Project No. RP-2

Comprehensive Research on Rice
Annual Report
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PROJECT TITLE: Cause and Control of Rice Diseases

PROJECT LEADER AND PRINCIPAL UC INVESTIGATORS:

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LEVEL OF 1987 FUNDING: $42,800

OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:

Continuing objectives of research project RP-2 are to determine the nature and control of rice diseases in California. We have proceeded by identifying the diseases, determining the extent to which they occur and studying factors that affect their severity. This information is used to determine the best approaches to control or minimize the effect of the diseases. We are emphasizing interactions of various cultural practices with an eye to determining alterations that minimize disease yet maximize production. Additional studies include identification of chemical controls and evaluation of germplasm for disease resistance. Many aspects of the project require consecutive years of evaluation in the field or information on reactions of new cultivars and as such are continuing.

Specific Objectives for 1987:

(1) Re-evaluate and test alternative rice seed treatment practices,

(2) Complete studies on occurrence and severity of Kernel Smut,

(3) Determine interaction and losses due to Stem Rot, Aggregate Sheath Spot and bordered sheath spot in relation to N and K fertilization on new varieties,

(4) Initiate studies on the potential enhancement of biodegredation of rice residue and over-wintering propagules of the rice pathogens, *S. oryzae*, *R. oryzae-sativae* and *R. oryzae*.

(5) Evaluate fungicides for control of Stem Rot and Aggregate Sheath Spot.

Experiments were carried out in 1987 in University of California greenhouses, laboratories, the Rice Research facility and in growers fields in Butte, Colusa, Sutter and Fresno counties. Kernel Smut samples were analyzed from all counties in the State where rice is grown. Butte County Rice Growers, Glenn Growers, Comet, DuPue Warehouses, Farmers Rice Cooperative, N. Davis Dryer and Rice Growers Association all assisted in this effort.

SUMMARY OF 1987 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVE:

Objective 1: Re-evaluate and test alternatives to current rice seed-treatment practices. Fungicidal seed treatments for control of rice seedling diseases have been used routinely throughout the industry. Recently, regulatory agencies have indicated that present practices of disposing of soak water from seed supplying warehouses will no longer be acceptable. In addition they have indicated that the use of Captan and Kocide as seed dressing will probably be terminated. The need to re-evaluate chemicals being used, methods and time of application and need vs benefits was evaluated in trials in Butte County and at the Rice Research Facility at Davis this past season. Commercially treated seed, untreated seed and experimentally treated seed of 3 cultivars were tested for percent stand established at three locations under varying environmental (primarily water temperature) conditions. The results are summarized as follows:

Table 1. Percent of Seed Planted that Established Plants in 1987 Rice Seed Treatment Trials.

Cultivar	Davis Rice Facility[1]		Butte Co.	Butte Co.
Treatment	A	B	Site 1[2]	Site 2[3]
S-201 T	59.2*	66.8*	69.8*	69.3*
S-201 UT	45.6	43.8	57.0	60.5
M-201 T	67.3	71.0*	76.3	76.5
M-201 UT	61.2	64.0	74.0	71.0
L-202 T	59.8	62.0*	85.3	79.8
L-202 UT	54.2	56.9	79.5	73.5

T = Captan 2.4 oz/100 wt; *Significantly different from untreated check for Variety at .05% at Davis B and Butte Co. 1 & 2.

T = Kocide SD 2.0 g/cwt at Davis A.

UT = Untreated.

[1]Water temperature = 50-60°F during stand establishment.

[2]Water temperature = 60°F during stand establishment.

[3]Water temperatures reached 86°F during stand establishment.

The results indicate that seed treatment benefits vary with cultivar and environment, i.e. water temperature effected mainly by planting later. It is well known that changes in planting dates of new cultivars, improved water management due to laser leveling and increased vigor in newer cultivars have benefited stand establishment problems. The fact that benefits are still obtainable with seed treatment under these conditions will need to be considered in decisions regarding the future of seed treatment in our industry.

Objective 2: Complete Studies on Occurrence and Severity of Kernel Smut.

Kernel smut of rice caused by *Neovossia horrida* (Tak.) Padwick and Khan (*Tilletia barclayana*) is wide spread in most rice growing areas of the world including Africa, North America, South America, Central America, Fiji and Asia. The disease was first reported in the United States in South Carolina in 1899, Arkansas in 1926, Texas in 1937 and Louisiana in 1953. In 1984 it was reported to be widespread in California by Matsumoto and coworkers. Using a seed wash-centrifugation technique, 382 seed samples gathered from storage facilities in eight counties were studied. Chlamdospores of *T. barclayana* were identified from 16% of the samples tested from the 1983 crop.

