COMPREHENSIVE RESEARCH ON RICE

ANNUAL REPORT
January 1, 1976 - December 31, 1976

I. PROJECT NUMBER and TITLE : RP2. Cause and Control of Rice Diseases

II. PROJECT LEADER AND PRINCIPAL UC INVESTIGATORS:

Project Leader: R. K. Webster, Plant Pathologist

Principal UC Investigators: J. Bolstad, Staff Research Associate; William Bockus, Research Assistant; L. F. Jackson, Postgraduate Research Plant Pathologist; C. M. Wick, Farm Advisor, Cooperative Extension; A. R. Weinhold, Plant Pathologist, UC, Berkeley.

III. LEVEL OF 1976 FUNDING: $18,800 + 4000 = 22,800

IV. OBJECTIVES ACCORDING TO 1976 PROPOSALS AND EXPERIMENTS BY LOCATION CONDUCTED TO ACCOMPLISH THESE OBJECTIVES:

Objective 1. Continue disease severity analysis and development of readily applicable methods for prediction of potential yield losses due to stem rot. These will be used in setting priorities to allocate burning acreages in the event burning becomes more restricted and in making decisions for the need, use, and potential benefits of applying fungicides for stem rot control. Trials: Butte Co. 8 sites, Yolo Co. 2 sites.

Objective 2. Interactions of cultural practices, varieties, herbicides, fertilization, and stem rot severity.
Greenhouse and laboratory trials; Davis Rice Research Facility and Butte Co., 1 site.

Objective 3. Biology of Sclerotium oryzae with emphasis on studies concerning the biology of sclerotia in the soil as it relates to inoculum survival and carry over under different cultural practices and residue disposal.
Laboratory and greenhouse studies at Davis.
Field studies at 2 sites at Davis
Trial at Butte Co.

Objective 4. Chemical control of stem rot.
Field trials at Davis Rice Research Facility.
Field trials at 7 locations in Butte Co.

Objective 5. Continue residue management study funded by State Solid Waste Board.
14.7 acre trial in Butte Co.

Objective 6. Investigate the etiology and epidemiology of Rhizoctonia sheath blight of rice (Cooperative with Dr. A. R. Weinhold, Plant Pathologist, U. C. Berkeley).

V. SUMMARY OF CURRENT YEAR'S WORK (MAJOR ACCOMPLISHMENTS) BY OBJECTIVE:

Objective 1. Disease severity analysis and prediction: The most effective means currently available to minimize stem rot of rice is burning infested residue. Anticipated restrictions on acreage allowed for burning in the fall or spring suggest that a system that would allow for the prediction of Sclerotium oryzae inoculum levels (IL) and stem rot severity (DS) is needed to determine when burning of residue is justified. Methods to determine IL and DS, and their relation to yield (Y) reduction, have been developed over the past 3 seasons. IL, DS, and Y have been observed to be highly correlated on at least 4 varieties when IL is between .05 and .8 viable sclerotia/gram soil in seedbeds. Observations of seedbed inoculum levels in all sites studied this year confirmed this conclusion. This was also found to be the case for random observations (at least 20 growers' fields) throughout the northern Sacramento Valley. Correlations between DS and Y are higher than those between IL and Y. Although determination of IL in seedbeds is reliable in predicting stem rot severity during the present crop, no means of minimizing the IL at that point is available with the exception of the introduction of protective fungicides (see Obj. 4).

Consequently, comparisons were made between DS from fall of 1975 with IL, DS and Y for 1976 in field trials. The results show that DS ratings made at the time water is drained can serve to predict if that field should be burned to minimize stem rot the following year under continuous rice culture. Observations from this past season and several hence verify that a DS of 1.2 justified burning of the residue in that field.

Disease severity determinations are easily made by the trained investigator but may be more difficult for individual growers. Consequently, a major effort under this objective was to determine a direct approach and time to estimate DS. This involved making weekly ratings at the several field sites studied in Butte Co. and determining the relationship of percent infected tillers to final season disease severity. We attempted to correlate this phase of prediction with a simple determination of whether the application of a protective fungicide would be economically beneficial. We found that percent infection at mid-tillering to internode elongation was correlated with expected loss to disease. Therefore, results from this season show that a determination of percent infection at mid-tillering can be used in both the decision process for application of fungicide or in burning that field after fall harvest.

