PROJECT NO. RU-5

ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 2008 - December 31, 2008

PROJECT TITLE: **Dairy Feeding of Rice Hay**

STATUS OF PROPOSAL: ____/New x___/Continuing

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Mário Coelho - Department of Animal Science Graduate Student

COOPERATORS:
Chris Greer, Rice Farm Advisor, Yuba City, Ca.

LEVEL OF 2OO9 FUNDING: $37,970

OBJECTIVES AND EXPERIMENTS CONDUCTED:

Objective A **– the Board asked for the project to develop a publication on the nutrient costs of straw removal.**

Rice Straw Removal Costs

In addition to the cost of baling rice straw (i.e. to bale and stack) there are costs associated with nutrient losses that occur with straw removal compared to incorporation. Burning rice straw volatizes most of the nitrogen and sulfur causing it to be lost to the atmosphere, whereas most of the potassium remains in the ash. Straw removal removes potassium and nitrogen as well as sulfur. Conversely the majority of nutrients are retained in the field when straw is incorporated. The nutrient impacts from various straw management processes need to be considered as part of the costs of the process.

Typical rice straw nutrient content based on 100% dry matter basis as reported by Summers (2001) are about 0.07% nitrogen and 1.7% potassium. Research by Nader and Robinson. (2004) on rice straw samples from 77 stacks over two years found similar N and K levels in rice straw, in addition to the concentrations of several other nutrients (Table 1).

Table 1. Concentration (%) of selected nutrients in rice straw collected at several locations.

	Nitrogen	Potassium	Calcium	Phosphorus	Magnesium	Sulfur	Sodium	Chloride
Average	0.77	1.74	0.30	0.10	0.20	0.08	0.15	0.52
Maximum	1.12	2.70	0.50	0.17	0.30	0.15	0.50	1.20
Minimum	0.53	1.10	0.19	0.05	0.12	0.04	0.01	0.10

Rice growers report that baling harvester windrows cut at the waterline yields an average of 1.5 tons of straw per acre. Most straw is baled at 6-12% moisture. Table 2 shows the average nutrient loss at different straw removal rates compared to incorporation. The example assumes the straw is baled at 6% moisture and that 100% of the nitrogen and potassium are recycled by incorporation.

Table 2. Average nutrient loss at different straw removal rates.

Tons straw removed/acre	**1**	**1.5**	**2**	**3**
Nitrogen (lbs) removed/acre	14.5	21.7	29	43.4
Potassium (lbs) removed/acre	32.7	49.1	65.4	98.1
Phosphorus (lbs) removed/acre	1.9	2.8	3.8	5.6

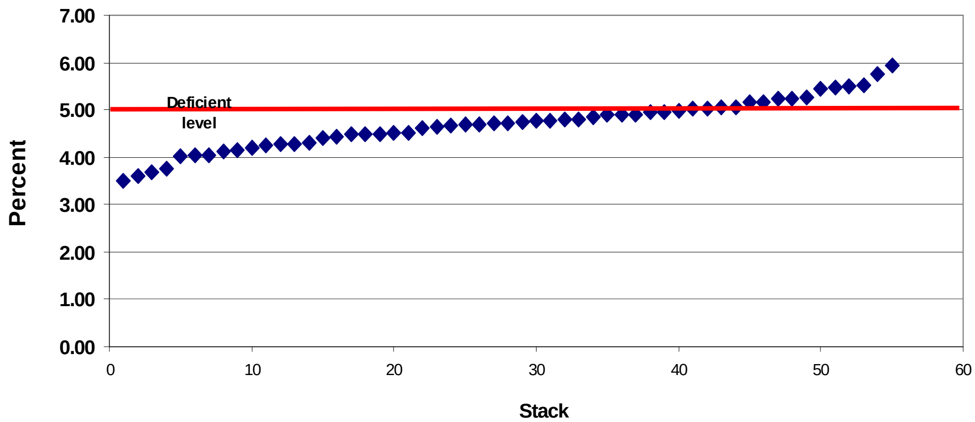
References

1. Nader, G.A., and P.H. Robinson. 2004. Rice Research Board Annual Report. http://www.carrb.com/04rpt/2004NaderRU-5.pdf
2. Summer, MD et al. 2001. Developing engineering data on rice straw for improvement of harvesting, handling, and utilization. Proceedings Rice Straw Management Update. UCCE, Yuba City, CA. March 2001.

