AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

BIBLIOGRAPHIC INPUT SHEET

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1. SUBJECT CLASSIFICATION

A. PRIMARY: Food production and nutrition — AF00-0150-0000

B. SECONDARY: Plant production--Rice

2. TITLE AND SUBTITLE

Rice leaf folder: mass rearing and a proposal for screening for varietal resistance in the greenhouse

3. AUTHOR(S)

Waldbauer, G. P.; Mercado, A. P.

4. DOCUMENT DATE: 1979

5. NUMBER OF PAGES: 18p.

6. ARC NUMBER: ARC 633.18.W157

7. REFERENCE ORGANIZATION NAME AND ADDRESS

IRRI

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)

(In IRRI res. paper ser. no. 27)

9. ABSTRACT

10. CONTROL NUMBER: PN-AAG-695

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Rice
Varieties
Insect control
Larvae

13. PROJECT NUMBER

14. CONTRACT NUMBER: AID/La-G-1074 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

IRRI RESEARCH PAPER SERIES
Number 27 March 1979

RICE LEAF FOLDER: MASS REARING AND A PROPOSAL FOR SCREENING FOR VARIETAL RESISTANCE IN THE GREENHOUSE

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PN-AAG-C.9

RICE LEAF FOLDER: MASS REARING AND A PROPOSAL FOR SCREENING FOR VARIETAL RESISTANCE IN THE GREENHOUSE[1]

ABSTRACT

A method for the mass rearing of the rice leaf folder in the greenhouse on potted rice plants is described. Eighty-four hours of labor is sufficient to produce about 15,000 first-instar larvae per week. This should be sufficient to maintain the leaf folder culture and to screen for varietal resistance at least 250 varieties/week.

A method is proposed for screening for varietal resistance based on the artificial infestation of rice plants grown in pots in the greenhouse. It involves: infesting the plants with newly hatched first-instar larvae in the greenhouse, scoring the plants for resistance when the larvae are nearly full grown, and estimating their level of resistance by comparing the scores with those of tested susceptible and resistant check varieties.

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[1]By G. P. Waldbauer, visiting scientist, University of Illinois, USA, and A.P. Marciano, research assistant, Entomology Department, The International Rice Research Institute, Los Baños, Laguna, Philippines. Submitted to the IRRI Research Paper Series Committee, January 1979.

RICE LEAF FOLDER: MASS REARING AND A PROPOSAL FOR SCREENING FOR VARIETAL RESISTANCE IN THE GREENHOUSE

Numerous authors (e.g. Dorge et al 1971, Velusamy and Subramaniam 1974, Chandramohan and Jayaraj 1977) have observed that the rice leaf folder (*Cnaphalocrocis medinalis* Guenee) (Lepidoptera: Pyralidae) was formerly a minor pest, but has become increasingly abundant since the introduction of the high-yielding rice varieties. The rice leaf folder is widely distributed in the rice growing areas of the eastern hemisphere except for Europe and Africa (Sakai et al 1942, Gonzales 1974).

Relatively little is known about the biology of this pest. Among the more useful works on it are those of Sakai et al (1942), Lingappa (1972), and Gonzales (1974).

