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, all released from the grower owned and funded Rice Experiment Station (RES) at Biggs, CA 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 the 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 RES. 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 the 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.

Acreage

Publicly developed and introduced rice varieties are grown annually on over 90% of the planted acreage and more than 40 introduced proprietary varieties are grown on the rest (See Tables 1 & 2). Most of the varieties grown in California are classified as "temperate japonicas," adapted to the cooler rice growing areas and temperate latitudes of the world. This is contrast to "tropical japonicas" (grown in the Southern US) or indicas that constitute the majority of the world's rice production. About 80% of the acreage is planted to 'Calrose' type medium grain varieties destined for a host of purposes including table rice and manufactured uses. California short grains and as well as introduced and proprietary varieties are also temperate japonica. Long grain varieties are tropical japonicas. California short and long grain varieties are also planted on two to three percent of the acres. Premium quality medium and short grain rice is grown on about 10% of acres, and is destined for higher priced table rice markets. Additional small acreages of specialty varieties are also planted, such as sweet rice (also called mochi, glutinous or waxy), arborio types (large or bold grain), and aromatic long grains including conventional, basmati, jasmine, and colored bran types.

Publicly developed and introduced rice varieties are grown annually on about 96% of the planted acres.

Table 1. Outline of the RES rice variety naming system and varieties offered in 2023. Grain type letter(s) are combined with a numeric descriptor. The first digit is the maturity group, the others are in the order of release.

Grain Type	Very Early (100-199)	Early (200-299)	Intermediate (300-399)	Late (400-499)
Short (S)	S-102 S-202	-	-	-
Medium (M)	M-105	M-206 M-209 M-210 M-211	-	M-401
Long (L)	-	L-205 L-208 L-207	-	-
Calmochi sweet rice (CM)	CM-101	CM-203	-	-
Aromatic (A)	-	A-202	A-301*	-
Calhikari short premium (CH)	-	CH-201 CH-202 CH-203	-	-
Calmati basmati type (CT)	-	CT-202	-	-
Calaroma jasmine type (CJ)	-	CJ-201	-	-
Calamylow (CA)	-	CA-201	-	-

**seed production discontinued.*

Table 2. Rice acreage estimates for Rice Experiment Station varieties in 2021 and 2022.

Variety	2021			2022		
	Seed Acres†	Percentage	Estimated Acres‡	Seed Acres†	Percentage	Estimated Acres‡
Medium Grain						
M-105	2,945	12.1	48,808	2,645	13.8	35,279
M-206	8,172	32.4	131,382	5,332	27.9	71,119
M-209	4,665	20.5	82,957	2,506	13.1	33,429
M-210	2,053	8.4	33,944	1,725	9.0	23,013
M-211	1,542	6.5	26,232	2,729	14.3	36,401
M-401	1,136	4.6	18,790	407	2.1	5,428
Total RES-Medium	20,513	84.5	342,113	15,343	80.3	204,669
Non-RES Medium	1,400	5.2	20,887	999	5.2	13,331
Total Medium Grain	21,913	89.6	363,000	16,343	85.5	218,000
Short Grain						
CA-201	1	0.04	143	7	0.1	170
CH-201	50	0.2	707	46	0.4	1,126
CH-202	145	0.5	2,067	232	2.2	5,622
CM-101	484	1.9	7,525	106	1.0	2,569
CM-203	346	1.5	5,889	193	1.8	4,689
S-102	198	0.7	2,816	256	2.4	6,206
S-202	16	0.1	221	2	0.02	54
Total RES -Short	1,238	4.8	19,368	842	8.0	20,436
Non-RES Short	613	3.9	15,632	394	3.8	9,564
Total Short Grain	1,851	8.6	35,000	1,236	11.8	30,000
Long Grain						
A-201	241	0.5	1,987	206	0.6	1,476
A-202	220	0.4	1,814	214	0.6	1,540
CJ-201	79	0.2	652	276	0.8	1,984
CT-202	17	0.0	140	18	0.1	129
L-205	20	0.0	167	46	0.1	331
L-207	207	0.4	1,707	155	0.4	1,114
L-208	10	0.0	78	19	0.1	134
Total RES -Long	794	1.6	6,545	934	2.6	6,710
Non-RES Long	1	0.0	455	40	0.1	290
Total Long Grain	795	1.7	7,000	974	2.7	7,000
USDA-NASS Acres						
Medium			363,000			218,000
Short			35,000			30,000
Long			7,000			7,000
TOTAL			405,000			255,000

† Seed acres represent the number of approved seed acres in the California Crop Improvement seed certification program.

‡ Estimated acres were determined by using the percent acres in seed production and the total reported USDA-NASS acres.

Naming System for Public Varieties in California

In 1979, the California rice industry developed a uniform naming system for new RES 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.

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, Calamylow for low amylose (≈7%) type rice, A for aromatic long grains, and Calaroma for jasmine long grains. 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-105 indicates a very early maturing medium grain variety which was fifth in order of release.

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. The 2020 list of all rice varieties in California approved for production, their commercial impact designation and tier is provided in Table 3a, 3b and 3c for medium, short and long grain varieties, respectively.

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 chosen 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 or herbicide resis-

Table 3a. Medium Grain Rice varieties approved for production in California and commercial impact and tier designation.