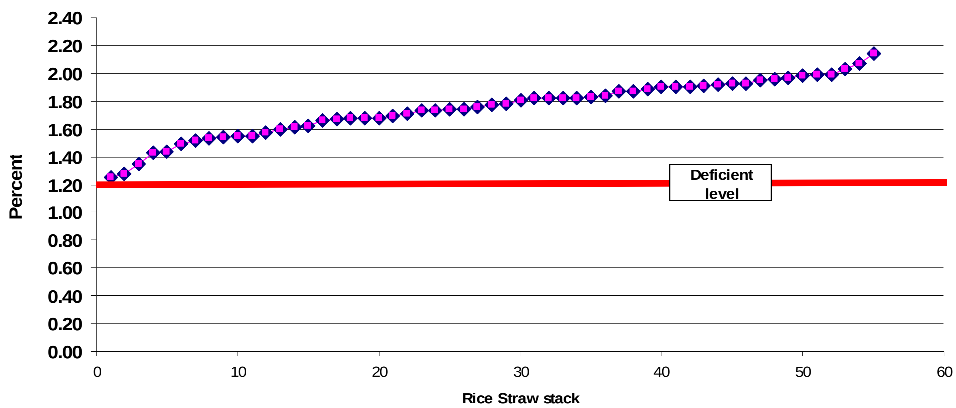
Additional Agronomy information

Information from the 2002, 2003 and 2008 rice straw surveys has been analyzed with the assistance of UC Rice Advisor Chris Greer in order to use straw nutrient levels to estimate if growers may be deficient in any nutrient. We have graphed the straw nutrient values against published deficiency levels. Straws have values that indicate silica deficiency. Silica is usually thought to be abundant, but it is important in disease prevention, prevention of transpiration losses and to help form erect leaves that optimize photosynthesis. Rice Advisors may want to confirm if this could be a real problem. The 2002-2003 data indicates some straws are low in potassium, phosphorus, copper and sulfur.

