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Effect of biotic and abiotic factors on the population of brown planthopper, *Nilaparvata lugens* (Stal) in relation to two varieties and planting dates

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ABSTRACT

A field experiment on population dynamics of brown planthopper was conducted during Kharif, *2011 and 2012 at CCS HAU Rice Research Station, Kaul, Kaithal (Haryana). During 2011, the population of BPH was positively correlated (r= 0.697) with parasitoid populations in June transplanting (D1) while, in July transplanting (D2), there was a positive correlation with spiders (r= 0.632), mirid bugs (r= 0.666) and sun shine hours (r = 0.629). The population of BPH was highly positive correlated with spiders (r= 0.758), parasitoids (r= 0.780) and highly negative correlated with Tmin (r= -0.818) and rainfall (r= -0.760) on variety CSR 30 planted in June during 2012 and none of the abiotic and biotic factors showed any significant impact on BPH population in D2 during 2012. Significant effect of biotic and abiotic factors was recorded on population of BPH during 2011 on variety PR 114 planted in June. The population of BPH was positively correlated with spiders (r= 0.662) and mirid bug (r= 0.955) while, Tmin (r= -0.844) and rainfall (r= -0.674) were negatively correlated in D1 of cultivar PR 114 during 2011. In July transplanting (D2), the spiders (r= 0.688) and mirid bugs (r= 0.903) and SSH (r=0.629) were highly positive correlated while, Tmin (r=-0.812) and rainfall (r= -0.685) had negative impact on population BPH. However, during 2012, none of the variables showed any relation with BPH population.*

Key words: *Brown planthopper, transplanting, population dynamics, parasitoids, mirid bugs, spiders*

Rice is the world most important crop and a staple food for more than half of the world's population. About 90 per cent of the world's rice is grown and produced (143 million hectares of area with a production of 612 million tonnes of paddy) in Asia (FAO, 2009). It is grown on an area of 43.97 million hectare in the country with total production of 104.32 million tonnes and productivity of 2372 kg ha^{-1}. However, Haryana occupied an area of 1.24 million hectare with total production of 3.76 million tonnes during 2011-12 (Anonymous, 2012). Rice is cultivated in varied environment like uplands, deep water, shallow lowlands and irrigated conditions. However, the most preferred ecology of rice plant is tropical and humid climate with temperature ranges of 15-35 ^{0}C and relative humidity of 85-100 per cent. This climate is also suitable for development and multiplication of many insects. There are more than 100 insect species recorded as feeding on rice plant. About 20-25 of them reached the status of pest causing economic losses under farmer's field situations. Among them, stem borers, planthoppers, leafhoppers, leaf folder, gall midge, rice hispa, gundhi bug, case worm, armyworm, cut worm and rice thrips are the most important in India and other countries (Krishnaiah *et al.*, 2008). The overall yield loss due to these insect pests varies between 21-51 per cent (Singh and Dhaliwal, 1994). In Haryana, planthoppers, leaf folder, stem borer, rice hispa, gundhi bug and army worm are some important insect pests. Among the planthoppers, two planthoppers of economic importance are the brown planthopper (BPH), *Nilaparvata lugens* (Stal) and white backed planthopper (WBPH), *Sogatella furcifera* (Horvath) of the family Delphacidae. From 2005-06, there were sporadic but large-scale occurrences of BPH in Bihar, Jharkhand, Uttar Pradesh, Haryana and Punjab. The severe outbreaks of BPH occurred in Haryana in 2008 and 2010 (Anonymous, 2008 and 2010). The BPH has become a major insect pest of rice in almost all rice growing tracts of India (Sain and Prakash, 2008). It damages plants directly by sucking the sap and by ovipositing in plant tissues, causing plant wilting and 'hopperburn'. When the crop is 'Hopper burned' they migrate to healthy crop in large numbers. It also causes economic damage to the rice crop indirectly by transmitting grassy stunt (Rivera *et al*., 1966 and David, 2005) and ragged stunt virus diseases (Ling *et al.*, 1978). The high population density may result upto 60 per cent yield loss (Panda and Khush, 1995). Pathak and Khan (1994) also observed that 400 newly hatched nymphs infesting plant at 25 and 50 DAT cause complete drying in 3 and 15 days, respectively. This insect has a high reproductive potential to multiply ten to hundred fold in each generation. Shepard *et al*. (1995) reported that the populations of both the BPH and WBPH increased after insecticide applications. Kenmore *et al*. (1984) submitted that due to the widespread misuse of insecticides natural enemies were killed which lead to the outbreaks of BPH. Promiscuous use of insecticides also promotes resurgence of the insect pest (Heinrichas and Mochida, 1984). Likewise, it was believed that excessive use of urea as a nitrogenous fertilizer could also lead to outbreak by increasing the fecundity of BPH (Preap *et al.*, 2002). It had high survival rate, greater population build up and a higher tendency for outbreaks (Li *et al.*, 1996 and Preap *et al.*, 2001). The various climatic factors such as temperature, rainfall and humidity greatly influence the insect population changes. Occurrence of BPH on bunds during rice cropping season (August 2009-January 2010) was observed. The predators of BPH (spiders, mirid bug and carabids) were also observed throughout the study period (Prashant *et al.*, 2012).

