PROJECT NO. RP-2

ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 1992 - December 31, 1992

PROJECT TITLE: Cause and Control of Rice Diseases

STATUS OF PROPOSAL: Continuing

PROJECT LEADER: R. K. Webster, Department of Plant Pathology, UCD.

PRINCIPAL UC INVESTIGATORS: C. M. Wick, UC Cooperative Extension
J. Burleigh, J. Thomas, CSU Chico,
(Objective 1b)

LEVEL OF 1992 FUNDING: 42,072

OVERALL OBJECTIVES AND STATUS OF THE PROJECT:

The primary objective of this project is to understand the biology of rice diseases that occur in California and to develop methods for their control. Previous work has clearly shown the relationship of rice residue management methods and the epidemiology of rice diseases, mainly stem rot and aggregate sheath spot. Both of these diseases have disease cycles that are dependant on overwintering inoculum in the form of sclerotia to initiate disease the following year. Also, both pathogens, [Sclerotium oryzae and R.oryzae sativae] are known to overwinter and increase in rice residue. These facts have been the basis for the benificial aspects of burning rice residue in the past in regard to rice disease management.

Also, extensive studies have shown that stem rot and aggregate sheath spot severity is affected by nitrogen fertilization practices, stand density and cultivar selection. Although manipulation of these can minimize loss to diseases, the most effective control has been the destruction of overwintering inoculum in the residue by open field burning.

It is now apparent that burning of residue will not be available to all growers as a means to dispose of the straw and stubble after harvest. As a result many different methods and schedules for incorporating the straw after harvest are being tried. During the past three years this project has been monitoring many of these attempts with the primary objectives of determining the amount of residue decomposition and their affects on pathogen populations.

We have collected microrganisms from straw and sclerotia in the various management treatments compared to determine if there are differences between manner in which the straw is incorporated and if there are differences in the degree of decomposition and sclerotial viability. We have also initiated studies to attempt to

exploit the findings related to potential biological control of stem rot in the field. The status of many of these ongoing studies is summarized in our 1991 report to the Board. The specific objectives for this year are derived from the results that we view as the most promising avenues of continued study in attempts to devise disease management strategies utilizing natural organisms to enhance straw decomposition and biologiacal degredation of overwintering pathogen populations. In season addition of organisms into controlled field trials as potential for control of stem rot is also in progress

SPECIFIC OBJECTIVES FOR 1992

[1] Continue monitoring populations of fungi known to reduce viability of sclerotia of pathogens in various residue management systems being attempted in various growers fields. These studies are necessary to determine if shifts in microorganism populations are occurring due to various management practices.

[2] Further screening and greenhouse experiments to test rates and time of application of microorganisms showing potential for biomanagement of diseases.

[3] Continue studies in the long-term trial established at the Rice Station to determine if the fungi showing mycoparasitic activity on S.oryzae become established and increase in the treatments and also if we are obtaining biomanagement of the diseases in the field.

[4] Establish field trials to test for possible differences in cultivar reaction to rice diseases in fields where residue has been incorporated.

[5] Establish and monitor trials in fields where various residue management, other than burning, is being practiced to determine effects of N level of fertilization on yield and disease severity.

Field research in 1992 was conducted in growers fields in Butte, Colusa and Sutter Counties. The continuous year control trial (2.5 acres) is located on the Rice Experiment Station. Laboratory and greenhouse studies were conducted in University of California facilities at Davis.

SUMMARY OF 1992 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVE:

Objective 1: (a) We continued monitoring of populations of fungi known to reduce viability of sclerotia (overwintering inoculum) of pathogens in various residue management systems being tried in growers fields. This is necessary to determine if shifts (favorable or unfavorable to disease control) are occuring due to various management practices being attempted. (b) We also attempted to obtain yield estimates and disease levels in the fields studied to

determine the effects of the practices. Soil samples were obtained prior to flooding of the fields for inoculum level determination and nutrient status (N,P,K,Zn,Fe,S), Soil pH,EC,and CEC for analysis and determination of possible correlations between residue management practice, disease level and yield. The fields being studied were selected to allow continuation of the monitoring of various fungal populations and a comparison of the effects of the practices being tried on occurrence of rice diseases in those fields.

