Breeding for Combined Resistance to Leaf Spot and Curly Top in Sugar Beet

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Introduction

Leaf spot, caused by Cercospora beticola, Sacc., has long been recognized as an important disease of the sugar beet (Beta vulgaris L.) in a large proportion of the sugar beet acreage east of the Rocky Mountains in the United States. Curly top, caused by the leafhopper-transmitted virus, Ruga verrucosans Carsner & Bennett, for many years has been a serious threat to the crop in much of the Western USA, especially west of the Rocky Mountains (6). The development of sugar beet varieties having some degree of resistance to leaf spot has given partial control of that disease east of the mountains, and the spectacular success in breeding curly top resistant varieties is well known.

Until recently, breeding work intended to produce varieties with combined resistance to leaf spot and curly top was not emphasized because of the fact that the sugar beet was not grown extensively in areas where both diseases were serious threats to the crop. In the last decade, however, the need for combined leaf spot and curly top resistance has increased substantially, especially because of expanded sugar beet production in areas where the crop is subject to both diseases. The most notable example of such a change occurred in the vicinity of Hereford, Texas, with the completion of the Merrill E. Shoup sugar factory by the Holly Sugar Corporation in 1964. Observation of the sugar beet crop in that area by the authors, for more than a decade, has shown that it is subject to severe attacks of leaf spot.
and curly top, either separately or concurrently. Leaf spot exposure of economic significance occurs in most years, and recognition of its importance is indicated by the fact that about 94% of the entire sugar beet acreage in that area (approximately 30,000 acres) was sprayed for leaf spot control in 1965. Curly top exposure ranges from negligible in some seasons to extremely severe in others. An example of the latter occurred in 1954 when the curly top susceptible check in a variety test at Hereford yielded only $\frac{1}{3}$ ton of roots per acre in contrast with a yield of 20 tons for the curly top resistant check. Except as affected by spraying and the use of resistant varieties, both diseases were relatively severe in that vicinity in 1965.

The feasibility of combining moderate to high levels of leaf spot and curly top resistance in the same sugar beet variety was demonstrated in 1961 by the performance of the open-pollinated variety, SP 6051-0, a product of breeding work conducted jointly by the Crops Research Division at Beltsville, Maryland, and the New Mexico Agricultural Experiment Station at University Park, New Mexico. Little, if any, commercial use has been made of SP 6051-0, but the combined levels of resistance in that variety represent a significant achievement.

Results of cooperative evaluation tests over a period of 5 years and results of other studies pertaining to the inheritance of resistance to leaf spot and curly top have led us to the general conclusion that resistance of F₁ hybrids, to either disease, is approximately intermediate between the resistance of the two parents. Consequently, it seems clear that high levels of combined resistance to leaf spot and curly top should be expected in F₁ hybrids only when both parents are high in resistance to both diseases. One of the principal objectives of this article is to report on progress in the development of such material. Except where otherwise indicated, the results presented were obtained in 1965.

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Cooperative Tests of LSR-CTR Varieties

Seed supplies of entries 1 through 7 (Table 1) were assembled at Fort Collins and distributed to cooperators who conducted and reported results for the evaluation tests listed below. Agronomic tests at two other locations were abandoned because of flood damage, poor stand, or other misfortunes.

Table 1.—Description of material in cooperative evaluation tests of LSR-CTR sugar beet varieties, 1965.

<table>
<thead>
<tr>
<th>Entry no.</th>
<th>Fort Collins no.</th>
<th>Description and supplier*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acc. 2634</td>
<td>SL (129 × 133) MS × SP 5822-0; monogerm; LSR-CTR; Farmers &amp; Manufacturers Beet Sugar Association and West Coast Beet Seed Company (WC lot 4475).</td>
</tr>
<tr>
<td>2</td>
<td>Acc. 2685</td>
<td>CT 5 MS × SP 5822-0; monogerm; LSR-CTR; F. &amp; M. and West Coast Beet Seed Company (WC lot 4494).</td>
</tr>
<tr>
<td>3</td>
<td>Acc. 2636</td>
<td>SL (129 × 133) MS × SP 6322-0; monogerm; LSR-CTR; F. &amp; M. and West Coast Beet Seed Co. (WC lot 4567).</td>
</tr>
<tr>
<td>4</td>
<td>SP 641204HOI</td>
<td>FC (502/2 × 503) MS × FC 901; monogerm; LSR-CTR; Sugarbeet Investigations, Fort Collins, Colorado.</td>
</tr>
<tr>
<td>5</td>
<td>SP 641204HO3</td>
<td>FC (502/2 × 504) MS × FC 901; monogerm; LSR-CTR; Sugarbeet Investigations, Fort Collins, Colorado.</td>
</tr>
<tr>
<td>6</td>
<td>Acc. 2623</td>
<td>SP 5822-0: a multigerm, USDA variety, resistant to leaf spot and black root, developed for use in eastern sugarbeet areas; included in these cooperative tests as an LSR check; seed furnished by G. E. Coe, USDA, Beltsville, Maryland.</td>
</tr>
<tr>
<td>7</td>
<td>Acc. 2633</td>
<td>US H6: a multigerm, USDA variety, resistant to curly top and bolting, developed for use in Calif.; included in these tests as a CTR check; seed furnished by J. S. McFarlane, USDA, Salinas, Calif.</td>
</tr>
<tr>
<td>8</td>
<td>Local check</td>
<td>furnished by cooperator.</td>
</tr>
<tr>
<td>9</td>
<td>Local check</td>
<td>furnished by cooperator (occasional).</td>
</tr>
</tbody>
</table>

