Project No. RP2

COMPREHENSIVE RESEARCH ON RICE
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PROJECT TITLE: Cause and Control of Rice Diseases

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OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION 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 diseases, determining the extent to which they occur, and studying factors that affect disease severity. We have found that basic biological information on some California rice diseases is lacking in the literature. Consequently basic studies to determine which aspects of their epidemiology, particularly kernel smut and Aggregate Sheath Spot (Sheath Blight), provides likely areas to emphasize control measures. Experiments to determine the best methods of disease management have emphasized interaction of various culture practices and their effects on disease severity. We have also emphasized experiments on time of application and rates of fungicides and identification of disease resistant rice germplasm.

The recent identification of Kernel Smut in California has resulted in extensive studies on this disease. It become apparent that little reliable information on the basic biology of this disease was known. Consequently we have studied many aspects including, distribution, means of spread, pathogen life cycle, sources of resistance and efficacy of various methods for control. Continuation of these studies will be a primary goal for the coming year.

The potential for use of minimum tillage (drill seeded rice) in the rice culture system requires that the impact of this practice on disease incidence and severity be determined. This year, Carl Wick took the lead in establishing trials to allow this.

Many aspects of the project require consecutive years of study in the field and are thus continuing.

Specific Objectives For 1985:

1) Continue study of the biology of Rhizoctonia oryzae-sativae and Rhizoctonia oryzae.

2) Evaluate the occurrence of Aggregate Sheath Spot and Stem Rot in minimum tillage systems in comparison with conventional tillage systems.

3) Evaluate fungicides and timing of application for control of Aggregate Sheath Spot, Stem Rot and kernel smut.

4) Complete studies on the effect of nitrogen fertilization on severity of Aggregate Sheath Spot and Stem Rot.

5) Continue studies on the effect of different water management regimes on disease severity of Stem Rot and Aggregate Sheath Spot.

6) Continue screening rice germplasm for resistance to rice diseases with emphasis on Stem Rot, Aggregate Sheath Spot, and Kernel smut.

7) Determine the efficacy of current rice seed treatments for control of seed rot and seedling diseases in drill seeded rice.

8) Continue studies on distribution, epidemiology and biology and control of kernel smut.

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 in growers fields in Colusa, Sutter and Butte Counties. Samples for study of kernel smut distribution were obtained from throughout the California rice growing areas.

SUMMARY OF 1985 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVE:

Objective 1: Biology of Rhizoctonia oryzae-sativae and Rhizoctonia oryzae.

Bordered Sheath Spot caused by R. oryzae was found in several fields in Butte Co. again this year. It is still present at a much lower frequency than either Stem Rot or Aggregate Sheath Spot, but the disease incidence may increase in the future to a level where it may become a problem. Indications are that Bordered Sheath Spot is a more aggressive disease than Aggregate Sheath Spot.

We are proposing to place the perfect state of R. oryzae in the genus Waitea as a new species. At the present time the genus contains only one species, Waitae circinata, which is the perfect state of R. zeae which causes a minor disease of rice in the southern U.S.

The perfect state of R. oryzae-sativae was found in the field again this summer in Butte Co. in mid-August. Since the basidiospore inoculum is produced late in the season when infections of Aggregate Sheath Spot

are well established, it is doubtful that basidiospores play a significant role contributing to disease incidence within a growing season.

Objective 2: Disease in Minimum Tillage Drill Seeded Rice.

Severity of Aggregate Sheath Spot and Stem Rot were assessed in a minimum tillage drill seeded trial set up in cooperation with Carl Wick in Butte Co. Three cultivars, M-201, L-202 and S-201 were compared in the drill seeded trial with seed treated, seed untreated and four nitrogen fertilization regimes. Data collected included disease ratings for Aggregate Sheath Spot, Stem Rot and yield. The results are summarized in Tables 1 and 2. The disease ratings collected in the check adjacent to the drill seeded trial under water-seeded conditions are summarized in Table 3.

