Screening of Rice Genotypes for Leaf Folder, *Cnaphalocrocis medinalis* (Guenee) and Bacterial Leaf Blight, *Xanthomonas oryzae* pv. *oryzae* (Ishiyama) Dye

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Seventy-four genotypes of different maturity groups of rice were evaluated for identification of resistant sources against rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) under field and screenhouse conditions during 1999. Forty-seven genotypes in 1998 and 57 genotypes in 1999 were also assessed for resistance against bacterial leaf blight, *Xanthomonas oryzae* pv. *oryzae* (Ishiyama) Dye through clip inoculation technique. Only 4 genotypes, namely, HKR 95-130, PAU 2023-80-1-3, PAU 1920-100-2-1-3-3 and PAU 1973-121-1-2-2-1 were found consistently promising in different situations and better than resistant donors against leaf folder whereas 10 genotypes *viz.*, Ajaya, PAU 1920-100-2-1-3-3, PAU 1061-19-2-2, PAU 1973-121-1-2-1-1, PAU 2212-25-1-2, CR 837, HKR 95-131, HKR 95-128, HKR 95-129 and PAU 1966-77-22-1 exhibited resistance to bacterial leaf blight during both the years. However, only two genotypes *viz.*, PAU 1920-100-2-1-3-3 and PAU 1973-121-1-2-1-1 can be used as promising sources of multiple resistance against rice leaf folder and bacterial leaf blight in rice protection breeding programmes.

Key Words: Bacterial Leaf Blight, Rice Germplasm, Rice Leaf Folder

The rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) (Lepidoptera: Pyralidae) is distributed in humid tropical to temperate countries of Asia, Oceania and Africa and now it has become widespread throughout the rice growing regions of Asia (Khan *et al.*, 1988; Islam and Karim, 1997). Similarly, bacterial leaf blight caused by *Xanthomonas oryzae* pv. oryzae (Ishiyama) Dye, has become a major constraint of rice production in South-east Asia (Leach *et al.*, 1995; Raina *et al.*, 1999).

In early 1980s, effective insecticides were identified to control leaf folder (Heinrichs and Valencia, 1980). But insecticides besides being increasingly costly, were often applied too late to prevent severe leaf folder damage and also caused resurgence of *Nilaparvata lugens* (Stal) (Reissig *et al.*, 1982) and even leaf folder (Panda and Shi, 1989; Dakshayani *et al.*, 1983). So far, there is no successful chemical control for bacterial leaf blight (Raina *et al.*, 1999). Hence, host plant resistance is the best alternative to combat these pests. The studies on search for resistance to leaf folder (Velusamy *et al.*, 1973; Heinrichs, 1986; Ramachandran and Khan, 1991; Singh *et al.*, 1993; Mandal *et al.*, 1997) and bacterial leaf blight (Panwar *et al.*, 1988; Saini *et al.*, 1992; Sing and Dodan, 1995; Raina *et al.*, 1999) were conducted but little success has been reported on multiple resistance against these pests. Therefore, present investigations were aimed to identify sources of resistance against leaf folder under field as well as screenhouse conditions. Some promising genotypes were also assessed against bacterial leaf blight.

Materials and Methods

Plant Material

A wide range of rice germplasm was obtained from the Directorate of Rice Research, Rajendranagar, Hyderabad, India. Seventy-four genotypes of rice comprising different maturity groups (Table 2) were evaluated at CCS Haryana Agricultural University, Rice Research Station, Kaul (29°51'N latitude, 76°41'E longitude, elevation 241msl) both under field (natural pest infestation) and screenhouse (artificial infestation) conditions during 1998 and 1999.

Field Screening against Leaf Folder

Thirty-day-old seedlings of each entry were transplanted in two rows of 1m length at 10×10 cm spacing in July, 1999. After every 10 test entries, two resistant donors (TKM 6 and Ptb 33) and two susceptible checks (HKR 120 and IR 36) were transplanted. Recommended agronomic practices were followed to raise the crop except the application of pesticides. The observations on total and leaves damaged by leaf folder were recorded from 10 randomly selected hills of each genotypes in the month of October. Percent damaged leaves and damage rating were worked out for each genotype (IRRI, 1988). The adjusted damage rating (D) was calculated, as given below and the genotypes were compared on the basis of 0-9 scale (IRRI, 1988).

