Improved Short Stature Rice

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When California rice growers established objectives for the research they have helped support for seven years, they expressed need for varieties with short stature for greater lodging resistance, early maturity (to facilitate harvest before fall rains), and glabrous or smooth hulls to reduce dust during harvesting and drying. We have taken a series of steps toward incorporating these features into Calrose, a high yielding variety with good cold tolerance and good milling and cooking qualities. Advantages of this procedure are that new desirable features are added step-by-step with minimal danger of losing past achievements.

The first step, to put short stature into Calrose, was achieved by using irradiation to induce short stature mutants in Calrose. In 1969 we exposed Calrose seeds to radioactive Cobalt-60. Gamma rays emitted from this radioactive isotope are known to induce mutations in rice (and in other plants). In 1971 Dr. Chao-Hwa Hu, a visiting scientist from Taiwan specializing in radiation genetics, made selections for short stature and early maturing mutants in the first segregating generation (M_2). By 1972 we had established genotypes which were true breeding for short stature.

The most promising short stature selection, designated D7 (Step 1, fig. 3), is similar to Calrose except for being 10 inches shorter and having more awning. In extensive tests with the check variety CS-M3 (a smooth hull, tall variety replacing Calrose) D7 has slightly higher yield, is 14 inches shorter (fig. 2), and is, hence, more lodging resistant. For all other characteristics (seedling vigor, maturity, grain length, milling yield, cooking quality) D7 is nearly identical to Calrose and CS-M3. We found that D7's short stature is inherited as a single recessive gene. In crosses with tall varieties such as CS-M3, 1/4 of the progenies of the first segregating generation (F_2) were true breeding for short stature. The D7 short stature gene confers a high degree of lodging resistance to the short progenies (fig. 1).

We used the same irradiation treatment to induce early maturing mutants in Calrose (no direct mutants that had both short stature and early maturity were found). The most promising early maturing mutants (Step 2, fig. 3) are 15 to 18 days earlier than Calrose. These genotypes are similar to the commercial variety Earlirose, but mature 1 to 5 days sooner than Earlirose.

Next we combined the short stature gene from Step 1 with the smooth hull gene of the tall variety CS-M3. We first hybridized CS-M3 and D7, then selected lines with short stature and smooth hulls (Step 3, fig. 3. Since short stature is controlled by a single recessive gene, 1/4 of the first segregating generation should be true breeding for short stature. Smooth hull is also inherited as a single recessive character, so 1/4 of the segregating generation should have smooth hulls. The expected frequency of genotypes carrying both recessive genes is 1/4 x 1/4 = 1/16. Thus, 1/16 of the first segregating generation is expected to be true breeding for the combination of the two desired features of short stature and smooth hull. By 1974 we had obtained this combination (Step 3, fig. 3).

In 1974 we selected a few spontaneous mutants for early maturity in the Step 1 genotypes. In progenies of these spontaneous mutants, we found a short stature genotype that was 15 days earlier than Calrose (Step 4, fig. 3).

Thus, by 1975 we had established a short stature genotype (Step 1), an early genotype (Step 2), a short stature, smooth genotype (Step 3), and a short stature, early genotype (Step 4).

Our next objective is to establish several short, smooth genotypes which are 7 to 15 days earlier than Calrose. Because we would like to have several such lines, each differing slightly in maturity, we are pursuing Step 5 by three different pathways (in effect, a "fail-safe" system) to maximize chances for success (fig. 3).

The first pathway is to select a few early maturing segregants which occurred in the cross between CS-M3 and D7, the cross which previously led to Step 3. Several early selections (7 to 10 days earlier than Calrose) have been identified from this pathway.

A second pathway to Step 5 is by hybridizing Step 2 genotypes and Step 3 genotypes. Step 2 genotypes have one desirable feature, early maturity, while Step 3 genotypes have two desirable features, short stature and smooth hulls. Only 1/16 of the segregants from the cross between Step 2 and Step 3 genotypes will recombine short stature and smooth hulls, and some fraction of this group should also be early maturing. Since more than one gene appears involved in the inheritance of early maturity, we cannot predict the exact frequency of early maturing segregants. By growing 600 plants of this segregating population, we obtained several plants which are true breeding for short stature

