**ANNUAL REPORT**
COMPREHENSIVE RESEARCH ON RICE
January 1, 1989 - December 31, 1989

**PROJECT TITLE:** Cause and Control of Rice Diseases

**PROJECT LEADER AND PRINCIPAL UC INVESTIGATORS:**

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Project Investigators: R.D. Cartwright, Research Associate
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**LEVEL OF 1989 FUNDING:** $36,081

**OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:**

Understanding the etiology and epidemiology of California rice diseases continue to be our long term objectives. Knowledge acquired through this research is used to devise improved disease control methods for growers. Due to restrictions on the use of chemical control methods in California, our research has concentrated on cultural practices and microbiological components of rice culture that influence disease incidence and severity. Our long range applied goal is to determine those management practices and microbiological components that can be used to minimize yield losses due to disease.

The major rice pathogens in California survive from season to season in the rice residue, so much of our research continues to emphasize residue management. Burning residue has been the most effective and economical cultural practice for controlling diseases in continuous rice production systems, however, this practice may not continue to be available. As we pointed out last year, many growers are investigating alternative rice management systems to sustain efficient and profitable rice production even if burning is eliminated. Several growers have experimented with alternate year rotation, winter legumes, summer fallow (wet and dry), and various straw incorporation techniques. We have investigated several of these options in a general way over the years, but have increased our efforts the past two years in determining the effect of these systems on rice diseases.

In addition to monitoring these management systems, we have continued our investigations on enhancement of straw degradation and destruction of overwintering pathogen inoculum using saprophytic microbes. In addition, a major effort in isolating, identifying, and testing various microorganisms for use as biocontrol agents of stem rot during the growing season was initiated.

Studies to screen alternative fungicides for seed treatment continued but due to warm April and May temperatures, little difference in treatment was noted. Unfortunately, Captan was removed as a rice seed treatment and some of the promising experimental materials we have tested have been further restricted. The prospects are not good for registered chemical seed treatments in the future.

Evaluation of resistance of California commercial cultivars to stem rot, aggregate sheath spot, and bordered sheath spot was continued in the greenhouse with emphasis on components of yield loss, and effect of disease combinations.

Specific Objectives for 1989 were:

(1) Continue studies on enhancement of rice residue degradation and destruction of overwintering inoculum of stem rot, aggregate sheath spot, and bordered sheath spot using saprophytic microbes.

(2) Continue monitoring of various rice culture systems with regard to residue management and disease levels.

(3) Continue isolation and testing of in-season biocontrol agents for stem rot.

(4) Evaluate resistance of commercial California rice cultivars with respect to stem rot, aggregate sheath spot, bordered sheath spot and combinations of the three.

(5) Continue evaluation of chemical seed treatments to replace Captan and Kocide.

Field research in 1989 was conducted in grower's fields in Butte County, Colusa and Sutter counties and the UC Rice Research Facility at Davis. Laboratory and greenhouse studies were conducted in University of California, Davis facilities.

**SUMMARY OF 1989 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVE:**

Objective 1: We further defined this study by concentrating on the saprophytic fungi of rice stubble and selecting one primary site for monitoring and experimental efforts - a commercial M-201 field in Butte County.

M-201 rice stubble was collected approximately every two weeks from December 5, 1988 to April 10, 1989. Burned-standing, non-burned standing, burned/rolled, and non-burned/rolled stubble was collected and analyzed. Cultural methods were used to determine fungi present and their relative populations.

We have tentatively identified the fungi isolated from the stubble (Table 1) and have also listed the probable ecological position of each fungus with respect to the residue. These ecological groups change in composition and population during stubble decomposition. Changes over time are illustrated in Figure 1a-1d (on the following page).

