PROJECT PROPOSAL
COMPREHENSIVE RESEARCH ON RICE
April 1, 2013 – July 31, 2014

PROJECT TITLE: Rice Disease Research and Management

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LEVEL OF 2013 FUNDING: $22,071.00

OBJECTIVES AND EXPERIMENTS CONDUCTED, BY LOCATION, TO ACCOMPLISH OBJECTIVES:
The proposed research is a compilation of individual projects focused on multiple California rice diseases. The overall objective of the proposed research is to increase understanding of the biology of California rice diseases and to develop effective and economically viable management practices for these diseases.

Specific objectives of the proposed research are:

1) To evaluate timing and potential of fungicide applications (widely used as well as lesser known products) for aggregate sheath spot, stem rot and rice blast disease management.
2) To develop an effective method for comparing genetic relatedness among *P. grisea* isolates in California and to determine the relationship of historic California isolates to a newly identified race of the fungus which is pathogenic to M-208 rice.

Objective 1: Evaluate timing and potential of fungicide applications
Over the past couple of years there have been several new fungicides registered for use in California rice but they are mostly reduced risk pesticides that have little or no efficacy data for California rice diseases or products that have only recently been made commercially available. Newer products that have been evaluated over the last few years have included QuiltXcel

(azoxystrobin + propiconazole), Regalia (a natural plant extract that triggers a plant's natural defense systems to protect against a variety of fungal and bacterial pathogens), and Actinovate AG (a bacterial biological control organism). The results of the reduced-risk products have been disappointing so disease management research in 2013 was focused on products that have demonstrated efficacy in recent years. In addition, for a second year efforts were focused on renewed evaluation of product efficacy for stem rot in addition to aggregate sheath spot management in California rice.

Three small plot fungicide trials were established in M-206 commercial rice fields (all in Sutter County) in 2013 to evaluate the industry standard Quadris fungicide (22.9% Azoxystrobin) alongside the more recently introduced product QuiltXcel (azoxystrobin + propiconazole) for aggregate sheath spot (AGSS) and stem rot (SR) management. Application timing was targeted specifically to aggregate sheath spot and rice blast diseases (5-15% panicle emergence) and (70% panicle emergence). Pro-Tron, a low-foaming nonionic surfactant which is reported to improve the deposition and penetration of active ingredients into the target plant, was include in each treatment application.

Treatments were applied to 10' x 20' plots with a CO_2-powered backpack sprayer. Treatments were replicated four times at each location. Plots were harvested with the UC research combine (Almaco) to determine yield and collect subsamples for milling quality analysis. Milling quality analysis was conducted using an S21 Rice Statistical Analyzer (Agromay Soluciones Técnicas, S.L.) that inspects cereal grains through image processing and subsequent statistical analysis to allow quantification of defects in a sample. Total and whole (head) rice percentages were determined for each plot using this methodology. Random tiller samples were cut from three locations prior to harvest within each plot and a subset of 25 tillers from this bulked sample were evaluated per plot to determine disease incidence and severity. Visual ratings were conducted to divide tillers into different severity categories based upon disease severity.

Aggregate sheath spot disease is categorized mainly by movement of the disease up the tiller.

- Category 0 = no disease
- Category 1 = disease affecting second leaf below flag leaf or lower
- Category 2 = disease affecting leaf below flag leaf
- Category 3 = disease affecting flag leaf
- Category 4 = disease affecting panicle

Stem rot disease is categorized mainly by penetration of the culm by the disease.

- Category 0 = no disease
- Category 1 = disease lesions on outer leaf sheath
- Category 2 = disease lesions have penetrated into inner leaf sheaths
- Category 3 = disease lesions on culm
- Category 4 = culm is rotted through

- Category ratings were used to calculate:
    - Disease incidence = (# of tillers in categories 1-4) / Total tillers
    - Disease severity = [(#tillers in cat. 0 X 0) + (#tillers in cat. 1 X 1) + (#tillers in cat. 2 X 2) + (#tillers in cat. 3 X 3) + (#tillers in cat. 4 X 4) / Total # of tillers

Table 1. Treatments for 2013 small plot fungicide trials

1	Untreated control
2	Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading
3	Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading
4	Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading
5	Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading

Objective 2: Develop an effective method for comparing genetic relatedness among *P. grisea* isolates in California

The geographic distribution, incidence and severity of rice blast were much greater in 2010 and 2011 than in recent years. There are several factors that may be contributing to this situation. M-208 is the only commercially available rice variety in California with a specific resistance gene to race IG-1 of the blast pathogen. IG-1 was the only race of this pathogen known to exist in California until recently. Unfortunately, confirmed cases of limited neck blast in 2010 M-208 fields and limited leaf and neck blast in 2011 and 2012 M-208 fields indicate that a new race of the pathogen has evolved through mutation or has been introduced into California. M-208 is still resistant to race IG-1 but is not resistant to this new race.

In previous collaborations with UC Riverside scientists, AFLP analysis with two primer pairs of the 2010 M-208 isolates indicated that these isolates were genetically similar to historic isolates from previous years. This evidence suggests that the new race of the pathogen has evolved through mutation/selection rather than through a new introduction from outside of the state. This information is important but more investigation is needed to determine the relationship of these M-208 isolates to each other as well as to those that do not infect M-208. This information will be critical in future monitoring of rice blast pathogen races in California as well as to breeders developing new rice blast resistant rice varieties.

In collaboration with Mike Davis (UC Davis Plant Pathology CE Specialist), we proposed to utilize genetic analysis resources on the UCD campus to study the pathogen population and identify genetic tools which will allow us to compare the M-208 isolate populations with historic isolates. Isolates from the 2012 season were collected in conjunction with California Crop Improvement and RES staff for culturing and storage of isolates. These isolates will be used for genetic analysis with the previously collected 2011 isolates. Genetic work was delayed and will be conducted in 2014. The goal is to identify genetic tools that will provide a better

understanding of the loss of resistance in M-208 and provide us with a solid base for future population genetics studies of *P. grisea*.

