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Population Fluctuations of Brown Plant Hopper *Nilaparvata lugens* Stal. and White Backed Plant Hopper *Sogatella furcifera* Horvath on Rice

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ABSTRACT

Population fluctuation of Brown Plant Hopper (BPH) and White Backed Plant Hopper (WBPH) were studied in Myanmar for two seasons (rainy and summer). Experiments was conducted on a 5 ha rainfed unsprayed field and done in 5 experimental units with an area of 100×100 m. BPH and WBPH were counted from 30 rice hills out of 2000 hills randomly. Relative humidity, temperature, rainfall were also recorded. Population fluctuation study revealed that BPH population was high at 64 and 74 days after transplanting (in Mid September 2007) associated with heavy rainfall, high temperature and high humidity. The BPH population was lowest (in mid week October 2007) suggesting that low rainfall and low humidity were at least partially responsible for the decrease population of BPH. The WBPH was being passed thorough the same weather regime as BPH. When the rainfall decreased or trend to stop the population began to build up reach its peak. This trend of population fluctuation is not directly related with rainfall, but rainfall could be in influencing the physiology of rice plant. This can be seen in the correlation and regression analysis. The fluctuation of plant hopper were correlated with temperature and showed higher correlation with rainfall patterns during the first cropping season. Second cropping season coincide with dry season, there was no rainfall and hopper population was observed to be correlated to temperature and relative humidity. Thus temperature, rainfall and relative humidity were observed to influence plant hopper population during the two different rice growing seasons.

Key words: Population fluctuation, BPH and WBPH, rice

INTRODUCTION

Pest and disease problems are major constraints for increasing rice production. Insect pests including plant hoppers can cause serious damage to rice crop. Brown Plant Hopper (BPH) *Nilaparvata lugens* Stal. And White Backed Plant Hopper (WBPH) *Sogatella furcifera* Horvath have become serious threat to rice production throughout South and South East Asia since the early 1970's. Lost of crop yield due to these pests is estimated at between 10 to 30%. Serious damage usually occurs during the early stages of plant growth with symptoms of hopper burns due to intensive sucking by the insect (Dale, 1994). The BPH is also a vector in transmitting virus diseases such as grassy stunt, ragged stunt and wilted stunt (Hibino, 1979). Dyck and Thomas (1979) observed serious outbreaks of WBPH in West Malaysia following the outbreak of BPH and in Myanmar, the first outbreak was recorded in 1981 and since then it has been recognized as one of the most serious and widespread pest of rice.

An insect population always fluctuates according to the dynamic condition of its environment. Both physical (abiotic) and biotic factors are believed to be the factors responsible for the change in a population. Canedo (1980) stated four components that influenced BPH populations, namely extension of irrigation which allowed double cropping of rice, short duration photoperiod intensive rice varieties used, more nitrogenous fertilizers applied and 4 intensive insecticides application There is evidence that these factors can cause plant hopper outbreaks. Andrewwartha and Birch (1954) noted four components of the environment that could influence insect population's viz. weather condition, food, other insects or organisms causing diseases and a place in which to live. Climatic factors such as temperature and rainfall and relative humidity have known to greatly influence the insect population change (Muhamad and Chung, 1993; Way and Heong, 1994; Zhu, 1999; Heong *et al.*, 2007; Siswanto *et al.*, 2008).

Knowledge of the seasonal abundance and trends in the population build up of a pest has become important for its effective control schedules (Siswanto *et al.*, 2008). Food supply, improved irrigation and water standing in the rice field are conducive to the growth of BPH and WBPH populations. Lowland rice fields have greater pest problems than upland fields. The change from upland to lowland culture caused the development of BPH and WBPH as the main rice pests and wet cultivation of rice leads to more BPH and WBPH (IRRI, 1979). Therefore, the objectives of this study were to investigate the population fluctuations of BPH and WBPH in the field and also to determine the influence of ecological factors to their populations in the field.