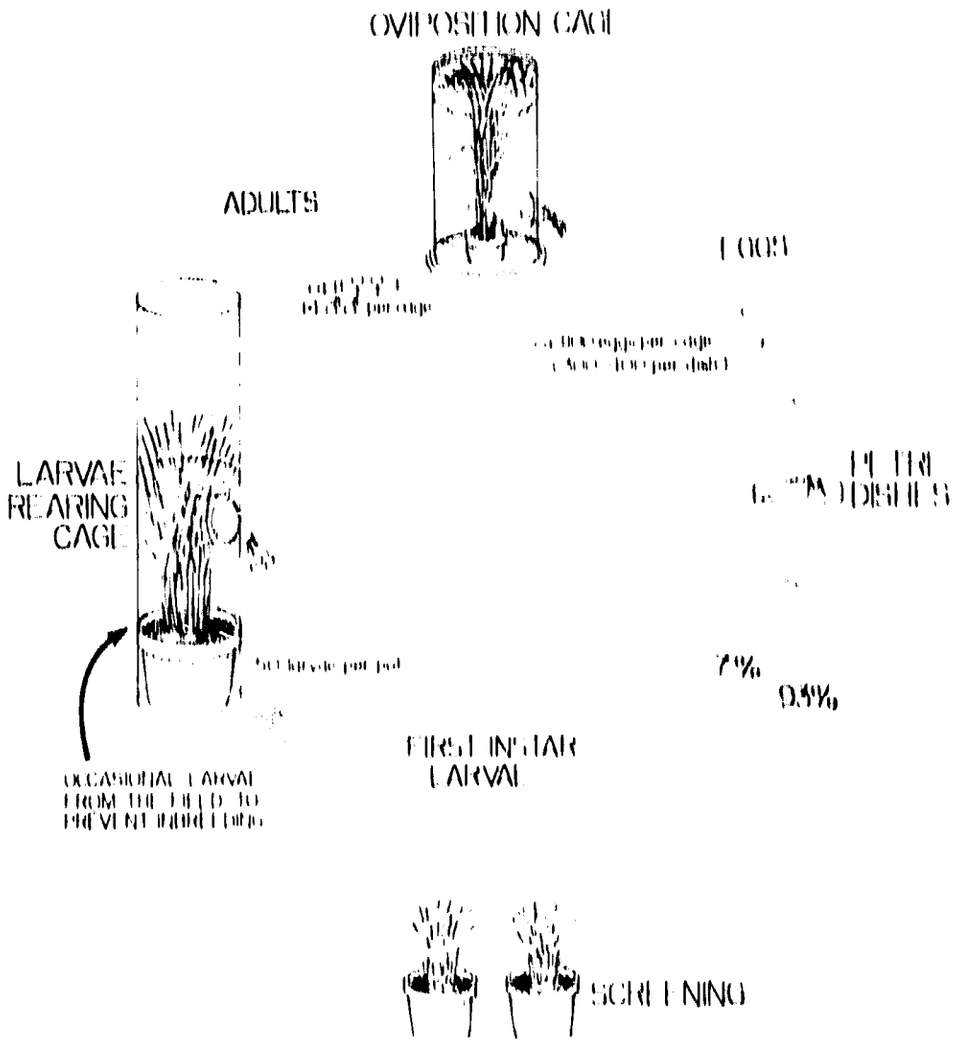
Because of the increasing destructiveness of the rice leaf folder and its wide distribution in rice-growing areas, rice varieties resistant to the insect should be developed. A first step in a method of rapid preliminary screening of the more than 44,000 varieties in the world rice germplasm collection. Screening them in the field at IRRI, or at any other research stations, is not practical because sufficiently large rice leaf folder populations occur only sporadically and seasonally.

We developed a method for mass rearing the rice leaf folder and for screening large numbers of varieties for leaf folder resistance in the greenhouse. We reared the insects on rice plants growing in pots rather than on an artificial diet because in the tropics, at least for laboratory and insectary use, rice plants are available throughout the year. Furthermore, screening should be done with insects that are as similar as possible to the wild insect population. Diet-reared insects are sometimes dwarfed or unhealthy and may differ significantly from wild insects in their choice of food plants. The larvae of the tobacco hornworm, for example, lose their host plant specificity when reared on an artificial diet (Schoonhoven 1967, Yamamoto 1974).

MASS REARING OF RICE LEAF FOLDER

The rearing method we developed at IRRI has four basic steps (Fig. 1):

- larvae were reared in a greenhouse on potted rice plants covered with mesh sleeves,



1. Procedure for rearing rice leaf folder and its relationship to varietal screening. The procedure starts with introduction of larvae from the field.

- Newly emerged adults were transferred from the sleeves to plastic oviposition cages that contain a pot of rice plants and a honey feeder. The cages were kept in an air-conditioned laboratory or in the shade in a screened and roofed insectary. We designed two types of oviposition cage, one for dry conditions and another for humid conditions.

- Eggs were collected daily and placed in petri dishes on moist filter paper.

- Newly hatched larvae were transferred daily from the petri dishes to the sleeved potted plants mentioned in the first step.

Rearing of larvae

The culture was first started with partly grown larvae from the field. Thereafter newly hatched larvae were placed on about 60-day-old-plants of CR94-13. We used this variety because it is susceptible to the rice leaf folder and resistant to the brown planthopper that sometimes infests screenhouses and greenhouses. Other varieties susceptible to leaf folder can be used. Our plants were grown in earthenware pots 28 cm tall with a 30-cm diameter top. Each pot held 30 plants and gave about 125 tillers. The pots stood in about 13 cm of water in a metal tray in the greenhouse.

The newly hatched first instars were transferred singly with a fine pointed, wet camel's hair brush. We also found that bits of leaf to which larvae clung could be wedged in the axils of the plants with forceps. We transferred larvae without the aid of magnification.

