Variety Selection and Management

Section authors:

Jack Williams, UCCE

Kent McKenzie, RES

Introduction and History

Since its beginning in 1912, California's rice industry limited its production and marketing largely to a few short and medium grain japonica varieties, developed from stocks originating in Japan and China. These varieties produced good yields of quality rice in the dry, temperate climate of the Sacramento and San Joaquin Valleys. For the grower, the choice of variety to plant was relatively simple because the few varieties available were similar in performance, yield potential and milling quality when properly managed. Included were Colusa, Caloro and Calrose released in 1918, 1921 and 1948, respectively, and Earlirose, a productive, early maturing, proprietary variety, released in 1965 which soon became a popular variety for cold areas and/or late plantings. These were the major rice varieties grown in California until the early 1970's.

Then, the variety picture began to change significantly. A powerful impetus for this was the enactment of California Rice Research Marketing Order that established the California Rice Research Board in 1969. This grower initiative provided significant and regular funding to hasten development and release of new varieties. The medium grain variety CS-M3 was released in 1970 and the short grain variety CS-S4 in 1971, from rice hybridizations made in 1946 and 1957 at the Rice Experiment Station (RES) at Biggs, CA. CS-M3 gained wide acceptance and competed with the older Calrose for acreage. But, CS-S4, though an improvement over Caloro, was not widely grown because of its susceptibility to low temperature induced sterility. The last tall stature variety from the RES breeding program, M5, was released in 1975.

In 1976, Calrose 76, the first short stature (semidwarf) California rice, was released. This late maturing medium grain variety was a radiation induced mutant selected by the USDA in Davis in 1971. It was soon followed by the semidwarf M9, developed by hybridizing the tropical "green revolution" variety IR-8 by RES. Thus began the era of short stature rice in California, which was to have enormous consequences. Subsequently, numerous varieties have been released in a range of maturity groups with different grain shapes and culinary characteristics. More detailed historical information regarding California varieties is given in Appendix A.

Acreage

Publicly developed and introduced rice varieties are grown annually on about 96% of the planted acres, and over twenty proprietary varieties are grown on the rest. See Table 1 for current acreage of varieties; long term acreage of varieties is given in Appendix B. Most varieties growing in California are short and medium grain japonica types with origins

from the cooler rice climates of the temperate latitudes. About 80% of the acreage is planted to 'Calrose' type medium grains varieties destined for a host of purposes including table rice and manufactured uses. California short and long grain varieties are also planted on one to two percent of the acres. Premium quality medium and short grain rice is grown on 10-11% of acres, and is destined for higher price table rice markets. Additional small acreages of specialty varieties are also planted, such as sweet rice (also called mochi, glutinous or waxy), arborio types, and aromatic long grains including conventional and a basmati type.

Naming System for Public Varieties in California

In 1979, the California rice industry developed a uniform naming system for new, public ally developed rice varieties, based on grain type, maturity group and order of release. This was necessary to avoid confusing the large number of varieties to prevent mixing of different type grains and to avoid inappropriate planting dates. Varieties should be referred to by their complete letter, numerical and descriptive name because deleting any component may lead to serious errors.

***Table 1**. 2003 Rice acreage by variety*[1]

Rice Variety by Grain Type	2002				2003			
	SEED[2]		TOTAL[3]		SEED[2]		TOTAL[3]	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
SHORT GRAIN								
S-102	508	2.25	8,943	1.66	342	1.78	9,071	1.85
Akitakomachi	NA	NA	5,618	1.04	NA	NA	7,497	1.53
Kosihihikari	NA	NA	6,320	1.17	NA	NA	4,659	0.95
Calmochi-101	262	1.16	13,869	2.57	469	2.44	15,843	3.23
Other	NA	NA	NA	NA	21	0.11	3,065	0.63
Subtotal	**770**	**3.41**	**34,750**	**6.43**	**833**	**4.33**	**40,135**	**8.19**
MEDIUM GRAIN								
M-103	68	0.30	2,045	0.38	87	0.45	7,756	1.58
M-104	2,453	10.87	41,862	7.75	2,322	12.09	62,865	12.83
M-201	0	0.00	1,475	0.27	0	0.00	4,000	0.82
M-202	8,162	36.18	247,200	45.77	7,180	37.37	221,883	45.28
M-204	2,146	9.51	56,629	10.48	1,520	7.91	33,261	6.79
M-205	6,175	27.38	88,497	16.39	4,218	21.96	69,635	14.21
M-206	8	0.00	8	0.00	591	3.07	591	0.12
M-401	1,838	8.15	32,210	5.96	1,449	7.54	18,607	3.80
M-402	360	1.60	6,607	1.22	164	0.86	9,466	1.93
Other	NA	NA	18,367	3.40	NA	NA	12,175	2.48
Subtotal	**21,210**	**94.00**	**494,900**	**91.63**	**17,530**	**91.25**	**440,238**	**89.84**
LONG GRAIN								
L-204	78	0.35	1,200	0.22	139	0.72	1,929	0.39
L-205	6	0.03	2,099	0.39	28	0.15	1,893	0.39
A-201	49	0.22	1,203	0.22	43	0.22	1,455	0.30
A-301	73	NA	1,469	0.27	92	0.48	790	0.16
Calmati-201	33	0.14	336	0.06	21	0.11	874	0.18
Other	NA	NA	NA	NA	NA	NA	500	0.10
Subtotal	**238**	**1.06**	**6,306**	**1.17**	**323**	**1.68**	**7,441**	**1.52**
Other[4]	346	1.53	4,153	0.77	525	2.73	2,235	0.46
TOTAL	**22,557**	**100.00**	**540,100**	**100.00**	**19,210**	**100.00**	**490,049**	**100.00**

[1]Estimates based on survey of rice millers and marketers and certified seed acreage conducted by Rice Experiment Station, PO Box 306, Biggs, CA 95917-0306, 530-868-5481.