Variety	CI	Non-CI	Tier
02-PY-014		✓	
02-PY-021		✓	
85-101-10		✓	
91-130-02		✓	
94-158-01		✓	
Amber (formerly00-117)		✓	
Arborio (incl CA Arborio)	✓		1
Black Japonica (LBJ-489)	✓		2
Black Rice – SWF	✓		2
Black Rice (SunWest)	✓		2
Calriso	✓		1
Carnaroli (all subtypes incl MH-1)	✓		1
Crystal (formerly 04-116)		✓	
Farah (formerly 02-121-03)		✓	
FRC #11		✓	
FRC #22		✓	
Frances	✓		2
Guadiamar		✓	
Hong Kong Black (HKB-102)	✓		2
Jade (formerly 07-122)		✓	
Kokuho Rose		✓	
LBJ-115	✓		2
LMR-206	✓		2
M-103 (not in seed production)		✓	
M-104		✓	
M-105		✓	
M-201		✓	
M-202		✓	
M-204 (not in seed production)		✓	
M-205		✓	
M-206 (formerly 98-Y-242)		✓	
M-207 (formerly 00-Y-805 not in seed production)		✓	
M-208		✓	
M-209		✓	
M-210		✓	
M-211		✓	
M-401		✓	

Table 3a. Continued

M-402		✓	
Millrose		✓	
NFD181		✓	
Riz Rouge Camargue	✓		2
Rojito (SunWest)	✓		2
Royce (formerly 95-164-01)		✓	
RRI -226		✓	
RRI-321		✓	
Shasta (formerly 98-102)		✓	
SP-211		✓	
SP-311		✓	
SP-411		✓	
Trisha (formerly KR4)		✓	
Wehani LWE-218 (Lundberg)	✓		2
Winsor (formerly 02-120)		✓	
WRM-3538		✓	
Remy		✓	
Royal		✓	
Jemma		✓	
Imperial		✓	

Table 3b. Short Grain Rice varieties approved for production in California and commercial impact and tier designation.

Variety	CI	Non-CI	Tier
A-17		✓	
A-20	✓		1
Akita Komachi		✓	
Asuka (formerly 04-302)		✓	
BL-2 (not in production)	✓		1
Calamylow-201 (formerly BL-1)	✓		1
Calhikari 202		✓	
Calhikari-201		✓	
Calmochi -101	✓		1
Calmochi --203	✓		1
Caloro		✓	
Calpearl	✓		1
Carnaroli (all subtypes incl MH-1)	✓		1

Table 3b. Continued

Variety	CI	Non-CI	Tier
Himenomochi (formerly PI 504474)	✓		1
Hitomebore		✓	
Kogane Mochi	✓		1
Koshihikari		✓	
NFD 108	✓		1
NFD 109	✓		1
S-102		✓	
S-201 (not in seed production)		✓	
S-202		✓	
S-6		✓	
Sasanishiki		✓	
SP-2	✓		1
Surpass	✓		1
Vialone Nano	✓		1
WRS-4431	✓		1
Yamada Nishiki		✓	

Table 3c. Long Grain Rice varieties approved for production in California and commercial impact and tier designation.

Variety	CI	Non-CI	Tier
A-201	✓		1
A-202	✓		1
A-301	✓		1
Aromatic Long Grain Red Rice	✓		2
Calaroma	✓		1
Calmati-201	✓		1
Calmati-202	✓		1
Donana		✓	
L-202 (not in production)		✓	
L-203 (not in production)		✓	
L-204 (not in production)		✓	
L-205 (not in production)		✓	
L-206		✓	
L-207		✓	
L-208		✓	
Long Grain Red Rice	✓		2
P-2 Denosa		✓	
P-3 Isla		✓	

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

	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	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
Mochi	5.3	3	1.8	23.9

tance, but will in the future, which may become a primary selection criterion. For those blast prone areas, a blast resistant variety would be consideration (M-210). Rice plant and grain characteristics are discussed below.

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.

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 it is. 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. Calaroma-201 has a low amylose content similar to medium grains and is softer cooking.

Scent: Aromatic and Basmati Types

A few California varieties, such as A-202, 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-202) 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. Calaroma-201 is also aromatic but has different cooking properties. 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 nighttime temperatures during grain fill, 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 amylose.

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 50% heading, 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 days faster after 50% heading than medium 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.

Table 5. Variety maturity group and days to 50% heading at RES.

Maturity Group	Days to 50% heading
Very Early	< 80
Early	81-90
Intermediate	91-99
Late	> 100

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 4% of the acres are 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, CH-202, CT-202, CJ-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 may 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°-60° 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 low temperature sterility tolerance.

Pest Resistance

Resistance to diseases is a long-term goal of rice plant breeding. To date M-208 and M-210 are the only blast resistant varieties in California. Relative levels of stem rot resistance are given in the Agronomy Fact Sheets, and all fall within a fairly narrow range. Efforts are continuing to try improve resistance to stem rot and blast. Resistant lines are being used but the problem continues to be in recovering good agronomic characteristics.

Characteristics of Varieties

UC Cooperative Extension produces Agronomy Fact Sheets annually. The brochure "Characteristics of Public California Rice Varieties" gives a comparison of RES varieties in production. There are individual brochures for varieties that are prepared when they are released as well.

Table 6. Relative ranking of RES rice varieties for cold temperature sterility tolerance. The + sign indicates better tolerance for the group.

