# International Rice Research Newsletter

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# Contents

## Style for IRRN Contributors

Units of measure and styles vary from country to country. To improve communication and to speed the editorial process, the editors of the *International Rice Research Newsletter (IRRN)* request that contributors use the following style guidelines:

- Use the metric system in all papers. Avoid national units of measure (such as cavans, rai, etc.).
- Express all yields in tons per hectare (t/ha) or, with small-scale studies, in grams per pot (g/pot) or grams per row (g/row).
- Define in footnotes or legends any abbreviations or symbols used in a figure or table.
- Place the name or denotation of compounds or chemicals near the unit of measure. For example: 60 kg N/ha; not 60 kg/ha N.
- The US dollar is the standard monetary unit for the IRRN. Data in other currencies should be converted to US$.
- Abbreviate names of standard units of measure when they follow a number. For example: 20 kg/ha.
- Express time, money, and measurement in numbers, even when the amount is less than 10. For example: 8 years; 3 kg/ha at 2-week intervals; 7%; 4 hours.
- Write out numbers below 10 except in 3 series containing some numbers 10 or higher and some numbers lower than 10. For example: six parts; seven tractors; four varieties. *But* there were 4 plots in India, 8 plots in Thailand, and 12 plots in Indonesia.
- Write out all numbers that start sentences. For example: Sixty insects were added to each cage; Seventy-five percent of the yield increase is attributed to fertilizer use.
- Type all contributions double-spaced. ■

# Genetic evaluation and utilization

OVERALL PROGRESS

### IRRI's program for rapid generation advance in rice breeding

*B. S. Vergara, plant physiologist, and W. R. Coffman, plant breeder, International Rice Research Institute*

Rapid generation advance (RGA) was suggested by Goulden as early as 1939. Japanese rice breeders began to use it in 1958. Essentially, the use of high temperature and short days hastens the growth of the rice plant and makes possible 2 or 3 generations/year. Thus, the plact-selection process from the $F_2$ to the $F_5$, which generally takes about 4 years, can be shortened to 2 years. RGA is particularly useful for photoperiod-sensitive crosses of which only 1 generation/year is possible under field conditions. It could shorten the breeding program of many rainfed wetland national programs where photoperiod sensitivity is required.

In 1976, IRRI began to experiment with the use of RGA in breeding for photoperiod-sensitive rices. The effectiveness of RGA and the cultural methods for its use, including the possible plant characters that can be screened, were tested under the leadership of H. Ikehashi.

Participants in the 1978 International Deepwater Rice Workshop in Calcutta, India, recommended that breeders working on photoperiod sensitivity should fully utilize IRRI's RGA facilities (see figure), which can accommodate 260,000 plants/planting or 790,000 plants/year. The participants agreed that the breeders could send 5 crosses/year to IRRI for RGA, or suggest crosses for IRRI to make and run through the RGA. Several breeders have already sent RGA materials to IRRI.

Researchers at the 1978 International Cold Tolerance Workshop at Suweon, Korea, also decided to use RGA to

**Two greenhouses and a large darkroom have been built at IRRI to accommodate the materials for rapid generation advance.**

accelerate cold tolerance breeding for high-elevation and high-latitude areas where only 1 rice crop/year is possible.

Bulk seeds of $F_3$ to $F_5$ RGA populations of photoperiod-sensitive materials and cold-tolerant crosses will be available for distribution early in 1980. Scientists may obtain a list of the materials by writing to the authors. It is hoped that plant breeders will take advantage of this IRRI service.

**Two new rice varieties released in Bihar, India**

*R. C. Chaudhary, chief scientist (rice), Agricultural Research Institute, Mithapur, Patna 800001, Bihar; S. Saran, rice breeder, Agricultural Research Institute, Patna; and S. C. Prasad, senior rice breeder, Agricultural Research Institute, Kanke (Ranchi), India.*

Two new rice varieties, Rajendra Dhan 201 and Rajendra Dhan 202, were recently named by Rajendra Agricultural University and released for cultivation in Bihar.

Rajendra Dhan 201 (from the cross IR8/Tadukan) has intermediate growth duration (135 days) and is suitable for irrigated transplanted areas. It has yielded 5 t/ha. It has medium-slender grain and disease resistance. Before its release, Rajendra Dhan 201 was tested for 6 years in experimental plots, and 3 years in minikits in farmers' fields.

Rajendra Dhan 202 (from the cross IR8/W1251) was previously known by its line number, RP9-4. It is suitable for gall midge-endemic areas of Chhotanagpur. It was tested through the All-India Coordinated Rice Improvement Program and in minikits in farmers' fields. The variety matures in 125 days and has long, bold grains. Its yields average 4.4 t/ha. When gall midge attack is severe, Rajendra Dhan 202 yields 70 to 80% higher than Jaya or IR8.

**Isolation of single cells from rice**

*Chin Ho Lin, Botany Department, National Chung Hsing University, Taichung, Taiwan*

A new method to isolate single cells from rice leaves was developed using the varieties Taichung 65 and Tainan 5. The method consists of mechanically pregrinding the leaf blades and macerating the leaf fragments in pectinase. The isolated single cells, as seen through a phase contrast microscope, were columnar and lobed. Their number varied with the age of the leaves used and the time of maceration. About $10^5$ to $10^6$ cells/g of fresh leaves were isolated in 3 hours' maceration. Leaf tissues from the same variety yielded more single cells when used at 34 days old than at 101 days. The number of single cells isolated did not differ significantly between the two varieties.

**Screening of rice cultivars against bird damage**

*S. K. Shrivastava and Raju Philip, Madhya Pradesh Rice Research Institute, Raipur, India*

Two thousand rice cultivars, maintained at the germplasm center, Baronda, were field screened against bird damage during 1978 kharif. Each cultivar was sown in 3 rows spaced 20 cm apart.

Scoring was based on the percentage of damaged grains. No cultivar escaped bird damage; 13 had as much as 10% damage and 1,987 had more than 60%. Cultivars damaged least were Ajan, Ajwaine, Barhi, Danwar, Dawar, Koliar, Lakhokuwar, Manjhaligurmatia, Nunji, Parhi, Ratna, Surjajota, and Surmatia. Cultivars with brown- to black-husked grain showed less bird damage. ■

**SR26BM, an EMS-induced mutant variety that is insensitive to photoperiod**

*R. Srikant Aradhya, M. Mahadevappa, and M. Sangaiah, University of Agricultural Sciences, Bangalore, India*

The variety SR26B is well adapted to saline soils in the irrigated tract of Karnataka, India. But its photoperiod sensitivity limits its cultivation to the wet season.

Hybridization of SR26B with Waner 1 gave fine-grained lines with early maturity, but the yield potential and the puffing quality of the grain were lost. Therefore, a study to obtain an isogenic mutant of SR26B with photoperiod insensitivity was initiated in 1972 at the Regional Research Station, Mandya, in collaboration with the Plant., Breeding Department, Agricultural College, Bangalore.

After presoaking in tap water for 10 hours, 200 g of SR26B seed was soaked in 1% EMS solution without buffer for 14 hours. The EMS had been prepared in double distilled water; the volume of solution used was three times that of the seed. The seeds in the solution were constantly shaken and maintained at a room temperature of about 21 °C. Both treated and control seeds were then washed with tap water 20 times. Twenty-five-day-old seedlings were transplanted at 1 seedling/hill in January 1973 at Bangalore to grow during the dry season. In May, a plant with normal panicle exsertion and flowering that resembled the original SR26B in spikelet and other plant characters was noticed in the treated plot. No other plant, treated or control, flowered at that time. But photoperiod-insensitive varieties planted at about the same time in a performance test flowered. Thus, the plant under consideration could only be a mutant of SR26B. It was seeded at Mandya in the 1973 wet season. Because all the plants looked alike they were bulk harvested and the mutant was designated SR26BM. It bred true when raised at Mandya in the 1974 dry season.

Since the variant appeared in the $M_1$ and bred true in subsequent generations, it could only be a homozygous recessive mutant. Reports of such mutants appearing in *Lycopersicon* in the $M_1$ were published in 1968. In such cases, the $M_1$ mutant seedlings arise from simultaneous mutation of the locus concerned in both homozygous chromosomes because the mutagen is highly

**Grain yield performance of SR26BM in Salt Tolerant Variety Trials in Karnataka, India, 1977.**

| Season | Location | Yield (t/ha) | |
|---|---|---|---|
| | | SR26BM | SR26B |
| Dry | Hiriyur | 6.1 | – |
| Wet | Hiriyur | 2.8 | 3.5 |
| Wet | Mandya | 2.1 | 2.1 |
| Wet | Gangavathi | 5.7 | 5.3 |

effective.

SR26BM was evaluated for yield in the regular Salt Tolerant Variety Trial (see table). The yield potential and puffing quality of the grain seemed unaffected. The plant type of SR26BM—tall and weak—needs improvement, but the variety can be cultivated in the dry season in salt-affected soils. ■

**BW100, a promising new variety in Sri Lanka**

*Paul E. Peiris, Regional Agricultural Research Station, Bombuwela, Sri Lanka*

BW100, a sister line of BW78, was selected in 1976 from the cross H50l//Podiwee A-8/H5. Since 1976 it has consistently yielded higher than BW78. Its gall midge resistance was shown in 1977 and 1978 yala, when it outyielded several varieties, including BG11-11.

In the 1978 Yala National Coordinated Rice Varietal Trials tested at 14 locations, BWl00 gave the highest mean yield—11.4 t/ha under various soil and climatic conditions. In the 1977-78 Maha Extension Field Trials, it outyielded BW78 in six of seven districts.

The intermediate-statured BWl00 matures in 4–4.5 months; responds well to nitrogen; has lodging resistance, weed competitive ability, superior grain quality, and resistance to storage pests; and performs well under adverse soil and climatic conditions. ■

**Sita: a variety for irrigated wetlands of Bihar, India**

*S. Saran, rice breeder, and V. N. Sahai, junior scientist, Rajendra Agricultural University, Agricultural Research Institute, Mithapur, Patna 800001, Bihar, India*

In 1975, the variety Sita (from the cross IR12-178-2-3/IR8) was released in Bihar for the intensively cropped irrigated areas.

Sita's relatively short growth duration (130-135 days, seed to seed) enables farmers to harvest by early November, then plant a winter crop such as wheat. Yields average 4 to 6 t/ha. Farmers prefer Sita to Jaya because it responds better to low levels of fertilizer (40–50 kg N/ha); it has long, slender grain; it is moderately resistant to tungro, blast, and bacterial blight; and its flowering is synchronous. Bihar farmers have adopted Sita widely and the variety is moving into Uttar Pradesh. ■

**Optimal use of space and plant containers in RGA**

*J. Peralta, B. S. Vergara, and G. Pateña, Plant Physiology Department, International Rice Research Institute*

Rapid generation advance (RGA) makes it possible to have 3 generations/year of breeding materials by reducing the growth duration, shortening the day length, and using high temperature. Spacing must also be close to plant thousands of progeny lines in a greenhouse of limited size. Use of large wooden boxes or individual plots has advantages and disadvantages. More plants can be accommodated in wooden boxes, but those boxes remain occupied until the last plant is harvested. Small pots take more space – but half of that space may be available 3 months after sowing. If plants are stressed at an early stage, elimination of susceptible lines provides additional space within a month after sowing.

An experiment was conducted at IRRI to study plant responses and advantages of different containers. Pregerminated $F_2$ seeds of the cross IR24389 (Sein Ta Lay (X69-2-27)/IR36//BKN6986-147-2), designated as RGA 079 were planted in wooden boxes, square pots, and round pots. The measurements of the wooden boxes were 1.27 × 1.27 × 0.1 m; each accommodated 1,600 plants at a spacing of 3 × 3 cm. In an equivalent area, 440 square pots (5.5 × 5.5 × 5.0 cm) can be accommodated but only 272 round pots (6.7 cm diam, 5 cm ht). We used Maahas soil mixed with ammonium sulfate, solophos, and muriate of potash at the rate of 4-2-2 g/4 kg of soil. The plants were grown in the greenhouse under natural day length until the 5th-leaf stage; then they were subjected to a short-day treatment of 10 hours light and 14 hours darkness. Additional nitrogen fertilizer was applied at the rate of 20 g ammonium sulfate/box at 15-day intervals.

The wooden box accommodated twice as many plants per unit of space as the pots did. The population reached 50% flowering at about the same time regardless of container. That means that half of a population planted in pots can be harvested after 90 days. The vacated space can be used to start another set of cross progeny. When wooden boxes are used, the space vacated is wasted and the box cannot be used to full efficiency until the last plant is harvested.

The number of plants processed per year is essentially the same regardless of whether wooden boxes or square pots are used. Wooden boxes may have an advantage for early generation materials that are not screened or selected and that require small amounts of seeds per plant.

The closer spacing of the large wooden box resulted in more dead plants at harvest. Closer spacing means more competition - not only for nutrients, even more so for light. In the wooden box, 74% of the plants survived; in the square pots 99% did; and in the round pots, 100%.

For screening, the individual plant containers are definitely better than the large wood boxes. Susceptible plants can be eliminated after testing; the remaining few plants can grow to maturity in a much smaller space.

The square pot is ideal for RGA screening, which is usually done at the $F_4$ or $F_5$ generation. In RGA, more seeds are needed for distribution to plant breeders because panicles are larger and scientists can easily discard dead or susceptible plants. ■

**Rice breeding progress at Bombuwela, Sri Lanka**

*Paul E. Peiris, Regional Agricultural Research Station, Bombuwela, Sri Lanka*

The variety H4 was released in 1959 and, like IR8 in Southeast Asia, it initiated the so-called green revolution in Sri Lanka. It

was most popular in the dry and intermediate zones for more than a decade. But in the low country wet zone it performed poorly because of disease, insect, climatic, and soil problems. Similar problems have caused the improved varieties such as BG11-11 and BG90-2 to perform poorly in the low country wet zone.

Until recently, the general opinion was that the area had low potential for rice. But the problems, particularly iron toxicity in mineral soils, were overemphasized.

The situation became clearer with the initiation of land classification of the wet zone. After problem areas were isolated, we could determine priorities. We have dropped the concept of releasing one variety to cover the entire area. Our present breeding program is geared to breed specific varieties to overcome problems peculiar to the following specific conditions: 1) tolerance for flash floods, 2) ability of seed to germinate under standing water, 3) rapid seedling growth, 4) ability to compete with weeds, 5) tolerance for adverse soils, 6) resistance to diseases and insects, 7) resistance to storage pests, 8) palatability, and 9) red pericarp.

Some of the local varieties screened and the traits peculiar to them follow:

- Muhudukiriyal — salinity tolerance
- Karamana, Molligoda, and Sula — ability to emerge through standing water
- Devereddiri — tolerance for floods and iron toxicity
- Podiwee A-8 — resistance to storage pests
- Batapolayal — rapid seedling growth

The results of screening of early generation material for resistance to gall midge, thrips, and iron toxicity are encouraging. In 1978 we began to test our promising materials in farmers' fields of varying land classes.

From the 4 to 4.5-month age group, LD66 and BW78 have been released and successfully cultivated in the wet zone. BW100 awaits release. Although we have released varieties for successful cultivation in the mineral and half bog soil, we have yet to find an alternative to the local variety Devereddiri, which is grown on about 10% of the rice area on the coastal floodplains.