A cylindrical frame (140 cm tall and 34 cm in diameter) of heavy wire was placed over each infested pot to support a nylon mesh sleeve of similar dimensions. The sleeves may be shorter; we used 140 cm sleeves from a previous project. The open bottom of each sleeve extended below the water surface to prevent insect escape. Access into the sleeve was through a side sleeve of the same material (19 cm in diameter and 43 cm long), which was attached 80 cm from the bottom (Fig. 2). The side sleeve was tied shut when not in use.

2. An open vial is used to catch newly emerged adults in a sleeve covered pot of rice on which rice leaf folder larvae are reared.

Each pot supported the complete development of at least 50 larvae. As many as 75 larvae can be raised in one sleeve if additional plants in small pots are introduced as needed, beginning about 14 days after infestation.

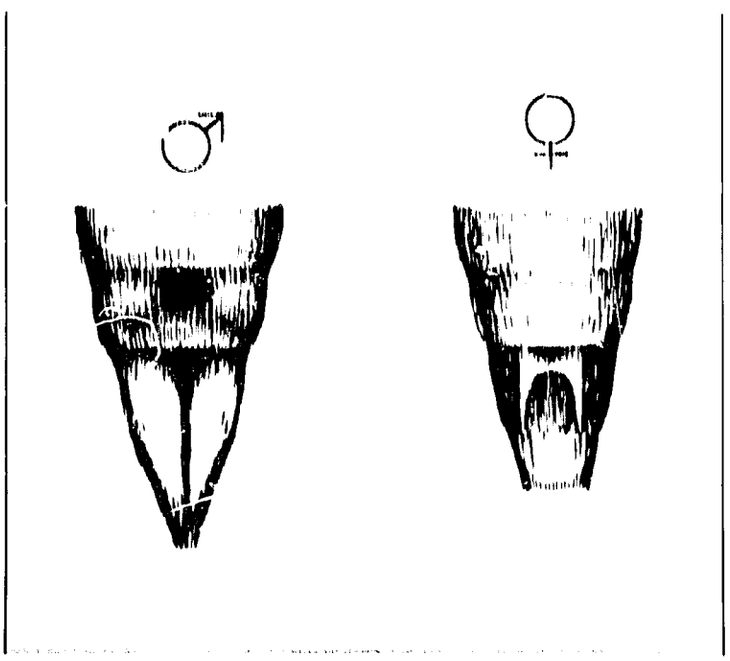
Because inbreeding and selection for survival in the sleeves will produce a strain that is not typical of the wild population, we frequently collected larvae from the field and introduced them into the culture.

Handling of adults

Pupation occurred and adults emerged on plants in the sleeves 22-13 days after infestation (mean median emergence date = 26.8 days) at ambient temperatures that ranged from a mean daily high of about 31°C to a mean daily low of about 25°C. Survival from the first instar to the adult in 22 sleeves ranged from 78.6-97.5% and averaged 87%.

Every morning we caught the adults that emerged the previous night by placing the opening of a large vial over them (Fig. 2). To minimize injury no more than 5 adults were caught and held in one vial.

The moths were sexed and sorted without removing them from the vials. The sexes were easily distinguished by the shape -- blunt in the female and pointed in the male -- and the dorsal color pattern of the terminal abdominal segments (Fig. 3). In



3. Abdominal terminalia of the male and female rice leaf folder.

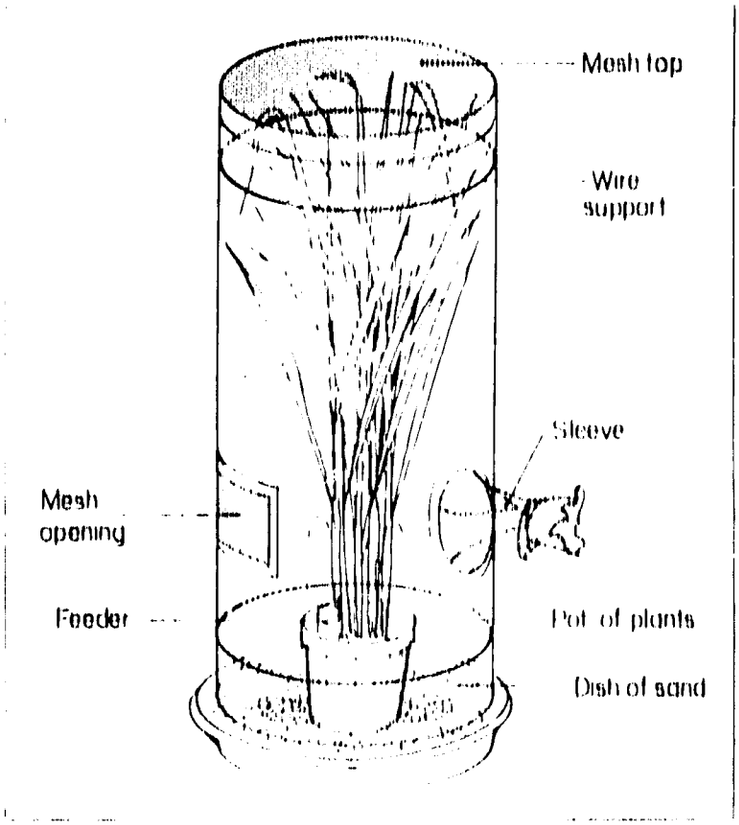
Table 1. Initial number of male (♂) and female (♀) rice leaf folder adults placed in each oviposition cage, their mortality during the 7-day oviposition period, and mean number of eggs laid per initial female. IRRI, 1978.