Low	Fair	Good	Excellent
Calmati 202	M-205	S-102	Calmochi 101
Calaroma 201+	M-209	S-202	
M-401	L-206+	M-206+	
A-202+	L-207+	M-105+	
	L-208+	M-210	
		M-211	
		Calmochi 203	
		Calhikari 201-	
		Calhikari 202-	
		Calhikari 203	
		Koshihikari-	
		Akitakomachi	

The brochures can be found online on the Rice Experiment Station Website (www.crrf.org) under the publications tab.

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 only 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.

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/ac. 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. 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.

Nitrogen Rates for Different Varieties

Varieties differ in their nitrogen (N) 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 N requirements among common short stature varieties. Nitrogen rate fertilization testing of new releases has not been a research priority in the decades since the shift to semidwarf varieties. Over fertilization increases the risk of lodging, disease, low temperature sterility, and is inefficient economically. Lower rates of N are used in the premium quality short grains or specialty varieties because of lodging is characteristic of these types. Varieties with good lodging resistance (M205 and M-209) may receive slightly a higher application of N.

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 planting early in warm areas with all early varieties. Advance all dates by 5- to 10-days in cool areas. CM-203 is early to flower but slow to fill grain.
Calmochi-101	May 1 - May 20	May 5	
Calmochi-203	May 1 - May 20	May 5	
Early			
M-206	April 20 - May 25	May 5 - 10	Adapted to most areas.
M-209	April 20 - May 25	May 5 - 10	Best used in warm areas.
M-210	April 20 - May 25	May 5 - 10	Adapted to most areas and areas prone to blast.
M-211	April 20 - May 25	May 5 - 10	Best used in warm areas and harvested at higher moistures.
L-205	April 20 - May 20	May 5 - 10	Best used in warm areas.
L-207	April 20 - May 20	May 5 - 10	Best used in warm areas.
L-208	April 20 - May 20	May 5	Best used in warm areas.
Calhikari 201	April 25 - May 20	May 5	Avoid cool areas and excess nitrigen.
Calhikari 202	April 25 - May 20	May 5	Avoid cool areas and excess nitrigen.
Calihikari 203	April 25 - May 20	May 5	Avoid cold areas.
A-201	April 25 - May 20	May 5	Avoid cold areas.
A-202	April 25 - May 20	May 5	Avoid cold areas.
Calmati 202	April 25 - May 20	May 5	Avoid cold areas.
Akitakomachi	April 20 - May 20	May 5	Avoid cold areas.
Koshihikari	April 20 - May 20	May 5	Avoid cold areas.
Late			
M-401	April 20 - May 10	May 1	Avoid cold areas.

Variety and Harvest Considerations

Short and medium grain rice typically produce higher head rice yields (HRY) than does long grain rice. This is due to the more rounded, thicker, and harder kernels of medium grains. Additionally, earlier-maturing varieties may yield less head rice than later-maturing varieties, which is thought to be a result of grain filling processes.

Flowering patterns with the panicle vary somewhat between varieties. Anthesis (flower opening) begins at the top of the panicle and proceeds downward, a characteristic present in all California varieties and referred to as nonsynchronous flowering. The number of days required for flower opening ranges from 4 to 8 depending on the variety (Figure 1). The delay in anthesis from the top to the bottom also means that all flowers do not reach the stage of development that is sensitive to low temperature induced pollen sterility at the same time. Brief periods of low temperature result in sections of the panicle being "blank".

Correspondingly, the range of moisture content of individual kernels within a panicle can vary from 15 to 30 percent moisture content even though the average may be around 24 percent (Figure 2). Research has shown that the kernels at 15 percent moisture or less are likely to fissure when exposed to several hours of dew. Rice harvested at a moisture content of 18 percent may contain a large portion of individual kernels with moisture contents as low as 10 percent. There is inherent risk if standard harvesting procedures are adopted that uses an average moisture content of 18 percent as the time to harvest a given field.

The range of maturity (i.e. harvestable moisture content) can be further accentuated by within field variability in plant growth and development. Such variation is attributable to such

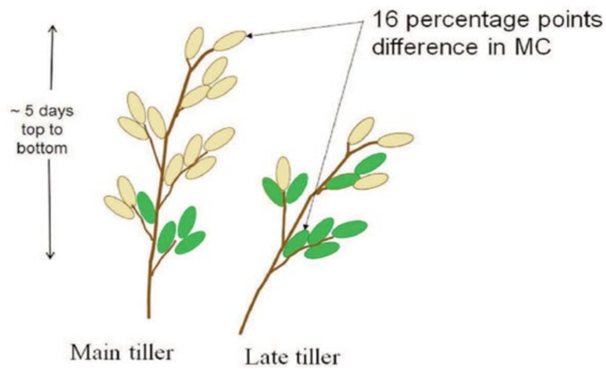

Figure 1. The moisture content of individual kernels varies due to the pattern of flowering within a panicle.