(a) In previous years we reported isolation of large numbers of fungi from straw in soil contact, standing stubble, and from sclerotia of S. oryzae from diferent systems of residue management. The basic objective being to determine what effects the significant changes in the rice culture system, incorporation of the straw, have on the populations of organisms that participate in the decomposition of straw and the viability and overwintering of pathogen inoculum levels. These studies have shown that certain fungi are more frequently associated with decomposing residue and sclerotia.(It was from these observations that test organisms for Objective 3 were selected.) Samples were collected again this year from most of the fields studied in the previous years to determine if changes in the microflora were occurring. Mostly those fields in which rice is being continuously grown were included in this years survey. A range of systems was surveyed including burned in the fall, chopped and incorporated in the fall, fall incorporated and flooded.

The majority of fungal species recovered from decomposing stubble continued to be Hyphomycetes, a result similar to previous years and also consistant with that reported in the literature for other crop residues. A succession of fungi from the early fall isolations to those in the spring continued to be observed. Ubiquitous epiphytes of the late growing season rice plant are the most frequently isolated from the stubble at the beginning of the decomposition period (early fall). The majority of these were Hyphomycetes in the genera Cladosporium, Epicoccum, Acremonium, Alternaria, Sporobolomyces, Nigrospora, and the rice pathogens S.oryzae, Rhizoctonia oryzae-sativae and the epiphytes R.oryzae and S.hydrophilum.

Cladosporium cladosporiodes, Acremonium strictum, Epicoccum purpurascens and Alternaria alternata were isolated frequently throughout the winter depending on the system. These resident fungi are apparently active throughout the decomposition period on rice residue regardless of temperature.

Acremonium strictum and Alternaria alternata were more sensitive to management system changes than the other species. Frequency of isolation of these fungi was lower in tilled systems suggesting the importance of soil contact in initiating the succession of residue decomposing fungi. In flooded systems, changes in frequency of isolation of most fungal species recovered was reduced. The general reduction in fungal activity under these

conditions (flooded) suggests both temperature and lower oxygen availability may be responsible for their lower occurrence in isolation attempts.

Disturbed systems,(featuring early soil contact of the residue) such as fall disc, spring tooth harrow etc. supported an earlier and more diverse succession of fungi. Zygomycetes such as Mucor species were usually more frequently recovered from these systems where residue was placed in early fall soil contact. They were recovered less frequently latter in the decomposition period. These fungi are typical of the fast growing fungi noted in early decomposition of other crop residues also.

Later in the decomposition process (March-April), several Basidiomycetes were more common in the stubble samples. These tended to dominate until sampling was stopped in the spring and are considered the secondary colonizers of decomposing organic matter. Predominant species isolated included Waitea circinata, Coprinus sp. a binucleate Rhizoctonia and Humicola grisea.

The Ascomycetes Gelasinospora seminuda and G. retispora were isolated only from systems where the residue had been burned in the fall and were usually not recovered later in the winter samplings.

The fungi that continued to be most frequntly isolated from sclerotia of S. oryzae were again mostly Hyphomycetes. The most frequently isolated fungus from sclerotia continued to be an Ascochyta species previously referred to as unidentified fungus C. This fungus is the most promising one that we have found in regard to its potential as a means of biological control of the stem rot pathogen. More results regarding this fungus are included under objective 3.

An additional unusual species of Acremonium was repeatedly isolated from sclerotia. This fungus appears to have a particular nutritional adaptation to S. oryzae sclerotia making it difficult to work with in culture but of a possible real significance regarding the biological effects of residue incorporation on the populations of rice pathogens.

The resident fungi C. cladosporiodes, E. purpurascens and A. alternata were most frequently isolated from sclerotia recovered from burned systems. I believe that since most sclerotia are killed as the fire burns through the stubble that these are in fact opportunistic saprophytes since they donot inhibit live sclerotia when tested in the laboratory.

(b) As stated earlier, we also attempted to determine disease levels and yields produced in the various grower fields in which much of the data reported in 1-a was obtained. The total analyses of the potential correlations between nutritional and soil factors and residue system, sclerotial populations, disease severities and yields has not been completed. We hope that when this is completed that suggestions toward possible manipulations in the cultural

system for better management of rice diseases may be possible. The residue management used by the grower, cultivar grown, disease level observed and yield obtained for the entire field (grower) for several of the fields under study are summarized below.

Survey of disease level and yield in fields where various methods of residue management are practiced, 1992 season.

