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Mechanisms of resistance in rice, *Oryza sativa* L. against the brown planthopper, *Nilaparvata lugens Stal.* (Homoptera: Delphacidae)

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Abstract : The levels of mechanism of resistance such as antixenosis (host preference) and antibiosis against brown planthopper, *Nilaparvata lugens* Stal was studied in certain resistant accessions under laboratory conditions. The levels of resistance were found to be varying in different resistance parameters in the tested accessions. However comparatively less honey dew excretion, low food ingestion and assimilation, decreased nymphal survival, increased nymphal duration, high growth index and reduction life span were recorded in all resistant accessions than the susceptible TN1. ***(Key words*** *: Rice, Nilaparvata lugens, Resistance mechanism, Antixenosis, Antibiosis, Resistance accessions).*

The brown planthopper (BPH) *Nilaparvata lugens* (Stal) (Homoptera : Delphacidae) has been a severe threat to rice production in tropical Asia. Though insecticide application is providing immediate control ill effects like resurgence, secondary out break, and development of resistance to insecticides are met with. Hence grwoing of resistant varieties has been a major tactic to manage the BPH.

International Rice Research Institute (IRRI), Philippines is being engaged in developing varieties resistance to BPH and more than 300 varieties have been identified with high levels of resistance. Mechanisms such as non-preference and antibiosis are the basis of resistance in rice varieties against BPH. Antibiosis was expressed in terms of low population levels (Reddy and Kalode, 1985) reduced feeding and oviposition slower growth rates (Bharathi, 1982) and low food ingestion and assimilation (Khan and Saxena, 1985).

The study was conducted to ascertain the levels of resistance in some of the resistant accessions.

Materials and Methods

Green house studies were conducted at the Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, India during 1995 with rice accessions. Ansphal, TC20/A, Sonasali, Nagurjuna, Chandan, IR 72, with Ptb and TN1 as resistant and susceptible checks. BPH reared on the susceptible TN1 plants were used for the studies.

Mechanism of Resistance

To determine the mechanism of resistance, the parameters employed were: honeydew excretion, quantity of food ingested and assimilated, nymphal growth and development, adult longevity, fecundity and egg hatchability and population growth. All the laboratory studies were conducted with 45 days old plants. All the experiments replicated four times except studies to access the quantity of food ingested and assimilated, which was replicated eight times.

Honeydew excretion

Feeding activity was indirectly accessed by quantifying the area of honeydew spots on the filter paper after 24 h of confinement of BPH on resistant accessions, following the method of Sogawa and Pathak (1970). The area of the honeydew spots was traced out on a graph paper and expressed in mm^2 (Bharathi, 1982).

Quantity of food ingested and assimilated

Ansphal, TC 20/A, Sonasali, Nagarjuna, Chandan, IR72, Ptb 33 (resistant) and TN 1 (susceptible) were the varieties used in the study. Individual insects were confined in a parafilm sachet on the stem (Pathak *et al.*, 1982). The amount of food assimilated (Khan and Saxena, 1985) and the sum of the assimilated food and fresh weight of the excreta or honeydew gave the total weight of the food ingested by the insect. The amount of honeydew excreted was determined by the parafilm (Saxena and Pathak, 1977) method.

Nymphal growth and development

Growth and development of nymphs were determined by confining 10 first instar nymphs to each accession. Insect growth was measured in terms of number of nymphs that became adults and time taken to reach the adult stage. A growth index was calculated as the ratio of percentage of nymphs becoming adults to the mean growth period in days.

Adult longevity

Adult longevity was measured on plants by infesting 10 pairs of newly emerged males and brachpterous females per pod. Survival was recorded for each sex separately until all the insects died.

Fecundity and egg hatchability

Fecundity and egg hatchability of BPH were determined on test accessions by confining with three pairs of newly emerged males and females. Emerging nymphs were counted daily and removed from the cage upto 41 days after infestation (DI), a period longer than the incubation period of BPH. Unhatched eggs were counted by dissecting the leaf sheaths under a 20 x binocular microscope.

Population growth

Population build-up of BPH was studied by confining three pairs of newly emerged males and females on potted plants enclosed in a mylar film cage (10 cm dia x 90 cm high). First generation progeny was counted at 30 DI.

Results and Discussion

Feeding efficiency of BPH

Honeydew exertion of BPH was low on resistant accessions (Table 1) than in the susceptible TN 1. The area of the honeydew spots ranged from 32.75 to 348.75 mm^2 in different accessions. The accession TC20/A recorded minimum (32.75 mm^2) honeydew excretion and the susceptible, TN 1 recorded maximum (348.75 mm^2). But all the tested accessions were significantly superior to the susceptible TN 1. Resistant varieties inhibited the feeding activity of BPH and was reflected in the low honeydew excretion and food assimilation.