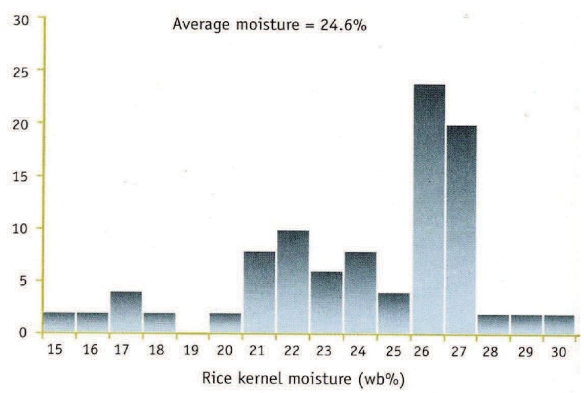

Figure 2. The range of kernel moisture content in a sample may be 15 perecnt or more

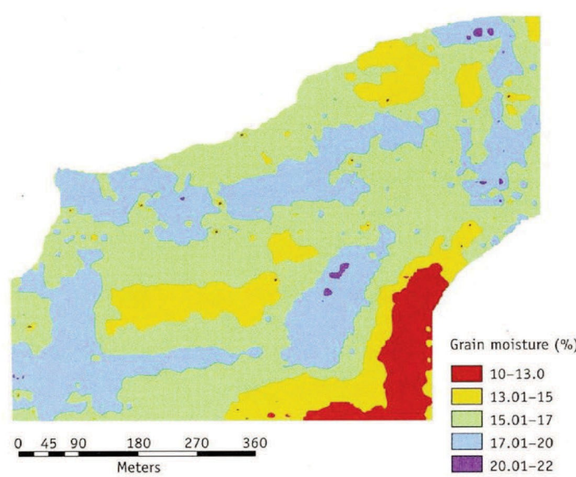

Figure 3. In field moisture content at harvest can vary widely due to management and soil type.

things as variable water depth, the uneven application of nitrogen fertilizer, water temperature, or soil type. Research showed that the moisture content in a California rice field can range from 10 to 22 percent under routine farm management practices (Figure 3). Without prior knowledge of specific field, a simple "nosing in" of the combine to check moisture content can be misleading.

Environmental Effects on Head Rice Yield

Rice harvested at low moisture content often does not produce low head rice quality if it has not been exposed to rehydrating conditions. During the dry north wind periods that commonly occur during harvest, rice can dry to quite low moisture contents and still produce good milling quality because dry conditions prevent dew formation.

However, when the north wind ceases and dew forming conditions return, head rice yield drops. In weather conditions with high dew point temperatures, rice can rehydrate to fairly high moisture contents, levels that normally associated with high head rice yield (Figure 4). Rice that rehydrates after a north wind can produce poor head rice quality even though it is harvested at the recommended moisture content. The history of rice moisture content is an important aspect of understanding the head rice yield produced in a particular field. Soil type also influences the time course of head rice loss. For example, a more rapid decline in head rice yield would be expected on light-textured soils exposed to dry, windy conditions.

In 2003 and 2004 at RES, harvest moisture content dropped 6.2 and 8.2 percentages points by the end of the windy period (Figure 5). During the north wind head rice yield declined by over 8 points in both years. Interestingly, growers' return per acre decreased by only $0.08 and $0.17 per cwt in 2003 and 2004, respectively (Table 8). During the dry weather, reduced drying costs offset most of the head rice yield loss. Typically, the west side of the Sacramento Valley experiences more north wind days than areas on the east side (Figure 6). The number of windy days during harvest ranges from a low of

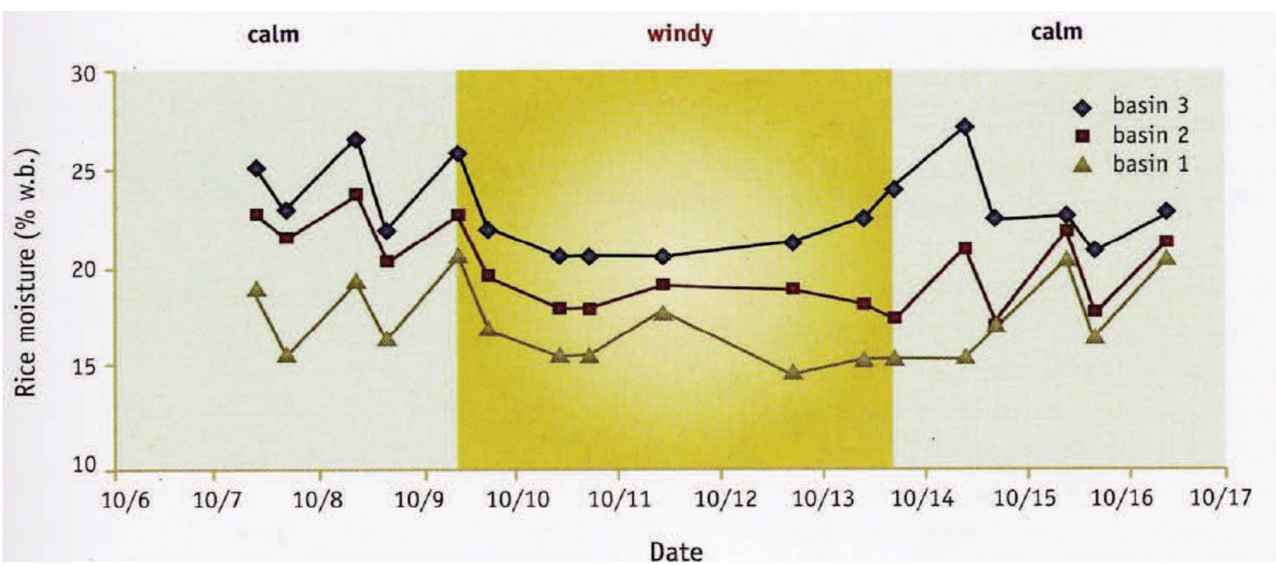

Figure 4 . Diurnal fluctuation in rice grain moisture before, during, and after a north wind period.