MATERIAL AND METHODS

The experiment to study the population dynamics natural enemies of brown planthopper in relation to variety and transplanting date consisted of two rice varieties *viz.*, CSR 30 (tall scented/*Basmati*) and PR 114 (semi-dwarf non-scented) and two dates of transplanting *viz.*, last week of June (25th June during 2011 and 27th June during 2012) and first week of July (5th July during 2011 and 7th July during 2012). The crop (30 days old seedlings) was transplanted in puddled field at 20x15 cm spacing on plots of size 10x7.5 m. The treatments were arranged in factorial randomized block design with 5 replications. The recommended agronomic practices were followed to raise the crop. However, no pesticide was applied till the harvest of the crop.

The number of different post embryonic development stages of the BPH natural enemies were collected from 10 hills selected randomly from each plot at weekly intervals. The first observation was taken 15 days after transplanting (DAT) and continued till harvesting. The population of BPH along with predators was recorded in the forenoon by tapping the plant by hand from the base of the plant to the top in to a 30 x 22.5 x 5 cm white enamel tray containing a little water. The planthopper along with natural enemies were counted and recorded. The tray was cleaned every time before next observation. The metrological data were recorded daily.

RESULTS AND DISCUSSION

A. Weekly population fluctuation of brown planthopper and natural enemies in relation to variety, date and abiotic factors

a. Weekly population fluctuation of brown planthopper during wet season 2011

The observation on weekly mean abundance of BPH, natural enemies and weekly averages of maximum temperature (Tmax), minimum temperature (Tmin), rainfall, morning relative humidity (RHm), evening relative humidity (RHe) and sun shine hours (SSH) were computed from the daily data and are presented with reference to the standard meteorological weeks (SMW) in figures 1 to 4.

i) Effect of variety planted in June

The data on BPH and its major predators (mirid bugs and spiders) on varieties CSR 30 and PR 114 planted during June, 2011 have been shown in Fig. 1. On CSR 30, the BPH first appeared in 31st SMW in the month of August although the population was very low (7.9 BPH/ 10 hills). The pest population increased from 31st SMW to 37th SMW and reached a peak population of 1392.4/10 hills of BPH during 37th SMW when Tmax was 32.8 ^{0}C, Tmin 25.1 ^{0}C, rainfall 8.7 mm, RHm 95%, RHe 75% and SSH 6.6 (Fig. 2). The second peak (909.2

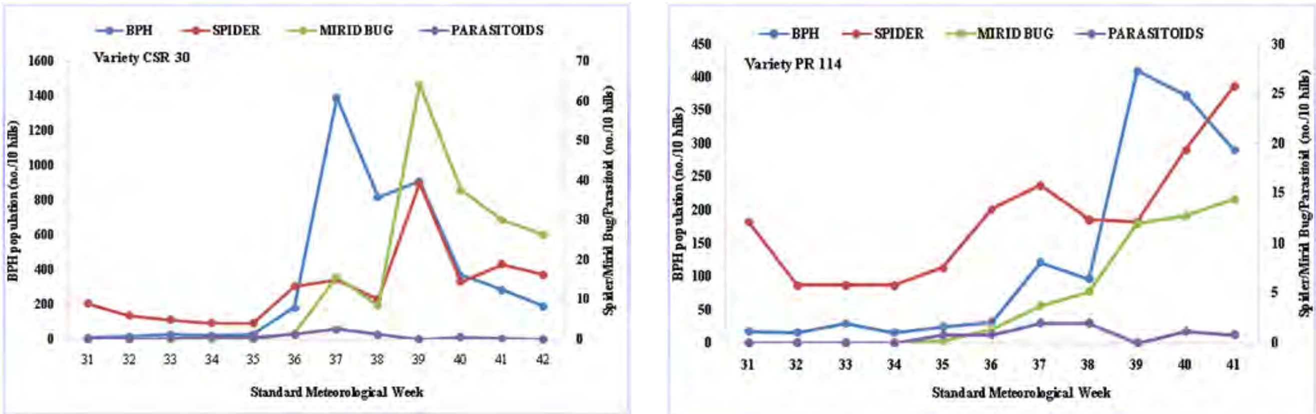


Fig. 1. Population dynamics of brown planthopper and natural enemies in relation to Variety planted in June, 2011