In all modesty, we can state that we have contributed positively toward the goal of making our country self-sufficient in rice. ■

**Importance of flag leaf area and grain-straw ratio in rice improvement**

*Devinder K. Mehan, plant breeder, All India Coordinated Rice Improvement Project (AICRIP), Rajendranagar, Hyderabad, 500030, India, and S. S. Saini, rice breeder, ITEC, Embassy of India, Kabul, Afghanistan*

The importance in rice yield improvement of physiological traits such as flag leaf area and grain-straw ratio was studied through statistical tools.

One hundred twenty rices were selected from the germplasm maintained at Punjab Agricultural University, Ludhiana, India. The strains were classified into four groups based on maturity period and plant height: early short, late short, early tall, and late tall. Thirty varieties in each group were grown in a randomized block design with three replications. The usual cultural practices were followed. Data on flag leaf area, and grain-straw ratio were collected from 10 randomly selected plants/replication.

Flag leaf area and grain-straw ratio varied widely in all groups. Although the range can provide an estimate of variability in the germplasm, the coefficient of variability could be more reliable. The grain-straw ratio showed a high coefficient of genetic and phenotypic variability (see table). The flag leaf area also showed appreciable coefficient of variation.

Heritability (which provides a basis for making selections based on the phenotypic performance) and expected genetic advance were high for both traits in all groups.

The study showed a strong positive correlation between yield and grain-straw ratio in the early short (0.5202) and the late tall group (0.6632) and only a positive correlation in the early tall (0.2305) and late short (0.3431) groups The flag leaf area and yield were correlated positively and significantly in the early short group (0.4075) but only positively in the other groups (see table). ■

**Statistical parameters for flag leaf area and grain-straw ratio in various rice cultures, Ludhiana, India, 1979.**[a]

| | Early short | | Late short | | Early tall | | Late tall | |
|---|---|---|---|---|---|---|---|---|
| | Flag leaf area (cm) | Grain-straw ratio | Flag leaf area (cm) | Grainstraw ratio | Flag leaf area (cm) | Grain-straw ratio | Flag leaf area (cm) | Grain-straw ratio |
| Mean ± SE | 40.544 ± 3.219 | 0.872 ± 0.065 | 31.185 ± 2.142 | 0.802 ± 0.033 | 56.991 ± 4.118 | 0.466 ± 0.028 | 58.574 ± 3.144 | 0.441 ± 0.027 |
| Range | 24.14 – 59.61 | 0.33 – 1.30 | 25.54 – 62.47 | 0.31 – 1.20 | 25.99 – 83.21 | 0.31 – 0.61 | 31.33 – 90.50 | 0.15 – 0.75 |
| Coefficient of phenotypic variation (%) | 25.51 | 28.08 | 23.25 | 30.02 | 27.82 | 27.18 | 23.94 | 31.30 |
| Heritability (%) | 21.49 | 24.83 | 19.56 | 29.13 | 24.84 | 24.99 | 21.63 | 29.35 |
| Expected genetic advance (as % of mean) | 40.73 | 45.30 | 36.66 | 5 8.26 | 44.47 | 47.10 | 43.65 | 56.71 |
| Phenotypic correlation with yield | 0.4075* | 0.5202** | 0.1653 | 0.3431 | 0.4200* | 0.2305 | 0.1868 | 0.6632** |
| Genotypic correlation with yield | 0.4966 | 0.5233 | 0.1947 | 0.3919 | 0.55 85 | 0.2846 | 0.2210 | 0.7635 |

[a]*Significant at 5% level. **Significant at 1% level.

GENETIC EVALUATION AND UTILIZATION

# Genetic resources program

**Rice germplasm collected from low-lying areas of Orissa**

*J. K. Roy, D. P. Ghorai, R. N. De, and A. Panda, Central Rice Research Institute (CRRI), Cuttack, India*

As a part of the India-wide rice germplasm collection program formulated in 1978, CRRI surveyed and collected rice germplasm from the typical low-lying areas of Orissa in 1978 kharif.

Although the germplasm in those areas in India is not threatened by immediate extinction (most current improved varieties are not suitable for such conditions), collection in such areas is being emphasized to locate donors for the development of improved varieties for flood-prone and waterlogged areas, which make up about a third of India's total rice area.

The survey resulted in the collection of 140 typical low-lying varieties. Some varieties such as Rabana, Dhusara, Magura, Champeisali, Cuttack Chandi, and Ratnachudi are common in several blocks. All the varieties collected, including two scented types, were late maturing with coarse, fine, or very fine grain. They arc being evaluated under waterlogged conditions in 1979 kharif. More than 15,000 viable accessions are now in the national germplasm collection at CRRI. ■

GENETIC EVALUATION AND UTILIZATION

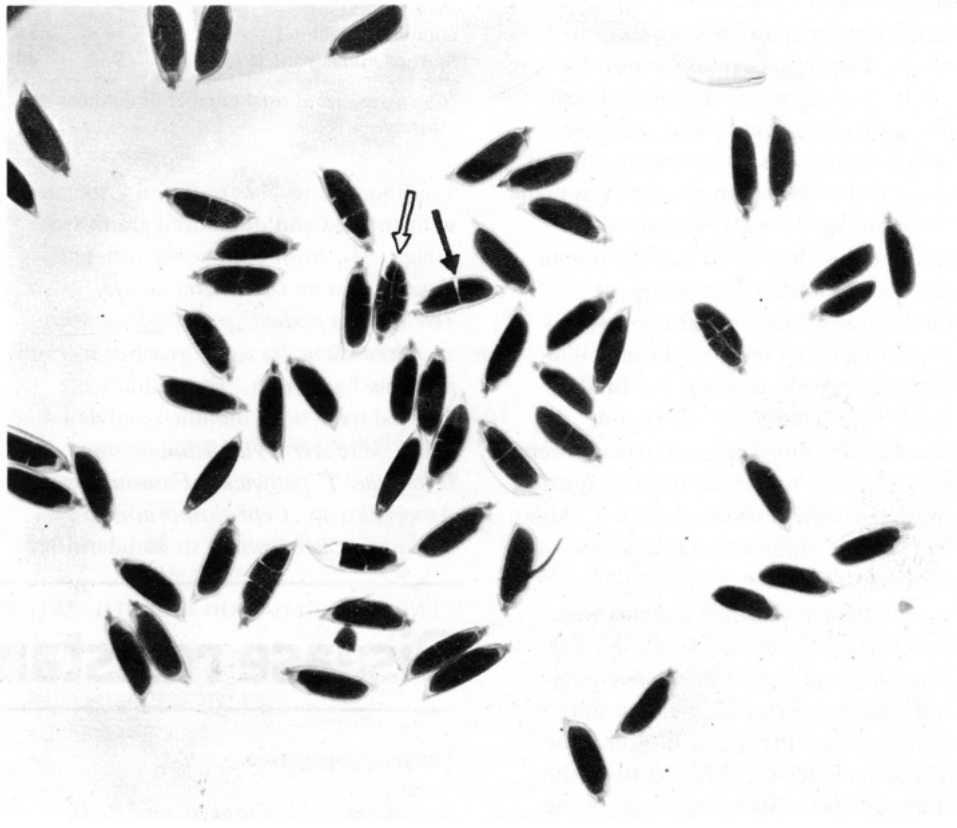
# Grain quality

**An X-ray technique to screen *sun cracks* in rice grains**

*R. C. Chaudhary and N. P. S. Kohli, Department of Plant Breeding, C. B. Pant University of Agriculture and Technology, Pantnagar 263145, India*

*Sun cracks* develop in mature rice grains exposed to variable humidity and temperature. Overmature crops left in the field or threshed grain left in the open are exposed to low temperature and humidity at night and high temperature and low humidity in daylight hours. The alternate soaking and drying lead to the "sun cracking" of the endosperm. The sun-cracked grains invariably break during hulling and milling. Other grains break independently of sun-cracking because of mechanical damage. When evaluating varieties for head-rice recovery, the broken kernels are separated after milling and expressed as a percentage of rough rice. But there has been no method to determine if sun-cracking or mechanical damage caused the breakage. Therefore head-rice recovery has been considered subjective and inheritance studies on the trait have been inconclusive.

An X-ray technique has been used to measure the degree of damage caused by sun cracks, thus allowing separate determination of breakage due to milling.



Grains with sun crack (white arrow) and mechanical damage (black arrow). Pantnagar, India.

An X-ray inspection unit (Faxitron model 804, 14 kV, current 2mA) was used. Rice samples suspected of high damage were spread on an X-ray plate 25 cm from the source. The samples were exposed for 3 seconds, then the plates were developed by the usual method. The cracks and damage appeared in the plate clearly (see photo). Damaged grain can also be counted from positive plates. The technique may be useful to breeders in determining genotypic differences and

inheritance of breakage components, and would ultimately help in the development of varieties with high head-rice recovery. Agronomists and technicians may use the method to develop recommendations on date of harvest, cultivation practices, drying method, and processing to ensure high head-rice recovery. ■

### Microorganisms associated with spotted and discolored rice grains in Bangladesh

*M. A. T. Mia, A. K. M. Shahjahan, and S. A. Miah. Bangladesh Rice Research Institute (BRRI), Joydebpur, Dacca, Bangladesh*

In Bangladesh, discoloration of rice grain (i.e. grain spotting) seems to have increased with the cultivation of high yielding varieties and the use of high nitrogen rates. Some varietal and seasonal differences in grain spotting seem to occur. The actual causes of spotting have not been confirmed. Although microorganisms have been found associated with it, pathogens of seedborne diseases could be involved. An attempt was made to isolate and identify the organisms associated with spotted and discolored rice grains. Grains from different varieties were collected at maturity by harvesting intact panicles during 1978 boro, aus, and T. aman at the BRRI farm. The healthy and spotted or discolored grains from each panicle were separated and the percentages of spotted grains per variety were calculated. About 100 spotted grains of each variety were then dehulled.

Unhulled and dehulled grains were then surface-sterilized in 0.5% NaClO for 5 minutes and 3 minutes, respectively, and plated at 10 grains/plate on potato dextrose agar (PDA) and Blotter. The plates were incubated for 10 to 14 days at about 28°C. Microorganisms in the grains grew in about 3 days of incubation. Some were transferred to fresh PDA plates for purification, sporulation, and identification; others were examined directly under the microscope and identified. The total numbers of each type of organism from grains of each variety were then recorded. Twenty microorganisms — 17 fungi, 2 bacteria, and 1 actinomycete — were found associated with spotted and discolored grains (see table). The most commonly isolated organisms were *Curvularia lunata, Trichoconis padwickii, Cephalosporium* sp., *Drechslera oryzae, Fusarium* sp., and a yellow bacterium. Those that were isolated from both unhulled and dehulled grains were *Acrocylindrium* oryzae, *D. oryzae, T. padwickii, Fusarium* sp., *Aspergillus* sp., *Cephalosporium* sp., *C. lunata, Chaetomium* sp., unidentified sp. I and IV, *Actinomycetes* sp., and two bacteria. The first four are the causal agents of sheath rot, brown spot, stack burn, and bakanae diseases. Four of the fungi did not sporulate and hence could not be identified. They were sent to the Commonwealth Mycological Institute for identification. Grain spotting, to which BR8 is susceptible, is lowest during boro. Further work on grain spotting and discoloration is in progress. ■

**Microorganisms isolated from spotted and discolored rice grains and the frequency of occurrence in different varieties and seasons in Bangladesh.**

| Organisms isolated | Occurrence (%)[a] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Boro | | Aus | | | | T. aman | | | |
| | Hbj BII | IR8 | Chandina | BR3 | BR6 | BR8 | IR20 | BR3 | BR6 | BR8 |
| *Acrocylindrium oryzae* | – | – | – | 3 | 2 | 1 | – | 4 | – | 5 |
| *Aspergillus* spp. | 6 | 14 | 2 | 2 | 2 | 4 | – | – | 1 | – |
| *Cephalosporium* sp. | – | – | 13 | 13 | 25 | 25 | – | – | 16 | 10 |
| *Chaetomium* sp. | – | – | 2 | 4 | 7 | 3 | – | – | – | 1 |
| *Curvularia lunata* | 5 | 3 | 7 | 10 | 16 | 4 | 18 | 9 | 25 | 12 |
| *Drechslera oryzae* | 7 | 6 | 6 | 14 | 10 | 13 | 8 | 15 | 28 | 22 |
| *Eurotium* sp. | 1 | 1 | – | – | – | – | – | – | – | – |
| *Fusarium spp.* | 1 | 1 | 7 | 8 | 8 | 13 | 11 | 4 | 4 | 10 |
| *Nigrospora oryzae* | – | – | 1 | – | – | – | 11 | – | – | – |
| *Penicillium* sp. | – | – | 5 | 2 | 2 | 5 | – | – | – | – |
| *Phoma* sp. | – | – | 2 | – | 8 | 8 | – | – | – | – |
| *Pyrenochaeta* sp. | – | – | – | 2 | 11 | 5 | – | – | – | – |
| *Trichoconis padwickii* | 6 | 5 | 1 | 16 | 22 | 9 | 5 | 38 | 62 | 52 |
| *Unidentified* sp. I | – | – | 2 | 2 | 5 | – | – | – | 1 | – |
| " sp. II | – | – | 2 | – | 2 | – | – | – | – | – |
| " sp. III | – | – | 1 | – | – | – | 5 | 5 | – | – |
| " sp. IV | – | – | 1 | 2 | 1 | 2 | – | – | – | 1 |
| *Actinomycetes* sp. | 5 | 9 | – | – | – | – | – | – | – | – |
| *Bacterium* (white) | – | – | 10 | 7 | 10 | 1 | – | – | – | – |
| *Bacterium* (yellow) | – | – | 14 | 3 | 9 | 41 | – | 3 | 4 | 9 |
| Spotted grains/panicle (%) | 6 | 9 | 44 | 55 | 31 | 96 | 54 | 52 | 35 | 61 |

[a]Calculated from total number of colonies appearing among 100 to 200 plated, discdored seeds per variety.

GENETIC EVALUATION AND UTILIZATION

# Disease resistance

### Tungro propagation

*K. C. Ling, E. R. Tiongco, and R. D. Daquioag, International Rice Research Institute*

A method for propagating tungro-infected rice seedlings and tungro vectors was developed. It consists of 1) rearing tungro vectors *Nephotettix virescens* and providing a tungro source for a constant supply of viruliferous insects, 2) raising TN1 seedlings in a seedbed covered with improvised wooden cages with metal screens, 3) inoculating the seedlings by releasing viruliferous insects into the cages, and 4) transplanting the seedlings after exposure to the viruliferous insects.

A field prepared as a seedbed was divided into eight sections (see photo). Each section is a plot. 1.3 × 3.8 m, subdivided info three lots, each about 1 × 1 m. Two sections of the seedbed are

Layout of covered seedlings for tungro production. IRRI.

used in each tungro propagation. About 750 g of TN1 seeds are soaked in water on Mondays. The following day, the soaked seeds are sown in 10-row lots individually covered with improvised cages. Fourteen days after seed soaking, 7,000 to 10,000 adult green leafhoppers are given a 4-day acquisition access time on tungro-diseased plants. Then 1,000 to 1,500 viruliferous insects are introduced into each cage for a11 inoculation access time of 6 days. After inoculation, the living insects are recovered from each cage to be used to generate new insect colonies. The seedlings are then pulled for transplanting. The procedures of tungro proopagation, from seed soaking to transplanting, take 3 weeks. The present schedule is to prepare the seedbed, soak seeds, and confine insects on diseased plants on Mondays; sow on Tuesdays; harvest on Thursdays; and inoculate seedlings on Fridays.

