PROJECT REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 2001 – December 31, 2001

PROJECT TITLE: Cause and Control of Rice Diseases

STATUS of PROPOSAL: continuing

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LEVEL OF 2001 FUNDING: $25,556.00

OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:

The major goals of this project continue to be to gain an understanding of the biology of the diseases that affect rice in California and to develop methods to minimize their damage to the rice crop. Emphasis is on Stem Rot, Aggregate Sheath Spot, Blast and Bakanae. Control methods under study include cultural practices that affect occurrence and severity of diseases and the potential use of fungicides.

Specific objectives for 2001:

Objective 1: Continue to monitor the occurrence and spread of the blast disease and to determine the variability of pathogenic races of *Pyricularia grisea* that are occurring in California.

Objective 2: Continue tests for timing of Quadris applications to determine benefits and efficacy in controlling Blast and Aggregate Sheath spot in relation to yield and quality increases.

Objective 3: Determine the occurrence, distribution and impact of Bakanae disease in California rice fields and factors that affect the occurrence of the disease.

SUMMARY OF 2000 RESEARCH ACCOMPLISHMENTS BY OBJECTIVE:
Objective 1.

We continued to monitor occurrence and spread of blast both in areas where it was known to occur prior to 2001 and also in areas where the disease is not known to have occurred previously. For the most part, blast disease was of little consequence in this years rice crop.

Leaf Blast was not found this crop year until mid August and then it was sporadic and occurred at very low levels in a only a few fields even in areas where it had occurred in previous years. Neck blast was observed only in a few fields and in these, loses due to blast were minor. Until this year blast was only known to occur in Colusa, Glenn, Sutter and Butte and Yuba Counties. In 2001 blast was not observed in areas where it had not been seen previously.

It is important to continue caution in using seed sources free of the pathogen and also to avoid the possibility of spread through transport of and use of equipment that may have residue or dust containing the blast pathogen on or in it.

An essential aspect of the continued monitoring of the occurrence and spread of the blast disease is the need to collect samples of the pathogen and determine if there is a change in the pathogenic race that is known to occur here. This knowledge of the races of *P. grisea* in California is essential to the plant breeding effort to produce improved resistance in California cultivars.

The DNA fingerprinting process for identification of the isolates collected during the 2000 and 2001 seasons has been completed. All isolates characterized thus far, are race IG-1 and only the MGR586 fingerprint group (lineage) has been detected. This is the same as that found in previous years. Thus the population of the blast pathogen in California still appears to be only one race.

Objective 2.

Trials testing timing of applications of Quadris were carried out to determine benefits and efficacy in controlling Stem Rot and Aggregate Sheath Spot in relation to yield and quality increases due to applications of the fungicide.

There are conflicting views within the industry regarding the effectiveness of Quadris for controlling Stem Rot and the time of application that it would be used if Stem Rot were the main disease for which control is being attempted. There is also a need to confirm which of the rice diseases (Stem Rot, Aggregate Sheath Spot or Blast) is being affected when applications of Quadris result in increased yields and or quality.

Label rates of Quadris and Messenger were tested on cultivars M-202 and M205 in replicated trials with individual plots per treatment 10 X 20 feet at 45, 70 and 95 days from planting. Disease severity, yield, and quality data were collected.
There were no significant differences in disease severity in any of the treatment times in both trials with either of the fungicides tested. Results for yield and quality are shown in Table 1.

Table 1

Effect of Application time of Quadris and Messenger on Aggregate Sheath Spot, and Stem Rot Severity, Yield and Quality

