PROJECT RP-2

ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 1994 - December 31, 1994

PROJECT TITLE: Cause and Control of Rice Diseases

STATUS OF PROPOSAL: Continuing

PROJECT LEADER: R.K. Webster

PRINCIPAL UC INVESTIGATORS: T. Miller, N. Cintas, Res. Associates

COOPERATORS: S. Scardaci, M. Brandon, S. Pettygrove

LEVEL OF 1994 FUNDING: 34169.00

OVERALL OBJECTIVES AND STATUS OF THE PROJECT:

The primary objective of this project continues to be to gain an understanding of the biology of rice diseases that occur in California and to develop methods for their control.

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.

We have identified microorganisms from straw and sclerotia that are mycoparasitic to sclerotia of S. oryzae and that limit stem rot in greenhouse tests. Field tests with these organisms in attempts to control stem rot have not been encouraging. Experiments to obtain a better understanding of the interaction between these organisms were conducted in an attempt to gain an understanding of the nature of the interaction between them. The hope is that an understanding of this relationship might be exploited in managing stem rot.

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 is justified.

The specific objectives for this year are derived from previous results that we view as promising avenues of continued study in attempts to devise disease management strategies.

OBJECTIVES FOR 1994 AND EXPERIMENTS TO ACCOMPLISH OBJECTIVES:

[1] Study the occurrence and severity of stem rot (S. oryzae) and aggregate sheath spot (R. oryzae sativae) under various residue management treatments. Comparisons between the effects of winter flooding, incorporation, burning, soil contact and removal of residue at the Canal Farms site (Colusa County) were made. We believe that continuous years of data are needed to determine the cumulative affects of these treatments on buildup or decrease of disease inoculum and the levels of disease that occur due to them.

Similar determinations were made at the continuous study at the Sills ranch. At this site the comparisons consist of fall and spring burning, fall and spring incorporation of residue each with and without a vetch cover crop.

[2] Continued study on the interaction of organisms that have been shown to affect viability of pathogen inoculum and\or infection of the rice plant. Emphasis was on the interaction between S. oryzae and R. oryzae sativae to attempt to understand the basis for the "inverse relationship" between stem rot and aggregate sheath spot that has been observed.

[3] Continue evaluations of germplasm sources for improved resistance to SR and AGSS.

[4] Continue data collection required for determining ability to predict which fields may justify continued burning. Emphasis this year was on determining when the determination must be made so to allow time to take action in the fall if needed.

SUMMARY OF 1994 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVE:

Study of the occurrence and severity of stem rot and aggregate sheath spot under various residue management treatments was carried out at Canal farms (Steve Scardaci, Project coordinator and at Sills (S. Pettygrove, Coordinator).

Canal Farms: 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.

Sills Ranch: This experimental site is coordinated by S. Pettygrove and J. Williams. Comparisons include straw burned in the fall and spring, straw incorporated in fall and spring each with and without a vetch cover crop. Each replicate has a separate water system.

Soil samples were collected from finished seedbeds from each of the replicated treatments at three sites per basin at the Canal farms site. Random samples were collected from mainplots at the Sill's site. 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 each sample were counted and plated on potato dextrose agar to determine their viability. Viability information is needed to determine differential survival of sclerotia from one season to the next due to various residue treatments.

Plant samples of rice 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.

Canal Farms: Total sclerotia recovered, viable sclerotia (inoculum level) and percent viable sclerotia obtained in each of the various residue treatments for S. oryzae (stem rot) are shown in Table 1.

The numbers of sclerotia recovered for R. oryzae sativae (aggregate sheath spot) were very low for this first year. In some samples none were recovered. Since aggregate sheath spot disease was observed at various levels of incidence in each of the basins we conclude that the method for recovering R. oryzae sativae sclerotia is affected by soil type and we are working to refine it's sensitivity. This is based on the fact this method is quite reliable at the Sill's site where the soil, is much lighter in texture as opposed to the heavier clay type at Canal farms.

