COMPREHENSIVE RESEARCH ON RICE
ANNUAL REPORT

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PROJECT TITLE: Cause and Control of Rice Diseases

PROJECT LEADER AND PRINCIPAL UC INVESTIGATORS:

R. K. Webster; J. Bolstad, Staff Research Associate;
P. Gunnel, Research Assistant; C. M. Wick, S. C. Scardaci,
J. Williams, Cooperative Extension.

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OBJECTIVES AND EXPERIMENTS CONDUCTED TO ACCOMPLISH OBJECTIVES:

Long-range objectives of research project RP-2 are to determine occurrence, nature and control of rice diseases in California. We are proceeding by identifying the diseases, determining the extent to which they occur and studying factors that affect severity of occurrence including biology of the pathogens and epidemiology of the diseases. Based on results from the above, experiments to determine effective methods of control are carried out. These include studies on interactions of various culture practices, i.e., residue management, fertilization, chemical control and development of resistant varieties. Specific objectives for 1981 were:

(1) Continue studies on distribution, etiology and occurrence of sheath blight of rice,

(2) Determine the relationship between the occurrence and severity of sheath blight and stem rot,

(3) Develop methods for determining inoculum levels of *Rhizoctonia oryzae sativae* (*S. oryzae sativae*),

(4) Determine the relationship between various methods of residue disposal and removal to severity of stem rot and sheath blight disease,

(5) Expand studies on chemical control of sheath blight and stem rot disease,

(6) Continue to evaluate wild rice species and early generations of crosses between current cultivars and those species to identify sources of disease resistant germplasm for use in the breeding program, (Cooperative with J. N. Rutger),

(7) Continue studies on the effects of excess nitrogen fertilization on severity of disease and yield reduction of currently grown rice varieties and,

(8) Determine the effects of potassium fertilization on severity of stem rot and sheath blight.

Experiments to accomplish these objectives were carried out in the laboratories and greenhouses of the Department of Plant Pathology, University of California, Davis, at the Rice Research Facility at Davis and at field sites in Yolo, Colusa, Butte, Yuba, and Sacramento counties. Surveys on the occurrence and distribution of sheath blight were conducted throughout the rice-growing areas of the state.

SUMMARY OF 1982 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVE:

Objective 1: The sheath blight disease of rice has been known in California since the late 1960s. Its incidence and severity has increased significantly in the past few years. This increase of sheath blight has coincided with the introduction and widespread culture of semi-dwarf, high-yielding rice varieties. Studies under this objective have included distribution, etiology and biology of the pathogen.

(a) Distribution: Routine surveys and observation have shown that the sheath blight disease of rice occurs throughout the California rice-growing area.

(b) Etiology: The causal organism of sheath blight in California was known as *Sclerotium oryzae sativae* until 1979 when Mordue placed it in the genus *Rhizoctonia* on the basis of its mycelial and sclerotial characteristics. A study of isolates from sheath blight diseased plants in California revealed the following: Mycelium of the fungus is at first colorless on PDA, later white, and eventually develops a brown pigmentation. Hyphal branches arise at acute angles, are constricted at their point of origin and are septate near the constriction. The mycelium is binucleate although occasionally hyphal cells with three to four nuclei were observed. On PDA the fungus produces numerous brown, irregularly globose, warted sclerotia. Sclerotia produced within diseased tissue are ordinarily cylindrical whereas those found on the surface of diseased sheaths are more globose than those formed on PDA. The sclerotia are undifferentiated in cross section and are composed of loosely aggregated, swollen hyphal cells. The description of *R. oryzae sativae* by Mordue is generally that of the above describing isolates from California. Some variation was observed in degree of mycelial pigmentation and habit of sclerotial production but not enough to consider the California sheath blight pathogen a new species.

Sclerotium hydrophilum and *Nigrospora oryzae* were isolated from some diseased plants collected during our survey but neither of these two fungi proved to be pathogenic in subsequent greenhouse tests.

Pathogenicity tests in the greenhouse on 12 California varieties revealed both differenes in varietal susceptibility and virulence of isolates. Field studies confirmed the results of the greenhouse tests.