Laboratory						Innoetary					
	Initial no. moths		No. dying		Mean no.		Initial no. moths		No. dying		Mean no.
Cage no.	♀♀	♂♂	♀♀	♂♂	eggs/♀	Cage no.	♀♀	♂♂	♀♀	♂♂	eggs/♀
1	14	10	3	5	108.1	1	12	12	0	1	152.4
2	8	9	3	1	88.9	2	11	14	0	4	22.4
3	8	10	4	4	90.2	3	10	10	1	0	176.3
4	5	4	0	1	27.4	4	11	13	1	3	131.9
5	5	9	2	6	76.2	5	11	10	7	4	119.8
6	11	15	1	3	147.8	6	14	12	1	0	78.2
7	12	9	1	5	133.6	7	9	9	1	0	114.8
8	13	12	1	6	89.6	8	10	11	4	2	174.6
9	13	12	5	6	62.8	9	10	10	1	3	180.3
10	12	13	1	5	88.0	10	10	10	1	1	124.8
11	12	13	0	3	139.1	11	10	13	0	1	55.6
12	12	13	2	1	136.9	12	12	13	2	0	235.2
-	-	-	-	-	-	13	11	13	1	0	176.5
Total	125	129	23	46			141	155	20	19	
Mean					104.3						133.7

addition, the tuft of setae on the basal tarsomere of the male's front leg is much denser and darker than the female's.

The vials containing sexed moths of the same age were sorted to form groups of from 20 to 25 moths with about a 1:1 sex ratio, with whenever possible, an excess of from 1 to 3 males to make up for the higher mortality of the males (Table 1). Each group was then released in a separate oviposition cage.

Rice leaf folder adults apparently require high relative humidity (RH). Ten adults placed at 55% RH in an air-conditioned laboratory died overnight. Therefore, we designed two styles of oviposition cage, a relatively closed, moisture-conserving cage for use in dry areas (50-65% RH in the IRRI laboratory) and a more open cage (Fig. 4) with extensive areas of mesh for use in humid areas (90% RH or more in IRRI's innoetary during the wet season). Potted plants in the cages were a source of considerable moisture.



4. Oviposition cage used in rearing rice leaf folder. This is the model recommended for use in humid conditions.

Both types of oviposition cages are essentially cylinders of stiff mylar plastic (N.A. Lim Commercial, EDSA, Pasay City, R.P.) 65 cm tall and 27 cm in diameter. They are reinforced with two heavy-gauge wire rings. Access into either cage is through a sleeve 14.5 cm in diameter and at least 26 cm long, which is set 10 cm from the bottom. When not in use the sleeve is closed with an elastic band. Both styles of cages are open at the bottom and are closed by pressing the bottom into an earthenware dish (5 cm high, 30 cm in diameter) almost full of sand. The moths tend to fly to and rest on the side of the cage toward the light; it is, therefore, advisable to place the cages so that the sleeves face away from the source of light. Moths are released into the cage through the sleeve and plants and feeders (see below) are put in and taken out through the sleeve.

The oviposition cages were easy and inexpensive to build. The cylindrical wall was formed by rolling the plastic and gluing the overlapping edges together with strong cement. The wire reinforcers were held in place by the same kind of cement. The sleeve and the roof were attached with masking tape or, for more permanency, with waterproof tape.

