Print : ISSN 0974-8431
Online : ISSN 0976-2485
NAAS Score : 3.94

Trends in Biosciences

An International Journal

Volume 10 Number 27 July, 2017

Online version available at
www.trendsinbiosciencesjournal.com

Dheerpura Society for Advancement of Science and Rural Development

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Dheerpura **Society for Advancement of Science and Rural Development**
Branch Office : Kanpur (U.P.) 208 018, India

Trends in Biosciences 10(27), Print : ISSN 0974-8431, 5733-5736, 2017

Mechanisms of Resistance in Paddy to Brown Planthopper *Nilaparvata lugens* Stal.

A. RAMULAMMA, D. SRIDEVI, V. JHANSILAKSHMI AND BHARATHI N BHAT.

Depatment of Entomology, Department of Plant Pathology,
Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad
email: rajithaas2011@gmail.com

ABSTRACT

The present studies were carried out in the glasshouse condition at DRR Rajendranagar, Hyderabad, with an objective to study the mechanisms of resistance of selected resistant and moderately resistant rice germplasm accessions were examined using antixenosis mechanism judged by honeydew production by BPH; antibiosis mechanism by nymphal survival, ovicidal test and gain in body weight of BPH; tolerance by days to wilting of BPH infested plants. In this the resistant and moderately resistant varieties showed varieties showed lower quantity of honeydew excretion,lower % nymphal survival, higher % unhatched eggs and more number of days to wilt.

Key words *mechanisms of resistance, screening, rice germplasm accessions*

Rice (*Oryza sativa*) is an important cereal crop and a source of calories for one-third of the world population. Rice has been reported to be infested by a wide array of pests and among them, the brown planthopper (BPH) *Nilaparvata lugens* (Stal.) (Homoptera: Delphacidae), is one of the major pest causing frequent outbreaks (Park *et al*., 2007) and severe yield reductions. Host plant resistance is one of the most economical, effective and most practical methods of pest management. The effect of resistant variety on the pest population is specific, cumulative and persistent. A resistant plant variety that reduces the insect population by 50 per cent in each generation is sufficient to eliminate an insect of economic importance within a few generations (Painter, 1958).

The necessity to identify suitable new donors resistant to BPH from different sources is of utmost importance in order to combat the pest and develop material resistant to different biotypes. It is also necessary to understand the mechanism and factors which are responsible for manifesting the resistance into the selected cultures with desirable characters so that these can be utilized effectively in the breeding programmes.

MATERIALS AND METHODS

Plant materials and BPH: BPH was mass reared on the susceptible rice variety Taichung Native 1 (TN1) to produce enough nymphs for infestation. BPH population was initially collected from the rice fields and pure culture was maintained in the glasshouse at a temperature of 30°C ± 5°C with a relative humidity of 60±5% on 40 -50 day old potted plants of TN1. Mass rearing was done in cages. Second and third instars were collected and used for experiments.

Non-preference/ preference mechanism

Honeydew excretion

In order to determine the extent of feeding by BPH on different test entries, honeydew excreted by the BPH nymphs was measured in the available germplasm accessions that were found to be resistant and moderately resistant to BPH along with the resistant check Ptb 33 and the susceptible check TN1. The study included estimation of honeydew area excreted by constant number of insects by feeding on different germplasm accessions with utilizing the method modified by Pathak and Heinrichs (1980).

The plants were used 30 days after sowing for conducting the honeydew experiment. Nine cm diameter circles of whatman number 1 filter paper with small hole and a longitudinal cut were prepared. and the filter paper circles were dipped in bromocresal green solutionit and dried in shade. The stem of the one month old plant was inserted through the hole and the card board square was kept at the base of the plant and the hole was plugged with nonabsorbent cotton. A polythene sheet and a paper were placed on the card board to prevent moisture absorption by the filter paper. The treated filter paper circle was placed on the card board at the base of the plant. A small plastic cup with small hole was taken placed on the filter paper with inserting the stem through hole.

The feeding/honeydew test was conducted using with releasing five third instar nymphs for one plant. The insects were allowed to feed for 24 hours, when the honeydew droplets come in contact with the filter paper turn into blue spots. The filter paper was taken out and the area of the spots was measured by graph paper method.