*The parental lines listed were developed by various USDA stations and may be described as follows:

<table>
<thead>
<tr>
<th>Line</th>
<th>Seed type</th>
<th>Curly top</th>
<th>Resistant to Leaf spot</th>
<th>Black root</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT 5</td>
<td>mono.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL 129 and 133</td>
<td>mono.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP 5822-0 and 6322-0</td>
<td>multi.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FG 502/2, 503, &amp; 504</td>
<td>mono.</td>
<td>X</td>
<td></td>
<td>X (mod.)</td>
</tr>
<tr>
<td>FG 901</td>
<td>multi.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The agronomic tests varied considerably in plot size, experimental design, disease exposure, number of replications, etc. Certain of these details are given in the tables of results, but otherwise no attempt will be made to describe the individual tests in this article.

General summaries of harvest results of the agronomic tests, expressed as percent of the standard variety, SL (129 X 133) MS \times SP 5822-0, are presented in Tables 2, 3, and 4. Leaf spot resistance comparisons in the agronomic tests at Fort Collins and Beltsville are shown in Table 5, and curly top resistance data, obtained in observational tests at Logan and Thatcher, are presented in Table 6. An indication of the degree of precision in the respective agronomic tests is given in the form of LSD values expressed as percent of the actual average yield or sucrose percentage of the standard variety. A striking varietal contrast under severe curly top exposure at Artesia, New Mexico, is shown in Figure 1.

Because of the wide range in the severity of leaf spot and curly top exposures at the various locations, average perform-
Table 2.—General summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR sugar beet varieties, 1965; as percent of the standard variety, SL (129 × 193) MS × SP 5822-0.

