New Hybrid Sugar Beet Varieties for California

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The discovery of cytoplasmic male sterility in the sugar beet by Owen (4)[3] provided a means of producing commercial hybrid seed. Methods of utilizing male sterility in the production of hybrid varieties have been developed and were described by Tolman and Johnson in 1956 (9). Advantages of hybrid varieties from both the standpoint of higher sugar yields and increased disease resistance have now been well demonstrated.

Fall and winter plantings in California require varieties that combine resistance to both bolting and curly top. Varieties used in the coastal valleys should also be resistant to downy mildew. Five new multigerm hybrids which meet the requirements of the major sugar beet-growing districts of California have been developed. These five hybrids are being released by the U. S. Department of Agriculture for use by the sugar beet growers.

Description of Hybrid Varieties

US H2

The US H2 hybrid variety has the parentage (MS of NB1 × NB3) × C663. The female parent is an F_1 hybrid between the male-sterile equivalent of the NB1 inbred and the NB3 inbred. The NB1 inbred (2) is an increase of an S_5 line resistant to bolting and curly top. This inbred is an excellent Type O, which insures that all its offspring from crosses to cytoplasmic male steriles will be completely male sterile. The male-sterile equivalent of NB1 has been produced by crossing NB1 to a cytopasmic male-sterile plant found in US 56 and then making repeated backcrosses to NB1.

The NB3 inbred is a moderately bolting-resistant segregate from the CT9 inbred developed by Owen (5). It possesses excellent curly-top resistance but lacks downy-mildew resistance. The F_1 hybrid between the MS of NB1 and NB3 has proved to be a high-performing female parent with excellent curly-top resistance and moderately good bolting resistance. The plants of this hybrid

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[3] Numbers in parentheses refer to literature cited.

are good seed producers and are all male sterile, which makes the hybrid an excellent female parent for use in producing commercial hybrid varieties.

The pollen parent C663 has been derived from a cross between US 15 and US 22. Selections for curly-top resistance, bolting resistance, and high sucrose content were made in the F_2 and F_3 generations. The curly-top resistance of C663 is similar to that of US 75 (3) and the bolting resistance to that of US 56 (6). C663 yields well but tends to be slightly inferior to US 56 and US 75 in sucrose content.

US H2 has been thoroughly tested during the past three years in each of the major sugar beet-producing districts of California. Gross sugar yields and sucrose contents expressed in percent of the performance of US 75 are summarized in Tables 1 and 2. These tests have been conducted by the U. S. Department of Agriculture, the University of California, and the four sugar companies operating in California. An average of these 47 California tests shows that the gross sugar yield of US H2 is 118% and the sucrose content 105% of those of US 75.

Production records (8) from 1958-59 commercial plantings made in the Imperial Valley of California by the Union Sugar Division of Consolidated Foods Corporation show that US H2 yielded 28.6 tons of beets per acre with 15.7% sugar on 235 acres. The commercial check grown in the same fields yielded 24.6 tons per acre with 15.8% sugar on 216 acres. The commercial check used in these fields was US 75 and US 56.

Tests at Jerome, Idaho, showed that US H2 is superior to US 75 in curly-top resistance. The bolting resistance of US H2 is slightly inferior to that of US 56 and US 75. The downy-mildew resistance is poor, and for that reason the variety should not be used near the coast.

US H2 is recommended for fall plantings in the Imperial Valley and for spring plantings in the Central Valley of California. It does not possess sufficient bolting resistance for fall plantings in the Central Valley. It can be used for winter and spring plantings in the inland portions of the coastal valleys, where downy mildew is not a problem.

US H3

The US H3 hybrid variety has the parentage (MS of NB1 $\times$ NB3) $\times$ C586. It has the same female parent as US H2, but a selection from the US 35 variety has been used as pollen parent in place of C663. This selection has been designated C586 and is the product of three successive selections for bolting resistance. C586 is similar to US 75 in bolting and curly-top resistance.

Table 1.—Gross sugar yields of US hybrid varieties in 1956-59 California variety tests expressed as percent of the yield of US 75.