Attempts to formulate control measures must be based on an increased knowledge of the epidemiology and nature of the disease cycle of kernel smut. For example, if the centrifuge-wash technique rated samples positive for smut that were in fact contaminated in the harvest, drying and storage process, then use of non-contaminated seed or disinfested seed might help limit further spread of the pathogen. Such misclassification could also confuse attempts to determine prevalence of the disease as related to cultivars and cultivar characteristics.

In an attempt to eliminate the possibility of samples becoming infested from other sources, we conducted an extensive survey for kernel smut as follows: Aggregate lot samples (1 per field) were collected at various dryers throughout California and observed directly for the presence of smutted or partially smutted kernels. We recognize that this sampling method may result in an underestimate of actual smut incidence but positive samples represent true occurrence of smut in the field from which it was drawn. This approach also allows for observation of a larger sample than would direct observation in fields.

By determining the incidence and distribution of Kernel smut over successive season, it should be possible to conclude the role of seed in spread of the disease and hence if restrictions on seed lots or specific kernel smut seed treatments are warrented. Further, such data provides insight into the epidemiology of the disease and suggests approaches for control such as cultivar selection.

The results of three years of extensive sampling of California rice are summarized in regard to distribution of Kernel Smut in rice producing counties, percent lots infected relative to cultivar and grain type and percent lots infected as related to maturity of cultivars.

(a) Distribution of Rice Kernel Smut in California: Table 2 contains results of percent infected lots by county over a three year sampling period. As seen there, kernel smut is widely distributed in California rice producing areas but more prevalent in Glenn, Colusa, Butte, Sacramento and Placer counties. The highest incidence of Kernel Smut occurred in the 1984 crop statewide. The data warrents the conclusion that Kernel Smut was introduced into the northern production areas. Whether it was spread by contaminated seed, water, equipment or airborne to adjacent fields can only be speculated. I believe field to field spread in the northern areas would be much easier due to the concentration of rice production as opposed to the sparse scattered fields in the Southern (Central Valley) areas. That the percent fields with Kernel Smut was actually lower in 1985 and 1986 than in 1984 suggests that incidence of the disease is highly dependent on environmental conditions and that this will effect future incidence considerably more than continued spread of the pathogen. In any event, my opinion is that quarantine of infested seed lots would not enhance control of kernel smut at this time.

(b) Percent lots infected with kernel smut relative to cultivar and grain type: Table 3 summarizes the kernel smut data relative to cultivar and grain type. As seen there, kernel smut incidence is clearly higher on long grain cultivars. The next highest incidence was observed on short grain cultivars with the medium grain cultivars the lowest incidence. These results are consistent with previous reports that high incidence of kernel smut on long grain cultivars may be due to the fact that florets open wider and anthesis duration is longer than on short and medium grain cultivars. This is supported in part by our greenhouse inoculation studies that show no inherent difference in susceptibility between grain types under artificial inoculation. This finding is also interesting where one compares the time of the first discovery of kernel smut in California with that of introduction and production of long grain cultivars for California production.

(c) Percent lots infected as related to maturity of cultivars: Table 4 summarizes the kernel smut data relative to cultivar maturity time. As seen there, kernel smut incidence is noteably higher on the early short grain S-201 and early long grains L-202 and California Belle. M-9 an early medium grain showed the highest incidence in it's class. Thus it appears for the most part that long grains and early maturing varieties sustained the highest incidence of kernel smut during the 3 years of observation. These results are in contrast with reports from the Southern United States where incidence is reported to be highest on late maturing cultivars. This fact and above observations support my conclusions that incidence of kernel smut is effected most by environmental conditions during flowering time and that the timing of flowering by variety is a factor in incidence (i.e. duration of anthesis and open florets).

The above conclusions are based on survey data where any amount of smut resulted in a sample rated positive. A portion of the smut positive samples were also analyzed to determine amount of smut per two pound samples. Samples so handled varied considerably from less than .05% smutted to over 11.0%. In all cases where percent of smutted kernels per sample exceeded 2 percent, the sample was from a long grain lot.

Table 2. Percent of Lots Infected with Kernel Smut from Different Counties.

