Comprehensive Research on Rice

Annual Report

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PROJECT TITLE: Cause and Control of Rice Diseases

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LEVEL OF 1983 FUNDING: $30,000

OBJECTIVES AND EXPERIMENTS CONDUCTED TO ACCOMPLISH OBJECTIVES:

Long range objectives of research project RP-2 are to determine occurrence, nature, and control of rice diseases in California. We are proceeding by identifying the diseases, determining the extent to which they occur, and studying factors that affect severity of occurrence including biology of the pathogens and epidemiology of the diseases. Based on results obtained, experiments to determine effective methods of control are designed and carried. out. These include studies on interactions of various culture practices, i.e., residue management fertilization, seedling rate, pesticides, and development of resistant varieties. Many aspects of the project require consecutive years of study in the field and thus are continuing.

Specific objectives for 1983:

1. Continue study of the biology and epidemiology of the sheath blight and stem rot diseases of rice.

2. Evaluate the effect of burning residue of short-statured rice varieties on rice disease control. Reduced amounts of straw in windrows and wet seasons have resulted in poorer burns in past seasons. Consequently it is not known if burning delayed until spring, large ruts and buried straw in the field, etc. are resulting in increased inoculum levels of the stem rot and sheath blight pathogens.

3. Since the use of resistant varieties would be the most desirable means of disease control, we will continue evaluating wild species of rice as potential germplasm sources. We also continued work on improved methods for disease evaluation to facilitate the rice breeding program.

4. Conduct further screening trials for candidate fungicides for use in disease control. Tilt, a fungicide showing promise in last year's screening trials was evaluated on different varieties grown at differing nitrogen levels this year. Additional candidate fungicides and rate and time of application were studied.

5. Our studies of past years have shown a close relationship between nitrogen fertilization, stand density and disease severity. Trials this year included evaluation of short-statured varieties under different nitrogen levels, stand densities (seedling rates), and MCPA time and rate of application.

6. Comparisons of disease severity and realized yields to determine actual disease impact were continued. Observations include grower estimates, disease evaluation and yield produced. Such information is needed in determining modifications in the culture systems being employed in our desired disease management program.

Experiments to accomplish the above objectives were carried out in the laboratories and greenhouses of the Department of Plant Pathology, University of California, Davis, at the Rice Research Facility at Davis and at field sites in Yolo and Butte counties.

Surveys to determine distribution of sheath blight of rice were conducted in all rice-growing counties of the State.

Data for determining disease impact on California rice, grower estimates, percent land infected and severity under different farming systems, i.e., rotations, etc. was extracted from a recent grower survey and analyzed.

SUMMARY OF 1983 RESEARCH (Major accomplishments) BY OBJECTIVES:

Objective 1: Sheath blight disease of rice has increased significantly in incidence and severity during the past few years. The increase has coincided with the introduction and wide-spread culture of semi-dwarf varieties. Studies under this objective include distribution, etiology and biology of the pathogen.

Pathogen isolation and Characterization: Fifty one samples consisting of 50-75 rice tillers were randomly collected from rice fields in Yolo, Sutter, Butte and Glenn counties in Northern California. Each sample was inspected for disease and any lesions typical of sheath blight were excised, surface sterilized for 3 minutes in 10% sodium hypochlorite, sectioned and plated on 2% water agar at room temperature. Hyphal tip cultures of fungus which grew from the tissue were established on potato-dextrose agar (PDA).

The nuclear condition of fungal isolates grown on potato dextrose broth was determined using one of two staining methods.

To establish cardinal temperatures for growth of the fungus, radial growth of two isolates was measured for six days on PDA in dam tubes incubated in increments of 3 degrees from 6-42 C. Four tubes of each isolate were incubated at each temperature and the experiment was repeated once.

Anastomosis tests were carried out between the sheath blight pathogen and two binucleate Rhizoctonia tester isolates, Bn 20 of Burpee's Ceratobasidium-anastomosis group 1 (CAG-1) and Ogoshi's AG-Bb.

Rhizoctonia oryzae-sativae (Saw.) Mordue was consistently isolated from sheath blight lesions. Mycelium of the fungus is at first colorless on PDA, later white, and eventually develops a brown pigmentation. Hyphal cells were found to be binucleate, although occasionally cells with three or four nuclei were observed. The fungus produces numerous irregularly globose sclerotia on PDA which are approximately .20-.90 mm in length. Sclerotia are white when young and become brown as they mature. Sclerotia of the fungus are undifferentiated in cross-section and are composed of near spherical hyphal cells. Besides sclerotia, the fungus sometimes produces chains of elongated monoloid cells in culture. Whether these monoloid cells serve as inoculum needs to be determined.