Table 1

Total Number of Sclerotia, Percent Viability and Viable Sclerotia\gram seedbed soil of S. oryzae at Canal Farms 1994

Treatment	Number Sclerotia	Percent Viable	Viable gram\soil	Stem rot Severity
Straw Burned, winter-flooded	5.1 ab	.18 a	1.0 a	2.54 a
Straw burned, non-flooded	5.6 ab	.19 a	1.1 a	3.10 a
Straw incorporated, winter-flooded	5.5 ab	.26 b	1.5 a	2.55 a
Straw incorporated, non-flooded	4.9 ab	.29 bc	1.4 a	2.78 a
Straw rolled, winter-flooded	5.4 ab	.26 b	1.5 a	2.60 a
Straw rolled, non-flooded	6.8 a	.34 c	2.4 b	2.93 a
Straw baled, winter-flooded	5.1 ab	.26 b	1.4 a	2.75 a
Straw baled, non-flooded	4.3 b	.28 bc	1.2 a	3.32 a

* 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 first years results show that there is a difference in total number of sclerotia and percent viability of the sclerotia between the residue treatments. Even so the viable sclerotia\per gram soil resulting in the finished seedbeds is 1.0 or higher in all of the treatments. Previous study has shown that inoculum levels this high frequently result in no significant differences in disease severity.

At Canal farms the experimental design is a main plot, flooding versus non-flooding with burning, incorporating, rolled and baled as subplots. The effect of the main and subplot on various parameters measured at the site are summarized in Table 2.

Table 2

Affect of flooding and various residue treatments on viability of S.oryzae inoculum, disease severity and yield at Canal farms, 1994.

Treatment	% viable	via.\scle gr.soil	Disease Severity	Yield * dry\wt.
Winter Flooded	.24	1.22	2.61	7764
Burned	.18 a	1.0 a	2.54 a	
Incorp.	.26 b	1.5 a	2.55 a	
Rolled	.26 b	1.5 a	2.60 a	
Baled	.26 b	1.4 a	2.75 a	
Not Winter Flooded	.27	1.52	3.03	7328
Burned	.19 a	1.1 a	3.10 a	
Incorp.	.29 bc	1.4 a	2.78 a	
Rolled	.34 c	2.4 b	2.93 a	
Baled	.28 bc	1.2 a	3.32 a	

Subplot	Yield *
Burn	8313
Incorp.	7309
Rolled	6924
Bale	7639
LSD = 552.7	

* The yield data given is for the large plot harvests at the experimental site. S. Scardaci is analyzing the effects of the practices at the site that are affecting yield. The differences in yield observed may be due to a number of factors. As the experiment progresses it should be possible to determine what factor or factors these differences are due to.

From a stem rot disease standpoint, the affects of the various treatments this year are most interesting regarding the differences in percent viability of sclerotia in the treatments and the total viable sclerotia that resulted in each treatment.

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 disease between the treatments this year. This site provides an ideal opportunity to measure affects of the treatments on stem rot epidemiology over successive years since each treatment will be repeated in the same basins.

Similar observations on Aggregate Sheath Spot disease were made at the Canal farms site. As mentioned earlier, the sclerotial numbers recovered from soil samples was very low and we are checking to see if this is the actual case at the site or if the recovery method being used is not as sensitive with the soil type at the site. The incidence of aggregate sheath spot observed during 1994 is summarized in table 3.

Table 3

Aggregate Sheath Spot Incidence Under Various Residue Management Treatments at the Canal Farms Site 1994

Treatment	Percent Tillers infected with Aggregate Sheath Spot
Straw Burned, winter flooded	0.06
Straw Burned, not flooded	0.05
Straw Incorporated, winter flooded	0.10
Straw Incorporated, not-flooded	0.07
Straw Rolled, winter flooded	0.05
Straw Rolled, not flooded	0.05
Straw baled, winter flooded	0.06
Straw baled, not flooded	0.04

* disease incidence determined as percent infected tillers
** the differences were not statistically significant

The first years data on Aggregate Sheath Spot provide an ideal base to determine the cumulative affects of various residue management treatments on the potential buildup of inoculum and disease severity under continuous rice cropping.

Sill's Ranch: Our study of the occurrence and severity and interaction of stem rot and aggregate sheath spot under various residue treatments with and without a vetch cover crop was continued at the Sills site this year. The experimental design for this continuous year trial is described under project RM-6. The main block comparisons are: Fall burn with and without Vetch, Fall Incorporation with and without vetch and Spring incorporation with and without vetch each replicated five times. Seedbed inoculum levels and disease severity for Stem Rot and Aggregate Sheath Spot for the 1994 season are summarized in Table 4.