SUMMARY OF 2013 RESEARCH, BY OBJECTIVE:

Objective 1: Evaluate timing and potential of fungicide applications

General Comments

In general, 2013 was an early planting season and somewhat of an "average" year for rice diseases in California. Both aggregate sheath spot disease and stem rot disease incidence and severity appeared to be greater than in 2012 when extended periods of high temperatures hindered disease progress.

Sutter Location 1

Aggregate Sheath Spot (Table 2, Figures 1 and 2)

With respect to aggregate sheath spot disease, disease pressure was moderate at this location and all fungicide treatments resulted in a significant reduction in disease incidence and severity. There were no significant differences among the fungicide treatments but in general, aggregate sheath spot incidence was reduced by 50-70%.

Stem Rot (Table 2, Figures 3 and 4)

Stem rot disease pressure was moderate while severity was fairly low. There were statistical differences among the treatments with respect to stem rot incidence and severity. Both timings of Quardis resulted in significantly lower stem rot incidence and severity than the control.

Yield (Table 3, Figure 5)

There were no statistical differences between treatments with respect to yield (range 9,170-9,470 lb/Ac).

Milling Yield (Table 3, Figure 6)

With respect to milling quality, all fungicide treatments resulted in a significant improvement in head rice milling yields (~9.6-11.5% increase over control). This is most likely a result of the lower grain moisture content at harvest for the untreated control. There were no statistical differences between treatments with respect to total rice milling yield.

Table 2. Sutter Location 1 2013 Small Plot Fungicide Trial Results – Disease Data

Treatment	Aggregate Sheath Spot		Stem Rot	
	Incidence (%)	Severity	Incidence (%)	Severity
1) Control (No Treatment)	57.0 a	1.13 a	68.0 a	1.85 a
2) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	24.0 b	0.36 b	42.0 c	0.92 b
3) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	16.0 b	0.22 b	61.0 ab	1.59 a
4) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	19.0 b	0.33 b	49.0 bc	1.07 b
5) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	20.0 b	0.36 b	56.0 abc	1.40 ab
P-value	0.0016	0.0007	0.0212	0.0064
LSD	18.6467	0.3711	15.2911	NS

Figure 1. Sutter Location 1 2013 Small Plot Fungicide Trial Results – Aggregate Sheath Spot Incidence

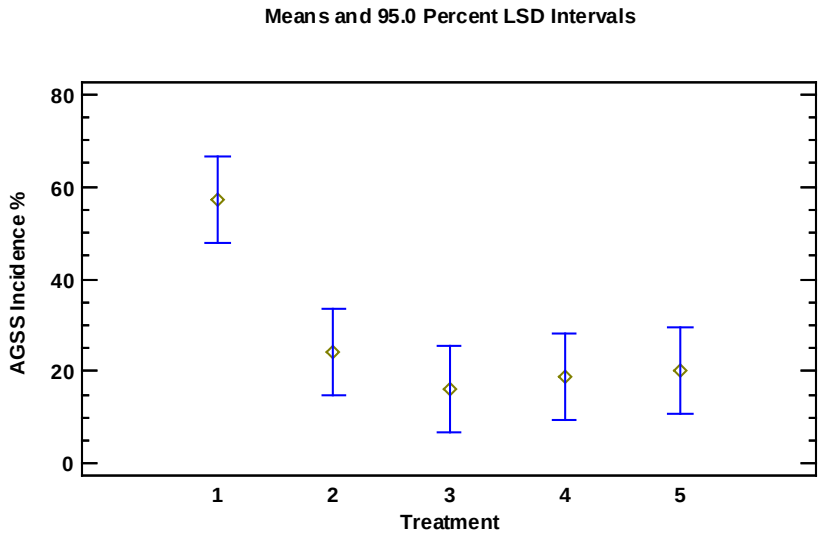


Figure 2. Sutter Location 1 2013 Small Plot Fungicide Trial Results – Aggregate Sheath Spot Severity

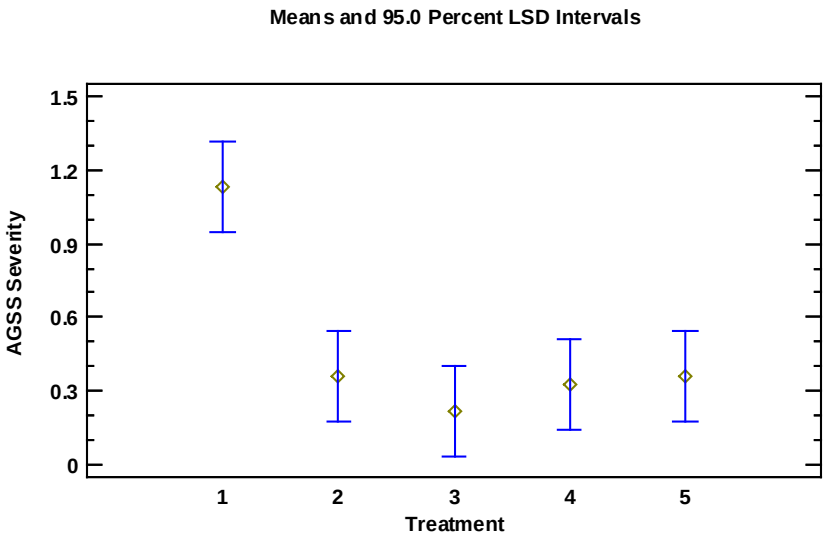


Figure 3. Sutter Location 1 2013 Small Plot Fungicide Trial Results – Stem Rot Incidence