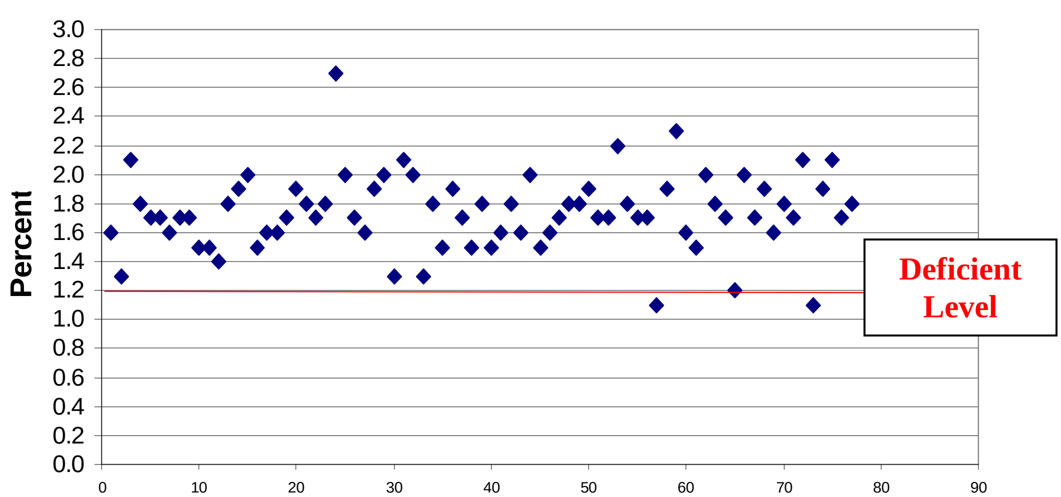
Silica
2008 Rice Straw

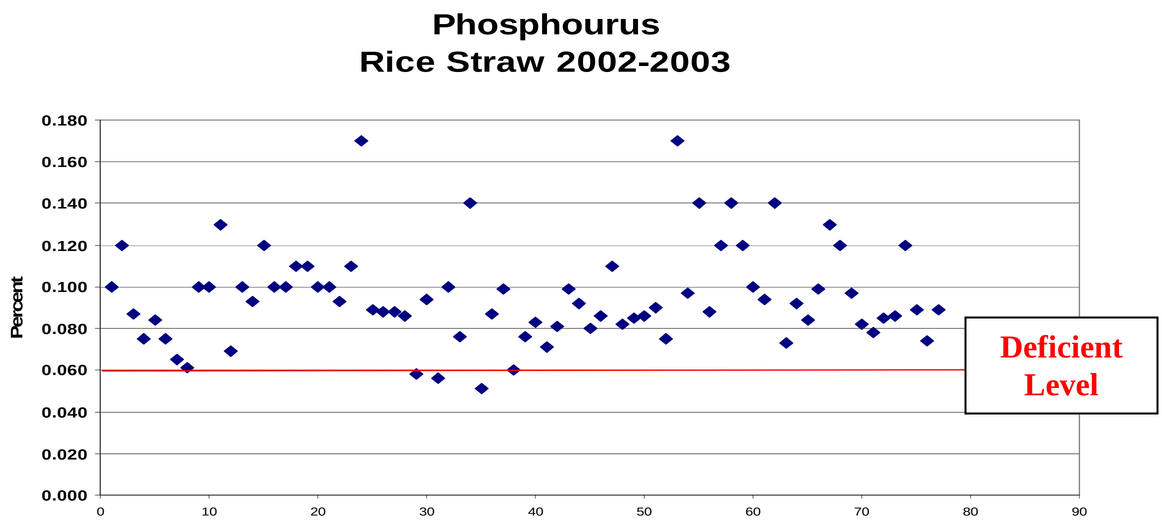


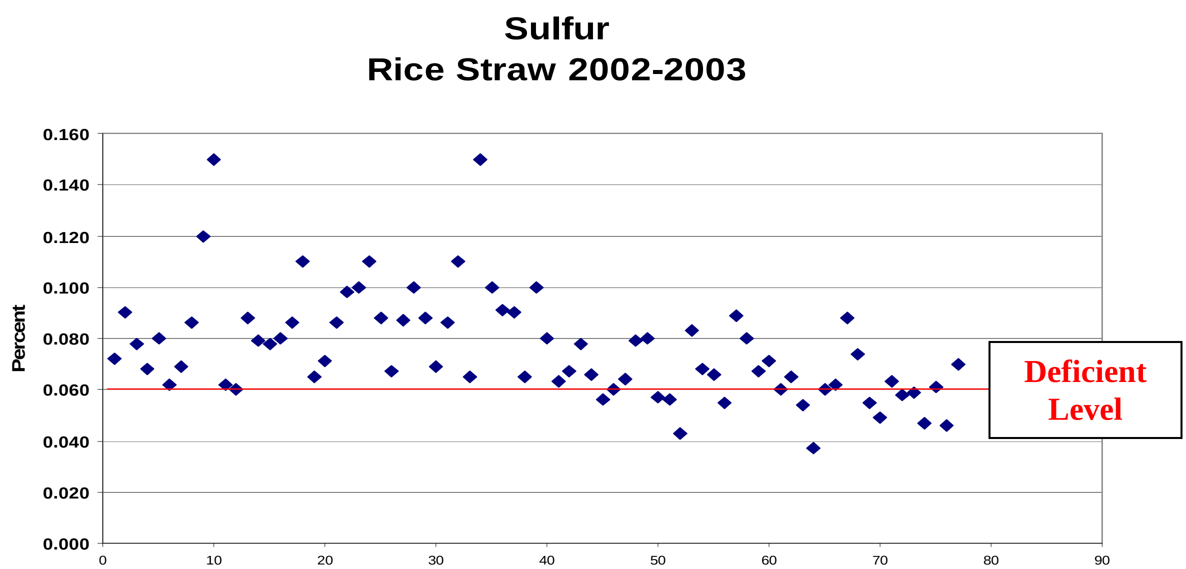
Potassium
2008 Rice Straw

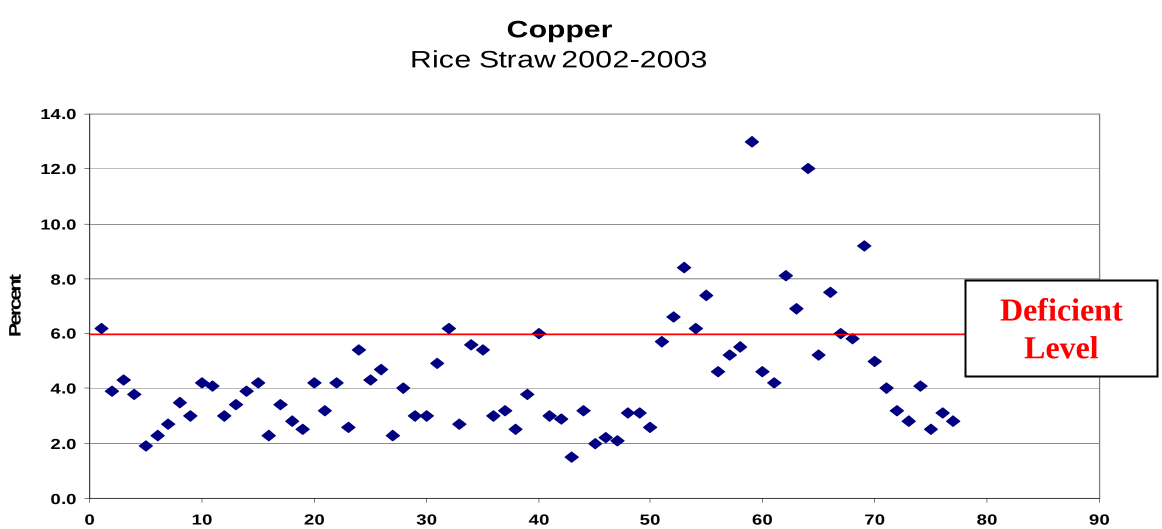


Potassium
Rice Straw 2002-2003

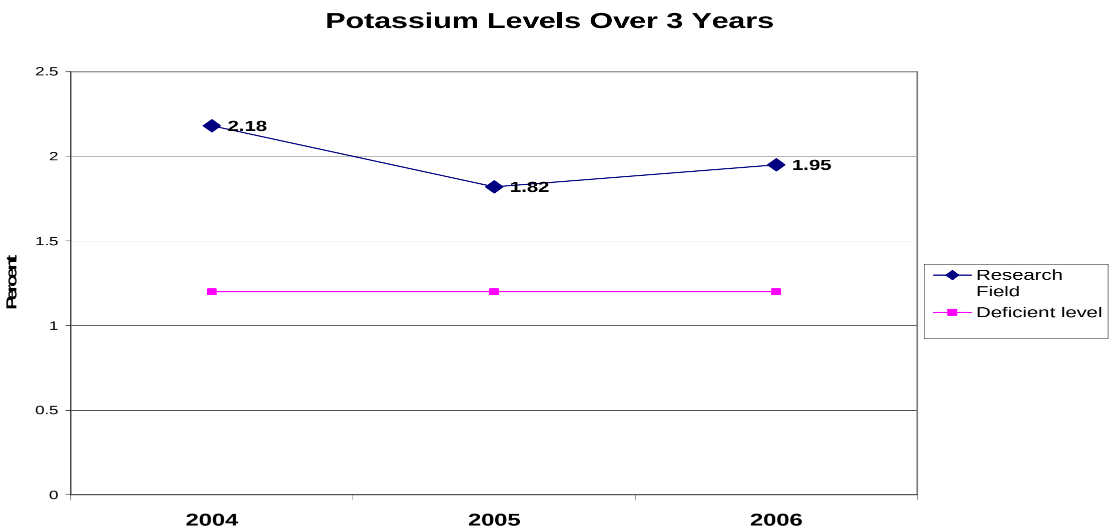



Phosphourus
Rice Straw 2002-2003
Percent
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0
10
20
30
40
50
60
70
80
90
Deficient Level


Sulfur
Rice Straw 2002-2003
Percent
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0
10
20
30
40
50
60
70
80
90
Deficient Level


Copper
Rice Straw 2002-2003
Percent
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
10
20
30
40
50
60
70
80
90
Deficient Level

Below is a graph of rice straw potassium values for a Colusa county rice operation that removed straw from the same field during three years of rice straw research.



