Report to the USA Rice Federation Rice Marketability and Competiveness Task Force

Quality Assessment of Rice Samples Produced in 2012

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Anna McClung

Summary

This survey was the third in a series to assess grain quality in U.S. and imported long grain sources. The main effort of this survey was to evaluate differences in U.S. long grain cultivars grown in the same environment for objective and subjective quality traits. Nineteen southern U.S. inbred varieties and hybrids were grown in 11 southern U.S. environments that included six locations and two plant dates. In addition two samples of a California produced long grain and two imported samples were included. Ten commercial rice mills evaluated a total of 226 samples of milled rice for five qualitative traits using a 1- 5 scale. In addition several other quality parameters were measured by lab (USDA and Biggs, CA) and commercial export standards (Russell Marine). Although the dataset in this survey is extensive, it is limited to one year (2012) and uses results from unreplicated trials. Thus, interpretations of the results of this survey cannot be extended beyond this dataset.

The results of this study demonstrated that:

- The U.S. does have cultivars that have high Mill score values and low chalk like high quality imported samples, however these cultivars are not the most predominantly grown. Some of the more widely grown cultivars, have lower Mill scores and higher chalk. These results suggest that breeders have access to genetic materials that can serve as the basis for on-going breeding improvements in U.S. long grain rice quality.

- Although cultivars differ in grain quality traits, growing environment was the major factor impacting whole milling yield. Whole milling yield was improved with earlier planting dates, lower heat units during grainfill, and ensuring uniform drying of samples prior to milling. These results indicate that optimizing the production environment and post-harvest handling are necessary to maintain high milling yields.

- Different methods of determining chalk were utilized. Although the amount of chalk differed greatly depending on the method used, the methods were moderately correlated with each other.

- As observed in other studies, some Mills evaluate samples quite differently than others. In addition, some Mills have greater repeatability in assessment of subjective traits.

Background

The USA Rice Federation (USA Rice) Rice Marketability & Competitiveness Task Force (Task Force) was appointed by USA Rice Federation's Board of Directors on February 14, 2011, to address the issues facing the marketability and competitiveness of U.S. rice domestically and internationally. U.S. long grain rice is facing increasing marketing challenges related to appearance characteristics such as irregular grain size, cook quality, color ("whiteness"), chalk, and amylose content. A key focus of the task force is to improve the competitiveness of U.S. long grain rice among U.S. and foreign customers in order to increase demand and consumption of U.S. rice.

The Task Force has developed a rigorous sampling and evaluation protocol to identify and assess qualities in long grain rice that carry a market premium and to share these findings with the rice research community for use in future varietal breeding. The Task Force seeks to facilitate communication between the U.S. rice industry and the research community that will lead to the production of new U.S. long grain cultivars that are high yielding and contain characteristics that meet market demands.

To this end, the Task Force has coordinated three studies to evaluate an array of subjective and objective quality traits using U.S. produced and imported rice samples. The first activity included an assessment of 18 U.S. and 1 imported samples by rice mills for 18 subjective traits using a scale of 1 to 5. In addition, the samples were evaluated for a battery of objective tests by public researchers. The second activity included 9 U.S. cultivars, some grown at several locations in 2011, and 1 imported sample. All samples were evaluated by participating mills for 5 parameters and by public research labs for several quantitatively measured traits. In general these studies demonstrated that there are differences in grain quality among U.S. cultivars, some U.S. cultivars are ranked similar or better than the high quality imported samples, commercial mills differ in their assessment of quality, subjective and objective measurements of quality are only moderately correlated, and location (growing environment) had a major impact on quality. Samples that were poorly ranked by mills were characterized as lacking uniformity, having a length:width ratio less than 3.0, and had high grain chalk. This report summarizes the results of a third study involving U.S. inbred and hybrid cultivars grown in a side by side study conducted at 11 southern U.S. environments. These samples, along with one CA variety and 2 imported samples, were evaluated by commercial mills and public researchers for subjective and objective quality traits.