Objective 2. The interaction of 3 varieties at 5 nitrogen levels was studied in relation to stem rot disease severity. Minimal levels of nitrogen in greenhouse trials revealed that the varieties M5, S6, and 74-Y-52 are similar in susceptibility to stem rot. All three varieties showed a linear increase response to increasing levels of nitrogen accompanied by a linear increase in disease susceptibility in field plots. Variety 74-Y-52 responded with the highest yields while sustaining similar levels of stem rot as nitrogen rate was increased to maximum yield levels. Based on this year's results it appears that the need for higher N by short stature varieties to obtain their maximum yield potential will not be a complicating factor in regard to stem rot.

Objective 3. The possibility of removing straw from fields in lieu of open field burning as a means of residue disposal prompted the need for additional information on the longevity and fate of sclerotia both associated with residue and those free in the soil. It was necessary to know if sclerotia knocked free of residue during the harvesting and baling operations were capable of germinating and colonizing organic matter in the soil and the effect of such on inoculum levels for subsequent crops. Laboratory and greenhouse experiments utilizing sclerotia with C^{14} incorporated as a label revealed the following:

(a) Mycelium from free sclerotia is not competitive with soil microorganisms.

(b) Sclerotia on or in rice residue are capable of generating new sclerotia during the periods of favorable temperature (57+ °F) and moisture between seasons.

(c) Stubble that has been burned over during open field burning does not support sclerotial increase as well as non-burned over stubble or stubble colonized by saprophytic microorganisms.

(d) In addition to the biotic fungistasis of S. oryzae sclerotia described earlier, there is also a form of abiotic fungistasis. Preliminary evidence indicates this is related to the oxidative potential the sclerotia are subjected to.

(e) Studies on the rate of disease increase from various inoculum levels were initiated. No results are available at this time. The information sought is envisioned as necessary in determining confidence limits for the prediction system sought under Objective 1.

Objective 4. Chemical control of stem rot: Studies on chemical control of stem rot were continued with emphasis on efficacy results and obtaining residue data required for registration. The results of 3 years' testing are summarized here to give a complete overview of the status of chemical control of stem rot.

Field experiments were conducted in 1974, 1975, and 1976 in Butte County, California, where stem rot of rice is endemic. Treatments were evaluated under conditions of natural infection. Disease severity in plots was determined by scoring a sample of tillers for disease on a scale of 1-5, where 1 = no symptoms, 2 = lesions only on the outer leaf sheaths, 3 = lesions extending through the sheaths to the culm, 4 = lesions penetrating the culm, and 5 = sclerotia and/or mycelium formed within the culm. A weighted disease index (DI) was calculated by multiplying the number of tillers in each category by their scores, combining the totals, then dividing by the total number of tillers. Plots were sampled by compositing tillers from a series of sites through the center of each plot. Yield data were converted to a per hectare basis at 14% moisture.

The fungicide Du-ter (47.5% Triphenyltin hydroxide), (TPTH), was provided by the Thompson-Hayward Chemical Company. Ground applications were made with a carbon dioxide powered sprayer with a 5-meter spray boom. Air applications were made by fixed wing aircraft. TPTH was applied as a water suspension in a volume of 200 liters per hectare at the stated rate (active ingredient).

1974 Experiments: Plots were located on the Lindberg Ranch in 1974 and consisted of eight basins, each 14 x 155 meters, separated by dirt levees and provided with individual water systems. This design precluded the opportunity for the exchange of inoculum or chemical between basins. The cultivar Colusa was grown and commercial rice production practices were followed. TPTH was applied as a ground spray at 1.2 Kg/hectare to a 9 x 155 meter area within four of the basins when the rice had reached the mid-to-late tillering (MLT) stage of growth. Four basins served as untreated checks. Disease ratings were made on three occasions during the season, the last when water was drained, with at least 300 tillers scored per basin each time. A swath 2.2 x 124 meters was harvested from each basin to determine yield.

1975 Experiments: In 1975 two experiments were conducted on the Rice Experiment Station at Biggs, California. In the first experiment six basins, each 6 x 31 meters, were separated by dirt levees and provided with individual water systems. The cultivar CS-M3 was grown and TPTH was applied at the rate of 2.24 Kg/hectare to three of the basins at the midtillering (MT) growth stage. A disease rating was made prior to draining the field. Yield was measured by harvesting a 2.2 x 31 meter strip from each basis.