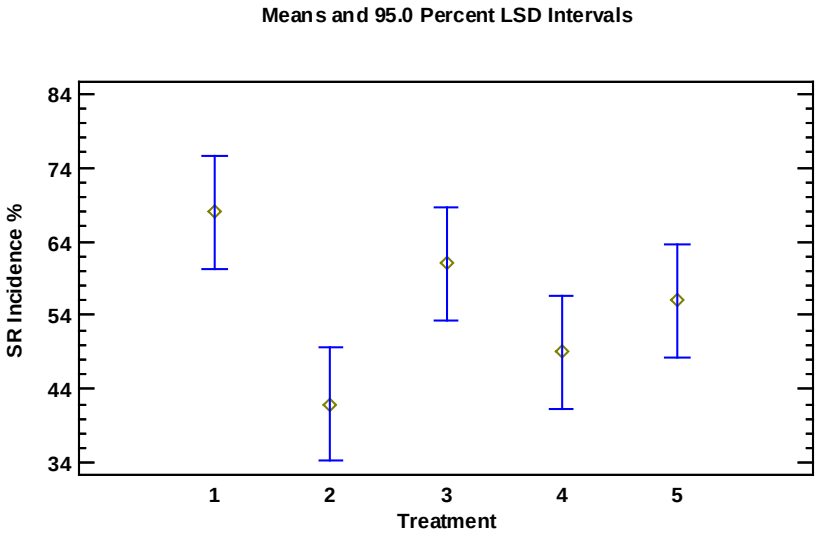


Figure 4. Sutter Location 1 2013 Small Plot Fungicide Trial Results – Stem Rot Severity

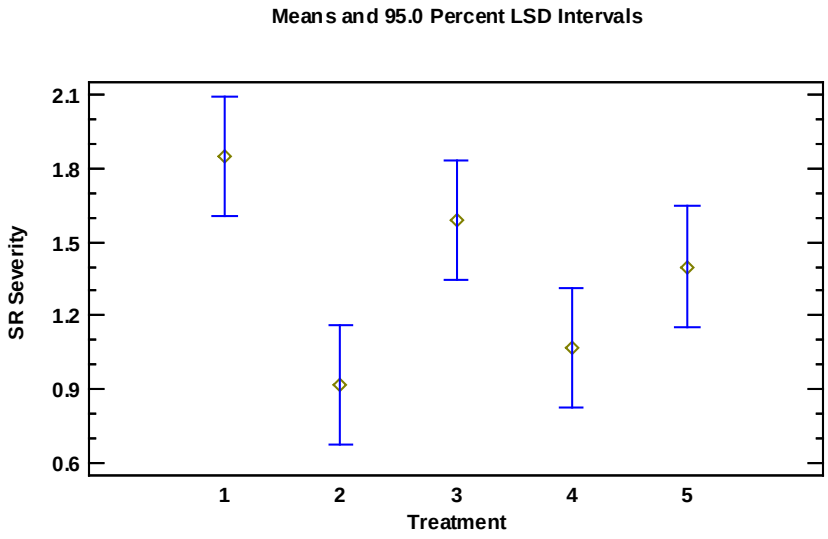


Table 3. Sutter Location 1 2013 Small Plot Fungicide Trial Results – Harvest Data

Treatment	Harvest Moisture (%)	Yield (lb/Ac)	Milling Quality % Total	Milling Quality % Whole	
1) Control (No Treatment)	16.73	9170	70.07	56.14	a
2) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	18.67	9470	69.65	61.55	b
3) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	18.44	9410	70.14	61.76	b
4) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	18.64	9153	70.01	62.57	b
5) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	19.10	9427	69.90	62.31	b
P-value	0.0869	0.0789	0.7211	0.0000	
LSD	NS	NS	NS	1.8028	

Figure 5. Sutter Location 1 2013 Small Plot Fungicide Trial Results – Yield

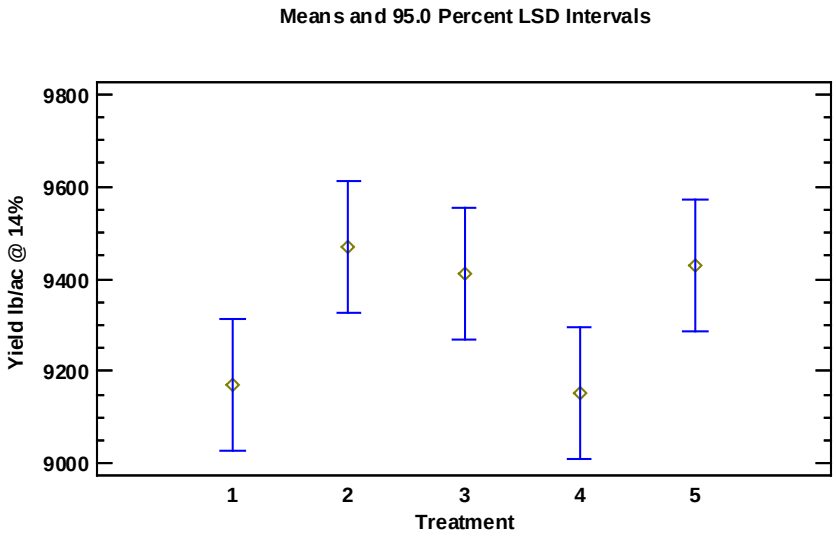
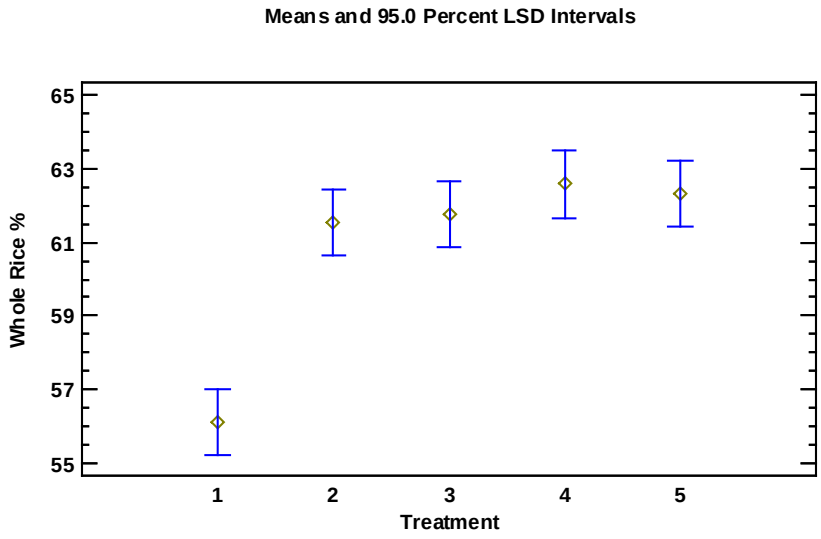


Figure 6. Sutter Location 1 2013 Small Plot Fungicide Trial Results – Head Rice Milling Yield



Sutter Location 2

Aggregate Sheath Spot (Table 4, Figures 7 and 8)

With respect to aggregate sheath spot disease, disease pressure was high at this location and all fungicide treatments resulted in a significant reduction in disease incidence and severity. There were no significant differences among the fungicide treatments but in general, aggregate sheath spot incidence was reduced by 55-80%.