Treatment Days\Planting	Rate ai\acre	Yield 14%	% Total	% head
		Cultivar M-202		
1. Qadris (45 days)	.3 lbs	85.2 a	69.1 a	49.8 a
2. Quadris (70 days)	.3 lbs	85.7 a	68.6 a	53.9 b
3. Quadris (90 Days)	.3 lbs	85.1 a	68.1 a	47.7 a
4. Messnger (45ays)	2.5 oz	85.4 a	68.3 a	50.6 a
5. Messenger (70 days)	2.5 oz	84.7 a	67.8 a	46.5 a
6. Messenger (90days)	2.5 oz	85.4 a	68.3 a	48.9 a
7. Control	0.0 oz	84.7 a	67.7 a	49.8 a
		Cultivar M-205		
1. Quadris (45 days)	.3 lbs	86.3 a	69.0 a	55.5 a
2. Quadris (70 days)	.3 lbs	86.5 a	69.2 a	55.2 a
3. Quadris (90 days)	.3 lbs	86.9 a	69.5 a	55.9 a
4. Messenger (45 days)	2.5 oz	86.9 a	69.2 a	54.8 a
5. Messenger (70 days)	2.5 oz	86.5 a	69.2 a	54.2 a
6. Messenger (90 days)	2.5 oz	86.2 a	69.0 a	55.6 a
7. Control	0.0	86.3 a	69.0 a	55.2 a

Quadris and Messenger treatments were applied at 20 gals\acre.
Values followed by the same letter do not differ significantly at the 5% level.

This year there were no significant differences in yield observed at any time of application with either chemical. The only significant difference in quality observed was in the % head on M 202 treated 70 days after planting. Over the last three years, later applications of Quadris provided some level of control for both blast and aggregate sheath spot and also increases in quality of treated rice. This years trials did not have blast in them so the 2001 results for disease control apply only to Aggregate Sheath Spot and Stem Rot. As stated there were no significant differences in yield between treatments and no observed differences in disease severity for either Aggregate Sheath Spot or Stem Rot. These results are consistent with earlier findings where no Stem Rot control was observed in any treatments after 45 days of planting. They differ from several trials in previous years in that no differences in yield were observed in the later application due to control of Aggregate Sheath Spot.

When the results of the past 4 years are compared it is clear that fungicide (Quadris) applications should only be used in cases of known high incidence of

Aggregate Sheath Spot or if it is apparent that there will be problems with neck blast during the present crop season due to observations of leaf blast early in the season. The trials of the past four years have resulted in several cases where there were increases in quality resulting from later applications of Quadris. Growers would need to determine if the quality differences were large enough to justify the cost of the fungicide treatments.

In the trials for both cultivars there was a low level of stem rot but there were no significant effects of the treatments on Stem Rot severity. This is consistent with earlier studies where treatments as late in the season as 70 or more days after planting were too late to affect the severity of stem rot and treatments before 70 days from planting were too early to minimize the severity of Aggregate sheath Spot.

Ojective 3:

Continue study of the occurrence, distribution, disease cycle, factors that affect disease development, and control measures for Bakanae disease. We believe that a better understanding of these factors is necessary in developing control procedures for the disease.

Bakanae disease was found in California for the first time in 1999. During the 2000 season we observed Bakanae disease in fields in Colusa, Butte, Glenn, Sutter and Yuba Counties. This season the disease also occurred in Yolo County and was again wide spread in Colusa, Butte, Glenn, Sutter and Yuba Counties. For the most part, the occurrence of the disease could be related to the source of the seed that was used to plant the field.

Causal Organism: Bakanae is caused by *Fusarium moniliforme* Sheld, which is the anamorph of the ascomycete, *Gibberella fujikuroi* Saw. *Gibberella* is a heterothallic fungus, and both mating types must be present for the production of perithecia and ascospores. Although the anamorph is the predominant stage found in the field, this year we found the *Gibberella* stage with mature ascospores in some California rice fields. The differences between these two spore stages are not known in regard to survival and difficulty in eliminating from infested seed with various treatments but a differential between the two could complicate the development of effective seed treatments.

Symptoms: Bakanae is generally thought of as primarily a seeding disease but it can be observed throughout the rice growing season. The earliest symptoms are manifested about a month after planting. Infected seedlings appear taller, more slender and elongated and lighter in color than healthy seedlings. The elongation of the leaves is due to the production of Gibberellin, a plant hormone, by the causal fungus. Bakanae infected plants are often visible arching above the healthy plants. Healthy plants continue to grow, while infected plants may begin to senesce and eventually most of the infected plants are not visible above the healthy plants although some may continue to elongate well into the season. As the season progresses, infected plants may die before reaching maturity, or if they survive to heading, the panicles produced are white to straw colored and mostly empty of mature seed.