Use of the propagation method results in the deposit of *N. virescens* eggs on 30,000 seedlings/week (5,000 seedlings/ lot); more than 90% of the seedlings are infected. In 65 randomized samplings for the hatchability of eggs laid on seedlings, from 0.01 to 13 nymphs/ seedling were found. an average of 7 nymphs/seedling. Transmission tests of' nymphs randomly collected from the inoculated seedlings indicated that 64% had acquired the tungro virus and were capable of infecting seedlings. ■

**Varietal resistance and possible components of horizontal resistance to blast**

*L. K. Chou, Genetic Evaluation and Utilization trainee from the People's Republic of China; F. L. Nuque, assistant plant pathologist; and Pat Crill, plant pathologist, Plant Pathology Department, International Rice Research Institute*

Plants of Tetep, Carreon, IR36, IR442, and Khao-tah-haeng 17 (KTH) were inoculated with *Pyricularia oryzae* isolates 7506 and 2017 at 21 days after seeding. The plants had been grown from seed in pots with high-nitrogen soil under 12-hour day/night temperatures of 29°/21°C. Inoculated plants were placed in a dew chamber at 21°C for 24 hours. then transferred to 25°/11°C day/night temperature conditions. Six days after inoculation the lesions and the spores in each lesion were counted. Three-cm-long leaf pieces with only 1 lesion were excised, washed with distilled water. placed in individual humidity chambers made from petri dishes. and incubated for 77 hours. Each lesion was vigorously washed in 0.5 ml distilled water and spores were counted with a haemocytometer. Each count was replicated 10 times; 5 lesions/isolate and 5 lesions/variety were examined. The lesions were further incubated for another 72 hours, counted, and then measured.

When inoculated with either isolate Carreon failed to produce symptoms, indicating vertical resistance to both isolates. Tetep expressed vertical resistance to isolate 7506 but was susceptible to 2017. KTH, IR36, and IR441 were susceptible to both

**Table 1. Average number of type 3 (T-3) and type 4 (T-4) blast lesions formed on the upper leaf of 30 plants of 5 rice varieties 6 days after inoculation.**

| Isolate | Lesions (no.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tetep | | Carreon | | IR36 | | IR442 | | KTH | |
| | T-3 | T-4 | T-3 | T-4 | T-3 | T-4 | T-3 | T-4 | T-3 | T-4 |
| 2017 | 0.5 | 3.9 | 0.1 | 0.3 | 0.1 | 0.3 | 0.1 | 1.5 | 3.4 | 16.9 |
| 7506 | 0 | 0 | 0 | 0 | 0 | 0.6 | 0 | 1.6 | 0.5 | 4.0 |

**Table 2. Mean size of lesions on leaves of 4 rice varieties 12, 13, 15, and 24 days after inoculation with two blast isolates.**

| Days after inoculation | Mean lesion size[a] (mm) | | | | | |
|---|---|---|---|---|---|---|
| | Isolate 2017 | | | Isolate 7506 | | |
| | Tetep | KTH | IR442 | IR36 | KTH | IR442 |
| 12 | 4.0 × 2.0 | 6.4 × 2.0 | 3.0 × 2.1 | 7.2 × 2.2 | 10.4 × 3.3 | 8.0 × 2.3 |
| 13 | 3.8 × 1.6 | 6.4 × 2.1 | 3.4 × 2.0 | – | – | – |
| 15 | 10.0 × 1.4 | 8.1 × 2.0 | 3.8 × 2.1 | – | 16.8 × 2.0 | 15.2 × 2.0 |
| 24 | 12.6 × 1.7 | 22.2 × 2.2 | 20.4 × 2.0 | – | 19.6 × 2.0 | – |

[a]Length × width.

**Table 3. Average number of spores produced by type 4 lesions on 4 rice varieties inoculated with 2 blast isolates and incubated for 36 and 72 hours, from counts at 4 inoculation intervals.**

| Days after inoculation | Spores (no./m × 1000) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Isolate 2017 | | | | | | Isolate 7506 | | | | | |
| | Tetep | | KTH | | IR442 | | IR36 | | KTH | | IR442 | |
| | 36 h | 72 h | 36 h | 72 h | 36 h | 72 h | 36 h | 72 h | 36 h | 72 h | 36 h | 72 h |
| 6 | 0.60 | 0.40 | 0.02 | 0.08 | 0.26 | 0.28 | 2.90 | 1.06 | 3.28 | 2.16 | 1.06 | 0.54 |
| 7 | 0.28 | 0.14 | 0.78 | 1.02 | 0.46 | 0.06 | – | – | – | – | – | – |
| 10 | 0.04 | 0.10 | 0.30 | 0.44 | 0.28 | 0.58 | – | – | 3.48 | 3.44 | 1.46 | 1.28 |
| 19 | 0.24 | 0.42 | 0.68 | 0.36 | – | | – | – | 1.22 | 0.40 | 0.30 | 0.81 |

isolates (Table 1). IR36 had fewer and smaller lesions than IR442 and KTH, indicating that number of lesions and size of lesions may be components of horizontal resistance to rice blast (Table 1, 2). The variety had no effect on spore production of either isolate of the blast fungus, indicating that sporulation capacity is not a component of horizontal resistance, but is a reproductive function of the blast fungus. That is further supported by the fact that lesion size did not affect the number of spores per lesion (Table 3).

**Reaction of indica and japonica rices to blast in Taiwan**

*W. L. Chang, L. C. Chen, and S. C. Yang, Chiayi Agricultural Experiment Station, Taiwan Agricultural Research Institute, Chiayi, Taiwan, Republic of China*

Five uniform blast nurseries were established yearly from 1974 to 1978 to test rice varieties and selections from various breeding stations for blast reaction in Taiwan. Four were on the western coast (Yilan, Nantou, Chiayi, Pingtung) and one in the east (Taitung). The program was jointly conducted by the Taipei, Taichung, Chiayi, Kaohsiung, and Taitung stations with the assistance of the Joint Commission on Rural Reconstruction.

Among the 693 entries were 499 japonicas and 194 indicas. Thirty-four percent of the entries showed resistance to leaf blast; 55%, to neck blast. Fifteen and 48% of the japonicas and 75 and 84% of the indicas were resistant to leaf and neck blast, respectively. Japonica varieties generally appear more sensitive to leaf blast; indicas have more overall blast resistance than japonicas under local conditions.

A positive relationship existed between leaf and neck blast reactions (correlation coefficients were 0.77 for japonicas, 0.64 for indicas, and 0.79 when pooled). All correlations were significant at the 1% level indicating varieties resistant to leaf blast were resistant to neck blast, but a smaller *r* value for indicas may lead to exceptions.

Of 35 varieties being commercially produced (28 japonicas, 7 indicas), only 8 (3 japonicas, 5 indicas) were resistant to both neck and leaf blast. Among the susceptible were two leading varieties, Tainan 5 and Tainung 67; the two were. planted on 384,000 ha in 1978 (51% of Taiwan's total planted areas). Chianung 242, until recently one of Taiwan's most popular resistant cultivars, was also susceptible. ■

GENETIC EVALUATION AND UTILIZATION

# Insect resistance

**Comparison of oxalic acid concentration in rice varieties resistant and susceptible to the brown planthopper**

*T. Yoshihara, postdoctoral research fellow, and K. Sogawa, visiting scientist, Entomology Department; and Ruth Villareal, senior research assistant, Chemistry Department, International Rice Research Institute*

Resistance to the brown planthopper (BPH) in certain rice varieties is mainly governed by chemicals in the phloem tissues that inhibit sucking. To test oxalic acid for its potential in inhibiting sucking by BPH, we isolated it from leaf sheath extracts of Mudgo, a resistant variety. We compared the oxalic acid concentration in the following 28 rice varieties, with special reference to differences in their varietal resistance to BPH.

- Susceptible varieties: IR8, IR20, IR22, IR24, TN1
- Resistant varieties with:

*Bph 1* gene – IR26, IR32058-78, Mudgo, CO 10, MTU15

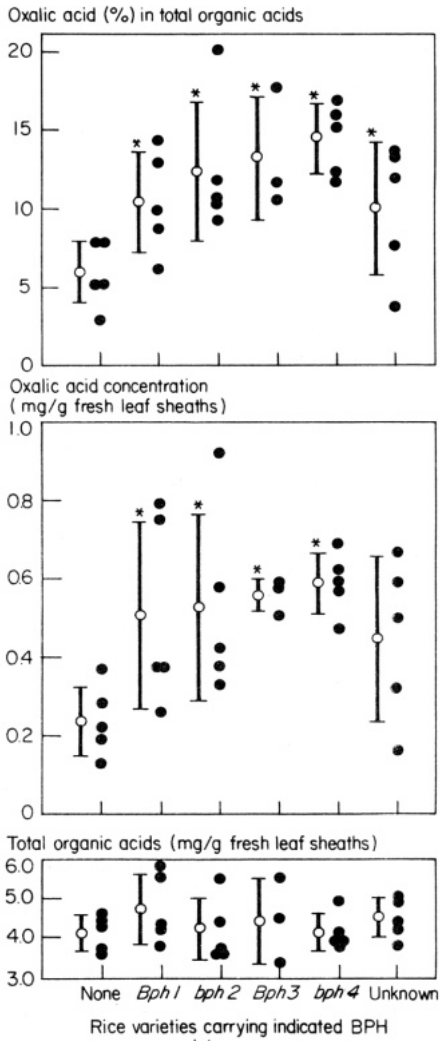
*Bph 2* gene – IR32, H5, H105, CR94-13, ASD7

*Bph* 3 gene – Kuruhondarwala, Gangala, Rathu Heenati

*Bph 4* gene – Heenhoranamawee, Babawee, Lekam Samba, Kalukuruwee, Kahata Samba

Unknown gene(s) – PTB21, PTB33, Sudu Hondarwala, Sinna Sivappu, Balamawee

Organic acids were separated from 70% EtOH extracts of fresh leaf sheaths from 40-day-old plants using ion exchange chromatography through Amberlite CG120 and Amberlite




Oxalic acid and total organic acid contents in rice varieties carrying different BPH resistance genes. ● = values for individual varieties; ⊢○⊣ = means and S.E. for each group of varieties; * = significantly higher means than the mean of susceptible varieties.

CG-4G. The quantitative measurement of oxalic acid was facilitated by gas-liquid chromatography after organic acids were methylated with diazomethane reagent. Although the varieties had almost identical total contents of organic acids (4.1-4.7 mg/g fresh leaf sheaths), the susceptible and resistant groups had significantly different oxalic acid concentrations (see figure). In susceptible varieties the average concentration of oxalic acid was 0.18 mg/g fresh tissue. In the 5 groups of resistant varieties, it was 0.34 to 0.45 mg/g fresh tissue. Similarly, the total organic acids in susceptible varieties contained significantly less oxalic acid (4.4%) than those in resistant varieties (7.6-11.0%,), suggesting that oxalic acid is a chemical Factor governing varietal BPH resistance in rice. But this possibility must be ascertained through experiments that examine the differential oxalic acid concentrations in the phloem sap — the dietary source of the BPH — between susceptible and resistant varieties. ■

**Whitebacked planthopper attacks before introduction of new rice varieties in Pakistan**

*M. S. K. Ghauri, entomologist, Commonwealth Institute of Entomology, c/o British Museum (Natural History), London, SW7 5BD, U.K.*

Reports say that the whitebacked planthopper (WBPH) became a serious rice pest in some areas of Pakistan only after the new varieties were introduced. But in 1953 — before the introduction of new rices — this writer was personally involved in the large-scale survey and control of a severe WBPH attack in the Sind. Dr. T. Ahmad reported the survey during the Sixth Commonwealth Entomological Conference in London in 1954. He noted a 60% loss to the WBPH in Sind in 1952 — a fact that corrects the impression that the new rice varieties are solely to blame for pest attack. ■

**Screening for resistance to *Rupela albinella* in Guyana, South America**

*Indal Rambajan, entomologist, Guyana Rice Board, Research and Extension Division, Guyana, South America*

Two species of stem borers attack rice in Guyana: *Rupela albinella* Cr. and *Diatrea sacharalis* F. R. albinella, or the white stem borer, is the more important. It occurs year-round throughout Guyana because of continuous cropping.

Twenty-seven cultivars were assessed for resistance to *R. albinella* at the Rice Research Station, Burma, Guyana, in the 1978 spring crop. A random sample of 40 tillers/cultivar was studied to ascertain infestation. Host plant resistance was determined by the percentage of tillers infested, and the number of egg masses, larvae, adults, deadhearts, and whiteheads per cultivar.

No rice tested showed total resistance, but three rices had high resistance (0–15% infestation) (see table). Moths showed distinct differences in ovipositional preferences for some cultivars. But the number of egg masses per cultivar was not correlated with the number of deadhearts or whiteheads. Plants with larvae or even holes through which adult stem borers emerged showed no whiteheads. Contrary to other reports, multiple infestation by 2 live larvae/internode was observed. ■

**Reaction of cultivars to *Rupela albinella* Cr. in the field. Burma, Guyana, 1978.**

| Cultivar | Infestation (%) |
|---|---|
| Bluebelle | 95 |
| Champion | 88 |
| 916-58 | 72 |
| Starbonnet | 70 |
| 406-20 | 68 |
| Cica 9 | 62 |
| GR 271 | 60 |
| Rustic | 55 |
| GR277 | 50 |
| IR22 | 42 |
| GR281 | 42 |
| Ciwini | 42 |
| 704-36 | 42 |
| 4444 | 42 |
| BG79 | 42 |
| Ceysvoni | 40 |
| "S" | 38 |
| 4440 | 38 |
| GR280 | 35 |
| "T" | 30 |
| 78708 | 30 |
| Cica 7 | 22 |
| 698-72 | 21 |
| 704-80 | 20 |
| "N" | 15 |
| Camponi | 10 |
| 698-71 | 8 |

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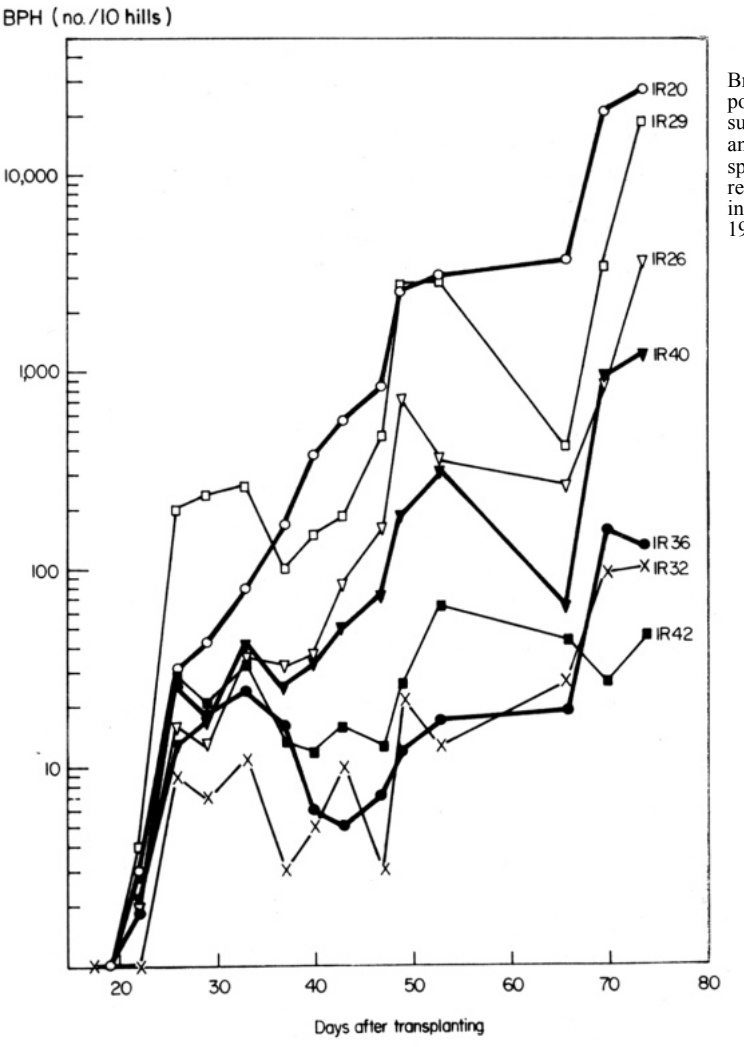
**Brown planthopper populations on resistant varieties treated with a resurgence-causing insecticide**

*G. Aquino and E. A. Heinrichs, Entomology Department, International Rice Research Institute*

Previous laboratory and field experiments at IRRI have shown that the application of certain insecticides to susceptible rice varieties can induce resurgence of brown planthopper (BPH) populations. Because most Philippine farmers grow BPH-resistant varieties, we sought to determine if high BPH populations would develop on resistant varieties sprayed with a resurgence-causing insecticide. The varieties tested were IR20 (no gene for resistance); IR26 and IR29 ( *Bph 1* gene); and IR32, IR36, IR40, and IR42 (bph 2 gene). The entries were sprayed 7 times with cypermethrin in 300 liters water at 20 g a.i./ha. The BPH population was assessed twice a week by counting the BPH in 10 randomly selected hills/replication.