**Table 1. Fungi isolated from decomposing rice stubble 1988-1989.**

| Isolate No. | Name | Comments |
|---|---|---|
| 89-1 | Cladosporium spp. | Primary colonist |
| 89-2 | Acremonium strictum | " " |
| 89-3 | Acremonium terricola | " " |
| 89-4 | Unidentified yeast | Year-round epiphyte |
| 89-5 | Sporobolomyces sp. | Primary colonist |
| 89-6 | Penicillium sp. (1) | Occasional resident |
| 89-7 | Epicoccum purpurascens | Primary colonist |
| 89-8 | Nigrospora sp. | " " |
| 89-9 | Alternaria alternata | " " |
| 89-10 | Microdochium bolleyi | Secondary colonist |
| 89-11 | Candida spp. | " " |
| 89-12 | Penicillium sp. (2) | " " |
| 89-13 | Penicillium sp. (3) | " " |
| 89-14 | Penicillium sp. (4) | " " |
| 89-15 | Zygomycete (Mucor) | Sugar Fungi |
| 89-16 | Fusarium sp. (1) | Secondary colonist |
| 89-17 | Fusarium sp. (2) | " " |
| 89-18 | Curvularia lunata | Occasional primary colonist |
| 89-19 | Sclerotium oryzae | Primary colonist and pathogen |
| 89-20 | Rhizoctonia oryzae-sativae | " |
| 89-21 | Gelasinospora sp. | Secondary colonist of burned straw |
| 89-22 | Paecilomyces sp. | Secondary colonist |
| 89-23 | Phoma sp. | Secondary colonist |
| 89-24 | Binucleate Rhizoctonia | Late season colonist |
| 89-25 | Sistotrema sp. | " |
| 89-26 | Trichoderma sp. | Occasional colonist |
| 89-27 | Gelasinospora retispora | " |
| 89-28 | Aspergillus sp. | Late season colonist |
| 89-29 | Phoma sp. (2) | Occasional colonist |
| 89-30 | Acremonium sp. (3) | " |
| 89-31 | Sclerotium hydrophilum | Occasional primary colonist of unburned stubble. |
| 89-32 | Multinucleate Rhizoctonia | Late season colonist |

The succession of fungi in decomposing rice stubble appears to follow that established in the literature for other crops. Primary colonists (such as Cladosporium) colonize the rice during

