son with the irrigated, started to slow down during the period of May 20 to May 27, when soil suction at the 2-ft level increased from about 0.8 bar to 1.8 bars (extrapolated). At picking time there was a significant difference in fruit diameter of 0.5 mm between the two treatments. The 200 fruit samples showed a 5% increase in fruit weight for the irrigated plots.

By extrapolation it can be estimated that the soil suction at harvest had reached about 2.5 bars at the 2-ft level in the nonirrigated plots.

In 1964, irrigation water was applied on May 12 when the soil suction in the dry plot was only 0.5 bar. A response was not detectable until the week of May 19 to May 27 when the soil suction at the 2-ft level in the nonirrigated plot increased from 0.8 bar to about 1.5 bars (extrapolated). At harvest time the irrigated fruits had an average fruit diameter 0.7 mm larger than the nonirrigated fruits. At that time soil suction had reached about 2.4 bars at the 2-ft level in the nonirrigated plot, while in the irrigated plot soil suction was 0.5 bar.

In 1966, the first irrigation was given on April 20. A few weeks later it was apparent that the nonirrigated fruits were growing slightly faster than the irrigated ones. On May 9, soil temperature measurements revealed that the irrigation had either cooled the soil or delayed its warming.

SOIL TEMPERATURE IN DEGREES CENTIGRADE AT THE DRIP LINE ON MAY 9, 1966

Plot	6 inches	18 inches	30 inches	42 inches
Nonirrig. Rep. 1 ...	21	20.5	19	17.5
Nonirrig. Rep. 2 ...	21	20.5	19	17.5
Irrigated Rep. 1 ...	19	19	18.5	17.5
Irrigated Rep. 2 ...	19	19	18	17

As shown in the table, temperatures were lower in the irrigated plots to a depth of 30 inches. Evidently this decrease in temperature slowed the fruit growth process slightly.

A second irrigation, on May 5, did not delay fruit growth further. Instead, it was accelerated—while fruit growth in the nonirrigated plots was slowed because of soil moisture stress. Soil suction readings on May 9, in the nonirrigated plots, were (on the average) 3 bars at the 1-ft and 0.8 bar at the 2½-ft level. At harvest time soil suction at the 1-ft level was about 4.5 bars and at 2½ ft, about 1.5 bars, five feet from the trunk. However, in the middles, considerably lower stresses were encountered. In spite of this, the fruit diameter at harvest was 0.4 mm larger in the irrigated than in the nonirrigated trees.

Conclusions

The average of the three years of testing showed that fruit size was increased 0.54 mm by irrigation. This means an increase of ¼ to ½ size grade. Preharvest irrigation is more critical on the heavier soil series of the district, such as Wyman, than on the lighter Ramada, Columbia, and Honcut soils. In all cases, irrigation in May about two to three weeks before harvest resulted in more rapid fruit growth during the final swell. An irrigation before May could result in a cooling effect which might slow fruit growth temporarily.

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Selection for canning quality in CALIFORNIA DARK RED KIDNEY BEANS

F. L. SMITH • R. L. DEMOURA

Certified seed of a new dark red kidney bean selection will be available for growers to replace the older California Dark Red Kidney bean within two years. The new selection, tested for the past four years, has shown less splitting, comparable canning quality, and yields as good or better than either the California or Michigan variety of dark red kidney bean.

RED KIDNEY BEANS have been grown in California since 1857. About thirty years ago, a dark red kidney variety was introduced in California for the purpose of supplying disease-free seed for Michigan. This variety was named Michigan Dark Red Kidney and was earlier, less vegetative, and lower yielding than California Red Kidney. To increase the yields, Michigan Dark Red Kidney was crossed with Maui Red Kidney, a late vigorous variety from Hawaii. The hybrids were selected for plant vigor, erectness and maturity; for seedcoat color, and for yield. A selection from the F_7 generation was released to growers as California Dark Red Kidney.

In the meantime, some canners in the state began to use the Michigan Dark Red Kidney for a canned salad bean. With two outlets—seed for Michigan and beans for the canners—the popularity of the dark red kidney increased to about one-third of the red kidney bean acreage in the state.

Soon after its release, canners called attention to one serious fault of the California Dark Red Kidney. Canning tests showed that the California Dark Red Kidney had more split beans than the Michigan variety. Since the Michigan variety was one of the parents of the new variety and no selection had been made for splitting, it seemed reasonable to assume that the California version of dark red kidney may have some genetic variability for canning quality. If so, it should be possible to select lines with low splitting percentages.

The splitting in the canned beans may be cross-sectional, longitudinal or both, ranging from small breaks in the seed coat to full length splits. In the more severe cases, the cotyledons are partially to completely separated. To grade the splitting according to the severity of the splits proved to be too cumbersome; therefore, it was decided to divide the

TABLE 1. PERCENTAGE OF NON-SPLIT DARK RED KIDNEY BEANS* IN TESTS WITH SIX LINES AND TWO VARIETIES, 1961–1964

Selection†	1961	1962	1963	1964
Sel. 33	..	39 ab	79 ab	39 b
46	56 ab	35 ab	71 bc	32 c
99	..	43 a	77 ab	35 bc
114	65 a	49 a	86 a	43 ab
165	..	38 ab	85 a	49 a
168	..	40 a	75 ab	46 a
Cal DRK	54 b	27 b	63 c	30 c
Mich DRK	67 a	41 a	81 a	43 ab
LSD at 5%	11.4	10.6	9.1	8.3

* Grouped by using the Duncan Multiple Range Test: a group, best entries; b group, next best; c group, poorest entries; and ab group, averages not significantly different from either a or b.