<table>
<thead>
<tr>
<th>Location</th>
<th>Diseasesa</th>
<th>No. reps.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8b</th>
<th>9b</th>
<th>LSDc (.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) N. Tracy, Calif.</td>
<td>LS-1</td>
<td>8</td>
<td>100</td>
<td>110</td>
<td>106</td>
<td>100</td>
<td>106</td>
<td>98</td>
<td>92</td>
<td>99</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>(2) Hamilton City, Calif.</td>
<td>LS-3</td>
<td>9</td>
<td>97</td>
<td>107</td>
<td>119</td>
<td>113</td>
<td>77</td>
<td>103</td>
<td>112</td>
<td></td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>(3) Ft. Collins, Colo.</td>
<td>LS-1, Rh-2</td>
<td>9</td>
<td>124</td>
<td>119</td>
<td>112</td>
<td>104</td>
<td>119</td>
<td>77</td>
<td>94</td>
<td>103</td>
<td>124</td>
<td>5</td>
</tr>
<tr>
<td>(4) Rocky Ford, Colo.</td>
<td>LS-1</td>
<td>9</td>
<td>100</td>
<td>115</td>
<td>106</td>
<td>109</td>
<td>99</td>
<td>106</td>
<td>106</td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>(5) Tribune, Kan.</td>
<td>LS-1, Rh-2</td>
<td>9</td>
<td>110</td>
<td>103</td>
<td>88</td>
<td>100</td>
<td>92</td>
<td>100</td>
<td>96</td>
<td>93</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>(6) Garden City, Kan.</td>
<td>LS-1</td>
<td>3</td>
<td>100</td>
<td>101</td>
<td>120</td>
<td>105</td>
<td>102</td>
<td>94</td>
<td>100</td>
<td>90</td>
<td>95</td>
<td>18</td>
</tr>
<tr>
<td>(7) Johnson, Kan.</td>
<td>LS-1</td>
<td>5</td>
<td>100</td>
<td>115</td>
<td>110</td>
<td>96</td>
<td>111</td>
<td>71</td>
<td>101</td>
<td>103</td>
<td>89</td>
<td>6</td>
</tr>
<tr>
<td>(8) Goodwell, Okla.</td>
<td>CT-1, LS-1</td>
<td>10</td>
<td>100</td>
<td>106</td>
<td>103</td>
<td>106</td>
<td>114</td>
<td>101</td>
<td>88</td>
<td>128</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9) Hereford, Tex.</td>
<td>CT-3, LS-3</td>
<td>9</td>
<td>100</td>
<td>115</td>
<td>110</td>
<td>96</td>
<td>111</td>
<td>71</td>
<td>101</td>
<td>103</td>
<td>89</td>
<td>6</td>
</tr>
<tr>
<td>(10) Artesia, N. M.</td>
<td>CT-3+, LS-1</td>
<td>4</td>
<td>100</td>
<td>95</td>
<td>93</td>
<td>97</td>
<td>105</td>
<td>49</td>
<td>98</td>
<td>128</td>
<td>134</td>
<td></td>
</tr>
<tr>
<td>(11) Moorhead, Minn.</td>
<td>LS-1?</td>
<td>9</td>
<td>100</td>
<td>103</td>
<td>113</td>
<td>105</td>
<td>111</td>
<td>96</td>
<td>120</td>
<td>109</td>
<td>94</td>
<td>15</td>
</tr>
<tr>
<td>(12) Mason City, La.</td>
<td>LS-1?, Rh-1?</td>
<td>9</td>
<td>100</td>
<td>105</td>
<td>100</td>
<td>97</td>
<td>112</td>
<td>96</td>
<td>120</td>
<td>94</td>
<td>110</td>
<td>24</td>
</tr>
<tr>
<td>(13) Beltsville, Md.</td>
<td>BR-1, LS-3</td>
<td>3</td>
<td>100</td>
<td>75</td>
<td>107</td>
<td>98</td>
<td>100</td>
<td>105</td>
<td>68</td>
<td>78</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td>100.0</td>
<td>104.5</td>
<td>107.0</td>
<td>103.2</td>
<td>108.4</td>
<td>91.3</td>
<td>97.9</td>
<td>103.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Disease exposure considered sufficient to affect harvest results appreciably: BR = black root (*Aphanomyces cochlioides*); CT = curly top (virus); LS = leaf spot (*Cercospora beticola*); RH = Rhizoctonia root rot. Estimated severity of disease exposure: 1 = mild; 2 = moderate; 3 = severe.

b The local checks, entries 8 and 9, were as follows, respectively (location numbers in parentheses): (1) HH 8; (2) HH 9; (3) GW 674-56C and SL (126 × 128) MS × SP 5822-0; (4) Am 2 Mono and Am 2 Multi; (5) SL (126 × 128) MS × SP 5822-0 and G.W.S. Co. monogerm; (6) Am 2 Mono and Am 2 Multi; (7) same as (6); (8) HH 10; (9) HH 10 and HH 12; (10) HH 10 and Holly 3227-05; (11) Am 3 S Mono and Am 3 N Multi; (12) Am 3 S Mono and Am 3 S Multi; (13) SP 64100-05.

c LSD (.05) expressed as percent of the gross sucrose yield of the standard variety.
Table 3.—General summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR sugar beet varieties, 1965; as percent of the standard variety, SL (129 × 133) MS × SP 5822-0.