MATERIALS AND METHODS

The experiments were carried out in Myanmar for two seasons within 2007 to 2008 during the rainy rice season and summer rice season successively. Unsprayed rice field was chosen for the experiments. The population study was conducted on a 5 ha rainfed rice field. The experiments were conducted in 5 experimental units with an area of 100×100 m (1000 m^2). The plant spacing being applied in each experimental plot was 20×15 cm to achieve 2000 rice hills. The data of plant hoppers (BPH and WBPH) were counted from 30 rice hills out of 2000 hills randomly. For the practical way of counting the insect, the plant hoppers were recorded from three rice plants per hill. The number of plant hopper, relative humidity, temperature and rainfall were recorded. Data included the maximum and minimum temperature and rainfall. Paired t-test at 5% level of probability was employed to compare the population density between two seasons. Regression analysis was done to determine the influence of abiotic factors on the insect population fluctuation. The population abundance of BPH and WBPH in relation to plant density, average temperature, rainfall and relative humidity was recorded in the rice field in 2007 and 2008 rice-growing seasons.

RESULTS AND DISCUSSION

Table 1 shows the coefficient correlation (R) between BPH and WBPH populations and environmental factors during rainy and dry seasons. The month of July-August 2007 was the middle of the rainy season. However, the month of September 2007 was post monsoon period in Myanmar. Thus during the July-September 2007 of the rainy season the BPH build up coincided with maximum tillering stage of rice plants in the field. Rainfall had reached its maximum and with

Table 1: Coefficient correlation(r) between BPH and WBPH populations and environmental factors during rainy (2007) and dry (2008) seasons

Plant hopper	Planting season	Month and year	Rainfall (mm)	Temperature (°C)	Relative humidity
BPH	Rainy	Jul-Nov 2007	0.918**	-0.868**	0.725**
	Dry	Dec-Apr 2008	-0.099^{ns}	0.813**	0.865**
WBPH	Rainy	Jul-Nov 2007	0.873**	-0.843**	0.717**
	Dry	Dec-Apr 2008	-0.151^{ns}	0.925**	0.736**

*Significant at p = 0.05, **Highly significant at p = 0.01, ^{ns}Non significant

Table 2: Coefficient correlation(r) between number of tillers with environmental factors during rainy (2007) and dry (2008) seasons

Tillers	Planting season	Month and year	Rainfall (mm)	Temperature (°C)	Relative humidity
Tillers hill^{-1}	Rainy	Jul-Nov 2007	0.940**	-0.812**	0.640*
Tillers hill^{-1}	Dry	Dec-Apr 2008	-0.081^{ns}	0.819**	0.871**

*Significant at p = 0.05, **Highly significant at p = 0.01. ^{ns}Non significant

the highest in July-August. However, it gradually declined in September. In October, the rainy had eventually ceased. Intermittent rainfall occurred continuously causing the BPH population to fluctuate until 4th October and reaching a peaks between July and September. However, as the tillering decreased during the period, the Early Panicle Initiation (EPI) stage of the rice plant was initiated. However, the population of BPH had declined. From November, the BPH population was clearly noted to increase. This was followed by another population peak and thereafter a decline. The whole of January to April 2008 (dry season) showed the decline of the BPH population.

Table 1 also shows that there was a significant correlation between populations of both plant hoppers with a biotic factor, except for during the dry season. There were positive correlations between BPH and WBPH populations with rainfall, temperature and relative humidity with the exception of negatively correlation with rainfall during the dry season and with temperature in the rainy season. BPH population was significantly correlated with rainfall (R = 0.918) and relative humidity (R = 0.725) but significantly and negatively correlated with temperature (R = -0.868) during the rainy season. The average temperature and relative humidity were 23.57-27.64°C and 58.59-9.28%, respectively. WBPH population was significantly correlated with rainfall (R = 0.873) and relative humidity (R = 0.717) but significantly and negatively correlated with temperature (R = - 0.843) during the rainy season. Both plant hopper populations were positively correlated with temperature in the dry season. However, BPH and WBPH populations were negatively correlated with rainfall in the dry season.