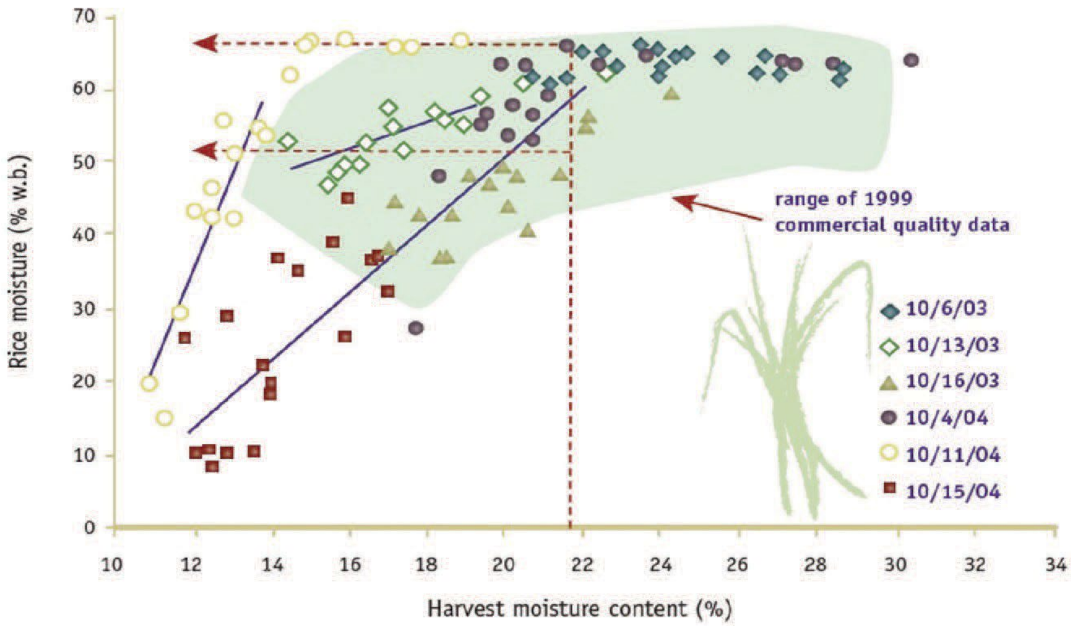

Figure 5. Head rice yield as related to harvest moisture content before, during, and after a dry north wind period in 2003 and 2004, Biggs, CA.

Table 8 . Rice quality and value before, during, and after a dry north wind period in 2003 and 2004 for M-202, Biggs, CA.

Harvest date		Moisture content (%)	Head Rice yield (%)	Grower Return ($/cwt)
2003	Oct. 6	24.3	63.8	5.63
	Oct. 13	18.1	55.6	5.55
	Oct.16	19.6	45.8	5.01
2004	Oct. 4	22.8	58.2	5.46
	Oct. 11	14.6	49.7	5.29
	Oct. 15	14.3	25.3	4.04

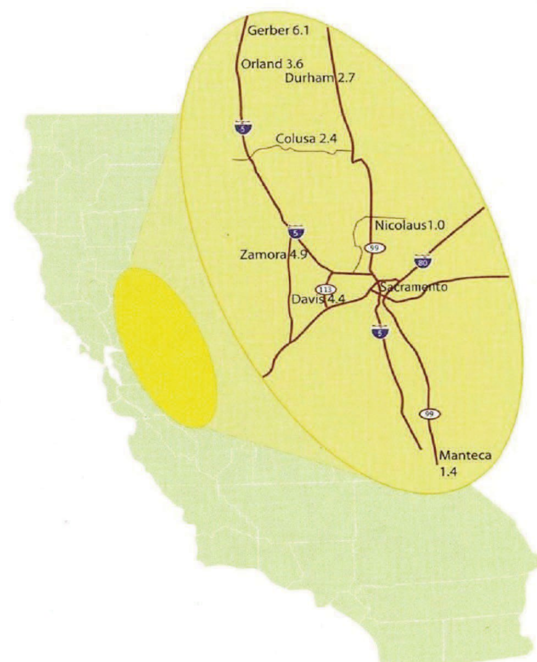

Figure 6 . Average number of north wind days at selected locations in the Sacramento Valley. Data based on 10-year averages.

1.0 around Nicolaus to around 4 near Orland.

Sampling for Harvest Moisture Content

Rice moisture content may fluctuate by 5 or more percentage points during a 24-hour period before and after a north wind period. When evaluating a field in preparation for harvest, it is important to sample at a consistent time of day, such as around noon. By doing so the moisture samples are comparable between days and provide a clearer picture of the dry down rate of the rice. Rice will generally dry down at a rate of about 0.5 percent per day, north wind and high temperatures notwithstanding. For best accuracy, use a harvester to cut the sample to provide the best representation of the true moisture content. Alternatively, one can hand strip heads from random locations. Be sure to take some of the sample from the lower, less-mature panicles. Avoid taking just the ripe grains from the topmost panicles; this will produce a sample with a lower moisture reading as compared to a combine cut sample.

