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Evaluation of Rice Cultivars for Resistance to *Cnaphalocrocis medinalis* Guenée (Lepidoptera: Pyralidae)

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Abstract

Greenhouse screening of 17,914 accessions of rice, *Oryza sativa* L., from 62 countries identified 115 accessions from 10 countries having resistant or moderately resistant reactions to *Cnaphalocrocis medinalis* Guenée. Of 264 wild rices (*Oryza* spp.) screened, 10 (3.7%) were resistant. Several breeding lines having "Ptb33" and "W1263" as donor parents were moderately resistant. All of the resistant accessions are from regions where *C. medinalis* is an important pest, except for one accession from Italy, which is beyond the range of *C. medinalis* distribution.

Cnaphalocrocis medinalis (Guenée) has in the last decade become a major threat to rice production in tropical and subtropical Asia. Severe outbreaks were common in North Vietnam in 1981, and in the 1983 crop season, *C. medinalis* infestations were common in China, where it was considered to be the second most important insect pest, next to a planthopper, *Nilaparvata lugens* (Stål) (E. A. Heinrichs, personal observation). Outbreaks of this pest have in recent years been reported from India (Chatterjee 1979), Malaysia (Ooi 1977), and Japan (Wada 1981).

C. medinalis larvae feeding within folded rice leaves remove the green tissue. Bautista et al. (1984) have shown that 1.5 larvae per plant or 4% damaged leaves reduce yield of variety "IR36" by 200 kg/ha and are considered as the economic injury levels. Populations that cause more than 4% damaged leaves are common in Asia. Unfortunately, nitrogen fertilizer, which greatly contributes to the high yield produced by modern rice varieties, also influences the degree of *C. medinalis* infestation. In studies in Thailand (Chantaraprapha et al. 1980) damaged leaves increased from 5% at 0 kg to 34% at 120 kg N, and 64% at 195 kg N/ha.

Because of the economic importance of the leaffolder, control tactics are under development at the International Rice Research Institute and in national rice research programs. Effective insecticides have been identified (Heinrichs and Valencia 1980), and chemical control is the commonly used control tactic. However, insecticides are becoming increasingly costly, are often applied too late to prevent severe leaffolder damage, and may cause *N. lugens* resurgence (Reissig et al. 1982).

The breeding of leaffolder-resistant varieties is considered a practical means of controlling this pest in Asia. Field evaluation to identify resistant donors to be used as parents in the breeding program has been conducted in China (Peng 1982), India (Nadarajan and Nair 1983), and at the International Rice Research Institute (IRRI) (Gonzalez 1974). Because of the unpredictability of field populations, a rearing method was developed at IRRI (Waldbauer and Marciano 1979) so screening could be conducted in the greenhouse. This paper reports on the results of greenhouse screening of rice accessions from the IRRI germplasm collection for resistance to *C. medinalis*.

Materials and Methods

Rearing C. medinalis

A modification of the rearing method developed by Waldbauer and Marciano (1979) was used (Fig. 1). To start the culture, moths were collected on the IRRI farm. Once the culture was started, the routine illustrated in Figure 1 was followed. To maintain the culture, 12 female and 13 male moths were placed in an oviposition cage containing one potted plant on Thursday. A 25% honey solution in cotton was added to serve as a source of sugar for the moths. On Friday the potted plants were removed from the oviposition cage. The leaf portions containing the eggs were clipped and placed on moist filter paper in a petri dish. These eggs were used to maintain the culture. Eggs were maintained in the petri dish for 4 days until hatching occurred. They then were infested on 21-day-old seedlings in a seed box that was covered with a fiberglass screen cage (A-cage). At 26 to 29 days after infestation, adult emergence occurred and the adults were placed in the oviposition cage.

