ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 1996 - December 31, 1996

PROJECT TITLE: Cause and Control of Rice Diseases

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LEVEL OF 1996 FUNDING: 32265.00

OBJECTIVES AND EXPERIMENTS CONDUCTED:

The major goals of this project continue to be to gain an understanding of the biology of rice diseases that occur in California and develop methods for their control. Control methods under study include: effect of culture practices (primarily residue management) on the overwintering and survival of inoculum for stem rot and aggregate sheath spot, improved sources of disease resistance and evaluation of fungicides for potential use in disease control.

Objective 1: Determine the occurrence and severity of stem rot and aggregate sheath spot under various residue management systems.

This objective is to determine the effect of the alternative rice residue management practices being tested at the Canal Farms and Butte County sites on the inoculum levels, disease severities and yield. The data collected from the continuous years study will also be analyzed to determine if predictions of expected disease levels in subsequent years are possible from disease severities observed in previous years.

The relationship of rice residue management methods and the epidemiology of stem rot and aggregate sheath spot is based in their disease cycles that are dependant on overwintering inoculum in the form of sclerotia to initiate disease the following year. Both pathogens, Sclerotium oryzae and Rhizoctonia oryzae sativae are known to overwinter and increase in rice residue. This has been the basis for the beneficial aspects of burning rice residue in regard to disease management.

It is apparent that burning of residue will not be available to all growers in the future. As a result, growers are exploring different methods and schedules for managing the straw after harvest. It is necessary to understand the effects of different methods of dealing with the residue between crops on both rice

pathogens and the potentially beneficial organisms, particularly those that affect the overwintering disease propagules.

As open field burning is phased out, the need for prediction of potentially high disease fields will increase due to the provision that growers will be granted permits to burn in fields where disease loss in the future is apparent. Disease severity data for subsequent sample times was collected for use in refining our ability to predict fields where continued burning may be justified.

Experiments: Continuous year trials for comparing residue management alternatives were established in Colusa and Butte Counties in cooperation with other UC researchers. Carry over inoculum levels, disease incidence and severity for stem rot and aggregate sheath spot has been collected for three years from the Colusa County trial and for two years from the Butte County trial.

Colusa County Site:

This site is a cooperative effort coordinated by S. Scardaci. Residue treatments under study include: straw burned, straw incorporated in the fall, straw rolled after harvest, straw baled and removed. Winter flooding is tested as a main plot treatment onto each of the above also with a non-flood comparison. Each treatment is established with a separate water system which precludes movement of pathogen inoculum between treatments.

Butte County Site:

This site is a cooperative effort with other UC researchers and is coordinated by Marlin Brandon, Superintendent of the California Rice Experiment Station. The treatments being compared are identical to those at the Colusa County trial. The experiment is designed with separate water systems for each replicate of the individual treatments. The individual plot sizes are smaller than at the Colusa county site due to limitation of the total size of the test site.

Soil samples were collected from finished seedbeds from each of the replicated treatments at three sites per basin at both the Colusa and Butte County sites. The samples were ground with a soil grinder and subsamples from each were processed by removing sclerotia by floatation and soil sieving. Sclerotia of both S. oryzae and R. oryzae sativae recovered from samples were counted and plated on agar to determine their identity and viability.

Plant samples were collected from each of the sites approximately where the soil samples were collected. These were rated for stem rot severity (1=healthy - 5 = severe disease).

Aggregate sheath spot incidence was also determined for each sample. The values obtained from the subsamples from each of the replicate basins per treatment were averaged for that treatment and the data analyzed by standard statistical methods.

SUMMARY OF MAJOR ACCOMPLISHMENTS:

Butte County Site:

Stem Rot (S. oryzae): Total sclerotia recovered, viable sclerotia (inoculum level) and percent viable sclerotia, stem rot disease incidence and severity and yield was obtained in each of the various residue treatments for the 1995 and 1996 rice growing season. The viable sclerotia per gram seed bed, stem rot severity and yield are shown in Table 1.

