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International Journal of Current Research
Vol. 6, Issue, 11, pp.10038-10041, November, 2014

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

ANTIBIOSIS EFFECTS OF SELECTED RICE CULTURES ON NYMPHAL SURVIVAL, DEVELOPMENT PERIOD, GROWTH, FECUNDITY AND EGG HATCHABILITY OF BROWN PLANTHOPPER, NILAPARVATA LUGENS (STAL.)

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ARTICLE INFO

Article History:
Received 14th August, 2014
Received in revised form
16th September, 2014
Accepted 11th October, 2014
Published online 30th November, 2014

Key words:
Rice Cultures, Brown Planthopper, Nymphal Survival, Development Period, Growth Index, Fecundity and Hatchability

ABSTRACT

Experiments were conducted to assess the antibiosis mechanism of resistance *viz.,* nymphal survival, development period, growth index, fecundity and hatchability of brown planthopper (BPH), *Nilaparvata lugens* on some selected resistant rice cultures. The rice cultures *viz.,* WGL II 218-5-1, Ptb 33 and RGL 7001 recorded significantly lowest per cent of nymphal survival than susceptible check, TN_1. Significantly prolonged development period of BPH nymphs was observed in rice culture MTU IJ 206-7-4-1, MTU PLA 99-1-3-1-2, WGL II 218-5-1 and resistant check, Ptb 33 than susceptible check, TN_1. All the tested rice cultures registered 1.31 to 6.37 time's lower growth index than the susceptible check TN1. Growth index was significantly lowest in the rice cultures *viz.,* WGL II 218-5-1, Ptb 33 and RGL 7001. Fecundity was significantly lowest on MTU IJ 206-7-4-1 and MTU 1075. The per cent hatchability of eggs was significantly lowest in MTU PLA 99-1-3-1-2.

INTRODUCTION

Rice (*Oryza sativa* L.) is an important staple food crop for more than half of the world population and accounts for more than 50% of the daily calorie intake (Khush, 2005). Increasing production of rice is an important requirement to meet the needs of ever increasing population in India. Insect pests and diseases remain the key biotic stresses limiting rice production significantly. Among the serious insect pests of rice, brown planthopper (BPH), *Nilaparvata lugens* Stal° (Homoptera: Delphacidae), is one of the most destructive insect pests causing significant yield losses in Asian countries and outbreaks have occurred frequently in the recent years as a result of insecticide resistance and resurgence (Park *et al*., 2008). It is a rice specific herbivore damaging the plants by sucking assimilates from the phloem resulting in a condition called ''hopper burn'' and transmits virus diseases like grassy stunt, ragged stunt and wilted stunt (Sogawa, 1982). Cultivation of resistant rice varieties is the most economical and efficient method for the management of BPH. Mechanisms of resistance that are responsible for manifesting the resistance among the plants need to be understand as it is essential for the development of varieties with durable resistance. Three mechanisms of resistance *viz.,* antixenosis, antibiosis and tolerance are generally recognized, in which antibiosis one of the major factors governing resistance to BPH. Hence, the study was conducted to study the antibiosis mechanism of resistance such as BPH nymphal survival, development period and growth in selected highly resistant (HR), resistant (MR) and moderate resistant rice cultures along with the resistant check (Ptb33) and susceptible check (TN1).

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MATERIALS AND METHODS

The advanced rice cultures developed at various Rice Research Stations under Acharya N. G. Ranga Agricultural University was screened initially in laboratory and later in field against BPH to identify resistant cultures as per the standard methods (Heinrichs *et al*., 1985). The rice cultures identified as highly resistant to moderately resistant were used to study the feeding BPH nymphal survival, development period and growth. The study was carried out in the glasshouse as pot culture experiments under controlled conditions at Andhra Pradesh Rice Research Institute and Regional Agricultural Research Institute, Maruteru, West Godavari district, Andhra Pradesh during the period 2010 to 2011.

Insect culture: The BPH was mass cultured in the greenhouse on the susceptible rice variety Taichung Native 1 (TN1). Initial BPH population was collected from rice fields. The adults were confined on 30 days old potted plants of TN1 placed in oviposition cages having wooden frames, glass top and door and wire-mesh side walls. The ovipositing insects were removed three day later and plants with eggs were taken out of cages, placed in separate cages for the nymphs to emerge. The emerged nymphs were then transferred to 10-15 days old seedlings raised in plastic pots and were allowed to develop to different instars until they became adults. The host plants in culture maintenance cage were changed twice a week and replaced them with fresh potted plants (Heinrichs *et al*., 1985).