Table 1
Aggregate Sheath Spot and Stem Rot Severity on Minimum Tillage Drill Seeded Rice 1985

Cultivar	AGSS[3]	Stem Rot[4]	N Rate lbs/Acre[5]	AGSS	Stem Rot
M-201 NT[1]	12.0	1.5	140	7.7	1.6
M-201 T[2]	9.2	1.6	190	6.8	1.6
L-202 NT	8.0	1.6	210	5.7	1.6
L-202 T	6.2	1.7	220	6.5	1.6
S-201 NT	3.0	1.6			
S-201 T	2.0	1.5			
LSD	2.426[6]	NS		NS	NS

[1]Untreated Seed

[2]Treated seed

[3]Disease index = ht. of disease on 100 tillers (cm)/100; each value is a mean of 4 replicates

[4]Disease index = 1-healthy; 5-severe

[5]Nitrogen applied as urea

[6]LSD = Least significant difference at P = 0.05 NS = not significant

Table 2
Yield of Cultivars in Minimum Tillage
Drill Seeded Rice

Cultivar	Yield 14% moisture lbs/acre	
M-201 NT	9072.5	a
M-201 T	9190.4	a
L-202 NT	8523.3	b
L-202 T	8463.2	b
S-201 NT	9076.9	a
S-201 T	9380.3	a

LSD 379.98

Table 3
Aggregate Sheath Spot and Stem Rot Incidence on Water-Seeded
Rice in Check Adjacent to Drill Seeded Rice 1985

Cultivar	Sample[1]	Aggregate Sheath Spot[2]	Stem Rot[3]
M-201	1	10.2	2.3
	2	15.7	2.3
	3	16.5	2.3
	4	15.3	2.1

[1]Each sample consisted of 200 tillers.

[2]Disease index = ht. of disease on 200 tillers (cm)/200.

[3]Disease index; 1 = healthy, 5 = severe.

The different rates of nitrogen fertilization did not effect disease development of AGSS or Stem Rot, but there were differences among cultivars in susceptibility to AGSS. There were no differences in Stem Rot severity among the cultivars used. Relative susceptibility of the cultivars used in the field trial to AGSS was the same as seen in previous years, with M-201 being the most susceptible cultivar. Disease pressure in the check where the trial was conducted was very low and this may account for the lack of differences in disease among the four nitrogen treatments. Disease samples were taken from the check adjacent to the minimum tillage trial where M-201 had been planted using standard cultivation techniques. The severity of AGSS and Stem Rot was low in the neighboring check, but was greater than that seen for M-201 in the minimum tillage trial. Plots of untreated M-201 seed had a greater incidence of AGSS than plots of treated seed. Incidence of AGSS did not differ between plots of treated and untreated seed of L-202 or S-201.

Further comparisons need to be made between minimum and conventional tillage systems in regard to disease incidence and severity of AGSS and Stem Rot. Indications from this year are that disease in a minimum tillage system is no greater, and perhaps less, than in a conventional tillage system.

Objective 3: Evaluation of Fungicides for Control of Aggregate Sheath Spot and Stem Rot.

Several fungicides applied at different rates and growth stages were evaluated in two duplicate trials in Butte Co. for control of AGSS and Stem Rot. Six fungicides were tested at different rates and application times on S-201. The results of the trials are summarized below (Table 4).

The disease incidence of Stem Rot in the check plots of both trials was essentially none and therefore no samples were rated for Stem Rot. AGSS was present in both trials. Treatments 4, 7, 8, 11 gave the best control of AGSS in both trials, but showed no significant increase in yield (except for treatment 4, Trial 1). Yields of treatments 4, 7, 8, 11 were often lower than some of the other treatments which did not control disease as well. Treatment 2 had significant greater yield than the check in both trials, but did not differ from the check in severity of AGSS.

Residue analysis for persistence of the fungicides in straw and grain are not yet complete.

Objective 4: Effect of Nitrogen and Cultivar on Disease Severity of Aggregate Sheath Spot and Stem Rot.

The effect of nitrogen and cultivar on disease was assessed in a Trial in Butte County. Treatments consisted of 5 rates of nitrogen at 0, 50, 100, 150 and 200 lbs/acre applied as ammonium sulfate. Cultivars tested were M-201, Cal Pearl, M09, Earlirose and S-201. Results are summarized in Table 5.