Table 1

Affect of flooding and various residue treatments on inoculum level (viable S. oryzae sclerotia per gram soil) Stem Rot Severity and Yield at the Butte County Site for 1995 and 1996

Treatment	Viable Scler/gr		Disease Severity		Yield* dry\wt\lb\ac	
	I995	1996	1995	1996	1995	1996
Winter Flood	1.71	3.14	2.74	2.74	6361	6788
Burned	1.42 a	2.49 a	2.64 a	2.77 a	6510	6734
Incorp.	2.13 b	3.52 b	2.81 a	2.86 a	6559	6961
Rolled	1.89 ab	2.98 ab	2.60 a	2.63 a	6412	6811
Baled	1.42 a	3.58 b	2.94 a	2.69 a	5960	6649
No Winter Flood	1.36	2.67	2.40	2.99	6867	6658
Burned	1.24 a	2.61 a	2.51 a	3.05 a	6937	6731
Incorp.	1.43 a	2.65 a	2.36 a	3.07 a	6937	6660
Rolled	1.24 a	2.89 a	2.33 a	2.84 a	6839	6779
Baled	1.54 a	2.55 a	2.43 a	3.01 a	6753	6462

* values with same letter are not significantly different
** significant differences based on Duncan's mean separation
*** stem rot severity based on 1=healthy - 5 severe disease.

The yield data given is for the large plot harvests at the experimental site. We believe that there are factors in addition to disease that are affecting yields in the various treatments. As the experiment progresses it should be possible to determine what factor or factors these differences are due to.

The experiment is designed to determine the cumulative affect of the various treatments on the production and survival of overwintering inoculum of S. oryzae. The beginning inoculum levels were beyond the limit of linear disease increase as affected by inoculum level and thus it was not expected to see differences in amount of stem rot disease between the treatments.

Aggregate Sheath Spot (R. oryzae sativae): Similar observations on aggregate sheath spot disease were made at the Butte site. The sclerotial counts and incidence of aggregate sheath spot observed during 1995 and 1996 are summarized in Table 2.

Table 2

Aggregate Sheath Spot Incidence Under Various Residue Management Treatments at the Butte County Site 1995 & 1996

Treatment	% Tillers infected with AGGS		Viable Sclerotia per gram soil	
	1995	1996	1995	1996
Burned, flooded	56.8 a	73.1 a	.071 a	.055 a
Burned, not flooded	78.2 ab	62.6 a	.114 bc	.055 a
Incorp. flooded	53.3 a	67.8 a	.116 c	.129 a
Incorp. not-flooded	84.2 bc	59.4 a	.121 c	.108 a
Rolled, flooded	59.7 ab	74.3 a	.076 a	.063 a
Rolled, not flooded	84.6 bc	58.9 a	.064 a	.083 a
Baled, flooded	56.1 a	72.4 a	.086 ab	.081 a
Baled, not flooded	76.5 ab	63.4 a	.081 a	.088 a

* disease incidence determined as percent infected tillers
* values with common letters not significantly different

Viable sclerotia per gram soil from the seed bed of the aggregate sheath spot pathogen are considerably lower than those for the stem rot pathogen. This is typical of the group of pathogens to which it belongs and comparisons between the two pathogens on numbers of propagules per gram soil are not valid.

Aggregate Sheath Spot incidence in flooded main plots was 56.5 and 80.9 in the non-flooded mainplots for 1995 and 71.9 and 61.1 for 1996 indicating no pattern for the effect of flooding in the first two years from the levels of inoculum observed.

Colusa County Site:

The 1996 season was the third year for data collection at the Colusa County site. Total number of S. oryzae sclerotia, viable sclerotia per gram soil and stem rot disease severity observed in 1994, 1995 and 1996 are summarized in Table 3.