Stem Rot (Table 4, Figures 9 and 10)

Stem rot disease pressure was moderate while severity was fairly low. There were statistical differences among the treatments with respect to stem rot incidence and severity. Both Quilt Xcel timings and the later application of Quardis resulted in significantly lower stem rot incidence and severity than the control.

Yield (Table 5, Figure 11)

There were no statistical differences between treatments with respect to yield (range 8,727-9,132 lb/Ac).

Milling Yield (Table 5, Figure 12)

With respect to milling quality, all fungicide treatments resulted in a significant improvement in head rice milling yields (~5-7.5% increase over control). There were no statistical differences between treatments with respect to total rice milling yield.

Table 4. Sutter Location 2 2013 Small Plot Fungicide Trial Results – Disease Data

Treatment	Aggregate Sheath Spot		Stem Rot	
	Incidence (%)	Severity	Incidence (%)	Severity
1) Control (No Treatment)	72.0 a	1.48 a	60.0 a	1.29 a
2) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	16.0 b	0.33 b	46.0 ab	0.97 ab
3) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	19.0 b	0.33 b	22.0 c	0.42 c
4) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	31.0 b	0.62 b	38.0 bc	0.81 b
5) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	13.0 b	0.27 b	39.0 bc	0.80 b
P-value	0.0001	0.0001	0.0071	0.0033
LSD	19.9493	0.4140	18.0021	0.3759

Figure 7. Sutter Location 2 2013 Small Plot Fungicide Trial Results – Aggregate Sheath Spot Incidence

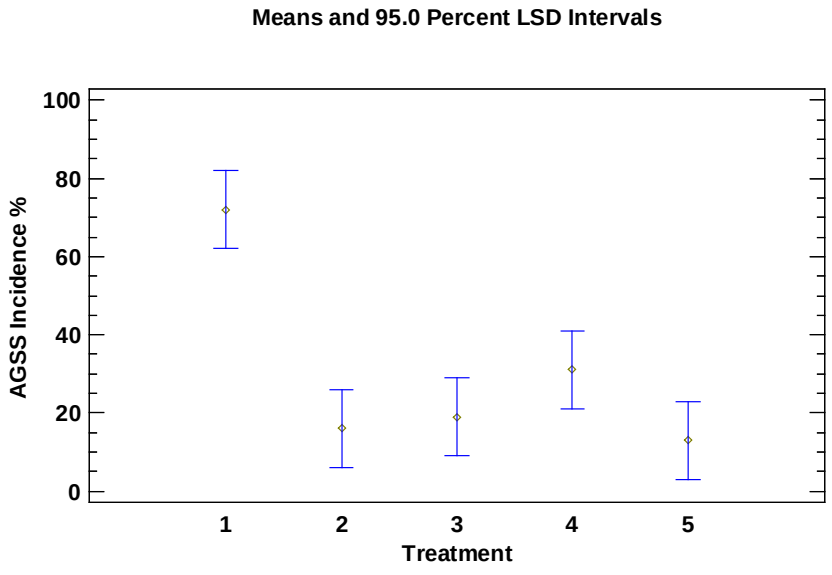


Figure 8. Sutter Location 2 2013 Small Plot Fungicide Trial Results – Aggregate Sheath Spot Severity

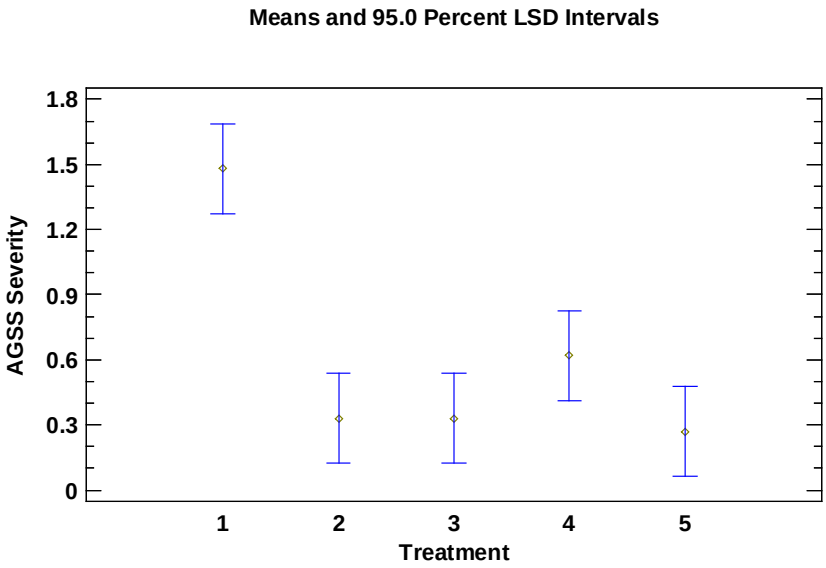


Figure 9. Sutter Location 2 2013 Small Plot Fungicide Trial Results – Stem Rot Incidence