[2]Planted acreage of all classes of certified rice seed provided by California Crop Improvement Association.

[3]Estimates of total rice acreage based on rice millers and marketers survey and seed acreage.

[4]Other varieties include: Short Grains S-201, Calhikari-201, and Hitomebore; Medium Grains SP 411; and specialty varieties.

The name of a new variety contains a prefix letter designating its grain type as long (L), medium (M) or short (S). Specialty rice will carry a descriptive word prefix, such as Calmochi for waxy or sweet rice, Calmati for basmati-like rice, Calhikari for premium quality short grain rice, and A for aromatic rice. Immediately following the letter or name descriptor is a three digit number separated by a dash (-) from the letter or name. The first digit in the number designates the maturity group as either 1 (very early), 2 (early), 3 (intermediate) or 4 (late). The last two digits indicate the order of release of this type, from 01 to 99, starting in 1979 when this system began. For example, M-202 indicates an early maturing medium grain variety which was second in order of release.

Table 2. *Outline of the California public rice variety naming system and public varieties grown in 2002. Grain type letter(s) are combined with a numeric descriptor. The first digit is the maturity group, the others are the order of release.*

Grain Type	Very Early (100-199)	Early (200-299)	Intermed. (300-399)	Late (400-499)
Short (S)	S-102	-	-	-
Medium (M)	M-103 M-104	M-201 M-202 M-204 M-205 M-206	-	M-401 M-402
Long (L)	-	L-204 L-205	-	-
Calmochi sweet rice (CM)	CM-101	-	-	-
Aromatic (A)	-	A-201	A-301	-
Calhikari short premium (CH)	-	CH-201	-	-
Calmati basmati type (CT)	-	CT-201	-	-

Proprietary and Introduced Varieties

In addition to the publicly developed varieties, some varieties of Japanese origin are also grown and retain their Japanese name, such as Akitakomachi and Koshihikari. Several companies also introduce or develop varieties for California while others have introduced varieties with unique characteristics such as colored bran, aroma, and special culinary properties. There are approximately 21 such proprietary varieties. They are named by the proprietor.

Table 3. *Proprietary and introduced rice varieties in California.*

Ownership	Short	Medium	Long
Proprietary	Calpearl NFD 108 NFD 109 SP-2 Surpass WRS-4431	NFD-181 85-101-10 91-130-02 94-158-01 95-164-01 KR-4 Kukuhorose Millrose SP-211 SP-311 SP-411 WRM-3538	Donana P-2 Denosa P-3 Isla
Introductions	Akitakomachi Hitomibore Koshihikari Sasanishiki Koganemochi	Arborio Calriso Baldo Guadiamar	Wehani Lundberg Black Japonica HongKong Black Rojto Black Rice

Grain and Plant Characteristics Important for Management

Successful production and marketing of rice requires knowledge of plant and grain characteristics. Since a rice grower's first concern is usually the market for which the crop is intended, primary consideration must be given to grain shape, appearance and culinary characteristics. Second, yield performance is usually an important criterion for variety selection, although for certain varieties, market quality outweighs yield. Varieties should also be chose on the basis of their relative maturity so they can fit the cropping schedule of a particular farming operation or are suitable to a particular climatic condition. For example, late maturing varieties fit early planting schedules; cold tolerant varieties are needed for cooler areas. Agronomic characteristics, such as lodging and nitrogen response may also be considered in addition to straw quantity and quality and pubescence (rough or smooth leaf and hull). Currently, no California varieties have insect, disease or herbicide resistance, but will in the future, which may become a primary selection criterion. Rice plant and grain characteristics are discussed below.

Grain Characteristics

Grain Shape

Rice grains are classified as short, medium or long grain. The specific size and shape classification limits of brown rice kernels are shown in Table 4.

Table 4. *Approximate size and shape classifications for California rice varieties, brown basis.**

Rice Class	Length (mm)	Width (mm)	Length/width	Kernel wt. (g/1000 kernels)
Premium short	5.2	2.8	1.8	20.2
Short	5.5	3.3	1.7	27.6
Premium medium	6.7	3.0	2.2	23.9
Medium	6.1	2.9	1.9	23.8
Arborio	6.3	3.3	1.9	25.3
Long	7.8	2.2	3.5	21.5
Aromatic	8.2	2.1	3.9	23.1
Basmati type	7.5	2.1	3.6	21.0
Mochi	5.3	3.0	1.8	23.9

*Adapted for California varieties from the publication *"Production of Quality Rice in South Eastern Australia"* (Chapter 13)

Grain Quality

Milling, market and cooking/culinary qualities are mentioned here because they are influenced by varietal selection and management methods. For example, genetic characteristics influence milling quality, which will influence choice of variety. In addition, many quality components of Japanese premium short grain varieties are influenced by production practices. Refer to "Rice Quality Workshop," UC Cooperative Extension website (http://agronomy.ucdavis.edu/uccerice/index.htm) for a more extensive treatment.