The knowledge that the sheath blight pathogen in California varies in virulence and that rice varieties differ in susceptibility is essential in formulating further research directed toward control of this disease. Our results support the conclusion that this pathogen belongs in the genus Rhizoctonia, another essential fact when considering possible chemical control.

(c) Symptomology: R. oryzae sativae produces circular lesions, approximately 0.5-1.0 cm in length, with pale green to tan colored centers and distinct brown margins. Initial infections occur on the outer leaf sheaths at the water line, during the tillering stage. The disease may progress upward on the plant attacking successively higher leaf sheaths and occasionally the leaf blade. Irregular brown lesions are sometimes found on the culm surface but rotting of the culm has not been observed. Often, dark brown, ncerotic areas are produced on the leaf sheath as lesion margins expand and lesions coalesce. Leaves of diseased sheath are usually killed, turning uniformly yellow. Numerous sclerotia may be produced in and on diseased sheaths. When infection progresses early in the season, panicles frequently either fail to emerge from the boot or only partially.

Objective 2: Field trials were established in Butte County and at Davis to determine the relationship between stem rot and sheath blight severity. All data collected this year indicated a strong inverse relationship between the two diseases in a given field. For example, plots with the most severe stem rot usually experience the least severe sheath blight. Frequently plants were infected by both pathogens but this was not the rule. Superficial infections by either pathogen made distinguishing between the two difficult until sheath blight had progressed upward on the plant. We conclude that the occurrence of the two diseases in the same field will frequently occur but that the disease that becomes established first on a particular plant will be most severe on that plant. These observations and conclusions indicate that any attempts to use fungicides for disease control will be most effective and economical if a chemical can be identified that controls both organisms.

Objective 3: Development of methods for determining inoculum levels of R. oryzae sativae is facilitated by the knowledge of when and where sclerotia are produced on diseased plants. Routine screening of soil samples followed by density floatation appears to be an effective way of quantifying sclerotial numbers per unit soil. More study is needed on factors affecting viability of R. oryzae sativae sclerotia however. When these methods are fully developed they will be invaluable in studying various approaches for control of sheath blight.

Objective 4: A three-year study to determine the effects of various rice harvest and straw removal procedures including burning, soil incorporation and harvest and removal from the field on *Sclerotium oryzae* (stem rot) and *Rhizoctonia oryzae sativae* (sheath blight) disease levels was completed this year. The study was designed to determine if epidemiological observations on stem rot disease observed on older tall California varieties are similar on semi-dwarf varieties now being grown.

Treatments compared included: (1) Ground level harvest, straw windrowed, baled and removed from field (GLHBR), (2) Normal height harvest, stubble swathed, baled and removed from field (NHHBR), (3) Normal height harvest, straw spread and burned (NHB), (4) Normal height harvest straw chopped and incorporated into soil (NHI). Progression of the experiment was from the middle of the 1979 crop season to mid season 1982. Residue management treatments recurred at the same site in the fall of 1979 and 1980. In the fall of 1981, all treatments were burned followed by normal tillage operations. Observations included determination of inoculum levels, disease severity and yield. The methods used for measuring stem rot inoculum and disease severity have been described in detail in previous reports to the board. Sheath blight severity is based on percent infection in this study. Results and conclusions from the study were as follows.

EFFECTS OF RESIDUE REMOVAL TREATMENTS ON *S. ORYZAE* INOCULUM LEVELS:

Inoculum levels were not obtained for 1979 since the experiment was not initiated until mid-season. Inoculum levels determined for spring 1980 represent the results of fall 1979 residue treatments and serve as a base to compare effects of continuing those treatments. Table 1 shows the mean inoculum levels for 3 seasons (1980, 1981, 1982). Inoculum levels between the four treatments compared differed with NHB(3) the lowest followed by GLHBR(1) NHHBR(3) and NHI(4) in that order. This trend persisted throughout the experiment. The biggest cumulative increase in inoculum occrred in checks where residue was incorporated.

(a). Stem rot disease incidence and severity.