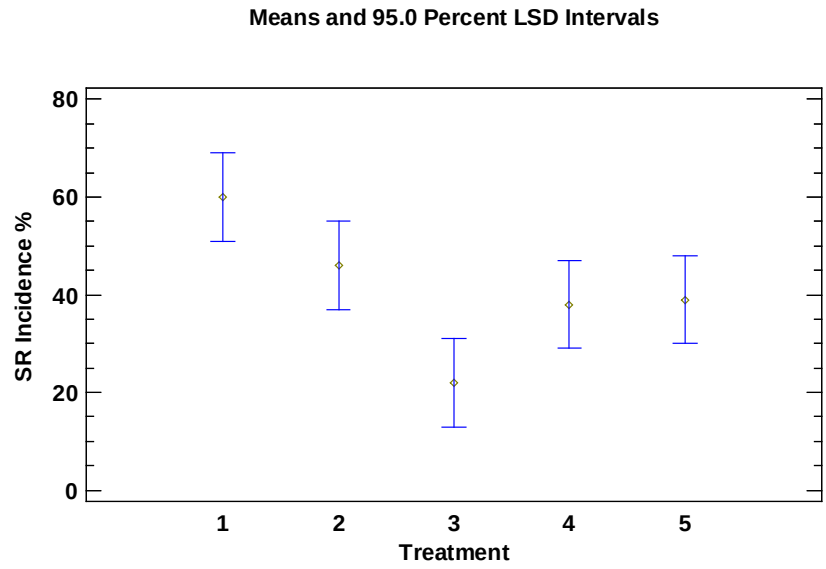


Figure 10. Sutter Location 2 2013 Small Plot Fungicide Trial Results – Stem Rot Severity

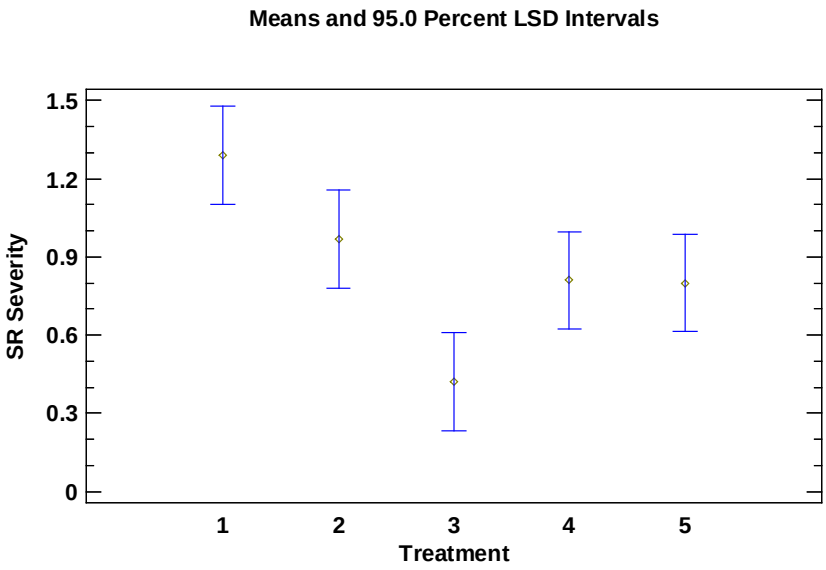


Table 5. Sutter Location 2 2013 Small Plot Fungicide Trial Results – Harvest Data

Treatment	Harvest Moisture (%)	Yield (lb/Ac)	Milling Quality % Total	Milling Quality % Whole
1) Control (No Treatment)	20.71 a	8754	70.85	59.47 a
2) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	21.11 ab	8782	71.48	62.52 b
3) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	21.17 ab	9112	71.08	62.26 b
4) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	22.13 bc	8727	70.90	63.21 b
5) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	22.33 c	9132	70.85	63.93 b
P-value	0.0360	0.0684	0.7267	0.0339
LSD	1.1435	NS	NS	2.7528

Figure 11. Sutter Location 2 2013 Small Plot Fungicide Trial Results – Yield

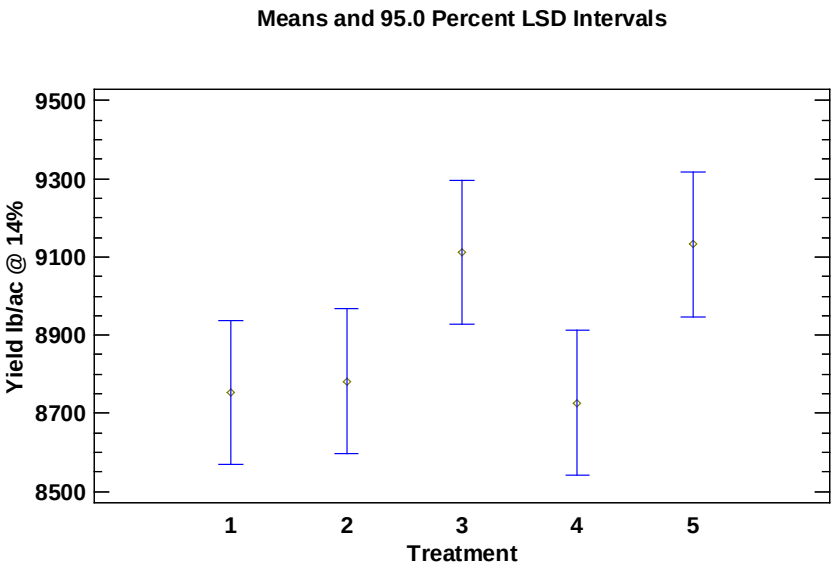
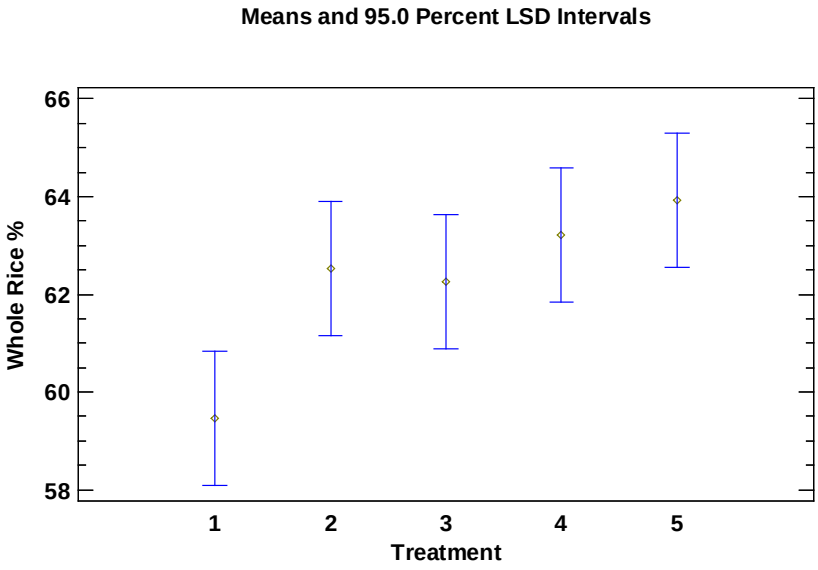