Table 3

S. oryzae inoculum levels and Stem Rot Severity at the Colusa County Study site for the 1994, 1995 and 1996 Rice seasons

Treatment	viable sclerotia per gram soil			Stem Rot Severity		
	1994	1995	1996	1994	1995	1996
Winter Flood						
Burn	1.0 a	.62 a	.59 a	2.54 a	3.06 a	3.55 ab
Incorp.	1.5 a	.79 ab	.71 a	2.55 a	2.92 a	3.26 a
Roll	1.5 a	1.47 c	1.33 b	2.60 a	3.21 ab	3.82 bc
Bale	1.4 a	1.04 b	1.13 b	2.75 a	3.51 b	4.00 c
Not Flooded						
Burn	1.1 a	.63 a	.65 a	3.10 bc	3.49 a	4.02 a
Incorp	1.4 a	1.51 b	1.94 c	2.78 a	3.86 b	4.19 a
Roll	2.4 b	2.25 c	2.12 c	2.93 ab	3.70 ab	4.11 a
Bale	1.2 a	1.35 b	1.33 b	3.32 c	3.78 b	4.16 a

Inoculum levels of S. oryzae in all treatments tested are relatively high (above .6 scl\grm) and thus correlations between inoculum level and disease severity do not occur due to saturation of the disease system. After the initial year (1994) the data clearly show that burning of residue in both the flooded and non-

flooded treatments reduced the number of overwintering sclerotia of S. Oryzae and that the lower levels were maintained in the following year.

Stem Rot disease severity levels in all treatments increased each year of the experiment. This was expected because inoculum levels were still above the .6 sclerotia per gram soil where disease incidence does not increase in the system above this level. Disease severity from these incidence levels did increase indicating that factors that effect severity were favorable. This is typical of observations throughout the rice producing areas in recent years. It is unknown what the effects of the wet winters of 1994 and 1995 were on the mainplot treatments of flooding and non-flooding.

Incidence of aggregate sheath spot disease that occurred in the various residue treatments at the Colusa site was also determined and the data for 1994, 1995 and 1996 are compared in Table 4.

Table 4

Aggregate Sheath Spot Incidence at the Colusa County Study Site for the 1994, 1995 and 1996 Rice Seasons

Treatment	Percent Tillers Infected		
	1994	1995	1996
Winter Flood	.067	1.20	2.15
Burn	.06	.92	1.70
Incorp.	.10	2.36	2.85
Roll	.05	.46	2.15
Bale	.06	1.07	1.90
Not Flooded	.052	1.26	2.95
Burn	.05	1.16	2.75
Incorp.	.07	1.73	2.25
Roll	.05	.08	4.90
Bale	.04	2.08	1.90

* variability of the incidence observed resulted in no significant statistical difference within years. The increases between years are significant.

There was an increase in aggregate sheath spot incidence in each of the seasons of the study in all treatments tested at the Colusa County site. This increase was greatest in the incorporated treatments and the roll or soil contact treatments.

This level of AGSS incidence occurred from very low levels of inoculum which are also slowly increasing differentially in the residue treatments.

Yield from the different residue treatments at the Colusa County site was determined by harvesting the whole plots and adjusting moisture to 14%. The results are summarized in Table 5.

Table 5

Yield for different residue treatments at the Colusa County Site for 1994, 1995 and 1996.

Treatment	Yield in lbs\acre at 14% moisture		
	1994	1995	1996
	Main Plot Treatments		
Winter Flood	8300	9080	9250
Not Flooded	7580	8080	8930
	Sub Plot Treatments		
Burn	8805	8560	9245
Incorp.	7820	8775	8785
Roll	7425	8730	9190
Bale	8165	8255	9135

Overall yields increased each successive year of the experiment in all of the residue management treatments tested. We believe that salinity effected yields the first year and that changes in the water system of the individual plots in the next two years minimized this effect. There also appears to be differences in effectiveness in weed management in some of the treatments which may also impact the yields of the different treatments. Additional differences observed between the residue treatments include nutritional effects, insect damage and levels of emission of gases

and differential straw decomposition. Reported results of other researchers should be consulted for their discussions of these effects.

