Project Number: RP-2
1976-1977

COMPREHENSIVE RESEARCH ON RICE
ANNUAL REPORT
January 1, 1977 - December 31, 1977

I. PROJECT NUMBER AND TITLE: RP-2. Cause and Control of Rice Diseases

II. PROJECT LEADER AND PRINCIPAL U.C. INVESTIGATORS:

Project Leader: R. K. Webster, Plant Pathologist

Principal UC Investigators: J. Bolstad, Staff Research Associate; William Bockus, Research Assistant; C. M. Wick, Farm Advisor, Cooperative Extension; D. M. Brandon, Cooperative Extension

III. LEVEL OF 1977 FUNDING: $20,500

IV. OBJECTIVES ACCORDING TO 1977 PROPOSALS AND EXPERIMENTS BY LOCATION CONDUCTED TO ACCOMPLISH THESE OBJECTIVES:

Objective I: Prediction and determination of potential yield losses due to stem rot. Trials: Butte Co. 5 sites, Yolo Co. 3 sites, Glenn Co. 1 site.

Objective II: (a) Interactions of cultural practices, varieties, fertilization, and stem rot severity. Greenhouse trials; Davis Rice Research Facility and Butte Co. 1 site (14.7 acres).

(b) Continue studies on effects of various methods of rice straw disposal on epidemiology of rice stem rot (emphasis on straw removal, fall vs. spring burning, and soil incorporation.)

Objective III: Biology of *Sclerotium oryzae*. Emphasis on biology of sclerotial populations in the soil as it relates to inoculum potential, survival and effect under different cultural practices, residue disposal and different soil types. Laboratory and greenhouse studies; Davis Rice Research Facility, Armstrong Experimental Facility; Yolo County and Butte Co. 1 site.

Objective IV: Chemical control of stem rot: efficacy data with Du-Ter, Yolo County, 2 sites, Butte Co. 2 sites. Environmental impact study of Du-Ter on non-target organisms in rice fields including invertebrates, fish and algae. (Cooperation with: A. Grigarick, Dept. of Entomology, D. Bayer, Dept. of Botany, K. Hiscox, Butte Co. Mosquito Abatement District, Stoner Labs, Santa Clara, Calif., and Thompson-Hayward Chemical Co., Kansas City, KA). Yolo Co. 1 site; Butte Co. 2 sites.

Additional fungicides with potential for controlling stem rot were tested at Davis Rice Research Facility and Butte Co. 1 site. In addition, preliminary tests with systemic fungicides were tested at Davis and in the greenhouse.

Objective V: Resistance to stem rot. Irradiated seed provided by Dr. H. Carnahan. Greenhouse tests.

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

Objective I. Components of disease loss:

Stem rot disease is most evident on rice plants nearing maturity. At this time it is not uncommon to observe extremely high percentages of the total number of tillers infected to some degree of severity. Results obtained this year show that percent infection is not as reliable in estimating expected losses in the current crop as is a determination of disease severity. Data from experiments designed to test the effect of inoculum level, time of infection on disease occurrence, severity and yield loss bear this out. For example, inoculation of Earlirose with 500 viable sclerotia per plant at internode elongation or the boot stage resulted in a 12% reduction in total number of mature tillers in plants inoculated at internode elongation over those inoculated in the boot stage. This reduction in tillers was accompanied by an 11% reduction in grain yield. Disease severity ratings were 3.18 for plants infected during internode elongation as opposed to 1.96 for those infected during the boot stage. Percent infection for both was 79 and 83%, respectively. Similar contrasts were observed under field conditions in a number of fields surveyed in Butte, Yolo, and Glenn counties. Data from three such fields are given in table 1.

Table 1

Mature panicle weights (grms) at five levels of disease severity.

	Disease severity				
Field	1	2	3	4	5
1	1.95*	1.77	1.75	1.73	1.59
2	1.58	1.51	1.55	1.54	1.48
3	1.63	1.44	1.29	1.37	1.15

1 = healthy; 5 severe, *values are averages of 6 random samples with about 70 tillers/sample.

These data show the obvious; the more severely infected tillers that do survive, produce less yield. When disease severity values are calculated and compared with percent infection the following was obtained, Table 2.

Table 2

Comparison of disease severity and % infection on Colusa rice at harvest.