The cage for dry areas was designed to conserve moisture by greatly restricting the air circulation. It has a top of flexible plastic film and a sleeve made from a flexible plastic bag. The top has a circular mesh-covered hole 5 cm in diameter, and the only other provision for air circulation is a series of 20 to 25 small holes (about 0.5 cm in diameter) cut into the upper base of the plastic sleeve. The cage bottom is set into a dish of moist sand (no puddles of free water). This cage cannot be used in areas of high humidity, even with dry sand, because water condenses on its inner surface, which shortens the lives of the moths and greatly reduces total oviposition.

The cage for humid areas (Fig. 4) was designed to maximize the free circulation of air. The sleeve and the entire top were nylon mesh. In addition, there was a 10 x 10 cm mesh-covered opening opposite the sleeve. The cage bottom was set into a dish of dry sand. In a low relative humidity (56-65%) moths died in 1 or 2 days in these cages.

We emphasize that the relative humidity should be about 90% in the cages, but not so high that condensate forms. We kept a recording hygrothermograph running near the oviposition cages at all times. Large seasonal deviations from the optimum relative humidity can be compensated for by switching to the cage of the appropriate design. Smaller deviations can be compensated for by varying the size of the openings for air circulation, by varying the moisture content of the sand, or both. For example, we compensated for a relative humidity of about 80% by partially covering the mesh top of the cage designed for humid conditions.

In both the insectary and the laboratory the moths were exposed only to the natural photoperiod and light. In the insectary they experienced ambient outdoor temperatures (a mean of about 28°C), and in the laboratory somewhat cooler and less variable temperatures (a mean of about 26°C).

Either style of cage contained plants for oviposition and a feeder (see below) at all times. We used plants of the Taichung Native 1 variety, about 60 days old and in pots (9 cm tall, 12.5 cm diameter at the top) that will easily pass through the sleeve. Other varieties can be used. Plants in each pot were pruned to only 5 to 8 large tillers. That decreased the effort required to find the eggs and lessened the danger of injuring moths when adding or removing a pot through the sleeve. We used relatively tall plants because moths prefer to oviposit on the drooping leaves that brush against the top and side of the cage. The plants were placed so that many leaves are so positioned. Short plants were placed atop inverted flower pots.

The leaf folder adults feed at night, and die in 3 to 4 days if not fed. A feeder was made from a plastic vial 6.5 cm high and 3.5 cm in diameter. The bottom 1 cm of the vial was cut off

with a hacksaw and then glued to the top of the vial with chloroform, thus forming a shallow dish on a pedestal. The dish was filled [illegible] with cotton wool, which was then saturated with a [illegible] by volume solution of honey in water. The feeder was placed on the [illegible] in the pot, and changed every 2 days to prevent molding.

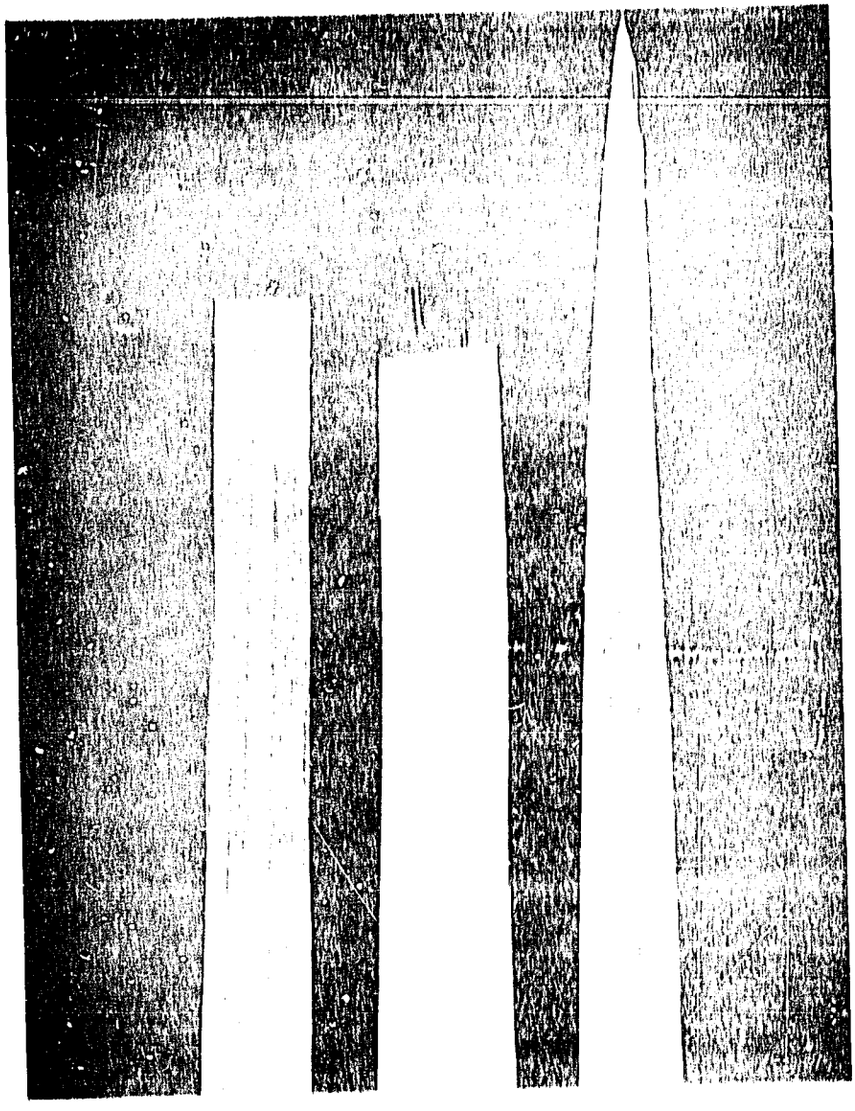
[illegible]