	2010	2011	2012
US Varieties	18	23	17 + 3 Hybrids
Imports	1 Vietnam	2 Thai, Brazil	2 Thai, Uruguay
Environments	Various Yrs, Locs	2011, Various Locs	2012, 11 Southern US
Total Samples	19	25	224
Subjective Traits	8	6	5
Data Points	~2200	~8000	~18,800

Objectives

- Determine the grain quality differences of 16 southern U.S. inbred cultivars and 3 hybrids grown in a side by side study at 6 mid-south locations.
- Evaluate the impact of optimum and delayed planting dates on grain quality parameters.
- Compare these southern produced samples with one California long grain produced at two plant dates in California and imported milled samples from Thailand and Uruguay.
- Assess consistency and relationship of subjective Mill scores and objective laboratory measures.
- Associate weather data and agronomic traits with grain quality.

Approach

Field Studies

Unreplicated field trials were conducted by Steve Linscombe (LA), Karen Moldenhauer and Chuck Wilson (AR), Tim Walker (MS), Brian Ottis (Northeast AR, MO), and L. Ted Wilson (TX). The cultivars were planted at an optimum plant date and at a delayed plant date, approximately one month later. In addition, one California variety that was produced at one CA location and at two plant dates was also included (Farman Jodari). Local recommended cultural management practices were used at each location. Samples were combine-harvested at approximately 18% moisture and dried to 12% moisture. Agronomic data including emergence, heading, and harvest maturity were recorded. Weather data including temperature and rainfall were recorded throughout the growing season at each southern location.

		Locations and No. Planting Dates					
	Cultivar	Beaumont	Crowley	Stoneville	Stuttgart	NE Ark	Missouri
1	Antonio	2	2	2	2	2	1
2	Bowman	2	2	2	2	2	1
3	Cheniere	2	2	2	2	2	1
4	CL111	2	2	2	2	2	1
5	CL142-AR	2	2	2	2	2	1
6	CL151	2	2	2	2	2	1
7	CL152	2	2	2	2	2	1
8	CL162	2	2	2	2	2	1
9	Cocodrie	2	2	2	2	2	1
10	Colorado	2	2	2	2	2	1
11	Francis	2	2	2	2	2	1
12	Presidio	2	2	2	2	2	1
13	Rex	2	2	2	2	2	1
14	Roy J	2	2	2	2	2	1
15	Taggart	2	2	2	2	2	1
16	Wells	2	2	2	2	2	1
17	XL723	2	2	2	2	2	1
18	CLXL729	2	2	2	2	2	1
19	CLXL745	2	2	2	2	2	1
20	L206	2 planting dates from CA					
21	Thai	1 commerical milled					
22	Uruguay	1 commerical milled					

Sample Preparation

Rough rice was shipped to the Louisiana Rice Mill where samples were milled to a consistent degree of milling using NIR and head rice and total milled rice percentage were determined for each sample. Each sample was given a randomized code number so that evaluators were not aware of variety name or production environment. Two imported samples of milled rice from Thailand and Uruguay were also included. In addition, a repeated blind check (CL111) was included randomly among the samples 13 times to determine consistency among the various assessment methods. A total of 226 samples were sent to 11 commercial grain quality assessors and two participating research labs (McClung - Dale Bumpers National Rice Research Center, Stuttgart and Jodari - California Rice Research Foundation, Biggs).

Sample evaluation

Qualitatively Assessed Traits and Rating Scale. A score sheet was provided to each of the mills that described 5 traits to be evaluated using a 1-5 scale. The traits and rating scale were decided upon based upon feedback from the 2010 analysis protocol and were deemed as important criteria common to the industry. For all of these traits, a low score was associated with poor quality. A "total score" was determined for each sample as the sum of the ratings for the 5 subjectively assessed traits. Thus, a perfect (high) score would equal 25.