Rice cultures: For this experimental study, twelve rice cultures *viz.,* NLR 3090, NLR 3093, MTU 1075, WGL 401, WGL II 218-5-1, MTU PLA 99-1-3-1-2, NLR 20131, BPT 2404, RDR 34, RGL 7001, RGL 7002, MTU IJ 206-7-4-1 and the resistant check (Ptb33) and susceptible check (TN1) were used.

Nymphal survival: Selected rice cultures along with resistant and susceptible checks grown separately in plastic pots (10 cm diameter) and were infested with ten first instar BPH nymphs on 30-days old Mylar sheet caged plants. The top open end of the tube was closed with muslin cloth to prevent migration. Each culture was replicated five times. At 20 days after infestation, counted the number of live hoppers on each test culture and calculated the survival percentage of nymphs (Heinrichs *et al*., 1985) to compare the antibiosis effect of different test cultures on nymphs.

Nymphal development period: Nymphal development period on selected rice cultures along with resistant and susceptible checks was studied by releasing five first instar BPH nymphs on 30-days old Mylar film caged plants. From 9^{th} day onwards, nymphs on each culture were observed daily for ecdysis and recorded the number of days taken for the nymphs to reach adult stage on each rice culture (Pongprasert and Weeraput, 1979).

Growth Index (GI): Growth index of BPH on each selected rice culture and the resistant and susceptible checks was computed by using the data obtained from the experiments on nymphal survival and development period (Panda and Heinrichs, 1983) as follows:

$$\text{Growth Index} = \frac{\text{\% nymphs survived on test culture}}{\text{Development period of nymphs on test culture}}$$

Fecundity and hatchability: To determine fecundity and hatchability, 30-days old Mylar film caged potted plants of each test culture was infested with five numbers of seven days-old gravid females reared on TN 1 plants and was replicated five times. The females were allowed to oviposit for 72 hours and after which the insects were removed. The plants were left until the nymphal emergence. The total number of nymphs emerged on the test cultures were recorded. After complete nymphal emergence, unhatched eggs were counted by dissecting leaf sheaths and examined under binocular microscope. Total number of eggs laid was arrived by adding total nymphs emerged and number of unhatched eggs. The data obtained from the experiments were subjected to ANOVA in simple RBD analysis after transforming the data into suitable transformations and the mean values were compared (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Nymphal survival, development period and growth index

The nymphal survival after 20 days of their release on the tested rice cultures was ranged from 28.0 to 100.0 per cent. Among the rice cultures, the resistant culture, WGL II 218-5-1 recorded significantly lowest per cent of nymphal survival (28.00) and was on par with the resistant check, Ptb 33 (40.00). RGL 7001 recorded 50.00 per cent nymphal survival and on par with resistant check Ptb 33. These were followed by NLR 20131 (54.00), RDR 34 (62.20), MTU 1075 (78.00), MTU IJ 206-7-4-1 (80.00). While, the per cent nymphal survival on the other two cultures *viz.,* NLR 3093 and WGL 401 was 100.00 and were on par with susceptible check, TN1 (100.00) (Table 1). Nymphal development period was significantly prolonged on the resistant and moderately resistant cultures (Table 1).

Nymphal period ranged between 14.60 to 26.00 days in the resistant and moderately resistant rice cultures as compared to 11.80 days in the susceptible check, TN1. Significantly prolonged development period was observed in rice culture MTU IJ 206-7-4-1 (26.0 days) and was followed by MTU PLA 99-1-3-1-2 (23.0 days). These two cultures took more days for the development even than the resistant check, Ptb 33 (20.8 days). The other rice cultures which recorded prolonged nymphal development period were WGL II 218-5-1 (21 days), NLR 20131 (20.40 days). The nymphal development period prolonged by 2.80 to 14.20 days in the resistant cultures compared to TN1.