The effects of the treatments on the inoculum levels and subsequent disease for both stem rot and aggregate sheath spot are being further analyzed over continuous years in an attempt to determine the feasibility of predicting disease expected in subsequent years from the level of disease observed in the previous year.

Objective 2: Continue evaluation of rice germplasm for sources of improved resistance to stem rot and aggregate sheath spot for use by the breeders.

A complete set of the rice germplasm collection was obtained from the United States Department of Agriculture National Small Grains Collection at Aberdean Idaho. The total collection contains over 13000 entries. We planted 6000 of these at the Rice Experiment Station at Biggs for evaluation during the 1996 season. Approximately 4 grams of seed was dry seeded in a 4 foot row, prior to flooding. After planting the basin was flooded for the remainder of the season. Inoculum in the form of sclerotia of Sclerotium oryzae was added to the basin 45 days after planting to enhance the disease pressure throughout the experimental area.

Plants were scored for both Stem Rot and Aggregate Sheath Spot reactions. Evaluations of infection and disease were made throughout the season as plants of the different entries headed. A final evaluation of all plants was made during the first two weeks of September. Table 6 lists entries on which neither stem rot or aggregate sheath spot were observed.

Field screening allows the possibility that plants rated as resistant may have escaped infection by one or both of the pathogens being screened for. To assure that those entries selected are in fact resistant to stem rot and aggregate sheath spot those listed above are being screened in greenhouse trials against both of the pathogens separately.

Seed of the entries selected from the screening nursery was collected for further evaluation regarding characteristics desired for crossing parents in cooperation with plant breeder Carl Johnson. Those entries that continue to show resistance to stem rot and or aggregate sheath spot will be used as parents in crosses in attempts to develop disease resistant cultivars.

Table 6

Entries from the USDA, ARS National Small Grains Rice Collection which were not infected in a disease screening trial at the Rice Experiment Station at Biggs in 1996

Row #	Item Accession	Inventory	Plant Name
603	778 PI 159709	Clor 8945 OR91	SD T 27
734	8992 Clor 9113	Clor 9113 OR91	SD B4564A2-11-4-3
1312	489 Clor 9877	Clor 9877 OR91	SD B6334A1-1-5
1398	390 CLOR 9971	Clor 9971 OR91	SD L-201
1437	5835 Clor 11041	Clor 11041 OR91	SD GPRL CaG-73525
1854	624 Clor 12497	Clor 12498 OR	SD PI 298965-2
3502	1479 PI 277218	PI 277218 OR	SD CHIA NAN 14
3610	6807 PI 279996	PI 279996 OR93	SD GPNO 12206
3805	1001 PI 291642	PI 291642 OR	SD KOSHI HIKARI
3806	6008 PI 291643	PI 291643 OR	SD KOSHI HIKARI
3845	6442 PI 294352	PI 294352 OR93	SD KANTO 53
3921	1502 PI 303685	PI 303685 OR91	SD HR539
4950	1208 PI 350362	PI 350362 OR	SDIR1317-137-3-3
5035	1197 PI 350466	PI 350466 OR	SDIR78151-2-3-2-2

Objective 3. Evaluate fungicides for potential use for stem rot and aggregate sheath spot control.

Field tests were established in three different areas (Butte, Sutter and Yuba Counties) with past history of stem rot and or aggregate sheath spot to determine the efficacy of Benlate and Quadris (Zenneca #5504) for control of these diseases. A fourth trial was established in Sutter County to test Benlate, Quadris, Moncut and Tilt. The rate, time of application, disease severity and yield for these tests are shown in Tables 7,8,9 and 10.