Objective 1 – Dairy demonstrations of rice straw in replacement heifer rations to expose more dairy owners and consulting nutritionists to a positive experience of mixing and feeding rice straw.

The dairy demonstrations are scheduled to start January 2010. The reason for the delay is that an objective is to invite rice growers to see the dairies and understand the dairy needs for high quality straw that mixes without chopping on-site in the feed wagons. In the past, the demonstrations were in October and November and many rice growers were not able to attend. The same data will be collected as in previous years (i.e. feeding level, refusal, and survey of the dairy feeders).

Objective 2 – Rice straw versus wheat straw in replacement heifer rations.

Wheat straw is the traditional bulk filler used in dairy heifer growing rations and is the major competition to rice straw. In January 2010, we will work with a dairy heifer growing operation to feed rice straw and wheat straw at the same intake levels in order to compare feeding performance using:

In vitro gas analysis of straws and the total TMR diet
Body weight gain
Body score
Feed intake
Fecal - lignin(sa) – using subset of heifers in the pen every 2 weeks

Objective 3 –Digestibility

<u>Experiment A.</u> Relationships between the chemical components and the forage quality of rice straw

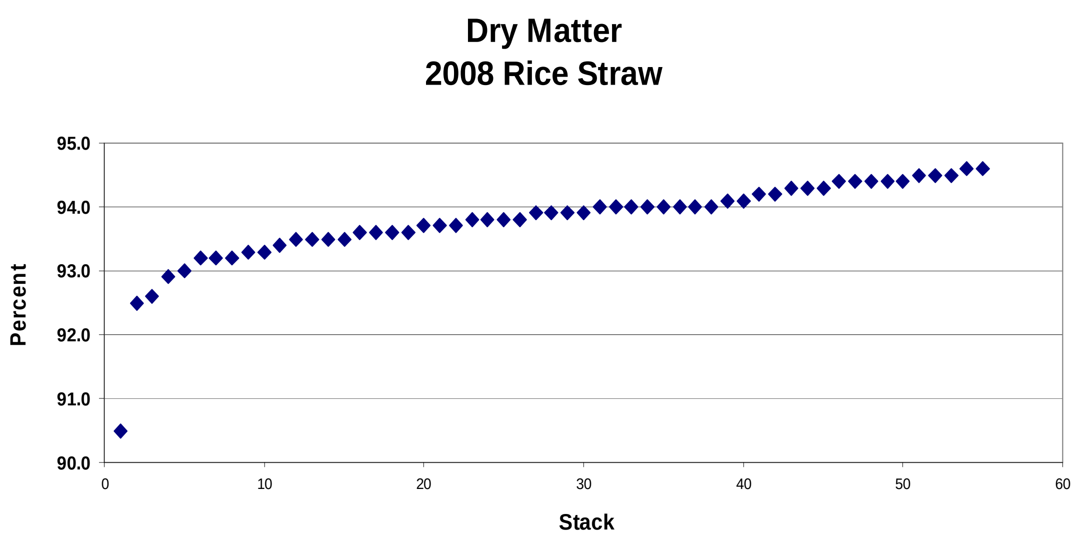
The objective was to evaluate the chemical composition and *in vitro* digestion of straw from 51 stacks of baled rice straw from across Northern California.

