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Interactive effect of temperature and CO_2 on resistance of rice genotypes to brown planthopper, *Nilaparvata lugens* (Stal.)

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Abstract

It is predicted that the current atmospheric CO_2 concentration will be doubled and global mean temperature will increase by 1.5-6 °C by the end of this century. Although a number of studies have addressed the separate effects of CO_2 and temperature on plant-insect interactions, few have concerned with their combined impacts. The present investigation was carried out to examine the interactive effect of temperature and CO_2on resistance of rice to brown planthopper, *Nilaparvata lugens* (Stal.) in different rice genotypesduring the period of 2015-2016 at Rice Research Centre, ARI, Rajendranagar and Agro Climatic Research Centre, ARI, Rajendranagar. The results revealed that, among the eight genotypes tested, six genotypes *viz*., MTU 1001, BPT 5204, MTU 1010, RNR 8860-5, GSR 221 and RNR 20933 showed no change in resistance reaction to BPH at different combination effects of two CO_2 levels *i.e.* 380±25ppm and 580±25ppm and four temperature regimes *i.e.* 25 ºC, 30 ºC, 35 ºC, 40 ºC. RNR 11718 showed moderate resistant reaction both at ambient and elevated CO_2 at 25 °C and 35 °C, respectively. However, it showed moderately susceptible at 30 °C both at ambient and elevated CO_2. While IET 23993, showed resistance reaction at combination of ambient CO_2 with 25, 30 and 35 °C and at elevated CO_2 with 35 °C but it showed moderately resistant reaction at elevated CO_2 and 30 °C.

Keywords: *Nilaparvata lugens*, rice genotypes, temperature and CO_2

Introduction

Rice (*Oryza sativa*) is one of the world's most important food crop and is the most widely consumed staple food for a large part of the world's human population, especially in Asia. The average per hectare yield in the country tends to be relatively low compared to China, Sri Lanka, mainly due to heavy losses caused by pests. Rice crop is attacked by 800 species of insect pests in both field and storage. Among these one of the most economically important insect pests is the Brown planthopper (BPH), *Nilaparvata lugens* (Stal.) (Homoptera: Delphacidae). The BPH has become more problematic, posing a threat to rice production throughout South and South East Asia. Due to infestation plants turn yellow and dry up rapidly. At early infestation, round and yellow patches appear, which soon turn brownish due to the drying up of the plants and is called as 'Hopper burn' which is reported to cause yield loss ranging from 10-75% (Tirumala rao, 1950) [1].

BPH occurs during both dry and wet seasons and its damage is more often seen in well irrigated, densely planted fields with high doses of nitrogen and frequent insecticide application. The BPH survival, growth, development and multiplication are effected by several biotic and abiotic factors. Among the abiotic factors, temperature and humidity play a major role. However, as a consequence of climate change CO_2 levels are also increasing. As a result of climate change it is predicted that current atmospheric CO_2 concentration will be doubled and global mean temperature will increase by 1.5-6.0 ºC by the end of the century (IPCC, 2001). Such changes will alter plant-herbivore interactions through effects on plant, insect growth, development and survival.

Some studies have been conducted on effect of temperature and elevated CO_2. However studies on combined effects of temperature and elevated CO_2 are meagre world wide in general and no such studies are conducted in Telangana state in particular, where BPH is a major insect pest of rice and different environmental conditions are present. Such information will pave way for devising suitable management strategies against BPH under climate change scenario. Further temperature and CO_2 levels may increase or decrease the resistance of different rice varieties to BPH.

Such studies aid in understanding the impact of BPH on different rice varieties under different climate conditions and take up climate resilient BPH tolerant rice varietal cultivation. The present investigation is an attempt to generate information on the effect of temperature and elevated CO_2 on resistance of rice genotypes to BPH.

Materials and Methods

Colonies of BPH were maintained in insect rearing cages on the susceptible rice variety Taichung Native 1 (TN1) in poly house facility available at Rice Research Centre, ARI, Rajendranagar. The present investigation was carried out to examine the interactive effect of temperature and CO_2 on resistance of rice to brown planthopper, *Nilaparvata lugens* (Stal.) in different rice genotypes during the period of 2015-2016 at Rice Research Centre, ARI, Rajendranagar and Agro Climatic Research Centre, ARI, Rajendranagar.

The combined effects of two CO_2 levels *i.e.* 380±25ppm and 580±25ppm and four temperature regimes *i.e.* 25 ºC, 30 ºC, 35 ºC, 40 ºC were studied on eight rice genotypes (Table 1) along with PTB33 as resistant check and TN1 as susceptible check.