† Mich DRK > Cal DRK 1961, 1962, 1963, 1964; Sel. 114 > Cal DRK 1961, 1962, 1963, 1964; and Mich DRK > Sel. 114, no year.

TABLE 2. DISTRIBUTION OF LINES IN THE DUNCAN RANGE FOR PERCENTAGE OF NON-SPLIT BEANS, 1961 AND 1962

1959–1960 Line ratings	Duncan Range a	ab	b	c	Average non-split beans
	1961 Distribution				%
6 Low Lines		2	3	1	50.1
10 Intermediate Lines	2	6	1	1	56.1
7 High Lines	1	5	1		57.9
Calif. DRK			X		54.0
Mich. DRK	X				67.0
	1962 Distribution				
1 Low Line				1	18.0
26 Intermediate Lines	2	12	10	2	29.2
7 High Lines	1	5	1		37.4
Calif. DRK			X		27.0
Mich. DRK	X				41.0

TABLE 3. YIELD OF SIX LINES AND TWO VARIETIES OF DARK RED KIDNEY BEANS WITH RATINGS ON THE DUNCAN RANGE SCALE, 1961–1964

Selection*	1961	1962	1963	1964
	Yield (sacks per acre)†			
Sel. 33	..	18.8 a	23.2	24.5 a
46	12.3 a	18.9 a	24.3	23.6 ab
99	..	19.6 a	23.5	22.2 bc
114	9.7 bc	17.8 b	22.4	21.8 bc
165	..	17.1 b	23.0	21.5 c
168	..	16.3 bc	23.3	21.5 c
Cal DRK	10.9 b	17.1 b	24.1	22.8 b
Mich DRK	7.7 d	15.3 c	22.9	20.7 c
LSD at 5%	1.3	1.5	N.S.	2.1

* Cal DRK > Mich DRK 1961, 1962, 1964; Sel. 114 > Mich DRK 1961, 1962; Cal DRK > Sel. 114, no year.
† A sack of beans is 100 pounds net weight.

canned beans into two groups—non-split and split. Beans with splits longer than the width of the hilum (about 1 mm) were counted as split. The readings of the samples were then expressed as the percentage of non-split beans.

To test the heritability of splitting, 198 random plant selections were made from a field of California Dark Red Kidney in the F_{11} generation. The seed was planted in progeny rows in 1959 and 1960, with every tenth row planted alternately with the Michigan and California varieties. Two 100-bean samples were taken from each row for the canning tests.

The 1959 canning tests showed that the 198 progeny rows varied from 3% to 52% non-split, averaging 18%. In 1960, the range was from 9% to 64%, averaging 32%. The eleven Michigan variety tests ranged from 17% to 66% non-split in 1959 and 39% to 62% in 1960, with averages of 42% and 52% respectively. California Dark Red Kidney ranged from 11% to 25% non-split with a 17% average in 1959 and from 15% to 40% non-split with a 26% average in 1960. In both years, the varieties were significantly different, and the average of the two selections was about the same as the California variety. In 1959 and 1960 the correlation ratio for the selections between the percentage of non-split beans was .44—indicating that some of the factors which caused splitting are probably inherited.

Selections

The selections were then divided into three groups, those with a low non-split percentage, those with a high non-split percentage, and those falling in between. Replicated plots in 1961 and 1962 compared the yield and the splitting percentage of the selections from each of these groups. Statistical analyses were made on the splitting to test for significant differences and were grouped using the Duncan Multiple Range Test; the best entries being in the *a* group, the next best in the *b* group, etc. The averages which were not significant from either *a* or *b* were in the *ab* group. The results from six selections and the check varieties can be seen in table 1.

In both 1961 and 1962, there was a relationship to the readings made from the non-replicated plots in 1959–1960. If the tendency to splitting was not heritable, it would be expected that the progeny from each group would be scattered over the whole range from *a–c* but this was not the case (see table 2). In both 1961 and 1962, only the progenies from the medium group were distributed throughout the range.

Soil

The 1963 results are from a planting on a heavy clay soil in San Joaquin County. Unfortunately, the planting at Davis was not harvested that year because of rain damage.

A summary of the canning tests on six selections from 1961–64 and the two variety checks are shown in table 1. The most consistently high performance was obtained from Selection 114. In four years' testing in replicated plots, the canning quality was not significantly different from Michican Dark Red Kidney in any year.

Yield records are presented in table 3, for the four-year period. In 1963, there was no significant difference in the yields between varieties. The Duncan range tests indicate that Selection 114 yielded as well as California Dark Red Kidney every year and significantly higher than Michigan in two of the four years.

Selection 114 was increased; and in 1966, foundation seed was made available for certified seed production. Through the "generation plan" of seed certification, there should be ample seed of this selection to replace the older California Dark Red Kidney within two years.

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