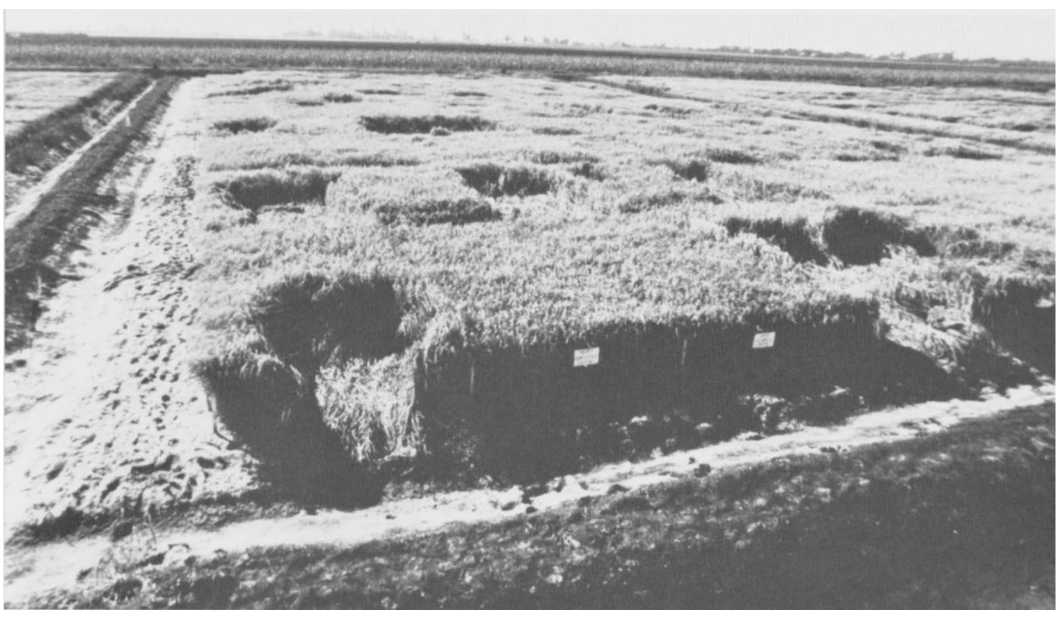

Fig. 1. The D7 gene for short stature confers lodging resistance to short progenies from crosses with tall varieties. Tall progenies are completely lodged ("holes" in photograph) while short lines remain erect.

Fig. 2. The short stature mutant D7 (from Step 1, fig. 3) is 14 inches (35 centimeters) shorter than the tall check variety CS-M3.

and smooth hulls and which are also 7 to 15 days earlier than Calrose. Because of the uncertain inheritance of early maturity, we will progeny test these plants in 1976.

A final pathway for achieving Step 5 is by hybridizing Step 3 and Step 4 genotypes. Since both Step 3 and Step 4 carry the same short stature gene, all of their progenies will be short. Thus, the breeding problem reduces to combining the smooth hull character of Step 3 genotypes with the early maturity of Step 4 genotypes. Work on this third pathway was initiated in 1975; we expect to achieve Step 5 by one or more of these three pathways in 1976 or 1977.

A spin-off of the processes outlined in fig. 3 has been the development of materials for testing the effects of single genes on grain yield in rice. Thus in hybridizing Step 1 genotypes with CS-M3, we obtained four combinations of the genes for stature and hull type: (1) short and smooth, (2) short and rough, (3) tall and smooth, and (4) tall and rough. All four combinations are in the late maturity background of Calrose and CS-M3.

The parent genotypes are known to be closely related—D7 is a direct mutant from Calrose, and Calrose was one parent of CS-M3, the other being a selection also related to Calrose. Since we observed little segregation in the cross except for

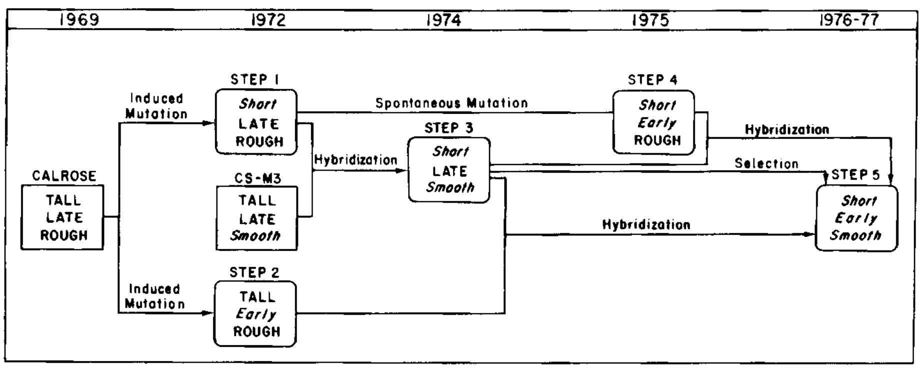

Fig. 3. Step-by-step addition of short stature, smooth hulls, and early maturity into California rice germplasm are delineated. Desirable attributes are italicized.

AGRONOMIC AND QUALITY CHARACTERISTICS OF THE SHORT STATURE GENOTYPE D7 COMPARED WITH THE TALL CHECK VARIETY CS-M3. YIELD DATA ARE THE MEANS OF 19 TRIALS IN 1973-1975.