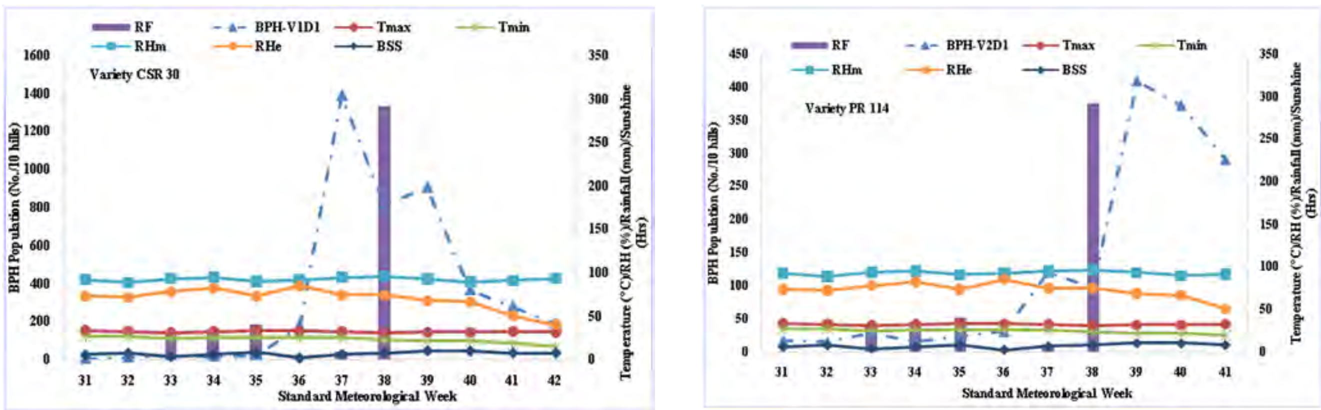


Fig. 2. Population dynamics of brown planthopper in relation to abiotic factors and variety planted in June, 2011

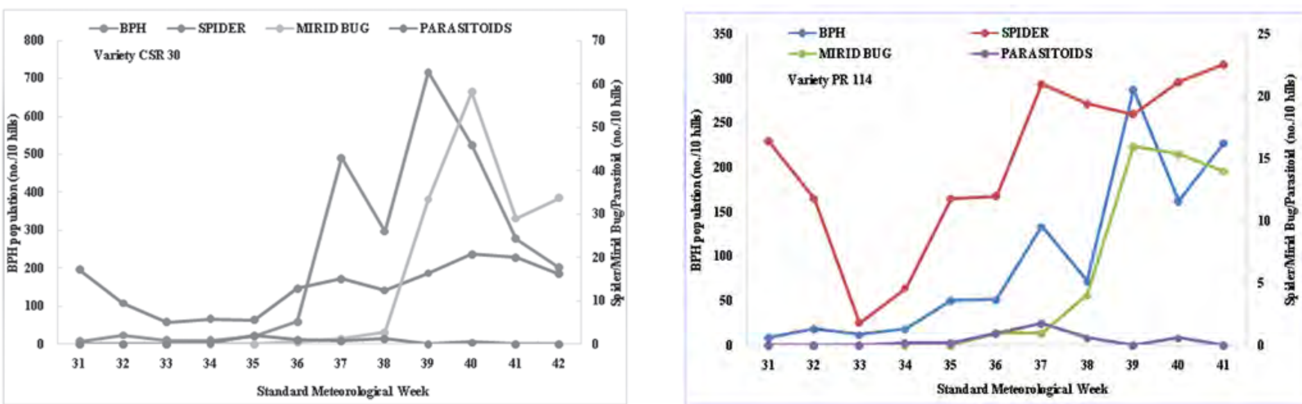


Fig. 3. Population dynamics of brown planthopper and natural enemies in relation to variety planted in July, 2011