Disease ratings were determined for each plot just prior to draining of water in preparation for harvest. The values obtained are presented in Table 1. Mean disease severity differed significantly (5%) between all three years of the study with the most severe disease experienced in the third year. This in not surprising since overall inoculum levels increased correspondingly. Lowest disease levels generally corresponded to lowest inoculum levels.

(b). Sheath blight disease incidence.

Mean sheath blight incidence (Table 3) increased as the study progressed in all treatments but only significantly in treatment 2 (NHHBR) between the 1980 and 1981 season.

TABLE 1. Inoculum level, stem rot disease severity and yield between burning, incorporating and collection and removal of rice residue treatments.

TREATMENTS	1979		1980			1981			1982		$\bar{X}$1980-1982		
	DS[1]	Y[2]	IL[3]	DS	Y	IL	DS	Y	IL	DS	IL	DS	Y
1. Ground Level Harvest Bale-Remove (GLHBR)	1.95 b	79.7a	.17ab	1.48 b	84.5 b	.33 b	2.30 b	83.1a	.46a b	2.49a	.32a	2.09 b	83.8a
2. Normal Height Harvest Swathed-Bale-Remove (NHHBR)	1.41a	80.7a	.25ab	1.82 bc	86.3 b	.26 b	2.44 b	84.5a	.38a	2.58a	.29a	2.28 bc	85.4a
3. Normal Height Harvest Spread-Burned (NHB)	1.36a	81.9a	.10ab	1.13a	91.4a	.17a	1.99a	85.8a	.34a	2.37a	.20a	1.83a	88.6a
4. Normal Height Harvest Chopped Incorporate (NHI)	1.35a	84.8a	.30 b	1.95 c	87.3 b	.57 c	2.57 b	87.8a	.67 b	2.81a	.51 b	2.44 bc	87.5a

Values followed by common letters donot differ significantly at 5% level.

[1]Disease severity 1 = healthy, 5 severe.

[2]Yield paddy rice at 14% moisture, cwt/acre.

[3]Inoculum level; viable sclerotia per gram soil.

TABLE 2. Statistical Significance at 5% Level of Stem Rot Disease Severity, Inoculum Level and Yield Between Years Within Treatments.

	Disease Severity			Inoculum Level		Yield	
Treatment	79-80	80-81	81-82	80-81	81-82	79-80	80-81
1. Ground level Harvest Baled and Removed	NS	S	NS	S	S	S	NS
2. Normal Height Harvest Swathed, Bale, Remove	S	S	NS	NS	S	S	NS
4. Normal Height Harvest Spread, Burned	NS	S	S	NS	S	S	S
5. Normal Height Harvest Chopped, Incorporated	S	S	NS	S	S	NS	NS

S = Significant at 5% level of probability; NS = not significant.

YIELD DETERMINATIONS:

Yield was determined for each check by harvesting the entire area and adjusting to standard moisture content (14%) for comparison. Mean yields for each treatment are shown in Table 1. The large increase in yield in all treatments between the 1979 and 1980 seasosn was due to the shift in varieties from S-6 a tall variety to M-9 a semidwarf high yielding variety.

This study was designed to monitor the effects of total straw removal, soil incorpoarion and burning of residue on incidence and severity of rice stem rot disease. Possible effects of these treatments on incidence of rice sheath blight were also studied. It was envisioned that three years of continuous treatment and observations would be required. Past studies on taller varieties had shown that burning residue and total removal of residue were nearly comparable in minimizing stem rot while incorporation of straw and residue enhanced the build up of this disease. No previous data on sheath blight are available.

Interpretation of results reported here must take into account that two distinctly different varieties were grown, namely S-6 and M-9. S-6 is a relatively tall variety with average yield potential. M-9 is a semi-dwarf variety, is more responsive to nitrogen fertilization and has a considerably higher yield potential that S-6. S-6 was grown in the 1979 season and M-9 in the 1980 and 1981 seasons. Consequently, yield comparisons between 1979 and 1980, 1981 seasons are not valid unless the inherent yield potential of the two varieties is considered. When comparing seasons when the same variety was grown, (1980-81) it is apparent that the overall average yield for 1981 was lower than that for 1980. This was accompanied by an overall increase in inoculum level and disease severity (Table 1). The effects of increased inoculum level on yield and disease severity were less pronounced between the 1980 and 1981 seasons where M-9 was grown both years (Table 2). The wet fall (1980) and reduced amount of straw resulted in a very poor burn in the burn treatments. Consequently stem rot severity increase was comparable in the burn treatment to that in other treatments.