Mass Screening against Leaf Folder in Screenhouse

Initially, the insect was mass reared in screenhouse as suggested by Waldbauer and Marciano (1979). Earthen pots of 3 kg capacity (20 cm height and 17 cm diameter) were filled with soil and saturated with water two days before sowing the seeds. Twenty seeds of each entry were sown in individual pots and fertilizer was applied on soil test basis in 3 split doses *i.e.* before sowing, subsequently at 20 days interval. The thinning of seedlings was done twice *i.e.* 10 and 12 days after sowing to retain 5 plants in each pot for screening. Tillers were removed to retain only one tiller/plant. Pots were arranged in 3 sections randomly and each section was caged separately with nylon net (190x60x70 cm). In each cage liquid diet (10% sugar solution) soaked in cotton swabs was provided by hanging on bamboo sticks in each corner for feeding of adult moths. Four pairs of 3-day-old adults were released on 17-day-old seedlings in each cage to oviposit on the test plants. After 7 days, cotton swabs and nylon net were removed to provide adequate light to the plants. The test genotypes were evaluated for leaf damage at 21 days after infestation following Heinrichs *et al.* (1985a) and the standard evaluation system for rice (IRRI, 1988).

Retesting of Entries Found Promising in Mass Screenhouse Screening

The entries with a damage rating scale of 0-5 in mass screening along with resistant donors (TKM 6, Ptb 33, ASD 7, ARC 11128 and Darukasail) and susceptible checks (HKR 120 and IR 36) were re-assessed in a completely randomized design (CRD) with five replications, each pot represented one replication. In each replication additional tillers were removed and only 5 seedlings/ pot were maintained at the time of infestation. At 21 days after sowing each tiller was infested with two first-instar larvae. The pots were covered with nylon net. Seventeen days after larval infestation, the plants were evaluated on the basis of mean leaf damage rating (Heinrichs *et al.*, 1985a).

Screening against Bacterial Leaf Blight

The screening of 47 genotypes in 1998 and 57 genotypes in 1999 was carried out under artificial conditions. Thirty-day-old seedlings of each test entry were transplanted in two rows of 4 m long each. The plants were clip inoculated 45 days after transplanting with the bacterial suspension prepared by soaking pieces of infected leaves of TN-1 in water for 20 min (Jennings *et al.*, 1979) and the observations for disease incidence were recorded 14 days after inoculation (IRRI, 1988) The entries showing a disease score of 0-3, 5 and 7-9 were categorized as resistant, moderately resistant and susceptible, respectively. To measure overall severity of disease under test conditions, location severity index (L.S.I) was calculated as per the method of IRRI (1988).

$$\text{L.S.I.} = \frac{0(\text{NG})+1(\text{NG})+3(\text{NG})+5(\text{NG})+7(\text{NG})+9(\text{NG})}{\text{Total number of genotypes evaluated}}$$

Where 0-9: Disease score

NG: No. of genotypes under respective score

The L.S.I. was 6.4 and 6.3 during 1998 and 1999, respectively, indicating screening was carried under high disease incidence for identification of disease resistant genotypes.

Results and Discussion

Field Screening against Leaf Folder

Out of 71 genotypes evaluated under natural conditions against leaf folder, 14 exhibited less than 39.75 % damage rating and were considered as resistant with a damage score of 3 (Table 1). These included two previously identified resistant donors *viz.*, TKM 6 and Ptb 33. The minimum damage rating was recorded on IR 48725-B-B-103-2-3 followed by resistant check Ptb 33 and HKR 95-492. The range of damage rating in resistant genotypes varied from 23.42 to 39.75 %. Earlier workers (Nadarajan and Nair, 1983; Valusamy and Chelliah, 1985; Sundrababu and Rajendran, 1986) also assigned 3 damage score to TKM 6 and Ptb 33 under field conditions. However, Garg (1984) rated TKM 6 as moderately resistant with a score of 5.