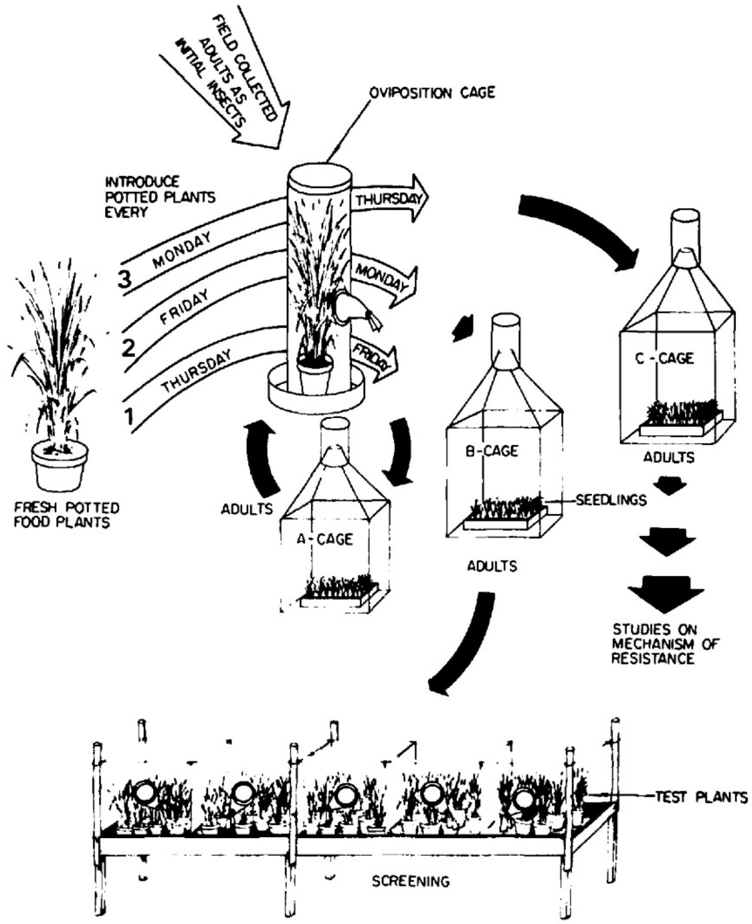

Figure 1. Procedure followed for the rearing of *C. medinalis* for studies on resistance.

The same procedure was used to provide larvae for screening. Eggs removed from the oviposition cage on Monday were placed in petri dishes and hatching larvae transferred to B-cages and reared to the adult stage to be used in the screening program.

Screening for Resistance

Seeds of the test entries were obtained from the IRRI germ plasm collection and Plant Breeding Department. A total of 19,034 entries was screened. The entries consisted of 17,914 *Oryza sativa* L. accessions from the germplasm collection which are primarily traditional varieties, 264 wild rices, *Oryza* spp., 171 *O. glaberrima* accessions, 53 varieties received from C. M. Smith of Louisiana State University, 632 IRRI breeding lines and the IR varieties "IR5" to "IR60," which have been commercially released in the Philippines.

Ten seeds of each entry were sown in a 12-cm-diameter clay pot. Potted plants were maintained in a galvanized iron tray containing water. Fifteen days after sowing, the plants were thinned to five per pot. Tillers were removed, leaving one tiller per plant.

The iron tray was divided into five sections (Fig. 1), each section consisting of 118 pots with test entries and one pot of a susceptible ("IR36") and a resistant ("TKM6") check. Each section was covered with a fiberglass screen cage. Each cage contained four feeding devices consisting of 25% honey solution in cotton maintained in a dish on a bamboo stick. Ten pairs (male and female) of adults were placed into each cage through a sleeve on the side and allowed to oviposit on the plants. Seven days after moth infestation, honey feeders were removed and within 3 days all moths were dead. Cages then were removed to increase the amount of light for plant growth.

Twenty-one days after moth infestation the pots were removed from the tray and extent of damage on each leaf determined.

A damage grade was determined based on the extent of leaf damage: 0, no damage; 1, up to 1/3 of leaf area scraped; 2, 1/3 to 1/2 of leaf area scraped; 3, more than 1/2 of leaf area scraped.