Table 4

Inoculum Level and Disease Severity of Stem Rot and Aggregate Sheath Spot at Sill's ranch Study Site in 1994

Treatment	Stem Rot Scl\gr*	Stem Rot Dis. Sev.	Agg. Sheath Spot Scl\gr*	Agg. Sheath Spot Dis. Inc.
Burn\Vetch	.67 a	2.03	.05 a	.44
Burn\No Vetch	.71 a	2.51	.07 a	.36
Fall Inc\Vetch	1.80 b	2.22	.16 bc	.51
Fall Inc\No Vetch	1.37 b	2.17	.11 ab	.50
Spring Inc\Vetch	3.26 c	2.19	.26 d	.56
Spring Inc\No Vetch	3.02 c	2.27	.20 cd	.65

* viable sclerotia \ gram soil from seedbed
** values with same letter are not significantly different
Stem rot disease severity based on 1=healthy - 5=severe
AGSS incidence = percent infected tillers

As in past years there appears to be a trend regarding the interaction between the amount of SR and that of AGSS. This is discussed under the section on interaction of SR and other organisms. The ratings were made in the main plots at the site. Yield data for the main plots was not collected by the grower and comparisons with disease and yield were not possible.

The results obtained at this site over the past three years indicate that the green manure crop has an affect on the total microflora in the field. We have not been able to determine if it influences populations of organisms beneficial in minimizing viability of pathogen inoculum. A comparison of the total number of S. oryzae sclerotia produced versus number of viable sclerotia in the seed bed (Table 5) indicates that the treatments differentially affect both production and survival of inoculum.

Table 5

Total Sclerotia of S. oryzae versus Viable sclerotia per Gram Soil in Seedbeds in Various Treatments at Sills

Treatment	Total Sclerotia per gram soil	Viable Sclerotia per gram soil
Burn\Vetch	3.91 a	.67 a
Burn\No Vetch	4.24 a	.71 a
Fall Inc\Vetch	7.81 bc	1.80 b
Fall Inc\No Vetch	6.05 ab	1.37 b
Spring Inc\Vetch	10.45 d	3.26 c
Spring Inc\No Vetch	9.08 cd	3.02 c

* values with the same letter do not differ significantly
** significant differences determined by Duncan's mean separation

Inoculum levels for both Stem Rot and Aggregate Sheath Spot are relatively high in the various treatments at this site and there has been a consistent high level of disease throughout our study there. For these reasons it has been an ideal sight to carry out a series of disease ratings at different times of the season. The purpose being to determine if disease rated at different times of the season is correlated to final disease ratings at harvest time. This information is essential if persons with the responsibility to determine if certain fields should be permitted to be burned have are to have time to make that determination prior to harvest of the fields.

Consecutive disease determinations at two week intervals were made at the Sill's site over the past two years. The results are summarized in table 6.