Table 4
Efficacy of Fungicide Treatments for Control of Aggregate Sheath Spot of Rice 1985

Treatment	Rate gms/ai/A	Treatment Time IL[1]	Early Boot	Early Head	Aggregate Sheath Spot Trial 1[2]	Severity[3] Trial 2	Yield (lbs) 14% moisture[4] Trial 1	Trial 2
1-Tilt 3.6 EC	125	X			14.6	16.9	28.6	27.4
2-Tilt 3.6 EC	75	X	X		15.2	17.8	29.8	29.4
3-GX-077	85		X	X	14.9	14.4	29.2	26.7
4-GX-077	170		X	X	12.9	12.7	28.6	26.7
5-GX-077	255		X	X	13.8	15.9	27.5	26.7
6-GX-094	85		X	X	13.5	16.2	28.6	26.3
7-GX-094	170		X	X	10.9	13.1	28.1	26.3
8-GX-094	255		X	X	12.7	14.3	28.4	26.0
9-Fugi 1	115	X	X		15.5	16.9	29.1	25.8
10-Bay 1608	680	X	X		17.0	17.8	28.4	25.7
11-Ortho XE-779	100	X	X		9.6	10.7	28.1	25.6
12-Check	-				15.8	17.5	26.4	25.2
				LSD	4.17	3.53	2.16	2.31

[1]Internode elongation

[2]Mean of 4 replications per trial, 10' X 20' plot size

[3]Disease index = ht. of disease on 100 tillers (cm)/100

[4]Yield per 140 ft^2 plot

[5]L.S.D. = least significant difference at P = 0.05

Table 5
Effect of Nitrogen Rate and Cultivar on Disease Severity of Aggregate Sheath Spot 1985

Cultivar	Disease Index[1]	N Rate lbs/acre[2]	Disease index
M-201	21.4	0	16.3
Cal Pearl	17.2	50	14.7
M-9	17.0	100	14.2
Earlirose	13.6	150	16.9
S-201	11.8		
	LSD 2.28[3]		

[1]Ht. of disease on 100 tillers (cm)/100

[2]Each value is a mean of 4 replicates

[3]Nitrogen applied as ammonium sulfate

[4]LSD = least significant difference at P = 0.05

[5]** = significant at P = 0.01

There was virtually no Stem Rot present in the field trial and so samples were not rated for Stem Rot. AGSS was present. There was no significant interaction between nitrogen and cultivar in terms of disease development of AGSS, but there were significant differences in disease among cultivars and there was a significant effect of nitrogen on disease development. The relative susceptibility of the cultivars to AGSS was the same as seen in previous years with M-201 being the most susceptible, Cal Pearl and M-9 having intermediate susceptibility, and S-201 and Earlirose being the least susceptible. The severity of AGSS was the lowest at the intermediate nitrogen rates which was the same trend as was observed last year.

Results from field trials over the past four years have shown that the particular cultivar grown is the primary determinant of the severity of AGSS. Of currently grown cultivars, M-201 is the most susceptible and S-201 is the least susceptible. Intermediate rates of nitrogen fertilizer result in the lowest disease incidence of AGSS and give the highest yields for most cultivars. Previous studies have shown that Stem Rot severity increases with increasing levels of nitrogen fertilizer. Intermediate levels of nitrogen fertilizer of 100-150 lbs/acre minimize disease incidence of AGSS and Stem Rot and optimize yields of the currently available cultivars.

Objective 5: Interaction of effects of different water management regimes on disease severity of rice.

Knowledge of the effects of culture practices on disease cycles and severity is necessary in formulating disease management recommendations. This is particularly significant in the case of diseases such as Stem Rot (Sclerotium oryzae) and Aggregate Sheath Spot (Sclerotium oryzae-sativae) of rice where primary inoculum is carried to the infection sites by flood water. The purpose of this phase of the overall project is to determine the persistence and efficacy of S. oryzae and S. oryzae-sativae sclerotia (primary inoculum) at different water depths and under continuous and discontinuous flooding.