Figure 12. Sutter Location 2 2013 Small Plot Fungicide Trial Results – Head Rice Milling Yield



Sutter Location 3

Aggregate Sheath Spot (Table 6, Figures 13 and 14)

With respect to aggregate sheath spot disease, disease pressure was moderate at this location and all fungicide treatments resulted in a significant reduction in disease incidence and severity. There were some significant differences among the fungicide treatments but in general, aggregate sheath spot incidence was reduced by 70-90%.

Stem Rot (Table 6, Figures 15 and 16)

Stem rot disease pressure was moderate while severity was moderate. There were statistical differences among the treatments with respect to stem rot incidence and severity. All fungicide treatments timings resulted in significantly lower stem rot incidence and severity than the control.

Yield (Table 7, Figure 17)

There were no statistical differences between treatments with respect to yield (range 8,510-8,988 lb/Ac).

Milling Yield (Table 7, Figure 18)

With respect to milling quality, there were no statistical differences between treatments with respect to total rice or head rice milling yield.

Table 6. Sutter Location 3 2013 Small Plot Fungicide Trial Results – Disease Data

	Aggregate Sheath Spot		Stem Rot	
Treatment	Incidence (%)	Severity	Incidence (%)	Severity
1) Control (No Treatment)	61.0 a	1.43 a	65.0 a	1.57 a
2) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	4.0 c	0.08 c	29.0 b	0.61 b
3) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	11.0 bc	0.22 bc	33.0 b	0.66 b
4) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	9.0 bc	0.17 bc	41.0 b	0.87 b
5) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	19.0 b	0.35 b	38.0 b	0.70 b
P-value	0.0000	0.0000	0.0227	0.0037
LSD	10.4420	0.2601	21.4562	0.4798

Figure 13. Sutter Location 3 2013 Small Plot Fungicide Trial Results – Aggregate Sheath Spot Incidence

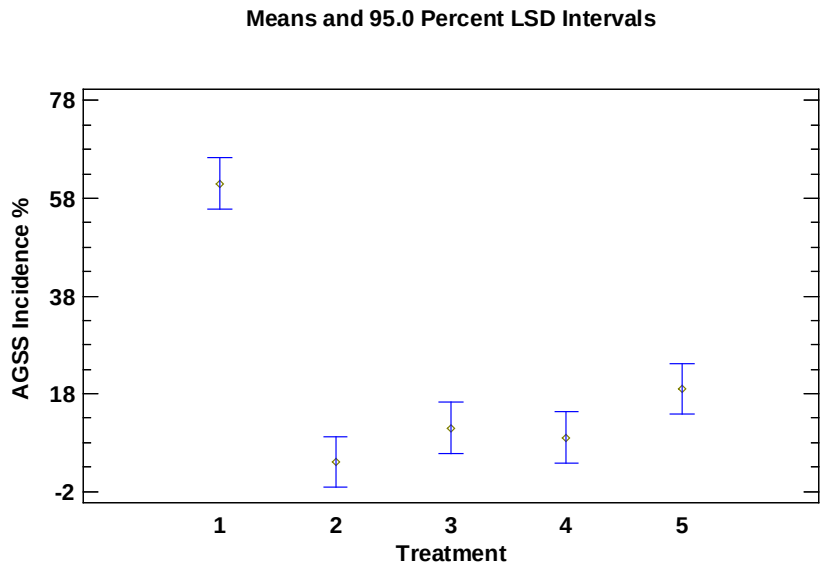


Figure 14. Sutter Location 3 2013 Small Plot Fungicide Trial Results – Aggregate Sheath Spot Severity

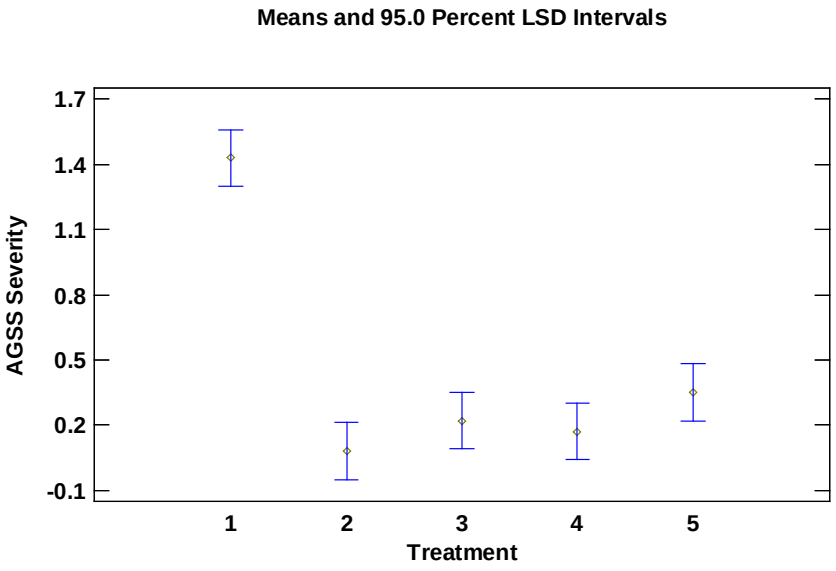


Figure 15. Sutter Location 3 2013 Small Plot Fungicide Trial Results – Stem Rot Incidence