Mill Trait	1		5
	Poor		Good
Bran Streaks	>20% Kernels		<10% Kernels
Chalk	>10% Kernels Opaque		Translucent, trace chalk
Kernel Color	Grey, rosy, beige		White, creamy
Uniform Length	Highly Irregular		Very uniform
Overall Appearance	Poor, unacceptable		Acceptable package quality

Mills were asked to use staff experienced in quality assessment for their review of the samples. Russell Marine provided a detailed assessment of chalk using criteria as required for export to Nicaragua, white belly%, and overall chalky appearance %.

Quantitatively Assessed Traits

The Winseedle Image Analysis system was used at the Dale Bumpers National Rice Research Center to determine grain length, grain width, percent chalk, and percent bran streaks on approximately 200 whole kernels per sample. For each sample, grain thickness was determined by calipers using 50 whole kernels and grain weight was determined using 200 whole kernels. The S21 image analysis system used at the Biggs, CA location analyzed over 3500 kernels per sample in determination of grain length and width, chalk, vitreousness, and whiteness.

Data Analysis

Statistical analysis was performed by Kathy Yeater, USDA ARS, Southern Plains Area Statistician. Weather and agronomic data from each location was used to calculate for each variety the cumulative growing degree days (GDD) (heat units) for various plant growth stages (emergence, heading, harvest) as well as at weekly intervals during grainfill.

GDD = (TempMax + TempMin)/2 – Tbase, where Tbase = 50 F

Analysis included correlation among traits, assessment of variability (stability), regression analysis, and principal component analysis and modeling to identify parameters explaining chalk and milling yield across all of the samples.

Results

Consistency and Relationship of Methods for Analyzing Grain Quality

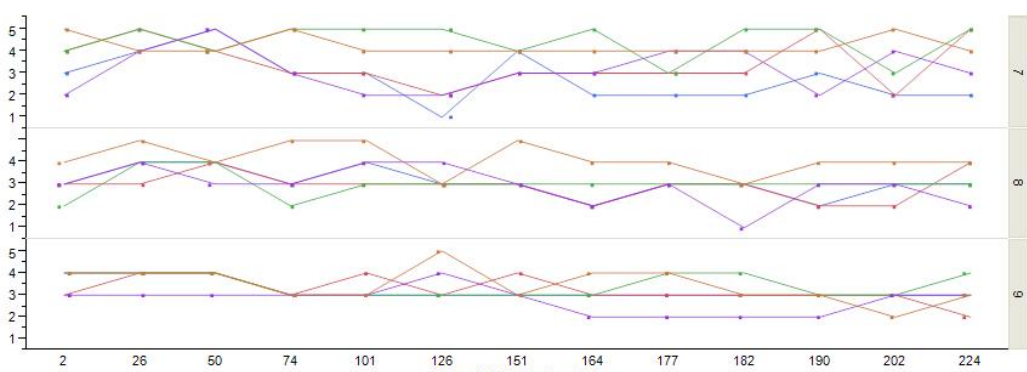
Mill Scored Trait	Winseedle		CA_Image		Russell Marine	
Bran Streaks	0.62	(%Bran)	0.62	(Color Damage)		
Chalk	0.59	(%Chalk)	0.43	(%Vitreous)	0.55	(% Nic. Chalk)
Kernel Color	0.65	(%Bran)	0.68	(Color Damage)		
Uniformity of Length			0.64	(%Whole Grain)		
Overall Appearance	0.59	(%Bran)	0.63	(Color Damage)		
All converted to positive numbers. Perfect relationship =1.0						

The different methods for measuring grain traits were evaluated to determine which were most correlated with the way the Mills scored the traits. Objective methods (lab) were moderately correlated with subjective methods (by Mills). Kernel Color, Bran Streaks, and Overall Appearance as scored by the Mills were most strongly correlated with lab measures of % Bran and Color Damage as determined by the Winseedle and S21 image systems, respectively. Overall Appearance which is the Mills' assessment if a sample has acceptable package quality, was most associated with reduced bran (r=-0.59) and reduced chalk (r=-0.42) using the Winseedle method and with low color damage (r=-0.63) using the S21 method.