But the extent of susceptibility increased when the genotypes were assessed under screenhouse conditions (Table 2). Among 74 genotypes evaluated only four *viz.*, HKR 95-130, PAU 2023-80-1-3, PAU 1920-100-2-1-3-3 and PAU 1973-121-1-2-1 could be designated as moderately resistant (score 5) and the rest were susceptible to highly susceptible. There was no genotype in the category of highly resistant or resistant group.

TKM 6, Ptb 33, ASD 7, ARC 11128 and Darukasail identified as resistant donors against leaf folder however, by earlier workers (Heinrichs *et al.*, 1985b; Joshi *et al.*, 1985; Rajendran *et al.*, 1986), these were found susceptible in screenhouse studies with a damage score of 7 to 9. This indicated the breakdown of resistance under no choice conditions. Besides, other plant factors and

Table 1. Evaluation of rice genotypes against rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) in field during 1999

Damage score* (0-9)	Damage rating (D)	Resistance rating	Genotype
0-1	-	HR	Nil
3	23.42-39.75	R	Early duration (100-110 days): BR 51-282-8-HR-45. Medium duration (130-140 days): PAU 2061-20-2-1, BRC 16-127-4-1, IR 48725-B-B=103-2-3 Long duration (140-150 days): HKR 95-401, HKR 95-407, HKR 95-412, HKR 95-479, HKR 95-492, HKR 95-499, Pusa Basmati-1, Haryana Basmati-1, TKM 6, Ptb 33.
5	41.32-58-64	MR	Medium duration (130-140 days): HKR 95-222, HKRH 1059, HKR 126, HKR 95-138, PAU 1920-100-2-1-3-3, PAU 1973-121-1-2-1-1. Medium early duration (115-125 days): HKR 95-131, HKR 95-130, PAU 2023-80-1-3, PAU 1966-77-22-1, PAU 2338-151-1. Long duration (140-150 days): Taraori Basmati.
7	62.62-79.90	S	Early duration (100-110 days): HKR 97-1, PAU 2017-56-1-3. Medium duration (130-140 days): HKR 95-173, IR 60821-34-1-2, HKR 95-72, HKR 95-20, PR 114, Tox 3133-59-1-2-4-1, HKR 95-123, HKR 95-124, PAU 1061-19-2-2, CR 837, HKR 120. Medium early duration (115-125 days): HKR 95-139, HKR 95-157, HKR 95-188, HKR 95-218, HKR 95-219, HKR-46, HKR-95-128 Long duration (140-150 days): HKR 95-410.
9	82.79-133.94	HS	Early duration (100-110 days): UPR 1230-9-2, AS 89044, PAU 2017-58-1-3, RP 2829-32546-1875, HKR 97-14, HKR 97-41, HKRH 1002, Govind, IR 36. Medium duration (130-140 days): PR 113, PAU 2338-151-1, HKR 95-239, Aaya, PAU 2212-25-1-2. Medium early duration (115-125 days): HKR 93-3, HKR 95-192, CT 9153-4-1-12-6-1, PK 2557-24-2-1, HKR 95-191, IR 64, HKR 95-129, HKR 95-66, MTU 11335. Long duration (140-150 days): HKR 95-465.

* Standard Evaluation System for Rice; HR = Highly resistant; R = Resistant; MR = Moderately resistant; S = Susceptible; HS = Highly susceptible

Table 2. Evaluation of rice genotypes against rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) in screen house

