TECHNICAL NOTES

U.S. Department of Agriculture Natural Resources Conservation Service

TN-AGRONOMY CA-52 (Revised) August 2007

STRAW-GRAIN RATIO FOR CULTIVATED RICE (REVISED)

Attached is Agronomy Technical Note No. 52 (Revised), "Straw-Grain Ratio for Cultivated Rice)

This technical note is a revision of Agronomy Technical Note No. 52. The technical note describes accurate estimates for amounts of residue remaining after cultivated rice (Oryza sativa L.) is harvested. Estimates for remaining residue are obtained by using a straw to grain ratio of 1.0 for both tall and semi-dwarf rice varieties.

This technical note also includes an updated list of current varieties of rice grown in California, as well as grain types, growth characteristics and availability.

Accurate residue estimates are needed for the Conservation Security Program (CSP) and for RUSLE2 templates.

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STRAW-GRAIN RATIO FOR CULTIVATED RICE

Before 1994, the Natural Resources Conservation Service in California used a straw-grain ratio of 1.5 to estimate the amount of residues remaining after cultivated rice (Oryza sativa L.) is harvested. Based on research results, more accurate estimates will be obtained by using a straw-grain ratio of 1.0 for both tall and semidwarf rice varieties.

The new ratio is based on 12 field experiments on the nitrogen response of 12 tall and semidwarf rice cultivars with plantings from 1976 through 1985 in Butte, Glenn, Colusa, and Sutter Counties (S.R. Roberts, et. al.). The semidwarf cultivars were: M-7, M-9, S-201, M-201, M-202, L-202, Calbelle, Calpearl, and Calrose 76. The tall cultivars were: S-6, CS-M3, and Earlirose.

The straw-grain ratio represents the yield of residues compared to the yield of harvested grain. Another ratio reported in research papers is the harvest index. The harvest index represents the yield of harvested grain compared to the biological yield (weight of grain plus residues). A harvest index of 0.5 translates into a straw-grain ratio of 1.0.

MATERIALS AND METHODS

The experimental design was a split plot in a randomized complete block with Nitrogen (N) rates as main plots and cultivars as subplots. Main plots were replicated four times in each experiment. Nitrogen was applied preplant at 0, 30, 60, 90, 120, 150, 180, and 210 lb/acre. The N source was Ammonium Sulfate banded 4-5 inches deep every 8 inches. The seeding rate was 140 lb/acre (55-60 seeds/sq. ft).

The nine semidwarf cultivars included two short grain types (very early Calpearl and early S-201), five medium grain types (early M-9, M-201, M-202, and late M-7, and Calrose), and two long rain types (very early Calbelle and early L-202). The three tall cultivars included one short grain type (early maturing S-6) and two medium grain types (very early Earlirose and late CS-M3).

The crops were grown using conventional California rice culture. Grain and straw yields are from a 150 square foot sample at the center of each plot harvested using a self-propelled plot combine with the header cutting at ground surface. Grain and straw weights were converted to a dry weight basis. Tables 1 and 2 are from the University of California ANR Publication 21498 “Rice Production in California” and provide more information on the rice variety naming system and several rice cultivars.

RESULTS AND DISCUSSION

Biological yield was not significantly different between tall and semidwarf cultivars. The straw yield represented a larger part of the biological yield of tall cultivars compared to semidwarf cultivars. Semidwarf cultivars produced less straw than tall cultivars at any applied N rate. The semidwarf cultivars had higher grain yields at all applied rates.

The experimental results were used to generate the following response functions to annual N applications (lb/acre):

Grain Yield

Tall Cultivars	3425 lb/acre + 45.85(N) – 0.1843(N^2)
Semidwarf	3489 lb/acre + 50.64(N) – 0.1699(N^2)

Straw Yield

Tall Cultivars	2368 lb/acre + 55.47(N) – 0.1131(N^2)
Semidwarf	2298 lb/acre + 49.35(N) – 0.1145(N^2)

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These response functions were used to generate the grain yield and straw yield curves presented in Figures 1 taken from ANR Publication 21498 “Rice Production in California”. They predict the maximum grain yields of the semidwarf cultivars to be 7,262 lb/acre at 149 lb N/acre and the maximum grain yield for the tall cultivars to be 6,277 lb/acre at 124 lb N/acre. Straw-grain ratios can be derived using these response functions.