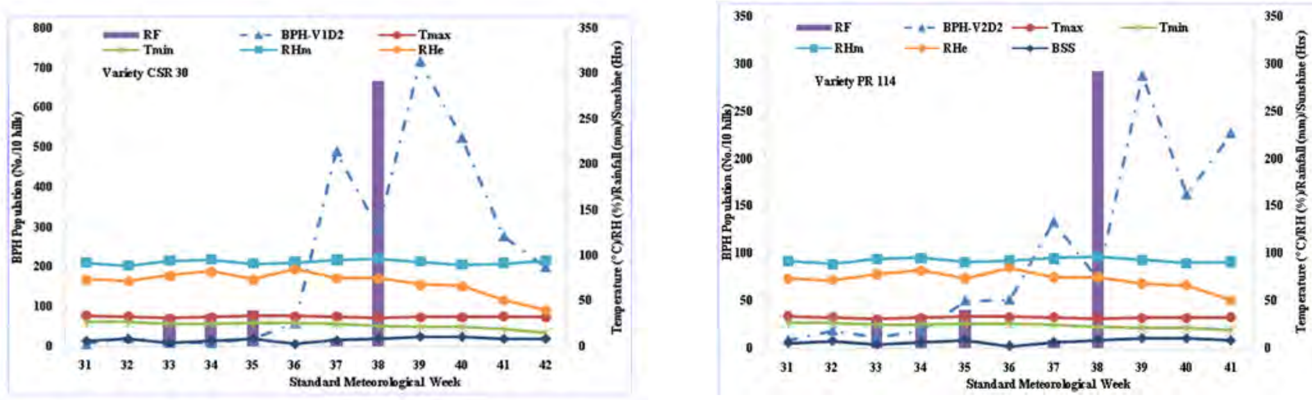


Fig. 4. Population dynamics of brown planthopper in relation to abiotic factors and variety planted in July, 2011

BPH/10 hills) was observed during 39th SMW. Subsequently, the pest population decreased till the end of sampling.

In contrast, the peak population (409.6 BPH/10 hills) of BPH on variety PR114 was recorded during 39th SMW when Tmax was 31.8 ^{0}C, Tmin 21.6 ^{0}C, rainfall 0.0 mm, RHm 93.3%, RHe 68.3% and SSH 10.5.

The spiders occurred simultaneously in both the varieties. The population of spiders reached on its peak during 37th SMW as compared to CSR 30 (39th SMW) and remained higher till end of sampling in variety PR 114 than CSR 30. The mirid bugs colonized early in PR 114 during 35th SMW than on variety CSR 30 (36rd SMW) and increased gradually attaining a peak population of 14.4/10 hills during 41st SMW while, in variety CSR 30, its peak population (64.2 mirid bugs/10 hills) was observed during 39th SMW. The population of nymphal-adult parasitoid was very low on variety PR 114 as compared to CSR 30 throughout the season. The population of parasitoids appeared during the 33rd SMW in CSR 30 and was maximum number during 37th SMW (Fig. 1 and 2).

ii) Effect of variety planted in July (D2)

The data recorded on population of BPH and natural enemies on varieties CSR 30 and PR 114 planted in July presented in Fig. 3 and 4 showed that the trend of occurrence of BPH on variety CSR 30 was similar to June planting. However, two peaks of population were registered on variety CSR 30 planted in July. The highest peak of BPH (716.4/10 hills) was recorded during 39th SMW in the month of September. Similarly, in variety PR114, two distinct peaks were apparent as it was observed in variety CSR 30. The first peak (133.6 BPH/10 hills) and the second (287.8 BPH/10 hills) were observed during 37th and 39th SMW, respectively. Where, the population of BPH was highest during 39th SMW when Tmax 31.8 ^{0}C, Tmin 21.6 ^{0}C, rainfall 0.0 mm, RHm 93.3%, RHe 68.3% and SSH 10.5.

The spiders occurred simultaneously in both the varieties. The number of different taxa of spiders occurred throughout the season and population varied from 5.0/10 to 20.8/10 hills. The population of mirid bugs varied from 0.0 to 58.2/10 hills and the highest peak was recorded during 40th SMW in October and decreased sharply thereafter. On variety PR 114, the population of spiders and mirid bugs varied from 1.8 to 22.6/10 hills and 1.0 to 15.4/10 hills, respectively. The population of nymphal-adult parasitoids was very low during the season (Fig. 3).

b. Weekly population fluctuation of brown planthopper during *wet season,* 2012

The weekly mean abundance of BPH, natural enemies and weekly averages of maximum temperature (Tmax), minimum temperature (Tmin), rainfall, morning relative humidity (RHm), evening relative humidity (RHe) and sun shine hours (HHS) were computed from the daily data and are presented (Fig. 5 to 8) with reference to the standard meteorological weeks (SMW).

i) Effect of variety planted in June (D1)

During 2012, the BPH was first recorded in 32nd SMW on CSR 30 and PR 114 planted in June and the population was low throughout the season. The first

