 and 4). In *kharif* season usually the population density of *N. lugens* was always high as compared to *rabi* seasons. A mixed population of *N. lugens* and *S. furcifera* was reported by Panda *et al*. (1995) but the former was dominant during the *kharif* and the later during the summer season.

Table 1. Population dynamics of Brown Plant Hopper (BPH), *N. lugens* during *Rabi, 2017*

Month and Week	DAT	Mean Population of BPH/ hill	Weather Parameters			
			Temperature (°C)		Relative Humidity (%)	
			Max.	Min.	Morning	Evening
Feb II	07	1.4	27.5	21.5	74	66
Feb III	14	1.2	31.0	22.0	70	65
Feb IV	21	0	31.0	22.5	59	49
Mar I	28	0	35.0	28.5	69	48
Mar II	35	0	32.0	19.0	41	41
Mar III	42	0	35.0	28.0	53	45
Mar IV	49	0	34.5	26.0	72	45
Mar V	56	0.2	36.5	26.5	53	39
April I	63	0	39.0	32.0	44	36
April II	70	0	39.0	31.0	52	39
April III	77	0	42.0	35.0	42	29
April IV	84	0	43.0	34.5	37	24
May I	91	0	41.5	33.0	44	35

DAT- Days after transplanting, **BPH-** Brown planthopper.

Table 2. Population dynamics of Brown Plant Hopper (BPH), *N. lugens* during *Rabi, 2018*

Month and Week	DAT	Mean Population of BPH/ hill	Weather Parameters			
			Temperature (°C)		Relative Humidity (%)	
			Max.	Min.	Morning	Evening
Feb II	07	0	30	14.3	78	33
Feb III	14	0	30	16.5	66	28
Feb IV	21	0	35	19	64	23
Mar I	28	0	34.5	18	50	20
Mar II	35	0	33.5	19.5	53	29
Mar III	42	0	39.5	25.5	57	21
Mar IV	49	0	41.5	21	51	16
Mar V	56	0	38	24	52	37
April I	63	0	40.5	31	48	25
April II	70	1.6	44	34	23	12
April III	77	2.2	43.5	33.5	43	18
April IV	84	6.6	42	33	48	25
May I	91	0	39.5	32	49	28
May II	98	0	41.5	30.5	60	36
May III	105	0	44	34	33	16

DAT- Days after transplanting, **BPH-** Brown planthopper.

Table 3. Population dynamics of Brown Plant Hopper (BPH), *N. lugens*, during *Kharif, 2017*

Month and Week	DAT	Mean Population of BPH/ hill	Weather Parameters			
			Temperature (°C)		Relative Humidity (%)	
			Max.	Min.	Morning	Evening
Aug. IV	07	0.2	28	24	92	87
Aug. V	14	0.4	29	26	92	92
Sept. I	21	0	27	24	92	81
Sept. II	28	0	29	25	92	92
Sept. III	35	0.8	33	27.5	84	76
Sept. IV	42	0.4	31	25	96	78
Oct. I	49	2.2	31	23	84	71
Oct. II	56	9.8	33.5	25.5	58	76
Oct. III	63	2.8	33	22	84	63
Oct. IV	70	5.6	29	20	78	60
Nov. I	77	11.8	33	24	84	71
Nov. II	84	14.4	32	21.5	75	56
Nov. III	91	18.4	30.5	19	81	49

DAT- Days after transplanting, **BPH-** Brown planthopper.

Table 4. Population dynamics of Brown Plant Hopper (BPH), *N. lugens* during *Kharif, 2018*

Month and Week	DAT	Mean Population of BPH/ hill	Weather Parameters			
			Temperature (°C)		Relative Humidity (%)	
			Max.	Min.	Morning	Evening
Aug. V	07	0	33	26	80	51
Sept. I	14	0	33	25.5	84	81
Sept. II	21	0	34	26	77	62
Sept. III	28	0	33	26	84	75
Sept. III	35	0	33	27	81	75
Oct. I	42	0	32.5	26	84	66
Oct. II	49	1.6	35.5	26	70	61
Oct. III	56	2.0	31.5	23	67	60
Oct. IV	63	2.0	32	21	62	49
Oct. V	70	2.2	32	21.5	67	52
Nov. I	77	3.8	31.5	21	65	57
Nov. II	84	0.6	33	24	79	59
Nov. III	91	0.9	31.5	19	72	42

DAT- Days after transplanting, **BPH-** Brown planthopper.

In the present investigation the incidence and adult populations of *N. lugens* /hill suggest that there may be carry over of hopper populations from one season to the next due to continuous cropping of rice in Bhandara district of Maharashtra state (Central India) in the *rabi* and *kharif* seasons. In the Krishna-Godavari zone of Andhra Pradesh, India the carry over contribution of *N. lugens* from *rabi* to *kharif* was observed to be higher than that from *kharif* to the following *rabi* (Krishnaiah *et al*. 2002). They further suggested that rain fall has no apparent effect on *N. lugens* populations. However, Vijay Kumar and Patil (2004) identified *N. lugens* as the major pest of rice under irrigated conditions during *kharif* season in Karnataka causing sever damage to the rice primarily from October to December.

