1974 Report
California Rice Research Board

PROJECT and TITLE: RP-2. Cause and control of rice diseases

PROJECT LEADER: R. K. Webster

PERSONNEL: C. M. Wick, J. Bolstad, R. Jones
(Dr. R. Keim and Dr. S. Ferreira were associated with the project during parts of 1974. Both have now left the project).

OBJECTIVES:

The primary objective of this project is to determine the occurrence and significance of rice diseases in California and through studies on their etiology and epidemiology, develop economic control measures. The epidemiology of stem rot disease caused by Sclerotium oryzae has received major emphasis during the past year, particularly in regard to residue management i.e. (incorporation vs. burning), predisposition, (herbicides, stand density and nutrition), heritability of resistance, biology of the pathogen (development and survival) and potential of stem rot control with fungicides.

The possible discontinuation of Difolatan as a seed treatment for control of seed rot and seedling disease prompted the necessity to conduct seed treatment trials seeking alternative chemicals.

WORK IN PROGRESS:

I. A. Biology of Sclerotium oryzae and epidemiology of stem rot disease.

B. Heritability of resistance to stem rot in rice.

C. Inheritance of virulence and fitness attributes in S. oryzae.

D. Biotic and abiotic factors affecting inoculum production and survival of S. oryzae and their relationship to potential control of stem rot disease.

Rationale for these studies is embodied in the concept that the better we understand a causal agent and the factors that affect its growth, development, survival, and interaction with its host and environments, the greater our chance for success in disease control.

II. Efficacy of fungicides for controlling stem rot disease.

III. Search for fungicides to replace difolatan as a rice seed treatment.

IV. Rice residue management: the effects of residue incorporation vs. burning on inoculum level, stem rot disease severity and yield reduction in rice.

EXPERIMENTS COMPLETED and MAJOR ACCOMPLISHMENTS:

I. Biology of S. oryzae and epidemiology of stem rot disease.

A. Evaluation of virulence in isolates of Sclerotium oryzae: A test to measure the disease reaction of individual S. oryzae isolate-host combinations was developed by estimating the ability of isolates to induce lesions or kill 25-day-old Colusa rice seedlings

Since the ability of isolates to incite lesions was correlated with the ability to kill seedlings and because results from the seedling test correlated with the results on mature plants in the greenhouse, virulence of individual isolates can be determined by measuring their ability to incite lesions.

When Colusa and Earlirose rice were compared by the seedling test, the initiation of lesions was delayed more on Colusa, indicating Colusa is more resistant to S. oryzae than Earlirose. Therefore, the seedling test can be used to evaluate rice varieties for stem rot resistance as well as virulence in S. oryzae.

B. Heritability of stem rot resistance in rice and the inheritance of virulence in S. oryzae: Comparison of 10 rice varieties revealed different levels of resistance to stem rot disease. When progeny from crosses between varieties differing in disease reaction were evaluated, stem rot resistance was found to be quantitatively inherited and transferable from a more to a less resistant variety. Heritability of resistance in a Bluebelle X Colusa cross was 43.5%.

A large potential for variation in virulence among isolates of S. oryzae was observed. When single ascospore progeny of crosses of isolates differing in virulence were evaluated, results indicated that virulence in S. oryzae is quantitatively inherited and transgressive segregation of factors controlling virulence in the progeny was evident. At the population level, there is a tendency for virulence to be stabilized at an intermediate level. Since the perfect stage of S. oryzae (Magnaporthe salvinii) can be found in nature on diseased rice stems, this mechanism may operate in nature suggesting that highly virulent isolates of the pathogen may not predominate.

C. The relationship of sporulation, sclerotia production and growth rate to virulence and fitness of S. oryzae. Attributes assumed likely to contribute to the relative success or fitness of S. oryzae were studied in 20 isolates. Quantitative differences in the rate and amount of conidia and sclerotia produced and growth rate did not correlate with an apparent lack of fitness among isolates extreme for virulence or an observed skewed distribution in nature of isolates carrying the "A" mating type allele. Production of conidia and sclerotia and growth rate are probably inherited independently of each other, virulence and mating type since no relationships between these characters were revealed with regression and correlation analysis.