Fig. 1a

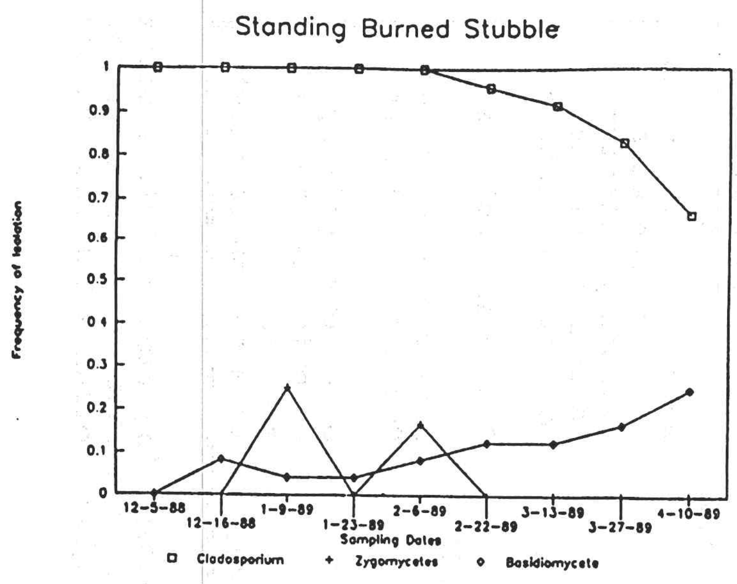



Fig. 1c

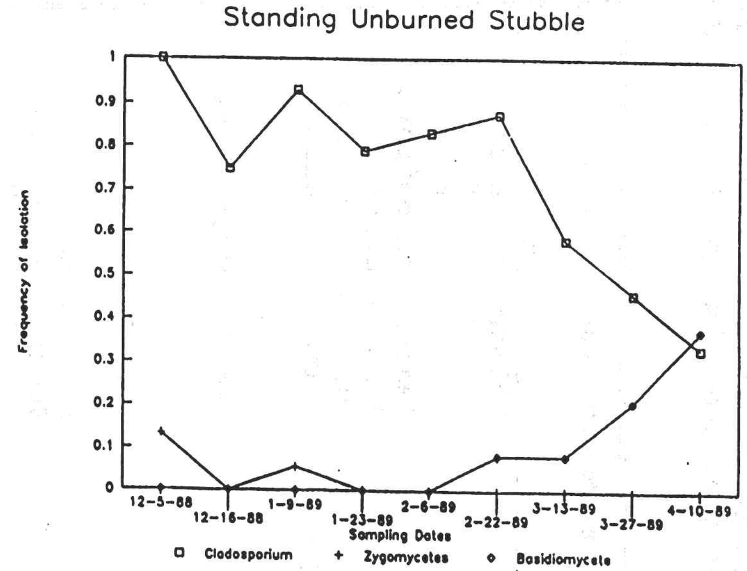



Fig. 1b

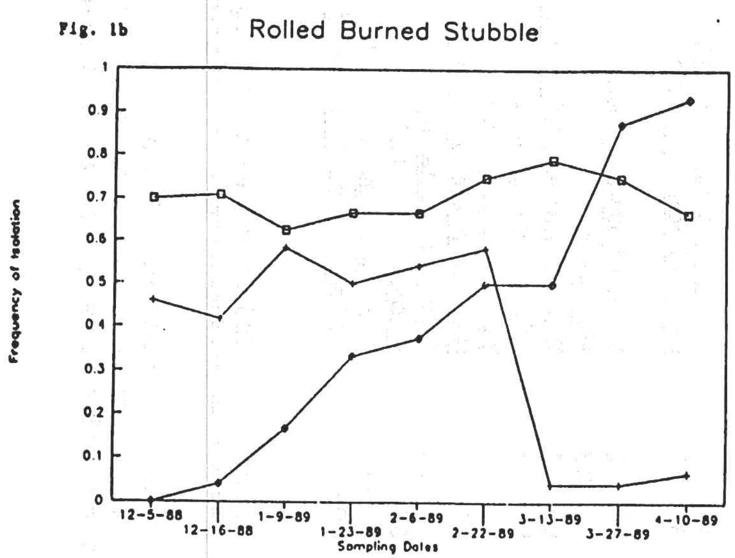
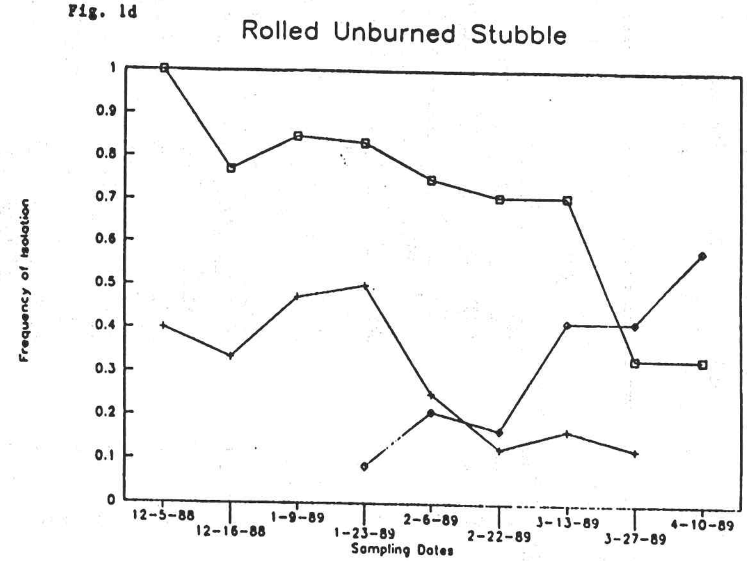



Fig. 1d



the growing season and dominate the residue at the beginning of the decomposition cycle. Depending on environmental conditions - including degree of soil contact - these resident fungi are gradually displaced. First a flush of Zygomycetes and secondary colonizers (exemplified by Mucor sp.) capable of fast growth on the few soluble sugars, etc. available occurs, followed by late season secondary colonists (Binucleate Rhizoctonia in our example) capable of degrading complex straw polymers.