Harvest Moisture Range by Variety

As a general rule most newer Calrose varieties (i.e. M-105, M-205, M-206, and M-210) with the exception of M-211 and M-209, can be harvested at a lower moisture content than the older varieties (i.e. M-104, M-202, and M-401). Head rice yields are fairly stable in the newer varieties down to a harvest moisture content of around 18 to 19%. M-209 and M-211 are not as stable as the other new varieties and harvest at low moisture should be avoided (Figure 7). Good milling returns below this moisture content are both variety and weather dependent. Fissuring of rice can be caused by repeated cycles of rice grains absorbing moisture during dew or rainfall events followed by quickly drying out again. These fissures are generally weaker and tend to break during the milling process. The drier the rice the more susceptible it is to fissure and results in lower milling yields. Rice varieties like M-211 and M-401 are more susceptible to fissuring and resulting in reduced milling at low harvest moistures (Figure 7). The potential for varieties to have reduced milling at lower moisture contents in some years but not others is often related to long periods of dew during dry down observed in those years. For example, during the 10-year period from 2003 to 2012, seven years had relatively few dew events of eight hours or longer (Table 9). During the 2011

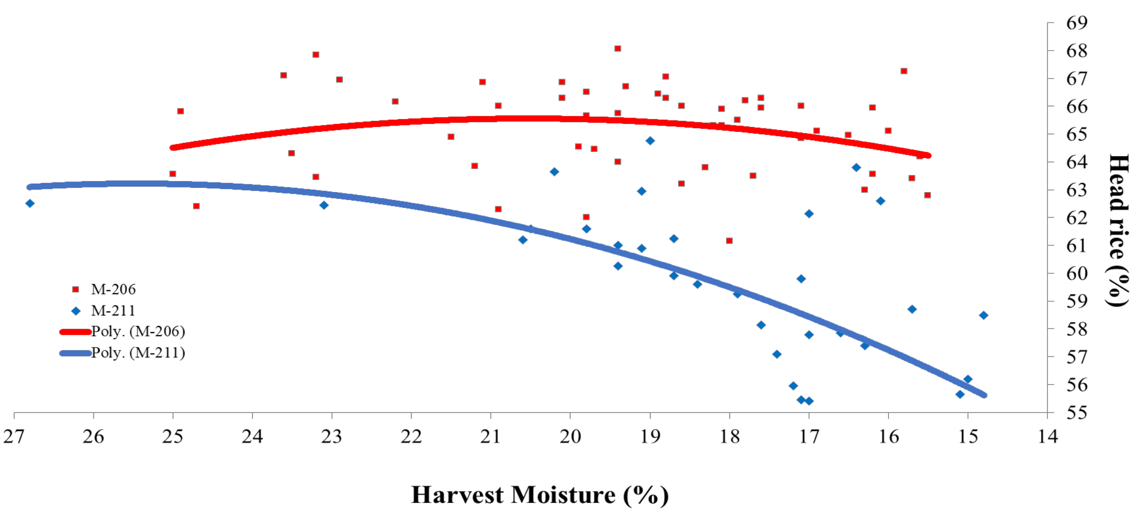

Figure 7. Effect of harvest grain moisture on head rice yield of M-211 and M-206.

Table 9.wwwW Total number of hours of dew at the Rice Experiment Station during harvest season , 2003 – 2012.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
21-Sep	16	14	2							
22	16	14	4		11	2		2		
23	14	14			12					
24	11	14		2	8					
25	16	15			5				11	
26	16	11								
27	16	14	5	2	2					
28	11	12		5	13					
29	17	11			8					
30	16	14		3	6					
Oct.1	17	14		5	1					
2	16	14	3	6	2	9				
3	14	14	6	7	4	18			16	
4	13	12	2		6	10		4	4	
5	16	10			4	12				3
6	16	14		13	2	11		3		5
7	15	8		11	4	4				
8	16	10							1	
9	14				10		1		6	
10	1				13				4	
11	12			2	16		2			4
12	15			1	16		3			2
13	3	5		4	12		14			
14	15	8	2	8	12		7			3
15	16		8	10	17	2	12			
16	16			5	16	3			3	
17					5	2	10	8		
18				1	5		9	9		
19			8		13	6	9	8	6	
20			8			4			4	4
21							8	1		6
22					7		11	3		
23					7	1		4		

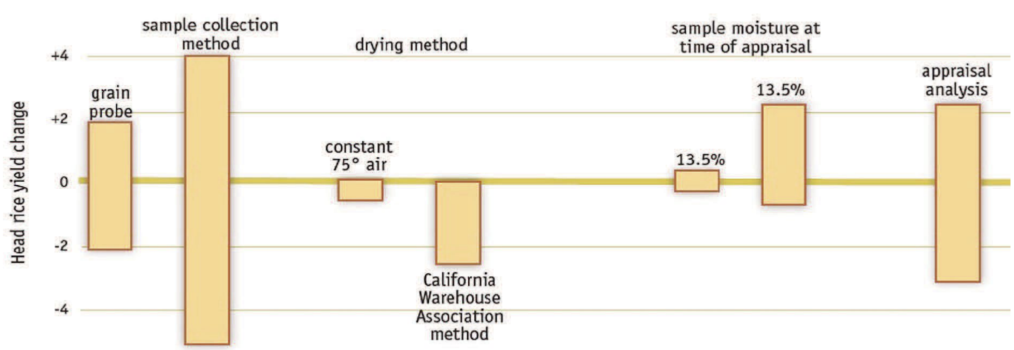

Figure 8. Variability and error in head rice yield results associated with appraisal sample collection, sample drying method, and sample analysis.

harvest season there were only two in nights with extended periods of dew and none in 2012. However, there were 7 continuous days of heavy dew during peak harvest in 2007.