Food ingestion and assimilation by BPH

The minimum amount of food ingested (2.80 mg) by a gravid female BPH in 24h was recorded on the resistant check, Ptb 33 rice variety while the maximum food ingestion (9.01 mg) was noted in the susceptible TN 1 (Table 1) As feeding on resistant rice varieties was often interrupted (Khan and Saxena, 1985) the quantity of food ingested and assimilated also was less compared to suitable check, TN 1 (Khan and Saxena, 1985) Minimum food assimilation (0.34mg) was recorded on the resistant check Ptb 33, while it was maximum (0.97 mg) on the susceptiable TN 1. All other accessions were intermediate between these two accessions (Table 1)

Similar findings were reported by many workers (Sogawa and Pathak, 1970 ; Reddy and Kalode, 1985)

Nymphal growth and development of BPH

The Percentage of nymphs becoming adults ranged from 40.10 to 49.20 on resistant accessions when compared to 94.00 percent in susceptiable TN 1. (Table 2). Reduced feeding with the resultant low food assimiliation lead to the impaired accessions is in agreement with the obsrvation of Sogawa and Pathak (1970).

The nymphal development was prolonged in resistant accessions by 4 to 7 days compared to 11 days in susceptiable TN 1 (Table 2). Prolonged nymphal period observed in the persent study is concurrence with the findings of Sogawa and Pathak (1970). Similar findings were reported by Reddy and Kalode (1985) with *N. lugens* on resistant verities.

The growth index (Table 2) was significantly lower in all the resistant accessions (2.225 to 3.285), than in susceptiable TN 1 (8.778). Since the growth index depends on per cent of nymphs becoming adults and growth period, the growth index was significantly lower in all the resistant accessions than the susceptiable TN 1.

Adult longevity

The longevity of male and female BPH was significantly shorter in resistant accessions and longer in susceptible TN 1. Among the resistant accessions, Sonasali recorded the minimum longevity for male (8.70 days) and IR 72 for female (9.30 days). Survival was low in males than in femeles (Table 2). Adults developed from the nutritionally deficiently food of resistant accessions lived only for a shorter period. This is in agreement with the similar findings of Saxena and Pathak (1977); Reddy and Kalode (1985).

Oviposition, hatchability and nymphal emergence

Oviposition of BPH was significantly high on susceptible TN 1, and low on resistant check Ptb 33. All the other resistant accessions exerted an adverse effect on the oviposition by BPH. The number of eggs laid by three female BPH ranged from 112.60 to 149.00 among resistant accessions compared to 486.20 eggs on TN 1 (Table 3).

The mean number of nymphs emerged was significantly high in susceptible TN1 (472.50), while very low nymphal population, ranging from 59.30 to 89.30 were observed among resistant accessions (Table 3).

Table 1. Feeding efficiency of BPH* and food ingestion and assimilation by BPH on rice accessions**

Accession	Mean area of honey dew spots (mm²)	Food ingested /o/ 24h (mg)	Food assimilated /o/ 24h (mg)
Ansphal	58.75ᵃ	3.77ᵈ	0.41ᵃᵇᶜ
TC 20/A	32.75ᵃ	3.11ᵃᵇ	0.39ᵃᵇᶜ
Sonasali	69.75ᵃᵇ	3.19ᵃᵇᶜ	0.38ᵃᵇ
Nagurjuna	40.50ᵃ	4.01ᵈ	0.47ᶜ
Chandan	163.50ᶜ	3.65ᶜᵈ	0.45ᵇᶜ
IR 72	134.00ᵇᶜ	3.60ᵇᶜᵈ	0.44ᵇᶜ
Ptb 33	98.00ᵃᵇ	2.80ᵃ	0.34ᵃ
TN 1	348.75ᵈ	9.01ᵉ	0.97ᵈ

* Mean of 4 replications, ** Mean of 8 replications.

In a column, means followed by a common alphabet are not significantly different at the 5% level by DMRT.

Table 2. Growth, development period and growth index of BPH nymphs and adult longevity of BPH on rice accessions*

Accession	Nymphs becoming Adults (%)	Development Period (days)	Growth Index	Longevity (days) Male	Longevity (days) Female
Ansphal	46.40ᵃᵇ	17.0ᵇᶜ	2.730ᵃᵇ	10.10ᵃ	12.30ᵇ
TC 20/A	40.10ᵃ	18.0ᶜ	2.225ᵃ	9.70ᵃ	9.90ᵃ
Sonasali	43.70ᵃᵇ	17.0ᵇᶜ	2.605ᵃᵇ	8.70ᵃ	9.40ᵃ
Nagurjuna	49.20ᵃᵇ	15.0ᵇ	3.285ᵃᵇ	9.30ᵃ	9.90ᵃ
Chandan	44.60ᵃᵇ	16.0ᵇᶜ	2.788ᵃᵇ	12.10ᵇ	13.60ᵇ
IR 72	41.10ᵃ	16.0ᵇᶜ	2.573ᵃᵇ	8.90ᵃ	9.30ᵃ
Ptb 33	42.80ᵃᵇ	15.0ᵇ	2.855ᵃᵇ	9.60ᵃ	9.80ᵃ
TN 1	94.00ᶜ	11.0ᵃ	8.778ᶜ	18.60ᶜ	22.00ᶜ

* Mean of 4 replications.

In a column, means followed by a common alphabet are not significantly different at the 5% level by DMRT.