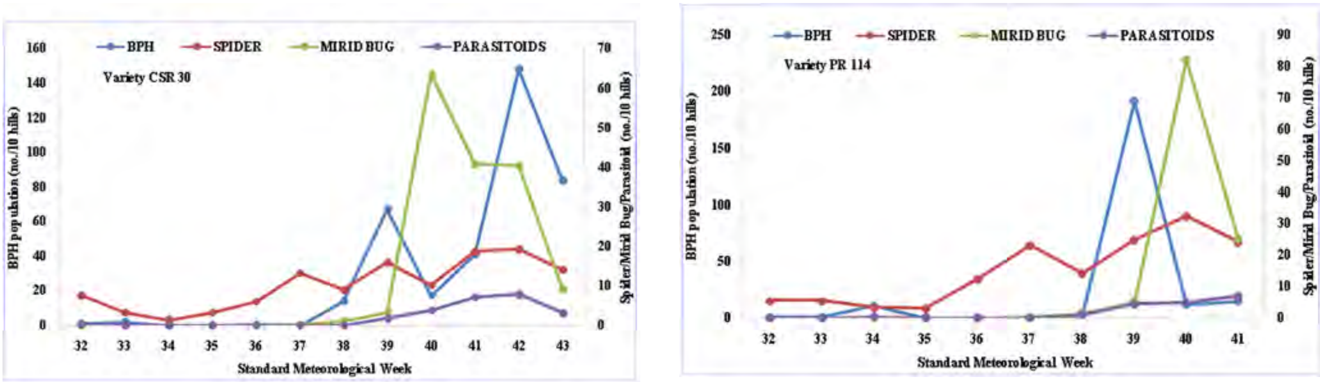


Fig. 5. Population dynamics of brown planthopper and natural enemies in relation to variety planted in June, 2012

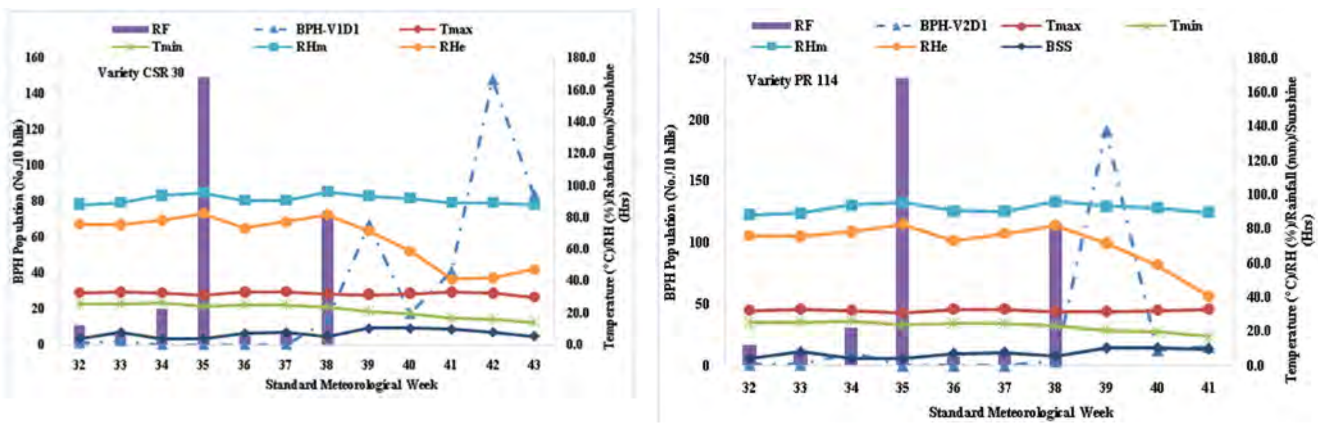


Fig. 6. Population dynamics of brown planthopper in relation to abiotic factors and variety planted in June, 2012