Grain Starch Content

Amylose is a straight chain glucose molecule, as contrasted to amylopectin, a larger highly branched glucose molecule. In general, the more amylose a variety has, the less sticky. The majority of California rice is Calrose type medium grain and has low amylose content which tends to make it soft when cooked and the grains tend to stick together. "Calrose" is a marketing term that refers to all non-premium quality medium grain rice varieties with cooking/culinary characteristics similar to the original Calrose variety. Demand for Calrose varieties remains strong, and they occupy over 80% of the state's acreage. California non-premium short grain rice also has low amylose and cooks similarly to Calrose and is used as table rice, brown rice, and rice cakes.

Long grain rice in California has higher amylose than medium and short grain which imparts a firm, dry characteristic when cooked. Most California long grain varieties released to date tend to cook softer than their Southern counterparts and are not generally sold in typical long grain markets, although the goal is to develop a long grain variety adapted to California with Southern US cooking characteristics.

Scent: Aromatic and Basmati Types

A few California varieties, such as A-301, are known as aromatic and have a distinctive scent, similar to popcorn, particularly when cooked. The scent is also discernible in the field. It is from a high 2-acetyl-1-pyrroline content compared to non-aromatic varieties. In addition to aroma, Basmati-type varieties (Calmati-201) also have a cell wall arrangement in the grain that results in grain lengthening during cooking as compared to other varieties which tend to expand uniformly when cooked. Otherwise, they have amylose starch content similar to other long grain varieties. Aromatic and Basmati type rice sells in a unique market. The presence of aroma makes it very important to maintain identity preservation of aromatic varieties to avoid mixtures with non-aromatic types.

Arborio/Chalky Types

Arborio is the name of a short grain variety from Italy and a market type for similar varieties grown in California. This type is characterized by having a very large kernel, and an excessive amount of chalkiness which is the presence of white, opaque areas within the milled kernel, as contrasted to the translucent whiteness of most varieties. Chalk is a heritable defect and is one of the first things rice breeders eliminate in most varieties because it results in low milling yields and poor appearance. Chalk is referred to as white belly and other names, depending on the position of the chalk on or in the milled kernel. But for Arborio, chalk is associated with superior culinary properties for specific dishes, primarily risottos. Other than genetics, chalkiness is caused by high harvest moisture, uneven ripening, and cultural practices that result in uneven ripening and presence of immature kernels at harvest.

Specialty varieties currently grown include aromatic rice (conventional, basmati type), arborio type (large, chalky grain), mochi, which has no amylose, and colored bran (red or nearly black). The latter has little or no amylase.

Plant Characteristics

Relative Maturity.

Maturity of California rice varieties is classified by the number of days from planting to 50% heading in the warmer areas of the state. Four categories are used, Table 5. Maturity differs primarily in the length of the vegetative stage. Beyond the 50% heading point, California short and medium grain varieties normally require another 40 to 55 days for grain maturity in warm areas, and 5 to 15 days more in cool areas. Long grain varieties usually ripen 5 to 10 faster after 50% heading than medi-

Table 5. *Relative maturity groupings of rice varieties grown in warm areas.*

Maturity Group	Days to 50% heading
Very Early	< 90
Early	90 to 97
Intermediate	98 to 105
Late	> 105

um grain varieties. Maturity is relative and can be advanced or delayed by planting date, nutritional status, temperature and other environmental factors.

Very early varieties are commonly grown in cooler areas and for late planting when later varieties are not well-suited. An increasing practice is to plant them early in warm areas to advance harvest to allow more time for straw management and to shorten the water season. Maintenance of milling quality can be more of an issue when very early varieties are planted early.

Early varieties occupy roughly 70-75% of the acreage. They are predominately Calrose type and are generally higher yielding varieties. Early varieties provide flexibility because they are suited to a wide range of planting dates.

Intermediate maturity varieties were intended to provide a more timely harvest sequence. However, there are few representatives in this category because of the industry preference for earliness.

Late maturity varieties were also intended to provide options for harvest sequencing. However, most late varieties currently grown are used because they have particular characteristics, such as premium quality, rather than for their value in scheduling harvest. They are generally planted before May 1. About 10% of the acres is typically planted to late maturing varieties.

Seedling Vigor

Seedling vigor refers to early growth and includes rapid leaf emergence through the water, stand density, growth rate after emergence, leaf droopiness, and leafiness. Vigor is an important component in variety evaluation because it helps improve stand establishment. For the grower, vigorous varieties make water management easier and may improve competition against weeds. California varieties vary in their vigor over a fairly narrow range, with the long grains having less vigor than medium and short grains.

Plant Height

Plant height is the distance between the soil surface and the tip of the erect panicle. Height is important because of its relationship to plant physiological processes and lodging which affects harvestability and yield. Height classifications include short, intermediate and tall. Short stature varieties at average soil fertility are less than 95 cm; intermediate stature varieties are 95-105 cm; and tall varieties are taller than 105 cm. Prior to 1976, all California varieties were tall and tended to lodge, particularly under high nitrogen fertility. Beginning with the release of Calrose 76, all varieties from the public program have been short stature. Since full adoption of short stature varieties from 1976 to about 1980, statewide average yields rose dramatically.