Peaks of mixed populations of *N. lugens* and *S. furcifera* in early May and late May to early June were observed in Guangdong province of China (Li *et al*., 2003), whereas two peaks every year, one in mid-September and the second in early to mid October were also demonstrated by Lu *et al*. (2003) in China. In the present study mixed populations of *N. lugens* and *S. furcifera* were evidenced during *kharif* and *rabi* seasons but 2-3 peaks of *N. lugens* populations were noticeable only during *kharif* season (Table 1, 2, 3 and 4). Its population peaks might be indicating its generations.

The rice fields receiving large amounts of nitrogenous fertilizers are mostly infested by both the planthoppers and there is also a difference in oviposition and survival of hatched nymphs (Suenaga, 196 3). The spraying of organic phosphorous in mid season (during first generation) induced a population resurgence of second generations of both *N. lugens* and *S. furcifera*. Moreover, rice fields fertilized early attracted more *N. lugens* immigrants from the adjacent fields. The main mechanism for the resurgence of *N. lugens* was suggested to be the stimulation of reproduction of first-generation adults and reduction of the density of predators, which in turn increased the survival of the planthoppers (Zhu *et al*., 2004). In the present study occurrence of 'hopper burns' during *kharif* 2017 and 2018 might be due the application of chemical fertilizers and reduction in the number of predators in the rice fields.

The average maximum temperature was reported as a congenial climatic factor for the increase in population of *S. furcifera*, whereas relative humidity was the negative contributing factor for the population of *N. lugens* and *S. furcifera* (Reddy *et al*., 1983). In the present study, population of *N. lugens* did not show significant correlation with any of the weather parameters in *rabi* season (Table 5). However, during *kharif* season population of *N. lugens* showed negative significant correlation with minimum temperature and relative humidity and confirmed the findings of Reddy *et al*., 1983 (Table 6). In warm and humid climates, the plant hoppers remain active through out the year and their population fluctuates according to the availability of the host plants, activity of natural enemies and other environmental factors prevailing in the locality (Pathak, 1967).

Table 5. Correlation between weather parameters and population of BPH, *N. lugens* during *Rabi*

PH	Weather Parameters	Rabi 2017		Rabi 2018	
		Correlation Coefficient (r)	Regression Equations	Correlation Coefficient (r)	Regression Equations
H1	A1	**-0.629***	H_1= 2.505+ (-0.064) A_1	0.366	H_1= - 4.510 + 0.135 A_1
	A2	-0.507	H_1= 1.503+ (-0.047) A_2	0.449	H_1= -2.103 + 0.010 A_2
	A3	**0.596***	H_1= -1.001+ 0.022 A_3	-0.273	H_1= 2.586 + (-0.037) A_3
	A4	**0.806****	H_1= -1.169+ 0.032 A_4	-0.166	H_1= 1.650 + (-0.039) A_4
	A5	0.278	H_1= 0.131+ 0.042 A_5	-0.033	H_1= 0.834 + (-0.017) A_5

$H_{1 - BPH}$ (*Nilaparvata lugens)*

A_1- Max.Temp; **A_2**- Min.Temp; **A_3**- Relative Humidity (Mor.), **A_4-** Relative Humidity (Eve.), **A_5**- Wind vel.

***** -Correlation is significant at 0.05 (5%) levels; ** -Correlation is significant at 0.01 (1%) levels.

Table 6. Correlation between weather parameters and population of BPH, *N. lugens* during *Kharif*

PH	Weather Parameters	Kharif 2017		Kharif 2018	
		Correlation Coefficient (r)	Regression Equations	Correlation Coefficient (r)	Regression Equations
H1	A1	0.419	H_1= -32.876 + 1.239 A_1	-0.379	H_1= 14.242 + (-0.406) A_1
	A2	**-0.603***	H_1= 42.380 + (-1.580) A_2	**-0.641***	H_1= 8.096 + (-0.297) A_2
	A3	**-0.608***	H_1= 37.536 + (-0.386) A_3	**-0.887****	H_1=10.930 + (-0.133) A_3
	A4	**-0.769****	H_1= 31.723 + (-0.363) A_4	-0.422	H_1= 3.716 + (-0.045) A_4
	A5	**-0.643***	H_1= 14.505 + (-1.170) A_5	-0.373	H_1= 1.529 + (-0.187) A_5

$H_{1 - BPH}$ (*Nilaparvata lugens)*

A_1- Max.Temp; **A_2**- Min.Temp; **A_3**- Relative Humidity (Mor.), **A_4-** Relative Humidity (Eve.), **A_5**- Wind vel.

***** -Correlation is significant at 0.05 (5%) levels; ** -Correlation is significant at 0.01 (1%) levels.

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