As the diseased plants senesce and die, mycelium of the fungus may emerge from the nodes and sporulation of the fungus may be easily visible above the water level in the paddy. After the water is drained, the fungus continues to sporulate profusely on the stems of the diseased plants. This sporulation appears as a cottony mass and serves to contaminate healthy seeds during harvest. The perithecia of *Gibberella* fujikuroi appear as dark blue flask shaped bodies on the nodes and stems of infected plants. Ascospores are produced in the perithecia and may also contaminate seed and serve as inoculum the following season.

Disease cycle: The bakanae pathogen is known to over season as spores (both conidia and ascospores) on the coat of infested seed. There is no evidence of internal infection of seed by the pathogen. The fungus can also over season in the soil and in residue, and infection of non-infested seed by spores in the soil has been demonstrated, although the length of time that spores can survive in soil is unknown at the present. It is likely that infested seed is the most important source of inoculum, leading to both infected plants in the field and also as a means of introducing the disease and pathogen to fields that were previously non-infested.

Current experiments are underway to determine the length of time that the fungus survives on seed, in the soil and in residue. Thus far we are able to recover the fungus from seed that is over a year old but there is a gradual decrease in percent seed from which the fungus is still recoverable. The fungus is still alive in soil stored in the laboratory after 9 months but this may not be identical to survival in nature where the organism is subjected to moisture and competition from other organisms.

There were no distinguishing culture practices found that significantly influenced the occurrence of Bakanae except that infested seed was determined to be the primary source of disease in all fields where remnants of the seed were available for assay. There were a few instances when the disease was observed that it was not clear that the source had been from an infected seed lot or where the incidence of bakanae plants was slightly higher than the seed assays for the pathogen would have indicted. This observation and that of infected seedlings from the organism in the soil in controlled experiments adds to the importance of determining the role of infection from infested soil and or infested residue and also the need to know the length of time that the organism can survive in soil and residue.

In a few cases where the finished seed bed appeared to be more "trashy" than most and there appeared to an excess of residue remaining on the surface or floating in the paddy, there were more infected plants observed than would have been expected based on seed assays for the pathogen. Here, the short time between crops under continuous cropping may not have been long enough for the complete demise of the pathogen in the soil and residue and at least a portion appears to survive from one year to the next with only a few months between crops. The pathogen is easily recoverable from residue of infected plants after harvest but it is not yet known how long the pathogen can survive in rice residue or the soil in fields where it occurred the previous year. Studies are continuing on these questions.

Plants showing Bakanae symptoms early in the season were marked and observed throughout the season. In most cases these plants were killed as the season progressed. For those that survived through the heading stage, there was usually no seed produced but these dead plants were heavily infested with the pathogen at the end of the growing season. Thus far, we have not observed spread of the disease from an infected plant to a neighboring healthy seedling or plant. As the season progresses, most of the tillers resulting on plants from infected seedlings are also infected indicating that initial infections occur on seedlings and progress through the crown resulting in infection of all or most of the tillers on that plant. This most evident toward the end of the season when sporulation by the fungus occurs on all or most tillers of an infected plant.

Seed was collected from harvest samples from fields that were known to have Bakanae. Seed was also saved from healthy plants that were adjacent to Bakanae infected plants. Experiments completed thus far show that seed harvested from plants adjacent to plants killed by Bakanae are externally contaminated with the pathogen and in some cases, the pathogen was recovered from over 90% of these individual seeds on media selective for *Fusarium*. In samples collected randomly from harvesters in fields known to have infected plants the percentage of infested seed was much lower.

Attempts to determine the level of disease in a given field were made by actually counting total plants in random grids and determining the percentage of infection. In no case did the percent infection exceed 0.5 %. It is probable that the seed to seedling transmission of the disease is lower than the percent infested seed used for planting since assays of seed from fields with infected seedlings have always been higher than the number of infected plants observed. This is most likely due to the difficulty of establishing infection of the seedling by the fungus under our water seeded culture practice and is consistent with laboratory studies. This phenomenon has been well demonstrated for seed to seedling infection with blast infested seed and is likely to apply to the bakanae disease based on our present knowledge.