County	1984			1985			1986			Total		
	No. Samples	No. Smutted	% Smut	No. Samples	No. Smutted	% Smut	No. Samples	No. Smutted	% Smut	No. Samples	No. Smutted	% Smut
Tehama	27	3	11.1	26	0	0.0	24	0	0.0	77	3	3.9
Glenn	201	22	10.9	316	22	7.0	263	29	11.0	780	73	9.4
Colusa	462	45	9.7	484	25	5.2	521	30	5.8	1467	100	6.8
Butte	420	34	8.1	65	5	7.7	355	12	3.4	840	51	6.1
Sutter-Yuba	148	9	6.1	144	5	3.5	187	7	3.7	479	21	4.4
Sacramento	41	6	14.6	81	5	6.2	124	4	3.2	246	15	6.1
Yolo	41	4	9.8	64	1	1.6	45	0	0.0	150	5	3.3
San Joaquin	24	2	8.3	28	0	0.0	34	0	0.0	86	2	2.3
Merced	-	-	-	59	0	0.0	71	1	1.4	130	1	0.8
Placer	21	0	0.0	66	3	4.5	57	3	5.3	144	6	4.2
Stanislaus	7	1	14.3	11	0	0.0	32	0	0.0	50	1	2.0
Kern	-	-	-	1	0	0.0	-	-	-	1	0	0.0
Tulare	7	0	0.0	-	-	-	-	-	-	7	0	0.0
TOTAL	1399	126	9.0	1345	66	4.9	1713	86	5.0	4457	278	6.2

Each sample represents a different lot (growers field) as collected at the dryer.

Table 3. Percent of Lots Infected with Kernel Smut as Related to Cultivar and Grain Type.

	1984			1985			1986			Total		
County	No. Samples	No. Smutted	% Smut	No. Samples	No. Smutted	% Smut	No. Samples	No. Smutted	% Smut	No. Samples	No. Smutted	% Smut
Short	532	40	7.5	325	42	12.9	360	39	11.6	1217	121	9.9
S-201	367	30	8.5	303	42	13.9	335	39	11.6	1005	111	11.0
Cal Pearl	165	10	6.1	22	0	0.0	25	0	0.0	212	10	4.7
Medium	741	39	5.3	934	6	0.6	1227	25	2.0	2902	70	2.4
M-7	7	0	0.0	8	1	12.5	-	-	-	15	1	6.7
M-9	88	15	17.0	36	1	2.8	43	1	2.3	167	17	10.2
M-101	42	2	4.8	39	0	0.0	61	0	0.0	142	2	1.4
M-201	519	14	2.7	823	4	0.5	941	15	1.6	2283	33	1.4
M-401	25	0	0.0	20	0	0.0	32	0	0.0	77	0	0.0
M-202	-	-	-	-	-	-	140	8	5.7	140	8	5.7
M-302	60	8	13.3	2	0	0.0	-	-	-	62	8	12.9
Earlirose	-	-	-	6	0	0.0	10	1	10.0	16	1	6.3
Long	126	47	37.3	86	18	20.9	126	22	17.5	338	87	25.7
L-202	1	1	100.0	79	17	21.5	126	22	17.5	206	40	19.4
Cal Belle	125	46	36.8	7	1	14.3	-	-	-	132	47	35.6
Total	1399	126	9.0	1345	66	4.9	1713	86	5.0	4457	278	6.2

Each sample represents a different lot (growers field) as collected at the dryer.

Table 4. Percent of Lots Infected with Kernel Smut as Related to Maturity of Cultivar.

	1984			1985			1986			Total		
Maturity	No. Samples	No. Smutted	% Smut	No. Samples	No. Smutted	% Smut	No. Samples	No. Smutted	% Smut	No. Samples	No. Smutted	% Smut
Very Early	332	58	17.5	74	1	1.4	96	1	1.0	502	60	12.0
M-101	42	2	4.8	39	0	0.0	61	0	0.0	142	2	1.4
Cal Belle	125	46	36.8	7	1	14.3	-	-	-	132	47	35.6
Cal Pearl	165	10	6.1	22	0	0.0	25	0	0.0	212	10	4.7
Earlirose	-	-	-	6	0	0.0	10	1	10.0	16	1	6.3
Early	975	60	6.2	1241	64	5.2	1585	85	5.4	3801	209	5.5
S-201	367	30	8.2	303	42	13.9	335	39	11.6	1005	111	11.0
M-201	519	14	2.7	823	4	0.5	941	15	1.6	2283	33	1.4
M-9	88	15	17.0	36	1	2.8	43	1	2.3	167	17	10.2
L-202	1	1	100.0	79	17	21.5	126	22	17.5	206	40	19.4
M-202	-	-	-	-	-	-	140	8	5.7	140	8	5.7
Intermediate	60	8	13.3	2	0	0.0	0	0	0.0	62	8	12.9
M-302	60	8	13.3	2	0	0.0	-	-	-	62	8	12.9
Late	32	0	0.0	28	1	3.6	32	0	0.0	92	1	1.1
Cal-76	-	-	-	-	-	-	-	-	-	-	-	-
M-7	7	0	0.0	8	1	12.5	-	-	-	15	1	6.7
M-401	25	0	0.0	20	0	0.0	32	0	0.0	77	0	0.0
Total	1399	126	9.0	1345	66	4.9	1713	86	5.0	4457	278	6.2

Each sample represents a different lot (growers field) as collected at the dryer.