Methods and Procedures: Studies are being carried out at a site in Colusa Co. and one in Sutter Co. Observations on inoculum level, disease severity and yield were taken from each replication of the various water regimes (8 were tested at Colusa site and 6 at the Sutter site). Specific methods were as follows:

1) determination of inoculum levels; random soil samples were collected from the seed bed (top 3 inches) from each plot (basin). Samples from each basin were combined and five sub-samples taken and processed by established methods to determine the number of viable sclerotia of S. oryzae and S. oryzae sativae per gram soil.

2) disease severity ratings: Random samples from the area designated for sampling plants in each basin were collected at the time water was drained from the permanent flood. Each sample consisted of at least 100 tillers. Stem rot severity was rated by methods described previously and expressed as 1 = healthy - 5 = severe. Aggregate sheath spot was rated on the basis of distance disease developed up the tiller from the base and expressed as the mean for total tillers rated.

Results: Colusa site: Inoculum level: S. oryzae (Stem rot) inoculum levels were essentially negligible i.e. less than 0.02 viable sclerotia/gram in 4 of the subsamples. No S. oryzae sclerotia were recovered from the remainder of the samples. Inoculum levels of S. oryzae sativae were very low, but the organism was detectable in all basins i.e. x 0.012 sclerotia/gram soil. This is a relatively low inoculum level but it was quite uniform throughout the experimental area at the time the study was begun.

Disease Severity: Stem rot was not a factor in this years results. The inoculum was extremely low and very little stem rot was observed. There were no significant differences in stem rot between any of the treatments. Aggregate Sheath Spot severity did differ between treatments. It was significantly less severe in treatment 8 where water was drained after the water holding period. It was most severe in treatments 4, 5 and 6. Treatments that remained flooded throughout the season developed varying levels of ASP (1-7), all significantly higher than where water was drained.

Results of the first season indicate that draining had a significant effect in minimizing Aggregate Sheath Spot. It will be interesting to see if this also affects carry over inoculum and disease severity developed in subsequent seasons. If the Aggregate Sheath Spot organism behaves like S. oryzae has in other studies we might expect that inoculum build ups will correspond to basins where disease is most severe. This will be possible to determine in the next years of the project. It will also be necessary to continue monitoring inoculum levels and disease severity in basins where water is drained. Results on the effect of the treatments tested during the second growing season on disease severity at the Colusa site are summarized in Table 6. Results from the first year at the Sutter Co. site are summarized in Table 7.

Table 6
Effect of Water Management on Severity of Aggregate Sheath Spot and Stem Rot - Colusa Co. 1985

Treatment* Water Depth (inches)	AGSS[1]	Stem Rot[2]
1-1-3, 5-7	2.2	1.0
2-1-3, 1-3	1.2	1.1
3-3-5, 5-7	3.0	1.0
4-3-5, 3-5	1.7	1.1
5-5-7, 5-7	4.7	1.3
6-3-5, 5-7	4.4	1.0
7-3-5, 5-7	4.3	1.1
8-5-7, 5-7	3.7	1.5
	NS[3]	NS

[1]Disease index = ht. of disease on 100 tillers (cm)/100 each value is a mean of 4 replicates

[2]Disease index = 1 - healthy; 5 - severe

[3]NS = not significant

*Water depth varied prior to herbicide application, during water holding period after herbicide application, holding period varied in time: Treatment 8 drained after water holding period for ten days, water level after panicle initiation 5-7 inches in all treatments.

Table 7
Effect of Water Management on Severity of Aggregate Sheath Spot and Stem Rot - Sutter Co. 1985

Treatment	No. Herbicide[4] AGSS[5]	No. Herbicide[4] Stem Rot[6]	With Herbicide AGSS	With Herbicide Stem Rot
1 - continuous 2" depth	3.3	2.2	3.5	1.6
2 - continuous 5" depth	1.1	1.4	5.1	2.2
3 - continuous 8" depth	1.8	1.4	5.5	2.4
4 - Leathers method[1]	6.7	1.9	4.6	2.2
5 - Delayed drainage[2]	2.7	2.2	6.2	2.0
6 - Old method[3]	1.2	1.5	8.2	2.4
	NS[7]	NS	NS	NS

[1]Flood for 2 days, drain for 5 days, reflood at 5"

[2]5" depth until day 19, drain until day 28, reflood at 5"