Our interest in this successional process is based on the hypothesis that artificially moving late season decomposers to the front end of the season (fall) would enhance residue degradation and reduce survival of overwintering rice pathogen inoculum associated with the stubble.

In order to test this, we began a preliminary field test in the fall of 1989 using several fungi identified as late season colonists, capable of low temperature growth, and efficient straw decomposers in lab tests. We have listed part of the results from lab screening trials of different rice residue fungi (Table 2). The five best decomposer fungi in this test have been inoculated onto weighed amounts of rice stubble in nylon mesh litter bags and placed in test plots in Butte County. These bags will be collected at monthly intervals beginning in January to determine weight loss, fungi present, and effect on pathogen inoculum contained in the straw.

**Table 2. Partial Results of 10C Decomposition Studies in the lab 1988-1989.**

| FUNGUS | | PER CENT INCREASED WEIGHT LOSS ABOVE CONTROLS |
|---|---|---|
| 89-1 | Cladosporium sp. | -1.9 |
| 89-2 | Acremonium strictum | 1.6 |
| 89-4 | Unidentified gray yeast | 13.2 |
| 89-7 | Epicoccum purpurascens | -5.6 |
| 89-9 | Alternaria alternata | 16.1 |
| 89-10 | Microdochium bolleyi | 6.9 |
| 89-12 | Penicillium sp. (2) | 5.0 |
| 89-13 | Penicillium sp. (3) | 24.8 |
| 89-14 | Penicillium sp. (4) | -1.2 |
| 89-16 | Fusarium sp. (1) | 14.5 |
| 89-21 | Gelasinospora sp. | 14.1 |
| 89-23 | Phoma sp. | 9.9 |
| 89-24 | Binucleate Rhizoctonia | 33.2 |
| 89-26 | Trichoderma sp. | 6.3 |
| 89-28 | Aspergillus sp. | 19.1 |
| 89-32 | Multinucleate Rhizoctonia | 31.5 |

Due to the high level of variability in our method, significant weight loss increases are those of 18% or higher. Weight loss increases for all other tested fungi were less than 12%.

Lab tests of the residue fungi against pathogen inoculum were inconclusive and we are attempting to develop better screening methods. General observations, however, suggest that Fusarium sp., Aspergillus sp., and Penicillium sp. were directly active against sclerotia of stem rot at low temperatures (10C). These fungi have been incorporated into the Butte County field test to determine if they can enhance destruction of inoculum under field conditions. Trichoderma sp. appeared active against stem rot sclerotia but only at room temperature.

We continued to investigate the detergent based fiber analysis method to analyze changes in the chemical composition of rice residue during decomposition. The method appears promising but is very time consuming and laborious. Additional equipment will be necessary to obtain results on all of the samples we have collected and stored.

Objective 2: Some changes were made in our continuing study of different rice management systems. We added an organic system and a residue management system that emphasizes winter flooding and subsequent incorporation of the straw. Monitoring sites in Colusa, Sutter, and Yolo counties have been added.

The data we have collected thus far appears inconclusive as to the value of any of the afore-mentioned systems for residue management and disease control. High disease levels appeared in all of the systems this year depending on location and cultivar grown. It appears that several years of monitoring will be required to adequately define these systems across all locations.

Additional observations are discussed under Objective 3.

Objective 3: The afore-mentioned management systems and sites were also used for this study.

We monitored the water line area of rice stems collected from these systems during the summer for resident microflora and possible biocontrol agents. Population data has not been thoroughly analyzed, but few, if any, patterns in relation to disease severity are evident. A few noteworthy observations were made, however.

Stem rot, Sclerotium oryzae, was common in all locations and management systems this year but other sclerotial fungi were not. We commonly found the aggregate sheath spot pathogen, Rhizoctonia oryzae-sativae and the non-pathogenic sclerotial fungus, Sclerotium hydrophilum only in non-burned straw management systems. Since these fungi preferentially colonize only the rice sheaths and produce relatively few sclerotia compared to stem rot, it makes sense that they would be more susceptible to burning of the stubble. In addition, when either R. oryzae-sativae or S. hydrophilum were present on the rice plant, stem rot severity appeared to be reduced.