California rice growers may apply 90 to 120 lb N/acre for tall cultivars but generally prefer the 90 lb/acre rate to minimize lodging. Semidwarf cultivars are fertilized at 120 to 150 lb N/acre. Lodging is not a problem at higher rates for semidwarf cultivars but can lead to delayed heading and floret sterility.

The following straw-grain ratios are based on the commonly used N application rates and the reported response function for grain yields and straw yields of rice.

Tall Cultivars

Applied N (lb/acre)	Straw Yield (lb/acre) 1/	Grain Yield (lb/acre) 1/	Straw-Grain Ratio
80	6,080	5,910	1.03
90	6,440	6,060	1.06
100	6,780	6,170	1.10

Semidwarf Cultivars

Applied N (lb/acre)	Straw Yield (lb/acre) 1/	Grain Yield (lb/acre) 1/	Straw-Grain Ratio
120	6,570	7,120	0.92
130	6,780	7,200	0.94
140	6,960	7,250	0.96
150	7,120	7,260	0.98

1/ Yields are rounded to nearest 10 lb/acre.

Based on this data and the recommendation of University of California Extension Agronomist J.E. Hill, adopting a straw-grain ratio of 1.0 will provide a reasonably accurate estimate of rice residues.

Eight to ten percent variability above or below this ratio is considered to be within the acceptable tolerance. This can be demonstrated using the data above for a field that produced a tall cultivar fertilized at the 90 lb N/acre. Using the 1.0 ratio, we would estimate 6,060 lb/acre of straw, which is 380 lbs or 6 percent less than expected. Likewise, if the crop was fertilized at 100 lb N/acre, we would estimate 6,170 lb/acre of straw, which is 610 lbs or 10 percent less than expected.

Our estimate could be 140 lbs/acre of straw or 2 percent too high in the case of a field that produced a semidwarf cultivar fertilized at 150 lb N/acre. Likewise, if the crop was grown using 120 lb N/acre, we would estimate 7,120 lb/acre of straw, which is 550 lbs or 8 percent more than expected.

Therefore, using a straw-grain ratio of 1.0 for cultivated rice in California produces acceptable estimates of crop residues and is more accurate than the old ratio of 1.5.

REFERENCES

J.E. Hill, S.R. Roberts, D.M. Brandon, S.C. Scardaci, J.F. Williams, C.M. Wick, W.M. Canevari, and B.L. Weir. 1992. *Rice Production in California*. University of California, ANR Publications, Publication 21498.

S.R. Roberts, J.E. Hill, D.M. Brandon, B.C. Miller, S.C. Scardaci, C.M. Wick, and J.F. Williams. 1993. *Biological Yield and Harvest Index in Rice: Studies on the Nitrogen Response of Tall and Semidwarf Cultivars.* Submitted for publication in the Journal of Production Agriculture.

Table 1. Outline of the California rice variety naming system. 1/ 2/

Grain type	Very Early	Early	Intermediate	Late
Short (S)	S-101 to S-199	S-201 to S-299	S-301 to S-399	S-401 to S-499
Medium (M)	M-101 to M-199	M-201 to M-299	M-301 to M-399	M-401 to M-499
Long (L)	L-101 to L-199	L-201 to L-299	L-301 to L-399	L-401 to L-499
Waxy or sweet (Calmochi)	Calmochi-101 to Calmochi-199	Calmochi-201 to Calmochi-299	Calmochi-301 to Calmochi-399	Calmochi-401 to Calmochi-499
Aromatic (A)	A-101 to A-199	A-201 to A-299	A-301 to A-399	A-401 to A-499