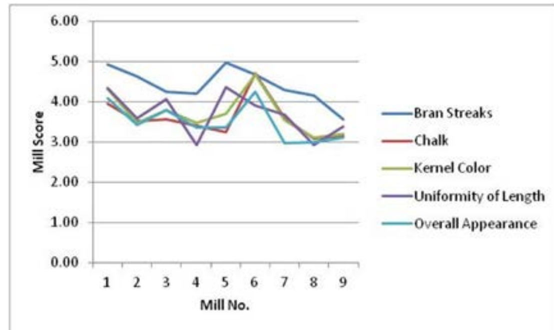
	S21_% Chalky Area	RM_%Nic. Chalk	Mill Chalk Score
WS_%Chalk	0.64	0.50	0.59
S21_%Chalky Area		0.36	0.35
RM_%Nic. Chalk			0.55

Correlations among the different methods for measuring chalk show that the Winseedle method was generally a good predictor of values as determined by the S21, Russell Marine, and Mill Score. A comparison of the means for chalk of the repeated check showed that the Winseedle method detected relatively small amounts of chalk compared to the S21 and Russell Marine methods but also had a much lower standard deviation (less sample to sample variability). This indicates that the Winseedle method is more precise for assessing chalk as compared to the other methods. Measurements for grain length, width and length:width ratio of the repeated check using the S21 method were 6.33, 2.05, and 3.09, respectively whereas with the Winseedle they were 6.52, 2.19, and 2.98, respectively. In addition, the S21 method was a bit more precise in grain dimension measurements than the Winseedle method.

Comparison of Methods of Chalk Assessment *	Average	Std Dev
WS % Chalk	3.75	0.86
S21 % Chalk	25.24	8.57
S21 % Chalky Area	37.57	5.25
RM % Nic. Chalk	19.68	7.00
RM % White Belly	9.36	3.88
RM % Overall Chalk	38.9	11.83
*Using repeated check data		



The repeated check was one milled sample of CL111 that was presented for analysis 13 times. The graph above shows the scores from Mills #7, #8, and #9, for example. The five different colored lines correspond to the five traits that the samples were scored for by the Mills. If the Mills observed no



variation among the repeated check, the lines would be flat. However, these results show that there is variability in how the Mills score the same sample repeatedly.

Comparison Among Mills

An evaluation of the mean scores for all samples from each Mills shows that there is considerable variability in the subjective assessment among the different Mills. In general, Mills 1 and 6 gave more favorable scores whereas Mills 4, 8, and 9 gave lower scores for the same samples.

Plant Date	Heading (d)	Harvest (d)	Grainfill (d)	Whole Milling %	Total Milling %
1	87.47	125.68	38.21	58.20	68.85
2	80.80	116.36	35.57	56.03	68.77
Difference	6.67	9.32	2.64	2.17	0.09

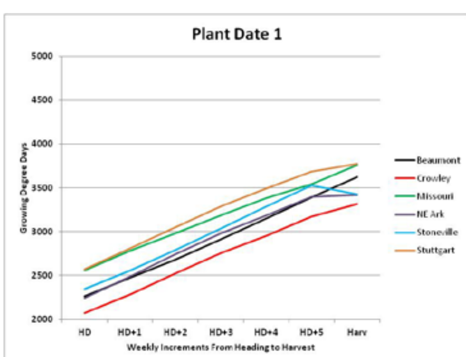
Comparison Between Plant Dates

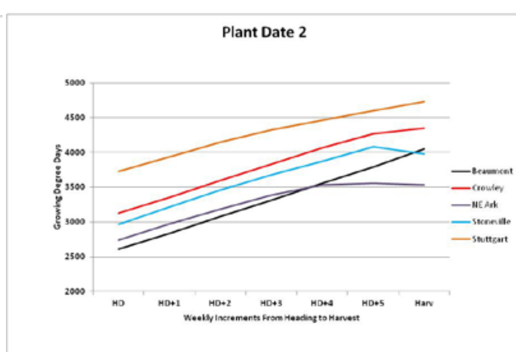
The second plant date occurred approximately one month later at each location and was characterized as having a shorter growth cycle, maturing earlier, having fewer grainfill days, and lower head rice yields. Quality measures indicated that the Mills scored the first plant date slightly more favorably, except for chalk. In contrast, the Winseedle and S21 methods identified slightly less chalk in the first planting date as compared to the second. The second plant date was also determined to have slightly larger grain dimensions.