From the samples, 26 isolates of R. oryzae-sativae were retained, all of which differed from one another in degree and shade of mycelial and sclerotia pigmentation, and habit of sclerotial production on PDA.

Sclerotium hydrophilum Sacc. and Nigrospora oryzae (Berk. and Br.) Petch were sometimes isolated from diseased sheaths but were not found to be pathogenic. In greenhouse tests.

Cardinal temperatures for growth of R. oryzae sativae were found to be 9 C, 30-33C, and 39 C.

Isolates of R. oryzae sativae obtained from affected plants, anastomized with the AG-Bb tester which is a R. oryzae-sativae isolate from rice in Japan. None of the isolates anastomized with the CAG-1 tester isolate Bn 20 which is a R. cerealis isolate from turfgrass in Pennsylvania.

Rhizoctonia oryzae-sativae (Saw.) Mordue was first reported causing a sheath blight disease of rice in Taiwan in 1922. Since then, the disease has been reported to occur in Japan,China,Vietnam, Thailand, and India. The disease is very similar in symptomatology to sheath blight of rice caused by R. solani Kuhn (AG-1), a destructive disease of rice in the southern USA and worldwide. R. oryzae-sativae is a less aggressive pathogen on rice than R. solani. In greenhouse studies conducted at UC Davis, R. solani isolates from rice in the southern U. . were found to infect and spread up tillers of California rice varieties much more rapidly than R. oryzae-sativae isolates. Since the two diseases are so similar, it is possible that in some cases disease attributed to R. solani has actually been caused by R. oryzae-sativae. In the United States, R. oryzae-sativae has not been reported on rice outside of California, and R. solani has not been found on rice in California.

Binucleate Rhizoctonia spp. pathogenic on gramineous hosts in the U.S., have so far been found to be isolates of Rhizoctonia cerealis and they comprise a common anastomosis group designated CAG-1. R. cerealis isolates cause cool weather diseases and are reportedly only pathogenic on hosts in the Gramineae (=Poaceae). R. oryzae-sativae is the first reported binculeate Rhizoctonia sp. in the U.S. pathogenic on a gramineous host that does not belong to the CAG-1 group. Furthermore, R. oryzae-sativae is a warm weather pathogen and is reported to be pathogenic on hosts other than those in the Gramineae.

Preliminary field trial results (objective 5) indicate that the California semi-dwarf varieties are more vulnerable to sheath blight than tall, statured varieties. Evidence suggests that differences in microclimatic conditions between short and tall varietal stands, rather than genetic differences between varieties, are responsible for the greater vulnerability of the semi-dwarf varieties. The semi-dwarf varieties have greater tillering capacity, can be seeded at denser rates, and respond to higher nitrogen levels than tall varieties. Denser rice stands and higher nitrogen levels have been shown to favor disease development of sheath blight caused by R. solani. Such conditions may also enhance disease incited by R. oryzae-sativae and are discussed under objective 5.

Symptomatology of Sheath Blight Caused by Rhizoctonia oryzae sativae. The diagnostic symptom of sheath blight is the occurrence of lesions on rice leaf sheaths. Lesions are circular to elliptical with gray-green to straw colored centers surrounded by distinct brown margins. A strip of necrotic cells runs down the middle of the lesion center. Frequently, additional margins form around the initial lesion, producing a series of concentric bands. Initial lesions range in length from approximately .5-4.0 cm.

Sheath blight lesions first appear on the lower leaf sheaths above the water line during the tillering stage. Initial infections are produced by sclerotia of Rhizoctonia oryzae-sativae floating on the paddy water. As the disease progresses, lesions spread vertically from the lower to the upper leaf sheaths and sometimes to the lower portion of leaf blades. On the sheath, lesions often coalesce and may cover the entire leaf sheath. Leaves of diseased sheaths are normally killed, at first turning a bright yellow. Under favorable conditions the disease can spread to the flag leaf and pannicle rachises, killing entire tillers.

The disease can also move inward to the culm where it may cause a culm rot, but this aspect of the disease is rare in California. As leaf sheaths become rotted, the fungus produces abundant brown sclerotia within and on diseased tissue. Sclerotia produced inside cells in the sheath are ordinarily short, cylindrical to rectangular in shape and are readily visible through the diseased tissue. Sclerotia produced on the surface of leaf sheaths are irregularly globose.