Pubescence of Hulls and Leaves

The predominant hull trait important to producers is the presence or absence of hairs. Pubescent/hairy/rough varieties have numerous hairs called trichomes distributed over the flower, seed covers and leaf surfaces. Glabrous/smooth varieties have a few hairs on the keel of the hull and the margin of the leaves, but are otherwise smooth. Before heading, smooth and rough varieties can be distinguished by running a leaf blade between thumb and finger and noting whether its surface (not edge) is rough. Of importance to producers is the fact that smooth varieties have a higher bulk density (test weight) than hairy varieties and result in heavier trucks which can be easily overloaded; and tighter packing in bin driers requires more pressure to move air compared to rough varieties. Smooth varieties are also less dusty during harvest and drying, resulting in less discomfort for harvest and drier personnel. With the exception of CM-101, CH-201, CT-201, and S-102, all public California varieties are smooth. Both Koshihikari and Akitakomachi are rough hulled.

Awns

Varieties may have long, medium, or short awns, or be awnless. The characteristic is under genetic, and to some extent, environmental control. The importance of awns for producers is in harvesting. Awns on some varieties may be difficult to remove resulting in lower bulk density and difficulty in unloading harvesters due to bridging, especially pubescent varieties.

Photoperiod Response

Some rice varieties respond to the length of the day, the time between sunrise and sunset. This is the photoperiod. The transition from vegetative to reproductive growth is triggered by day length in photoperiod sensitive varieties which are mostly grown in the tropics. However, with the exception of M-401, most rice grown in temperate zones, including California, is generally insensitive to photoperiod, and responds primarily to temperature.

Tolerance to Low Temperature Sterility

Low temperatures during formation of the pollen mother cell (microsporogenesis) is a primary cause of panicle sterility (blanking). This physiological stage coincides with the time when the collar of the flag leaf is adjacent to the penultimate leaf (next to the last leaf), and when the panicle is still entirely inside the boot. The cause is low temperature for a sufficient duration, particularly if it occurs for several successive nights. While many combinations of time and temperature can cause blanking, an overnight low of 55° or lower can be used as an alert that temperatures may be low enough to cause damage. All varieties are screened for tolerance to blanking. Table 6 gives approximate ranking of varieties by their general level of sterility tolerance.

Table 6. *Relative ranking of Public California rice varieties for cold temperature sterility tolerance*

Low	Fair	Good	Excellent
Calmati 201 L-204	M-201 M-204 M-205 L-205 M-401 Calhikari 201 A-201 Koshihikari M-402	S-102 M-202 Akitakomachi	M-103 M-104 M-206 CM-101

Pest Resistance

Resistance to diseases and rice water weevil have been long term goals of rice plant breeding. To date, however, all varieties have similar resistance to pests, with none having tolerance or resistance. Relative levels of stem rot resistance are given in Appendix C, and all fall within a fairly narrow range. Efforts are progressing to improve resistance to stem rot and blast. Suitable lines are being used but the problem continues to be in recovering good agronomic characteristics. Similarly, RWW resistance must be transferred to adapted California lines.

Characteristics of Varieties

A concise description of currently grown public varieties, giving important agronomic characteristics, is in Appendix C.

Management of Rice Varieties

Planting Date

Suggested planting dates for public varieties are given in Table 7. These suggestions assume average weather conditions will prevail. Within the preferred planting date range the variety should perform well if other conditions are optimum. Planting outside these ranges increases risk of weather related damage. Planting dates are not rigid and many growers accept the risk and successfully plant outside these ranges. They are meant as a guideline. Warm areas in Table 7 refer to the Sacramento Valley north of Highway 20 and west of Highway 99. Cool areas include south of Highway 20 and east of Highway 99. Cold areas include south Natomas and Escalon areas.

Table 7. *Suggested planting date ranges for public varieties.*

Variety by Maturity Group	Preferred Date Range	Optimum	Comments
Very Early			
S-102	May 1 - May 25	May 10	Avoid early planting in warm areas
M-103	May 1 - May 25	May 10	with all very early varieties.
M-104	May 1 - May 25	May 10	Advance all dates 5-10 days in cool
CM-101	May 1 - May 20	May 5	areas.
Early			
M-201	April 25 - May 20	May 5	Avoid cool areas
M-202	April 20 - May 25	May 5 - 10	Avoid cold areas
M-204	April 25 - May 20	May 5	For warm areas
M-205	April 25 - May 20	May 5	For warm areas
M-206	April 20 - May 25	May 5 - 10	Adapted to most areas
L-204	April 25 - May 20	May 5	For warm areas
L-205	April 20 - May 20	May 5 - 10	Suited to all but cold areas
Calhikari-201	April 25 - May 20	May 5	Avoid cool areas
A-201	April 25 - May 20	May 5	For warm areas
Calmati-201	April 25 - May 20	May 5	Avoid cool areas
Akitakomachi	April 20 - May 20	May 5	For most areas
Koshihikari	April 20 - May 20	May 5	Avoid cool areas
Late			
M-401	April 20 - May 10	May 1	For warm areas
M-402	April 20 - May 5	May 1	For warm areas

Seeding Rate

Short stature rice varieties perform well at uniform densities of 10 to 20 vigorous plants per square foot. However, many rice fields have plant populations over 30 plants. Plant density can be quite variable and still produce optimum yield. For example, approximately 40 productive tillers per square foot, each giving 100 grains, will produce about 10,000 lbs/acre. The rice plant responds to different populations. Low density planting increases tillering, whereas high density reduces tillering so that the number of panicles per square foot remain fairly constant across

a wide range of planting rates. In addition, the number of kernels per panicle also increases or decreases, depending on the density of the panicles. Modern rice fields are usually sown heavily to provide quick cover, weed competition and insurance against catastrophic stand loss. Research has shown that seeding rate, within a wide range, does not dramatically affect yield, assuming normal growing conditions. Table 8 shows the approximate seed population of different varieties when sown at a range of common planting rates. At all sowing rates, the number of seeds is much higher than needed for healthy stands if all the seeds made strong seedlings. However, the consequence of too dense planting is primarily cost although some data suggests that stem rot severity may increase in dense stands. While seed cost remains low in California, growers may continue to use high seed rates without great penalty.