Damage score* (0-9)	Damage rating (D)	Resistance rating	Genotype
0-1	-	HR	Nil
3	-	R	Nil
5	39.04-43.68	MR	Medium duration (130-140 days): PAU 1920-100-2-1-3-3, PAU 1973-121-1-2-1-1. Medium early duration (115-125 days): HKR 95-130, PAU 2023-80-1-3.
7	50.98-73.32	S	Medium duration (130-140 days): PAU 1061-19-2-2, PAU 2016-20-2-1, IR 48725-B-B-103-2-3 Medium early duration (115-125 days): HKR 95-129, MTU 11335, PAU 1966-77-22-1. Long duration (140-150 days): Ptb 33.
9	81.72-100.00	HS	Early duration (100-110 days): UPR 1230-9-2, AS 89044, PAU 2017-58-1-3, RP 2829-32546-1875, HKR 97-1, HKR 97-14, HKR 97-41, HKRH 1002, Govind, PAU 2017-56-1-3, BR 51-282-8-HR-45, IR 36. Medium duration (130-140 days): PR 113, HKR 95-173, IR 60821-34-1-2, PAU 2338-151-1, HKR 95-72, HKR 95-20, HKR 95-222, PR 114, Tox 3133-59-1-2-4-1, HKR 95-239, HKR 95-123, HKR 95-124, HKRH 1059, HKR 126, Aaya, HKR 95-138, PAU 2212-25-1-2, CR 837, BRC 16-127-4-1, HRR 120. Medium early duration (115-125 days): HKR 93-3, HKR 95-131, HKR 95-192, CT9153-4-1-12-6-1, PK 2557-24-2-1, HKR 95-139, HKR 95-157, HKR 95-188, HKR 95-191, HKR 95-218, HKR 95-219, HKR 46, IR 64, HKR 95-128, HKR 95-66, PAU 2338-151-1 Long duration (140-150 days): HKR 93-401, HKR 95-407, HKR 95-410, HKR 95-412, HKR 95-465, HKR 95-479, HKR 95-492, HKR 95-499, Pusa Basmati-1, Haryana Basmati-I, Taraori Basmati, TKM 6, ASD 7, ARC 11128, Darukasail

* Standard Evaluation System for Rice; HR = Highly resistant; R = Resistant; MR = Moderately resistant; S = Susceptible; HS = Highly susceptible

environmental factors may also influence the behaviour of ovipositing females (Rajendran *et al.*, 1986). For confirmation, four promising genotypes selected from initial mass screening along with resistant donors were re-tested with two first instar larvae/tiller (Table 3). All the four genotypes that were found moderately resistant (5 damage score) in initial mass screening were found susceptible to leaf folder under no-choice conditions with a damage score of 7. Therefore, it may be concluded that rice genotypes respond differently when exposed to natural infestation conditions are artificial exposure to ovipositing females and larval stages. However, expression of resistance is further altered by prevailing environmental conditions (Rajendran *et al.*,

Table 3. Evaluation of rice genotypes (selected from initial mass screening) against *Cnaphalocrocis medinalis* (Guenee) in screen house**

Damage score* (0-9)	Damage rating (D)	Resistance rating	Genotype
0-1	-	HR	Nil
3	-	R	Nil
5	-	MR	Nil
7	51.65-71.23	S	Medium early duration (115-125 days): HKR 95-130, PAU 2023-80-1-3. Medium duration (130-140 days): PAU 1920-100-2-1-3-3-, PAU 1973-121-1-2-1-1 Resistant donors: Ptb 33, ASD 7, ARC 11128, TKM 6, Darukasail.
9	81.90-100.00	HS	Early duration (100-110 days): IR 36 Medium duration (130-140 days): HKR 120

* Standard Evaluation System for Rice

** Genotypes under re-testing infested with two Ist-instar larvae per tiller

1986). Stable sources of resistance will be those genotypes which perform better under different experimental situations. From the present studies, four genotypes *viz.*, PAU 2023-80-1-3, PAU 1920-100-2-1-3-3, PAU 1973-121-1-2-1-1 and HKR 95-130 were found consistently better than others and can be further used as sources of resistance against leaf folder.