[illegible] were collected from a group of moths only during the first [illegible] of their life. The females continued to lay eggs for several days, but we calculated from the data of Gonzales (1974) that 95% of the eggs are laid during the first 7 days. [illegible] problems [illegible].

Gonzales (1974) found that no eggs are laid on the first day. Therefore, we left the same oviposition plants in the cages for days 1 and 2. Plants were removed and replaced daily on the morning of days 3 to 6 and the last plant was removed on day 7. The daily distribution of eggs is shown in Table 2. Because relatively few eggs were laid by day 1, we often discarded the first plant if there were too few eggs to make collection worthwhile. The plant with eggs on them was left in a tras[illegible]

Table 2. Eggs laid daily in the laboratory by an initial population of [illegible] heat-holder females in 12 cages, and in the insectary by an initial population of 131 females in 13 cages, IRRI, 1975.

		Day					
		1 & 2	3	4	5	6	7
Laboratory							
	No.	521	2084	4459	4111	2400	1667
	%	4.2	16.0	26.5	24.8	17.6	12.7
Insectary							
	No.	1416	4264	4913	4846	2919	2394
	%	8.2	22.6	20.8	20.4	15.5	12.7



the eggs were attached was cut off with scissors and stored in petri dishes on moist filter paper, with 100 to 400 eggs per dish. In an air-conditioned room where the temperature ranged from 24 to 27°C about 97% of the larvae hatched on the morning of the fourth day after oviposition. The remaining 3% had hatched by the next morning. In a screened insectary where the mean temperature was about [illegible]°C hatching began a few hours earlier. The mean hatching rate of eggs laid in the laboratory was 91.7%. The black head of the developing embryo became visible through the chorion about 24 hours before the eggs hatch.

Table 1 shows that the mean number of eggs laid per female during the first 7 days varied somewhat from cage to cage both in the laboratory and the insectary. The mean overall egg harvest was about 105 fertile female in the laboratory and about 134/fertile female in the insectary. This difference is not accounted for, as discussed below, by the difference in mortality of the females (Table 1).

Gonzales (1974) reported that pairs of rice leaf folder moths kept alone in small glass jars produced on the average about 250 eggs during the first 7 days. When we allowed for females that died in our oviposition cages during the first 7 days, the mean number of eggs per female increased only to 114 in the laboratory and 137 in the insectary. Eggs laid on the sides of cages rather than on the plants were not harvested because they were difficult to find. These did not, however, seem to be enough to explain the difference. Perhaps oviposition was reduced in our cages because the moths were in groups. We believe our method is practical, requires a moderate amount of labor, and produces sufficient eggs to support an extensive program of varietal screening in the greenhouse.

Yield of Larvae

A relatively small investment in labor yields a surprisingly large number of first-instar larvae that can be used in varietal screening. Our calculations here are based on our experience with a culture of a size that can easily be maintained with 84 hours of labor in a 7-day week. Additional labor will, of course, be needed to grow and infest the plants to be screened and to record the results.