This raises the interesting possibility of using the ecologically competent (but non-pathogenic) S. hydrophilum as a bio-control agent for stem rot and aggregate sheath spot. A preliminary greenhouse experiment was conducted to test the bio-control potential of this organism against stem rot. The results are shown in Table 3. It appears that S. hydrophilum reduces damage by stem rot even when inoculated simultaneously. We intend to expand and repeat this test in the greenhouse, followed by preliminary field testing next summer if warranted.

**Table 3. Results of Greenhouse test of Sclerotium hydrophilum as a biocontrol agent of stem rot of rice.**

| | DISEASE INDEX* FOR CULTIVAR | | |
|---|---|---|---|
| TREATMENT | S-201 | M-202 | L-202 |
| None | 1.00 | 1.00 | 1.00 |
| S. hydrophilum only | 1.00 | 1.00 | 1.00 |
| S. oryzae only | 3.00 | 3.41 | 4.00 |
| S. oryzae only (one week later) | 2.86 | 3.24 | 4.39 |
| S. hydrophilum + S. oryzae coinoculated | 1.39 | 1.92 | 3.46 |
| S. hydrophilum followed by S. oryzae one week later | 1.34 | 1.74 | 2.38 |

*Note: Disease Index (DI) represents the mean index for 3 replicate pots each containing 5 plants with 4-5 grain bearing tillers per plant. DI is calculated according to the rating system of Krause and Webster,(1972), Phytopathology 63:518-523 DI of 1.00 represents all healthy tillers while 5.00 represent all tillers severely diseased with culm containing the stem rot fungus.

Numerous other bacteria and fungi collected from rice plants were screened in the lab for antagonistic activity to sclerotial germination of S. oryzae. It appears that plate screening is of limited value since major antagonistic effects appear to be media dependent. Of 139 bacteria screened, none were completely inhibitory to germination and/or growth of S. oryzae on all media. Many of the bacteria were strongly inhibitory on nutrient agar (NA) or potato dextrose agar (PDA) but much less so on weaker media such as corn meal agar (CMA). The effect appeared independent of growth on the weaker medium since longer incubation times for the bacteria before addition of the sclerotia made no difference. Nevertheless, 5 bacterial isolates were found that were strongly inhibitory on all media, if not completely so.

Thirty-five fungi were screened using a similar plate method and several were strongly inhibitory to stem rot sclerotia on all media. Trichoderma sp., Sclerotium hydrophilum, Chaetomium sp., Penicillium sp., Pythium spp., Acremonium sp., and an unidentified pycnidial fungus all appeared promising. Although S. hydrophilum is already known to be ecologically competent and antagonistic, these other fungi require further testing on the rice plant to establish whether they have bio-control potential.

Of the two actinomycetes isolated, both appeared very antagonistic to S. oryzae in plate assays.

Many of these organisms require additional and more effective screening for bio-control activity, preferably in the greenhouse if methods can be developed to effectively handle the large number of organisms involved.

Objective 4: During the summer of 1989, we conducted a greenhouse experiment on the reaction of present California rice cultivars to stem rot, aggregate sheath spot, and bordered sheath spot. The experiment was replicated 3 times and data collected for each tiller. Variables included grain weight, filled grain number, grain bearing tillers, tiller height, and disease rating.

A second experiment to test the reaction of S-201, M-202, and L-202 to single and combined inoculations of the above diseases was also conducted with similar data collected.

Our objectives in these experiments was to determine the major yield loss components for each disease, update our disease severity scale for yield loss on the newer cultivars, and investigate effects of combined diseases on yield. This last objective is based on field observations of co-infection by aggregate sheath spot and stem rot as well as continued reports of bordered sheath spot in certain counties. Hopefully, this information can be used for cultivar improvement and disease control.

Most of the data has not been analyzed because some yield data is still being collected, however, some preliminary conclusions can be drawn.