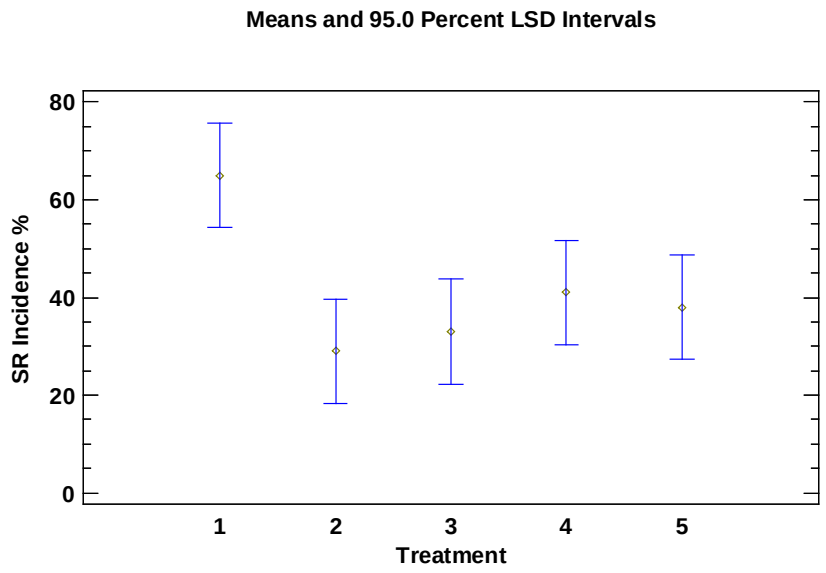


Figure 16. Sutter Location 3 2013 Small Plot Fungicide Trial Results – Stem Rot Severity

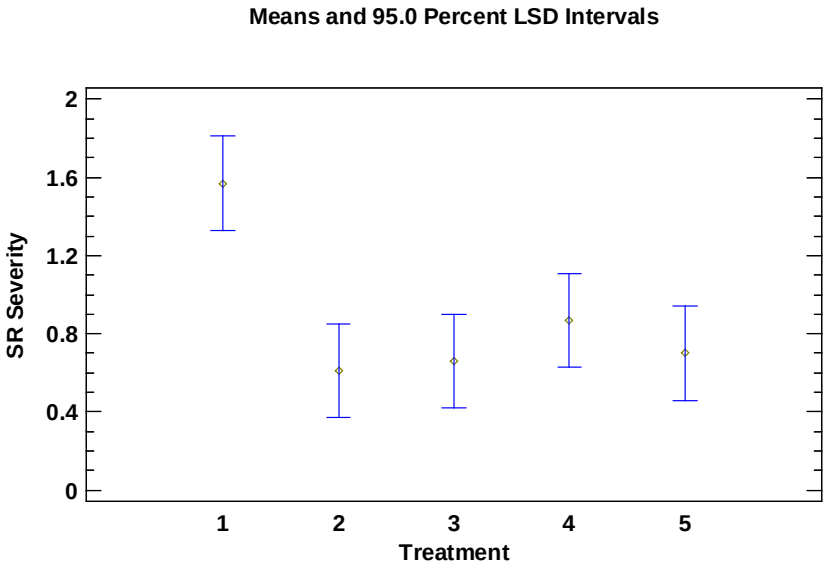


Table 7. Sutter Location 3 2013 Small Plot Fungicide Trial Results – Harvest Data

Treatment	Harvest Moisture (%)	Yield (lb/Ac)	Milling Quality % Total	Milling Quality % Whole
1) Control (No Treatment)	18.60 a	8510	69.98	53.88
2) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	19.30 b	8784	69.34	56.53
3) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	19.26 ab	8988	69.98	56.56
4) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	19.66 b	8594	69.58	57.00
5) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	19.49 b	8677	69.67	57.81
P-value	0.0371	0.2045	0.0983	0.4955
LSD	0.6592	NS	NS	NS

Figure 17. Sutter Location 3 2013 Small Plot Fungicide Trial Results – Yield

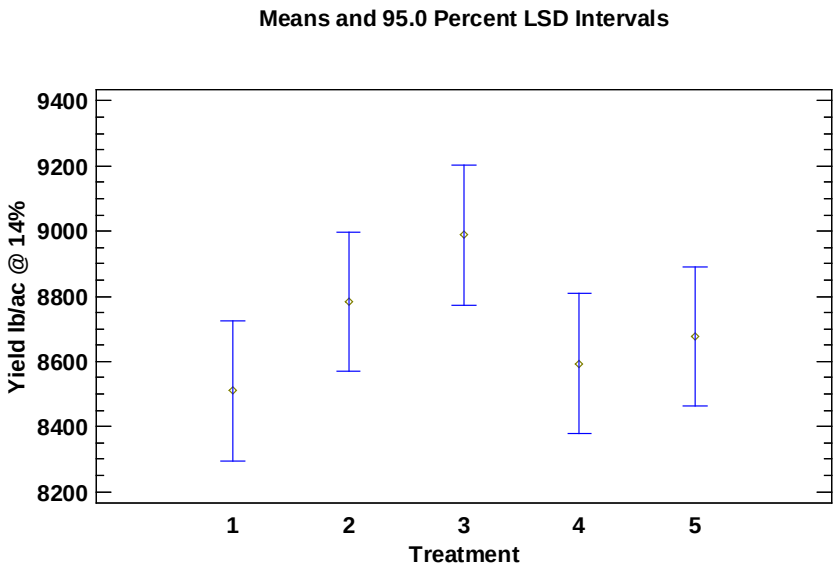
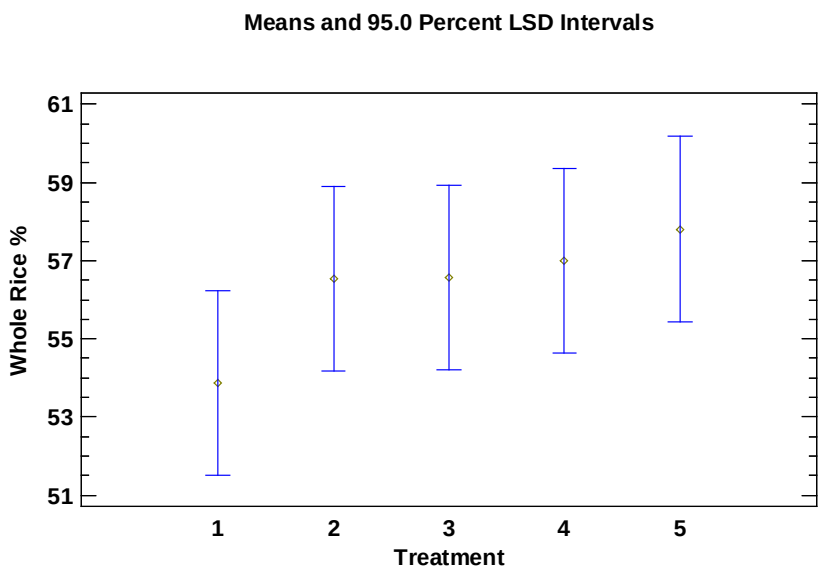