All treatments were burned in the fall of 1981. The resulting disease severity in 1982 reflected this, i.e. no significant difference between treatments. The increase in inoculum level in all treatments in 1982 over that observed in 1981 is considered due to reduced effectiveness of burning in the short statured variety M-9.

TABLE 3. Sheath Blight Disease Incidence Between Burning, Incorporated and Collection and Removal of Rice Residue Treatment.

Treatments	% Tillers Infected 1980	1981	1982	$\bar{X}$
1. Ground Level Harvest Baled and Removed	25.3	20.4	27.5	24.3
2. Normal Height Harvest Swathed, Baled, Removed	26.9	35.5	28.0	30.1
4. Normal Height Harvest Spread, Burned	21.7	29.7	28.8	26.7
5. Normal Height Harvest Chopped, Incorporated	25.7	25.8	27.5	26.3

The effect of the residue treatments on stem rot epidemiology is of interest when the 1979 and 1980 seasons are compared. S-6, grown in 1979 resulted in a large volume of straw and a good burn in the burn treatment. The 1980 inoculum level and disease severity were relatively low and the yield in these checks increased from 81.9 cwt (S-6) to 91,4 cwt (M-9) while yield in the incorporation treatment checks was 84.8 (1979-S.6) and 87.3 (1980-M9). Clearly, M-9 expressed its inherent yield potential much better in the burn treatment checks than in the incorporation treatment checks. The data for inoculum and disease severity are significantly different between the two treatments indicating the effect of stem rot on yield. Treatments where residue was removed were intermediate for this comparison for all parameters measured.

Residue treatments resulting in the greatest reduction in yield between the 1980 and 1981 seasons were Burn (NHB), Normal harvest remove (NHR), Ground level harvest remove (GLHBR) and incorporated (NHI) in that order. Mean grain yield in the NHB-treatment was higher in 1981 than in the GLHR and NHHBR treatments although none of the yield differences were statistically significant that season. The fact that a very poor burn was obtained due to wet weather and less straw (M-9) in 1980 appears to have resulted in equal effects of stem rot between NHB and NHI during the 1981 season. Yield in the two checks (5 & 6) where residue was burned was the most consistent over the entire experimental period. This may be because they were side-by-side in the field and thus subject to less variability in soil, etc, than were the incorporated checks which were the most variable and at opposite ends of the field (Checks 3 & 8).

Minimization of or increases in viable sclerotia per gram soil due to residue treatments generally followed that known in other studies, i.e. largest increases where residue is incorporated. Increases in disease severity measured also correlated well with inoculum level. The tendency for disease severity levels as measured in this study to result in lower reductions in yield on the semi-dwarf M-9 than on taller varieties in other studies is probably due to considerably less lodging in the M-9 variety by diseased plants since enhanced lodging is a known component of the loss brought about by stem rot. The incidence of sheath blight did not differ significantly between treatments 1 (GLHBR), 3 (NHB) and 4 (NHI), while all three had significantly less sheath blight than treatment 2 (NHHBR) at the end of the experiment. More study on the disease cycle and effects of residue management on sheath blight epidemiology are needed.

The results of this study on effects of rice residue management on rice disease epidemiology are similar but not identical to earlier studies. This is most likely due to the differences between the older tall California varieties (upon which earlier studies were based) and the new semi-dwarf varieties that are now grown extensively, inherent yield ability, lodging and completeness of residue burned being the probable differences.

<u>Objective 5</u>: The failure to obtain registration for use of DuTer in California rice culture prompted efforts to identify other chemicals for potential use in rice disease control. Trials conducted in Butte and Yolo counties are summarized in Table 4. As seen there, chemicals other than Duter are available. Of particular interest is the fungicide Tilt. It was used on rice in the Southern States this year under a temporary permit. Further, large scale trials will be conducted with Tilt next year. Residue samples were collected from this year's trials and submitted to the company that manufactures Tilt in efforts to assist in obtaining registration.