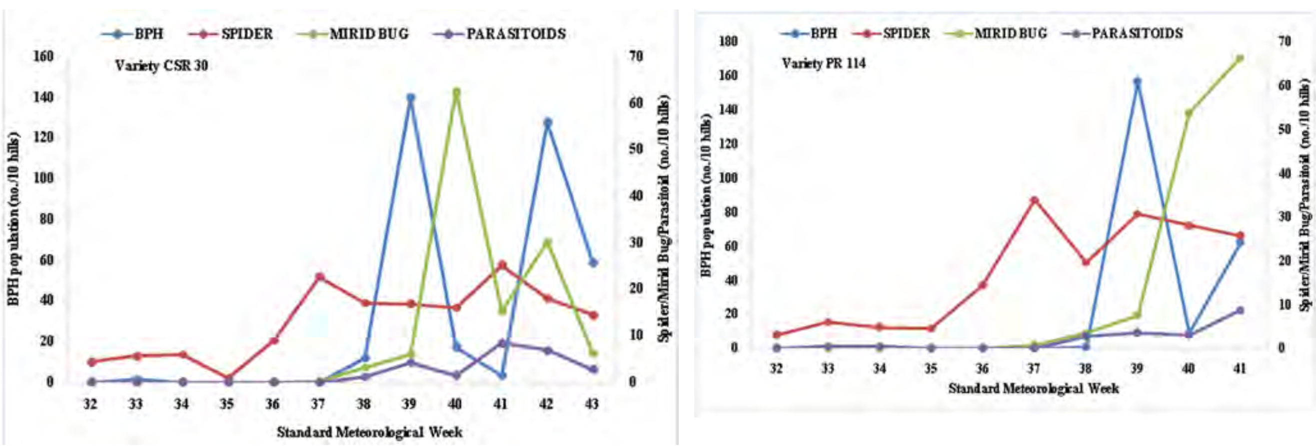
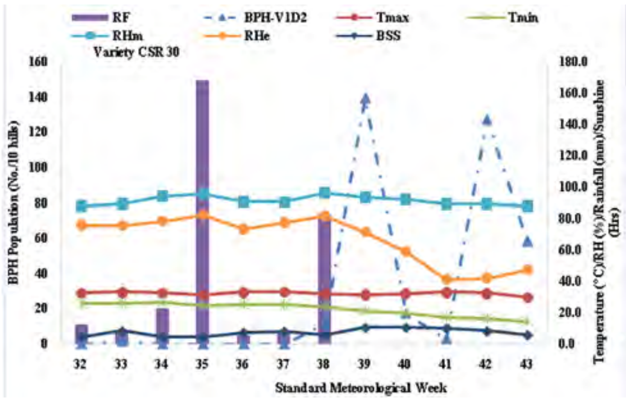


Fig. 7. Population dynamics of brown planthopper and natural enemies in relation to variety planted in July, 2012



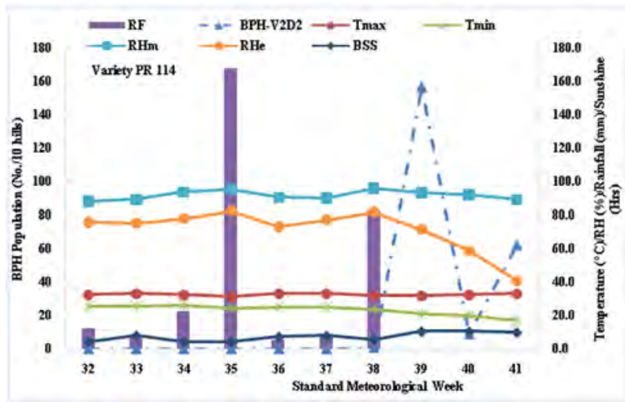


Fig. 8. Population dynamics of brown planthopper in relation to abiotic factors and variety planted in July, 2012

small peak (67.2/10 hills) of BPH was recorded during 39th week and the second largest peak (148.2 BPH/10 hills) was observed during 42nd SMW in October when temperature and RH range was 16.4 -32.4 ^{0}C and 42.1-89.6%, respectively and SSH 8.1 hours and decreased suddenly thereafter. In case of variety PR 114 the peak population (191.4/10 hills) of BPH was recorded during 39th SMW when Tmax 31.6 ^{0}C, Tmin 21 ^{0}C, rainfall 0.0 mm, RHm 93.6%, RHe 71.9% and SSH 10.5 hours, was recorded during this week (Fig. 5 and 6).

The spiders occurred throughout the season (Fig. 5) and their population varied from 1.4 to 19.2/10 hills and 3.0 to 32.4/10 hills on CSR 30 and PR 114, respectively. The population of mirid bugs was first recorded during 37th SMW on both the varieties. Maximum number of mirid bugs 63.6/10 hills and 82.2/10 hills of mirid bugs were recorded during 40th SMW on CSR 30 and PR 114, respectively. The population of parasitoids remained low throughout the season on both the varieties. The highest population of nymphal-adult parasitoids was observed during 42nd SMW in CSR 30 (8/10 hills) as compared to 41st in PR 114 (7.0/10 hills).

ii) Effect of variety planted in July

Two distinct peaks of BPH were observed on CSR 30 planted in July, the highest number of BPH were 139.8 and 127.6/10 hills during 39th and 42nd SMW. The weather during 39th SMW was Tmax 31.6 ^{0}C, Tmin 21 ^{0}C, rainfall 0.0 mm, RHm 93.6%, RHe 71.9% and SSH 10.5 hours. On variety PR 114, only single peak (157.0/10 hills) was observed during 39th SMW. The population of BPH crashed thereafter and was about half of its peak during 41st SMW (Fig. 7 and 8).