Variety and year	Coastal District		Central Valley District		Imperial Valley District	
	No. of tests	Percent of US 75	No. of tests	Percent of US 75	No. of tests	Percent of US 75
US H2						
1957	3	113	4	123	3	118
1958	5	111	3	104	7	124
1959	2	124	12	121	8	118
US H3						
1956	1	116	2	112	1	104
1957	4	107	4	101	2	108
1958	5	96	1	96	7	106
1959	2	111	7	104	7	111
US H4						
1956	2	106	2	113	1	108
1957	4	109	3	113	1	113
1958	5	113	1	101	6	105
1959	1	107	11	111	6	115
US H5A						
1958	8	113	1	103	7	115
1959	5	108	0		1	111
US H5B						
1959	8	116	2	126	2	119

Like the parent US 35 variety, it has a relatively high sucrose content but tends to be low in yielding ability. Hybrid varieties which result from the use of C586 as the pollen parent are superior in sucrose content to those in which C663 is utilized as the pollen parent but are inferior in yield.

The results of 43 tests conducted with US H3 during the past four years in the major sugar beet-production districts of California are summarized in Tables 1 and 2. In these tests both the gross sugar yield and the sucrose content of US H3 averaged 105% of US 75. Tests at Salinas, California, and Jerome, Idaho, showed that resistances to curly top, bolting, and downy mildew are similar in US H2 and US H3.

US H3 is adapted to the same districts and planting dates as is US H2. Although sucrose percentages of US H3 are consistently higher, gross sugar yields are lower than those of US H2. US H3 is recommended for areas which have a problem with low sugar.

US H4

The US H4 hybrid variety has the parentage (MS of NB1 × NB2) × C586. The parentage is similar to that of US H3 except for substitution of the NB2 inbred for NB3. The NB2

inbred has been developed from a cross made at Salt Lake City, Utah, in 1943 between a bolting-resistant clone and a self-fertile line. Following selection work at both Salt Lake City and Salinas, California, a high-performing S_5 line was designated NB2. This inbred possesses good vigor, moderately good bolting resistance, and fair curly-top resistance. It has demonstrated good combining ability especially from the standpoint of sucrose content. The F_1 hybrid between the MS of NB1 and NB2 has moderate resistance to both bolting and curly top. It has good vigor and male sterility and has performed well as a female parent in the production of hybrid varieties.

US H4 possesses moderately good bolting and curly-top resistance. It has been included in 43 variety tests during the past four years. A summary of these tests (Tables 1 and 2) show that it produced an average of 10% more gross sugar per acre than did US 75 and that its sucrose content was 107% of US 75. It has performed especially well in the Imperial Valley where it has maintained a high sucrose content during June and July, when the temperatures are extremely high. The variety may also be used in winter and spring plantings in the coastal valleys of California.

Table 2.—Sucrose contents of US hybrid varieties in 1956-59 California variety tests expressed as percent of the sugar content of US 75.

Variety and year	Coastal District		Central Valley District		Imperial Valley District	
	No. of tests	Percent of US 75	No. of tests	Percent of US 75	No. of tests	Percent of US 75
US H2						
1957	3	104	4	105	3	103
1958	5	102	3	101	7	101
1959	2	102	12	105	8	102
US H3						
1956	1	109	2	109	1	106
1957	4	107	4	106	2	104
1958	5	103	1	107	7	104
1959	2	104	7	107	7	105
US H4						
1956	2	103	2	109	1	107
1957	4	107	3	107	1	111
1958	5	107	1	106	6	105
1959	1	105	11	109	6	108
US H5A						
1958	8	102	1	99	7	100
1959	5	102	0		1	101
US H5B						
1959	8	101	2	99	2	101

US H5A and US H5B

The US H5A hybrid variety has the parentage (MS of NB1 × NB4) × C586 and US H5B has the parentage (MS of NB1 × NB4) × C663. These varieties are similar to US H2 and US H3 except for substitution of the NB4 inbred for NB3. The NB4 inbred is an S_5 line which originated from the same cross as did NB2. It combines bolting and downy-mildew resistance with good combining ability but lacks vigor and is susceptible to curly top. The F_1 hybrid between the MS of NB1 and NB4 has good bolting and moderately good curly-top resistance. Good male sterility and seed-setting ability make this F_1 hybrid a desirable female parent for use in the production of commercial hybrid varieties.