Field No.	Cultivar Grown	Stem Rot Severity	Aggregate Sh. Spot	Yield cwt 14 %
	Fall Incorporated - Not Winter Flooded			
11	M-201	2.8	1.1	82.4
13	M-401	2.3	1.2	75.8
17	CM-101	2.5	1.8	70.8
20	L-203	3.2	1.0	94.1
21	A-301	2.4	1.0	75.8
22	A-301	2.6	1.0	86.0
	Fall Incorporated - Winter Flooded			
1	M-201	1.2	1.6	85.3
3	M-201	2.2	2.4	98.2
5	M-201	2.2	2.2	85.9
8	M-201	1.1	2.5	91.0
2	M-202	1.8	2.4	99.5
9	M-202	2.3	1.3	92.8
	Fall Burned - Not Flooded			
6	M-201	1.5	2.5	98.9
14	M-201	3.0	1.0	85.9
16	M-202	1.8	1.1	79.9
	Field Fallow in 1991-residue incorporated 1990.			
18	L-203	3.6	1.0	70.8
19	L-203	3.5	1.0	70.8

Stem Rot,1= healthy, 5 = severe: AGSS,1= healthy, 4 = Severe
Yields as reported by growers for the entire lot.

The above results should be interpreted as representative of the several practices being tried by growers in Butte County. They reflect the exceptional yields that were obtained during 1992 but more importantly the large differences encountered by different growers, between different grower fields and cultivars.

Highest yields occurred when disease rankings were lowest with the exception of fields 20, 3 and 9. Additional analysis of other factors in the fields is necessary to determine what other factors may have affected yield. It is difficult to tell at this time

wheather the frequencies of organisms that affect viability of stem rot sclerotia are providing some level of biological control in fields where residue is incorporated or not. Only additional time and continued incorporation affects on populations of organisms other than rice pathogens will tell. Nevertheless, data thus far indicate that some of the populations of organisms that occur in rice fields are being affected by continuous incorporation of residue. The long term effects of these changes are not yet known.

Yield of M-201 in the various fields ranged from 98.9(fall burned, not flooded) to 82.4(fall incorporated-not flooded). Of our current cultivars, M-201 is the most resistant to stem rot and quite susceptible to Aggregate Sheath Spot. Past study has shown that the presence of the AGSS pathogen limits to some extent the development of stem rot. This interaction is also somewhat apparent in the data from the various fields this year.

Objective 2: In field and greenhouse tests where both S. oryzae and Rhizoctonia oryzae-sativae are established, stem rot often appears to occur at a level less than would be expected from the known S. oryzae inoculum level. Analysis of data from a large field trial and several greenhouse tests gave a R= -.702 showing that stem rot severity was negatively correlated with AGSS incidence. Other studies in the laboratory have shown that R. oryzae-sativae, Sclerotium hydrophylum and the Ascochyta sp. isolated from sclerotia are mycoparasites of the sclerotia of S. oryzae. Consequently, additional greenhouse experiments to determine the optimum inoculum levels for applying these fungi as potential biological control agents of the stem rot disease were carried out. These consisted mainly as co-inoculation onto rice plants with sclerotia of S.oryzae, the cause of stem rot. Rates tested for S.hydrophulum and R.oryzae-sativae ranged from 10 - 100 viable sclerotia per plant. In all tests with S.hydrophylum, stem rot was minimized to insignificant levels by all concentrations tested and S. hydrophylum was recovered from 100% of the test plants. R.oryzae-sativae coinoculations resulted in significant stem rot reduction only when inoculation levels exceeded 25 sclerotia per plant.

Coinoculation experiments with S. oryzae and the Ascochyta species that is strongly mycoparasitic on sclerotia in the field did not result in stem rot reduction in the "in-season" greenhouse tests. This result was expected since this mycoparasite occurs on and in the sclerotia during the overwintering season and is not generally an epiphyte. Thus its effect on viability of stem rot sclerotia occurs during the soil and saprophytic stages of the stem rot pathogen.

Objective 3: A continuous year trial was established at the Rice Experiment Station in 1991 with separate water systems for each plot to ensure that treatments were kept separate. Each plot is .18 of an acre. Residue from the previous years rice crop was chopped and incorporated into the soil in the fall each year. All other cultural practices were standard as established at the rice

station. Soil samples were taken from the finished seed bed of each plot to determine the beginning S.oryzae inoculum levels.

The trial was established to test the most promising fungi from our studies as potential biocontrol agents for the stem rot disease. Inoculum of R.oryzae-sativae, S.hydrophylum, and the Ascochyta. sp. was grown in the laboratory for use in inoculating the plots in the field with the test organisms. Each treatment was replicated three times. The test organisms were added to the basins during mid-tillering of the first experimental year by sprinkling sclerotia (2.0 kgms\basin) throughout. The Aschochyta was inoculated into the basins as allgenated pellets(2.0 kgms\basin) since this species does not make sclerotia.

Disease ratings for stem rot were made at the time the fields were drained prior to harvest.

The cultivar M-202 was grown each year. Harvest was done of the entire plots at maturity and grain weights and moisture were determined.