	Mill Scores					Winseedle					
Plant Date	Bran Streaks	Chalk	Kernel Color	Uniform Length	Overall Appearance	Length	Width	Chalk	S21_Chalk Area	RM_Nic Chalk	Kernel Weight
1	4.45	3.56	3.71	3.72	3.50	6.59	2.17	2.15	30.39	12.97	18.28
2	4.34	3.63	3.64	3.65	3.43	6.63	2.19	2.50	34.15	11.83	18.45
Difference	0.11	0.07	0.07	0.07	0.07	0.03	0.02	0.43	3.76	1.14	0.17

Comparison Between Locations

The graphs below show the GDD for each location for the two plant dates. Stuttgart location had very high temperatures through the growing season for both plant dates. In plant date 1 Crowley had the coolest season, whereas in plant date 2 both Beaumont and NE Ark were cooler.

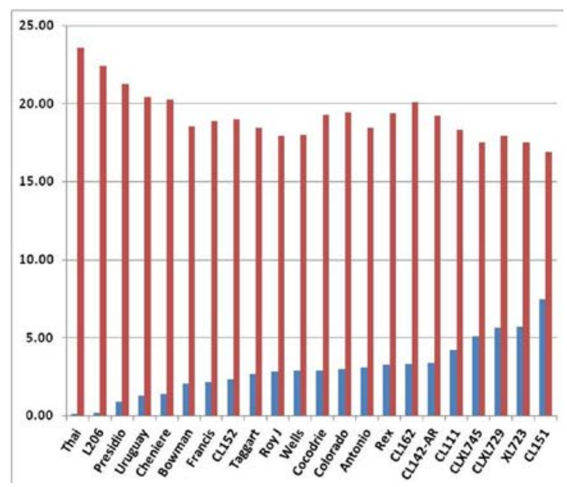




Location	Plant Date	Total Score	Chalk	Kernel Color	Uniformity of Length	Overall Appearance	Length	Width	Length: Width	WS % Chalk	S21 % Chalk	RM%Nic Chalk	RM% White Belly	RM% Overall Chalk
Beaumont	1	17.70	3.22	3.57	3.42	3.27	6.71	2.16	3.12	2.56	13.97	13.58	4.64	25.01
Crowley	1	20.08	3.65	4.14	3.74	3.86	6.54	2.15	3.04	1.96	18.94	13.47	5.74	25.94
Missouri	1	20.39	3.84	4.02	3.98	3.98	6.57	2.16	3.04	1.24	8.31	14.94	6.55	28.95
NE Arkansas	1	17.92	3.61	3.25	3.77	3.04	6.59	2.19	3.02	1.40	8.32	9.81	5.21	19.92
Stoneville	1	17.30	3.09	3.35	3.48	2.99	6.54	2.22	2.94	4.34	27.96	16.24	3.96	28.34
Stuttgart	1	19.66	3.78	3.84	3.81	3.72	6.54	2.16	3.03	1.68	20.29	10.97	5.51	21.97
Beaumont	2	17.67	3.25	3.64	3.25	3.29	6.67	2.15	3.10	2.89	13.65	16.01	4.64	28.66
Crowley	2	19.45	3.86	3.82	3.89	3.65	6.59	2.17	3.04	3.63	39.32	10.00	5.84	20.85
NE Arkansas	2	18.11	3.87	3.16	3.81	3.04	6.72	2.22	3.03	0.96	9.25	8.26	4.10	16.49
Stoneville	2	18.37	3.46	3.61	3.48	3.37	6.51	2.19	2.98	3.84	28.66	14.25	3.71	25.08
Stuttgart	2	19.83	3.72	3.95	3.80	3.80	6.61	2.20	3.01	1.16	14.38	10.94	8.58	25.00