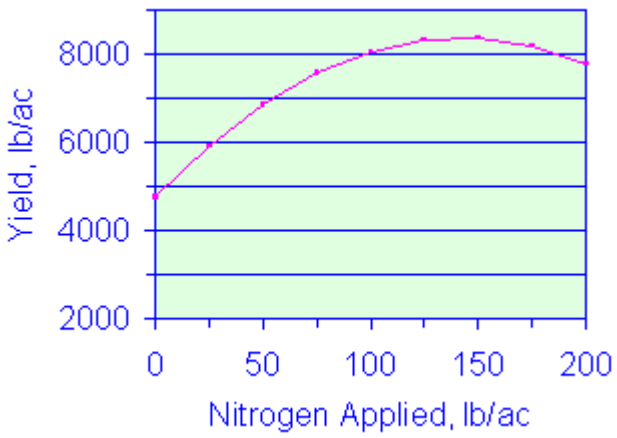
1/ University of California ANR Publication 21498: *Rice Production in California*.
2/ Maturity group is the number of days to 50 percent heading at the Rice Experiment Station at Biggs.

Table 2. Grain Type and Growth Characteristics of California Rice Cultivars.

Variety	Grain Type	Growth Characteristic and Availability 3/
Akitakomachi	Short Grain	Tall
Arborio	Short Grain	Tall
Kokuho Rose	Medium Grain	Tall - Private variety
Koshihikari	Short Grain	Tall
S-102	Short Grain	Semidwarf
S-201	Short Grain	Semidwarf - No more seed production
Calhikari-201	Short Grain	Semidwarf
Calmochi-101	Short Grain	Semidwarf
Valencia 87	Short Grain	Semidwarf
M-103	Medium Grain	Semidwarf - No more seed production
M-104	Medium Grain	Semidwarf
M-201	Medium Grain	Semidwarf - No more seed production
M-202	Medium Grain	Semidwarf
M-203	Medium Grain	Semidwarf - No more seed production
M-204	Medium Grain	Semidwarf - Seed production ended in 2006
M-205	Medium Grain	Semidwarf
M-206	Medium Grain	Semidwarf
M-207	Medium Grain	Semidwarf - Seed production ended in 2007
M-208	Medium Grain	Semidwarf
M-401	Medium Grain	Semidwarf
M-402	Medium Grain	Semidwarf
CalPearl	Medium Grain	Semidwarf
L-202	Long Grain	Semidwarf - No more seed production
L-203	Long Grain	Semidwarf - No more seed production
L-204	Long Grain	Semidwarf - Seed production ended in 2007
L-205	Long Grain	Semidwarf
L-206	Long Grain	Semidwarf
A-201	Long Grain	Semidwarf
A-301	Long Grain	Semidwarf
Calmati-201	Long Grain	Semidwarf
Calmati-202	Long Grain	Semidwarf

3/ Groupings based on the following plant heights: Semidwarf being < 37.4 inches (95 cm), Intermediate from 37.4 to 41.3 inches (95-105 cm), and Tall being > 41.3 inches (105 cm).

Figure 1. A Typical Nitrogen Response of California Semidwarf Rice Varieties. 4/



4/ Copy of Figure 15 from "Rice Production in California" by J.E.Hill, et. al., University of California Cooperative Extension.

Table 3. Rice Varietal Characteristics 5/

S-102

Grain Type: Short grain Maturity: Very Early Growth: Semidwarf Height: 36.2 in (92 cm)
Relative Yield Potential (lb/acre, 1996): 96% of M-202
Comments:
Very high yield potential and two weeks earlier than S-201. Released in 1996 with good resistance to low temperature blanking. Grain is 8% larger than S-201 with less chalkiness. Pubescent leaves and hulls; grain dries down rapidly during ripening. Susceptible to stem rot.

M-104

Grain Type: Medium grain Maturity: Very Early Growth: Semidwarf Height: 35.9 in (91 cm)
Relative Yield Potential (lb/acre, 1999-2003 5-yr. avg. at Biggs RES): 100 % of M-202
Comments:
M-104 is a glabrous, Calrose quality variety released in March 2000. Compared to M-103 which is no longer being grown, it heads at the same time, has improved lodging resistance, yields 8% higher and has similar whole grain and milled rice yields. Compared to M-202, M-104 heads 8 days earlier, has similar resistance to blanking by cool temperatures, and has similar yield, seed size and kernel weight. M-104 is susceptible to blast race IG-1 found in California.