Sheath Blight Caused by Rhizoctonia oryzae. During survey and routine isolations, a second Rhizoctonia species, namely R. oryzae, was discovered. Pathogenicity tests revealed that it causes a sheath blight disease and that symptoms are similar but not identical to those caused by R. oryzae sativae and R. solani. R. oryzae was found to also produce a basidiospore stage. This finding was confirmed in the greenhouse. The implication of an air-borne inoculum stage impacts on our attempts to control the disease. Further study is being carried out.

Methods to determine the inoculum levels of R. oryzae sativae, R. oryzae and the stem rot pathogen Sclerotium oryzae have been developed. An understanding of the epidemiology of all three diseases is needed as control measures for each disease are developed. We will continue our studies on the biology of all three of these pathogens to the degree that information regarding control is facilitated.

Study has shown that a single rice plant can be infected with both the sheath blight pathogens and the stem rot pathogen. The interaction of the two diseases is not known at this time but control measures should be correlated.

Objective 2: Fields were selected that varied in straw spread vs. windrowed, fall burn vs. spring burn and general condition of soil surface, i.e., rutted, to compare effectiveness of burning in controlling stem rot and sheath blight inoculum levels. This study was initiated to determine if burning in short-stature rice is as effective in minimizing disease as data showed burning to be when the old, tall varieties were grown. Data should be collected for at last one more season before conclusions can be drawn. The methods developed for determining inoculum level and disease severity of sheath blight and stem rot are essential to this study.

Objective 3: Screening of weedy Oryzae species and progeny from crosses with common varieties has been continued for both stem rot and sheath blight. sources of resistance more resistant than our present varieties have been identified and further crosses are being made. Progress is slow but results thus far are encouraging that increased resistance can be incorporated into future varieties.

Objective 4: Trials to determine if fungicides can be identified that will control stem rot and sheath blight were carried out in Yolo and Butte counties. The results from three trials are summarized in Table 1. As seen there, none of the chemicals at the rate and time tested were as effective as Duter in controlling stem rot or sheath blight. In last year's trials, Tilt showed more promise than it did this year in the screening trials.

A trial conducted at the Rice Research Facility in 1983 comparing the effectiveness of Tilt for control of stem rot on five varieties at two nitrogen levels is summarized in Table 2. The results indicate that Tilt can effect significant disease control, particularly when nitrogen levels are high enough (see Objective 5) to allow maximum yield. Unfortunately, past and present studies have substantiated that the higher nitrogen levels, to which the new short stature varieties respond, also enhance stem rot severity. The results of this test and goal of maximum production emphasize the need for fungicides in our rice disease control program. Studies on Tilt and attempts to obtain residue data to facilitate registration will be continued.

Objective 5: Past results have shown a close relationship between stem rot disease severity and resultant yield reduction with high nitrogen fertilization, stand density and herbicide injury. The majority of data available was obtained from trials studying the old tall varieties. With the advent of the short stature varieties nitrogen fertilization and stand density (seeding rates) have in general increased significantly. The need for information regarding varietal susceptibility, and appropriate fertilization, seeding and weed control practices when growing the short varieties is imperative if the potential of the varieties is to be realized. Paramount in this regard is the affect these factors have on stem rot and sheath blight disease severity. In addition, studies to determine if short varieties are inherently more susceptible to stem rot and sheath blight
indicate increased severity of these diseases observed on the short varieties may be due primarily to the manner in which the short varieties are being

Table. 1. Effect of foliar applications of fungicides for control of rice diseases 1973.

Treatments	Rate gr ai/A	Butte Co. % Sheath Blight[1]	Yolo Co. Stem Rot[2] 1-5	Yolo Co. Stem Rot[3] 1-5
1. Tilt 3.6 EL	71	33.0 a	2.98 abcd	---
2. Tilt 3.6 EL	113	20.3 a	3.05 abcd	---
3. Tilt 3.6 EL	226	20.1 a	3.04 abcd	2.48 b
4. CGA 64251 1.0 EL	71	32.4 a	3.02 abcd	---
5. CGA 64251 1.0 EL	113	34.9 a	3.08 abc	---
6. CGA 64251 1.0 EL	226	27.4 a	3.02 abcd	2.57 ab
7. Duter 39 WP	454	26.0 a	1.84 e	1.87 c
8. Bay NTN 75 WP + Benlate 50 WP	150 228	17.9 a	2.89 bcd	---
9. Bay NTN 75 WP	150	21.6 a	2.86 d	2.45 b
10. Baycor 50 WP	170	37.2 a	2.87 cd	2.55 b
11. Benlate 50 WP	228	28.7 a	3.10 ab	---
12. Check	---	37.1 a	3.21 a	2.76 a

[1] % sheath blight, 2 applications mid-tillering, internode elogation: Duter, 1 application at MT.