Table 9. *Approximate number of seeds per square foot of different varieties sown at four different rates. **

Variety	1000 kernel wt. grams	Seeding rate - lbs/ac			
		125	150	175	200
Akitakomachi	26.2	50	60	70	80
Koshihikari	23.8	55	66	77	88
CH-201	26.0	51	62	70	81
CM-101	29.1	45	54	63	72
S-102	34.0	38	46	54	61
M-104	30.2	43	52	60	69
M-202	29.0	45	54	63	72
M-204	27.4	48	57	67	76
M-205	30.7	42	51	59	68
M-206	25.0	43	51	60	69
M-401	32.0	41	49	57	65
M-402	27.7	47	56	66	75
A-301	28.0	47	56	65	74
A-201	29.0	45	54	63	72
CT-201	25.5	51	61	72	82
L-204	31.4	42	50	58	66
L-205	27.2	48	57	67	77

*Values estimated from published variety release articles and supporting data.

Nitrogen Rates for Different Varieties

Varieties differ in their nitrogen requirements, particularly when comparing short stature Calrose and short grain types to taller premium short and medium grain types, and certain proprietary tall varieties, such as Kokuhorose. The yield of grain + straw (biological yield) is similar for tall and short varieties. However, with short varieties, more of the biological yield is grain, due to more efficient partitioning of plant energy (photosynthates). In addition, they do not lodge as easily under

high N fertility. Both higher efficiency and less lodging result in higher yield than tall varieties. Recent field trials have demonstrated small differences in nitrogen requirement among common short stature varieties. In Table 9 preplant nitrogen rate is given relative to the rate required for maximum yield of M-202 at several locations. M-202 is a commonly grown rice variety for which most growers have knowledge of the rate to apply. For example, if one were planting M-205, they would use 96% of the rate they would for M-202. Additional experience may change these numbers somewhat.

Table 9. *Response to preplant N rates of common California rice varieties, as a percent of M-202.*

Variety	Number of Locations	N rate as a % of M-202
CH-201	3	75
CT-201	3	89
L-205	3	114
M-104	6	104
M-205	6	96
M-206	2	102
M-402	3	95
S-102	2	93

Rice Certification Law

California's complex market and variety situation requires procedures to ensure that different types of rice do not get mixed. In addition, transgenic varieties with unique production and quality traits are on the horizon, although none are currently grown commercially in California. While biotechnology has enormous potential to create rices with a wide variety of nutritional, medicinal and industrial uses, it is important to prevent mixtures with other, similar-looking rices that are not transgenic. Processors are demanding assurances of purity in response to the consumer reaction to transgenic crops, particularly in export markets. Hence, the California rice industry sponsored the California Rice Certification Act of 2000 to ensure consistently high quality of California rice, maintain consumer confidence, and enhance and protect California's reputation as a provider of high quality rice.

The Rice Certification Act of 2000 (Assembly Bulletin 2622) was signed into law on September 22, 2000 and its provisions will go into effect for the 2003 crop year. This legislation contains both mandatory and voluntary IP components allowing for the certification of any verifiable attribute of rice. The California Rice Commission (CRC) recognized that "There is a growing need to maintain the identity of various types of rice

to satisfy increasing consumer demand for specialty rice varieties. This demand requires providing the industry with the ability to establish the terms and conditions for the production and handling of rice in order to minimize the potential for the commingling of various types of rice, and in order to prevent commingling where reconditioning is infeasible or impossible." All rice varieties for commercial production in California possessing "traits of commercial significance" will be required by statute to be produced within an IP certification system. The cost of the mandatory program will be borne by the growers of the specialty rice seed and grain. The CRC is empowered to collect fees, receive and investigate complaints, provide notice of action regarding alleged violations, and seek injunctive relief and other legal means to prevent violation of the Act. The Rice Certification Act is an example of a product-based IP system.

Any characteristics that may adversely affect the marketability of rice if mixtures occur are defined as having "commercial impact." Included are those that can be visually identified (e.g., bran color, grain shape, grain size, etc.) or that require specialized equipment to determine their identity or composition (e.g., lab cooking tests, taste panels, DNA or specific protein tests). For example, if rice with red bran were mixed with Calrose type medium grain, the mixture would have lower value, and hence be commercially impacted. All rice grown, sold or processed in California will be evaluated for characteristics of commercial impact, including rice brought into California for processing or sale, and IP protocols can be required for production, handling, transportation and storage of a given variety to prevent contamination of other rice. Several specialty rices currently being grown and successfully segregated in California (e.g., sweet, scented, basmati, arborio, and colored bran rices) may eventually be identified as having commercial impact. IP procedures for these varieties are already in place. However, traits that are not visible, such as herbicide tolerance, especially if the varieties are grown widely, will require extra vigilance to keep them separate from other similar varieties.