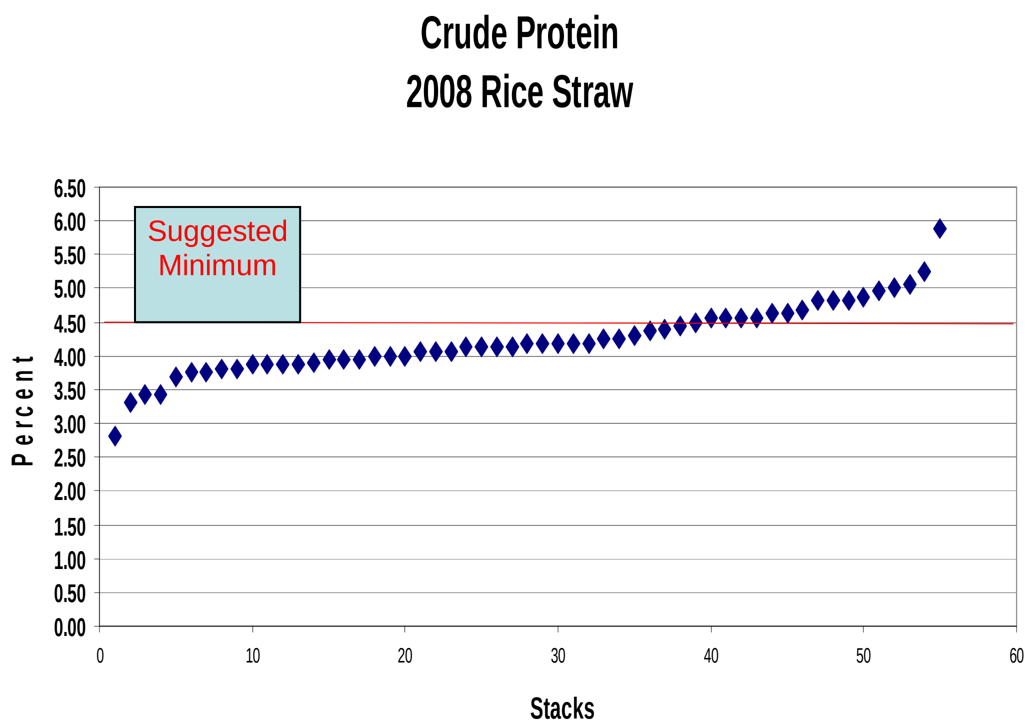
	Location	DM %	Crude Protein %	ADF %	Si (Total) [SOP 585.02] %	Ash [SOP 670.01] %	Lignin with Ash [SOP 640.03] %	Lig-Ash Free [SOP 640.03] %	ADF Ash Free [SOP 640.03] %	ADF-Reflux [SOP 640.03] %	aNDF Ash Free [SOP 650.02] %	aNDF-Reflux [SOP 650.02] %	K [SOP 550.02] %
1	Biggs	93.5	4.41	51.3	5.49	18.4	16.2	4.6	38.7	51.3	62.6	72.0	1.99
2	Biggs	93.9	4.44	49.2	5.24	16.3	15.0	4.8	37.7	49.2	61.0	69.5	1.77
3	Biggs	94.3	4.31	49.8	5.27	16.3	14.6	4.4	38.4	49.8	62.8	71.4	1.69
4	Biggs	94.4	4.81	49.4	5.05	15.7	14.8	4.8	38.8	49.4	62.8	70.7	1.57
5	Willows	94.1	4.06	47.6	4.69	15.8	14.0	4.5	37.6	47.6	61.1	68.3	2.03
6	Maxwell	93.2	5.88	48.5	4.90	16.5	15.4	5.2	37.8	48.5	60.9	68.7	2.07
7	Maxwell	94.0	4.19	49.9	5.03	16.0	14.1	4.3	39.1	49.9	64.7	72.5	1.81
8	Maxwell	94.5	3.44	48.3	5.76	18.3	15.3	4.0	38.1	48.3	62.2	71.9	1.97
9	Williams	94.6	2.81	50.6	5.03	14.6	13.4	3.9	37.7	50.6	63.4	70.8	1.28
10	Williams	93.6	4.06	47.3	4.43	15.0	12.9	4.2	37.9	47.3	63.3	69.7	1.82
11	Williams	94.6	3.94	46.7	4.69	15.2	13.2	4.3	37.2	46.7	61.0	67.6	1.93
12	Maxwell	94.4	3.94	49.2	4.51	15.1	13.4	4.4	39.3	49.2	64.6	71.6	1.71
13	Maxwell	93.7	4.13	48.9	4.25	14.6	13.6	4.8	39.7	48.9	65.0	71.2	1.53
14	Maxwell	94.5	4.63	50.4	4.79	16.1	14.0	4.5	40.4	50.4	64.8	72.0	1.99
15	Maxwell	93.5	4.38	49.2	4.73	15.3	12.2	4.1	39.5	49.2	65.5	72.4	1.84
16	Maxwell	93.8	4.56	48.7	4.95	17.4	14.7	3.9	36.8	48.7	61.0	70.2	1.66
17	Williams	93.2	4.19	48.3	4.77	15.3	13.3	4.3	38.1	48.3	63.9	70.8	1.62
18	Williams	93.6	3.81	47.2	4.31	15.1	12.1	4.0	38.0	47.2	67.6	74.1	1.92