Forty-seven genotypes in 1998 and 58 genotypes in 1999 were evaluated through inoculation against bacterial leaf blight (Table 4). Ten genotypes *viz.*, Ajaya,

Table 4. Evaluation of rice genotypes against bacterial leaf blight during 1998* and 1999**

Damage score* (0-9)	Resistance rating	Genotypes	
		1998	1999
0-1	HR	–	–
3	R	Medium duration (130-140 days): Ajaya, PAU 1920-100-2-1-3-3, PAU 1061-19-2-2, PAU 2061-20-2-1, PAU 1973-121-12-1-1, PAU 2212-25-1-2, CR 837	Medium duration (130-140 days): PR 114, Ajaa, PAU 1920-100-2-1-3-3, PAU 1061-19-2-2, PAU 1973-121-1-2-1-1, PAU 2212-25-1-2, CR 837
		Medium early duration (115-125 days): HKR 95-131, HKR 95-128, HKR 95-129, HKR 95-130, PAU 2023-80-1-3, PAU 1966-77-22-1	Medium early duration (115-125 days): HKR 95-131, HKR 95-128, HKR 95-129, PAU 1966-77-22-1
5	MR	Long duration (140-150 days): HKR 95-492.	Early duration (100-110 days): PAU 2017-58-1-3
			Medium duration (130-140 days): HKR 95-239, HKR 95-124, PAU 2061-20-2-1.
			Medium early duration (115-125 days): HKR 95-130, PAU 2023-8-0-1-3
7	S	Early duration (100-110 days): UPR 1230-9-2, Govind	Early duration (100-110 days): UPR 1230-9-2, AS 89044, RP 2829-32546-1875, HKR 97-14, HKR 97-41, HKRH 1002, Govind.
		Medium duration (130-140 days): PR 113, HKR 95-173, IR 60821-34-1-2, PAU 2338-151-1, HKR 95-20, HKR 95-123, HKR 95-124, HKR 126, HKR 95-138, HKR 120.	Medium duration (130-140 days): PR 113, HKR 95-173, IR 60821-34-1-2, PAU 2338-151-2, HKR 95-72, HKR 95-20, HKR 95-123, HKRH 1059, HKR 126, HKR 95-138, HKR 120.
		Medium early duration: (115-125 days) HKR 95-188, HKR 95-191, HKR 95-218, HKR 95-219, PAU 2338-151-1	Medium early duration (115-125 days): HKR 93-3, HKR 95-192, PK 2557-24-2-1, HKR 95-157, HKR 95-188, HKR 95-191, HKR 46, IR 64, PAU 2338-151-1.
		Long duration (140-150 days): HKR 95-407, HKR 95-465, Taraori Basmati	Long duration (140-150 days): HKR 95-407, HKR 95-410, HKR 95-465, HKR 95-479, HKR 95-492, HKR 95-499, Haryana Basmati, Taraori Basmati
			Early duration (110-111 days): HKR 97-1
9	HS	Medium duration (130-140 days): HKR 95-72, HKR 95-222, HKRH 1059	Medium duration (130-140 days): HKR 95-222
		Medium early duration (115-125 days): HKR 93-3, HKR 95-192, PK 2557-24-2-1, HKR 46, IR 64, HKR 95-66	Medium early duration (115-125 days): HKR 95-218, HKR 95-219
		Long duration (140-150 days): HKR 95-410, HKR 95-479, Pusa Basmati-I, Haryana Basmati	Long duration (140-150 days): HKR 93-401, Pusa Basmati-II

* Forty-seven genotypes were evaluated in 1998 from the list given in Table 1.

** Fifty-eight genotypes were evaluated during 1999 from the list given in Table 1.

PAU 1920-100-2-1-3-3, PAU 1061-19-2-2, PAU 1973-121-1-2-1-1, PAU 2212-25-1-2, CR 837, HKR 95-131, HKR 95-128, HKR 95-129 and PAU 1966-77-22-1 exhibited resistance with damage score of 3 in both the years. Partial resistance in rice genotypes against bacterial leaf blight has also been reported earlier (Saini *et al.*, 1992; Singh and Dodan, 1995; Raina *et al.*, 1999). It is worth mentioning that two genotypes *viz.*, PAU 1973-121-1-2-1-1 and PAU 1920-100-2-1-3-3 were found consistently resistant against both leaf folder and bacterial leaf blight and thus can prove as a good source for multiple resistance and fit in present day integrated pest management programme of rice.

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