The spiders occurred throughout the season and their population varied from 0.8 to 25.2/10 hills on CSR 30 and 3.0 to 34.0 spiders/ 10 hills on PR 114, respectively. The population of mirid bugs first appeared during 37th SMW and remained low till 39th SMW than the population increased and reached to its peak (62.6/10 hills) during the 40th SMW and decreased thereafter on CSR 30 whereas, the population of mirid bugs was maximum in 41st SMW (66.4/10 hills). The population of parasitoids was very low during early growth stage of the crop and the maximum number (8.4/10 hills) were recorded during 41st SMW. The population trend of BPH, predators and parasitoids was in July planting was similar to the June planting (Fig. 7).

The incidence of pest during a season varies from region to region as influenced by many factors. Earlier workers reported the peak incidence from beginning to end of September (Varadharajan, 1979), first week of October (Behera *et al.*, 2010), from last week of August upto third week of September (Firake *et al.*, 2010). Prashant *et al.* (2012) observed the maximum number of BPH during November followed by December and October 2009. Suenaga (1963) reported the peak activity of BPH during September and October, from the end of September to early October and the third ten days of October (Zhong *et al.*, 2008). Yan *et al.* (2008) from China reported two peaks of BPH, the first peak appeared in late July-late August and the second peak (late rice peak) appeared in September-October. The results of these earlier workers support the present findings. Heong (1989) reported that wolf spiders are polyphagous predators.

They feed on pests such as planthoppers and leafhoppers, but they also prey on other beneficial species in the rice ecosystem, such as mirid bug *C. lividipenis* and hymenopteran parasitoids. The predators of BPH (spiders, mirid bug and carabids) were also observed throughout the study period by Prashant *et al.* (2012). Behera *et al*. (2010) reported that spiders *Tetragnatha mandibulata* was the dominant species. Population of spiders and *C. lividipennis* started concurrently along with the appearance of hoppers in the farmer's field at Kandabindha. During both the years and at both the sites of trial the population of spiders was always lower than that of *C. lividipennis*. Chandra (2005) reported that the *Anagrus* sp. and mirid bug were the common parasitoids and predators in field. Chandra (1980) observed that the field parasitism of nymphal and adult parasitoids (drynids) was highest during July to October, when the highest field parasitism was recorded 40 per cent. In Mandya, 18 and 12 per cent parasitism was observed during 1990 and 1991, respectively (Anonymous, 1990 and 1991). Pena and Shepard (1986) from Philippine reported 39 and 21 per cent parasitism of *N. lugens* by drynids in Kalayan and Pakil, respectively. Wang *et al.* (2011) observed the population dynamics of *C. lividipennis* in Karst rice-planting areas in Guizhou in 2010. They found that the number of *C. lividipennis* was small in the early stage but big in the late stage of rice, with peak appearing from 20-30th of July to 20-30th of August. The synchronism existed in the population dynamics of *C. lividipennis* and *N. lugens*. The work of these workers especially on the occurrence of natural enemies supports the present findings.

B. Correlation of brown planthopper with abiotic and biotic factors

In order to know the effect of different weather parameters and biotic factors on the population of brown planthopper, correlation coefficient values were worked out by taking weather parameters and biotic factors as independent variables and population of BPH as dependent variables.

a. Correlation of brown planthopper, *Nilaparvata lugens* (Stal) with abiotic and biotic factors on rice cultivar CSR 30 at different dates of transplanting during wet season 2011 and 2012