The second experiment in 1975 was planned to determine the effects of fungicide concentration and timing of application on disease. Forty basins, each 8 x 37 meters, separated by aluminum levees and provided with individual water systems, were planted with the cultivar CS-M3. TPTH was applied at the rates of 0.56, 1.12, and 2.25 Kg/hectare at either mid-tillering (MT), internode elongation (IE), panicle initiation (PI, MT and IE, or MT, IE, and PI (0.56 and 1.12 KG/hectare rates only). Checks included untreated basins and basins treated with Benlate (methyl 1-butylcarbamoyl-2-benzimidazole-carbamate) at 1.12 Kg/hectare as a standard. Disease progress was monitored through the season by determining the percentage of infected tillers in each basin each week for ten consecutive weeks from late July to late September. The percentage of infected tillers was determined from a sample of at least 100 tillers from each basis. Yield data were not obtained due to failure of weed control.

A preliminary test of the commercial applicability of the fungicide was conducted on the La Malfa Ranch. TPTH was applied by aircraft to a 4-hectare section of a 20-hectare field of the cultivar Colusa at MT at the rate of 1.12 Kg/hectare. A disease rating was made prior to draining the field. Disease samples consisted of 10 subsamples of 100 tillers each from both treated and untreated areas. Yields were compared on a per hectare basis.

Greenhouse studies on disease development were also conducted in 1975. Four cultivars, CS-M3, CS-M5, Calrose, and Colusa, were grown in Yolo clay loam in plastic buckets and treated with either TPTH or BRAVO 6F (54% chlorothalonil) at the rate of 1.12 Kg active ingredient per hectare by atomizing a water suspension of the fungicide on the plants at the MT growth stage. Plants were inoculated at the same time by adding 150 mg of sclerotia from two isolates of S. oryzae from Butte County to the water in each bucket. Untreated checks were either inoculated or not inoculated. The appearance of lesions was noted over time.

1976 experiments: The effectiveness of TPTH on a commercial scale was tested. Five sites in Butte County were selected to receive an application of TPTH by fixed wing aircraft. Each site consisted of a treated and an untreated area in the same field. Treated areas, each 2 hectares in size, received a MT application of TPTH at the rate of 1.12 Kg/hectare. Disease was rated twice during the season at each site, at midseason and when the fields were drained. At least 600 tillers were scored for disease from each treated and untreated area each time. Yields were compared on a per hectare basis.

The feasibility of comparing fungicides for the control of stem rot by using small replicated plots without separate water systems, as is done for foliar diseases of rice in the Southern states, was tested in 1976. Five chemicals, Du-ter, Bravo 6F, Benlate, Mertect 340-F [42.28% 2-(4-thiazolyl)-benzimidazole], and Daconil 2787 (75% chlorothalonil) were included in the experiment. Each chemical was applied at either MT, IE, or both stages. Two rates were used with each chemical, and only the lower rate was applied twice. Each chemical was represented by five treatments. Rates of active ingredients were as follows: TPTH, Daconil, and BRAVO 6F, 1.12 and 2.24 Kg/hectare; Benlate, 0.56 and 1.12 Kg/hectare; Mertect 340F, 0.58 and 1.17 liters/hectare. Two check treatments were also included for a total of 27 treatments. Each treatment was replicated six times in a randomized complete block design at two locations. Individual plots were 3.7 x 9.3 meters. Disease was rated twice during the year, at midseason and when water was drained. Yield data were obtained from a 2.2 meter swath harvested from each plot.

RESULTS

1974: Disease was significantly reduced (P=0.01) in basins on the Lindberg Ranch receiving the TPTH compared to untreated check basins. A reduction in the final average DI from 2.32 to 1.67 was accompanied by an average increase in yield of 538 Kg/hectare, a 10% increase.

1975: Basins on the Rice Experiment Station treated with TPTH had significantly less disease (P=0.01) than untreated basins. Treated basins had an average DI of 1.28, compared to 2.03 for untreated basins, a difference which was accompanied by an average increase in yield equivalent to 1322 Kg/hectare, a 24% increase.