D. Fungistasis of sclerotia of Sclerotium oryzae: Sclerotia of S. oryzae germinate readily on distilled water but not in rice field soils. Soil inhibition of sclerotial germination apparently can only be effected by the presence of living cellular organisms because it can be annulled by filtration (0.45μ), heat sterilization or by a 7-day period of soil microbial inactivity (dry at 1 C). Certain bacteria, actinomycetes or fungi were found to produce inhibitory substances when incubated on potato-dextrose agar while bacteria were found to do so apparently with only a substrate of sclerotial exudate. Organisms from a field soil with disease-free rice caused inhibition of sclerotial germination of higher magnitude than those from field soil endemic with stem rot disease.

The significance of these results is related to our ability to manipulate populations of soil microflora in rice fields as a potential form of biological control. Studies on this aspect are included in the following section.

II. Rice residue management:

A. A five-year study on the effects of residue incorporation versus burning on inoculum level, stem rot disease severity and yield reduction in rice was completed this year. Results obtained can be summarized as follows: burning rice residue minimizes inoculum levels of the stem rot organism available for affecting rice crops

in the following season. Incorporation of residue enhances inoculum level buildup. Increases in stem rot disease and accompanying decreases in yield resulted in all treatments where residue was incorporated over the entire period of the study. Conversely, no increase in inoculum level, disease severity or yield loss was observed over the 5-year period when residue was burned.

A complete separate report of our studies at three sites is being prepared and will be forwarded in the near future.

B. Quantitative effects of incorporating rice residue on populations of soil microflora: Populations of dominant members of the microflora in rice field soil were studied in relation to total populations of microorganisms. The relative populations of 13 fungi differed significantly either in different depths of rice soil or under different regimes of tillage and soil incorporation of rice straw. Total populations of bacteria or actinomycetes were generally unaffected by various residue management and tillage practices but were affected by soil depth.

C. Relative vertical distribution and survival of Sclerotium oryzae under various tillage methods: The effects of various residue management practices on vertical distribution and viability of sclerotia of S. oryzae were compared as they relate to the survival and availability of inoculum under continuous rice culture. Open field burning of residue is most effective in minimizing inoculum levels. When residue is incorporated, moldboard plowing results in burying a high percentage of the surviving inoculum rendering it unavailable to infect water-sown rice. A differential survival of sclerotia at various soil depths was observed.

III. Efficacy of the fungicide Duter as a control for stem rot disease:

The effect of a single application of Duter at 1 lb/acre at the late tillering stage on stem rot severity and yield is summarized below:

Treatment	Stem rot rating (1 = healthy - 5 = severe)	Yield/cwt/A 14% moisture
Duter 1 lb/A	1.67	51.2
Check	2.32	46.3

It is apparent that Duter had a significant effect in controlling stem rot. Further study is needed to determine the feasibility of obtaining registration for use of chemicals in conjunction with burning residue to control the stem rot disease.

IV. Search for fungicides to replace Difolatan as a rice seed treatment:

Even though Difolatan is very effective as a rice seed treatment to prevent seed rot and seedling disease, it has undesirable effects on workers at seed plants when not used cautiously. Consequently, trials to determine effective replacements were carried out this year. Captan in combination with certain copper-containing compounds was as effective in most trials as was Difolatan. We will continue with this phase to insure that suitable seed treatment is available for California growers.

WORK PLANNED:

Detailed in 1975 project proposal to the Board.

IMMEDIATE APPLICABLE RESULTS:

1. An understanding of rice soil microflora and their possible exploitation in minimizing stem rot inoculum has been obtained.