Reducing Variability in Quality Appraisal Samples

- Variability and error in appraisal samples can be minimized by:
- collecting a representative sample; do not use a single catch can sample,
- drying samples with room temperature air to maximize head rice quality,
- drying samples to the same moisture content, because lower moisture samples have slightly, higher head rice quality than samples at 14 percent moisture content,
- using a standard multi-sample vacuum probe and a splitter to obtain the needed amount.

Analysis of replicated head rice samples appraisals by the CDFA showed that results fall within a range of 4.8 percent (± 2.4 percentage points). Variability was greater when the samples were appraised within a few days of drying but did not change after longer periods of storage (Figure 8).

Sample Drying

Air temperature used for sample drying can affect head rice quality. Maximum quality is achieved by using air at a constant room temperature of 75°F or lower (Figure 8). If the air is heated, the rice should be exposed to warm air only periodically and allowed to temper between exposures. For example, the California Warehouse Association recommends heated air at 100°F followed by a 4-hour tempering before the next 30-minute exposure. This procedure produces head rice yields about 2.5 percentage points lower than the room temperature air method.

Sample Moisture

Sample moisture content at milling appraisal affects head rice yield. For example, medium grain rice gains about 2 percentage points of head rice when the sample moisture drops from 13.5 to 12 percent. Short grain rice is less affected by sample moisture. In contrast, long grain rice may have a 6-point spread over this range of grain moisture content.

Rice Certification Law

California's complex market and variety situation requires procedures to ensure that different types of rice do not get mixed. Transgenic varieties with unique production and quality traits are not currently grown commercially in California. While biotechnology has enormous potential to create rice varieties with a wide variety of nutritional, medicinal and industrial uses, it is important to prevent commingling with other, similar looking varieties 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 went to effect in the 2003 crop year. This legislation contains both mandatory and voluntary identity preservation (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 varieties currently being grown and successfully segregated in California (e.g., sweet, scented, basmati, arborio, and colored bran varieties) may eventually be identified as having commercial impact. IP procedures for these varieties are already in place.

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 or rice that is intended for commercial use. 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 although it has not been used to any extent to date. 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, 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.

Regulations on Varieties and Rice Seed

Rice seed can only be introduced into the US through a USDA APHIS approved quarantine permitted greenhouse protocol. A similar quarantine protocol is also required to bring seed rice into California from the rice producing states in the southern US. All rice varieties grown in California must be reviewed by Rice Certification Committee of the California Rice Commission for determination of commercial impact (CI) and approved for commercial production.

Varieties are classified as;

1. No commercial impact (standard medium, short and long grains).
2. Tier 1 premium short grains, waxy or mochi, bold grains, or aromatics.
3. Tier 2 colored bran, or genetically modified (currently none in the US).
4. Tier 1&2 have requirement for identification, handling, planting and harvest to prevent contamination.
5. Testing for the presence of the transgenic "Liberty Link" event that contaminated southern US long grains will only continue on "foundation" seed for all commercial varieties.
6. Beginning in 2019 all commercial rice planting in California must use a class of certified seed, (see California Crop Improvement Association) or an approved seed program for varieties not able to be certified or proprietary (e.g. Quality Assurance (QA) seed).

Intellectual Property Protection

Since the unauthorized export of RES rice varieties to Spain in 1989, rice varieties released by the California Cooperative Rice Research Foundation's (CCRRF) Rice Experiment Station have been protected under the US Plant Variety Protection Act (Title 5 to be sold as a class of certified seed only and not for export) and since 2000 all releases have been protected with US Utility Patent. Use of these varieties for breeding or genetic research requires a material transfer agreement. Beginning in 2018 all seed producers of RES rice varieties will be licensed by CCRRF that includes registering with complying with the requirement of the California Crop Improvement Association and the California Department of Food Agriculture.

Appendix A
story of California Rice Varieties

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, an 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-206 has been the predominant variety produced in the state over the last several years. 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 marketplace 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 A-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 3 California developed semidwarf varieties Calhikari-201, Calihikari-202, and Calihikari-203. 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 A-III contain quality characteristics for California long grains.

Specialty types include the waxy short grains Calmochi-101 and Calmochi-203; the long grain aromatics A-201and A-202; and the aromatic basmati type Calmati-202; and the jasmine type Calaroma-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]		Gel Temp.[3]	Brown Rice Kernels[4]			
		%	Brown	Milled	High/Int/Low	Length	Width	L/W	Weight
M-104	Calrose	17.8	7.8	7.0	Low	6.3	2.8	2.3	24.1
M-202	Calrose	16.5	7.5	6.6	Low	6.1	2.9	2.1	23.9
M-205	Calrose	17.8	7.1	6.3	Low	6.4	2.7	2.3	24.4
M-206	Calrose	17.7	6.7	5.9	Low	6.2	2.8	2.2	24.6
M-208	Calrose	17.3	6.2	5.6	Low	6.6	2.9	2.3	24.9
M-209	Calrose	17.1	6.8	6.0	Low	6.23	2.8	2.2	24.6
M-210	Calrose	15.7	7.3	6.4	Low	6.31	2.8	2.2	23.1
M-211	Calrose	14.1	5.8	5.1	Low	6.33	3.0	2.1	26.1
M-401	Premium	18.1	5.9	5.2	Low	6.4	2.8	2.3	25.6

[1]Apparent amylose content. [2]N%x 5.95 dry basis. [3]Gelatinization temperature type: High, Intermediate, low
[4]Kernel dimensions in mm, L/W, length width ratio, and 1000 kernel weight in g.