[2] Stem rot, 1 = healthy - 5 = severe, 2 applications MT and IE, except Duter which 1 application at MT.

[3] One application at Mid-tillering - SR 1 = healthy, 5 = severe.

Table 2. Effect of Tilt for control of stem rot on 5 rice varieties at 2 nitrogen levels (Tilt applied at Mid-tillering, 225 gr ai/A).

		Disease Rate		Yield	
		Tilt	No Tilt	Tilt	No Tilt
S-201	LN[1]	1.86[2]	2.03	61.1[3]	54.1
	HN	2.07	2.45	70.4	58.4
M-5	LN	2.07	2.20	41.7	48.4
	HN	2.19	2.38	62.4	56.4
M-302	LN	1.89	1.98	56.4	60.7
	HN	2.12	2.31	55.1	53.8
Calrose	LN	1.84	2.07	73.7	48.1
	HN	1.98	2.48	63.2	52.0
Calrose 76	LN	1.20	2.16	65.4	54.8
	HN	1.93	2.07	78.2	70.8
L.S.D.	.05	0.147		3.21	

[1] LN = Nitrogen fertilization less than required for maximum yield. HN = Nitrogen fertilization at or above level needed for maximum yield.

[2] Stem rot severity: 1 = healthy, 5 = severe.

[3] Yield at 14% moisture.

grown. Consequently, a major effort of our field studies this year was directed toward comparisons of the effects of various culture practices, i.e., MCPA rate and timing, nitrogen rate, seeding rate, varietal susceptibility and interactions of these on disease severity and subsequent effects on yield. Experiments conducted and results obtained included:

A. Variety X Nitrogen Rate X Seeding Rate - Butte County

Six varieties, M-201, M-302, S-201, M-7, Cal Pearl, and Cal Belle were sown at each of three seeding rates, 120, 150, and 180 lbs per acre at two nitrogen rates, 200 lbs/A (16-20) plus 70 lbs Aqua for the low rate and 100 lbs Aqua for the high rate. Sheath blight disease severity and yield was determined for each. General results were as follows:

(1) Sheath blight disease index between the two nitrogen levels did not vary significantly when varieties were viewed collectively. Viewed alone M-201 was significantly more susceptible than all other varieties at both N levels and all seeding rates. M-7 was the least susceptible while M-302, S-201, Cal Pearl, and Cal Belle were equal to each other.

(2) Stand density (seeding rate) X variety: Sheath blight severity was significantly higher on M-201 at all densities and increased significantly as N increased. M-7 showed no change in sheath blight over the three densities. Increases in sheath blight as density increased occurred from M-302, S-201, Cal Pearl, and Cal Belle but they were not significantly different from each other.

(3) Sheath blight was highest at the high nitrogen level and high density rate for all varieties. The 120 and 150 lb seeding rates showed higher disease level at the lower N levels than the 180 density probably due to N levels being higher in the lower number of plants/area. This may also explain the overall trend for lower sheath blight as densities increased at lower N levels.

(4) Yields of six varieties at three seeding rates and two nitrogen levels obtained in 1983 trial are summarized below:

Variety	Seeding Rate lbs/A	Yield cwt/A @ 14% High N	Low N
M-201	120	81.4	83.9
	150	79.4	76.7
	180	78.4	80.3
M-302	120	79.1	76.5
	150	78.4	76.9
	180	77.3	77.8
S-201	120	83.6	84.7
	150	87.2	80.4
	180	82.2	83.8
Cal Pearl	120	85.9	85.3
	150	88.1	83.2
	180	84.6	85.9
Cal Belle	120	72.9	71.5
	150	81.1	73.1
	180	75.4	74.3
M-7	120	80.3	76.8
	150	82.4	75.5
	180	80.7	76.7

As seen here, highest yeilds were obtained at seeding rates of 150 lbs/acre for 5 of the varieties and at 120 lbs/acre for one, M-201.