The results obtained for 1991 and 1992 seasons are summarized below:

Effect of addition of microorganisms on Stem Rot severity and Yield in M-202 Rice grown under continuous incorporation of rice residue

1991				
TEST ORGANISM	S.oryzae scl\gm	Stem Rot Severity	AGSS Inci.	YIELD cwt\a
R.oryzae-sativae	.16	1.27	43.4	83.3
S. hydrophylum	.14	1.18	32.0	80.1
Ascochyta sp.	.19	1.24	34.5	78.3
Control	.15	1.19	36.0	81.5
1992				
R.oryzae-sativae	. 25	1.43	41.7	79.2
S. hydrophylum	.21	1.31	36.2	80.6
Ascochyta sp.	.28	1.81	34.2	76.0
Control	.26	1.93	35.1	79.9

scl\gm =S.oryzae sclerotia per gm soil in seed bed;
SR severity, 1=healthy-5=severe; AGSS inci.= % tillers infected

The only significant differences between the two years of study were in increased S.oryzae inoculum level in the seed bed and in increased Stem Rot disease severity between years. The differences between both of these parameters was not significant within years. The incidence of AGSS in the treatments in which R.oryzae-sativae was added were significant in 1991 (the year the fungus was added to the basins) but not in the second year, 1992. It appears that incorporation of the residue has had the effect of increasing stem rot severity at this location.

Isolations from residue and sclerotia from the test sites did not reveal any significant differences in frequency of isolation of the test organisms between the treatment basins in 1992. This result indicates that if benifits are to be derived from addition of these fungi to rice fields over the levels that occur naturally that they would have to be added each year.

Objectives 4 and 5: The efforts of growers to determine the best methods of disposing of the rice crop residues for their individual operations provides field sites for comparing the differences that might occur in regard to rice disease occurrence and severity. In addition, most of our available information on performance and disease reaction of our present cultivars was obtained in fields where the residues have been routinely burned.

Previous study has shown that N fertilization rates above that required to obtain maximum yields enhance the severity of stem rot and aggregate sheath spot and that losses in yield often result to to increased disease severity in fields where the diseases are prevalent. Field trials established by the UC Cooperative Extension research program to evaluate cultivars and advanced breeding lines at different locations, N fertilization levels, and different residue management practices from previous crops were rated for the occurrence and severity of rice diseases. Yield values were determined by UC CE researchers. Disease ratings were made at the time fields were drained prior to harvest.

Site 1 was located in Butte County in a field where the residue from the previous two years crops (1990,1991) had been incorporated in the fall and flooded during the winter. M-202 was planted on May 5, 1992.

Sites 2 and 3 were located in Butte County. The residue from the previous crop was incorpoated in the fall (1991) in field 2 and burned in the fall (1991) in field 3. M-201 was planted on May 18 at site 2 and on May 15 at site 3. These fields were located on the same ranch and provide an interesting comparision.

Site 4 was located in Butte County where a 1991 crop of Sudan grass had been grown for seed and the remaining residue after harvest of the seed was incorporated in the fall (1991). Calmochi-101 was planted on May 11, 1992.

Site 5 was located in Sutter County where the reisdue from the previous year was wet rolled into the field surface in the fall of 1991. M-202 was grown in 1992.

Site 6 was located in Colusa County. The straw was baled and removed from the field in the fall of 1991 and M-202 was grown in 1992.

The yields and disease determinations from these sites were as follows:

N Rate (lb/A)	SR sev.	AGSS inci.	YIELD cwt/A	SR sev.	AGSS inci.	YIELD cwt/A
		Site 1 (M-202)			Site 4 (Calmochi 101)	
0	2.3	35	54.2	1.9	11	66.9
30	2.6	49	70.6	1.9	13	83.3
60	2.8	44	85.6	1.8	13	91.7
90	2.8	52	93.7	1.9	12	99.7
120	3.0	41	95.3	1.8	21	96.6
150	2.9	48	98.2	1.8	17	97.7
180	2.9	54	94.0	1.6	13	94.2
X	2.75	41.5	84.5	1.81	14.2	90.0
		Site 2 (M-201)			Site 3 (M-201)	
0	2.0	37	47.0	2.0	38	66.7
30	2.1	32	68.8	1.9	28	84.2
60	2.3	31	77.4	1.9	36	101.1
90	2.5	35	88.0	2.1	18	104.6
120	2.8	45	90.6	2.1	28	107.0
150	2.5	57	93.0	2.0	40	102.0
180	2.9	39	93.4	2.3	19	102.8
X	2.44	39.4	79.8	2.04	29.5	95.5
		Site 5 (M-202)			Site 6 (M-202)	
0	1.0	8	38.4	1.02	6	45.4
30	1.07	7	52.5	1.09	5	58.3
60	1.0	11	63.8	1.06	7	80.9
90	1.0	12	79.9	1.05	10	108.6
120	1.11	3	84.9	1.13	15	122.8
150	1.06	17	102.7	1.11	16	137.7
180	1.13	15	111.0	1.20	18	130.7
X	1.05	10.4	76.2	1.09	11	97.8