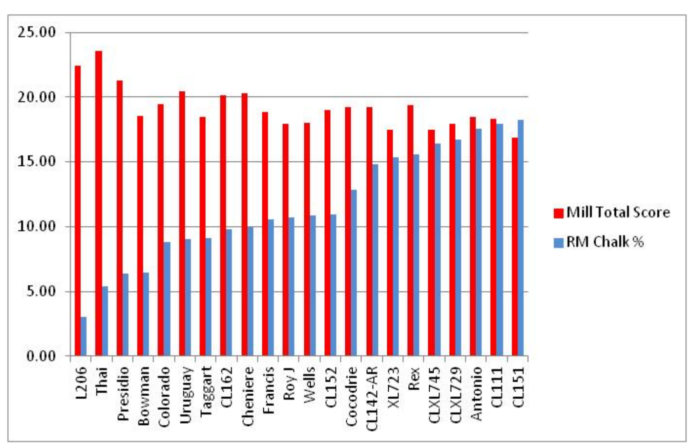
The above table shows the average scores for the quality traits at the different environments. Blue colors are associated with more desirable scores and red with less desirable. The Missouri location (plant date 1 only) had the highest Total Mill score (sum of all of the scores for all traits measured with perfect score being 25) and low WS chalk, but high RM chalk assessments. The Stoneville location had less favorable ratings for quality traits in plant date 1. During plant date 2 NE Ark had more favorable quality scores whereas Beaumont had less favorable ratings.

Comparison Among Cultivars



Data were summarized over locations and plant dates to compare cultivar performance. This analysis also includes the two imported samples which were commercially milled and L206, the one variety grown in California. The bar chart shows the Total Mill Score (red) and Winseedle chalk (blue). In general, the cultivars with the highest Total Mill score and lowest Winseedle chalk were the two imports, L206, Presidio, and Cheniere. The cultivars with some of the lowest Total Mill scores and highest chalk included CL111, CLXL745, CLXL729, XL723 and CL151. These latter cultivars are also some of the most widely grown in the southern states. The other cultivars were very similar to each other in their Total Mill scores and Winseedle chalk amounts.

Evaluation of Total Mill score along with the Russell Marine measure of chalk shows some similarities with the previous chart. The cultivars with the most favorable scores by the Mills and lowest chalk were L206, imported Thai, and Presidio. The cultivars with the lowest Total score by the Mills and highest chalk were CLXL745, CLXL729, Antonio, CL111, and CL151.

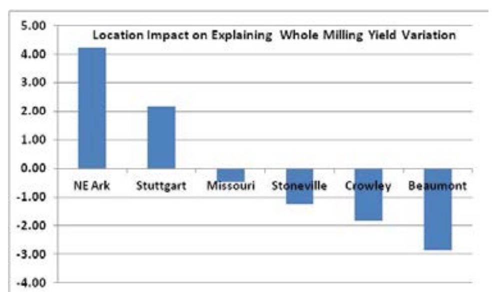


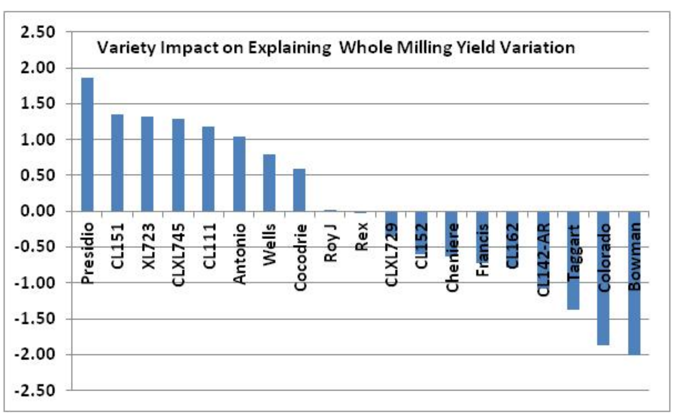
Influence of Weather Factors on 2012 Grain Quality