Screening of selected rice entries was carried out in CO_2 chambers at Agro Climatic Research Centre, ARI, Rajendranagar, Hyderabad by following Standard Seed box Screening Technique (Heinrichs *et al.*, 1985) [2]. The seeds of selected cultures were soaked in water for 24 hours by placing them in petri plates containing optimum quantity of water. The water was drained out after 24 hours and the soaked seeds were kept in the same petri plate for another 24 hours to allow proper germination. The pre-germinated seeds were sown individually with the help of forceps in 45 x 30 x 5 cm size plastic trays containing well puddled homogenous soil. The sown seeds were covered with thin layer of soil and watered as and when required. Each tray comprised of eight rice varieties with 20 seedlings per entry with one middle row of standard resistant check PTB 33 at the centre and susceptible check TN1 all around the tray as boarder rows. All the entries were replicated thrice. A total of three such screening trays were considered as three replications. Each entry was provided equal opportunity by randomizing them.

At three leaf stage *i.e.*, 20-25 days after sowing, the second instar nymphs @ 5 nymphs/ plant were released uniformly in the screening tray. The screening trays with BPH nymphs were covered with mylar sheet to prevent escape of the nymphs. The infested trays were monitored regularly for the plant damage. To ensure uniform reaction the trays were rotated round twice daily for attaining even reaction of plant response to BPH infestation. The test entries were monitored regularly until the susceptible check TN1 showed 90 per cent hopper burn symptoms. When more than 90 per cent plants of the susceptible check, TN1 were killed, the scoring was done based on 0-9 scale using Standard Evaluation System (SES) developed by the International Rice Research Institute (IRRI, 2014) as detailed in Table 2.

The test entries were scored, when more than 90 percent plants of susceptible check TN1 showed hopper burn symptoms based on a 0-9 scale as per Standard Evaluation System of IRRI, 2014.

Table 1: Selected rice genotypes for screening against BPH following Standard Seed box Screening Technique (SSST)

S.No.	Rice Genotypes
1	MTU 1001 (Vijetha)
2	BPT 5204 (Samba mahsuri)
3	MTU 1010 (Cotton dorasannalu)
4	RNR 8860-5
5	RNR 11718
6	GSR 221
7	RNR 20933
8	IET 23993
9	PTB 33- Resistant check
10	TN1- Susceptible check

Table 2: Standard Evaluation System (SES) for Brown plant hopper (IRRI, 2014) [3]

Damage score	Reaction
0	No damage
1	Very slight damage
3	First and second leaves of most plants showing partial yellowing
5	Pronounced yellowing and stunting or about half of the plants wilting or dead
7	More than half the plants wilting or dead and remaining plants severely stunted or dying
9	All plants dead

After scoring individual seedlings of a variety, the score for all the seedlings of an entry was computed and average of all three replications was used as an indicator of resistance reaction for that particular entry. Based on the mean damage score the entries were categorized as described in the Table 3 (Jegadeeswaran *et al.*, 2014) [4]

Table 3: Categorization of levels of resistance based on damage score

Mean damage score	Resistance classification
0	Highly resistant (HR)
1 - 3	Resistant (R)
3.1 - 5	Moderately resistant (MR)
5.1 - 7	Moderately susceptible (MS)
7.1 - 8.9	Susceptible (S)
9	Highly susceptible (HS)

Results and Discussion

Results pertaining to screening of eight test genotypes of rice in CO_2 chamber at different temperature regimes and CO_2 levels for their reaction to BPH are presented in Table 4.

The studies on the interactive effect of temperature and CO_2on eight rice genotypes revealed that, among the eight genotypes tested, six genotypes *i.e.* MTU 1001, BPT 5204, MTU 1010, RNR 8860-5, GSR 221 and RNR 20933 showed no change in resistance reaction to BPH at different combination effects of two CO_2 levels *i.e.* 380±25ppm and 580±25ppm and four temperature regimes *i.e.* 25 ºC, 30 ºC, 35 ºC, 40 ºC. All these genotypes showed same reaction across different temperature regimes and CO_2 interactions. However, Two genotypes *viz.* RNR 11718 and IET 23993 showed different resistance reaction among different temperature and CO_2 interactive treatments. RNR 11718 showed moderately resistance reaction both at ambient and elevated CO_2 at 25 °C with a damage score of 5 and 5 and at 35 °C with a damage score of 4.7 and 4, respectively. But, at 30 °C, it showed moderately susceptible both at ambient and elevated CO_2 with a damage score of 5.1 and 5.6, respectively. IET 23993, showed resistance reaction at combination of ambient CO_2 and 25, 30 and 35 °C with a damage score of 2.6, 2.8 and 2.6 and at elevated CO_2 at 35 °C (DS 2.7), but it showed moderately resistant reaction at elevated CO_2 and 30 °C (DS 3.6). Second instar nymphs were not survived at 40 °C both with ambient CO_2 and elevated CO_2, so the reaction of rice cultures to BPH at these treatments were not observed.