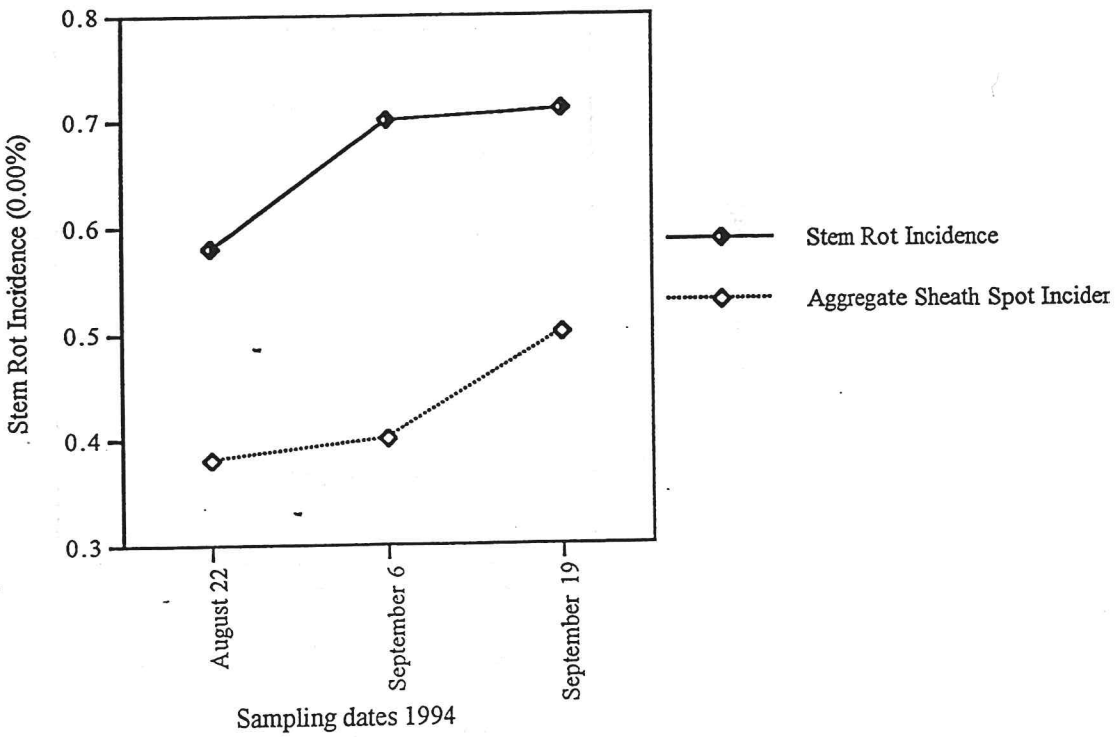
Table 6

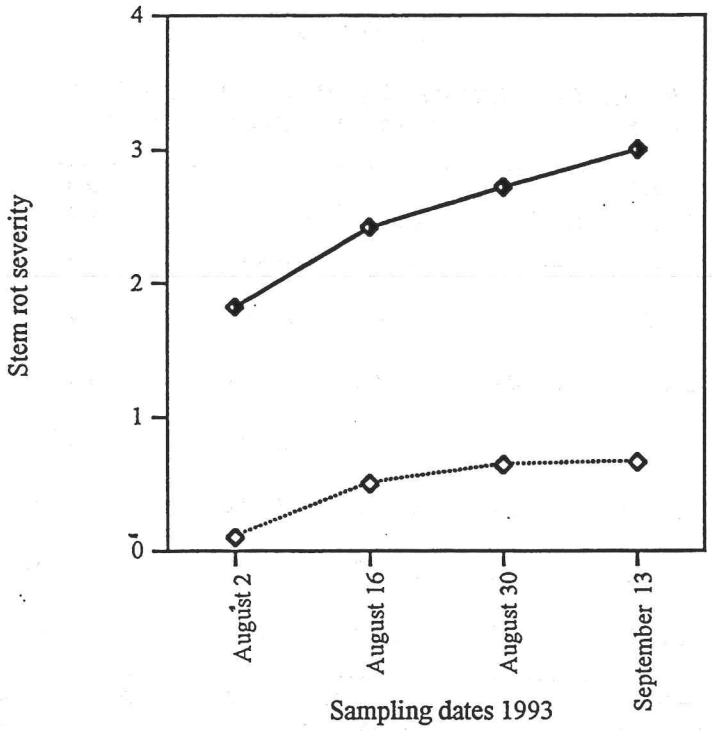
Consecutive Stem Rot Severity Ratings in Two Growing Seasons Under Various Residue Treatments

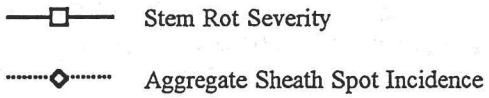
Treatment	1993 8\2	8\16	8\30	8\13	1994 8\22	9\6	9\19
Burn\Vet	1.36	1.74	2.10	2.44	1.63	1.93	2.03
Burn\no Vet	1.62	2.02	2.32	2.60	1.99	2.22	2.51
Fall In\Vet	1.38	1.94	2.28	2.58	1.90	2.07	2.22
Fall In\no Vet	1.56	1.94	2.28	2.48	1.88	2.12	2.17
Spr Inc\Vet	1.58	2.20	2.20	2.32	1.99	2.04	2.19
Spr. Inc\no Vet	1.58	2.20	2.42	2.56	2.02	2.28	2.27