Table 4. Effectiveness of Foliar Applications of Fungicides for Control of Stem Rot and Sheath Blight of rice.

Location 1 Treatment at Midtillering	Rate lb/ai/ac	D.I. $\bar{X}$ Stem rot	Location 2 Treatment at boot stage	Rate lb/A	D.I. $\bar{X}$ Sheath blight
Tilt (2.5 G)	.25	1.55 ab	Duphar 51-04	.5	2.46 a
Tilt (2.5 G)	.50	1.48 b	NTN 19701 (25-WP)	1.0	2.53 a
Tilt (2.5 G)	1.0	1.18 c	Baylor (50 WP)	.5	2.39 a
Tilt (3.6 EC)	0.5	1.10 c	Tilt (2.5 G)	1.0	2.32 a
Duter (WP)	1.0	1.14 c	Duter (WP)	1.0	2.29 a
Check	-	1.57 a	Check	-	2.68 a

Location 3 Treatment at Midtillering	Rate lb/ai/ac	D.I. $\bar{X}$ Stem rot	Location 4 Treatment	Rate lb/ai/ac	Application Time	D.I. $\bar{X}$ Sheath blight
Tilt (2.5 G)	.25	1.65 b	Duphar 51-04	.5	B	1.99 b
Tilt (2.5 G)	.50	1.50 cd	Duphar 51-04	.5 + .5	B + H	1.96 b
Tilt (2.5 G)	1.0	1.30 e	NTN 19701	.25	B	1.98 b
Tilt (3.6 EC)	0.5	1.37 de	NTN 19701	.25 + .25	B + H	1.93 b
Baylor (50 WP)	.25	1.58 bc	Baycor	.25	B	1.97 b
NTN 19701 (25 WP)	.25	1.44 d	Baycor	.25 + .25	B + H	1.92 b
Duter (WP)	1.0	1.29 e	Tilt (2:5 G)	1.0	B	1.52 c
Check	-	1.89 a	Tilt (3.6 EC)	.5	B	1.45 c
			Duter (WP)	1.0	B	1.41 c
			Check	-	-	2.48 a

Location means followed by common letters did not differ significantly at the 5% level (DMR).

D.I. Stem Rot 1 = healthy - 5 = severe disease.

D. I. Sheath Blight 1 = healthy, 4 = severe disease.

MT = Midtillering: B = Boot stage: H = heading

Objective 6: We continued efforts to identify disease resistant germplasm in greenhouse evaluations this year. Wild species again appeared to be potential donors of both stem rot and sheath blight resistance. This study is in cooperation with Dr. Rutger and is covered in greater detail in his report.

Objective 7: Our studies over the past years have conclusively shown that excess nitrogen fertilization enhances stem rot severity. We also had data suggesting that the new semi-dwarf varieties may be more susceptible to sheath blight. Trials comparing early short, early tall, late short and late tall varieties under different nitrogen levels for effect on sheath blight and stem rot severity and subsequent yield reduction were carried out in Yolo and Butte counties this season. The results can be summarized as follows: Early varieties differ in susceptibility to both diseases more than do late varieties. The early varieties are generally affected greater by the stem rot and sheath blight disease. For example the correlation between stem rot severity and yield reduction for Earlirose, S-6, M-9 and S-201 was very high at all trial sites. When considering nitrogen levels (0-210 lbs preplant) disease increased in all varieites as N level increased. No yield response occurred above 150 pounds of N per acre. Results this year support earlier findings on all varieties tested, namely excess nitrogen above levels giving yield response result in severe disease accompanied by reduction in yield.

Comparison of sheath blight incidence and severity on tall and short, early and late varieties indicated that the short varieties may not be significantly more susceptible to sheath blight as previously thought. The major difference and reason for dramatic increases of sheath blight in growers' fields is most likely due to the way we are growing the new short varieties, i.e. high nitrogen fertilization and dense stands. More research is needed in this area and is proposed for next year.