Based on the mean damage score of eight test genotypes of rice in eight interactive treatments, out of eight genotypes, five genotypes *viz.*, MTU 1001, MTU 1010, GSR 221, RNR 20933, IET 23993 and resistant check PTB33 showed resistant reaction, one genotype *viz.*, RNR 11718 exhibited moderately resistant reaction, two genotypes *viz.*, BPT 5204, RNR 8860-5 exhibited susceptible reaction along with susceptible check TN1.

The results are in agreement with the results of Wang *et al.* (2010) [5] who reported that IR26 and IR36 showed a decreased trend in the resistance from 25 ℃ to 34 ℃, and they fully lost the resistance at 31 ℃ and 34 ℃. The present findings also indicate that under optimum CO_2 and temperature levels some varieties may become susceptible, while there may be some varieties which often resistance across different temperature and CO_2 levels. Under climate change situations one needs to identify such stable rice varieties, so that breakdown of host plant resistance can be delayed. Most of the tested genotypes have not shown any change in resistance reaction at different temperature and CO_2 levels. The results are in accordance with Corlett and LaFrankie (1998) [6] who reported that many plant species in tropical regions have the capability to withstand the phenological changes as a result of climate change.

Table 4: Reaction of different rice genotypes against brown planthopper at different temperature and elevated CO_2 levels

S. No.	Varieties	Treatments												Mean damage score	Mean reaction
		380ppm & 25 °C	Reaction	580ppm & 25 °C	Reaction	380ppm & 30 °C	Reaction	580ppm & 30 °C	Reaction	380ppm & 35 °C	Reaction	580ppm & 35 °C	Reaction	380ppm & 40 °C	580ppm & 40 °C		
1	MTU 1001	2.0	R	2.1	R	2.3	R	2.7	R	1.7	R	1.8 R	R	*	*	2.1	R
2	BPT 5204	7.1	S	7.2	S	7.5	S	7.3	S	7.1	S	7.2 S	S	*	*	7.2	S
3	MTU 1010	1.3	R	2.0	R	2.0	R	2.3	R	1.2	R	1.2 R	R	*	*	1.7	R
4	RNR 8860-5	7.4	S	7.6	S	7.5	S	7.4	S	7.1	S	7.4 S	S	*	*	7.4	S
5	RNR 11718	5.0	MR	5.0	MR	5.1	MS	5.6	MS	4.7	MR	4.7 MR	MR	*	*	5.0	MR
6	GSR 221	2.1	R	2.5	R	2.6	R	2.5	R	2.0	R	2.2 R	R	*	*	2.3	R
7	RNR 20933	2.3	R	2.6	R	2.7	R	2.8	R	1.6	R	1.8 R	R	*	*	2.3	R
8	IET 23993	2.6	R	3.4	MR	2.8	R	3.6	MR	2.6	R	2.7 R	R	*	*	3.0	R
9	TN1 (Susceptible check)	9.0	HS	9.0	HS	9.0	HS	9.0	HS	9.0	HS	9.0 HS	HS	*	*	9.0	HS
10	PTB 33 (Resistant check)	1.4	R	1.6 R	R	1.9	R	2.0	R	1.1	R	1.2 R	R	*	*	1.5	R

R= Resistant; MR= Moderately Resistant; S= Susceptible; HS=Highly Susceptible

***** The 2nd instar nymphs of BPH did not survive and hence no reaction could be observed at 40 °C

Conclusion

Host plant resistance to insects is one of the most environmental friendly components of pest management. However, climate change may alter the interactions between the insect-pests and their host plants and it may result in breakdown of resistance to certain insect pests. Further, many plant species in tropical regions have the capability to withstand the phenological changes as a result of climate change. From the present study it is concluded that the interactive effect of temperature and CO_2 have not changed the resistance reaction in most of the genotypes to BPH at different combination of CO_2 levels and four temperature regimes, indicating that the populations have not shown any differential reaction among the different genotypes to environmental changes. However, the genotypes IET 23993 and RNR 11718 showed moderately resistant reaction indicating that further studies need to be conducted in future on screening of different rice varieties at different temperature and CO_2 levels against BPH in order to evolve climatically stable rice varieties.

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