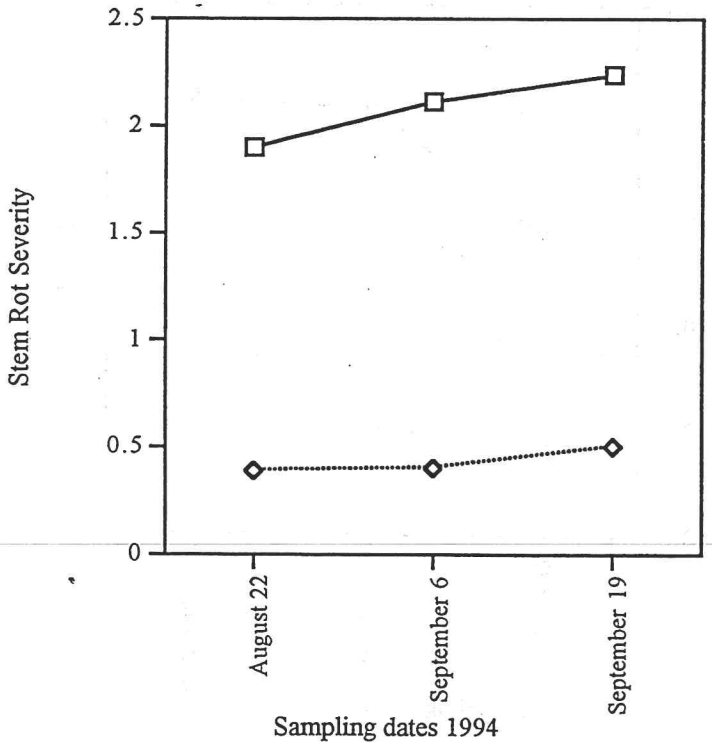
*stem rot is rated on a scale of 1=healthy - 5= severe
** each value is the mean of five replications per treatment.

The results show that stem rot severity increased comparably over the time period sampled in both years. A similar progression was observed for Aggregate Sheath Spot. The increase of stem rot and aggregate sheath spot is shown graphically over time below.




Stem rot severity
4
3
2
1
0
August 2
August 16
August 30
September 13
Sampling dates 1993


Stem Rot Severity
Aggregate Sheath Spot Incidence


Stem Rot Severity
2.5
2
1.5
1
0.5
0
August 22
September 6
September 19
Sampling dates 1994

These results indicate that it will be possible to accurately predict fields that would be expected to have high disease levels with subsequent high levels of carry over inoculum for both stem rot and aggregate sheath spot. This determination could also be made early enough in the season to allow for decisions as to method of residue management to be used in those fields that would be most beneficial in minimizing carry-over inoculum.

Continued study on the interaction of organisms that affect disease emphasized the relationship of S. oryzae and R. oryzae sativae. This was based on the inverse relationship between incidence of SR and AGSS that we have observed both in greenhouse and field studies in the past. The objective of these experiments was to determine if the behavior of SR sclerotia is adversely affected by the presence of AGSS sclerotia during the germination and possible infection period. Studies were conducted on both excised rice leaves and seedings. Germination rates and attachment (initial step of infection) of S. oryzae and R. oryzae sativae on leaves and seeding stems over time are summarized in the following figures.