B. MCPA Rate X Time X Nitrogen Rate

Four application times of MCPA at two rates were compared at three nitrogen levels to determine effects of varying these culture practices n sheath blight severity and yield. The variety grown was M-201. Nitrogen rates tested were: (L) 110, (M) 125 and (H) 140 units N preplant. All treatments were top dressed with 30 units at mid season. MCPA application dates were 41, 48, 53 and 60 days after planting. MCPA rates were 1 and 2 lbs/acre. The entire experimental area was treated with Basagran, which resulted in reasonably good weed control. Consequently the differences in treatments are assumed to be due to affects of MCPA treatments in the absence of weed competiton. Results for yield obtained for various treatments were as follows:

MCPA Rate (lbs/A) and time of application from planting		Yield cwt/A @ 14% nitrogen level H	M	L
41 days	1 lb	85.6	85.3	78.3
	2 lbs	83.4	79.1	80.0
48 days	1 lb	85.6	81.5	77.5
	2 lbs	81.9	80.0	76.3
53 days	1 lb	80.7	81.7	79.0
	2 lb	83.3	83.7	76.8
60 days	1 lb	83.3	85.9	82.2
	2 lbs	78.3	80.5	80.4
Check	---	87.7	89.6	85.2

Considering nitrogen level alone there was no increase in yield in the high nitrogen level over the medium nitrogen level. Overall yields were higher with 1 lb MCPA treatments than those treated with 2 lbs. Highest yields were obtained at allnitrogen levels in which no MCPA was applied. Single-pound applications of MCPA resulted in higher yields than 2 lb applications over most of the nitrogen levels and time of applications tested.

Sheath blight severity throughout the trial was in the low to medium range. In cases where yield was significantly lower in MCPA treatments, sheath blight severity was generally higher.

C. Combined results of experiments conducted to determine the affects of varietal differences, nitrogen fertilization, seeding rates and MCPA rate and time of application on rice disease severity and yield indicate that significant improvements in production can be made by careful management and that current varieties respond differently to various culture practices. We hope to continue similar studies to further our knowledge of such interactions.

PUBLICATIONS OR REPORTS:

1. Webster, R. K. 1982. Report to California Rice Research Board. Project RP-2. Cause and control of rice diseases. In Annual Report of Comprehensive Rice Research 1982. University of California and U. S. Department of Agriculture. pp. 33-45.

2. Gunnell, P. S., and R. K. Webster. 1983. Sheath blight of rice in California. Abs. Proc. American Phytopathological Society 1983. Abs. No. A238. Ames, Iowa, June 26-30.

3. Figoni, R. A., J. N. Rutger, and R. K. Webster. 1983. Evaluation of wild Oryza species for stem rot (Sclerotium oryzae) resistance. Plant Disease 67:998-1000.

4. Rutger, J. N., R. K. Webster, and R. A. Figoni. 1983. Weedy species of rice show promise for disease resistance. California Agriculture, Vol. 37:7-9.

CONCISE GENERAL SUMMARY OF CURRENT YEARS RESULTS:

Rhizoctonia oryzae-sativae, a binucleate Rhizoctonia sp. is the causal organism of a sheath blight disease of rice in California. Recent increase in incidence and severity of the disease has paralleled an increase in the use of semi-dwarf varieties. Symptoms of the disease are very similar to those of sheath blight of rice caused by Rhizoctonia solani in the southern U. S. The fungus is the first reported binucleate Rhizoctonia sp. in the U. S. pathogenic on a gramineous host that is not a R. cerealis isolate (CAG-1).

Another Rhizoctonia sp., namely R. oryzae, was identified as pathogenic to rice this year. Its role as a rice pathogen in California is being studied.

Stem rot continues to be a disease of rice of major concern. Rice plants may be infected by both stem rot and sheath blight. In fields where both diseases occur, one or the other is usually most severe.

Studies to determine whether bruning of short-statured rice is as effective in controlling stem rot and sheath blight as was burning for disease control on tall varieties are being continued. Preliminary results suggest that effectiveness of burning for disease control is directly related to proportion of residue removed by burning.

Weedy Oryzae species show promise as sources of disease resistance to both stem rot and sheath blight. Breeders are continuing efforts to exploit these resistance sources as parents in the rice breeding program.

Tests to evaluate fungicides for potential use in controlling stem rot and sheath blight were continued. No chemicals as effective as Du-Ter were found. Tilt, a fungicide showing promise last year, gave erratic results this this year. However, in one trial wih Tilt highly significant reductions in disease and increases in yield were obtained on three of five varieties tested at two nitrogen levels.

A major effort to determine the effects of culture practices, i.e., variety grown, ntirogen fertilization rate, seeding rate, MCPA application rate and time and treatment with fungicide on disease interaction was carried out this year. The results indicate that disease management and higher yields are attainable by manipulation of thse culture practices. For example, varieties were found to differ in response to nitrogen rate, seeding rate and MCPA time and rate. Maximum yield and disease suppression usually occurred at seeding rates and nitrogen levels lower than those used by most growers. Further study is needed to delimit the most favorable culture system for a particular variety and in various locations. We plan to continue and expand these studies in the future.