M-202

Grain Type: Medium grain Maturity: Early Growth: Semidwarf Height: 36.5 in (93 cm)
Relative Yield Potential (1999-2003 5-yr. avg. at Biggs RES): 9,950 lb/acre
Comments:
Very high yield potential. Performs better in cooler growing areas than M-201 which is no longer being grown. Matures three days earlier, ripens more uniformly, and more resistant to blanking than M-201. Moderate lodging. Threshes easily but does not shatter. Harvest moisture should not be below 18% nor above 22%.

M-205

Grain Type: Medium grain Maturity: Early Growth: Semidwarf Height: 34.0 in (86 cm)
Relative Yield Potential (lb/acre, 1999-2003 5-yr. avg. at Biggs RES): 109% of M-202
Comments:
M-205 heads four days later and is 2-3 inches shorter than M-202. It has improved lodging resistance and its milling quality is comparable to or better than M-202. M-205 is sensitive to cool temperature blanking similar to M-202. Avoid excessive seeding rates.

5/ Conversions: inches * 2.54 = cm and cm * 0.3937= inches

M-206

Grain Type: Medium Maturity: Very Early to Early Growth: Semidwarf Height : 38.6 in (98 cm)
Relative Yield Potential (lb/acre, 1999-2003 avg. at Biggs RES): 101 % of M-202

Comments:

Compared to M-204, M-206 has improved lodging resistance, slightly more yield, and improved potential for whole kernel milled rice. Compared to M-202, it has improved lodging resistance, improved resistance to blanking caused by cool temperatures, slightly more yield, and has improved potential for whole kernel milled rice. M-206 is susceptible to blast race IG-1 found in California. Matures four days before M-202. Avoid excessive seeding rates.

M-208

Grain Type: Medium Maturity: Early Growth: Semidwarf Height: 39.4 in (100 cm)
Relative Yield Potential (lb/acre.): 102 % of M-202

Comments:

M-208 was released in 2006 with blast resistance to race IG-1 found in California. It has improved lodging resistance and improved total and whole kernel milling yield compared to M-207 whose seed production ended in 2007. It is adapted to the majority of M-202 growing areas. Fertilization requirements are similar to M-202.

M-401

Grain Type: Medium Maturity: Late Growth: Semidwarf Height: 38.7 in (98 cm)
Relative Yield Potential (lb/acre, last 5-yr. avg.): 96% of M-202

Comments:

Premium quality rice with large kernels. Good yield potential but susceptible to blanking, lodging, and damage from early drainage. Use somewhat less nitrogen than on other varieties. Best adapted to warmer areas. Milling yields lower than other medium grains.

M-402

Grain Type: Medium Maturity : Late Growth: Semidwarf Height: 39 in (99 cm)
Relative Yield Potential (lb/acre, last 5-yr. avg.): 104% of M-202

Comments:

Premium quality rice variety released in 2001. M-402 heads 6 days earlier, about two inched shorter in height, and half as much lodging as M-401. Seedling vigor, disease resistance, cold tolerance, and grain yield potential comparable to M-401. Kernel size and weight are smaller than M-401. M-402 has a higher head rice milling yield compared to M-401. M-402 is susceptible to the IG-1 race of blast.

L-205

Grain Type: Long Maturity: Early Growth: Semidwarf Height: 35.8 in (91 cm)
Relative Yield Potential (lb/acre, 1994-98 5yr avg.): 87% of M-202

Comments:

L-205 is an early maturing, smooth, semidwarf Newrex type long grain, with improved milling yield and dry cooking characteristics. Photoperiod insensitive, it heads 2 days later than L-204 whose seed production ended in 2007. It heads at the same time as L-203 which is no longer being grown. Seedling vigor is slightly weaker and it is about 2 inches taller than L-203 and L-204. It is slightly more susceptible than L-203 and L-204 to stem rot and aggregate sheathspot. Due to cold weather sensitivity, do not grow in the coolest rice areas of California. L-205 seed is smaller and weighs less than L-203 and L-204. L-205 has milling yields similar to L-204 and higher than L-202. Harvest at relatively low moisture content, 16-18%, for maximum head rice. L-205 is suitable for traditional US long-grain markets and for processing (parboiling, soup, noodles).