Field	% Infection	Disease (x) severity	Average pannicle weight (gms)
4(y)	63 a	1.77 a	1.90 a
5	68 a	2.83 b	1.57 b
6	79 b	3.03 c	1.39 c

[x] Disease severity rated from 1 (healthy) to 5 (severe).

[y] Average of at least 800 tillers per field.

[z] Values without common letters differ significantly at the 5% level.

Combined these results support the conclusion that disease severity rather than percent infection is the most reliable determination for predicting loss to stem rot disease. This conclusion applies particularly to the new varieties M-7 and M-9 since both exhibited significantly more tolerance to stem rot infection than did Earlirose or 1600 in this year's trials.

Observed disease severity in the fall continued to show significant correlations with amount of inoculum carryover in seed beds (the following spring) under continuous rice cropping, particularly when residue was incorporated.

An additional parameter of disease loss to stem rot is that of the relationship of disease severity to lodging. In all cases studied, significant correlations (.56-.74) between percent lodging and disease severity ratings were observed.

An additional parameter of disease loss is the possibility of reduction in quality. Forty separate samples from plots of known disease severity on variety S-6 were tested and head rice values for each obtained. Disease severity ratings for the plots ranged from 1.96 to 2.91. Head rice ranged from 38.9 to 50.9. A significant correlation coefficient of $r = -0.86$ between increase in disease severity with corresponding reductions in quality was observed.

The value of disease severity determination in predicting potential yield reduction due to stem rot disease is seen most clearly in comparisons where disease is minimized by the application of the fungicide Du-Ter. In this case on S-6 this season, 5 acres of treated rice yielded 88 cwt/A and had a disease severity rating of 1.21. The untreated rice yielded 80.2 cwt/A and had a disease severity rating of 2.34.

Summarizing, results obtained this year, including observations on newly released varieties, indicate disease severity is more reliable than percent infection in predicting loss in yield, quality and potential for carryover inoculum. Decisions on residue management and/or the application of a fungicide for the succeeding rice crop should be made on the basis of severity of disease in that field the preceding fall. Benefits in minimizing inoculum level can be obtained by burning residue in fields showing as low a disease severity as 1.2.

Objective II. Interactions of cultural practices and stem rot severity:

(a) Varieties, nitrogen level and stem rot severity: Disease severity ratings on variety X nitrogen level trials conducted by Cooperative Extension were determined. In general, stem rot severity increased with increases in nitrogen fertilization whereas maximum yield was obtained for most varieties between 120-150 lb. N/acre. Table 3 gives a mean disease severity and yield at 150 lb. nitrogen/acre at seven different locations.

Table 3

Mean stem rot disease severity and yield at 150 lb. nitrogen per acre

	Site-1		Site 2		Site 3	
Variety	lb./A	Disease severity	lb./A	Disease severity	lb./A	Disease severity
Earlirose	7634	2.04	6464	2.67	7441	3.23
ESD7	8069	1.69	7534	2.00	8390	1.93
76-Y-11	8301	1.95	8450	1.90	8638	1.69
CS-M3	5855	2.35	8072	1.16		
Calrose 76	7861	1.83	8991	1.04		
M-7	8043	1.71	9159	1.05		
M-5	6805	1.38	8678	1.16		
S-6	7332	1.48	9032	1.14		
M-9	7981	1.45	9845	1.10		

Disease severity did not increase significantly with an increase of nitrogen from 150 to 180 lb./A on the above varieties with the exception of Earlirose and CS-M3. Consequently the earlier conclusion that applications of high rates of nitrogen to new California varieties will not be a complicating factor in regard to stem rot appears valid.

(b) Effects of various methods of rice straw disposal on the epidemiology of rice stem rot. Emphasis in this area is on comparisons between straw removal, fall vs. spring burning and soil incorporation under continuous rice cropping. Primary funding for the project comes from the California State Air Resources Board. The residue management treatments compared and a summary of 3 years results are given in Table 4. It appears that total straw removal is nearly equal to burning in minimizing surviving inoculum levels for following rice crops. A complete analysis and interpretation of the results from this project are being prepared and will be available in February 1978.

It became apparent early in our study on removal of rice residue that additional study on the survival of sclerotia under the various residue management regimes was needed. Such a study was initiated at Davis under our project RP-2. The results thus far are presented under Objective III.