19	Colusa	93.7	3.88	50.3	4.76	15.2	13.1	4.2	41.0	50.3	63.2	69.4	1.54
20	Colusa	94.2	3.91	50.0	4.49	15.3	13.4	4.4	39.9	50.0	65.5	72.7	1.55
21	Williams	94.0	4.50	48.7	4.66	15.4	12.9	3.9	39.0	48.7	64.0	71.0	1.68
22	Williams	93.3	4.00	50.2	5.15	19.0	16.3	3.7	37.2	50.2	61.6	71.4	1.60
23 A	Willows	94.2	3.88	51.0	5.52	17.3	15.4	4.4	39.3	51.0	63.3	72.0	1.96
23 B	Willows	94.0	3.88	50.1	5.47	16.0	15.6	5.1	39.1	50.1	62.6	70.7	1.49
23 C	Willows	93.8	3.69	50.3	4.48	15.1	14.4	4.8	40.1	50.3	64.8	72.0	1.44
24	Willows	93.3	4.63	48.4	4.01	14.4	12.4	4.2	39.3	48.4	63.6	69.8	1.83
25	Willows	93.5	4.19	48.7	4.50	15.5	14.1	4.6	38.8	48.7	63.6	70.7	1.90
26	Willows	93.6	3.75	49.7	3.75	14.0	13.1	4.7	41.0	49.7	66.5	72.3	1.73
27	Willows	94.1	4.00	49.3	3.68	13.3	12.3	4.4	41.0	49.3	67.6	73.1	1.43
28	Marysville	93.5	3.44	50.5	5.44	17.8	16.1	4.2	37.5	50.5	62.7	73.3	1.52
29	Glenn	92.6	4.19	49.4	3.49	13.7	11.8	4.2	41.1	49.4	67.5	73.3	1.87
30	Glenn	93.2	4.13	50.1	4.75	15.6	13.9	4.4	39.7	50.1	64.5	72.1	1.82
31	Glenn	92.9	4.56	48.3	4.19	15.5	14.2	4.4	38.3	48.3	62.9	70.4	1.76
32	Glenn	94.0	4.56	48.1	4.04	15.2	13.8	4.6	38.7	48.1	61.9	68.7	1.82
33	Glenn	93.7	4.88	49.5	4.40	15.9	14.5	4.8	39.2	49.5	63.7	71.1	1.73
34	Glenn	94.4	5.06	46.6	4.65	15.6	14.3	4.4	36.8	46.6	59.3	66.4	1.93
35	Willows	94.0	4.81	48.1	4.15	14.6	13.2	4.2	38.6	48.1	63.2	70.0	1.68
36	Willows	93.9	4.13	48.7	4.29	14.3	16.1	4.6	39.6	48.7	65.6	71.6	1.82
37	Willows	90.5	4.06	51.3	5.16	16.7	14.0	4.7	39.1	51.3	64.4	73.6	1.67
38	Willows	94.0	3.88	48.6	4.61	16.3	13.5	4.0	38.6	48.6	62.8	70.5	1.78
39	Princeton	93.6	4.19	46.9	4.89	16.4	14.2	4.3	36.1	46.9	59.1	67.0	1.90
40	Williams	93.8	3.31	46.5	4.28	14.4	13.3	3.7	36.9	46.5	60.9	67.8	1.25
41	Williams	94.3	4.00	48.2	4.05	14.4	12.3	4.2	39.4	48.2	65.4	71.4	1.61

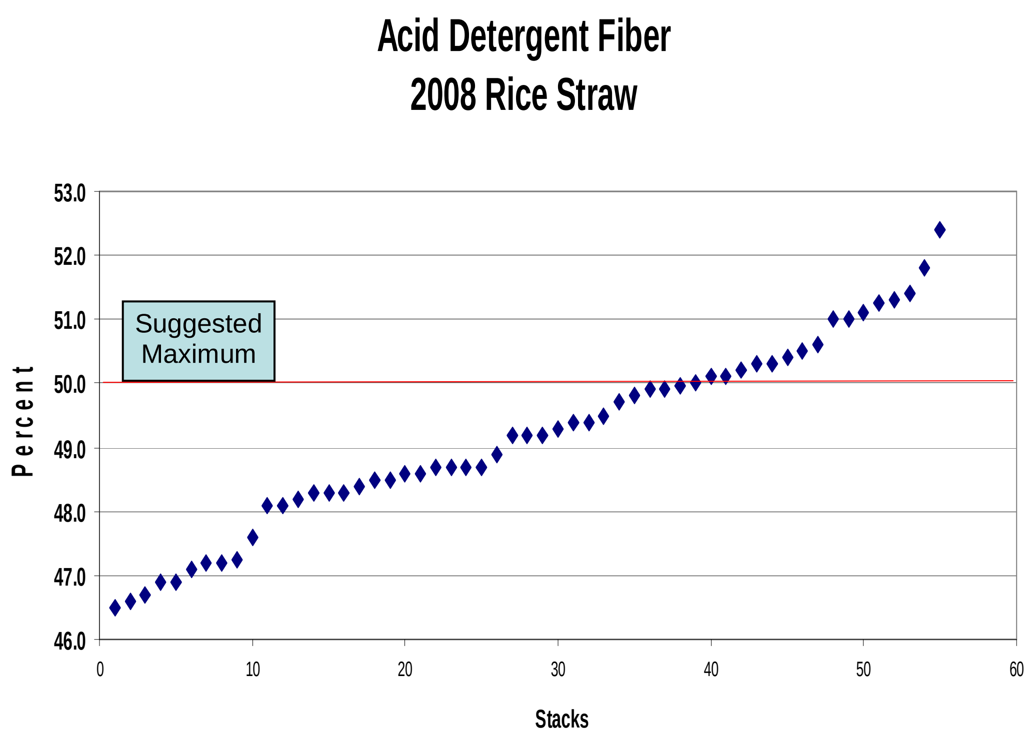
42	Williams	94.5	3.75	48.6	4.97	16.2	14.0	3.6	37.6	48.6	62.8	70.8	1.74
43	Colusa	94.0	3.81	51.8	5.24	19.6	17.1	4.4	38.6	51.8	62.9	73.7	1.55
44	Williams	93.9	4.56	47.1	5.05	16.3	13.3	3.8	36.4	47.1	59.5	67.5	1.90
45	Williams	94.4	4.81	51.0	4.89	17.2	14.6	4.2	39.4	51.0	63.3	71.6	1.68
46	Winters	94.0	5.25	48.5	3.60	13.8	12.0	5.0	41.0	48.5	67.7	72.2	1.95
47	Winters	94.4	4.25	51.1	4.80	17.7	16.1	4.9	39.9	51.1	64.8	73.0	1.98
48	Winters	94.3	4.97	47.2	4.50	16.9	14.6	4.7	37.4	47.2	60.4	67.3	1.89
49	Woodland	93.8	4.25	51.4	4.71	17.1	14.1	4.4	40.8	51.4	66.8	74.3	2.14
50	Marysville	93.4	5.00	46.9	4.94	19.2	16.7	4.5	34.4	46.9	57.6	66.9	1.91
51	Sutter Basin	93.0	3.94	52.4	5.95	20.1	18.8	5.1	37.8	52.4	61.9	73.5	1.87
52	Marysville	92.5	4.13	49.9	4.86	16.6	15.2	4.6	38.5	49.9	64.9	73.7	1.74
53	Sutter	93.9	4.69	50.0	4.12	13.6	13.3	4.9	40.9	50.0	68.6	75.0	1.35
	Maximum	94.6	5.9	52.4	6.0	20.1	18.8	5.2	41.1	52.4	68.6	75.0	2.1
	Minimum	90.5	2.8	46.5	3.5	13.3	11.8	3.6	34.4	46.5	57.6	66.4	1.3
	Average	93.8	4.2	49.2	4.7	16.0	14.2	4.4	38.7	49.2	63.4	71.0	1.7