Biotypes 1 and 2 were predominant. The highest populations were on IR20 (susceptible to all biotypes), on IR29 and IR26 (susceptible to biotype 2) (see figure). All varieties with the *bph 2* gene, except IR40, had low populations. In previous field tests IR40 was less resistant to biotype 2 than IR32, IR36, and IR42. The study indicates that BPH populations remain low on varieties that are highly resistant to the prevailing biotype in spite of being sprayed with a resurgence-causing insecticide.




Brown planthopper populations on susceptible (IR20) and resistant varieties sprayed with a resurgence-inducing insecticide. IRRI, 1979.

Resurgence can be a serious problem for farmers when a biotype shifts and a previously resistant variety is rendered susceptible (this happened with IR26 in Indonesia and the Philippines). Although this is speculation, we are concerned about the possibility that application of resurgence-causing insecticides could accelerate biotype selection on resistant varieties. ■

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**Soluble silicic acid and insoluble silica contents in leaf sheaths of rice varieties carrying different BPH-resistance genes**

*T. Yoshihara, postdoctoral research fellow, and K. Sogawa, visiting scientist, Entomology Department, International Rice Research Institute*

In experiments to identify the chemical factors that influence varietal resistance to the brown planthopper (BPH), we found that soluble silicic acid, common in rice plants, strongly inhibits sucking by the BPH. Such inhibitory action was effective at rates as low as 0.01 mg Si/ml. To test the assumption that soluble silicic acid might be involved in BPH resistance, we compared soluble and insoluble silica contents in the rice leaf sheaths of 28 varieties. Soluble silicic acid was extracted with 70% ethanol and measured colorimetrically by the molybdic acid method. Leaf sheaths after ethanol extraction were digested with a mixture of nitric acid, sulfuric acid, and 60% perchloric acid (5:1:2, vol/vol) for the analysis of insoluble silica. The residues were ashed in the digested samples and the silica contents were weighed.

The absence of significant differences in contents of soluble silicic acid and insoluble silica among susceptible and resistant varieties (see table) indicates that silicic compounds do not influence BPH resistance. That was supported by evidence that the resistance level of Mudgo grown in a silica-free culture solution did not change. The silicic acid, usually distributed in the peripheral tissues outside the BPH phloem-sucking area, possibly influences phloem

localization by the inscet, thus preventing an erroneous sap intake from parenchymal tissues. ■

GENETIC EVALUATION AND UTILIZATION

# Drought resistance

### Studies on physiological aspects of drought in rice

*Md. Zahurul Haque and Mujibur Rahman Khan, Plant Physiology Division, Bangladesh Rice Research Institute (BRRI), Joydebpur, Dacca, Bangladesh*

Different aspects of drought resistance in rice were studied in the field and greenhouse at IRRI.

The water-retention capacity at wilting stage of seedlings of different varieties ranged from 2 to 4.11 g/g dry matter. BR3 had the highest water-retention capacity and IR442, the lowest. Wilted seedlings of IR442 could hardly recover when watered.

When watered in the greenhouse 24 hours after wilting at the active tillering stage. the seedlings recovered from 32 to 72% of their length within 3 days. When watered 48 hours after wilting BR3 had the highest leaf-recovery efficiency and Kataktara, the lowest. No variety recovered when watered 72 hours after wilting.

The wilting rates of rice varieties subjected to water stress developed by 1.5% NaCl at the active tillering stage varied widely.

When grown under prolonged desiccation in the field, BR3 gave the highest yield and Chandina the lowest. Root length development varied from 13 to 65 cm among varieties grown under moisture stress in polyvinyl chloride (PVC) pipes.

A variety's drought resistance may vary under different conditions. Drought tolerance and drought avoidance mechanisms may be functions of separate genes. For example, in the PVC-pipe experiment, IR26 had higher resistance in terms of leaf tolerance for wilting, but its roots developed poorly and its ratio of root to shoot length was low. Dular and Mala were moderately tolerant of leaf wilting, although their avoidance capacity was high, as shown by their deep root systems and high root-to-shoot length ratios. Therefore, evaluation for these two drought-resistance mechanisms should be separate. ■

**Soluble silicic acid and insoluble silica contents in rice varieties carrying different BPH resistance genes. IRRI, 1979.**

| Gene | Variety | Soluble silicic acid (mg Si/wet g) | Insoluble silica[a] | |
|---|---|---|---|---|
| | | | mg $SiO_2$/dry g | mg $SiO_2$/wet g |
| No gene | IR8 | 0.121 | 94 | 10.7 |
| | IR20 | 0.113 | 106 | 11.0 |
| | IR22 | 0.128 | 113 | 12.8 |
| | IR24 | 0.121 | 104 | 11.4 |
| | TN1 | 0.125 | 100 | 11.3 |
| *Bph 1* | IR26 | 0.116 | 114 | 10.5 |
| | IR2058-78 | 0.110 | 100 | 13.4 |
| | Mudgo | 0.115 | 97 | 10.8 |
| | CO 10 | 0.109 | 112 | 14.9 |
| | MTU15 | 0.101 | 116 | 13.4 |
| *bph 2* | IR32 | 0.127 | 115 | 13.0 |
| | H5 | 0.118 | 96 | 8.8 |
| | H105 | 0.118 | 107 | 11.0 |
| | CR94-13 | 0.125 | 114 | 11.4 |
| | ASD7 | 0.106 | 91 | 11.6 |
| *Bph 3* | Kuruhondarwala | 0.110 | 112 | 11.4 |
| | Gangala | 0.109 | 107 | 10.8 |
| | Rathu Heenati | 0.120 | 105 | 11.4 |
| *bph 4* | Heenhoranamawee | 0.124 | 91 | 9.8 |
| | Babawee | 0.109 | 105 | 9.3 |
| | Lekam Samba | 0.096 | 91 | 10.6 |
| | Kalukuruwee | 0.103 | 107 | 11.2 |
| | Kahata Samba | 0.121 | 102 | 9.6 |
| Unknown gene | PTB21 | 0.107 | 98 | 13.0 |
| | PTB33 | 0.119 | 124 | 13.5 |
| | Sudu Hondarwala | 0.116 | 100 | 11.9 |
| | Sinna Sivappu | 0.114 | 91 | 11.8 |
| | Balamawee | 0.113 | 102 | 11.6 |
| | Av | 0.115 | 104.3 | 11.5 |

[a] In leaf sheaths after ethanol extraction.

GENETIC EVALUATION AND UTILIZATION

# Deep water

### Deepwater rice yields in Bangladesh

*H. D. Catling, entomologist, Deepwater Rice Pest Management Project; P. R. Hobbs, associate agronomist, IRRI-Bangladesh Project; Z. Islam and Q.M.A. Razzaque, entomology scientific officers, Bangladesh Rice Research Institute, Dacca, Bangladesh*

Results of the first systematic assessment of Bangladesh deepwater rice yields in 1977 were described earlier (IRRN 35 October 1978). The study was continued in 1978.

Growth conditions for deepwater rice were generally favorable; inundation was later but more rapid, and water

depths were 30 cm lower than in 1977. No significant flood damage was reported.

The overall mean yield for 75 crop-cuts was 1.3 t/ha, 9% higher than the mean yield estimated by farmers. The mean yield for the Old Meghna floodplain was higher than that for the lower Ganges and lower Jamuna floodplain. Yields tended to be slightly lower than those of 1977, but the difference was statistically significant only on the lower Ganges floodplain.

Thirty-one varieties were sampled; 15 were new varieties not included in the 1977 survey. The mean yield of 9 varieties exceeded 2.5 t/ha. Varieties were strongly zone specific and, in many areas, particular varieties are grown every year along a topographic sequence at different water depths. As in 1977, highest yields were associated with water depths of 1.5 to 1.8 m. Late-maturing varieties yielded lower than medium and early varieties.

Half of the fields were pure stands of deepwater rice, a third were mixed with aus rice (in shallower sites), and 15% were mixed with other crops (millet, sesame, chilli). Two fields were transplanted deepwater rice following boro rice, 88% were double or triple cropped. A rabi crop of pulses, mustard, or wheat followed deepwater rice in 81%, of the fields. Deepwater rice yields were 23% higher in pure stands but total rice production was higher in deepwater rice mixed with aus rice. Fertilizer applied to 35% of the pure stands and 26% of the mixed stands yielded no higher than those in the unfertilized fields. Ninety-five percent of the fields were weeded an average of 1.9 times. Annual production was often 3 to 4 t/ha of milled product.

No farmer reported using plant protection measures; damage by ear-cutting caterpillars, rats, and ufra nematode was minor. Whiteheads from 75 counts averaged 4.3% The survey probably underestimated damage by rats and ufra and completely overlooked yield loss from infestations of yellow rice borer in the vegetative phase.

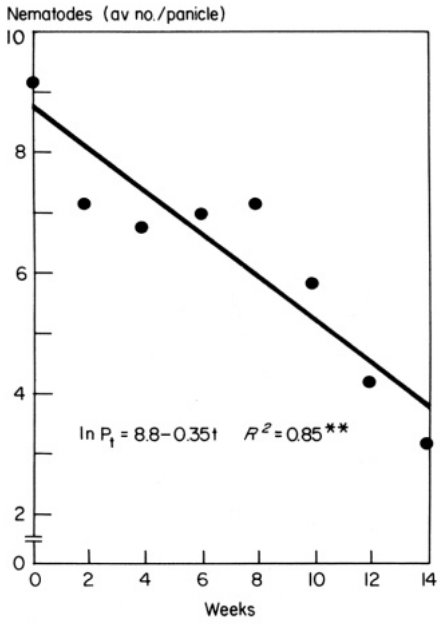
A comparison of 9 sites and 13 varieties for 1977–78 showed no significant changes in the proportion of mixed cropping and cropping patterns. No changes in fertilizer use or amount of weeding were evident. ■

**The overwinter decay of *Ditylenchus angustus***

*P. G. Cox, plant pathologist and L. Rahman, scientific officer, BRRI-Ministry of Overseas Development Deepwater Rice Pest Management Project, Bangladesh Rice Research Institute (BRRI), Joydebpur, Dacca, Bangladesh*

Ufra disease is caused by the rice stem nematode *Ditylenchus angustus* Filipjev, which usually overwinters in crop residue left after harvest in deepwater rice fields in southern Bangladesh. Panicles with typical ufra symptoms (incomplete emergence) were collected from an infested field in late November 1978, randomly sorted into bundles of 10, and left in the laboratory. Every 2 weeks starting early in January, the average number of active nematodes per panicle in one bunch was estimated by extracting the nematodes from each panicle into 10 ml water and counting them with a Peters 1-ml nematode counting slide.

Although there was some indication of variation in the rate of decay of the nematode population (perhaps associated with changes in age structure), the data may be represented by a simple exponential decay model (see figure). The average half-life of the nematode population was about 2 weeks. By mid-April, the population had decayed to less than 1% of that present in January. At the end of April, no live *D. angustus* were detected, although a few free-living nematodes (saprophage *Panagrolaimus*) were still active.




The average number of individual *Ditylenchus angustus* per panicle (logarithmic scale) against time (in weeks from 5 Jan 1979).

*D. angustus* appears well adapted to the deepwater rice cropping pattern in Bangladesh. Much of the crop is sown with the early April rains. Even if infested crop residues are burned during the winter, the nematode manages to survive from one season to the next. This phenomenon helps explain ufra's peculiar distribution – its patchiness in individual fields and its frequent occurrence in southern Bangladesh where deepwater rice is generally harvested relatively late (late November, early December) and sown early (March). It also suggests that ufra in deepwater rice may be controlled at least partly by any procedure that prolongs the winter decay phase, even by only a few weeks. For example, farmers might plant varieties that flower early (although they may have to be harvested by boat), sow later (risking early flood damage), or transplant after the floods arrive (if the water level does not rise too quickly). ■

**Crop losses in deepwater rice due to yellow rice borer**

*H. D. Catling, entomologist, Deepwater Rice Pest Management Project; Z. Islam, entomology scientific officer, Bangladesh Rice Research Institute, Dacca, Bangladesh*

The yellow rice borer *Tryporyza incertulas* (Walker) caused greater damage to Bangladesh deepwater rice in 1978 than in 1977. An average of 25.3% of 4,300 stems removed from 43 farmers' fields were infested in the stem elongation stage. In 10 fields infested

stems exceeded 40%. Two crop loss assessment experiments indicated that substantial yield loss is caused by larval feeding.

To control yellow rice borer, half of a farmer's field received 22 insecticide applications (2 basal applications of carbofuran and 20 sprays of diazinon). The other half served as a check. Grain yields and borer incidence at harvest were assessed in 5 paired plots 16 $m^2$ each. Yellow rice borer was the predominant pest species. Despite the intensive insecticide schedule, 9% of the stems in the treated plot were infested and whiteheads were present (see table). The high level of borer activity in the untreated plot was associated with a 21.0% reduction in yield. Correcting for the infested stems in the treated plot gave a 31% total yield loss.