In the rate and timing of application experiments, all TPTH treatments had less disease than untreated checks. Benlate did not control stem rot. The 1.12 Kg/hectare rate of TPTH at MT and the 1.12 Kg/hectare rate at MT and IE were as good or better than any other combinations and rates used. Disease incidence peaked at about the fourth week of observation (three months after planting) and leveled off thereafter. Treatments that developed the highest disease incidences had the highest DIs at the end of the season. Rate of disease increase in each treatment was similar, but the initial levels of disease were considerably lower in the treated basins. Initial disease sampling revealed only 2% infection for both the 1.12 Kg/hectare rate at MT and the 1.12 Kg/hectare rate at MT and IE, while untreated checks had 13% infection (means of four replications).

The air application of TPTH on the La Malfa Ranch successfully reduced disease. The treated area had a DI of 1.59, compared to 2.14 for the untreated area, and outyielded the untreated area by 549 Kg/hectare, a 9% difference.

In the greenhouse experiment, inoculated plants in check and BRAVO treatments developed severe stem rot. Plants treated with TPTH did not develop any lesions until six weeks after the check plants had begun to show symptoms.

1976: Disease was controlled and yield increases were attained in four of the five airplane trials. In the one instance where disease was not controlled, the spray tank of the airplane had been plugged, preventing delivery of the correct rate of TPTH. At the four sites where the application was effective, DI averaged 1.06 for the first rating, essentially no disease, and remained virtually unchanged for the second rating, averaging 1.09. Initial disease incidence was minimized, thus preventing later disease build-up. In contrast to treated areas, untreated areas had an average DI of 1.52 for the first rating, increasing to 1.85 for the second rating and resulting in substantial yield reductions. The four treated areas yielded an average of 8814 Kg/hectare, compared to 7394 Kg/hectare for untreated areas, a 16% difference.

Table 1. Disease Indices and Yields of 2-Hectare TPTH-Treated Plots and Untreated Check Plots in Butte County, California, 1976

Site		Disease Index[a] Mid-season	Disease Index[a] End of season	Yield kg/hectare	Yield Increase % treated over check
1	treated[b]	1.02	1.03	9038	9
	check	1.23	1.60	8235	
2	treated	1.03	1.03	8312	6
	check	1.30	1.75	7832	
3	treated	1.08	1.13	9202	25
	check	1.79	2.11	6860	
5	treated	1.12	1.17	8705	24
	check	1.76	1.92	6651	

[a]Disease severity index: 1 = healthy, 5 = most severe; see text for details.

[b]Treated plots received TPTH at rate of 1.12 Kg/hectare at mid-tillering growth stage.

In the small replicated plots where treatments were not provided with separate water systems, the effectiveness of fungicides in stem rot control could not be determined. There were no statistical differences in DIs or yields between treatments at either locations.

Over the past 3 years residue data on rice, rice soil, water and nontarget organisms have been accumulated. In addition, alternate crops including corn, wheat, barley, sugar beets and others were grown by pumping water from rice basins treated with TPTH to analyze for the fate of the fungicide in run-off water. Cooperative studies with the Department of Fish and Game were carried out in experimental sites to determine the effects of TPTH on fish. All samples from the above are being analyzed for TPTH residues by the Thompson Hayward Chemical Co. Results are not available at this time.

TPTH has consistently controlled stem rot for the past 3 years. It reduces the number of early infections delaying disease progress and minimizing final disease severity. We envision TPTH as a part of an integrated control program in conjunction with burning.

Objective 5. Determine effects of various methods of rice straw disposal on epidemiology of rice stem rot: This study was funded by the California State Department of Food and Agriculture up until August 31, 1976. Negotiations are still in progress regarding funding for its continuation. Nevertheless, disease ratings, harvest and fall residue treatments for 1976 were carried out in anticipation that the project would be continued by the state. Expenses incurred since August 31, 1976 have been offset by the Department of Plant Pathology and, where possible by use of travel expenses and personnel paid on funds provided under project RP-2 by the Rice Board. A brief summary on the status and preliminary conclusions available follows.

The background rationale, specific objectives, experimental set up and procedures were outlined in our 1975 report.