Objective 8: The effect of five levels of potassium fertilization at two nitrogen levels on stem rot and sheath blight severity was studied in trials carried out in Yube County this year. Most significant differences occurred between the two nitrogen levels at both sites. At one of the sites high levels of prepalnt potassium (100 KCl preplant + 100 top dress at midtillering and 200 KCl at midtillering) resulted in lower stem rot severity than other treatments. No differences in sheath blight were noted.

PUBLICATIONS OR REPORTS:

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2. Figoni, R. A., J. N. Rutger, and R. K. Webster. 1981. Inheritance of resistance to stem rot (Sclerotium oryzae) in rice. American Society of Agronomy (Atlanta, Georgia - Dec. 1981).

3. Figoni, R. A., J. N. Rutger, and R. K. Webster. 1982. Evaluation of wild oryzae species for stem rot resistance. Plant Disease (In Press).

4. Figoni, R. A., J. N. Rutger, and R. K. Webster. 1982. Inheritance of stem rot resistance in crosses between cultivated rice and wild oryzae species. Crop Science (In Press).

5. Rutger, J. N., R. K. Webster, and R. A. Figoni. 1982. Weedy species of rice show promise for disease resistance. California Agriculture (In Press).

6. Webster, R. K., and S. C. Scardaci. 1982. Effects of collection and handling field crop agricultural residues for alternative uses - effects on stem rot and sheath blight of rice. 21 pp mimeo. Report to California Solid Waste Management Board. November 1982.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

The causal agent of sheath blight has been identified as Rhizoctonia oryzae sativae. It is widespread in California and is increasing in occurrence and severity. Early varieties appear to be more affected than late varieties. Disease severity of both sheath blight and stem rot is more severe under conditions of excess nitrogen.

Tilt, a newly developed fungicide, shows considerable potential as a control measure for both sheath blight and stem rot. Registration of Tilt is pending but FDA permitted its use on rice in Southern States during the 1982 season.

Resistance to stem rot and sheath blight has been identified in wild Oryzae species. The prospoect of transferring it to cultivated rice is promising.

Improved methods for determining disease severity to sheath blight are being developed for use in determining loss, control measures, and evaluating breeding lines.

There is a direct relationship between increased severity of rice diseases and excess nitrogen fertilization.

A three-year study to determine the effects of various rice harvest and straw removal procedures including burning, soil incorporation and harvest and removal from the field on *Sclerotium oryzae* (stem rot) and *Rhizoctonia oryzae sativae* (sheath blight) disease levels was completed this year. The study was designed to determine if epidemiological observations on stem rot disease observed on older tall California varieties are similar on semi-dwarf varieties now being grown. General conclusions from the study are: (1) Burning of rice residue is effective in minimizing carryover inoculum levels of *S. oryzae* and subsequent stem rot disease severity. (2) Since *S. oryzae* infects rice at the water level and infections are mostly confined to parts of the plant at the water level, the removal of stubble and straw by either burning or cutting at ground level and baling had near similar effects on overwintering inoculum levels. (3) Semi-dwarf rices now being grown in California lodge significantly less than tall rices when grown under proper cultural practices. If removal of straw should become common practice, rice should be cut below infection sites (water level) to ensure the removal of overwintering sclerotia. This aspect of harvest should also be followed if straw is to be burned. This conclusion is based on the fact that burning is often insufficient to minimize *S. oryzae* when non-lodged semi-dwarf varieties are harvested well above the water level where the overwintering sclerotia reside. Such harvest practice often results in "poor" burns, [i.e. 1980 burn for experiments reported here]. (4) Epidemiological principles of stem rot disease of rice elucidated on tall varieties generally apply under conditions where semi-dwarf varieties are grown. An exception indicated by this study may be that higher disease severities must occur on semi-dwarfs before plants lodge, minimizing subsequent losses due to lodging of infected plants. (5) Incorporation of rice residue and stubble for consecutive years results in a build-up of *S. oryzae* sclerotia and an increase in stem rot disease potential. In this study the tall variety S-6 was followed by the semi-dwarf M-9. In this case the burn treatment (1980) yielded significantly more than the other three treatments. In the following season (1981) the high yielding semi-dwarf M-9 was not as affected by disease potential in the incorporation treatment, supposedly due to less lodging.