L-206

Grain Type: Long grain Maturity: Very Early to Early Growth: Semidwarf Height: 33.5 in (85 cm)
Relative Yield Potential (lb/acre): 100 % of M-202

Comments:

L-206 was released in 2006 with better taste characteristics than L-204 and L-205. Seedling vigor is similar to L-205 and slightly lower than M-202.. It is 6 cm shorter than L-205 and 11 cm shorter than M-202. L-206 has slightly higher resistance to cold induced blanking than L-204.

A-201

Grain Type: Long grain Maturity: Early Growth: Semidwarf Height: 39.4 in (100 cm)
Relative Yield Potential (lb/acre, 5-yr. avg.): 92% of M-202

Comments:

Aromatic (popcorn aroma) long grain specialty rice variety that matures eight days earlier than A-301. It has moderate yield potential similar to L-202 and A-301 but becomes leafy under excessive nitrogen. A-201 has poor milling yield. Need to use slower cylinder speed and harvest at 18-20 percent grain moisture. Need to air dry without heat to retain aroma.

A-301 Grain Type: Long grain Maturity: Intermediate Growth: Semidwarf Height: 33.9 in (86 cm)
Relative Yield Potential (lb/acre, 5-yr. avg.): 92% of M-202

Comments:

An aromatic ("popcorn" aroma) long grain specialty variety. Moderately high yield in warmer areas. Not adapted to late seeding dates, deep water or cool areas. Seedling vigor fair to poor. Suggest harvest moisture of 20-22% and air drying without heat to retain maximum aroma. Has excellent straw strength.

Akitakomachi

Grain Type: Short grain Maturity: Very early Growth: Tall Height: 42 in (107 cm)
Relative Yield Potential (lb/acre, 5-yr. avg.): 70% of M-202

Comments:

This premium quality specialty Japanese variety is agronomically inferior to California rice varieties but it has exceptional milling yields. Seedling vigor is weaker than most California varieties, about equivalent to A-301. Slow seedling growth may increase risk of herbicide damage and poor stand establishment. The hulls are pubescent resulting in a quicker drydown than smooth varieties. The straw is weak and lodging is usually severe. Low nitrogen rates should be used, 30 to 60 lb N/acre preplant followed with a topdressing at panicle initiation if needed (no more than 100 lbs total. Harvest at 22% moisture or less.

Arborio

Grain Type: Short grain Maturity: Early Growth: Tall Height: 51.2 in (130 cm)

Comments:

This premium quality Italian variety is named after a town in northwest Italy and is one of the most popular varieties used for Italian risotto recipes. Arborio rice is a short, pearly white, very plump rice that contains more soluble starch than many other types of rice. The starch is released during cooking which makes a smooth and creamy risotto or soup.

Calamylow-201

Grain Type: Short grain Maturity: Early Growth: Semidwarf Height: 35 in (88 cm)
Relative Yield Potential (lb/acre, 2002-2004 3 yr avg.): 75% of M-202

Comments:

This premium quality low amylase cultivar was released in 2006 for a new developing rice market. Low amylose (6-10%) rice has been found to be more resistant to staling and this trait has been incorporated into Japanese cultivars for use in chilled or frozen rice products. Agronomic performance and adaptation is below improved California rice cultivars but was released because of its special cooking and processing characteristics. It is very similar to Calhikari-201 but has smaller kernel size and significantly lower grain yields. High rates of nitrogen fertility induced severe lodging.