At each location information was collected on temperature, rainfall, as well as plant growth parameters (emergence, heading, harvest maturity). This information was used to determine growing degree days (GDD) for various plant stages for each variety at each location. In addition, during the approximate 35 days between heading and harvest, the cumulative GDD for weekly intervals during grainfill were determined. The purpose was to evaluate the impact of weather events and plant growth and development on grain quality. Regression analysis was used to identify the factors most influential on % head rice yields. The data collected was able to explain 76% of the variation in whole milling yields in this study. Results showed that Location where the rice was grown had the largest single effect on whole milling yields explaining 32% of the variation whereas Variety (aka "cultivar") and their response across Location explained much less of the variation in milling quality (9.19% and 12.86 %, respectively). Of the measured traits plant date, moisture at milling, and growing degree days during grainfill were the only factors significantly impacting milling yield. Planting the crop earlier, avoiding very high temperatures during grainfill, and not having high grain moisture at the time of milling were associated with higher milling yield. Further analysis (using Best Linear Unbiased Predictors –"BLUPs") showed the relative impact of the different locations on whole milling quality. In 2012 experimental sites, the NE Ark and Stuttgart locations were associated with more positive milling yields, whereas Missouri, Stoneville, Crowley, and Beaumont had more negative milling yields.

Random Effect	Var Ratio	Component	Std Error	95% Lower	95% Upper	Pct of Total
Location	0.7262239	9.3498302	7.6153073	-5.575898	24.275558	32.789
Variety	0.2036825	2.622328	1.6938475	-0.697552	5.9422081	9.196
Variety*Location	0.2849366	3.6684405	1.8969355	-0.049485	7.3863659	12.865
Residual		12.874584	1.9015828	9.8311838	17.595589	45.150
Total		28.515183	7.7687095	17.816786	52.868008	100.000

This same type of analysis (BLUPs) was used to look at the impact of cultivar on whole milling yield, although, as stated previously it was much less important than growing location in 2012. Presidio was the best performer for whole milling yield in this study, whereas Colorado and Bowman were lower.





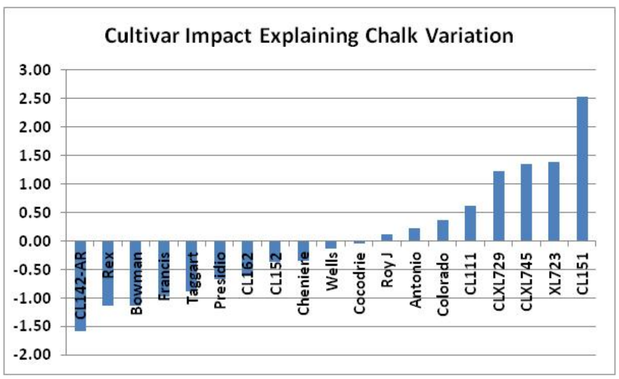
Cultivars Associated with the Most Positive Whole Milling Yields at each Location in 2012.					
Beaumont	**Crowley**	**Missouri**	**NE ARK**	**Stoneville**	**Stuttgart**
Presidio	Cocodrie	Cocodrie	Colorado	CL142-AR	Francis
Roy J	Cheniere	Cheniere	Francis	CL111	Bowman
CLXL745	CLXL729	CLXL729	Taggart	Presidio	CL142-AR
Wells	CLXL745	CLXL745	CL162	Bowman	Presidio

Analysis (BLUPs) was used to evaluate whole milling yield performance at each location. The table above shows the best performing 4 cultivars for whole milling yield at each of the locations in 2012. These results show that although some cultivars are common across more than one environment, there is variability in which cultivars performed the best among the locations.

This same type of analysis was performed to look at Winseedle chalk. Of the different methods of measuring chalk, the Winseedle method was chosen for analysis because it was more precise in its measurement of chalk. The statistical model explained only 54% of the variation in Winseedle chalk partly due to there was not a lot of chalk in the samples. Interestingly, more of the variation in chalk that was present was attributed to Variety (aka “cultivar”) (26%) and less due to Location (13.8%). This is the opposite of what was found for whole milling yield. Of the measured traits, the only ones that had a significant impact on chalk were grain length, grain width, and growing degree days during grainfill. Cultivars that have longer and more slender grains, and experience fewer hot days during grainfill are more translucent.