Below are the graphs of the above data that illustrates variations in dry matter, crude protein and acid detergent fiber (ADF).





Crude Protein
2008 Rice Straw
Suggested Minimum
Percent
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
10
20
30
40
50
60
Stacks



Acid Detergent Fiber
2008 Rice Straw
Suggested Maximum
Percent
53.0
52.0
51.0
50.0
49.0
48.0
47.0
46.0
0
10
20
30
40
50
60
Stacks

<u>Experiment B.</u> Effect of Silica content on rice straw *in vitro* digestion

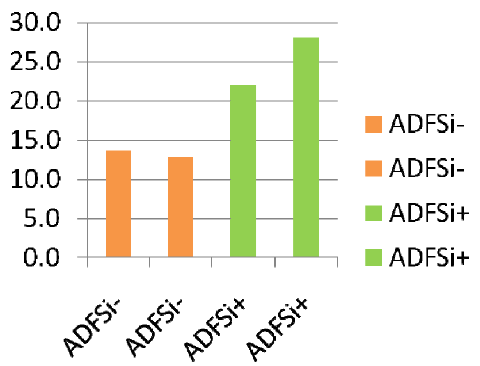
The purpose of this experiment was to determine whether the silica content of two rice straws affected their chemical composition and degradation *in vitro*. In this study, i*n vitro* measures were used to determine whether changes in degradation were related to higher silica content.

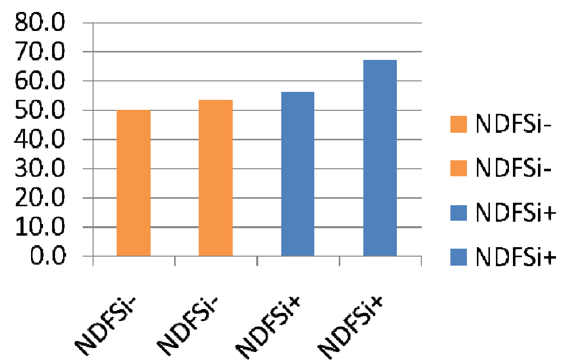
Two plots of M206 rice plants were grown under controlled conditions (plant laboratory, photo period of 11 h 30 min per day, 60 and 80% relative humidity +/- 5% day and night, respectively, temperature 28 and 26 ºC day and night, respectively), on two different culture media.

Each plant had the seed head removed and was clipped at the waterline. Plant contents were analyzed for total silica, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (lignin(sa)) and *in vitro* gas production. Ash-free NDF and ADF were calculated from the determination of their ash contents.

Silica Deficiency - ADF/NDF

	LowSi		HighSi		P				SEM	R^2
	-	+	-	+	linear	Si-vsSi+	LoHiSi	Si-vsSi-		
ADF(%DM)	13,6	22,0	12,9	28,1	0,0004	<,0001	<,0001	0,4187	1,24	0,96
NDF(%DM)	50,0	53,6	56,1	67,2	0,0004	<,0001	<,0001	0,0029	2,29	0,90





Silica Deficiency - In Vitro

	LowSi		HighSi		P				
	-	+	-	+	linear	Si-vsSi+	LoHiSi	Si-vsSi-	SEM
Si (%DM)	0,008	2,4	0,006	4,3	<0,0001	<0,0001	<0,0001	0,9921	0,18
4hgas(ml/gOM)	61,6	62,5	54,6	62,9	0,1316	0,169	0,9352	0,1479	6,256
24hgas(ml/gOM)	190,0	179,9	217,6	220,9	<0,0001	0,505	<0,0001	0,0021	9,848
48hgas(ml/gOM)	231,9	217,3	269,8	276,2	<0,0001	0,3792	<0,0001	<0,0001	8,93
72hgas(ml/gOM)	250,0	239,6	289,3	300,5	<0,0001	0,927	<0,0001	<0,0001	8,95