Objective III: Biology of *Sclerotium oryzae*.

The results on effects of residue removal presented under objective II accentuated the need for information regarding the survival and potential increase of sclerotial numbers in the soil under various conditions. For example: (1) Do sclerotia survive and increase when in soil free from infected straw. This situation would arise if sclerotia from infected rice were liberated from residue during harvest, baling and removal of straw. (2) Does the survival and/or increase of sclerotia differ when infected rice straw is incorporated into soil from that of incorporating free sclerotia into soil and (3) Are the results obtained during the last two drought years applicable under seasons of normal rainfall?

Table 4. Percent change in stem rot inoculum and disease severity between residue disposal treatments after 3 consecutive years of rice cropping.

Residue management treatments	Viable sclerotia/gram soil			Stem Rot Disease Severity (1 - Healthy - 5 - Severe)		
	% Change Between Seasons		Cummulative	% Change Between Seasons		Cummulative
	1975-1976	1976-1977	1975-1977	1975-1976	1976-1977	1975-1977
1. Harvested 8-12", straw spread; fall burned and fall stubble disked	+ 22	+144	+137	- 6	0	- 5
2. Harvested 8-12", straw spread spring burned; spring stubble disked	- 22	+101	+121	-12	-5	-1
3. Harvested 8-12", straw windrowed and chopped, fall stubble disked	+170	+ 93	+419	+15	+5	+2
4. Harvested 8-12", straw windrowed and chopped, spring stubble disked	+ 54	+ 93	+279	+13	-1	+2
5. Harvested 8-12", straw windrowed, baled and removed, fall stubble disked	+121	+131	+500	+14	-1	+2
6. Harvested 3", straw windrowed, baled and removed, spring stubble disked	+ 17	+ 68	+111	- 3	+2	-1
7. Harvested 8-12", straw windrowed, baled and removed, spring stubble disked	+210	+153	+255	+ 9	+2	+3
8. Harvested 3", straw windrowed, baled and removed, fall stubble disked	+ 13	+ 48	+130	+10	+5	+1
9. Harvested 3", straw windrowed, baled and removed, spring moldboard plowed	- 13	+106	+128	0	-4	-3

Values represent relative percent differences between treatments with seasonal variation (between years) removed.

Attempts to obtain answers to the above questions were carried out in laboratory and greenhouse experiments and in the field at Davis. A summary of results obtained thus far follows:

1. The competitive saprophytic ability of free sclerotia of *Sclerotium oryzae*.

Radioactive sclerotia (C^{14}) of *S. oryzae* were incubated in moist soil in petri dishes to determine their ability to give rise to new sclerotia saprophytically. Soil from two locations on which rice had been grown for a number of years was used. Since the soils were infested with *S. oryzae*, the naturally occurring sclerotia were removed by sieving before the introduction of labeled sclerotia. Treatments included both autoclaved and unautoclaved soil, with or without an amendment of uninfected rice straw. Sclerotia produced in the soil as a result of saprophytic colonization by *S. oryzae* of organic material were unlabeled and thus distinguishable from the labeled sclerotia originally introduced.

Results showed that the competitive saprophytic ability of *S. oryzae* was too low to enable it to utilize endemic organic material in either unautoclaved or autoclaved soil. In autoclaved soil amended with rice straw the labeled sclerotia germinated, colonized the straw and increased in number. In unautoclaved soil amended with straw only a few new sclerotia were produced and these did not contribute significantly to the sclerotial population in the soil.

These results indicate that the competitive saprophytic ability of free sclerotia is limited in unsterile soil. Therefore, the formation of sclerotia on parasitically infected rice residue remains the most important means of sclerotial production.

2. Production of sclerotia in infected rice straw which has been incorporated into field soil.

Four, 10' X 10' basins were infested with infected rice straw by turning the straw into the soil with hand shovels to a depth of 6". Each basin received all of the straw from a 10' X 10' area in a rice field naturally infected with *S. oryzae*. The disease rating of the rice was 2.51. Relatively few sclerotia had formed in the infected straw prior to incorporation.

Two 10' X 10' basins were infested as above except the straw was obtained from a lodged portion of a different field where relatively many sclerotia had been formed prior to incorporation.