Antibiosis mechanism

Nymphal survival (%)

The seeds of the test entries were soaked in petri dishes and the germinated seeds were sown in 1000 ml plastic/earthen pots filled with fertilizer enriched puddled soil. The plants were covered with mylar tubes provided with fine muslin cloth pasted ventilating windows. Fifteen one day old first instar nymphs were released onto the plant in the mylar tube and the open end of the tube was covered with a muslin cloth. The plants were observed daily and the number of adults were counted whenever they emerged and removed from plant. The sex and wing form of the adults were recorded. There were three replications per each test entry. The per cent nymphal survival was calculated by the following formula % nymphal survival = number of adults emerged X 100 / number of nymphs released

Ovicidal Test / % Egg hatching

The seeds of test entries were soaked in petri dishes and the germinated seeds were sown in 1000 ml plastic pots filled with fertilizer enriched puddled soil. Two germinated seeds were planted in each pot and for each test entry, seedlings were raised in 8-10 pots. When the plants were 30 days old, they were covered with mylar tubes with ventilating windows. One pair of adults i.e. one gravid female (7 days old) and a male were released The adults were removed on 5th day of release. The plants were observed for nymphal hatching. The hatched nymphs were counted, number was recorded and removed from the plant.

% of unhatched eggs= 100 X number of unhatched eggs / (number of nymphs + number of unhatched eggs

Weight gain by adults and third instar nymphs

Newly emerged females, males and third instar nymphs of brown planthopper were weighed individually in small vials and were released on the test entries covered with mylar tubes. The open end of mylar tube was covered with muslin cloth and tied with a rubber band. The insects were allowed to feed for 48 hours, then collected individually, and reweighed to record the difference in the weight gain.

Tolarance mechanism

Days to wilting

Four pre-germinated seeds of the test entries were sown in pots (16 x 16 cm) and thinned to two per pot at 7 days after sowing. A 4 cm x 45 cm cylindrical mylar cage was placed over each plant. Plants were infested with 25 first instar BPH nymphs. The plants were observed daily for plant health and observations were recorded on the wilted test plants with all leaves dead. The experiment was terminated at 40 days after the release of nymphs and the number of plants which did not wilt at end of the study were recorded.

Days to wilt= Date of wilting of test entry-date of release of nymphs

RESULTS AND DISCUSSION

The three resistant accessions, viz. IC Nos. 578151, 464186 and 463837 and thirteen moderately resistant accessions viz., IC Nos. 577478, 578145, 463851, 578665, 577482, 465106, 577741, 578144, 577663, 463887, 464128, 578017, 578413 were studied f or mechanisms of resistance in comparision with resistant check Ptb 33 and susceptible check TN1 for their nature of resistance to preference, antibiosis and tolerance.

The honeydew excreted (area in mm^2) by third instar nymphs caged on 16 germplasm accessions, one susceptible (TN1) and one resistant variety (Ptb 33) is given in table 4.2. From the results, it was evident that the honeydew excretion varied significantly amongst the test cultures. The resistant culture 464186 recorded least honey dew excretion of 30.33mm^2 and was on par with the resistant check Ptb 33 (31.33mm^2), 578151 (34.33 mm^2) and 463837 (37.00 mm^2). Thus, the range of honey dew excretion by the third instar nymphs ranged from 30.33 mm^2 (464186) to 163.00 mm^2 (TN1). The quantity of excretion of honeydew by BPH, in general, is directly related to the intake of plant sap. Therefore, the amount of honey dew excreted by the insect in unit time when fed on different rice cultures is considered as an index for its feeding preference. Kalode and Krishna (1979) reported that on resistant cultivars (Ptb 33, Ptb 27, CR-57-MR-1523 and ARC 6650), the insect had restricted feeding and little amount of honey dew was excreted.

Antibiosis tests revealed that among the resistant cultures, 578151 adversely affected the nymphal development and only 48.33 per cent nymphs became adults. Similarly the resistant cultures 464186 and 463837 also affected the nymphal development wherein only 61.67 and 70.00 per cent nymphs, respectively, became adults compared to 96.00 per cent in the susceptible check. The wingless females and males were higher than winged females and males in all the cultures including the susceptible check TN1. Kisimoto (1965) reported that nymphs reared on unsuitable hosts generally developed into macropterus adults. Sogawa and Pathak (1970) reported that the macropterus adults were higher in resistant cultures than susceptible culture TN1 which is in lieu with the present findings.

The resistant and moderately resistant cultures affected the hatchability of BPH. The percentage of unhatched eggs were approx. seven times more (76.62%) in accession 578151 (Table 4.4 and Figure 4.3.) than on TN1 (12.33%) while they were on par with the resistant check Ptb 33 (68.68%). The % of unhatched eggs in accession 578151 was also on par with the accessions 464186 (68.74%) but significantly different from the remaining accessions. Saxena and Pathak (1979) observed that the number of eggs laid on resistant and susceptible plants did not differ but hatching of BPH eggs was reduced on the resistant varieties than on the susceptible varieties.