Similar result of relationship between number of rice tillers with abiotic factor (Table 2) as significant correlation between numbers of tillers with abiotic factor except for during dry the season in 2008. However, there were positive correlations between number of tillers with both relative humidity and rainfall. On the other hand, the number of tillers were negatively correlated (R = -0.812) with temperature during the rainy season as opposed to the dry season. Tiller numbers were significantly correlated with rainfall (R = 0.940) and relative humidity (R = 0.640) during rainy season. While number of tillers per hill of rice plants appeared to show similar trend for BPH and WBPH populations in the rice fields, seven maximum numbers of tillers were recorded. Beginning in July, the highest number of tillers was recorded. During the middle of raining and post monsoon season (August-September), there was two peaks of tillers numbers recorded. This

Table 3: Stepwise regression of plant hoppers against rainfall and temperature during rainy (2007) and dry (2008) seasons

		Regression parameter			
Planting season	Plant hopper	(a) Intercept	(b) Gradient of variable selected	R^2	p-value
Rainy	BPH	17.783	Rainfall: 0.087	0.842(84.2%)	0.000
			Temperature: 0.510	0.063(6.3%)	0.012
	WBPH	18.498	Rainfall: 0.079	0.761(76.1%)	0.000
			Temperature: 0.546	0.071(7.1%)	0.036
Dry	BPH	-5.568	Temperature: 0.276	0.748(74.8%)	0.000
			RH: 0.075	0.219(21.9%)	0.000
	WBPH	-4.665	Temperature: 0.317	0.855(85.5%)	0.000
			RH: 0.039	0.123(12.3%)	0.001

Table 4: Stepwise regression for number of tillers against environmental factors during rainy (2007) and dry (2008) seasons

		Regression parameter			
Planting season	Parameters	(a) Intercept	(b) Gradient of variable selected	R^2	p-value
Rainy	Tillers $hill^{-1}$	3.149	Rainfall: 0.125	0.884 (88.4%)	0.000
Dry	Tillers $hill^{-1}$	-13.834	RH: 0.125	0.758 (75.8%)	0.000
			Temperature: 0.461	0.223 (22.3%)	0.000

was followed by number maximum tillering stages, until the number of tillers/plant was decreased up to October. However, between December and January was dry season, 2 peaks of tillers/plant were recorded between February to March. During the dry season, the number of tillers/plant was gradually declined.

The stepwise regression analysis constructed to investigate which abiotic factors contributed the most to the variation of plant hopper population (Table 3). Step wise regression analysis showed that rainfall significantly contributed more than 80 (84.2%) to the variation of BPH and 75 (76.1%) to the variation of WBPH population during the raining season. Stepwise regression analysis also showed that temperature significantly contributed only 6.3 and 7.1% to the variation of BPH and WBPH populations during rainy season. Relative humidity did not significantly contribute to the variations observed. During the dry season, temperature significantly contributed about 75 (74.8%) to the variation of BPH population. Relative humidity contributed only 21.9 and 12.3% the variation of BPH and WBPH population, respectively. Rainfall did not significantly contribute to the population variations. The population was significantly and positively correlated with average temperature and relative humidity. However, stepwise regression analysis showed that contribution of lower population of WBPH in the dry season was average temperature. Average temperature significantly contributed more than 80 (85.5%) to the variation in WBPH population. The relative humidity contributed only (12.3%) to the variation in population. Rainfall did not significantly contribute to the population variation.

Table 4 shows that during the rainy season, rainfall significantly contributed to 88.4% in variation of number of tillers. Temperature and relative humidity did not significantly contribute to the plant hopper population. During dry season, relative humidity significantly contributed 75.8% to the variation in number of tillers while temperature contributed 22.3% to the variation in the number of tillers. However, rainfall did not significantly contribute to the variation in number of tillers. The findings of this study showed that the increase population of plant hoppers could be associated with the heavy rainfall (32.86 mm), high temperature (28°C) and high relative humidity (92%) at the time of sampling. However, the results also suggested that low rainfall and low humidity to be partially responsible for decrease populations of BPH and WBPH.

The step wise regression analysis was also constructed to investigate which abiotic factors contributed to the most number of tillers (Table 4). The number of tiller increments appeared to coincide with maximum tillering stage during the raining season. The rainfall pattern was high in the first week of July, August and September. However, the rainfall started to decrease in October and subsequently to January and April 2008. Therefore, rainfall was directly correlated with the trend of number of tillers increment. This can be observed by looking at the results of correlation and regression analysis of these parameters which showed rainfall to be significantly and positively correlated with number of tillers per plant. Meanwhile correlation analysis between numbers of tillers per plant with temperature had shown negative correlation during the rainy season. This study indicated that rainfall and relative humidity both influenced the number of tillers per plant as well as plant hopper populations. Regression analysis however, suggested that rainfall was (R^2 = 0.884) contributed to the increment of number of tillers (Table 4).