Stem rot was by far the most serious disease in these experiments. In the data so far analyzed, average yield loss in the first experiment was 42.5% for all cultivars infected by stem rot, 8.05% for aggregate sheath spot, and 14.1% for bordered sheath spot. Cultivar M-102 appears to have fair resistance to all 3 diseases in these tests while L-202 appeared moderately resistant to stem rot and bordered sheath spot. It should be noted that these results may not accurately reflect field performance as we have continued reports of stem rot problems with L-202 from farm advisors. S-201, M-201, M-202, and M-203 all exhibited similar yield losses to stem rot with respect to the primary tillers but differed somewhat in secondary tiller reaction. M-203 lodged completely when infected by stem rot and would be of concern in fields with stem rot history. Stem rot reduced kernel weights an average of 10% and filled grain number 30% for the cultivars tested. Kernel weight loss due to aggregate sheath spot and bordered sheath spot was nil, and filled grain number loss was 6% and 11.3%, respectively.

The second experiment involved combinations of the different diseases on cultivars L-202, M-202, and S-201. Effects of various disease combinations on M-202 are shown in the following table utilizing one variable.

| | %LOSS IN GRAIN WEIGHT FOR | | |
|---|---|---|---|
| DISEASE | MAIN TILLER | SECONDARY TILLERS | TOTAL |
| Stem rot(SR) | 34.2 | 81.4 | 65.2 |
| Aggregate Sheath Spot(AgSS) | 2.8 | 24.2 | 15.2 |
| Bordered Sheath Spot(BSS) | 19.6 | 29.0 | 42.8 |
| SR + AgSS | 58.9 | 41.3 | 63.9 |
| SR + BSS | 44.7 | 70.6 | 50.5 |
| AgSS + BSS | 16.5 | 34.9 | 31.7 |
| SR + AgSS + Bss | 33.1 | 41.3 | 30.9 |

In general, yield losses for multiple disease combinations was less than expected based on simply adding loss effects for each single disease. The greatest reduction was in the 3 component system where total losses were 30.9%, less than either stem rot (65.2%) or bordered sheath spot (42.8%) alone. This probably reflects competition between the fungi for possession of the plant, although actual parasitism of one fungus on the other cannot be ruled out. As in the first experiment, secondary tiller losses appear more significant than those for primary tillers, but this is not always the case.

It should be noted that M-202 was quite susceptible to bordered sheath spot in both experiments. This could be a future problem as acreage of this cultivar expands and the reports of this disease in California continue to increase.

Objective 5: Evaluation of various experimental seed treatment fungicides continued in 1989. No differences were noted between treatments as seedling establishment rates in all plots were high. Temperatures were exceptionally high in April and May and few growers experienced stand establishment problems even with untreated seed. Chemical seed treatment options appear limited in the future.

**PUBLICATIONS OR REPORTS:**

Webster, R.K. Report to the California Rice Research Board. Project RP-2. Cause and Control of Rice Diseases, pp. 18-24. In: Annual Report of Comprehensive Rice Research. 1988. University of California and U.S. Dept. of Agriculture.

**CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:**

Several fungi capable of enhancing decomposition of rice stubble in lab tests have now been placed in preliminary field tests in Butte County. Monitoring of different management systems continued with respect to straw decomposition and disease level differences. Additional study will be required before conclusions can be drawn about application to the entire rice growing area.

Several fungi and bacteria antagonistic to the stem rot fungus have been isolated as potential in-season biocontrol agents. One fungus, *Sclerotium hydrophilum*, effectively reduced stem rot severity in a greenhouse trial on two of three tested rice cultivars. This fungus does not appear to be pathogenic but is adapted to the water line area of the rice plant, thus competing with the stem rot fungus.

Resistance of 10 commercial California rice cultivars to 3 fungal diseases was investigated in the greenhouse. Stem rot caused the greatest yield losses followed by bordered sheath spot, then aggregate sheath spot. Yield losses due to stem rot were primarily from reduced numbers of filled grains per panicle with secondary tillers generally being more affected than main tillers. The cultivar M-102 appears to have good resistance to all three diseases.

Although various chemical seed treatments were again tested, little information was gained due to better than usual stand establishment conditions in 1989. Emphasis on non-chemical seed protection treatments should be considered since companies are hesitant to pursue registration of promising fungicides.