The weight gain by the female BPH adults caged on the resistant and moderately resistant cultures ranged from 0.004 (578151) to 0.011mg (578017), while that of male adults ranged from 0.0005 (578151) to 0.0019mg (578413 and 577663) and weight gained by the BPH nymphs ranged from 0.0005 (578151) to 0.0017mg (578413) as compared to 0.012 mg, 0.00207 and 0.0018mg, respectively, in the susceptible check TN1. However there was no significant difference in the weight gain by the females, males and nymphs among the resistant cultures and the susceptible check (TN1) and resistant check (Ptb 33). The weight gain in nymphs and males was very less compared to females. Sogawa (1973) and Baqui (1989) also observed less body weight gain by BPH on the resistant cultures and attributed this to less intake of sap.

The susceptible TN1 had taken 14.00 days to wilt (Table 4.5 and Figure 4.5.), and moderately resistant cultures had taken 15.67 days (578017) to 25.33 days (577478) to wilt. Resistant cultures took a maximum of 34.33 days (464186) and a minimum of 27.67(578151) to wilt. These were significantly different from the susceptible check TN1. The feeding by BPH was less in resistant cultures hence the plants could withstand wilting compared to susceptible TN1 and moderately resistant cultures. Days to wilting of BPH infested plants was considered as a measure of tolerance, The resistant culture while 464186 took maximum days to wilt (34.44 days) and was on par with resistant check Ptb 33

Table 1. Percent of nymphal survival, percent of unhatched eggs ,mean weight gain in BPH and Days to wilt of selected rice germplasm accessions.

S.No	IC Nos.	Reaction	% nymphal survival	%unhatched eggs	Mean weight gain by BPH 72 hours after feeding (mg)			Days to wilt
					Female	male	Nymph	
1	578151	R	48.33^{gh} (44.02)	76.62^{a} (61.16)	0.004	0.00057	0.0005	27.67^{bcd}
2	464186	R	61.67^{fg} (51.76)	68.74^{ab} (56.04)	NT	NT	NT	34.33^{ab}
3	463837	R	70.00^{ef} (56.81)	63.76^{bc} (53.04)	0.005	0.00087	0.0008	32.00^{abc}
4	577478	MR	83.33^{bcde} (68.07)	64.15^{bc} (53.23)	0.007	0.0009	0.0011	25.33b^{cde}
5	578145	MR	70.00^{ef} (56.94)	NT	NT	NT	NT	21.67^{cde}
6	463851	MR	85.00^{bcde} (68.07)	NT	0.008	0.0015	0.0009	22.67^{cde}
7	578665	MR	73.33^{def} (59.22)	56.95^{cd} (48.98)	0.007	0.0013	0.0013	20.33^{de}
8	577482	MR	75.00^{def} (60.29)	54.36^{bcd} (47.51)	NT	NT	NT	NT
9	577741	MR	80.00^{cdef} (63.52)	63.83^{bc} (53.01)	0.006	0.0014	0.0010	24.00b^{ce}
10	465106	MR	81.67^{cdef} (64.67)	57.03^{cd} (49.03)	NT	NT	NT	20.67^{de}
11	577663	MR	90.00^{abc} (74.79)	50.35^{de} (45.18)	NT	NT	NT	21.67^{cde}
12	578144	MR	96.67^{a} (81.37)	41.69^{ef} (40.18)	0.009	0.00193	0.0012	19.33^{de}
13	463887	MR	83.33^{bcde} (66.23)	NT	NT	NT	NT	NT
14	464128	MR	75.00^{def} (60.67)	38.30^{f} (38.22)	0.004	0.00147	0.0012	18.67^{de}
15	578017	MR	85.00^{bcde} (68.07)	35.33^{f} (36.44)	0.011	0.0012	0.0011	15.67^{e}
16	578413	MR	90.00^{abcd} (71.92)	24.11^{g} (29.37)	0.008	0.0019	0.0017	16.00^{e}
17	TN1(S)	MR	96.00^{ab} (78.64)	12.33^{h} (20.09)	0.0012	0.0021	0.0018	14.00^{e}
18	Ptb33 (R)		38.33^{h} (38.23)	68.68^{ab} (55.96)	0.002	0.00077	0.0005	38.33^{a}
19	SEm±		3.995	1.802	0.001	0.00	0.00	3.391
20	CD (P = 0.05%)		11.483	5.230	NS	NS	NS	9.787

R= Resistant; MR= Moderately resistant; S= Susceptible; NT= Not tested

Figures in parentheses are angular transformed means.

Means with same letter are not significantly different at 5% level by DMRT.

(38.33 days) while the susceptible TN1 wilted by 14 days. Jhansi Lakshmi *et al.* (2012) reported that the wild rice accessions survived for more than 34 days after exposure to BPH nymphs as compared to 5-6 days in susceptible check TN-1 indicating the presence of high level of tolerance mechanism.

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Received on 17-07-2017 Accepted on 20-07-2017