**Yellow rice borer incidence at harvest and grain yields in a farmer's field at Agrakhola and in a pot experiment at Joydcbpur, Bangladesh, 1978.**

| Treatment | Infested stems (%) | Whiteheads (no./16 $m^2$) | Grain yield (t/ha) | Grain wt (g/pot) | Panicle wt (g) |
|---|---|---|---|---|---|
| | | *Farmer's field, Agrakhola* | | | |
| Insecticide-treated | 9.0 | 14.4 | 3.8 | | |
| Check | 33.2 | 31.2 | 3.0 | | |
| Difference | 24.2** | 22.8** | 0.8** | | |
| | | *Pot experiment, Joydebpur* | | | |
| Pots exposed to borers | 21.5 | – | – | 16.6 | 1.6 |
| Pots not exposed to borers | 1.5 | – | – | 26.2 | 2.2 |
| Difference | 20.0** | – | – | 9.6** | 0.6** |

At Joydebpur, two matched sets of potted Habiganj Aman II plants were allowed to elongate in metal tanks. One set was then exposed to yellow rice borers. Larval feeding reduced grain weight by 36.7%. Yield loss was due mainly to a reduction (27.7%) in panicle weight and, to a lesser extent, to a reduction in panicle number (13.2%). As a result of larval feeding, plants exposed to borers had fewer main stems and basal tillers but compensated for the damage by producing more branches (nodal tillers). ■

GENETIC EVALUATION AND UTILIZATION

# Temperature tolerance

**Reaction of rice varieties to heat injury**

*R. S. Tripathi and K. B. Agrawal, Agricultural Research Station, Borkhera, Kota, Rajasthan, India*

Seventy-three IRRl rice cultivars were sown in raised nursery beds on 2 June 1979 at Borkhera. Germination was good and uniform. When seedlings were 9 days old, the maximum daily temperature rose suddenly and ranged from 45.6 to 47.2°C during a 1 week period.

The degree of seedling mortality due to heat injury varied considerably. The varieties with less than 30% seedling mortality were rated as resistant; those with 31 to 60% mortality were moderately susceptible; and those with more than 60% highly susceptible. The rices were classified according to seedling mortality as follows:

- *Resistant:* Getu, CSR 1, CSR 3, IET5233, IR2053-436-1-2, IR2307-247-2-2-3, IR4227-104-3-3-1, IR4227-109-1-3-3, IR4422-480-2-3-1, IR4573-22-3-17, IR4707-34-3-1, IR4711-34-2-3, IR34816-70-1, IR4819-77-1-2, IR4859-38-3-3, IR5623-97-3, IR5623-189-3, Pokkali, MR359, Nona Bokra, Nona Sail, C23-2-1, C23-51, IR4-11, IR4639-57-3-1, IR153-9430-3, IR26, IR4432-28-5, IR4595-4-1-15, IR4619-48-3-3-6-1, IR4630-22-2-5-1-2, IR4763-73-1-12, IR9884-3-3, IR9884-54-3, IR10168-52-4-2, IR10198-66-2, IR330206-18-3, IR330206-29-2, K19-1, KI14-1, Pattambi 25315, Pattambi 25316, Pattambi 25331, Pattambi 25333, Pattambi 25335, Pattambi 25336, Pattambi 25337, TNAU17069, TNAU13223-7-2, H33, M23, M114, M117, M152, M242, and M432.
- *Moderately susceptible:* IR4829-89-2-1, IR5785-37-1, IR35785-162-3, IR5853-118-5, IR11418-15-2, Lemo, IR42, IR1820-210-2, and TNAU 17005.
- *Susceptible:* Palman 579, IR4870-15-1-1, IR9109-71-2-1, IR11418-19-2-3, and M148. ■

# Pest management and control

**Search for alternate insect vectors of rice ragged stunt disease**

*V. M. Aguiero, R. D. Daquioag, and K. C. Ling, International Rice Research Institute*

The ability of *Nephotettix nigropictus, N. virescens, Recilia dorsalis,* and *Sogatella furcifera* to transmit rice ragged stunt was tested through daily serial transmission with different acquisition access times.

A total of 14,443 seedlings of TN1 were inoculated by 1,182 insects (542 seedlings by 98 N. nigropictus with 2- or 4-day acquisition feeding, 2,290 seedlings by 120 *N. virescens* with 4-day acquisition feeding, 8,546 seedlings by 785 *R. dorsalis* with 1- to 16-day acquisition feeding, and 3,065 seedlings by 179 *S. furcifera* with 2- or 4-day

acquisition feeding). None of the inoculuted seedlings showed symptoms of rice ragged stunt disease. Consequently these species of insects may not be vectors of' rice ragged stunt. ■

**Occurrence of tungro disease in Nepal**

*V. T. John, consultant, and W. H. Freeman, project supervisor, International Agricultural Development Service; and B. B. Shahi, rice coordinator, Rice Research Station, Parwanipur, Nepal*

Rice plants with symptoms characteristic of tungro were observed in the early to mid-tillering stages at the Rice Research Station, Parwanipur, in Nepal's tarai region. The plants were stunted; some leaves, particularly the outer ones toward the tips, were bright orange-yellow. A casual examination of vectors clearly showed the predominance in the area of *Nephotettix virescens,* the most efficient tungro vector.

Insects fed on suspected material were taken to the greenhouse at Khumultar and inoculated under protected conditions to Taichung 176 seedlings at the 3- to 4-leaf stage. Thirty percent of the seedlings reacted positively within 10 days; their symptoms were similar to those described earlier. Parwanipur is near Bihar, India, where tungro occurs. More work is under way to further characterize the virus disease. ■

**Interaction of sugars on the sporulation of *Drechslera oryzae***

*Srikant Kulkarni, K. Ramakrishnan, and R. K. Hegde, Plant Pathology Department, College of Agriculture, Dharwad 580005, Karnataka, India*

Preliminary studies have indicated that mannose, starch, and sucrose enchance *D. oryzae* sporulation in Richards medium. Sporulation was not increased by arabinose, carboxycellulose, fructose, galactose, glucose, rhamnose, ribose, or xylose. Because glucose is abundant in fresh rice tissue, further experiments were conducted to compare glucose with other sugars.

The glucose concentration was varied from 0.4 to 3.2% in a basal medium containing 2.5%, of sucrose, 2.5%, of mannose, and 6.5% starch. Those concentrations maximized sporulation, so they were used in the study.

Glucose at 0.4% suppressed sporulation completey in media containing 2.5% sucrose and 2.5% mannose. In a medium with 6.5% starch, 0.4% glucose failed to completely suppress sporulation but sporulation was reduced with increased glucose concentration (see table). Concentrations of more than 0.8% completely suppressed sporulation.

The effects of cellulose, glucose, and starch on sporulation were further tested, both individually and in combination because those sugars are abundant in the rice plant. Concentrations of those sugars were standardized by using maximum mycelial growth or sporulation observed in preliminary experiments.

Sporulation was observed only in starch and in the carboxycellulose + starch combination. Sporulation was highest in the carboxycellulose + starch combination. ■

**Effect of different carbon sources on sporulation of *D. oryzae.* Karnataka, India.**

| Carbon source and concentration | Spores (%) |
|---|---|
| Carboxycellulose (3.5%) | *a* |
| Glucose (0.8%) | *a* |
| Starch (6.5%) | $88.50 \times 10^4$ |
| Carboxycellulose (3.5%) + glucose (0.8%) | *a* |
| Carboxycellulose (3.5%) + starch (6.5%) | $102.50 \times 10^4$ |
| Glucose (0.8%) + starch (6.5%) | *a* |
| Carboxycellulose (3.5%) + glucose (0.8%) + starch (6.5%) | *a* |

[a] = no sporulation.

**Leaf blast control by seed treatment with systemic fungicides**

*J. M. Bandong, F. L. Nuque, C. Q. Torres, and J. P. Crill, Plant Pathology Department, International Rice Research Institute*

Leaf blast, caused by *Pyricularia oryzae,* is often a serious disease in seedbeds. and may severely damage dryland rice at the seedling stage. Several experiments were conducted to determine the effectiveness of systemic fungicides as seed treatments in *P. oryzae* control. Seeds of the blast-susceptible line IR442-2-58 were treated with powder formulations of the fungicides and then either planted in soil in plastic trays and placed in blast nursery beds, or seeded directly into blast nursery beds. The seedlings were continuously exposed to *P. oryzae* spores produced on inoculated border rows of IR442-2-58. Two weeks after seeding, the plants

**Effect of seed treatment with systemic fungicides on leaf blast control in rice variety IR442-2-58 at 3–6 weeks after seeding.**

| Treatment | | Lesions[a] (mean no./seedling) | | | |
|---|---|---|---|---|---|
| Fungicide | Rate (g/kg seed) | 3 wk | 4 wk | 5 wk | 6 wk |
| CGA49104 50 WP | 4 | 0.015 | 7.7 | 13.6 | 23.5 |
| | 8 | 0.05 | 2.3 | 5.5 | 8.9 |
| | 16 | 0.0 | 1.9 | 1.9 | – |
| | 32 | 0.0 | 0.0 | 0.0 | – |
| | 40 | 0.0 | 0.0 | 0.9 | – |
| PP389 50 WP | 16 | 0.0 | 47.1 | 57.6 | – |
| | 20 | 15.3 | 41.9 | 57.6 | 79.2 |
| | 32 | 0.2 | 19.4 | 19.6 | – |
| | 40 | 0.7 | 5.0 | 9.1 | 8.8 |
| Thiophanate methyl | 20 | 40.0 | 106.0 | 138.4 | 158.8 |
| | 40 | 17.5 | 57.7 | 71.0 | 120.5 |
| Benomyl 50 WP | 20 | 52.0 | 129.8 | 166.6 | 188.4 |
| | 40 | 22.6 | 100.5 | 145.3 | 159.0 |
| Untreated | 0 | 53.7 | 165.0 | 196.1 | 234.7 |

[a] – means no data (experiment was terminated).


Control of leaf blast by treating seeds with CGA49104. Left, 6-week-old plants from untreated seed; right, 6-week-old plants from seed treated with CGA49104 at 8 g/kg seed.

were covered with polyurethane sheets for 3 consecutive nights to create an environment optimum for rapid blast development. The number of lesions per seedling was determined starting at 3 weeks after seeding.

In several preliminary experiments benomyl 50 WP at rates of 8 to 40 g/kg seed gave 71 to 100% leaf blast control for 3 to 5 weeks. Effective as seed treatments in preliminary screening trials were CGA40104 50 WP (Ciba-Geigy Werke Schweizerhalle AG. Switzerland), PP389 (4,5-dihydro-4-methyltetrazole [1,5-a quinazolin-5-one ], Imperial Chemical Industries, Ltd., Fernhurst, England), and thiophanate-methyl.

Several experiments were conducted to compare the effectiveness of the four fungicides as seed treatments.

All four fungicides controlled leaf blast (see table). CGA49104 was the most effective and benomyl 50 WP, the least. Seed treatment with CGA49104 reduced blast by as much as 99% at both the 8 and 4 g/kg seed rate 6 weeks after seeding (see figure). The PP389 and thiophanate methyl formulations resulted in 97 and 72% control of blast, respectively. Phytotoxicity was noted with the higher rates of benomyl 50 WP, CCA49104, and PP389. Plants treated with benomyl 50 WP and PP389 at 40 g/kg seed showed temporary blighting of the leaf tips. The treatment with CGA49104 at 16 to 40 g/kg seed showed slightly delayed germination. At 32 to 40 g/kg seed, the fungicide slightly reduced percentage of germination.

The results suggest that treatment with several fungicides already available commercially or being developed can control leaf blast to acceptable levels early in the growing season. Furthermore, expanded fungicide screening may identify compounds that protect against leaf blast throughout most of the season, or that control blast completely throughout the season, by the relatively inexpensive seed-treatment technique.■

**Histochemical studies of the toxicity of carbofuran to brown planthopper**

*H. T. Feng and C. N. Sun, Entomology Department, National Chung-Hsing University, Taichung, Taiwan*

Brown planthoppers (BPH) treated topically with carbofuran exhibited typical symptoms of carbamate insecticide poisoning: hyperactivity, convulsion, and paralysis.

On the basis of $ED_{50}$ (mean effective dose) and $LD_{50}$ (mean lethal dose) values obtained at different time intervals after treatment, carbofuran could reach the site of action within 30 minutes and kill the insect within 2 hours.

Histochemical demonstrations of acetylcholinesterase (AChe) activity and inhibition by carbofuran were observed using thiocholine incubated with cryostat-frozen sections of BPH. AChe activity was detected only in the central nervous system (CNS). Its inhibition in the peripheral region of the CNS was closely related to symptoms of carbofuran poisoning. AChe activity in dead BPH treated with carbofuran and two other carbamate insecticides methomyl and MTMC — was recovered. On the other hand, its inhibition by diazinon was more obvious; after the death of the BPH no recovery of AChe activity was detected.

The similarity in patterns of inhibition of AChe activity in both brain and thoracic ganglia indicated that carbofuran was translocated throughout the body via the hemolymph.

The preferential inhibition of the peripheral AChe activity of CNS was due, not to differential penetration of carbofuran to the site, but probably to the difference in sensitivity or intrinsic activity of AChe located in the peripheral and central regions.

In vitro experiments showed that AChe from the thorax of the BPH was more susceptible to carbofuran inhibition than that from the head.■

**Parasitic nematodes in continuously cropped uplands**

*A. S. Fofie, field technician, and S. A. Raymundo, pathologist, Rice Research Station, Rokupr, Sierra Leone, West Africa*

Plant growth and vigor progressively

declined at the Makassa farm, site of the upland experimental fields of the Rokupr Station, where rice had been continuously planted since 1974. The 1978 crop was markedly stunted, and affected plants had short, fibrous, and discolored roots. The long, plump, and light-colored roots typical of healthy plants were conspicuously absent.

The following parasitic species were found in soil samples examined:

| Nematode | No./liter |
|---|---|
| *Pratylenchus* sp. | 262 |
| *Helicotylenchus* sp. | 174 |
| *Rotylenchulus* sp. | 178 |
| *Criconemoides* sp. | 115 |
| *Tylenchus* sp. | 67 |
| *Aphelenchus* sp. | 39 |
| Total | 835 |

The exact influence of the nematodes on the decline in plant growth and vigor has not yet been determined. In a 1978 test, yields of plots treated with the soil fumigant D-D were four times those of untreated control plots.

The soil pH at the site declined from about pH 5.2 in 1974 to pH 4.2 in 1978. Other organisms, including fungi and bacteria, were also isolated from the roots of affected plants.

F. E. Caveness, nematologist, International Institute of Tropical Agriculture, assisted in identifying the nematodes. ■

**Correlation between brown planthopper (BPH) and stem rot disease, Annamalainagar, Tamil Nadu, 1973 kuruvai.**

| Productive tillers (no.) | BPH adults and nymphs (no.) | Sclerotia (no.) | BPH location from plant base (cm) |
|---|---|---|---|
| 8 | 17 | 7 | 5 |
| 7 | 27 | 10 | 10 |
| 9 | 40 | 10 | 12 |
| 8 | 40 | 58 | 10 |
| 7 | 47 | 50 | 12 |
| 8 | 50 | 50 | 8 |
| 9 | 51 | 50 | 15 |
| 11 | 55 | 100 | 12 |
| 14 | 55 | 170 | 15 |
| 9 | 62 | 70 | 18 |
| 11 | 65 | 70 | 10 |
| 6 | 80 | 75 | 8 |
| 9 | 87 | 75 | 10 |
| 12 | 90 | 70 | 15 |
| 15 | 100 | 140 | 10 |
| 8 | 105 | 150 | 12 |
| 5 | 107 | 140 | 10 |
| 8 | 110 | 120 | 8 |
| 9 | 127 | 155 | 15 |
| 7 | 160 | 170 | 12 |

## Relationship between incidence of brown planthopper and rice stem rot pathogen

*P. Narayanasamy and P. Baskaran, Plant Protection Laboratory, Faculty of Agriculture, Annamalai University, Annamalainagar, Tamil Nadu, India*

The exploratory, feeding, and ovipositional punctures of the brown planthopper (BPH) seem to predispose rice plants to fungal and bacterial infections. Although information on this possibility is not definite, infection of BPH-infested plants by two mold fungi — *Cladosporium* sp. and *Dematium* sp. — has been reported. Stem rot disease caused by *Sclerotium oryzae* Tullis, a wound pathogen, might occur in BPH-damaged portions of the plant. Therefore, a study was conducted in 1974 kuruvai to determine possible relationships between BPH population and incidence of stem rot pathogen.