Greenhouse experiments to determine the affects of different water depths during the seedling stage on the occurrence of bakanae are being continued to determine if infection of the seedlings produced from infested seed is encouraged by different water practices used during stand establishment and weed control applications. Thus far it appears that the percentage of infected seedlings is much lower than the percent infested seed planted when the water depth is maintained. When the water depth is less than a half inch, the percent infection of seedlings from infested seed is higher than when water is maintained at a level of four inches. These studies need to be refined and repeated before firm conclusions are drawn.

PUBLICATIONS OR REPORTS:

Webster, R.K. Report to the California Rice Research Board: Project Rp-2. Cause and Control of Rice Diseases, 14 pp. In Annual Report of Comprehensive Research. 2000. University of California and the U.S. Department of Agriculture.

Greer, C.A. and R.K. Webster, 2001. Occurrence, Distribution, Epidemiology, Cultivar Reaction and Management of Rice blast Disease in California. Plant Disease 85:1196-1102.

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Webster, R.K. and Jung-Sup Choi. 1999. Rice Blast - Case Study. In: Exotic Pests and Diseases: Biology, Economics, Public Policy. Pg.137-147. UC Agricultural Issues Center 1999

Webster, R.K. and N.A. Cintas 2001. Effects of various methods of straw management of *Sclerotium oryzae*, stem rot severity and yield of rice. In: Proceedings-Rice straw management – Update. Pp 9-17. Published by University of California Cooperative Extension March, 2001.

Williams, J. and R.K. Webster. 2001. Training and Certification Program for Rice Disease Inspection. "Cousre Guide and Resource Materials for the Trainer". Prepared by UC Cooperative Extension in Sutter and Yuba Counties. Disease and Identification Guides prepared by RKW.

CONCISE GENERAL SUMMARY OF CURRENT RESULTS:

Rice Blast disease was of little consequence in the 2001 California rice crop. It was not observed until mid August and then only in a few fields where it had been known to occur in previous years. It is important to continue caution when possible to use seed sources free of the pathogen and to avoid the possibility of spread through transport of and use of equipment that may have residue or dust containing the blast pathogen.

Collection of blast infected plants in 2001 and DNA analyses of the pathogen isolates obtained from them, revealed that there is still only one known race (IG -1) of *Pyricularia oryzae* in California. This information is essential for plant breeders attempting to develop blast resistant cultivars for California.

Results of 2001 fungicide trials on M-202 and M-205 to determine optimum time of application of Quadris for control of Aggregate Sheath Spot and Stem Rot showed no significant increase in yield as a result of minimizing severity of either disease at the application times tested. The only significant increase in quality occurred when Quadris was applied to M-202 70 days after planting. These and previous years results reaffirm our conclusion that fungicide (Quadris) applications should only be used in cases of known high incidence of Aggregate Sheath Spot or if it is apparent that there will be problems with neck blast during the present crop season based on observations of leaf blast early in the season. Growers should also determine if increases in quality (head or total) are large enough to justify the cost of possible benefits from fungicide treatments.

The disease cycle of Bakanae disease has been further elucidated. The perfect stage (perithecia and ascospores) of the pathogen were found in a few fields this year indicating that the population of *G. fujikuroi* in California is variable. This has also been confirmed by anastamosis tests with isolates of the *Fusarium* stage. The impact these findings may have on the development of control measures is unknown at present.

This year the bakanae disease was observed to varying degrees in most of the rice producing area North of Interstate 80 (Colusa, Glenn, Butte, Sutter, Yolo and Yuba Counties) Laboratory study has shown that seedlings may become infected from the pathogen in soil or residue but all available information still indicates that the disease is primarily seed born. The pathogen is abundant in residue of killed plants at harvest time providing the main source for infestation of seed. Studies have shown that the pathogen is primarily a surface contaminant of the seed and no internal infection has been observed.

Initial studies with fungicide seed treatments indicate that Maxim treatments of infested seed result in highly significant reductions in diseased plants when the treated seed is planted in the greenhouse. Further study, especially field tests are needed to determine the effectiveness of fungicide seed treatments under field conditions and also the possibility of phytotoxicity resulting in inhibition of root elongation and effects on stand establishment.