If 15 sleeves with larvae are set up each week, there will always be about 60 sleeves on hand because it takes larvae about 27 days to develop to the adult stage. If there are 50 larvae per sleeve and survival is about 87%, yield will be about 652 adults/week. This is theoretically enough to set up 26 oviposition cages, but it is not always possible to sort the moths so as to yield the maximum number of cages. Therefore, we allowed a large safety margin by assuming that only 15 oviposition cages are set up each week.

Fifteen oviposition cages with 11 females each should produce about 16,500 eggs/week if the females lay an average of 100 eggs each. At a hatching rate of about 90%, about 14,850 first-instar larvae/week should be available. About 1,000 (7%) of these larvae (allowing a loss of 250) must be used each week to maintain the culture.

This leaves about 13,850 (93%) larvae for varietal screening. Given sufficient labor and greenhouse space and allowing a loss of 10%, this should be enough to screen 415 varieties/week using 30 larvae/variety or about 250 varieties/week using 50 larvae/variety (see Screening). This figure will not be realized if the artificial infestation of varieties is not continued over the weekends, but, even without working on weekends it should be possible to screen about 300 varieties per week.

Problems in rearing

The major rearing problem encountered was, as discussed above, the control of relative humidity in the oviposition cages. We emphasize that the moths do well at 90% RH, but the occurrence of water condensate in the cages is injurious to them and greatly decreases oviposition.

We found that exposure to bright artificial light during the first 2 or 3 hours after sunset greatly decreases oviposition.

Originally we used large outdoor metal cages without sleeves (as did Gonzales 1974), but found them unsuitable. They were not tight enough to exclude spiders, which killed the moths, and the moths, which become active if disturbed (even in daylight), escaped when we opened the cage doors.

At first the moths in the oviposition cages often died during the first 4 or 5 days even when the relative humidity was suitable for them. We believe this was caused by a low-level insecticide contamination of the clay pots. This was not proved by analysing the pots, but the deaths stopped after we used new pots.

Ants can be a serious problem and it is necessary to protect all stages of the culture from them. The cages for larvae were protected because the pots stood in water. In the insectary the oviposition cages were kept on a table with its legs in pans of water.

Larvae that hatched on the side of the cage began to appear in large numbers on the oviposition plants on day 8. They were a nuisance because they webbed the leaves and made it difficult to find the eggs. This is another reason for not collecting eggs after day 7.

PROPOSAL FOR SCREENING FOR VARIETAL RESISTANCE

The screening method we propose is based on the artificial infestation of rice plants grown in pots in the greenhouse. The plants, infested with newly hatched first-instar larvae, are held in the greenhouse until the larvae are nearly full grown; then the plants are scored for resistance by determining the number and percentage of folded leaves and the number of surviving larvae. The level of resistance is estimated by comparing these scores with those of concurrently tested susceptible and resistant check varieties. The quantitative details of scoring will have to be worked out as more experience is gained with these varietal trials. This method should reveal the effect of nonpreference (antixenosis, cf. Kogan and Ortman 1978) and antibiosis on the larvae, but it cannot reveal the effects of antixenosis on the ovipositing adults (Painter 1951). This disadvantage must, however, be weighed against the overall practicality and rapidity of the method.

[illegible]

We used 31-day-old plants of the susceptible variety (R94-13, growing 5 to a pot). Newly hatched larvae were picked up with a fine pointed, wet camel's hair brush and placed on one of the [illegible] plant (10/pot) and 25 received 1 larva/plant (15 pots). The pots with 2 larvae/plant were divided into 3 groups: a group of 15 with the pots touching and the leaves of separate pots intermingling, and a group of 10 with the pots widely spaced so that the leaves of separate pots did not touch. The pots with 1 larva/plant were similarly arranged in two groups of 15 and 9. The pots were held for 17 days in a [illegible] greenhouse.

For each pot we determined the total number of leaves, the number of folded leaves, and the number of surviving larvae. The small dead leaves at the base of the plant were not counted nor were the only leaves that were not at least one-half unfurled. Leaves that were [illegible] folded but without tissue loss, variable in extent but always slight, were not counted as folded leaves. Leaves webbed together were counted as 1 folded leaf. [illegible] the leaves of separate plants were webbed together, a [illegible] percent it was designed [illegible] the [illegible] feeding injury.

The results of the preliminary trial are shown in table 1. Overall survival in this test was lower than the 87% survival obtained in our rearing cleanup. This was to be expected because the pots in the present trial were not covered with cheese cloth. Yet substantial evidence suggests that a few larvae

Table 3. Results of artificially infesting pots of 5 CR94-13 rice plants each with either 2 or 3 rice leaf folder/plant (10 or 15/pot). IRRI greenhouse, 1978.