Figure 1a and b again showed that the population abundance of WBPH in relation to tiller numbers, average temperature, rainfall and relative humidity. Two population peaks of WBPH were noted in July and September. The population of WBPH fluctuated until 11th October 2007. When the tillering stage ended, Early Panicle Initiation (EPI) stage of rice was initiated followed by the decline in October. Through out this period, the average temperature and relative humidity

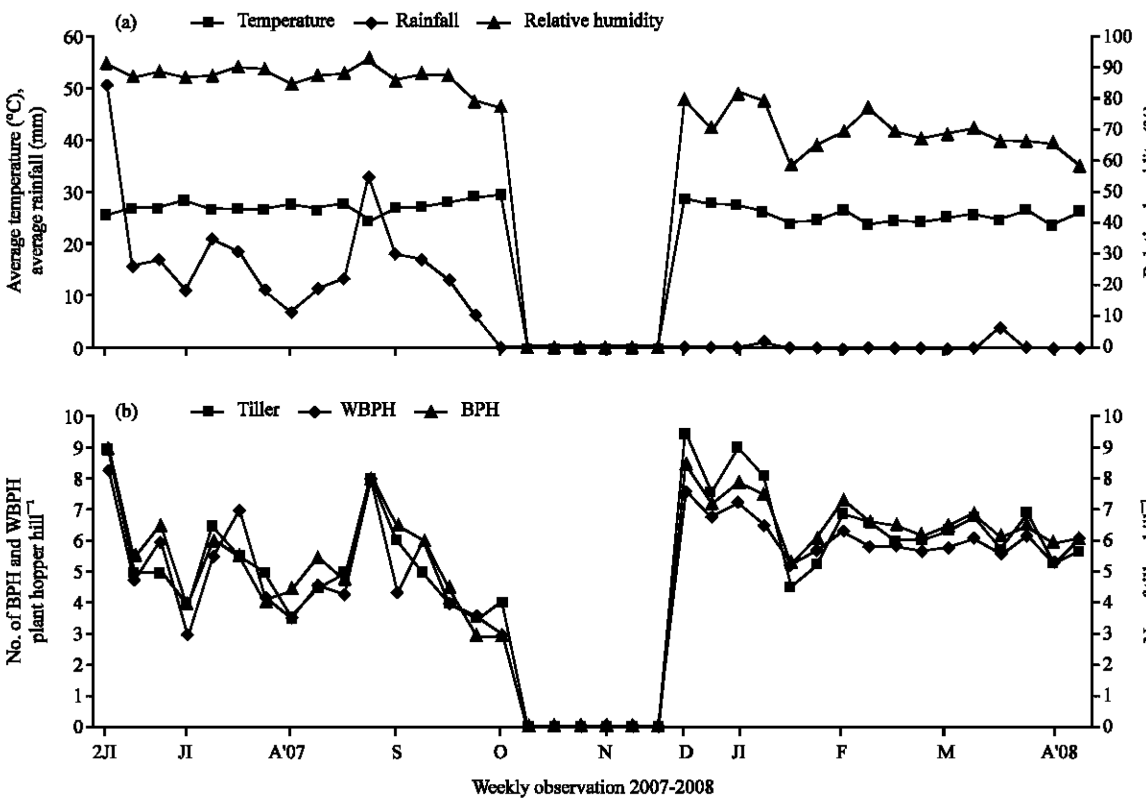

Fig. 1: (a, b) Population abundance of BPH and WBPH on rice plant in relation to number of tillers per hill, rainfall, temperature and relative humidity at Hmawbe rice field within July, 2007-April, 2008

were similar as previously discussed. In the analysis of correlation (Table 1), WBPH population fluctuations were significantly correlated with rainfall (R = 0.873) and relative humidity (R = 0.717) but significantly and negatively correlated with temperature (R = -0.843).

During the dry season and after the cessation of rainfall, heading and flowering occurred followed by grain filling and maturity of the rice plants. During the middle of this period, rainfall was relatively very low with rainfall recorded in December to February. During this rice maturity period and harvesting season, BPH began to build up and populations peaked in December and January 2008. The BPH population was significantly correlated with temperature (R = 0.813) and relative humidity (R = 0.865) and identified as factors significantly contributing to the build up of the plant hopper populations.