Figure 18. Sutter Location 3 2013 Small Plot Fungicide Trial Results – Head Rice Milling Yield



Summary of Small Plot Fungicide Trials

Disease levels in 2013 resulted in an excellent year for evaluating rice disease control materials. We can gain some measure of efficacy of the tested materials by examining individual trials as well as taking a look at the bigger picture. To look at the big picture we analyzed data were analyzed across all locations to gain more degrees of freedom in the analysis and allow us to examine the results of the treatments across all locations. When analyzed across all locations, both timings of Quadris and Quilt Xcel significantly reduced both stem rot and aggregate sheath spot incidence and severity over those of the control (Table 8). Aggregate sheath spot incidence was reduced by 69-77% with Quadris or Quilt Xcel applications. Stem rot incidence was reduced by 31-40% with Quadris or Quilt Xcel applications.

With respect to yield data, head rice milling quality and harvest grain moisture were significantly higher in plots treated with Quadris and Quilt Xcel at either timing when analyzed across all locations (Table 9). Harvest grain moisture was 1-1.5 percentage points higher and head rice milling quality was 3.5-4.5 percentage points higher in fungicide treated plots. All fungicide treatments except for the late timing of Quadris significantly increased yields over that of the control plots (200-360 lb/ac).

Table 8. All Locations 2013 Small Plot Fungicide Trial Results – Disease Data

Treatment	Aggregate Sheath Spot Incidence (%)	Aggregate Sheath Spot Severity	Stem Rot Incidence (%)	Stem Rot Severity
1) Control (No Treatment)	63.3 a	1.3467 a	64.3 a	1.57 a
2) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	14.7 b	0.2567 b	39.0 b	0.83 b
3) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	15.3 b	0.2567 b	38.7 b	0.89 b
4) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	19.7 b	0.3733 b	42.7 b	0.92 b
5) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	17.3 b	0.3267 b	44.3 b	0.97 b
P-value	0.0000	0.0000	0.0000	0.0000
LSD	9.2086	0.1933	10.0511	0.2459

Table 9. All Locations 2013 Small Plot Fungicide Trial Results – Harvest Data

Treatment	Harvest Moisture (%)	Yield (lb/Ac)	Milling Quality % Total	Milling Quality % Whole
1) Control (No Treatment)	18.68 a	8811 a	70.30	56.49 a
2) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	19.69 b	9012 bc	70.16	60.20 b
3) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 5% heading	19.62 b	9170 c	70.40	60.19 b
4) Quadris @ 12.5 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	20.14 b	8825 ab	70.17	60.93 b
5) Quilt Xcel @ 21 fl oz/Ac + 3 pints/100 gal Pro-Tron @ ~ 70% heading	20.31 b	9079 c	70.14	61.35 b
P-value	0.0002	0.0019	0.7539	0.0000
LSD	0.6914	199.6120	NS	1.8158

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

For a second year, efforts were focused on renewed evaluation of fungicide product efficacy for stem rot in addition to aggregate sheath spot management in California rice. Three small plot fungicide trials were established in M-206 commercial rice fields in 2013 to evaluate the industry standard Quadris fungicide (22.9% Azoxystrobin) alongside the more recently introduced product Quilt Xcel (13.5% azoxystrobin + 11.7% propiconazole) for aggregate sheath spot and stem rot management. Application timing was targeted specifically to aggregate sheath spot and rice blast diseases (5-15% panicle emergence) and (70% panicle emergence).

When results were analyzed across all locations, both timings of Quadris and Quilt Xcel significantly reduced both stem rot and aggregate sheath spot incidence and severity over those of the control. Aggregate sheath spot incidence was reduced by 69-77% while stem rot incidence was reduced by 31-40%. With respect to yield data, head rice milling quality and harvest grain moisture were significantly higher in plots treated with Quadris and Quilt Xcel at either timing. Harvest grain moisture was 1-1.5 percentage points higher and head rice milling quality was 3.5-4.5 percentage points higher in fungicide treated plots. All fungicide treatments except for the late timing of Quadris significantly increased yields over that of the control plots (200-360 lb/ac).

Future research will continue to elucidate the biology of California rice pathogens to assist in developing effective management practices for these pests. This ultimate goal is to develop an integrated rice disease management program for California growers based on sound fungicide efficacy data and pathogen biology to define the conditions under which a fungicide application is beneficial and economical. Future research will focus on evaluating Quadris, Quilt Xcel, and Stratego to evaluate efficacy of these products for disease management in California rice. In addition to aggregate sheath spot management, a continued focus will be placed on stem rot disease management in light of the results of the 2012 and 2013 studies. In doing so, we plan to evaluate even earlier fungicide timings to include a "propanil application timing" that might have even more of an impact on stem rot disease. In addition, we will continue to evaluate experimental compounds in conjunction with product registrants as these materials become available.

Rice blast fungus isolates from the 2011 and 2012 season were collected in conjunction with California Crop Improvement and RES staff for culturing and storage. These isolates will be used for genetic analysis with previously collected isolates. Genetic work will be conducted in 2014. The goal is to identify genetic tools that will provide a better understanding of the loss of resistance in M-208 and provide us with a solid base for future population genetics studies of *P. grisea*.