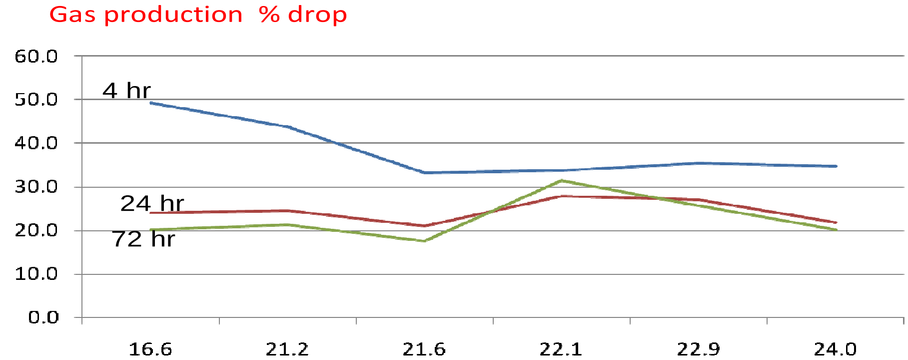
<u>Experiment C.</u> Assessment of nutritional and chemical changes in the rice plant during drying

This experiment was designed with the intent of describing differences in the *in vitro* digestion between fresh and dried rice plants and to assess changes during this process in the silica fraction of the rice plant by measuring its solubility in acid and neutral detergents.

The rice plants were grown in individual pots at the Rice Research Center in Biggs under controlled conditions (plant laboratory, photoperiod of 11 h 30 min per day, 60 and 80%relative humidity +/- 5% day and night, respectively, temperature 28 and 26 ºC day and night, respectively). The rice plants were grown in 6 groups of 6 replicates. The 6 groups were planted in intervals of 4-5 days and brought to UC Davis at the same time when the plants ranged from 135 to 155 days old.

The rice grains were collected to different containers for “head moisture” determination. As the plants were being harvested, samples were chopped by office paper choppers to generate particles between 0.5 and 2 mm in length which were placed in individual plastic containers. The samples varied from 2.5 to 6 grams each. The samples were subsequently sub-sampled for *in vitro* gas production, ADF and DM. The rest of the sample was left spread to dry for 7 days at normal room temperature (25ºC) , after which all the assays were repeated.

Wet verses Dry
In Vitro Gas Production



- 4h gas production registered the biggest drop from fresh to dry plants

	Fresh rice plants						Dry rice plants					
Groups	1	2	3	4	5	6	1	2	3	4	5	6
Grain Moisture %	22,12	23,97	22,90	21,58	21,20	16,65	-	-	-	-	-	-
DM%	32,1	32,4	31,2	34,8	33,1	34,6	92,8	92,9	92,3	93,5	92,8	93,4
Total Si %	-	-	-	-	-	-	4,92	5,19	5,00	5,23	5,22	5,00
ADFSi %	7,31	7,98	7,77	7,53	8,35	7,54	5,45	5,35	5,49	5,72	5,53	5,83
NDADFSi %	2,93	3,17	3,13	3,28	4,20	3,39	4,50	5,12	4,63	5,03	5,34	4,26
ADF (%DM)	40,13	37,84	37,51	38,93	36,34	38,63	47,93	47,88	46,41	47,64	48,57	45,72
NDADF (%DM)	34,09	32,08	30,87	32,44	36,01	34,63	37,75	39,66	44,54	38,52	39,24	36,81
24h Gas Production ml/g OM	88,43	96,79	91,83	96,79	87,47	86,01	88,43	96,79	91,83	96,79	87,47	86,01
72h Gas Production ml/g OM	169,0	181,4	177,8	176,8	176,3	168,2	169,0	181,4	177,8	176,8	176,3	168,2

PUBLICATIONS OR REPORTS:

Nader, G. and Robinson, P.H. 2008. Effects of maceration of rice straw on voluntary intake and performance of growing beef cattle fed rice straw based rations. Anim. Feed Sci. Technol. 146, 74-86.

UC web publication titled "Marketing Rice Straw" has been accepted and will be online by this spring.

UC web publication titled "Rice Straw Use in Dairy Heifer Rations" has been accepted and will be online by this spring.

CONCISE GENERAL SUMMARY OF CURRENT YEARS RESULTS

The straw data from multiple years of study was used to calculate the amount of nutrients loss from straw removal. Potassium and silica have the largest amounts removed per ton of straw, at 33 and 100 pounds per acre respectively. If growers are in an area of nutrient deficiency, straw removal may require fertilization to make for lost nutrients.

The 2002/2003 straw had some nutrients that were below required levels for maximum grain production (i.e. potassium, copper. phosphorus, sulfur). In the 2008 samples, there were some fields that were below values for required silica levels for maximum grain production. A straw baling study of one Colusa County farm that removed 1.5 tons of straw each year did not reveal a deficient level during the three year study.

Results of nutritional analysis of 53 stacks of rice straw illustrated wide variation in straw nutritional content. Results from 2008 showed lower acid detergent fiber (better digestibility) and lower crude protein than in the past. Research showed that acid detergent fiber is still the best indicative laboratory analysis of rice straw nutritional value for cattle.

Plants that were low in silica did not have any less loss in nutritional value during drying. This suggests that silica is not the reason the high loss in nutritive value during field drying.

In vitro gas production provides a good estimate of straw digestibility. Gas production, at 24 hours, was reduced by 20 to 29% with drying. The later the maturity of the plant, then the higher the loss in gas production. This demonstrates a major loss in digestibility during field drying of rice straw creates a very low nutritional value forage from one with a moderate value. **To further increase the use of rice straw by livestock, future research must focus on the reasons for this loss in nutritive value, and ways to prevent it from occurring.**