Based on the number of leaves with each damage grade, the following computation was made for each replication.

$$\text{rating \%} = \frac{\begin{pmatrix}\text{No. leaves with}\\ \text{a damage grade}\\ \text{of } 1\times 100\end{pmatrix}1}{\text{Total no. leaves examined}} \times \frac{\begin{pmatrix}\text{No. leaves with}\\ \text{a damage grade}\\ \text{of } 2\times 100\end{pmatrix}2}{\text{Total no. leaves examined}} \times \frac{\begin{pmatrix}\text{No. leaves with}\\ \text{a damage grade}\\ \text{of } 3\times 100\end{pmatrix}3}{\text{Total no. leaves examined}} \div 6$$

Next, the rating for each replication of the test entry was adjusted for extent of damage in the corresponding replication of the susceptible check:

$$\text{adjusted damage rating } (D) = \frac{\text{rating of test entry}}{\text{rating of susceptible check}} \times 100$$

The adjusted damage rating (*D*) was converted to a scale as follows:

D (%)	Scale
0	0
1–10	1
11–30	3
31–50	5
51–75	7
75	9

The scales of all replications for a given accession were averaged, and entries with a mean scale of 0 to 3 were considered resistant; 5, moderately resistant; and 7 to 9, susceptible.

In initial screening, entries were not replicated. Those entries having a rating of 0 to 5 were retested in 10 replications, each pot consisting of one replicate. Treatments were arranged in a randomized complete block design. Plants and tillers were thinned to five per pot 21 days after sowing, and two first-instar larvae were placed on each tiller with the aid of a camel's-hair brush. Seventeen days after larval infestation the plants were evaluated for damage and damage ratings determined for each replication as previously described.

Final damage ratings were based on the mean of the 10 replications. Mean damage ratings of the susceptible check "IR36," and each test entry accession were compared using the least significant difference (LSD) test (Gomez and Gomez 1984). All accessions rated as resistant or moderately resistant had a significantly lower damage rating than the susceptible check ($P < 0.01$).

Results

Of the 17,914 accessions from the germ plasm collection screened, 35 (0.20%) were resistant (Table 1) and 80 (0.45%) moderately resistant. Four accessions, "Darukasail" (Acc. 45493) and "Choorapundy" (Acc. 49529) from India and "Balam" (Acc. 49020) and "Gora" (Acc. 49086) from Bangladesh were most resistant, having ratings of 1. The selected accessions come from 10 countries: Bangladesh, China (People's Republic and Taiwan), India, Indonesia, Italy, Malaysia, Philippines, Sri Lanka, and Thailand (Table 2). Most of the accessions screened (8,297) were from India, and most of the selected accessions (60) were also from India. Sixteen accessions from Bangladesh were selected as resistant or moderately resistant.

Table 1. List of IRRI germ plasm collection accessions found to be resistant to *C. medinalis*

IRRI acc. no.	Cultivar name	Origin	Rating
237	"TKM6"	India	3
5909	"GEB24"	India	3
6041	"CO 7"	India	3
15327	"Muthumanikam"	Sri Lanka	3
19325	"Ptb33"	India	3
21166	"ARC10982"	India	3
36408	"Yakadayan"	Sri Lanka	3
39433	"IR5865-26-1"	Philippines	3
39558	"BR1l6-3B-19"	Bangladesh	3
45493	"Darukasail"	India	1
46020	"Kamalbhog"	India	3
46048	"Karpurkanti"	India	3
46077	"Kataribhog"	India	3
46671	"Shete"	India	3
47166	"Calixto"	Philippines	3
47774	"Khao Gaw Diaw"	Thailand	3
47852	"Khao Mah Khaek"	Thailand	3
48069	"Khao Rad"	Thailand	3
48078	"Khao Sa Ahd"	Thailand	3
49020	"Balam"	Bangladesh	1
49081	"Dolachikon"	Bangladesh	3
49086	"Gora"	Bangladesh	1
49088	"Gorsa"	Bangladesh	3
49099	"Kalachikon"	Bangladesh	3