An advisory committee will recommend regulations to the Secretary of the California Department of Food and Agriculture pertaining to rice identified as having characteristics of commercial impact. The advisory committee will consider each variety separately and render a judgment, using science, economics and market experience, as to whether a given attribute has the potential for commercial impact. If it does, the committee will then establish terms and conditions of production, transportation, drying and storage to segregate the commodity from other rice types. These may include the method of seed application to prevent contamination of neighboring fields, buffer zones between fields, handling requirements to prevent mixtures, and other IP requirements.

An expressed intent of the Act is to encourage research and development

of new types of rice. However, to prevent contamination and introduction of exotic pests, the committee must approve research protocols to ensure that the research will not have negative commercial impact. Researchers will be required to submit their research protocols, location of the research and acreage to the advisory committee and follow required procedures. Specific attributes of the rice for research do not have to be revealed. "Research" is limited to 50 or fewer acres of a single type of rice. The advisory committee also reviews procedures for rice brought into the state from other states or countries for research purposes. Current state or federal regulations for bringing such rice into California will apply unless the committee can justify that they are not acceptable. This Act does not apply to rice research conducted by the University of California except when such rice enters the channels of trade.

Separate from the work of the advisory committee, the Act allows the CRC to establish a voluntary program to certify any verifiable attribute of rice. Certified rice may be labeled with the words "This lot of rice certified (specified attribute) in accordance with the California Rice Certification Act of 2000." Certifiable attributes include any of those characteristics that can be verified, such as origin, scent, herbicide tolerance, colored bran, mochi quality, variety, etc. One may certify, with the appropriate documentation and procedures, that a given lot of rice has or does not have a particular attribute. Hence, rice could be certified as non-transgenic or free of colored bran. Rices with and without commercial impact and seed, rough, and milled rice can all be certified. The Act does not certify rice as organic, although specific attributes of organic rice could be certified.

Selected References

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Appendix A - History of California Rice Varieties

Appendix author:
Kent McKenzie, RES

The short grain varieties, predominantly Caloro and Colusa, occupied essentially all of California's production until the late 1950's. The state's production shifted to Calrose following its release in 1948. California's short grain acreage continued to decline due to the success of Calrose and its progeny that currently occupy more than 80 percent of the rice acreage. Long grain, waxy short grains, aromatic long grains have been developed but have never occupied a large percentage of California's rice production. A detailed review of California's rice history from it's beginnings to 1980 had been prepared by J. H. Willson (Willson, 1979).

The accelerated rice breeding program initiated in 1969 began delivering new rice varieties to growers beginning in 1976. The successful development of semidwarf Calrose mediums grains was accomplished by Rugter et al (1977) through induced breeding and Carnahan et al (1978) through backcrossing. These founding semidwarfs formed the germplasm pools that have allowed the development and release of 19 improved medium and short grain California varieties. The medium grain decedents of Calrose were selected to have Calrose cooking and processing characteristics and are predominantly commercially commingled in drying, storage, and utilization.

The California breeding program began to develop adapted long grains from different parentage for California. Tseng et al (1984) released the well adapted and productive L-202. L-202 has been a successful parent in the development of recent long grain varieties Cypress and Cocodrie developed in Louisiana. L-202 seed was also exported to Spain and renamed "Thaibonnet" and it has become the major long grain variety grown in that region. Additional long grains were released by Tseng et al with improvements in agronomic, milling, and cooking quality; however, long grain production still occupies <5% of California's rice acreage.

California's traditional short grain acreage has remained small in recent years after losing a major market in Puerto Rico. Premium quality short grains, primarily the Japanese varieties Koshihikari and Akitakomachi, developed in the late 1990s in response to the opening of the Japanese market to rice. Satisfying the quality requirement for the Japanese market has proven to be a significant challenge at the commercial level with the Japanese varieties. Developing high yielding adapted varieties with premium quality characteristics has proven to be an even more difficult task. Premium short grain production seems to have become established in California but the acreage is fluctuating being subject to trade and marketing issues.

California has an established premium quality medium grain production. These types cook similar to the Japanese premium short grains with

a similar texture appear very shiny and remain soft after cooling. They trace their ancestry back to the proprietary tall late maturing medium grain varieties Terso and Kokuhorose. M-401 and induced semidwarf of Terso is the predominant variety.

Specialty rice varieties occupy a small acreage. They include Calmochi-101, waxy short grain, aromatic long grains, Mediterranean bold grains, and colored bran. They are grown under contract and include proprietary lines and introductions.

The Calrose market type grown in California may include several medium grain varieties. M-202 (Johnson et al 1986) has been the predominant variety produced in the state with new releases M-205 and M-104 (Johnson 2002; 2002a) the next most widely grown Calrose medium grains. Table I contains a summary some of the major physicochemical characteristics of several Calrose medium grains. They have a low apparent amylose content and low gelatinization temperature. The kernel size and shape are identifiable features of these varieties. Cooking and processing characteristics including desirability for breakfast cereals are recognized in the market place but not well characterized in standard laboratory testing methods. Environmental factors like climate and temperature in the California rice production region also contribute to grain quality.