As seen in Tables 7 -10 there were no significant increases in yield in any of the treatments at the four sites where the treatments were tested. At the Butte County site AGSS was reduced by two applications of Benlate and Quadris but this was not reflected in increased yield. Stem rot severity was higher after two applications of Benlate at this site supporting past results that Benlate does not control stem rot and that when AGSS is reduced that stem rot is actually more severe. Similar results were observed in the Sutter and Yuba County trials. In the larger trial where Moncut and Tilt were tested there were no significant differences between chemicals tested in either disease severities or yield.

Table 7

Efficacy of Benlate and Quadris for control of Stem Rot and Aggregate Sheath spot at the Butte County Site

Treatment	Rate\Time lb\pd\acre	Stem Rot Severity	AGSS Severity	Yield lb\ac 14%
Benlate	1 @ MT	1.77 b	3.05 a	8801 a
Benlate	1 @ MT & IL	2.15 a	2.44 c	8609 a
Quadris	.175 @ MT	1.78 b	3.06 a	8840 a
Quadris	.175 @ MT & IL	1.59 b	2.67 b	8948 a
Control	none	1.64 b	3.11 a	8530 a

Stem Rot severity = 1 healthy - 5 severe. AGSS severity 1 = no disease, 2 = 2nd leaf disease, 3 = 3rd leaf diseased, 4 = 4th leaf diseased, 5 = flag leaf diseased.
MT = midtillering, IL = internode elongation.
Benlate applied as 50SP; Quadris applied as 80 WG.

Table 8

Efficacy of Benlate and Quadris for Control of Stem Rot and Aggregate Sheath Spot at the Sutter County Site

Treatment	Rate\Time lb\pd\ac	Stem Rot Severity	AGSS Severity	Yield lb\ac\ 14%
Benlate	1 @ MT	1.29 a	2.99 a	9358 a
Benlate	1 @ MT & IL	1.34 a	2.77 b	9410 a
Quadris	.175 @ MT	1.32 a	3.02 a	9977 a
Quadris	.175 @ MT & IL	1.32 a	2.78 b	9175 a
Control	none	1.26 a	2.85 ab	8281 a

Ratings and time of application as shown for table 7.

Table 9

Efficacy of Benlate and Quadris for control of Stem Rot and Aggregate Sheath Spot at the Yuba County Site

Treatment	Rate\Time lb\pd\ac	Stem Rot Severity	AGSS Severity	Yield lb\ac 14%
Benlate	1 @ MT	1.95 a	3.30 a	7755 a
Benlate	1 @ MT & IL	1.84 a	2.80 b	8235 a
Quadris	.175 @ MT	1.54 a	3.18 ab	8114 a
Quadris	.175 @ MT & IL	1.78 a	2.82 b	8055 a
Control	none	1.79 a	3.40 a	7877 a

Ratings and time of application as shown for Table 7.

Table 10

Efficacy of Benlate, Quadris, Moncut and Tilt for control of Stem Rot and Aggregate Sheath Spot at Sutter County Site 2.

Treatment	Rate\Time lb\pd\ac	Stem Rot Severity	AGSS Severity	Yield lb\ac 14%
Benlate	1 @ MT	1.66 a	2.54 a	8466 a
Benlate	1 @ MT & IL	1.78 a	2.15 a	8328 a
Quadris	.175 @ MT	1.66 a	2.44 a	8049 a
Quadris	.175 @ MT & IL	1.50 a	2.15 a	8300 a
Moncut	2 @ MT	1.60 a	2.30 a	7930 a
Moncut	2 @ MT & IL	1.64 a	2.44 a	8377 a
Tilt	.5 @ MT	1.77 a	2.66 a	7759 a
Tilt	.5 @ MT & IL	1.51 a	2.87 a	8158 a

Ratings and time of application as shown for Table 7.
Moncut applied as 50 WP; Tilt applied as 3.6E; Benlate applied as 50SP; Quadris applied as 80 WG.

Addendum objective: In early September we confirmed that the Blast disease caused by Pyricularia grisea was occurring in Glenn and Northern Colusa Counties. This was the first known occurrence of Blast in California. The Blast disease causes considerable damage and yield loss throughout the rice producing areas of the world. If it becomes established in California it could easily have a significant impact on our future rice production in the state.