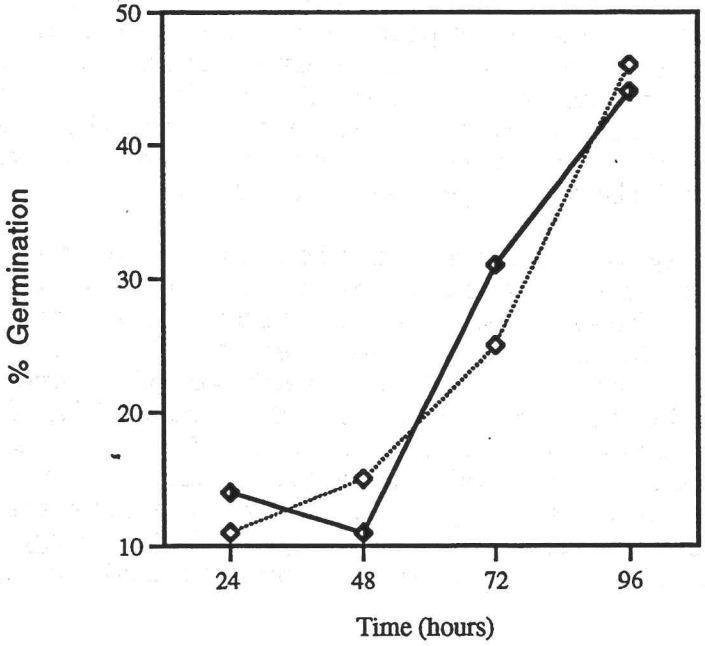
The results indicate that although there are no apparent differences in rate of germination when the fungi are alone versus growing next to a potential competitor, there are obvious differences in the germination rates of SO vs ROS. This may be due to the differences in sclerotial structure of the two fungi. However this lag in germination time of SO may allow ROS to "claim" the infection site first which may explain previously observed reductions in SR severity in the field and greenhouse when both organisms were present or coinoculated. Whether this is the basis for observed reductions of SR in earlier studies with other organisms tested for in season of stem rot remains to be determined.

Evaluation of collections of wild Oryzae species were continued in an attempt to identify improved sources of resistance to both stem rot and aggregate sheath spot. Accessions studied varied greatly in plant type, maturity time, seed size and sterility. None tested were considered as useful for future breeding efforts. This year we will screen large numbers of collections of O. sativae from the National Germplasm Collection concentrating on collections from countries with a similar climate as that of California.

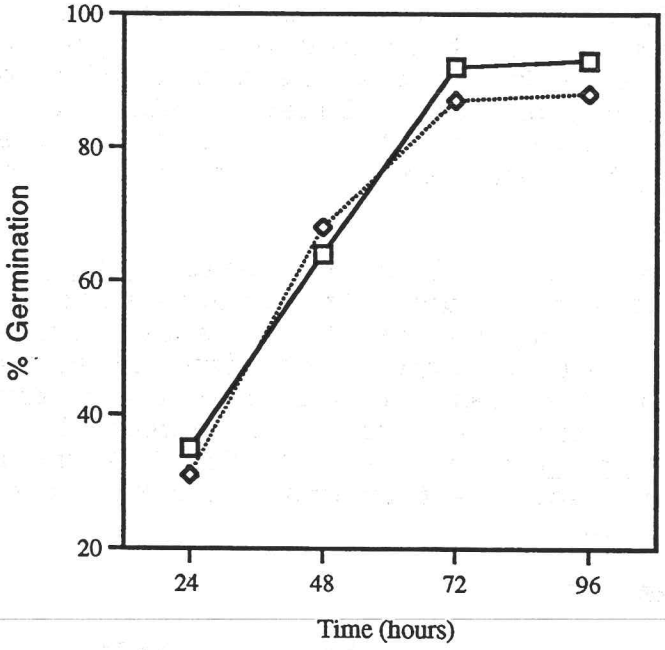
PUBLICATIONS OR REPORTS

Webster, Robert K. Report to the California Rice Research Board: Project RP-2. Cause and Control of Rice Diseases, 10 pp. In: Annual Report of Comprehensive Research. 1993. University of California and the U. S. Dept. of Agriculture.

Germination rates of Sclerotium oryzae on excised leaves when grown alone or aside a potential competitor