The values of growth index ranged from 1.33 to 8.48. All the rice cultures registered low growth index than the susceptible check TN1. Significantly lowest growth index was observed in the rice culture WGL II 218-5-1 (1.33) and was on par with resistant check Ptb 33 (1.91). These were followed by other rice cultures *viz*., NLR 20131 (2.64), RGL 7001 (2.74) and MTU IJ 206-7-4-1 (3.07). The rice cultures MTU PLA 99-1-3-1-2 (4.01), RDR 34 (4.26), MTU 1075 (4.38) and RGL 7002 (4.89) registered moderate growth index. All the tested rice cultures registered 1.31 to 6.37 time's lower growth index than the susceptible check TN1 (8.48) (Table 1).

In the present study the resistant and moderately resistant cultures recorded lower per cent of nymphal survival, prolonged development period and low growth index of BPH than susceptible check. Similar adverse effects on nymphal survival, development period and growth index of BPH on resistant cultures were reported earlier by several workers (Adiroubane and Letchoumanane, 2000; Soundararajan *et al*., 2003; Loka Reddy *et al*., 2005 and Alagar *et al*., 2007). The lowest growth index of BPH on all the rice cultures compared to TN1 is due prolonged development period and low per cent nymphal survival.

Table 1. Nymphal survival, developmental period and growth index of BPH on selected rice cultures

Rice culture No.	Reaction to BPH	Nymphal survival* (%)	Nymphal period (days)**	Growth index**
NLR 3090	MR	98.00 (86.31)	17.00 (4.12)	5.78 (2.40)
NLR 3093	MR	100.00 (89.99)	16.80 (4.10)	5.96 (2.44)
MTU 1075	R	78.00 (62.53)	17.80 (4.22)	4.38 (2.09)
WGL 401	MR	100.00 (89.99)	15.80 (3.97)	6.34 (2.52)
WGL II 218-5-1	MR	28.00 (31.88)	21.00 (4.58)	1.33 (1.15)
MTU PLA 99-1-3-1-2	MR	92.00 (75.25)	23.00 (4.79)	4.01 (2.00)
NLR 20131	MR	54.00 (47.31)	20.40 (4.51)	2.64 (1.62)
BPT 2404	MR	94.00 (80.99)	14.60 (3.82)	6.46 (2.54)
RDR 34	MR	62.00 (52.20)	14.60 (3.82)	4.26 (2.05)
RGL 7001	R	50.00 (45.12)	18.20 (4.26)	2.74 (1.63)
RGL 7002	R	92.00 (79.67)	18.80 (4.33)	4.89 (2.21)
MTU IJ 206-7-4-1	HR	80.00 (68.99)	26.00 (5.10)	3.07 (1.74)
Ptb 33	HR	40.00 (38.95)	20.80 (4.56)	1.91 (1.36)
TN 1	S	100.00 (89.99)	11.80 (3.43)	8.48 (2.91)
SEm		4.49	0.044	0.077
CD (0.05)		12.70	0.12	0.22
CV (%)		14.96	2.30	8.34

*Figures in parenthesis are arcsine transformed values
**Figures in parenthesis are square root transformed values
HR= highly resistant; R=resistant; MR= moderately resistant; S= susceptible

Table 2. Fecundity of BPH and hatching of eggs on selected rice cultures

Rice culture No.	Survival of BPH adults * (%)	No. of eggs**/5 gravid females	No. of eggs hatched	Hatching (%)
NLR 3090	65.32 (54.46)	240.00 (15.48)	187.80 (13.69)	78.41 (62.53)
NLR 3093	76.00 (61.11)	165.40 (12.82)	125.20 (11.13)	75.26 (60.30)
MTU 1075	54.67 (47.74)	36.80 (6.03)	29.60 (5.40)	80.50 (64.19)
WGL 401	57.33 (49.58)	312.80 (17.66)	210.40 (14.49)	67.28 (55.12)
WGL II 218-5-1	53.33 (46.96)	92.20 (9.58)	53.60 (7.28)	57.64 (49.42)
MTU PLA 99-1-3-1-2	48.02 (43.82)	307.60 (17.50)	150.80 (12.24)	48.94 (44.39)
NLR 20131	57.35 (50.57)	237.20 (15.39)	194.00 (13.91)	81.97 (65.29)
BPT 2404	52.02 (46.27)	326.60 (18.06)	243.00 (15.58)	74.48 (59.71)
RDR 34	44.05 (41.37)	435.40 (20.85)	305.40 (17.45)	70.07 (56.93)
RGL 7001	44.00 (41.44)	96.80 (9.81)	61.00 (7.79)	63.65 (52.99)
RGL 7002	75.93 (61.07)	138.00 (11.74)	89.20 (9.42)	64.30 (53.38)
MTU IJ 206-7-4-1	24.12 (25.22)	35.40 (5.91)	21.80 (4.61)	60.69 (51.29)
Ptb 33	32.08 (32.92)	200.40 (14.15)	102.00 (10.10)	50.99 (45.57)
TN 1	94.57 (79.27)	530.20 (22.96)	502.80 (22.37)	94.99 (77.17)
SEm	3.14	0.43	0.41	1.80
CD (0.05)	8.85	1.23	1.17	5.09
CV (%)	10.82	6.85	7.83	7.06