[3]8" depth for 19 days, lower to 5" depth

[4]50 lbs Ordiam/acre at day 7; 10 gpa Basagran day 28

[5]Disease index = ht. of disease in 100 tillers (cm)/100 each value is a mean of 4 replicates

[6]Disease index = 1 - healthy; 5 - severe

[7]NS = not significant

Disease incidence of both AGSS and Stem Rot was very low in both trial locations as was anticipated since soil samples showed extremely low levels of inoculum. In both trials there was no significant difference in disease development among any of the water management treatments this year. Differences in disease among treatments may have been apparent if the disease pressure had been greater. In the Sutter Co. trial Stem Rot incidence was greater in the herbicide treated plots than in the untreated plots.

Objective 6: We have continued to cooperate with Dr. Rutger in attempts to identify and determine the inheritance of disease resistant germplasm. Studies on resistance to Aggregate Sheath Spot have identified sources available in wild species. Details are included in Dr. Rutgers report.

Objective 7: The advent of drill seeding into the California production system requires an evaluation of current rice seed treatment practices and their possible effects on stand establishment in drill seeded rice.

Greenhouse experiments comparing emergence of different cultivars with seed planted at different depths in pasteurized soil are summarized in Table 8. The first seedlings emerged within 5 days with seed planted at 1/2 and 1 inch depths emerging first. After 7 days some seedlings emerged from planting depths of 2 inches. After 9 days seeds planted at 1 inch had all emerged and the first from those planted at 3 inches had emerged. After 11 days all seedlings from 2 inch plantings had emerged.

Seed planted at 3 inch depths gave the poorest total emergence and were often twisted and weak. Seedlings emerged from 1/2, 1, and 2 inch depths were comparable. Only M-201 showed no difference in total emergence over all four planting depths.

These preliminary results indicate that emergence of our cultivars may vary when drilled and suggest a need for further study on planting depths under field conditions. Experiments with various seed treatments in non-pasteurized soil are underway.

Objective 8: Kernel Smut of rice, caused by the fungus Neovossia horrida, was recently detected affecting California rice. We initiated studies to develop methods to (1) determine extent of infestation in California rice growing areas, (2) eliminate smut chlamydospores from infested seed, (3) determine disease cycle and biology of the kernel smut organism, (4) develop reliable inoculation methods for determining relative susceptibility of cultivars and (5) develop control measures.

Seed treatments with NaOCl were shown to be effective in disinfecting seed. Our standard seed treatments currently used for controlling seed rot and seedling disease, especially Kocide was also effective. Only captan was not effective in completely eliminating smut from seed sources.

Results from our studies on the disease cycle and biology of the smut organism do not correspond completely with published information on this disease organism. Most importantly, the stage at which infective hyphae becomes dikaryotized is unclear. This is particularly important in attempts to understand the infection process. This information is needed in attempts to develop control measures and our studies are continuing.

We have developed a reliable and repeatable method of inoculation for comparing cultivar differences. Studies thus far suggest that some of our newer cultivars are more susceptible than older ones, i.e. Calrose. This may be one of the reasons the disease has appeared in California at this time.

Table 8
Seedling Emergence Trial - Greenhouse - 1985 Comparison of Cultivars within Each Depth

3" Depth

Cultivar	# emerged* seedling
M-201	9.00 a
L-202	8.00 ab
Cal Belle	6.75 b
M-101	5.00 c
M-401	4.75 cd
M-9	4.25 cde
Cal Pearl	3.25 de
S-201	3.00 e
M-7	3.00 e
M-302	3.00 e
M-202	2.00 e

2" Depth

Cultivar	# emerged* seedling
L-202	9.75 a
M-101	9.50 a
M-202	9.25 a
M-401	9.25 a
Cal Belle	9.00 a
M-201	9.00 a
M-9	9.00 a
S-201	8.50 ab
M-7	8.25 ab
M-302	8.25 ab
Cal Pearl	7.00 b

1" Depth

Cultivar	# emerged* seedling
M-202	10.00 a
L-202	10.00 a
M-302	10.00 a
M-201	9.75 ab
M-401	9.50 ab
Cal Belle	9.00 abc
Cal Pearl	9.00 abc
M-7	9.00 abc
M-9	9.00 abc
M-101	8.25 bc
S-201	7.50