Traditional California short grains have low amylose and low gelatinization temperature. The kernels are relatively large and may have some chalkiness. This chalky spot or region being whiter than the surrounding endosperm and these short grain types were referred to as "pearl" rice. In addition to table rice these short grains like S-102 are often used in production puffed rice cakes. Table II also contains the physicochemical characteristics for premium quality short grains grown in California. These short grains have a smaller very translucent kernel and produce very high whole kernel milling yields. Koshihikari, a Japanese short grain variety released in the 1950's, is the established standard for Japanese premium quality. The breeding, production, and quality of Koshihikari have been recently reviewed by Iwate (2001). Other premium short grains grown in California include Akitakomachi, a very early maturing variety developed in Japan, and Calhikari-201 is a semidwarf variety developed in California. Eating quality is considered one of the most important traits of rice in Japan and has been the focus of extensive research as well as evaluation of rice for use and sale in the marketplace. Near infra-red based "Japanese taste machines" that measure components like amylose, protein, moisture, K and Mg, and fatty acid content correlated with taste panel results are used to analyze samples and issue a taste score for commerce in Japan. A review of rice grain quality from a Japanese perspective is available from Matsuo et al (1997).

Development of long grains for production in California faces both the agronomic challenge of cold tolerance and the need to achieve the

milling, cooking, and processing properties found in long grains grown in the southern US. Breeding efforts have been directed toward developing adapted long grains that cooked firmer and less sticky because of the soft cooking tendency of California grown conventional long-grain rice. As part of this approach, L-205 was developed with the Newrex quality that is characterized by having 2 to 3% higher amylose content and a stronger viscogram profile than conventional long grains. Because of these characteristics, Newrex types cook dry and exhibit minimal solids loss during the cooking process, and are regarded as a superior type for canned soups, parboiling, and noodle making. Considerable improvement in whole kernel milling yields have also been achieved in the more recent California long grains. Table III contain quality characteristics for California long grains.

Specialty types include the waxy short grain Calmochi-101; the long grain aromatic A-201; and the aromatic basmati type Calmati-201. These special purpose varieties are usually grown under contract and some of their physicochemical characteristics can be found in Table A-I, A-II, A-III. There has been a significant increase in interest in these and other specialty types including the Jasmine, basmati, Mediterranean varieties like Arborio, and colored bran types in recent years in both the public and private sector. Some common features of these types are that they are generally ethnic foods, have low agronomic productivity, may present milling or handling challenges, and a lack of established quality evaluation criteria that make them a particularly challenging target for rice breeding or marketing.

Table A-I. *Characteristics of California medium grain varieties.*

Variety	Type	AC[1]	% Protein[2]		KOH Score[3]		DSC[4]	Brown Rice Kernels[5]			
		%	Brown	Milled	1.7%	1.5%	C°	Length	Width	L/W	Weight
M-104	Calrose	17.9	8.2	7.2	6.7	6.0	68.5	6.3	2.8	2.3	24.2
M-202	Calrose	16.9	8.1	7.0	7.0	6.3	66.7	6.0	2.8	2.1	23.3
M-204	Calrose	18.4	7.7	7.0	7.0	6.3	66.6	6.2	2.8	2.2	24.7
M-205	Calrose	17.9	7.5	6.4	6.9	6.3	67.0	6.5	2.7	2.4	25.1
M-401	Premium	18.1	6.0	5.7	7.0	6.4	65.9	6.4	2.8	2.3	25.9
M-402	Premium	18.0	6.9	5.9	7.0	6.5	65.8	6.2	2.7	2.3	22.8

[1]Apparent amylose content.

[2]N%x 5.95 dry basis.

[3]Dilute alkali reaction score 1 to 7.0.

[4]Gelatinization temperature as measured with a Differential Scanning Calorimeter.

[5]Kernel dimensions in mm, length width ration, and 1000 kernel weight in g.

Table A-II. *Characteristics of California Short Grain Varieties*

Variety	Type	AC[1]	% Protein[2]		KOH Score[3]		DSC[4]	Brown Rice Kernels[5]			
		%	Brown	Milled	1.7%	1.5%	C°	Length	Width	L/W	Weight
S-102	Short	18.5	7.6	6.9	6.8	6.0	69.2	5.8	3.2	1.8	27.7
Koshihikari	Premium	17.8	6.8	5.6	7.0	6.3	66.5	5.1	2.8	1.8	20.3
Akitakomachi	Premium	17.2	7.4	6.5	7.0	6.0	68.9	5.3	2.9	1.8	21.6
Calhikari-201	Premium	18.0	7.0	6.0	7.0	6.0	68.3	5.1	3.0	1.7	20.5
Calmochi-101	Waxy	0.0	7.4	6.5	6.3	6.0	69.1	5.3	2.9	1.8	23.4

[1]Apparent amylose content.
[2]N%x 5.95 dry basis.
[3]Dilute alkali reaction score 1 to 7.0.
[4]Gelatinization temperature as measured with a Differential Scanning Calorimeter.
[5]Kernel dimensions in mm, length width ration, and 1000 kernel weight in g.

Table A-III. *Characteristics of California Long Grain Varieties*

Variety	Type	AC[1]	% Protein[2]		KOH Score[3]		DSC[4]	Brown Rice Kernels[5]			
		%	Brown	Milled	1.7%	1.5%	C°	Length	Width	L/W	Weight
L-204	Long	22.7	7.8	7.4	4.7	3.9	73.8	7.9	2.3	3.4	24.6
L-205	Newrex	24.5	8.6	7.9	5.3	3.9	73.7	7.3	2.3	3.2	21.8
A-201	Aromatic	24.2	8.1	7.7	5.8	4.1	73.2	7.8	2.2	3.6	22.2
Calmati-201	Aromatic	23.3	10.0	9.5	6.3	6.0	73.8	7.3	2.1	3.5	20.5

[1]Apparent amylose content.
[2]N%x 5.95 dry basis.
[3]Dilute alkali reaction score 1 to 7.0.
[4]Gelatinization temperature as measured with a Differential Scanning Calorimeter.
[5]Kernel dimensions in mm, length width ration, and 1000 kernel weight in g.