Calhikari-201

Grain Type: Short grain Maturity: Early Growth: Semidwarf Height: 34.6 in (88 cm)
Relative Yield Potential (lb/acre, 1996-1998 3-yr. avg. at Biggs RES): 88% of M-202

Comments:

This variety represents the first release of an adapted premium quality short grain for California. It has the cooking characteristics of Koshihikari and the advantages of California short grains. Agronomic performance and yield are better than Koshihikari but its cooking quality is below Koshihikari. Calhikiri-201 is susceptible to stem rot and cool temperature induced blanking. Yields are less than S-102. Susceptible to the IG-1 race of blast. Seed first available in 2001.

Calmati-201

Grain Type: Long grain Maturity: Early Growth: Semidwarf Height: 39.4 in (100 cm)
Relative Yield Potential (lb/acre, 1996-1998 3-yr. avg. at Biggs RES): 77% of M-202

Comments:

Specialty – basmati type released in 1999. Has cooked kernel elongation and cooking qualities that approach those of imported basmati rice with slightly less flakiness. It is susceptible to cold induced blanking. Yields are lower than standard varieties due to their small and slender kernels.

Calmati-202

Grain Type: Long grain Maturity: Early Growth: Semidwarf Height: 35.8 in (91cm)
Relative Yield Potential (lb/acre): 74% of M-202

Comments:

Specialty – basmati type released in 2006 for its improved basmati-type kernel and cooking characteristics that approach those of imported basmati rice. Milled kernels were significantly longer than Calmati-201 and slightly shorter than imported basmati rice. Grain width is more slender than Calmati-201 but not as slender as imported basmati rice. Seedling vigor is similar to L-205 and M-202. Plant height is the same as L-205 and 8 cm shorter than M-202. Yield potential was significantly lower than L-205 and M-202 in 2003 to 2005 testing.

Calmochi-101

Grain Type: Short grain Maturity: Very Early Growth: Semidwarf Height: 36.5 in (93 cm)
Relative Yield Potential (lb/acre, 7-yr. avg.): 94% of M-202

Comments:

A sweet glutinous, waxy specialty rice. Matures two weeks earlier than S-201. Excellent resistance to low temperature blanking. Has rough leaves and hulls, no awns. Grains dry down rapidly during ripening. Be careful not to contaminate with other varieties. FSA non-program rice.

CalPearl

Grain Type: Medium grain Maturity: Very Early Growth: Semidwarf Height: 35.4 in (90 cm)
Relative Yield Potential (lb/acre, 5-yr. avg.): 94% of M-202
Comments:
For specialty market. Pubescent 1981 release with stiffer culms and better lodging resistance than Calrose 76. Yields are 10% higher than Calrose 76.

Kokuho Rose

Grain Type: Medium grain Maturity: Late Growth: Tall Height: 48.8 in (124 cm)
Relative Yield Potential (lb/acre, 5-yr. avg.): 74% of M-202
Comments:
Introduced in 1963 for specialty market. Has light nutty flavor with slightly sweet aroma. Grown exclusively by Rice Researcher, Inc. and Koda Farms in Dos Palos.

Koshihikari

Grain Type: Short grain Maturity: Late Growth: Tall Height: 44 in (112 cm)
Relative Yield Potential (lb/acre, 5-yr. avg.): 62% of M-202
Comments:
This premium quality specialty Japanese variety is agronomically inferior to California rice varieties but it has exceptional milling yields. Seedling vigor is better than Akitakomachi but lower than most California varieties. Slow seedling growth may increase risk of herbicide damage and poor stand establishment. The hulls are pubescent resulting in a quicker drydown than smooth varieties. The straw is weak and lodging is usually severe. Low nitrogen rates should be used, 30 to 60 lb N/acre preplant followed with a topdressing at panicle initiation if needed (no more than 100 lbs total. Harvest at 22% moisture or less.

Valencia 87

Grain Type: Short grain Maturity: Intermediate Growth: Semidwarf Height: 35.8 in (91 cm)
Yield Potential (lb/acre, last 5-yr. avg.): 107% of M-202
Comments:
Sensitive to blanking, sensitive to early planting, dries down fast. Grains are large, translucent kernels.
Specialty rice