1/2" Depth

Cultivar	# emerged* seedling
M-202	10.00 a
M-7	10.00 a
M-401	9.75 a
Cal Belle	9.50 a
L-202	9.50 a
M-101	9.50 a
M-302	9.50 a
Cal Pearl	9.25 a
M-201	9.25 a
M-9	9.00 ab
S-201	7.50 b

each value is a mean of 4 reps
LSD, P = 0.05

* out of 10

We have spent considerable effort attempting to determine the extent of the kernel smut disease in California during the past year. Over 1100 samples representing an equal number of fields (lots) were examined from the 1984 crop and we are currently processing over 1700 samples (lots) from the 1985 crop. Data from the 1984 samples indicate that kernel smut was present in nearly 11 percent of the samples tested. No smut was found in samples collected from the San Joaquin Valley in the 1984 samples. Smut was found in all counties in the Sacramento Valley. A break down of smut found in samples from Butte Co. as to variety is given below:

1984 Butte County Samples examined for Kernel Smut

Cultivar	# Samples	# With Kernel Smut
S-201	99	13
Cal Pearl	14	2
M-9	2	2
M-302	17	1
M-201	146	22
Cal Belle	54	32

The results thus far indicate that kernel smut is quite widely distributed in much of our rice growing area and strongly suggests that control methods other than clean seed or seed treatment are needed.

Publications or Reports:

Webster, R. K. Report to the California Rice Research Board. Project RP-2. Cause and Control of Rice Diseases. 14 pp. in: Annual Report of Comprehensive Rice Research. 1984. University of California and U.S. Department of Agriculture.

Gunnell, P. S. and R. K. Webster. 1985. The effect of cultural practices on Aggregate Sheath Spot of Rice in California. Phytopathology 75:1340.

Gunnell, P. S. and R. K. Webster. 1985. The perfect state of Rhizoctonia oryzae sativae: causal organism of Aggregate Sheath Spot of Rice. Phytopathology 75:1383.

Concise General Summary of Current Years Results:

The perfect state of R. oryzae sativae the cause of Aggregate Sheath Spot of Rice has been identified. Sexual spores are produced in the field but supposedly too late to be a factor in disease incidence. Bordered sheath spot, caused by R. oryzae was found in several fields in Butte Co. This disease is similar in appearance to Aggregate Sheath Spot and is a more aggressive disease.

Incidence and severity of Aggregate Sheath Spot are primarily dependent on cultivar differences. In general, short-statured cultivars are more susceptible than tall. Nitrogen fertilization effects on Aggregate Sheath Spot severity also were found to be cultivar related, but overall disease incidence and severity were greatest at lower nitrogen levels. This situation is opposite from the effects of nitrogen fertilization on Stem Rot. Seeding rate and differences in stand density had little effect on AGSP severity. Stem rot caused by Sclerotium oryzae is usually more aggressive on those cultivars which are least susceptible to Aggregate Sheath Spot.

Severity of Aggregate Sheath Spot and Stem Rot was not different in a drill seeded trial testing possible effects resulting from various nitrogen levels and cultivars than has been observed in water seeded rice. A preliminary study indicated that seedling emergence of cultivars may vary depending on planting depth. Further study is needed in this area and also to determine potential cummulative effects of minimum tillage on severity of rice diseases.

Trials to determine effects of water management on disease severity were continued. Disease pressure was low at both locations. Draining was the only treatment that had a significant effect in minimizing Aggregate Sheath Spot. In the Sutter County trial Stem Rot incidence was greater in herbicide treated plots than in untreated plots. This observation is consistant with earlier studies.

Resistance to AGSS is available in wild Oryzae species. These materials are available to the plant breeders.

Kernel smut of rice was found in 11 percent of over 1100 fields sampled in the 1984 crop. The disease appears to be concentrated in the Sacramento Valley rice growing region. Most cultivars appear to be susceptible but highest incidences were observed in long grains. Methods for reliable inoculation and screening of cultivars are now available. Sodium hypochlorite is effective in eliminating smut chlamydospores from seed. Studies on the disease cycle are being continued in attempts to find effective avenues whereby control measures can be developed.