SR= Stem Rot severity = 1 = healthy ; 5 = severe disease
AGSS inci= percent of tillers infected with Aggregate Sheath Spot
Nitrogen as Ammonium Sulfate, preplant.

The disease levels that occurred at sites 5 and 6 during the 1992 growing were insignificant and considered not to have an effect on the rice at any of the N levels. It is clear from these two trials that the yield potential of M-202 in the absence of disease preasure under adequate fertilization is very good.

At site 1 where residue has been incorporated the last two years, relatively high levels of disease occured. At site 4 disease levels were not particularly high for that area based on previous observations. This may have been due to lower disease potential due to growth of sudan grass in the field the previous year.

The results from site 2 (residue incorporated) and site 3 (residue burned) are interesting. Here the fields are separated only by a farm road and the same cultivar (M-201) was grown and they were planted within the same week. The growers yield over the entire field (site 2) was 77 cwt\A. The grower yield for the entire field (site 3) was 85 cwt\A.

The stem rot disease levels that occurred in field 2 were significantly higher than those in field 3. Aggregate sheath spot was higher in field 2 than in field 3 but the differences in AGSS for the two sites were not as great as were the differences for stem rot.

The UC Cooperative Extension regional variety trial for Butte County was located at site 2. This allowed for an evaluation of disease occurrence on the different cultivars under conditions of fairly high disease preasure. The disease ratings were made at the time the field was drained. Results for the currently grown cultivars were as follows:

CULTIVAR	STEM ROT SEVERITY	AGSS INCI.	YIELD cwt/A
M-204	2.00	.68	95.8
L-203	2.13	.72	95.2
M-202	1.94	.67	93.8
M-201	2.07	.52	91.5
M-103	2.24	.42	91.5
L-202	2.82	.37	90.3
M-203	2.68	.46	89.2
Calmochi 101	2.54	.51	86.7
S-201	2.28	.56	81.2

The yields of all cultivars in this test trial are quite impressive even though there was a relatively high disease level throughout the trial. The field in which the trial was located yielded 77 cwt/A of M-201.

PUBLICATIONS OR REPORTS:

Webster, Robert K. Report to the California Rice Research Board: Project RP-2. Cause and Control of Rice Diseases, pp. 66-92. In: Annual Report of Comprehensive Rice Research. 1991. University of California and U.S Dept. of Agriculture.

Cartwright, Richard D. Biodecomposition of Rice Residue and Biocontrol of Sclerotium oryzae in California. PhD Dissertation, University of California, Davis, 1992.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

Continued study of fields in which various methods of residue incorporation are being practiced revealed similar population frequencies of organisms that participate in straw degredation and mycoparasitism of S.oryzae sclerotia as seen in previous years. Most notable, the mycoflora from fields where residue is incorporated in the fall are more frequently recovered and are more diverse than in fields where the residue is burned in the fall. In the fields where the residue was incorporated and then flooded, frequency of recovery most of the species being monitored are reduced. It is apparent that shifting from burning to incorporation of the residue is affecting the populations of mycoflora that occur in rice fields. What the long term effects of these shifts will be is not yet known.

Stem Rot was generally less severe in fields in which the residue had been burned the previous fall, intermediate in fall incorporated then flooded fields and most severe in fall incorporated and not-flooded fields. This general pattern also occurred in regard to yield obtained by the growers regardless of cultivar grown. Yields in the fields under study ranged from a high of 98.9 cwt/A (M-201) field fall burned to 70.8 cwt/A (L-203) field fallow after residue was incorporated in 1990.

Combined factors over the 1992 growing season resulted in some very high yields for some growers. In the majority of fields in which our studies were conducted this year, the highest yields occurred in those fields in which there was the lowest amount of disease. Aggregate Sheath Spot was generally more abundant in fields where residue was incorporated and then flooded in the fall than it was in other systems tried.

Addition of the most promising biocontrol organisms that we have identified into controlled field trials has not resulted in a significant reduction of the Stem Rot pathogen at the test site after two years of study.