During the early part of the dry season, the temperature and relative humidity also fluctuated slightly. During the post flowering-maturity season, WBPH population slightly dropped and increased again and was positively correlated with average temperature. However, stepwise regression analysis showed that the contribution to plant hopper population was due to temperature, significantly contributing to more than (70%) in the variation of BPH population. Relative humidity contributed to 21.9% in the variation of BPH population during the dry season.

The stepwise regression analysis results showed that average temperature significantly contributed to the variation in BPH (R^2 = 0.748) and WBPH (R^2 = 0.855) populations during the dry season. The actual pattern of population fluctuation appeared very distinct during the first 4-5 weeks after transplanting. The macropterous adults that emigrated from the outside field became dominant while some brachypterous adults had originated from nursery beds. Three distinct peaks could be observed, each between 3 to 4 week intervals corresponding to the period of approximately one BPH generation recorded in South East Asia countries. In rice fields within these regions the plant hopper populations were known in many cases to show rather discrete generation cycle (Sawada *et al*., 1993). This could be the most probable cause, or partially explained by the preference of macropterous immigrants to young rice plants.

Predators are the most important natural enemies of plant hoppers and together with parasitoids and insect pathogens keep their populations down. Observations in rice field show a high population of predators especially spiders which are carnivorous arthropods. Research had shown that spiders in rice fields can play an important role as predators in reducing the densities of plant hoppers and leaf hoppers (Holt *et al*., 1987; Tanaka, 1989; Mu *et al*., 2000). Among the predators identified are several species of spiders such as *Lycosa* sp., *Oxyopos* and a mirid, *Cyrtorhinus* sp. which attacked eggs and young nymphs that were predominantly found in abundance (Sawada *et al*., 1993).

Muhamad and Chung (1993) reported that *H. theivora* population fluctuations appeared to be influenced by rainfall and by the numbers of available pods as shown by positive correlation between mired numbers, rainfall and numbers of pods. This study concurs with the results of the present investigation where plant hopper populations were strongly and positively correlated with rainfall. Patnaik *et al*. (1985) reported that a well-distributed heavy precipitation could increase the mesospheric humidity to more than 85%. Statistical analysis of data had shown a positive and significant correlation between midge incidence and relative humidity. This was in agreement with the present investigations which recorded higher population of BPH due to heavy rainfall, high relative humidity and high temperature at the time of sampling. The BPH population was found to be strongly and positively correlated win rainfall and relative humidity. The results of this study were, however, inconsistent with the findings of Isichaikul and Ichikawa (1993) that microhabitat of nymphs and the adults of BPH were found to be on the lower parts of the rice plants. It was proven in this study that relative humidity was an important environmental factor to determine the microhabitat at of the nymphs of BPH as they prefer very humid conditions of more than 90% R.H.

The number of WBPH immigrants were highest on rice plants 17 to 30 Days After Transplanting (DAT) suggesting that they prefer to settle or remain more on rice plants at the tillering stage of approximately 20-30 DAT. Plots that were fertilized early attracted more BPH. Reproduction of WBPH immigrants was enhanced by early fertilization in rice fields. The WBPH was found to be dominant species in the early season <60 DAT, while BPH was more dominant in the late season >60 DAT (Zhu *et al.*, 1993; Matsumura, 1996; Zhu, 1999). These findings differed from the present investigation where BPH and WBPH populations were also shown to increase at 64 days after transplanting.

CONCLUSIONS

The population abundance of BPH and WBPH in relation to plant density, average temperature, rainfall and relative humidity was recorded over two rice growing seasons in Myanmar. During the rainy season, BPH population was found to build to coincide with increase in plant tillers in the rice field. Two peaks of BPH populations were noted in July and August. The population peaks recorded for WBPH were similar with BPH.

During the period of rice maturity and harvesting season, BPH population began to build up and peaking in December 2007 and January 2008. The population subsequently declined in January. It began to increase and recorded 3 population peaks in February, March and April 2008 during the dry season. WBPH which passed through a similar weather regime showed a more or less similar trend to BPH. The plant hopper population abundance was strongly associated with standing plant population in the rice field. As with the plant hopper populations in the field, increase in BPH numbers per tiller began in the field and reaching two peaks during the rainy season. The BPH number per tiller also increased with two peaks in December 2007 and January 2008. The WBPH numbers per tiller showed fluctuations that were similar to those observed for BPH in rice field.

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