Both US H5A and US H5B possess good bolting and moderately good curly-top resistance. Although accurate evaluations of downy-mildew resistance have not been made, both hybrids are expected to be moderately resistant. The US H5A hybrid was included in 22 variety tests during 1958 and 1959. A summary of these tests (Tables 1 and 2) shows that the gross sugar yield averaged 112% and the sucrose content 101% of US 75. A summary of 12 tests with US H5B in 1959 shows that its gross sugar yield averaged 118% and its sucrose content 101% of those of US 75.

These two hybrids are adapted to fall planting in the Imperial Valley and to winter and spring plantings in the coastal valleys. They lack sufficient curly-top resistance for use in the San Joaquin Valley and in the southern part of the Sacramento Valley.

Seed of the Hybrid Varieties

Seed of the bolting-resistant varieties used in California is produced either in Oregon or in the Tehachapi Mountains of California. Each of the new hybrid varieties reproduces satisfactorily in these two areas provided it is planted by August 15. The hybrid seed is produced either by mixing the pollinator with the male-sterile parent or by the strip method.

The strip method of seed production requires the planting of alternate strips of male sterile and pollinator. For commercial seed production the male-sterile strips are usually 16 rows wide and the pollinator strips four rows wide (Figure 1). The pollinator strips are removed prior to harvest as a precaution against seed mixing. Seed produced by the strip method is entirely hybrid provided pollen-producing plants do not occur in the male-sterile parent and contamination with windborne

foreign pollen is avoided. Production costs are higher with the strip method because more labor is required and approximately one-third of the land is taken up by the pollinator strips.

When a good-performing pollen parent such as C663 or C586 is used the practice of mixing the male-sterile parent and the pollinator has proved to be a satisfactory method of hybrid-seed production. From 5 to 7% of the pollinator is thoroughly mixed with the male-sterile parent prior to planting. The pollinator plants intercross and the seed is harvested along with that of the hybrid. The presence of approximately 5% of C663 or C586 in the commercial hybrid has failed to cause a measurable adverse effect on the performance of the hybrid. This method of seed production has the advantage of bringing the male-sterile plants into close proximity with the pollen source and thereby provides a much higher concentration of pollen around the male-sterile plants (7) than when the strip method of seed production is used. This tends to reduce the amount of outcrossing which occurs when small amounts of pollen are windborne from other fields and when occasional pollen-producing contaminants are present in the male-sterile parent. This method of seed production is used extensively with the hybrid varieties described in this paper.

The male-sterile parents used to produce US hybrid varieties have also been made available to the sugar company breeders through the Beet Sugar Development Foundation and are used

Figure 1.—Seed field of the US H2 hybrid sugar beet variety near Salem, Oregon. The male-sterile parent is planted in 16-row strips and the pollen parent in 4-row strips. Photographed June 11, 1959.

in the production of sugar company hybrid varieties. The pollen parents used in these varieties have been developed by the sugar company breeders. Production of hybrid seed (1) in which bolting-resistant US male steriles were used in conjunction with sugar company developed pollinators totalled 918,000 pounds in 1959 and 1,658,000 pounds in 1960.

Summary

Five new sugar beet hybrid varieties adapted to California have been developed.

US H2 and US H3 combine good curly-top resistance with moderately good bolting resistance. US H3 is higher in percent sucrose and lower in gross sugar yield than is US H2. Both varieties are adapted to all beet-growing areas of California with the exceptions of those portions of the coastal valleys subject to downy mildew.

US H4 possesses moderately good bolting and curly-top resistance. Best performance has been in the Imperial Valley where a high sucrose content has been maintained during June and July.

US H5A and US H5B combine good bolting resistance with moderately good curly-top and downy-mildew resistance. They are adapted to the coastal and Imperial valleys.

The male-sterile components of the US hybrid varieties have been made available to the sugar company breeders and are being used extensively in the production of company varieties.

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