Table 1. *continued*

IRRI acc. no.	Cultivar name	Origin	Rating
49154	"Biron"	Bangladesh	3
49157	"Bora"	Bangladesh	3
49175	"Coti"	Bangladesh	3
49235	"Madhu-Madub"	Bangladesh	3
49378	"Anaikomban CO. 4BK"	India	3
49456	"Bir-Me-Fen"	China (Taiwan)	3
49529	"Choorapundy"	India	1
50332	"Cygalon"	Italy	3
50362	"Kaohsiung Sen Yu 169"	China (Taiwan)	3
51275	"Ching-Gan-Tsan"	China	3
54440	"Hema"	Malaysia	3

Table 2. Country of origin and percentage of resistant or moderately resistant accessions of the IRRI germplasm collection

Origin	No. accessions evaluated	Resistant or moderately resistant	
		No.	%
Afghanistan	32	0	0
Africa	12	0	0
Argentina	15	0	0
Australia	3	0	0
Bangladesh	665	16	2.41
Brazil	245	0	0
Bulgaria	11	0	0
Burma	448	0	0
Cameroon	1	0	0
Central America	1	0	0
Chad (Tshad)	2	0	0
Chile	3	0	0
China	1,480	2	0.14
China (Taiwan)	108	2	1.85
Colombia	31	0	0
Costa Rica	4	0	0
Cuba	108	0	0
Dominican Republic	1	0	0
Ecuador	34	0	0
Egypt	4	0	0
El Salvador	1	0	0
France	13	0	0
Gambia	9	0	0
Guinea-Bissau (Portuguese Guinea)	31	0	0
Guinea-Conakry (French Guinea)	166	0	0
Guatemala	1	0	0

Table 2. *Continued*

Origin	No. accessions evaluated	Resistant or moderately resistant	
		No.	%
Guyana (British Guiana)	4	0	0
Holland	4	0	0
Hungary	10	0	0
India	8,297	60	0.75
Indonesia	821	6	0.73
Iran	10	0	0
Iraq	6	0	0
Italy	35	1	2.86
Ivory Coast	461	0	0
Japan	162	0	0
Kenya	19	0	0
Korea (North and South)	332	0	0
Laos	14	0	0
Liberia	6	0	0
Malagasy (Madagascar)	30	0	0
Malaysia	238	3	1.26
Mexico	23	0	0
Mozambique	5	0	0
Nepal	336	0	0
Nigeria	9	0	0
Pakistan	26	0	0
Papua New Guinea	2	0	0
Peru	20	0	0
Philippines	996	3	0.30
Portugal	12	0	0
Senegal	207	0	0
Sierra Leone	219	0	0
Spain	12	0	0
Sri Lanka	387	10	2.58
Sudan	4	0	0
Surinam	29	0	0
Tanzania (former Tanganyika)	40	0	0
Thailand	1,036	12	1.16
United States	117	0	0
USSR	209	0	0
Vietnam	175	0	0
West Africa	19	0	0
Zambia	14	0	0
Origin unknown	139	0	0
Total	17,914	115	0.64

The IRRI collection of wild rices consists of about 1,000 accessions. Eight of the 257 accessions screened were resistant, and three were moderately resistant (Table 3). An *O. sativa* × *O. rufipogon* Griffith cross from Taiwan, four accessions of *O. brachyantha* Chev. et Roehr from Sierra Leone, and one from Guinea, had ratings of 1. Only one of the 171 *O. glaberrima* Steudel accessions from West Africa was resistant (Table 3).