California's medium-grain market was developed using the variety Calrose released in 1948. The name “rose” indicates medium-grain shape and “Cal” to indicate California origin and production. Specific processing and cooking properties were associated with Calrose. Over the years new varieties with the same cooking properties as Calrose were released. These medium- grains were commingled with Calrose in storage and later replaced the variety in commercial production. Calrose, as a market class, was established and is still used to identify California medium-grain quality. Physicochemical and cooking tests are used to screen experimental entries and verify that new medium-grain variety releases have acceptable Calrose cooking and processing characteristics.

Newrex is special quality rice that has 2 to 3% higher amylose content and a stronger viscogram profile than conventional long grains. Because of these characteristics, Newrex types cook dry, exhibit minimal solids

loss during the cooking, and are a superior type for canned soups, parboiling, and noodle making. The dry cooking characteristics of a Newrex type variety may help address the soft cooking tendency of California grown conventional long-grain rice.

"Premium quality" is a term used to identify the California medium-grain varieties like M-401 that have unique cooking characteristics preferred by certain ethnic groups (e.g., Japanese and Korean). Premium quality medium grains are very glossy after cooking, sticky with a smooth texture, and remain soft after cooling. Aroma and taste are also cited as important features. These types are similar to the high quality short-grain Japanese varieties like Koshihikari. Premium quality is a complex rice quality characteristic and developing improved high yielding premium quality varieties adapted to California continues to be a challenge.

Table A-IV. *Grain shape, year of release, maturity category and parentage of California public rice varieties.**

Cultivar	Grain	Year	Maturity	Parents
Caloro	S	1917	L	Early Wateribune
Colusa	S	1921	L	Chinese
Calrose	M	1948	L	Caloro/Calady*2
CS-M3	M	1971	L	C6 Smooth/Calrose
CS-S4	S	1972	L	Caloro/Smooth No. 3//Caloro/3/Caloro
M5	M	1975	L	CS-M3 natural mutation selections
S6	S	1975	E	Colusa/CS-M3
Calrose 76	M	1976	L	Induced mutant of Calrose
M7	M	1978	L	Calrose 76/CS-M3
M9	M	1978	E	IR-8/CS-M3*2//10-7*2
Calmochi-201	S	1979	E	Induced mutant of S6
L-201	L	1979	E	CI 9701/3/R134-1/R48-257//R50-11
M-101	M	1979	VE	CS-M3/Calrose 76//D31
M-301	M	1980	M	Calrose 76/CS-M3//M5
S-201	S	1980	E	Calrose 76/CS-M3//S6
Calmochi-202	S	1981	E	R57-362-4/D51//Calmochi-201
M-302	M	1981	M	Calrose 76/CM-M3//M5
M-401	M	1981	L	Induced mutant of Terso
M-201	M	1982	E	Terso/3/IR-8/CS-M3*2//Kokuhorose
L-202	L	1984	E	723761/ 7232278//L-201
Calmochi-101	S	1985	VE	Tatsumi mochi//M7/S6
M-202	M	1985	E	IR-8/CS-M3*2//10-7*2/3/M-101
A-301	L	1987	M	IR-22/R48-257//5915C35-8/3/Della
M-102	M	1987	VE	M-201/M-101
M-203	M	1988	E	Induced mutant of M-401
S-101	S	1988	VE	0-6526//R26/Toyohikari/3/M7/74-Y-89//SD7/73-221
M-103	M	1989	VE	SD7//Earlirose/Reimei/3/M-302
S-301	S	1990	M	SD7/73-221/M7P-1/3/M7P-5
L-203	L	1991	E	L-202/83-Y-45
M-204	M	1994	E	M-201/M7/3/M7//ESD7-3/Kokuhorose
A-201	L	1996	E	L-202/PI 457920//L-202
L-204	L	1996	E	Lemont//Tainung-sen-yu 2414/L-201
S-102	S	1996	VE	Calpearl/Calmochi-101//Calpearl
Calhikari-201	S	1999	E	Koshihikari/(Koshihikari/S-101)*2
Calmati-201	L	1999	E	82-Y-51/83-Y-45//L202/PI373938/3/83-Y-45/PI457918
L-205	L	1999	E	M7/R660//M7/R1588/3/82-Y-52/4/Rexmont/83-Y-45
M-402	M	1999	L	Kokuhorose/4/M7*2/M9//M7/3/M-401/Kokuhorose
M-104	M	2000	VE	M-103/6/F1(M-102/4/M-201/3/M7/M9//M7/5/M-103)
M-205	M	2000	E	M-201/M7//M-201/3/M-202
M-206	M	2000	E	S-301/M204

*Parts taken from Rice Origin, History, Technology, and Production Smith and Dilday Wiley & sons 2002

Appendix B - Rice Variety Acres by Grain Type

Appendix authors:

Kent McKenzie, RES

Dana Dickey, RRB

Appendix C - Characteristics of Public Varieties