Twenty hills of the variety Triveni with high BPH populations and stem rot incidence were selected at the Annamalai University Experimental Farm. Adult and nymph hoppers and black bodies (sclerotia) were counted and the total number was used as the criterion for indexing.

The correlation between the BPH population and the fungal disease was positive (r = 0.80**). Because the stem rot pathogen is basically a wound parasite, its occurrence might be facilitated by damage from insects, by lodging, or by other injuries. The increases in BPH population coincide with increases in sclerotia number (see table).

Thus, when BPH occurs, efforts to combat the stem rot pathogen might be initiated along with BPH control measures. ■

## Effect of fungicides on disease control in dapog

*S. Kannaiyan and K. Govindarajan, Plant Pathology Laboratory, Paddy Experiment Station, Tirur 602025, Chingleput District, Tamil Nadu, India*

Fungicidal control of rice seedling diseases in a dapog nursery was evaluated in December 1978. Seeds were sown at 1 kg/m$^2$. Fungicides were applied as a) a 12-hour wet-seed treatment b) a foliar spray at 10 clays after sowing (DS), and c) a soil drench at 10 DS. At 25 DS, the seedlings were observed for infection by diseases caused by *Rhizoctonia solani, Fusarium* spp.,

**Effect of fungicides on seedling infection in rice, Tamil Nadu, India.**

| Fungicide | Mean seedling infection[a] (%) | | |
|---|---|---|---|
| | 12-h wet-seed treatment | Foliar spray 10-DS | Soil drenching 10 DS |
| • *Rhizoctonia solani, Fusarium* spp., *Phythium* spp.[b] | | | |
| Hinosan | 30.7 | 31.2 | 34.0 |
| Dithane R-24 | 32.3 | 29.6 | 40.5 |
| Bavistin | 39.2 | 30.1 | 32.3 |
| Fytolan | 32.7 | 26.6 | 43.6 |
| Agallol | 16.6 | 27.8 | 34.1 |
| Difolatan | 32.8 | 27.4 | 32.7 |
| Control | 44.3 | 44.3 | 44.3 |
| • *Pyricularia oryzae*[c] | | | |
| Hinosan | 34.23 | 41.39 | 13.48 |
| Dithane R-24 | 20.55 | 17.27 | 12.31 |

*continued on next page*

**Effect of fungicides.** . . . *cont.*

| Fungicide | Mean Seedling infection[a] (%) | | |
|---|---|---|---|
| | 12-h wet-seed treatment | Foliar spray 10 DS | Soil drenching 10 DS |
| Bavistin | 11.84 | 11.16 | 12.38 |
| Fytolan | 38.44 | 36.81 | 24.03 |
| Agallol | 53.07 | 39.42 | 28.17 |
| Difolatan | 55.64 | 45.72 | 27.82 |
| Control | 58.77 | 58.77 | 58.77 |

[a] DS = days after seeding, [b] S.E. = 4.51, CD = 13.40, [c] S.E. = 6.07, C.D. = 18.01.

*Phythium* spp., and *Pyricularia oryzae.* The wet-seed treatment with Agallol most effectively controlled seedling diseases caused by *R. solani, Fusarium* spp., and *Phythium* spp. (see table). All three treatments with Bavistin best controlled blast caused by *P. oryzae.* Chemical control of rice seedling diseases in dapog culture appears promising. ■

# Pest management and control

## INSECTS

### Effect of seedling density on gall midge infestation and rice yields in northern Thailand

*Weerawooth Katanyukul, Sawang Kadkao, Chalerm Sindhusake, and Jirapandu Chantaratad, Entomology and Zoology Division, Department of Agriculture, Bangkok, Thailand*

Rice generally tillers profusely and yields several times more in northern Thailand – where soils are relatively fertile and rain is uniform throughout the growing season - than in the northeast. Previous studies indicated that rice yields under gall midge-infested conditions in the northeast can be increased by planting more seedlings per hill. A study was conducted to determine if seedling density could be increased in the north.

The experiment was in a randomized complete block design, replicated three times. Niew Sanpatawng, a susceptible traditional variety, was transplanted in 4- x 6-$m^2$ plots in a farmer's field at Ban Parauk, Cheingrai province. The seedlings were transplanted 3, 5, and 7/hill at 25-x 25-cm spacing and at 3/hill at 15- x 15-cm spacing. Gall midge-damaged tillers were counted at the peak of infestation (20 Sep 1978).

Rice planted at high seedling density had a higher percentage of damaged tillers (see table). The average numbers of tillers and panicles did not differ significantly among the treatments at 25- x 25-cm spacing, but they differed from the averages for rice planted at 15 x 15 cm. The yield of rice planted at 3 seedlings/hill at 25- x 25-cm spacing was highest, but it was not significantly higher than that of the other treatments at that spacing. The results do not agree with our past observations in the northeast – probably because the high-tillering rice in the north can rapidly compensate for gall midge-damaged tillers. ■

**Gall midge infestation, yield components, and grain yields of Niew Sanpatawng rice planted at different numbers of seedlings per hill and different spacings at Ban Parauk, Cheingrai, Thailand, 1978.**

| Treatment | | Damaged tillers (%) | Tillers (no./hill) | Panicles (no./hill) | Yield (t/ha) |
|---|---|---|---|---|---|
| Spacing (cm) | Seedlings (no./hill) | | | | |
| 15 x 15 | 3 | 34 | 4.8 | 3.2 | 3.4 |
| 25 x 25 | 3 | 23 | 9.0 | 6.9 | 5.0 |
| 25 x 25 | 5 | 25 | 9.4 | 7.2 | 4.6 |
| 25 x 25 | 7 | 32 | 9.5 | 7.1 | 4.9 |
| LSD (5%) | | 6.6 | 0.73 | 0.73 | 0.7 |

### Egg parasites of the yellow stem borer in West Bengal

*Indrani S. Hikim, Rice Research Station, Chinsurah, West Bengal, India*

Natural enemies play an important role in the control of populations of the rice yellow borer *Tryporyza incertulas* (Wlk.). They should be considered for maintaining homeostasis, particularly in the wet season when chemical protection is neither economical nor feasible in low-lying areas of West Bengal. Egg parasites are important components in the faunal composition of natural enemies. Five hymenopteran insects have been noted on yellow borer egg masses at the Chinsurah Station and identified from IBP Handbook 14 as *Tetrastichus schoenobii* Ferr., *Telenomus dignus* Gahan, *Telenomus dignoides* Nixon. *Telenomus rowani* Gahan, and *Trichogramma japonicum* Ashm. The percentage of parasitism was estimated from the emergence of parasitoids from the viable eggs of field-collected egg masses (see table).

The low parasitism in March and April and high parasitism in May and August suggest that parasitoid activity might not be dependent on the density of egg masses in the field. Sterility in borer egg masses was caused by high temperature, particularly in May. Many parasitoids could not emerge from eggs when the air temperature was higher than 32°C. ■

**Egg parasitization of the yellow stem borer at Chinsurah, West Bengal, India.**

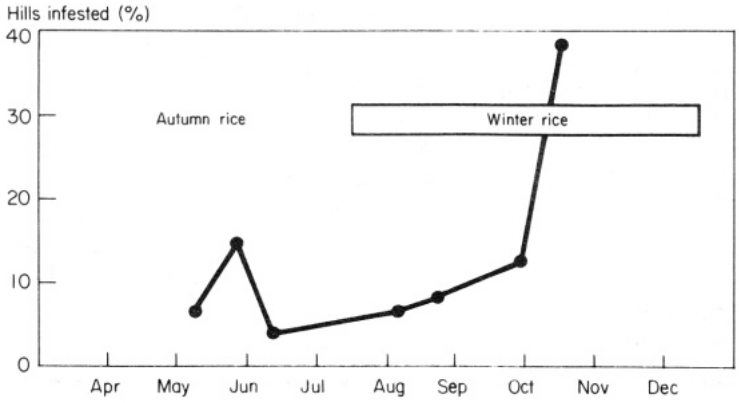
| Month | Egg masses (no.) | Sterile egg masses (no.) | Parasitized egg masses (no.) | Parasitization (%) |
|---|---|---|---|---|
| Feb | 136 | 24 | 70 | 62 |
| Mar | 117 | 25 | 48 | 52 |
| Apr | 136 | 34 | 41 | 40 |
| May | 44 | 24 | 14 | 71 |
| Jun | 45 | 10 | 12 | 34 |
| Jul | 36 | 2 | 16 | 48 |
| Aug | 26 | 2 | 17 | 71 |
| Sep | 35 | 2 | 21 | 63 |
| Oct | 137 | 9 | 70 | 55 |
| Nov | 164 | 54 | 98 | 89 |

**Incidence of whorl maggot in Onattukara, Kerala, India**

*N. K. Sasidharan, A. E. S. Kurup, M. Vijayan, and S. Santha Kumari, Rice Research Station, Kayamkulam, Kerala, India*

The larvae of the rice whorl maggot *Hydrellia philippina* migrate to the furled central whorl of rice leaves and feed on them, nibbling the inner margin. When unfurled, infested leaves are disfigured, with whitish blotches. Plants are stunted and do not tiller satisfactorily.

The extent and periods of whorl maggot infestation were studied in the 1977 winter rice and 1978 autumn rice at Kayamkulam. In autumn, infestation symptoms appeared in the first week of June and reached a maximum level (16%) tile last week of June. Low infestation continued until the first week of July. In winter, infestation commenced soon after planting. Infestation was 8% in September, and 12% in October; then it peaked at 39% the first week of November (see figure). In both seasons, the peak infestation occurred 50–60 clays before harvest.




Extent of infestation and periods of occurrence of *H. philippina* in Onattukara, Kerala, India.

In whorl maggot control, applying a water solution of carbofuran to the root zone 3 to 4 days after transplanting was superior to the conventional broadcast application. ■

**Some predatory spiders on brown planthopper and other rice pests**

*P. B. Chutterjee and S. Dutta, Operational Research Project on Integrated Control of Rice Pests, Pandua 712149, Hooghly, India*

The observation that some insecticides cause resurgences of brown planthopper (BPH) populations has renewed interest in pest parasites and predators. Through periodic surveys conducted front the heading to the ripening stages of rice in Hooghly and Midnapore districts, West Bengal, the following spiders were observed to prey on BPH and other insects:

Family : Araneidae

- *Araneus* sp.

  Host: *Nilaparvata lugens, Nephotettix* spp., Arambagh, West Bengal.

- *Neoscona theisi* (Walckenaer)

  Host: *Nilaparvata lugens, Nephotettix* spp., Balagarh, West Bengal.

Family: Lycosidae

- *Lycosa* sp.

  Host: *Nilaparvata lugens, Nephotettix* spp., *Tettigella spectra,* Panshkura, West Bengal.

- *Pardosa annandalei* (Gravely)

  Host: *Leptocorisa acuta, Recilia dorsalis, Tettigella spectra,* Pandua, West Bengal.

Family: Oxyopidae

- *Oxyopes* sp.

  Host: *Nilaparvata lugens, Nephotettix* spp., Pandua, West Bengal.

Family: Salticidae

- *Marpissa* sp.

  Host: *Leptocorisa acuta, Nephotettix* spp., *Peregrinus maidis,* Pandua, West Bengal.

- *Marpissa decorata* Tikader

  Host: *Nilaparvata lugenss, Nephotettix* spp., *Sogatella furcifera,* Egra, West Bengal.

Family: Tetragnathidae

- *Tetragnatha mandibulata* (Walckcnaer)

  Host: *Leptocorisa acuta, Nephotettix* spp., Pandua, West Bengal.

Family: Theridiidae

- *Theridion* sp.

  Host: *Nilaparvata lugens, Recilia dorsalis,* Balagarh, West Bengal. ■

**Rice mealybug outbreak in Bangladesh, 1979**

*Shamsul Alam, M. Shamsul Alam, and A. N. M. Rezaul Karim, Bangladesh Rice Research Institute (BRRI), Joydebpur, Dacca, Bangladesh*

Widespread and severe outbreaks of the rice mealybug *Heterococcus rehi* were noted in Bangladesh during the drought years 1950, 1957, 1966, and 1972. Drought intensity caused extensive infestation in 1979. Infestation was most serious in late boro (Feb-Jun) and early aus (Mar-Jul) but the insect also attacked the broadcast aman (deepwater rice) crop before flooding, and the transplanted aman crops.

All varieties, traditional or improved, were susceptible. Damage to the aus crop in Rangpur district varied from 0 to 100%. In Bogra and Rangpur districts, the aus crop losses were estimated at 15% and 30%, because of the combined effect of drought and mealybug.

Sheath blight and sheath rot were associated with mealybug infestation. Rice in sandy soil or in soil with low water-holding capacity was attacked more severely than rice in other soils.

The following insecticide sprays are recommended for mealybug control: 0.75 fenthion 50 EC, 0.06% diazinon 60 EC, 0.1% phosphamidon 100, 0.1% dicrotophos 100, and 0.03% fenitrothion 50 EC.

Recommended mechanical and physical control measures include the removal of infested plants at the post-panicle initiation stage, burying them in the soil, and replanting. Extension workers and farmers have been advised to monitor the rice crop regularly during

drought years to prevent the spread of mealybug. ■

**Operational research on the control of brown planthopper in boro paddy**

*S. Acharya Chaudhuri, subject matter specialist (plant protection), All India Coordinated Project on National Demonstrations; G. L. Ray, assistant director of agricultural extension; and A. B. Mukherjee, head, Agricultural Entomology Department, Bidhan Chandra Krishi Viswa Vidyalaya, West Bengal, India*

The brown planthopper (BPH) has been endemic in boro paddy in Khanakul since 1974, and has now spread to other blocks of Hooghly district and into Midnapore district.

To find an effective chemical control measure for BPH, a field experiment was conducted in March-May 1979.

Hand compression sprayers, widely used in the area for BPH control, have not been very effective. Therefore, foot sprayers fitted with high jet lance and double delivery hose were tested in the plots of 15 local farmers. Lindane and other recommended insecticides were tried.