The egg hatchability of BPH was also significantly low in all the resistant accessions. It ranged from 49.00 to 61.60 per cent in resistant accessions and 96.20 percent in TN 1 (Table 3). The cumulative effect of the insect devloping on resistant accessions with unbalanced nutrients was reflected in poor oviposition rate on them. Consequently, nymphal emergence was also low on resistant accessions. It agrees with the earlier reports of Pathak *et al.* (1969) and Reddy and Kalode (1985).

Table 3. Rate of oviposition, egg hatchability, nymphal emergence and population build up of BPH* on rice accessions

Accession	Rate of oviposition (No. of eggs laid by 3 females)	Egg hatchability (%)	Nymphal emergence (No.)	Population (No.)
Ansphal	128.40[bc]	57.10[abcd] [49.09]	73.3[c]	37.00[cd]
TC 20/A	124.60[abc]	52.20[abc] [42.26]	65.0[b]	34.00[d]
Sonasali	116.80[ab]	50.80[ab] [45-46]	59.3[a]	36.75[cd]
Nagurjuna	132.50[c]	61.60[d] [51.73]	81.5[d]	46.25[bcd]
Chandan	149.00[d]	59.60[cd] [50.55]	89.3[e]	51.25[bc]
IR 72	127.60[bc]	49.00[a] [44.43]	62.5[ab]	55.50[b]
Ptb 33	112.60[a]	57.60[bcd] [49.38]	66.00[b]	40.00[cd]
TN 1	486.20[e]	96.20[e] [80.28]	472.5[f]	366.00[a]

* Mean of 4 replications.

Figures within parenthesis are arcsine transformed values.

In a column, means followed by a common alphabet are not significantly different at the 5% level by DMRT.

Low hatching of eggs of *N. lugens* was observed in resistant accessions. This is in consonance with that of Reddy and Kalode (1985).

Population build up of BPH

Population build up of BPH on resistant rice accessions was comparatively low than susceptible TN 1. Population build up ranged from 34.00 to 366.00 (Table 3) in different accessions. The accession TC 20/A recorded the minimum population (34.00) and susceptible TN 1 recorded the maximum (366.00). All the tested accessions were significantly superior to the susceptible TN 1. Differences in population increase between resistant and susceptible accessions were apparent due to the differences in insect's ovipositional preference, survival and nymphal development, food ingestion and metabolic utilisation on resistant and susceptible accessions.

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Quality management of irrigation water through native tree materials

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Abstract : Laboratory experiments were conducted to study the effect of amla tree dried lopping on the improvement of irrigation water quality. The irrigation water from three different sources, with varying water quality and distilled water as control was treated with amla *(Pyllanthus emblica)* tree dried lopping at four concentration levels viz., 0, 5, 10 and 15 percent. The study was conducted in FRBD with three replications. The results clearly indicated that treatment of amla tree dried lopping at varying concentrations on different irrigation water quality sources invariably decreased the pH and slightly increased the electrical conductivity. In the high RSC water used, treatment with amla at 5 per cent level decreased the pH from 9.1 to 7.1 within a day after treatment and stabilized to 6.5, but EC increased from 1.8 to 1.98 and stabilized to 2.14 after a week. In all the treatments, Na and K concentrations increased leading to slight increase in electrical conductivity. The treatment of alkali (high RSC) water with amla tree dried lopping improved the quality for irrigation. ***(Key words** : RSC, EC, pH, Amla tree dried loppings, Irrigation water, quality).*

Poor quality irrigation water is a major and ever present threat to permanence of irrigated agriculture. Unless the irrigation water is of good quality, productivity decreases, land value drops, and in severe cases, the land become unproductive because of the accumulation of soluble salts especially sodium. Well water forms an important source of irrigation in Tamil Nadu. Its quality is highly variable due to climatalogical and hydrogeological conditions prevailed. Regardless of source, some soluble salts are always present in irrigation water. The nature and extent of salts however depends upon the source of water and its course before use. Since water is the chief carrier of salts, salnity control and reclamation is essential for irrigation purposes. The water intended for irrigation must be free from excess soulble or tolerable level salts and specific chemicals that may be hazardous to soil with respective salinity, sodicity, alkalinity and toxicity as the same has been recognized all over the world.

Amla, native of tropical Asia, is a deciduous medium tree with small narrow leaves arranged in two opposite rows. It has the capability of with standing even under stress conditions. The wood contains about 20 per cent tannin which on hydrolysis produces gallic and ellagic acid with a small amount of glucose. (Sinha, 1993).

The poor quality irrigation water can be successfully utilized for irrigation without any adverse effect in the soil or crop by following some agronomic management practices *viz.*, using chemical amendments, growing salt tolerant crops or dilution with good quality water or controlled irrigation. In addition to the above, there are certain experiences from the farmers that quality of irrigation water can be improved by treating it with wood cuttings of amla for which no scientific evidences are available. Hence, an attempt is made with an objective to find out the change in chemical composition on different level of alkaline water over a period of time when treated with dried lopping of amla tree.

Materials and Methods

Laboratory experiments were conducted at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli during the month