*Figures in parenthesis were angular transformed values
** Figures in parenthesis were square root values

Fecundity and hatchability

The effects of different tested rice cultures on the fecundity and per cent eggs hatched were presented in Table 2. All the gravid female BPH released on to the rice cultures did not survive. The data indicated that the survival per cent of released adults on different rice cultures varied significantly. All the cultures recorded significantly lowest per cent survival of gravid females than susceptible check, TN1 (94.57). Significantly lowest per cent survival of gravid females was observed in MTU IJ 206-7-4-1 (24.12) and was followed by resistant check, Ptb 33 (32.08). The resistant and moderately resistant rice cultures, which served as food plants for the BPH had certain adverse effects on the biology of BPH and proved detrimental to the BPH and the susceptible TN1 favoured the multiplication of the BPH. The results from the Table 2 indicated that there was a decrease in the fecundity of BPH that fed on resistant cultures as compared to susceptible check, TN1. Among the rice cultures, MTU IJ 206-7-4-1 (35.40) and MTU 1075 (36.80) recorded significantly lower number of eggs and were followed by WGL II 218-5-1 (92.20) and RGL 7001 (96.80). The other rice cultures *viz*., RGL 7002 (138.00), NLR 3093 (165.40) recorded moderate number of eggs per five gravid females and were on par with resistant check, Ptb 33 (200.40). Significantly highest number of eggs were recorded in RDR 34 (435.40), WGL 401 (312.80) and both were lower than susceptible TN1 (530.20) and the eggs laid by gravid BPH females fed on the different categories of resistant rice cultures along with resistant and susceptible check were allowed to hatch to assess the possible effects of the food plants, if any, on hatching and the results were furnished in table 2. All the tested rice cultures recorded significantly lowest number of nymphal emergence compared to susceptible TN1 (502.80). Among the rice cultures, MTU IJ 206-7-4-1 (21.80) and MTU 1075 (29.60) recorded significantly lowest number of nymphs emerged and followed by WGL II 218-5-1 (53.60) and RGL 7001 (61.00), which were lower compared to resistant check, Ptb 33 (102.00).

Based on the number of eggs laid and the number of nymphs emerged on the tested rice cultures, the per cent hatchability of eggs were calculated and presented in table 2. The reduction in per cent egg hatching was significant on the resistant test cultures compared to susceptible TN1 (94.99). Significantly lowest per cent of egg hatching was observed in MTU PLA 99-1-3-1-2 (48.94) and was on par with resistant check, Ptb 33 (50.99) and were followed by WGL II 218-5-1 (57.64). The other rice cultures which recorded lowest per cent of egg hatching were MTU IJ 206-7-4-1 (60.69), RGL 7001 (63.65), RGL 7002 (64.30), WGL 401 (67.28) and were on par with each other. In the present investigation the number of nymphs emerged and per cent egg hatchability was low on tested resistant rice cultures than on TN1. These results were in agreement with Saxena and Pathak (1979); who reported reduced hatching of BPH eggs on the resistant varieties than on the susceptible varieties. Lower rate of reproduction on resistant varieties was mainly due to the failure of ovarian eggs to undergo maturation (Sogawa and Pathak, 1976). Early embryonic development indicated by the onset of eye pigmentation proceeds normally but hatching is affected probably because of the failure of developing larvae to split the chorion. The findings of the present investigation were also in agreement with the earlier reports of Adiroubane and Letchoumananae (2000), Loka Reddy *et al.* (2005) and Alagar *et al.* (2007).

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