2. It is now apparent that differences in susceptibility to stem rot between varieties is heritable and could be transferred in the plant breeding program. Reliable methods for quickly screening large numbers of progeny have been developed.

3. Burning of rice residue is our best means of minimizing stem rot disease and growers should continue this practice.

4. The probability that stem rot could be controlled by development of more resistant varieties, or fungicide applications is hopeful. The use of these methods should be pursued with the expectation that best results will be obtained when either or both are used in conjunction with burning residue.

5. In the event that Difolatan be eliminated as a rice seed treatment fungicide, effective replacement chemicals have been identified.

EVALUATION OF PROJECT:

A. Residue management: At the outset of this phase of the project, little was known of the potential impact elimination of open field burning of rice residue could have on our present system of rice culture. The data accumulated over the last five years clearly indicate such would result in considerable loss from at least two aspects: 1) reduced yields due to increased stem rot disease and 2) increased production costs necessary in the operations of incorporating residue and preparing seed beds for subsequent rice crops in fields where residue was incorporated. The uncertainty of future fuel, labor, and equipment costs makes it difficult to estimate precise costs of the latter but it is evident they would be substantial.

Perhaps the greatest benefits to be derived from results obtained through this project are that it is now possible for the rice industry to respond to queries and critics regarding burning of rice straw from a factual basis.

We now have substantial scientific data on the biology of S. oryzae and a sound background in experimental methodology to obtain needed answers as future questions arise. This is particularly true as we approach the many unknowns regarding suggested alternatives to burning such as removal from fields, livestock feeding of straw, etc.

Efforts to develop chemical control and increased disease resistance must be continued. I believe these goals are possible to achieve but should be used in conjunction with burning. This is based mainly on the fact that burning does not eliminate stem rot disease, but it does minimize its detrimental effects and prevent its buildup in areas where it is of lesser significance. This must be our objective if the California rice industry is to realize its potential role of maximum food production in the future.

PUBLICATIONS or REPORTS:

1. Ferreira, Steven A. 1974. Stem rot of rice: an evaluation of resistance in rice (Oryza sativa L.) and virulence and fitness in Sclerotium oryzae. Ph.D. thesis, University of California, Davis pp. 73.

2. Ferreira, S. A., and R. K. Webster. 1974. Evaluation and inheritance of virulence in Sclerotium oryzae. No. 383. 66th Annual Meeting, American Phytopathological Society, Vancouver, B.C. (Aug. 11-15).

3. Grigaric, A. A., et al. 1974. Crop residue management by soil incorporation. California Air Resources Board Project 2-908-1, 34 p. mimeo.

4. Keim, Randolph. 1974. Effects of biotic and abiotic factors on viability of Sclerotium oryzae. Ph.D. thesis, University of California, Davis pp. 63.

5. Keim, R., and R. K. Webster. 1974. Nitrogen fertilization and severity of stem rot of rice. Phytopathology 64:178-183.

6. Keim, R., R. K. Webster, and C. M. Wick. 1974. Factors affecting germination and survival of sclerotia of Sclerotium oryzae. Proc. 15th meeting Rice Technical Working Group, Fayetteville, Arkansas, Mar. 11-14, p. 44.

7. Webster, R. K. 1973. Report to California Rice Research Board, Project RP-2.

8. Webster, R. K. 1974. The effect of rice residue incorporation on severity of stem rot disease. 12 p. mimeo. Dept. of Plant Pathology, UCD.

9. Webster, R. K. 1974. Relationship between inoculum level, disease severity and yield reduction in stem rot of rice. No. 388, 66th Annual Meeting, American Phytopathological Society, Vancouver, B.C. (Aug. 11-15).

10. Webster, R. K., C. M. Wick, J. Bolstad, and R. Keim. 1974. Manipulating culture practices to minimize stem rot disease of rice. Proc. 15th meeting Rice Technical Working Group, Fayetteville, Arkansas, March 11-14, p. 71-73.