Observations and work completed:

A. Determination of 1976 inoculum levels: Soil samples collected from finished seed beds in May of 1976 were processed to determine inoculum levels resulting from the various treatments being compared. These consisted of composite samples from four areas (approximately 50 ft^2) in each of the 45 plots. The composite samples were ground to provide even mixing and numbers of viable sclerotia per gram soil were determined for each subsample taken from the composites. These inoculum levels indicate the effect of the various straw removal treatments on inoculum level increase or decrease for one complete rice-cropping season (Table 2).

Table 2. Comparison of Percent Change in Stem Rot Inoculum Levels and Disease Severity After One Season Between Residue Disposal Treatments

Residue Management Treatments	Viable sclerotia/ gram soil 1975-76	Disease* Severity 1975-1976
(1) Harvested 8-12", Straw spread; fall burned and fall stubble disked	+ 22	- 6
(2) Harvested 8-12", straw spread spring burned; spring stubble disked	_ 22	_12
(3) Harvested 8-12", straw windrowed and chopped, fall stubble disked	+170	+15
(4) Harvested 8-12", straw windrowed and chopped, spring stubble disked	+ 54	+13
(5) Harvested 8-12", straw windrowed, baled and removed, fall stubble disked	+121	+14
(6) Harvested 3", straw windrowed, baled and removed, spring stubble disked	+ 17	- 3
(7) Harvested 8-12", straw windrowed, baled and removed, spring stubble disked	+210	+ 9
(8) Harvested 3", straw windrowed, baled and removed, fall stubble disked	+ 13	+10
(9) Harvested 3", straw windrowed, baled and removed, spring moldboard plowed	- 13	0

*Disease severity 1976 was 10% less overall from that observed in 1975. Values represent relative % difference (less disease) between treatments with seasonal variation removed.

B. Disease incidence and severity: Plants (at least 400/plot) were collected from each plot in late August and disease severity determined. Overall, the environmental conditions for stem rot disease development were not as favorable in 1976 as in 1975. Nevertheless, significant stem rot occurred throughout the experimental area. The highest levels of disease measured in 1976 occurred in areas where inoculum levels were highest. The effects of the various treatments on inoculum level and subsequent disease severity are summarized in Table 2.

C. Yield determination: Yields for each treatment were obtained at maturity. A significant positive correlation occurred between inoculum level, disease severity and yield reduction due to disease.

D. Fall residue management and observations: Following harvest of the 1976 rice crop all residue management treatments were performed as specified in the experimental outline. Fall soil and straw samples were collected for analysis.

Preliminary conclusions:

Inoculum level: Stem rot inoculum levels were reduced in spring burning and complete removal followed by moldboard plowed treatments. In cases where straw was harvested at 3" (complete removal), inoculum levels increased near equal to that in fall burning and significantly less than the increases observed where harvest was normal height followed by straw removal.

Disease severity: Correlations between disease severity and inoculum level are most valid when observed values for each variable occur in the linear phase of the stem rot disease severity vs. inoculum level curve. This is essentially linear when inoculum levels range between .05 and .8 viable sclerotia/gram soil. Treatments showing 54% or higher increases in inoculum level over one season all exceed the inoculum level within the linear phase of the disease severity curve. The fall burned, fall disked (1); spring burned, spring disked (2); complete removal, spring disked (6); fall disked (8) and spring moldboard plowed (9) treatments showed positive correlation between inoculum levels and reduced disease severity. In the case of fall burned, fall stubble disked treatments (1), the actual inoculum increase was the smallest but the adjustments for seasonal means reflect a greater percent increase in inoculum over other treatments showing favorable effects on disease severity. Yield increases or decreases due to stem rot in 1976 were positively correlated with disease severity observed.

Current status of project:

The project is proceeding on schedule. Results thus far emphasize the need for data on an accumulative basis as was conceived in the original plans for the project. The fall treatments were completed in the event this will become possible even though the current status of future funding is uncertain.