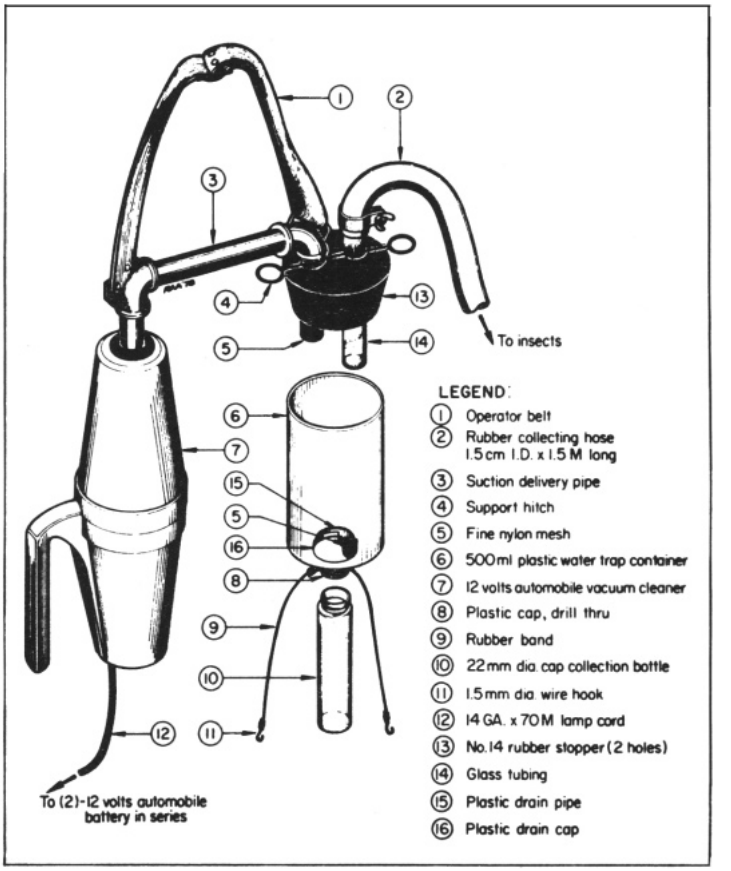
Foot sprayers were more effective both in placing insecticides in the affected zone of the paddy plants and in covering the area. Foot sprayers could cover about four times the area of hand compression sprayers.

Lindane at 2 ml/liter of water was effective in controlling BPH. ■

**The *FARMCOP* suction sampler for hoppers and predators in flooded rice fields**

*F. O. Cariño, P. E. Kenmore, and V. A. Dyck, Entomology Department, International Rice Research Institute*

Research in rice insect ecology has been hampered by the difficulty or obtaining accurate absolute estimates of pest and natural enemy populations. *FARMCOP,* a simple new sampling device, was developed to remedy the problem; the name was derived from the names of the persons responsible for its construction.




The FARMCOP suction sampler. IRRI, 1979.

Sampling with FARMCOP and enclosure in flooded rice field.

FARMCOP consists basically of a light weight automobile vacuum cleaner, two batteries, and a collecting container (see figure). A square wire-frame enclosure of transparent plastic is care-

fully placed over a rice hill and insects are sucked into the container by moving the transparent hose by hand over the plant and water surfaces (see photo). After the machine is turned off, the plastic drain cap is removed and the machine is tipped to drain off any water sucked in. The wire hooks are released, the container is slipped off the rubber stopper, alcohol is squirted into the container, and the newly preserved insects are collected in the removable collection bottle.

The materials needed to construct a FARMCOP suction sampler (excluding batteries) cost about $40, much less than the price of commercial motorized sampling machines. An important feature is that it can sample arthropods on the surface of paddy water. But it is convenient to have two men rather than one man operating the FARMCOP. It requires about twice as much time for sampling as the D-VAC sampler, and the batteries must be recharged frequently.

**Density in transplanted rice of brown planthoppers and predators ripple bugs *Microvelia atrolineata* and spiders *Lycosa pseudoannulata* determined by different sampling techniques.[a] IRRI, 1979.**

| Sampling technique | Brown planthoppers (no./5 hills) | | | Ripple bugs (no./5 hills) | | Ripple bugs (no./5 hills) | |
|---|---|---|---|---|---|---|---|
| | Nymphs | Adults | | Nymphs | Adults | Juveniles | Adults |
| | 34 DT[b] | 34 DT | 55 DT | 83 DT | 83 DT | 83 DT | 83 DT |
| FARMCOP[c] | 22 a | 24 b | 13 a | 216 a | 224 a | 68 a | 8 a |
| D-VAC[c] | 8 b | 48 a | 6 a | 51 b | 184 ab | 28 b | 4 b |
| UNIVAC[c] | 2 c | 25 b | 9 a | 20 c | 64 bc | 19 b | 8 a |
| Visual count | 1 c | 14 b | 8 a | 32 bc | 32 c | 9 b | 3 b |
| Mouth aspirator[c] | 2 c | 17 b | 6 a | 0 d | 0 d | 15 b | 5 b |

[a]In a column means followed by the same letter are not significantly different at 5% level. [b]DT = days after transplanting. [c]Using enclosure.

Great care must be taken to prevent damage to maturing plants when the enclosure is placed over them.

Samples taken in wetland rice by the FARMCOP, the large D-VAC and UNIVAC suction machines, a mouth aspirator, and visual counting were compared. FARMCOP almost always gave the most accurate densities of brown planthopper nymphs and predators such as ripple bugs and spiders. But its estimate of adult hopper density is not the best (see table). Therefore it is necessary to place a cover over the enclosure during the initial phases of sampling a hill to prevent escape of active adults.

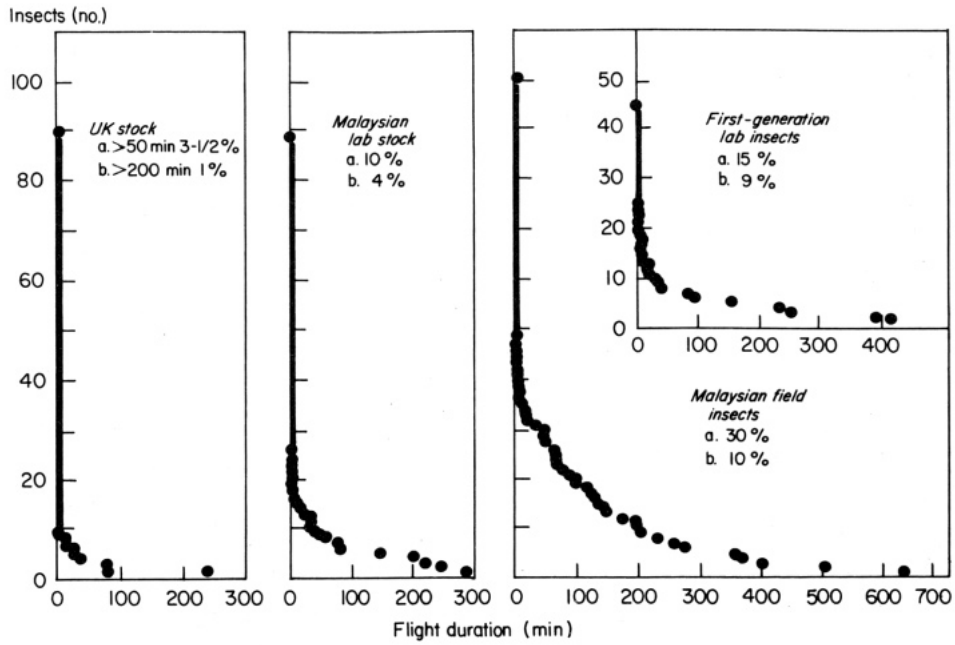
Individuals interested in FARMCOP construction details and operating instructions should write to the Entomology Department, IRRI. ■

**Flight capabilities of the brown planthopper**

*R. J. Cooter, P. S. Baker, D. B. Ogden, Centre for Overseas Pest Research (COPR), College House, Wrights Lane, London, W8 5SJ, UK*

The brown planthopper (BPH) *Nilaparvata lugens* migrates from China and Korea to Japan each spring. There has been much speculation as to whether the BPH in the tropics make migratory flights. The flight capabilities of a field population of BPH were studied at a Malaysian field site in June and July 1978 and the results were compared with those obtained in the COPR laboratory in London.

The adult field insects used developed from late-instar hoppers taken into the laboratory on mature plants removed from naturally infested paddy fields. The laboratory-reared insects came from three sources: 1) BPH stock, of Japanese origin, held in the UK for more than 2 years, 2) caged insects held near the field site for a number of generations, and 3) first-generation adults reared from eggs laid by the field adults brought back to and reared in London. All insects were flown in still air (36–30°C, 80–85% relative humidity, 1,000–2,000 lux) on simple flight balances that indicated the amount of lift being produced. The figure summarizes the experimental results for flight duration. Percentages refer to all macropterous insects tested and therefore include nonfliers. The proportion of field-reared insects that flew for more than 200 minutes was larger than that of any other group.




Numbers of insects and flight duration. Percentage figures refer to all insects tested (including nonfliers).

Two points are of interest. First, the results may serve as a warning to other behaviorists and physiologists working on the BPH that even first-generation

laboratory insects respond differently from field-reared insects, at least in flight performance. Second, the tropical field population contained a proportion of adults capable of sustaining flights of long duration. Questions to be answered include whether, how often, and under what conditions the BPH exploits this capability. ■

# Soil and crop management

### "Catch" crops for summer annual fallow

*A. E. S. Kurup, N. K. Sasidharan, and S. Santha Kumari, Kerala Agricultural University, Rice Research Station, Kayamkulam, Kerala, India*

Eight crops were evaluated to determine the most suitable as a local summer annual (catch) crop after winter rice. The experiment was in a replicated randomized block design and was continued for 3 seasons (1976-78). The test crops included sesame (locally called gingelly) — the traditional catch crop in the area — as well as short-duration tapioca, groundnut, cowpea, sweet potato, mung bean, finger millet, and black gram. During early growth the crops depended on residual soil moisture and, later, on occasional summer showers.

**Performance of crops in summer rice fallow. Kayamkulam, Kerala, India, 1976-78.**

| Crop | Duration (days) | Yield[a] (t/ha) | Returns[b] (US $/ha) |
|---|---|---|---|
| Tapioca[c] | 103[d] | 13.5 | 487 |
| Groundnut | 103 | 2.8 | 842 |
| Cowpea | 67 | 0.6 | 206 |
| Sweet potato | 103[d] | 2.8 | 132 |
| Mung bean | 66 | 0.2 | 61 |
| Finger millet | 103 | 0.5 | 123 |
| Sesame | 76 | 0.3 | 119 |
| Black gram | 78 | 1.3 | 394 |

[a]Mean for 3 seasons. [b]In terms of the prevailing Kerala market rate. [c]Grown in only 1 season. [d]Harvested before full maturity.

Groundnut gave the highest returns (see table). Although it matures 20 to 25 days later than sesame, it can easily fit into the region's current cropping pattern. The 110-day interval between the winter and autumn rice crops is sufficient for a crop of 103 days duration. Tapioca and sweet potato require more than 110 days to mature.

The growth durations of black gram and cowpea are similar to that of sesame; their input costs are low and their returns relatively high. Hence for the local summer rice fallow, groundnut, black gram, and cowpea can be used as summer annual catch crops. ■

### Improved management practices for raising boro seedlings

*Mujibur Rahman Khan and Md. Zahurul Haque, Plant Physiology Division, Bangladesh Rice Research Institute (BRRI), Joydebpur, Dacca, Bangladesh*

Cold temperature in the boro season (min, 10-12°C) retards and stunts the growth of seedlings, especially of modern rices, even if transplanting is delayed to 60 days after sowing. BRRI experiments indicate that improved seedbed management involving the use of farm-yard manure and night cover during the cold season can produce more vigorous seedlings. When transplanted at 30 or 45 days after sowing, such seedlings were taller, had higher dry matter production, and lower mortality. They produced higher yields in a shorter growth period than conventionally grown seedlings. ■

### Root distribution and root biomass production of rice under different soil water regimes in Entisols of northern India

*Rudraraju A. Raju and Suresh C. Varma, Department of Agronomy, Banaras Hindu University, Varanasi 221 005, India*

Rice plants were grown in the greenhouse under four water management regimes: a) saturation (0-0.1 atm ) throughout crop growth, b) saturation up to maximum tillering and flooding up to ripening, C) flooding up to maximum tillering and saturation up to ripening. and d) continuous flooding (water depth of 3 ± 5 cm) throughout crop growth. Plants were spaced 40 cm apart to keep their roots separate.

Horizontal root growth (distance between the plant base and the farthest root cores around the hill) was measured. Cores were taken from various lateral zones around the plant with a 2-cm-diameter core sampler. The roots were spray washed and separated from the cores.

The water management practices at the initial vegetative phase affected root distribution and root mass production

**Root distribution and biomass of rice under 4 water regimes in Entisols, Varanasi, India.**

| Water regime | Root color | Intensity of distribution | Lateral spread (cm) | Vertical spread (cm) | Root biomass production (g/hill) |
|---|---|---|---|---|---|
| Continuous saturation | Deep brown | Sparse | 13 | 26 | 12.2 |
| Saturation + flooding | Brown | Less abundant | 14 | 23 | 13.2 |
| Flooding + saturation | Light brown | Abundant | 16 | 18 | 15.6 |
| Continuous flooding | Lighter brown | Dense mat | 16 | 16 | 18.1 |

(see table). On flooded soil the root system was compact and developed horizontally. The roots were spread like a thick mat all over the superficial soil layers.

In the saturation regimes the rice plants developed vertical root growth. Water roots or nodal roots that started at panicle initiation were absent but appeared in the flooded regimes.

The deep brown color of roots in the saturation regime may have been caused by the formation of ferric compounds that coat root surfaces under oxidized conditions. The flooded regime favors the accumulation of ferrous compounds around the root surface and causes a light brown color. ■

## Effects of foliar spray of *Azotobacter chrococcum* on rice

*S. Kannaiyan, K. Covindarajan, and H. D. Lewin, Plant Pathology Laboratory, Paddy Experiment Station, Tirur 602025, Chingleput District, Tamil Nadu, India*

*Azotobacter chrococcum* occurs in the phyllosphere of water hyacinth *Eichhornia crassipes*. The presence of *Azotobacter* spp. in the phyllosphere of several field crops, vegetables, and ornamental plants has been reported. An attempt was made to determine how the phyllosphere bacterium *A. chrococcum* that occurs with water hyacinth affects the rice crop.

The field experiment was conducted in a randomized block design with four replications in 1977–78 samba (Sep—Jan). A pure culture of *A. chrococcum* (phyllosphere bacterium of water hyacinth) was obtained from the Indian Agricultural Research Institute, New Delhi. The bacterium was grown in Jensen's nitrogen-free medium. The variety ADT31 was grown in a 5- × 4-m plot with various fertilizer treatments, both with and without *Azotobacter* spray. The rice plants were sprayed 3 times with a foliar spray of the *Azotobacter* culture suspension at 100 ml/m$^2$ (16 × 10$^8$ cells/ml) on the 15th, 30th, and 45th day after transplanting.

**Effect of foliar spray of *A. chrococcum* on grain and straw yield of rice.[a] Tamil Nadu, India.**

| Treatment | Grain yield | | Straw yield | |
|---|---|---|---|---|
| | t/ha | Increase over control (%) | t/ha | Increase over control (%) |
| 0–50–50kg NPK/ha | 1.4 | – | 4.1 | – |
| 0–50–50kg NPK/ha + *Azotobacter* spray | 1.7 | 7.6 | 4.5 | 9.0 |
| 50–50–50 kg NPK/ha | 2.2 | 37.3 | 5.6 | 36.4 |
| 50–50–50kg NPK/ha + *Azotobacter* spray | 2.3 | 42.9 | 5.6 | 36.4 |
| 50–50–50 kg NPK/ha + topdressing of 50 kg N/ha | 2.4 | 49.6 | 6.8 | 63.6 |

[a] Differences significant at 5% level. Grain yield: SE = 0.102. C.D. = 0.315. Straw yield: SE = 0.56. C.D. = 1.73.