Larvae placed per pot (no.)	Pots (no.)	Mean no. ± SD per pot[a]		
		Total leaves	Folded leaves	Surviving larvae
		Pots touching[b]		
10	15	58.9 ± 12.6[c]	20.9 ± 6.8	7.5 ± 2.2
15	15	47.1 ± 8.2	21.4 ± 4.7	9.2 ± 3.1
		Pots spaced[d]		
10	10	47.9 ± 8.9[c]	21.0 ± 4.9	7.2 ± 2.1
15	9	35.2 ± 7.1	21.0 ± 5.5	8.4 ± 3.6

[a]Data were recorded 17 days after infestation. [b]Two separate groups of pots with 10 or 15 larvae each were placed so that the pots touched and their leaves intermingled. [c]Members of the pair are significantly different from each other, $p < 0.01$, Student's t test. [d]Two groups of pots were spaced so that the leaves of no. 2 pots touched.

may have left our pots - probably those from pots with 3 larvae/plant - and swam to uninfested plants about 1.5 m away. The ability of the larvae to leave the trial plants or to move from plant to plant is probably an advantage in varietal screening because it enhances the expression of antixenosis. We also found two larvae on the trial plants that were parasitized by groups of minute larval hymenopteran whose adults would certainly be small enough to fly through the screen wall of the greenhouse. Our results do not indicate a need to cover the plants with fine mesh to exclude parasitoids. However, the parasitoids may be more abundant at other times and places and so, adversely affect a screening program.

Table 3 also shows that in each treatment the plants with 3 larvae each had a significantly smaller total no. leaves than did the plants with two larvae. This probably reflects the effect of the higher infestation rate on the development of new leaves during the experiment.

The most important conclusion to be reached from Table 3 is that there is no advantage in infesting with 3 rather than 2 larvae/plant. Whether the pots were touching or spaced, a greater proportion of the larvae survived (75% vs 61% and 72% vs 56%, respectively) when the initial infestation rate was 2/plant. In either case the initial infestation rate did not significantly affect the number of survivors or the number of folded leaves per pot (Table 3). This suggests that 3 larvae/plant results in overcrowding.

There was also some variability in survival, even under the same conditions, leading us to conclude that in screening trials each variety should be represented by at least 3 pots of 5 plants each or perhaps by 5 pots of 5 plants each. Data in Table 3 indicate that the pots need not be spaced in the screening trials.

REFERENCES CITED

Chandramohan, N., and S. Jayaraj. 1977. Effect of different levels of nitrogen and granular insecticides in the control of the rice leaf folder, *Cnaphalocrocis medinalis* Guenee. Madras Agric. J. 64:544-548.

Dorge, S. K., D. S. Ajri, and R. B. Dumbre. 1971. Occurrence of paddy leaf roller, *Cnaphalocrocis medinalis* Gn., on high yielding rice varieties in the Konkan region of Maharashtra State. Indian J. Entomol. 33:474-475.

Gonzales, J. C. 1974. Resistance to the rice leaf folder, *Cnaphalocrocis medinalis* Guenee, in rice varieties. Unpublished MS thesis, University of the Philippines at Los Banos, XIV + 104 p.

Kogan, M., and E. F. Ortman. 1978. Antixenosis - a new term proposed to define Painter's "nonpreference" modality of resistance. Bull. Entomol. Soc. Am. 24:175-176.

Lingappa, S. 1972. Bionomics of the rice leaf folder, *Cnaphalocrocis medinalis* Guenee (Lepidoptera: Pyralidae). Mysore J. Agric. Sci. 6:123-134.

Painter, R. H. 1951. Insect resistance in crop plants. MacMillan Co., New York. 520 p.

Sakai, K., T. Ueda, and T. Samoshima. 1947. Studies on bionomics and control measures of *Cnaphalocrocis medinalis* Guenee [in Japanese]. Oyo Kontyu (Appl. Entomol.) 411-24.

Schoonhoven, L. M. 1967. Loss of hostplant specificity by *Manduca sexta* after rearing on an artificial diet. Entomol. Exp. Appl. 10:270-272.

Valusamy, R., and T. R. Subramaniam. 1974. Bionomics of the rice leaf roller, *Cnaphalocrocis medinalis* Guen. (Pyralidae: Lepidoptera). Indian J. Entomol. 36:185-189.

Yamamoto, R. T. 1974. Induction of hostplant specificity in the tobacco hornworm, *Manduca sexta*. J. Insect Physiol. 20:641-650.

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