Objective 6. Etiology and epidemiology of Rhizoctonia sheath blight: Rhizoctonia is an important pathogen on a wide variety of crop plants. In Southern rice-producing states, Rhizoctonia sheath blight, caused by R. solani, is a serious disease often limiting production by 50% or more. In California we have consistently observed a disease caused by a Rhizoctonia sp. similar to that described in other rice-producing areas, the exception being that after

initial infections disease progression stops and rice plants are not defoliated. Our primary interest has, therefore, been to determine if the Rhizoctonia sp. that occurs widespread in California is identical to that causing severe damage in the south. The importance of this study lies in the fact that there are many examples of minor diseases becoming of major significance when cultural practices change or new varieties are introduced. Pathogenicity tests conducted in the greenhouse on 11 rice varieties utilizing isolates from California and Louisiana showed no significant differences in susceptibility of the varieties to any of the isolates tested with the exception that isolates from Louisiana tended to produce larger lesions in a somewhat shorter period of time. Laboratory studies utilizing standard anastomosis tests to determine if isolates from California are genetically related to those from other states and also R. solani were all negative. Pathogenicity tests of the California Rhizoctonia isolates on alternate hosts normally susceptible to R. solani also proved negative. We are, therefore, concluding that the Rhizoctonia sp. causing sheath blighting in California is not identical to that causing the disease in the Southern states.

Observations over the past few years in the field have led to the conclusion that at the present this disease does not pose a threat to the California rice industry. The occurrence of a high amount of Rhizoctonia sheath blight on the experimental line 73-4-52 in an experimental trial in the San Joaquin Valley this year suggests it should be monitored as new varieties are released.

VI. PUBLICATIONS OR REPORTS:

1. Webster, R. K. 1975. Report to California Rice Research Board, Project RP-2.

2. Webster, R. K., J. Bolstad, C. M. Wick, and D. H. Hall. 1976. Vertical distribution and survival of Sclerotium oryzae under various tillage methods. Phytopathology 66:97-101.

3. Ferreira, S. A., and R. K. Webster. 1976. Evaluation of virulence in isolates of Sclerotium oryzae. Phytopathology 66:1151-1154.

4. Webster, R. K., C. M. Wick, and L. F. Jackson. 1976. Rice Stem Rot Disease Control. UCD Mini Rice Field Day. August 24, 1976. Mimeo 3 pp.

5. Wick, C. M., R. K. Webster, D. Lindberg, and A. Lindberg, Sr. 1976. Comparative cash costs of methods for incorporation of rice residue into soil.

6. Jackson, L. F., R. K. Webster, and C. M. Wick. Efficacy of fungicides for controlling stem rot of rice.

7. Webster, R. K., C. M. Wick, L. F. Jackson, and J. Bolstad. Effect of tillage methods on functional inoculum levels and survival of Sclerotium oryzae.

(Above three in: Proc. of 16th Rice Technical Working Group March 2-4, 1976. Lake Charles, La. Agricultural Information Dept. Texas A&M University, College Station, Texas.

8. Webster, R. K. 1976. Effects of various methods of rice straw disposal on epidemiology of rice stem rot. Interim report May 5, 1976.

9. Webster, R. K. 1976. Effects of various methods of rice straw disposal on epidemiology of rice stem rot. Interim report Nov. 30, 1976.

VII. CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

Potential losses due to stem rot can be predicted from mid-tillering to internode stage of rice development. These predictions will facilitate management decisions regarding use of chemical control, residue management and cropping sequences for given fields.

Preliminary results indicate that even though stem rot severity increases as rate of nitrogen fertilizer is increased for optimum production of short stature varieties, the advantages of short stature rice will not be negated by stem rot disease.

The application of one pound per acre of Triphenyltin hydroxide (Du-ter) at mid-tillering resulted in significant control of stem rot disease accompanied by increases in yield ranging from 9-25%. This disease control was achieved over those possible with open field burning since experimental sites involved had been burned the previous fall. We propose to use Du-ter in conjunction with burning and other cultural manipulations as part of an integrated control program for stem rot. Registration of Du-ter for use in California is pending.

Results from the second year of a 3-year project to compare the effects of complete removal of rice residue and fall and spring burning in combinations with fall and spring tillage indicate that complete removal of straw followed by fall tillage is quite effective in minimizing *Sclerotium oryzae* inoculum levels. Studies on the accumulative effects of these practices are being continued. The effects of complete removal of residue on the populations of *S. oryzae* in relation to survival and increases or decreases in inoculum are being studied.

Rhizoctonia sheath blight as it occurs in California differs from that in the southern states. The pathogen is apparently a new species that is not as aggressive as *R. oryzae* on rice and is not pathogenic on hosts normally susceptible to *R. solani*.