We directed efforts to determine the extent of the infection, susceptibility of our different cultivars and which blast races were in California. We also participated in the effort to obtain permission to burn as much of the infected area as possible.

A major effort at this time is to determine the feasibility of reintroducing the practice of soaking seed in a mixture of water and sodium hypochlorite to eliminate possible spread in seed.

We are continuing study of the blast disease in an effort to develop a logical industry approach in steps to take in efforts alleviate damage from this disease in future California rice crops.

PUBLICATIONS OR REPORTS:

Cintas, N.A., R.K. Webster and Tom Miller, 1995. Interactions of Sclerotium oryzae and Rhizoctonia oryzae sativae on rice. Phytopathology 85: 1038.

Cartwright, R.D., R.K. Webster and C.M. Wick, 1996. Mycoparasitism of Sclerotium oryzae and other fungi by an unusual Ascochyta sp. from California rice fields. Mycologia. (in press)

Miller, Thomas, C. 1996. A method for recovering sclerotia of the fungal pathogen Rhizoctonia oryzae sativae from rice field soils. Ms. Thesis, University of California, Davis.

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 Research. 1995. University of California and the U.S. Department of Agriculture.

CONCISE GENERAL SUMMARY OF CURRENT YEARS RESULTS:

The initial levels of stem rot at the Butte site were higher than those at the Colusa site. Thus far the second and third years of burning residue at the Colusa site resulted in a decrease of sclerotia while they have stayed nearly the same in the other treatments. At the Butte site, inoculum levels of S. oryzae for all treatments increased in the second year. Soil types and field histories differ at these sites raising the question as to the role

of soil type on the effects of the different treatments. Information on the possibility of differential effects of the treatments on populations of other organisms due to incorporation and or flooding is needed. Particularly in regard to competition with the pathogens and effects on straw decomposition.

The initial levels of the aggregate sheath spot pathogen were very low at the Colusa site and relatively high at the Butte site. R. oryzae sativae increased in all treatments at the Colusa site over the three years with the largest increases in the not flooded plots. Results from both sites indicate that the flooding treatment results in a lower build up and carry over of this pathogen than for stem rot. We have data on total number of sclerotia produced for both of these pathogens as compared to those that are viable and capable of causing disease for all treatments. It is premature at this time to conclude the effects of the various treatments on the viability of the sclerotia since information on the effects of treatments on other organisms that may be effecting the viability is not complete.

In separate studies we have observed an inverse relationship between the incidence of aggregate sheath spot and stem rot. This is most likely due to competition between the two pathogens for the infection site at the water level. This may explain the large differences between the amount of the two disease observed thus far at the Colusa site but probably not for the relative high levels of both diseases at the Butte site. Thus it is important to continue attempts to gain an understanding of the effects of the various treatments on the microbial communities in the various treatments and also what the interactions between these organisms are. We are particularly interested in increases or decreases under different treatments of organisms that effect the viability of pathogen inoculum and also it's infection process of the rice plants. We expect that the initial years of study at both sites nay have just begun to influence such changes and that additional years of the continuous treatments are needed to allow observation and study of the effects of these phenomena.

Screening of over 6000 entries from the USDA rice germplasm collection resulted in the identification of 14 promising sources of genetic resistance to stem rot and aggregate sheath spot. Cooperation with plant breeders will be continued in the hope of exploiting these sources of resistance in improved cultivars for California.

Fungicide trials at four sites to determine candidate chemicals for use in stem rot and aggregate sheath spot control were not encouraging. Some reductions in disease severity were noted but no significant increases in yield were observed at the rates and time of application tested.

Quadris was the most promising chemical tested. Work next season will involve different rates and time of application than those tested this year. This chemical is expected to be available for use in the Southern states in the near future. It is considered to be an environmentally "friendly" chemical and that it's registration will be approved.