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

Variety	Type	AC[1]	% Protein[2]		Gel Temp.[3]	Brown Rice Kernels[4]			
		%	Brown	Milled	High/Int/Low	Length	Width	L/W	Weight
Akitakomachi	Premium	17	7.2	6.4	Low	5.3	2.9	1.9	21.3
Koshihikari	Premium	17.6	6.5	5.5	Low	5.1	2.9	1.8	20
Calhikari-201	Premium	18.2	6.7	5.7	Low	5.1	3.0	1.7	20.3
Calhikari-202	Premium	16.9	6.2	5.7	Low	4.9	2.9	1.7	19.2
Calhikari-203	Premium	19.8	6.5	5.8	Low	4.9	2.9	1.7	19.2
S-102	Short	18.6	7.0	6.4	Low	5.8	3.2	1.8	27.5
S-202	Short	14.4	8.2	7.5	Low	6.3	3.3	1.9	25.2
Calmochi-101	Glutinous	0.1	6.8	6.1	Low	5.3	2.9	1.8	22.7
Calmochi-203	Glutinous	0.0	6.2	5.7	Low	5.4	3.2	1.7	24.5
Calamylow-201	Low amylose	6.3	6.5	5.7	Low	4.8	2.9	1.6	18.5

[1]Apparent amylose content. [2]N%x 5.95 dry basis. [3]Gelatinization temperature type: High, Intermediate, low
[4]Kernel dimensions in mm, L/W, length width ratio, and 1000 kernel weight in g.

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

Variety	Type	AC[1]	% Protein[2]		Gel Temp.[3]	Brown Rice Kernels[4]			
		%	Brown	Milled	High/Int/Low	Length	Width	L/W	Weight
L-205	Newrex	24.1	8	7.7	Intermediate	7.3	2.3	3.2	21.7
L-206	Long	23.1	6.9	6.2	Intermediate	8.0	2.2	3.6	23.2
L-207	Long	24.3	6.5	5.6	Intermediate	8.0	2.2	3.6	23.5
L-208	Long	23.9	6.4	5.4	Intermediate	7.8	2.2	3.6	22.5
A-201	Aromatic	23.7	8.0	7.7	Intermediate	7.9	2.2	3.6	23.0
A-202	Aromatic	22.4	6.6	5.6	Intermediate	7.9	2.4	3.3	24.7
Calmati-202	Basmati	24.8	8.0	7.5	Intermediate	8.0	2.1	3.9	22.2
Calaroma-201	Jasmine	15.7	6.4	5.8	Low	8.0	2.1	3.7	22.8

[1]Apparent amylose content. [2]N%x 5.95 dry basis. [3]Gelatinization temperature type: High, Intermediate, low
[4]Kernel dimensions in mm, L/W, length width ratio, and 1000 kernel weight in g.

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	SPQ	1999	E	Koshihikari/(Koshihikari/S-101)*2
Calmati-201	LB	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
M-208	M	2006	E	M-401/3/Mercury//Mercury/Koshihikari/4/M-204
Calmati-202	LB	2006	E	A-201/9543483 (Calmati-201 sib)
L-206	L	2006	E	L-203/4/Lemont/3/R1588/L-201//R1588/Labelle
Calamylow-201	SLA	2006	E	Induce mutant of Calhikari-201
M-105	M	2011	VE	M-206/M-104
Calhikari-202	SPQ	2012	E	Koshihikari*2/S-101//Koshihikari/S-101/3/Hitomebore
A-202	LA	2014	E	03Y551(94Y39//JSMN85 /Della)/02Y045(L204/95Y442)
M-209	M	2015	E	M-205/5/M-201/M7//M-201/3/M-202/4/M-204
Calmochi-203	SWX	2015	E	M7//D51/R57/3/M-302/4/CM-101(87Y259)/5/CM101/6/NFD108/7 / M102/CM101/3/AKENO//CP/CM101
L-207	L	2016	E	F1R32425(05P3310(PI614958)/02Y516)/99Y529
M-210	M	2018	E	M-206*8/97-Y-315vE
Calaroma-201	LJ	2018	E	00KDMX3-3/4/90Y563/3/L202/QUIZHAW/L2O2/5/JES
S-202	S	2019	E	84Y254//M-102/85Y13/3/DENGYU1/88Y013/4/84Y254 /85Y013//Calpearl/ CM-101/3/S-102
M-211	M	2020	E	M-206/4/M203/K397//M205/3/87P1309//M401/M203
L-208	L	2020	E	05P3310/02Y516//99Y529
Calhikari-203	SPQ	2023	E	10Y2049/04Y177/4/Kosh*2/S-101//Kosh/S-101/3/Hitome

Market type: L= long; M=medium; S=short; SPQ=premium short; SLA=low amylose short; SWX=waxy ; LA=Aromatic long; LB=Basmati; LJ=Jasmine

Maturity: VE=very early; E=early; M=medium/intermediate; L=late