During 2011, the population of BPH was positively correlated (r= 0.697) with parasitoid populations in June transplanting (D1) while, in July transplanting (D2), there was a positive correlation with spiders(r= 0.632), mirid bugs (r= 0.666) and SSH (r= 0.629). The population of BPH was highly positive correlated with spiders (r= 0.758), parasitoids (r= 0.780) and highly negative correlated with Tmin (r= -0.818) and rainfall (r= -0.760) on variety CSR 30 planted in June (D1) during 2012 and none of the abiotic and biotic factors showed any significant impact on BPH population in D2 during 2012 (Table 1). Yadav and Chander (2010) reported that weather parameters had significant influence on BPH population. The negative correlation was observed with Tmax, Tmin and RH and light trap catches. Mancharan and Jayaraj (1979) reported the positive correlation of BPH with SSH. The results of these scientists are in line with the present findings. However, a positive correlation with Tmax and Tmin was observed by Win *et al.* (2011), Varma *et al.* (2008) and Mancharan and Jayraj (1979). There was no correlation between BPH and Tmax, Tmin (Kumar and Patil, 2004; Prashant *et al.*, 2012 and Chander and Palta, 2009). The correlation between morning and evening relative humidity was significantly positive (Yadav and Chander, 2010; Chander and Palta, 2009 and Win *et al.*, 2011). However, a negative correlation was found with these parameters by Varma *et al*. (2008). The studies of Mancharan and Jayraj (1979) and Kumar and Patil (2004) did not reveal significant correlation. When rainfall was correlated with population of BPH, a positive relation was found by Varma *et al.* (2008) and Win *et al.* (2011). The studies of Kumar and Patil (2004) and Chander and Palta (2009) showed non-significant correlation. Similarly, the correlation between BPH and wind speed was positive as reported by Chander and Palta (2009) while negative relationship was observed by Mancharan and Jayaraj (1979) (Table 1).

b. Correlation of brown planthopper, *Nilaparvata lugens* (Stal) with abiotic & biotic factors on rice cultivar PR 114 at different dates of transplanting during wet season 2011 and 2012

Significant effect of biotic and abiotic factors was recorded on population of BPH during 2011 on variety PR 114 planted in June (D1). The population of BPH was positively correlated with spiders (r= 0.662) and mirid bug (r= 0.955) while, Tmin (r= -0.844) and rainfall

Table 1. Correlation of brown planthopper, *Nilaparvata lugens* (Stal) with abiotic and biotic factors on rice cultivar CSR 30 at different dates of transplanting during wet season 2011 and 2012

Biotic and abiotic factors	Mean population of BPH			
	2011		2012	
	D1	D2	D1	D2
Spiders	0.555	0.632*	0.758**	0.319
Mirids	0.493	0.666*	0.426	0.238
Parasitoids	0.697*	-0.097	0.780**	0.568
Temperature Max. (ºC)	-0.277	-0.371	-0.375	-0.401
Temperature Min. (ºC)	-0.130	-0.425	-0.818**	-0.570
Relative humidity Morning (%)	0.268	0.012	-0.323	-0.288
Relative humidity Evening (%)	0.433	0.084	-0.309	-0.061
Rainfall (mm)	0.001	-0.273	-0.760**	-0.431
Sunshine hours (SSH)	0.303	0.629*	0.301	0.396

D1 = Last week of June; D2 = First week of July
*Significant at 5% level; **Significant at 1% level

Table 2. Correlation of brown planthopper, *Nilaparvata lugens* (Stal) with abiotic and biotic factors on rice cultivar PR 114 at different dates of transplanting during wet season 2011 and 2012

Biotic and abiotic factors	Mean population of BPH			
	2011		2012	
	D1	D2	D1	D2
Spiders	0.662*	0.688**	0.376	0.503
Mirids	0.955**	0.903**	-0.020	0.242
Parasitoids	0.148	0.053	0.424	0.547
Temperature Max. (ºC)	-0.337	-0.223	-0.442	-0.332
Temperature Min. (ºC)	-0.844**	-0.812**	-0.346	-0.574
Relative humidity Morning (%)	-0.159	-0.161	-0.230	-0.279
Relative humidity Evening (%)	-0.191	-0.076	0.203	0.077
Rainfall (mm)	-0.674*	-0.685**	-0.074	-0.345
Sunshine hours (SSH)	0.303	0.629*	0.480	0.593

D1 = Last week of June; D2 = First week of July
*Significant at 5% level; **Significant at 1% level

(r= -0.674) were negatively correlated in D1 of cultivar PR 114 during 2011. In July transplanting (D2), the spiders (r= 0.688) and mirid bugs (r= 0.903) and SSH (r=0.629) were highly positive correlated while, Tmin (r=-0.812) and rainfall (r= -0.685) had negative impact on population BPH. However, during 2012, none of the variables showed any relation with BPH population (Table 2). Kumar and Patil (2004) and Prashant *et al.* (2012) also observed positive correlation of BPH with spiders and mirid bugs. The mirid *C. lividipennis*, spiders (theridiids, erigonids and lycosids) and nematodes were the main natural enemies, and their density in the field was positively correlated with that of the delphacids (Luo, 1985).

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