Table 3. List of wild rices and *O. glaberrima* resistant or moderately resistant to the rice leaffolder

Acc. no.	Variety name	Origin	Rating
100581	*O. sativa* × *O. rufipogon*	Taiwan, China	1
100115	*O. brachyantha*	Guinea	1
100197	*O. nivara* Sharma et Shastry	Burma	5
101231	*O. brachyantha*	Sierra Leone	1
101232	*O. brachyantha*	Sierra Leone	1
101233	*O. brachyantha*	Sierra Leone	1
101234	*O. brachyantha*	Sierra Leone	1
101236	*O. brachyantha*	Mali Republic	3
101970	*O. rufipogon*	India	5
102188	Natural hybrid of *O. perennis* (Moench)	India	5
103622	*O. glaberrima* "Diako Mango"	Mali Republic	3

None of the varieties from the United States were resistant. Only four of the 632 breeding lines were resistant. All were from cross IR18815 (Utri Rajapan/IR46). Five lines having "Ptb33" as a parent (Ptb33/IR30//IR42 and Ptb33/IR30//IR2863) and two lines having "W1263" as a parent (W1263/IR36//IR36) were moderately resistant.

Discussion

The level of resistance in some of the selected accessions is sufficiently high to warrant their use as donors in breeding for resistance to *C. medinalis*. Some have already been used by IRRI breeders in the hybridization program. Several of the *C. medinalis*-resistant accessions also have resistance to other major rice insect pests. "TKM6" is resistant to the striped stem borer, *Chilo suppressalis* (Walker) and has a gene for *N. lugens* resistance. "GEB24" is resistant to the yellow stem borer, *Scirpophaga incertulas* (Walker). Among the accessions with moderate resistance to *C. medinalis*, "ASD7" (Acc. 6303) is resistant to *N. lugens* and the green leafhopper, *Nephotettix virescens* (Distant), and "W1263" (Ace. 11057) is resistant to the gall midge, *Orseolia oryzae* (Wood-Mason), and *S. incertulas*, "Ptb33" is one of the few varieties that is highly resistant to *lugens* in all countries throughout Asia (IRRI 1982).

The wild rices that are resistant to *C. medinalis* have multiple resistance to several insects (E. A. Heinrichs, unpublished data), For example, *O. brachyantha* (Acc. 101236) is resistant to *N. lugens* biotypes 1, 2, and 3, the whitebacked planthopper, *Sogatella furcifera* (Horvath), *S. incertulas*, the whorl maggot, *Hydrellia philippina* Ferino, the zigzag leafhopper, *Recilia dorsalis* (Motschulsky), and moderately resistant to *N. virescens*.

All except one of the resistant *O. sativa* accessions originate from regions of south and southeast Asia where *C. medinalis* is a serious pest. These accessions have possibly been selected by farmers for *C. medinalis* resistance and other traits over thousands of years. Only accession 50332, "Cygalon" from Italy, is from a country where *C. medinalis* does not occur. The wild rices, *O. brachyantha*, are from West Africa, which is beyond the distribution of *C. medinalis*. However, screening of the wild rice accessions against other insects at IRRI has indicated that many have allopatric resistance (E. A. Heinrichs, unpublished data). Only 3.8% of the wild rices and 0.6% of the *O. glaberrima* accessions were resistant. This is in contrast to studies on the hoppers, *N. virescens* and *N. lugens*, where about 50% of these same accessions are resistant (E. A. Heinrichs, unpublished data).

Although the moderately resistant lines having "Ptb33" and "W1263" as parents were not specifically bred for resistance to *medinalis*, the presence of resistance in these lines suggests that *C. medinalis* resistance can be transferred from a resistant parent to its progeny. As a result of these tests, breeders will begin a breeding program for *C. medinalis* resistance in which "TKM6," "GEB24," "W1263," "Muthumanikam" and "Ptb33" will be used as donors. Although wild rices are highly resistant to *C. medinalis*, *O. brachyantha* is of a different genome than *O. sativa* and cannot be crossed using conventional breeding techniques. However, with the development of innovative breeding techniques these accessions may be useful in the breeding program. In the meantime there is sufficient resistance in *O. sativa* to develop varieties that can be expected to have levels of resistance, which when combined with other control tactics can play an important role in the integrated control of *C. medinalis* on rice. Studies to determine the mechanisms involved in resistance to *C. medinalis* are currently being conducted.

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