Overall the results indicate that kernel smut will not become a major California rice disease since the California environment does not appear to enhance kernel smut severity. On the other hand the experience with long grain cultivars indicates new cultivars should be very carefully evaluated for kernel smut susceptibility prior to release to the industry. Quarantine of infected seed lots does not appear warranted since the disease is currently widely distributed throughout most of our rice production areas.

Objective 3: Determine Interaction and Losses Due to Stem Rot, Aggregate Sheath Spot and Boardered Sheath Spot in Relation to N and K Fertilization on New Varieties.

(a) Effects of Nitrogen: Severity and incidence of Stem Rot, Aggregate Sheath Spot and Boardered Sheath Spot differ on cultivars and under various culture practices. A major goal of our overall project is to determine culture practices conducive to minimizing disease severity and optimizing yield. Our studies on the effect of nitrogen fertilization, timing and rates have been an integral part of achieving this objective. As new cultivars are released it is essential to obtain data on the effect of fertilization practices on disease severity on them. Consequently, we established trials to determine the effects of various N levels on disease severity on the cultivar M-401. Eight N levels, 0, 30, 60, 90, 120, 150, 180 and 210 lbs N/acre were tested to determine the effects of N level on disease severity and yield. Stem Rot severity increased from 0 to 210 pounds N as has been observed for all other cultivars. Maximum yield was obtained at 150 lbs N (71.8 cwt/acre) and decreased to 66.8 cwt/acre at 210 lbs N/acre. Stem rot severity increased significantly from 150 lbs N/acre to 210 lbs N/acre and was accompanied by the decrease in yield.

Aggregate Sheath Spot was much less affected by increases in N with highest severity at 60 lbs N/acre. These results are consistent with those obtained in the past on other cultivars.

An identical trial was conducted testing the cultivars M-201 and M-202 at 8 N levels. Similar results were obtained for both cultivars and diseases regarding N fertilization. Combined these results show that excess N fertilization enhances Stem Rot damage on all cultivars presently grown. Aggregate Sheath Spot and Boardered Sheath Spot are more severe when N is inadequate to obtain maximum yield.

(b) Effects of Potassium: Some workers in other countries have reported beneficial disease suppression effects by the application of Potassium. Many rice soils in California contain adequate potassium for maximum yield and thus this element is not included in many growers fertilization programs. Trials were conducted in Butte County to determine if the inclusion of potassium as a preplant fertilizer results in suppression of Stem Rot and Aggregate Sheath Spot.

Muriate of Potash KCl at 100 lbs/acre was added to the seedbed surface as the potassium treatment in trials with 8 replications at three locations in Butte County. Nitrogen was adequate for maximum yield. The disease readings at all three sites are summarized below.

Effect of Potassium on Rice Disease Severity

	Field 20	Field 67	Field 214
	Yield $\bar{X}$ lbs/plot for 8 replications		
Treatment			
100 lbs K/acre	29.05	21.74	28.29
No K	28.34	22.24	28.29
	Aggregate Sheath Spot Severity		
100 lb K/acre	26.88	37.51	41.68
No K	39.44	30.58	31.33
	Stem Rot Disease Severity		
100 lb K/acre	2.99	2.44	1.98
No K	2.69	2.19	1.36

In all these trials the addition of potassium did not result in yield increases or in significant reduction of disease except in the case of AGSS in field 20. On the other hand, Stem Rot was more severe at all three locations when K was added as a treatment. This was probably due to growth response of the rice resulting in more lush plants which have been observed in the past to sustain higher disease levels. On the other hand, this did not result in yield increase, perhaps due to the increased severity of stem rot.

Disease levels for N effects were negligible in all treatments in a trial in Fresno Co.

Objective 4: Initiate studies on the potential for enhancement of biodegradation of rice residue and overwintering propagules of the pathogens, *S. oryzae*, *R. oryzae sativae* and *R. oryzae*.