Random Effect	Var Ratio	Component	Std Error	95% Lower	95% Upper	Pct of Total
Location	0.2304896	0.7410141	0.6416722	-0.51664	1.9986685	13.837
Variety	0.4353161	1.3995225	0.5792473	0.2642186	2.5348265	26.132
Variety*Location	-0.120614	-0.387769	0.3124373	-1.000135	0.224597	0.000
Residual		3.2149568	0.462364	2.471282	4.3551598	60.031
Total		5.3554934	1.0121182	3.8171841	8.0596114	100.000

Looking at individual cultivars demonstrates their influence on chalk. Vertical bars below 0 are cultivars that have lower chalk (like CL142 AR) whereas those above 0 have higher chalk (like CL151).



Conclusions from 2012 Study

This study was conducted to evaluate a set of U.S. rice cultivars grown in side-by-side field trials for both subjective and objective quality traits. The goal was to determine how U.S. cultivars compare to high quality imports and to learn more about the relationship between subjective and objective assessments of quality. In addition, agronomic and weather data from each production site allowed analysis of how these factors may impact quality. This study demonstrated that the different estimates of chalk as determined by Winseedle and S21 Image analysis system and by Russell Marine (graders for export market) differed widely in the amount of chalk. The Winseedle system was calibrated to score much lower levels of chalk than the S21 system or that as subjectively determined by Russell Marine. However, all three methods tracked chalk variability in a similar manner, although the scale was much different. Correlations among the Winseedle, S21, Russell Marine, and the Mill method demonstrated that the Winseedle method was generally more highly correlated with all other methods and was more precise.

Ten commercial Mills participated in evaluation of 226 rice samples using established criteria for 5 subjective traits. As in previous studies, there was significant variability in how the Mills scored the same samples. Some Mills scored samples more favorably while others were less favorable. In this study, Mills were provided with a repeated check of a sample that was presented at random to them 13 times. Results from this assessment of the repeated check demonstrated that there was significant variation for some

Mills in how a sample was scored, as would be expected in subjective assessment. This suggests that identifying baseline standards that all Mills would agree to may help the research community to better meet their goals for quality.

Nineteen southern U.S. long grains were grown at different locations and planting dates for a total of 11 production environments in the Southern U.S. Results demonstrated that location accounted for the biggest difference in whole milling yield of samples. The Stuttgart location was characterized as the hottest in 2012, while the Beaumont location had the poorest milling yields and Mill assessments of quality. The NE Ark and Stuttgart locations had a relatively positive impact on milling yield as compared to Missouri, Stoneville, Crowley, and Beaumont. In addition, careful post-harvest handling to dry samples to a uniform moisture also enhanced milling quality.

Two planting dates, optimum and delayed, were compared. The delayed planting date was associated with higher growing degree days, faster plant growth cycles reaching heading and maturity earlier, decreased milling yields, less favorable Total score by Mills, larger grain dimensions, and greater chalk. Thus, planting earlier in 2012, enhanced milling and grain quality.

The imported, commercially milled, samples from Thailand and Uruguay were ranked high by the Mills and had low chalk. U.S. cultivars that were similar to the imported samples according to Mill scores and estimates of chalk were Presidio and Cheniere grown in the Mid-south and L206 grown in California. Thus, the U.S. does have cultivars that can compete with high quality samples from other regions of the world in the export market if evaluated on a variety basis (not blended). However, some of the most predominantly grown cultivars in the southern U.S. were found to be ranked low for Total Mill scores and high for chalk. Thus, the cultivars with the highest yield and commercial acceptance may not have the highest quality. However, the results show that breeders have access to genetic resources with high milling quality and low chalk that can be used in on-going breeding efforts to improve these traits. New technology like the image analysis scanners for grain dimensions and quantifying chalk will be helpful in objectively selecting for these traits.