Character	D7	CS-M3
Yield, lb./A at 14% moisture	7530	7200
Plant height, inches	34	48
Lodging, %	18	45
Seedling vigor score*	3.96	4.00
Days to heading	112	111
Brown rice kernel length, mm	5.80	5.96
Head rice yield, %	69.1	68.8†
Amylose, %	18.4	18.9†

*1 = poor, 5 = excellent vigor.

†Average of CS-M3 and Calrose from the same trials.

the single gene characters of short stature and smooth hull, we were able to obtain sets of genotypes differing mostly by single genes. Such genotypes, known as "near-isogenics," are excellent materials for testing the effects of a single gene on yield and other important characters.

The four types of near-isogenics noted have been used to determine the effect of short stature on yield and lodging resistance. Short lines are much more lodging resistant (fig. 1) and hence yield more at high fertility levels (unpublished data). The near-isogenics have also been used to determine the effect of smooth hulls on yield. No significant differences in yield between smooth and rough hull near-isogenics have been observed (unpublished data).

Early and late maturing near-isogenics are currently being developed from the processes outlined in fig. 3. When the development is completed, we will be able to determine whether early maturity affects yield when all other characters are essentially identical.

Another way of obtaining short stature (and hence lodging resistance) is through using the short tropical variety IR8 from the International Rice Research Institute in the Philippines. While preliminary studies indicate that the gene for short stature in D7 may be the same as the gene for short stature in IR8, a major difference in the two sources is that the D7 gene is already in the California japonica germplasm, whereas the IR8 gene is the tropical indica background. Thus, attempts to transfer the IR8 gene into California germplasm have been complicated by sterility in early generations and by cold susceptibility and unacceptable grain and cooking quality from the IR8 parent. Since the D7 mutant is already in the California germplasm, it has the definite advantages of possessing suitable cold tolerance and good cooking quality. In California, therefore, it has been easier to utilize the D7 source of short stature than the IR8 source.

A possible disadvantage of D7 is that lines developed from it rely on the germplasm base characteristic of older California rice varieties. After the difficulties of the cold susceptibility and poor grain quality of the IR8 source are overcome, lines developed from IR8, by introducing new genetic variability, may show greater long-term advantages.

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Fungicides for Control of Sugarbeet Powdery Mildew

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Powdery mildew of sugarbeet, caused by *Erysiphe polygoni*, was first found in California in 1934, but did not become prevalent statewide until the 1974 season. Results of trials in 1974 indicated sulfur dust (40 pounds per acre) or wettable sulfur provided excellent control of sugarbeet powdery mildew. Trials were initiated in 1975 to compare 20 pounds of sulfur dust per acre, wettable sulfur, Benlate + oil, and various other combinations.

1975 trial

Seeds of the sugarbeet, cultivar US H9, were planted on February 26, 1975 at the University of California, South Coast Field Station near Santa Ana. Plots consisted of single rows, 30 inches wide and 25 feet long, for the fungicide spray portion of the experiment. Dust plots were six single row beds. The plot was replicated five times. Sprays were applied with a 2 gallon Hudson CO_2 pressurized sprayer at 30 psi. Dusts were applied with a small hand duster. Rates of the sprays are per 100 gallons of water and complete coverage of the foliage was obtained. Sprays and dusts were applied on June 25 shortly after mildew appeared in the field and again on August 15. Disease rating was made on August 4 on a scale of 0 to 4, leaves completely covered by powdery mildew rating 4. Sugarbeet root yields were taken from 15 feet of row on August 11.

CONTROL OF POWDERY MILDEW OF SUGARBEET WITH APPLICATIONS OF FUNGICIDE SPRAYS AND DUSTS, SANTA ANA, CALIFORNIA, 1975.

Treatment	Dis. rating	Tons, fresh wt./acre
Sulfur dust, 20 lb./acre	0.3*a	31.4
DPX 110, 4 lb.	1.0 a	30.8
Thiolux wettable sulfur 80%, 5 lb.	1.7 b	29.2
Benlate 50W, 8 oz.	2.4 bc	28.2
Benlate 50W, 4 oz. + Agrodex 2 pt.	2.8 c	28.7
No treatment	3.7 d	24.9
		NS

*Treatment means followed by no letter in common are significant at the 5% level.

Results

Sulfur dust or DPX 110 provided excellent control of sugarbeet powdery mildew. DPX 110 is an experimental product of DuPont and contains a high amount of sulfur. Five pounds of wettable sulfur per acre provided intermediate control. The addition of Agrodex oil to Benlate did not enhance control of mildew.

A 20.7 percent loss in sugarbeet root yield was sustained when comparing no treatment with the sulfur dust treatment.

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