Studies this year on this objective consisted of isolation and identification of fungi and bacteria resident in rice residue after harvest. Organisms were also isolated from sclerotia of *S. oryzae* and identified and tested for inhibition of *S. oryzae* sclerotial germination. The following fungi were identified: *Penicillium* spp., including one with yellow perithecia; *Paecilomyces* spp. (monophialidic and non-monophialidic); *Phoma* spp.; *Cladosporium* spp.; *Aspergillus* spp.; *Cephalosporium* spp.; *Fusarium oxysporum* Schlect. ex Fr.; *Chaetomium* sp.; *Trichoderma* spp.; *Stachybotrys atra* Corda; *Fusarium episphaeria* (Tode) Snyder et Hansen; *Humicola* spp.; *Alternaria alternata* (Fries) Keissler; *Wallemia* sp.; *Cylindrocarpon* spp.; *Mucor* sp.;

Mortierella sp.; Coniothyrium sp.; Gliomastix sp.; Acremoniella verrucosa Togn.; Rhodotorula sp.; Epicoccum spp.; Verticillium spp.; Periconia macrospinosa Lefebre et A. G. Johnson; Nigrospora spp.; Helminthosporium pedicellatum Henry; Alternaria sp.; Stemphylium botryosum Wallr.; Candida spp. and a Helminthosporium sp. Attempts to identify bacteria isolated are not yet complete. Two Penicillium sp. and one Trichoderma sp. were highly inhibitory to germination of S. oryzae sclerotia. These studies are being continued both in relation to ability to decompose rice straw and inhibit fungal germination of propagules.

Objective 5: Evaluate fungicides for control of Stem Rot and Aggregate Sheath Spot. Attempts to determine optimum time of application, rates and efficacy of selected fungicides to control Stem Rot and Aggregate Sheath Spot were continued in two trials in Butte County. Tilt gave fair control of Stem Rot in both trials. Benlate showed good efficacy against Aggregate Sheath Spot. Neither chemical gave satisfactory control of both diseases. Rovral showed promise for control of AGSS but not Stem Rot. Even though reductions in disease severity occurred as noted, no significant increase in yield occurred due to fungicide treatments tested this year.

Publications or Reports:

Webster, R. K. 1986. Report to the California Rice Research Board. Project RP-2. Cause and Control of Rice Diseases, p. 12-23. In Annual Report of Comprehensive Rice Research. 1986. University of California and U.S. Department of Agriculture.

Gunnell, Pamela S. and Robert K. Webster. 1987. Ceratobasidium oryzae-sativae SP. Nov., The Teleopmorph of Rhizoctonia oryzae sativae and Ceratobasidium setariae comb. Nov., the probably teleomorph of Rhizoctonia fumigata comb. Nov. Mycologia 79(5):731-736.

Webster, R. K. Strategies for the utilization and preservation of resistant and tolerant plant germplasm in integrated pest management, p. 87-91. In Proc. 1987 California Plant and Soil Conference, Calif. Chap. American Society of Agronomy.

Gunnell, Pamela S. and Robert K. Webster. Waitae circinata var. oryzae var. Nov. and W. circinata var. zeae var. Nov., the teleomorphs of Rhizoctonia oryzae and R. zeae. (Mycologia)

Rutger, J. N., R. A. Figoni, R. K. Webster, J. J. Oster and K. S .McKenzie. 1987. Registration of early maturing, marker gene and stem rot resistant germplasm lines of rice. (Crop Science, Nov-Dec.).

Concise General Summary of Years Results:

Reevaluation of seed treatments confirmed their benefits for improved stand establishment. This was particularly significant under cold water conditions. Cultivars differed in response to seed treatment with S-201 showing greatest benefit. Captan gave slightly better results than Kocide SD.

Results of 3 years of extensive monitoring of Kernel Smut show the disease is widely distributed in California rice areas but most prevalent in Northern counties. Incidence and severity of Kernel Smut does not appear to be increasing. We conclude California conditions do not favor the disease. Kernel smut is most prevalent and severe on long grain cultivars. In regard to maturity, Kernel smut is clearly more prevalent on early cultivars in California. Based on present distribution of Kernel Smut, quarantine of seed lots does not appear warranted.

The lesson from kernel smut thus far appears to be increased care to prevent introduction of disease organisms and continued evaluation of newly developed cultivars for disease susceptibility and prevalence.

Cultivar M-401 is affected in the same manner as other cultivars by stem rot when grown under excess nitrogen fertilization. Trials to determine if potassium applications limit stem rot and AGSS severity showed no reduction in disease severity between K treatments and the controls.

Several fungi and bacteria were isolated and identified for potential use to enhance degradation of rice residue and rice pathogen propagules. Three organisms were effective in inhibiting germination of S. oryzae sclerotia.

Fungicide tests to determine rice disease control showed that some chemicals would control either Stem Rot or AGSS but not both. Tilt gave average control of Stem Rot. Benlate was effective against AGSS. Both are registered for use on rice in the Southern States.