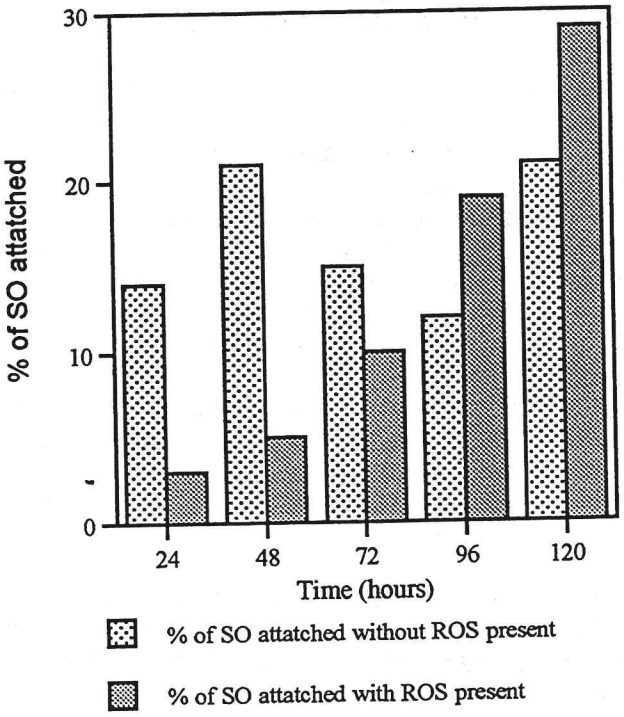
Germination rates of Rhizoctonia oryzae-sativa on excised leaves when grown alone or aside a potential competitor



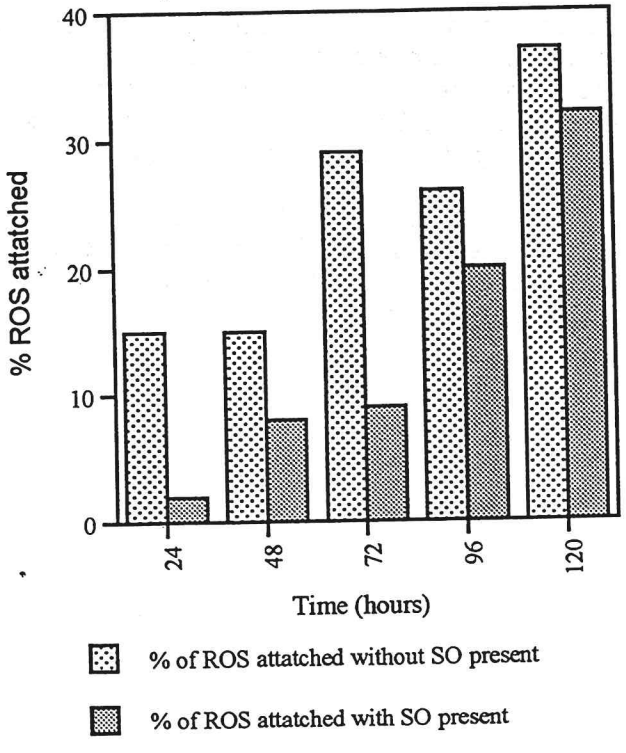
% germination of Rhizoctonia oryzae-sativa (ROS) grown alone

% germination of ROS grown aside Sclerotium oryzae

% attatchment of Sclerotium oryzae in the presence or absence of a competitor Rhizoctonia oryzae sativa



% attatchment of Rhizoctonia oryzae sativa in the presence or absence of a competitor Sclerotium oryzae



Results presented are a combination of 7 replicated experiments

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS

The establishment of continuous year trials to monitor the affects of various residue management treatments on rice disease epidemiology is essential in determining the optimum rice disease management system as open field burning is curtailed. The first years results obtained from the Canal Farms site on inoculum production and survival provide a basis for determining the multi-year cumulative affects of the treatments being compared. This in turn should facilitate the decision process regarding the optimum practices regarding disease management. Lower inoculum and disease severity and higher yield was observed in flooded treatments during the first full year of study at this site. Highest yield was obtained when residue was burned, baled, incorporated and rolled in that order. These results are consistent with findings of previous studies. Conclusions on long term affects of these treatments awaits further study.

A long term experiment similar to that at Canal Farms was established in Butte County in the fall of 1994. Studies at this site will be similar to those at Canal Farms and should provide invaluable data regarding affects of different residue treatments on a different soil type.

Our results from consecutive sampling of disease severity and incidence indicate that it is possible to reliably determine fields that justify continued burning early enough in the season to allow timely action.

Studies on the interaction of organisms at the infection site on the rice plant indicate that competition for the infection site may explain differences in the proportion of stem rot and aggregate sheath spot in a particular field. This also relates to differences in inoculum levels of the pathogens in a particular field.

No promising sources of improved resistance to both stem rot and aggregate sheath spot were identified in additional screenings of wild Oryzae species this year. The search will be continued on a large collection of O. sativae.