The foliar *Azotobacter* spray significantly increased grain and straw yields. The plots treated with 0—50—50 kg NPK/ha + *Azotobacter* spray yielded 7.6 and 9.0% more grain and straw, respectively, than the unsprayed plots (see table). Plots treated with 50—50—54 kg NPK/ha + *Azotobacter* yielded about the same as the unsprayed plots. ■

## Azolla as a nitrogen source for rice in northeast Thailand

*Prayoon Swatdee and Wittaya Seetanun, Rice Fertilization Research Branch, Rice Division, Bangkok, and Ubon Ratchathani Rice Experiment Station, Ubon Ratchathani, Thailand.*

The use of *Azolla pinnata* as a substitute for nitrogen fertilizer in rice was evaluated in a field trial. The experiment was in a randomized complete block with four replications. Azolla was seeded at 312.5 kg/ha. Phosphorus was applied in solution with a watering can, and potassium was applied basally. Yield increases attributed to azolla were comparable to those attributed to applied nitrogen (see table). The treatment where azolla was incorporated into the soil after transplanting and that where it was not were equally effective. Yields were similar when azolla was seeded before or after transplanting. One crop of azolla supplied at least 37.5 kg N/ha, equivalent to about 200 kg/ha of ammonium sulfate. ■

**Response of RD7 rice to azolla and chemical fertilizers, Ubon Ratchathani Rice Experiment Station, 1979 dry season.**

| Azolla[a] | Treatment: Fertilizer (kg/ha) N | $P_2O_5$ | $K_2O$ | Azolla fresh wt[b] (t/ha) | Rice yield[c] (t/ha) |
|---|---|---|---|---|---|
| 0 | 0 | 25 | 25 | 0 | 2.3 b |
| 0 | 18.5 + 18.5[d] | 25 | 25 | 0 | 3.4 a |
| Seeded after T | 0 | 12.5 + 12.5[e] | 25 | 17.4 | 3.7 a |
| Seeded after T | 0 | 12.5 + 12.5[e] | 25 | 18.1[f] | 3.7 a |
| Seeded 26 DBT | 0 | 12.5 + 12.5[e] | 25 | 15.1[f] | 3.5 a |

[a] T = transplanting. DBT = days before transplanting. [b] 20 days after seeding (DS). [c] Any 2 means followed by the same letter are not significantly different at the 5% level. [d] Split at T and panicle initiation. [e] Split just after seeding and 10 DS. [f] Incorporated 20 DS.

## Correction of zinc deficiency in direct-seeded rice

*D. B. Mengel, Agronomy Department, Purdue University, West Lafayette, Indiana; and F. E. Wilson, Rice Experiment Station, Louisiana Agricultural Experiment Station, Crowley, Louisiana, USA*

Zinc deficiency in rice seedlings is common in Louisiana. It is usually corrected with a foliar application of zinc (Zn-EDTA). But stands of small seedlings are reduced severely before farmers recognize the deficiency and

apply zinc.

Field experiments were conducted to evaluate the prevention of zinc deficiency by direct application of Zn-EDTA to soil and by coating seed with zinc rather than by foliar sprays of Zn-EDTA. The soil was a Crowley silt loam soil, a Typic Albaqualf with a pH of 7.7. The 0.1 N HCl-extractable soil zinc was 0.5 ppm. The rice was sown at 100 kg seed/ha and adequate NPK was applied.

Without zinc application, rice could not grow on this severely zinc-deficient site. Fewer than 10 plants/$m^2$ survived to produce panicles. Applications of 0.95 kg Zn/ha as Zn-EDTA directly to the soil surface before sowing, and seed coatings of 0.56 and 1.12 kg Zn/ha as ZnO and Zn-lignosulfonate prevented severe stand reduction, and increased panicle numbers and grain yield (sec table). Seed coatings of 0.08 kg Zn/ha and foliar sprays of 0.47 kg Zn/ha were less effective.

In summary, both the application of 0.95 kg Zn/ha as Zn-EDTA to soil, and seed treatment with ZnO or zinc lignosulfonate at 0.56 kg Zn/ha effectively ameliorated zinc deficiency. Higher rates of zinc as seed coatings offered no advantage; lower rates as seed coatings and foliar sprays were less effective.

**Effect of application on plant stand, panicles harvested, and grain yield of Saturn rice, Crowley, Louisiana, USA.**

| Application method | Zinc | | Plants (no./$m^2$) | | Harvested panicles (no./$m^2$) | Yield (t/ha) |
|---|---|---|---|---|---|---|
| | Source | Rate (kg/ha) | Pre-flooding[a] | post-flooding[b] | | |
| | | | *Dry-seeded* | | | |
| No zinc | | 0 | 172 | 107 | 5 | 80 |
| Foliar spray | Zn-EDTA | 0.47 | 183 | 118 | 73 | 470 |
| Soil applied | Zn-EDTA | 0.95 | 215 | 172 | 166 | 1280 |
| Seed coating | Zn-ligno sulfonate | 0.08 | 194 | 118 | 65 | 460 |
| Seed coating | Zn-ligno sulfonate | 0.56 | 194 | 140 | 144 | 1030 |
| Seed coating | Zn-ligno sulfonate | 1.12 | 291 | 237 | 185 | 1370 |
| Seed coating | ZnO | 0.08 | 258 | 97 | 40 | 230 |
| Seed coating | ZnO | 0.56 | 226 | 161 | 199 | 1030 |
| Seed coating | ZnO | 1.12 | 258 | 172 | 153 | 1530 |
| LSD .05 | | | 65 | 65 | 76 | 460 |
| | | | *Wet-seeded* | | | |
| No zinc | | 0 | 280 | 129 | 8 | 60 |
| Foliar spray | Zn-EDTA | 0.47 | 355 | 140 | 65 | 540 |
| Soil applied | Zn-EDTA | 0.95 | 334 | 231 | 165 | 920 |
| Seed coating | Zn-ligno sulfonate | 0.08 | 334 | 118 | 45 | 520 |
| Seed coating | Zn-ligno sulfonate | 0.56 | 387 | 269 | 238 | 1240 |
| Seed coating | Zn-ligno sulfonate | 1.12 | 355 | 226 | 216 | 1200 |
| Seed coating | ZnO | 0.08 | 323 | 108 | 21 | 220 |
| Seed coating | ZnO | 0.56 | 344 | 226 | 222 | 1200 |
| Seed coating | ZnO | 1.12 | 312 | 215 | 242 | 1320 |
| LSD .05 | | | N.S. | 91 | 83 | 520 |

[a]Five days before flooding. [b]Nine days after flooding.

# Rice-based cropping systems

### Ratoon cropping of rainfed rice

*T. Gopala Reddy, M. Mahadevappa, and K. R. Kulkarni, University of Agricultural Sciences, Bangalore 560024, Karnataka, India*

About 179,000 ha of the 685,000 ha of rainfed rice in Karnataka are monocropped. The crop seeded in May and June is harvested in December and January, after which the land lies fallow until the next seeding. The growing season is too short for a second crop of even an early-maturing rice variety. Upland crops have not been successfully introduced. The continuous prolonged monsoon makes the growing of early-maturing rices as first crop impossible. In such a situation, rice ratooning might be advantageous

**Yield data of plant and ratoon crops at Karemane, Karnataka, India, 1977–78.[a]**

| Treatment to plant crop | Plant crop yield (t/ha) | Ratoon crop | | |
|---|---|---|---|---|
| | | N applied (kg/ha) | Yield | |
| | | | t/ha | % of plant crop |
| $F_0N_0$ | 2.1 | 0 | 2.3 | 110 |
| $F_0N_0$ | 2.0 | 50 | 7.0 | 350 |
| $F_0N_{120}$ | 3.0 | 25 | 6.5 | 211 |
| $F_0N_{120}P_{60}$ | 4.6 | 25 | 6.3 | 137 |
| $F_0N_{120}P_{60}K_{60}$ | 5.5 | 0 | 4.2 | 76 |
| $F+N_0$ | 3.1 | 50 | 1.7 | 248 |
| $F+N_0$ | 3.3 | 25 | 6.1 | 185 |
| $F+N_0$ | 3.3 | 12.5 | 4.2 | 127 |
| $F+N_{60}$ | 3.3 | 12.5 | 5.2 | 158 |
| $F+N_{90}$ | 4.2 | 12.5 | 4.6 | 110 |
| Mean | 3.4 | – | 5.4 | 159 |

[a]$F_0$ = no organic fertilizer, F+ = with organic fertilizer.

The good ratooning ability of the variety Intan at the Mercara Agricultural Research Station led to its uses in a

preliminary study of rice ratoon patterns in 1976. On a 1.800-$m^2$ area, the plant crop or main wet season crop matured in 166 days. It was harvested 30 January and yielded 2.2 t/ha. In the same area, a ratoon crop of the same variety was grown without additional fertilizer and with only natural see page and residual water. It yielded 1.7 t/ha in 109 days. It was harvested on 18 May, well before the onset of rains, but the regular second crop of Mangala, Baroda, or CH45 was heavily damaged by continuous rains after flowering. The yield of the ratoon crop. which was 77%, of that of the plant crop, was obtained at little additional cost. A few private farmers in the arcas reported successful ratoon crops of Intan.

Another study of rice ratoon patterns with Intan was conducted on a private farm in Chikmagalur district in the 1977–78 wet season. The experiment was seeded on 10 June 1977, transplanted on 16 July, and harvested on 12 December The ratoon crop was ready for harvest on 24 April 1978, but was harvested on 2 May because it was maintained as a demonstration crop for visitors.

The ratoon crop – which matured in 133 days – generally yielded more than the plant crop (see table). Ratoon crop yields ranged from 76 to 350% of the plant crop yields. At 0 kg N/ha, they averaged 93% of the plant crop yield; at 17.5 kg N/ha, 132%, at 25 kg N/ha, 180%; and at 50 kg N/ha, 300%. The ratoon crop had 24% shorter growth duration and 59% higher mean yield than the plant crop.

Because the plant crop treatments were not originally planned for a ratoon crop study, a lack of replications limits the data's value. But the treatment that received the recommended dose of NPK in the wet season and no N in the ratoon crop might be close to an average farm situation. Interestingly ratoon yields were high even in plots where the plant crop yields were low. ■

**Productivity and management of farmers' transplanted aman rice on a rainfed double rice cropped area of Bangladesh**

*Md. Nazrul Islam Miah, M. Zahidul Hoque, and Peter R. Hobbs, Division of Rice Cropping Systems, Bangladesh Rice Research Institute (BRRI), Joydebpur, Dacca*

During the 1975 and 1976 aman seasons, crop-cut studies were conducted in farmers' fields in the BRRI project area where 2 rainfed rice crops/year are grown. T. aman is grown after harvest of either direct seeded or transplanted aus rice. The choice of a high yielding variety (HYV) or local variety of T. aman is largely dependent on the preceding crop. Direct seeded local aus crops provide a long growing season for rainfed HYV T. aman. In general, the local photoperiod-insensitive variety is preceded by HYV transplanted aus. while the HYV T. aman is preceded by a short-duration direct-seeded aus rice. Usually a HYV or a local variety of T. aman is transplanted in late July lo early August and harvested in November and December.

Rice samples were taken from 5-$m^2$ areas in farmers' fields during harvest. Each sample was threshed, cleaned, and weighed, and the moisture content was determined in the field. The yield of each variety was computed at 14% moisture. The farmers were interviewed to determine the level of crop management used in each plot.

**Data on average productivity and farm management of Transplanted aman rice collected by crop-cuts in the 1975 and 1976 aman seasons, BRRI, Bangladesh.**[a]

| | 1975 | | 1976 | |
|---|---|---|---|---|
| | HYV | Local | HYV | Local |
| Samples (no.) | 113 | 174 | 28 | 100 |
| Yield (t/ha) | 3.3 | 2.3 | 2.8 | 2.2 |
| Yield range (t/ha) | 1.0–4.7 | 1.2–3.4 | 1.2–4.3 | 1.0–3.8 |
| Field duration (days) | 116 | 119 | 120 | 113 |
| Plowings (no.) | 5.1 | 5.2 | 4.9 | 5.1 |
| Harrowings (no.) | 5.4 | 5.7 | 5.0 | 5.6 |
| Date transplanted | 3 Aug | 31 Aug | 31 Jul | 16 Aug |
| Seedling age (days) | 37 | 43 | 34 | 44 |
| Farmers using N-P-K (%) | 94-84-2 1 | 80-75-6 | 91-57-19 | 88-76-13 |
| Kate of fertilization (kg N-$P_2O_5$-$K_2O$/ha) | 47-47-15 | 41-43-31 | 55-57-37 | 45-37-34 |
| Farmers that did not weed (%) | 20 | 35 | 38 | 53 |
| Farmers that weeded once (%) | 46 | 47 | 48 | 41 |
| Farmers that weeded twice (%) | 31 | 16 | 14 | 3 |
| Farmers that weeded twice (%) | 3 | 2 | 0 | 3 |
| Weed control index[b] | 1.9 | 2.4 | 1.6 | 2.0 |
| Farmers that used pesticide (%) | 36 | 15 | 33 | 18 |
| Monthly rainfall (cm) Aug, Sep, Oct, Nov | 25.0, 31.7, 37.4, 0.8 | | 30.5, 17.2, 7.3, 0.8 | |

[a] High yielding varieties were Pajam, IR5, IR20. and BR4. The local varieties were Nizersail, Chandrasail, Chinigura, Larhibilash, Kaocha, Binni, and Tulsimalati. [b] 1 = excellent, and 5 = poor weed control.

The HYV significantly outproduced local varieties in both years (see table); however, variability among samples was larger in 1975 than in 1976. The average productivity of the HYV was about 15% higher in 1975, probably because of the rainfall pattern during flowering and grain filling. The HYVs were transplanted earlier and remained in the field longer than the local varieties. The HYVs are transplanted early to escape cold during flowering. The local photoperiod-sensitive aman varieties can be transplanted later because they flower before the cold nights begin. Their low yield is attributed mainly to a shorter vegetative phase and fewer tillers per plant.

Farmers generally gave higher management levels and applied more fertilizers at more balanced doses to the HYVs than to the local rices. ■

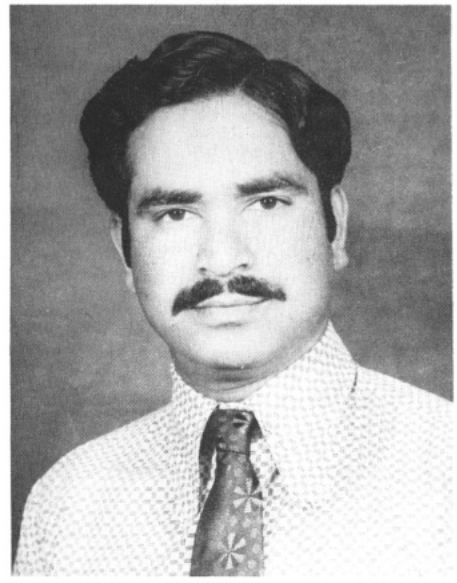
# Announcements

**E. P. Alyoshin elected to USSR Academy**

In the May 1979 session of the All-Union Agricultural Academy of the USSR, E. P. Alyoshin, director of the All-Union Rice Research lnstitute and chief of the plant physiology and biochemistry departments of the Kuban Agricultural Institute, was elected corresponding member. ■

**Dr. S. Kulkarni receives Jawaharlal Nehru award in India**

Dr. Srikant Kulkarni junior pathologist, All-India Coordinated Wheat Improvement Project, Agricultural College, Dharwar, Karnataka, India, recently received the *Jawaharlal Nehru Award* for outstanding postgraduate research in plant pathology for 1978. The award was lor his Ph D thesis "Epidemiology and control of brown leaf spot of rice caused by *Drechslera oryzae* in Karnataka." ■



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