Weekly samples were taken to determine if changes in sclerotial populations in soil occurred. In both cases, the populations of sclerotia more than doubled within 3 weeks and have shown increases with each sampling to date. These experiments will be continued throughout the winter of 1978.

3. Longevity of sclerotia in soil.

Experiments to compare sclerotial populations arising from infested rice straw (part 2) with those added free from residue were initiated. Four 10' X 10' basins were infested with sclerotia (3-4/gr soil) from six isolates of *S. oryzae* by sprinkling the sclerotia on the surface of the soil and incorporating them with a hand-rototiller throughout a depth of 6". Four additional basins were infested as above except 10 lb./basin of chopped, non-infected rice straw was also tilled in. Moisture conditions were similar to those of the natural season. Weekly samples were taken to monitor the sclerotial populations under these conditions.

For this relatively dry period the half-life of sclerotia (survival) in soil is about 1.5 years. Sclerotia mixed with noninfected rice straw declined at about the same rate. Combined, these results indicate that sclerotial populations increase in soil when infected rice residue is incorporated. In addition, sclerotial populations are much more persistent in soils under the dry conditions experienced the last two years than under years of normal rainfall.

Objective IV. Chemical control of stem rot.

An environmental impact study of Du-Ter on nontarget organisms in rice fields, including invertebrates, fish and algae was carried out. In addition, residue analysis of alternate crops grown with water from Du-Ter-treated fields and complete EPA required residue analysis samples of water, soil and rice were collected. Analysis is being done by Stoner Labs of Santa Clara, CA and data are not yet available.

Stem rot control tests were carried out with five new chemicals and formulations. None were nearly as promising as Du-Ter in regard to disease control. Systemic fungicides applied as seed treatment that had shown promise for stem rot control in the greenhouse did not perform significantly under field conditions in three trials this season.

One large-scale field trial with Du-Ter was conducted this year. Five acres of S-6 rice treated with Du-Ter (1 lb./A) yielded 7.8 cwt/A more than the untreated check.

Representatives from Thompson-Hayward Chemical Company have informed me they expect action with EPA regarding the registration of Du-Ter this winter.

Objective V. Resistance to stem rot.

Irradiated seed provided by Dr. H. Carnahan was screened in the greenhouse for potential sources of stem rot resistance. No promising sources were identified. New varieties released by CCRRF show higher levels of resistance than those intended for replacement. It appears that the stem rot resistance screening conducted by M. Morse at the station has been beneficial in increasing levels of resistance in the breeding program.

VI. PUBLICATIONS OR REPORTS:

(1) Webster, R. K. 1976. Report to California Rice Research Board, Project RP-2.

(2) Jackson, L. F., R. K. Webster, C. M. Wick, J. Bolstad, and J. A. Wilkerson. 1977. Chemical control of stem rot of rice in California. Phytopathology 67:1155-1158.

(3) Webster, R. K., and C. M. Wick. 1977. Diseases affecting rice in California. I. The Rice Journal 80:No. 5. pp 10-18.

(4) Webster, R. K., and C. A. Wick. 1977. Diseases affecting rice in California. II. The Rice Journal 80: No. 6. pp 12-15.

(5) Webster, R. K., L. F. Jackson, and C. M. Wick. 1977. Chemical control of stem rot of rice. Rice Field Day, Biggs, California. Sept. 7, 1977. pp. 7-8.

VII. CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS

Losses to stem rot are due to reduction in numbers of tillers, enhanced lodging, yield and quality (head rice) reduction. Above parameters are dependent on time of infection and can best be measured by disease severity ratings.

Disease severity ratings determined in the fall are reliable in predicting inoculum carryover or potential for disease the next season and decisions on residue management and use of a fungicide for control.

New rice varieties are more tolerant to stem rot than the older varieties when grown with levels of nitrogen fertilization adequate to allow their maximum yield production.

Straw removal by harvesting at ground level, baling and hauling from the field result in carryover stem rot inoculum levels nearly equal to fall and spring burning. Incorporation of rice residue allows highly significant carryover and buildup of inoculum levels accompanied by increases in disease severity and yield loss in continuous rice cropping. Sclerotia in infected straw survive longer and increase to greater numbers than free sclerotia in soil.

Efficacy of Du-Ter for significant chemical control of stem rot was observed in all trials again this year. Other chemicals tested were not effective.