Root Yield

<table>
<thead>
<tr>
<th>Location</th>
<th>Diseasesa</th>
<th>No. reps.</th>
<th>Entry no.</th>
<th>LSD&lt;sup&gt;c&lt;/sup&gt; (05)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 2 3</td>
<td>4 5 6 7 8 9</td>
</tr>
<tr>
<td>(1) N. Tracy, Calif.</td>
<td>LS-1</td>
<td>8</td>
<td>100 113 109</td>
<td>96 104 99 97 100</td>
</tr>
<tr>
<td>(2) Hamilton City, Calif.</td>
<td>LS-3</td>
<td>9</td>
<td>100 99 107</td>
<td>113 109 96 98 104</td>
</tr>
<tr>
<td>(3) Ft. Collins, Colo.</td>
<td>LS-1</td>
<td>9</td>
<td>100 110 107</td>
<td>115 108 80 107 122</td>
</tr>
<tr>
<td>(4) Rocky Ford, Colo.</td>
<td>LS-1, Rh-2</td>
<td>9</td>
<td>100 126 123</td>
<td>109 106 119 84 100</td>
</tr>
<tr>
<td>(5) Tribune, Kan.</td>
<td></td>
<td>9</td>
<td>100 112 106</td>
<td>100 107 98 108 103</td>
</tr>
<tr>
<td>(6) Garden City, Kan.</td>
<td></td>
<td>8</td>
<td>100 106 93</td>
<td>83 90 88 96 89 86</td>
</tr>
<tr>
<td>(7) Johnson, Kan.</td>
<td></td>
<td>8</td>
<td>100 102 116</td>
<td>106 100 98 100 91</td>
</tr>
<tr>
<td>(8) Goodwell, Okla.</td>
<td>CT-1, LS-1</td>
<td>10</td>
<td>100 115 107</td>
<td>107 113 95 101 127</td>
</tr>
<tr>
<td>(9) Hereford, Tex.</td>
<td>CT-3, LS-3</td>
<td>9</td>
<td>100 115 109</td>
<td>94 110 72 104 105</td>
</tr>
<tr>
<td>(10) Artesia, N. M.</td>
<td>CT-3+, LS-1</td>
<td>4</td>
<td>100 92 101</td>
<td>93 105 42 134 114</td>
</tr>
<tr>
<td>(11) Moorhead, Minn.</td>
<td>LS-1?</td>
<td>9</td>
<td>100 106 112</td>
<td>100 109 101 121 106</td>
</tr>
<tr>
<td>(12) Mason City, La.</td>
<td>LS-1?, Rh-1?</td>
<td>9</td>
<td>100 101 96</td>
<td>95 104 93 132 90</td>
</tr>
<tr>
<td>(13) Beltsville, Md.</td>
<td>BR-1, LS-3</td>
<td>3</td>
<td>100 82 110</td>
<td>99 115 106 81 91</td>
</tr>
</tbody>
</table>

Average 100.0 106.3 107.4 100.8 106.2 91.3 104.8 105.2

<sup>a</sup> Disease exposure considered sufficient to affect harvest results appreciably: BR = black root (*Aphanomyces echioides*); CT = curly top (virus); LS = leaf spot (*Cercospora beticola*); Rh = Rhizoctonia root rot. Estimated severity of disease exposure: 1 = mild; 2 = moderate; 3 = severe.

<sup>b</sup> The local checks, entries 8 and 9, were as follows, respectively (location numbers in parentheses): (1) HH 8; (2) HH 9; (3) GW 67456C and SL (126 × 128) MS × SP 5822-0; (4) Am 2 Mono and Am 2 Multi; (5) SL (126 × 128) MS × SP 5822-0 and G.W.S. Co. monogerm; (6) Am 2 Mono and Am 2 Multi; (7) same as (6); (8) HH 10; (9) HH 10 and HH 12; (10) HH 10 and Holly 3227-05; (11) Am 3 S Mono and Am 3 N Multi; (12) Am 3 S Mono and Am 3 S Multi; (13) SP 64100-05.

<sup>c</sup> LSD (.05) expressed as percent of the root yield of the standard variety.
Table 4.—General summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR sugar beet varieties, 1965; as percent of the standard variety, SL (129 × 133) MS × SP 5822-0.

<table>
<thead>
<tr>
<th>Location</th>
<th>Diseases</th>
<th>No. reps</th>
<th>Entry no.</th>
<th>LSD (0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(1) N. Tracy, Calif.</td>
<td></td>
<td>8</td>
<td>100</td>
<td>98</td>
</tr>
<tr>
<td>(2) Hamilton City, Calif.</td>
<td>LS-I</td>
<td>8</td>
<td>100</td>
<td>95</td>
</tr>
<tr>
<td>(3) Ft. Collins, Colo.</td>
<td>LS-3</td>
<td>9</td>
<td>100</td>
<td>99</td>
</tr>
<tr>
<td>(4) Rocky Ford, Colo.</td>
<td>LS-1, Rh-2</td>
<td>9</td>
<td>100</td>
<td>98</td>
</tr>
<tr>
<td>(5) Tribune, Kan.</td>
<td></td>
<td>9</td>
<td>100</td>
<td>101</td>
</tr>
<tr>
<td>(6) Garden City, Kan.</td>
<td></td>
<td>3</td>
<td>100</td>
<td>103</td>
</tr>
<tr>
<td>(7) Johnson, Kan.</td>
<td></td>
<td>3</td>
<td>100</td>
<td>99</td>
</tr>
<tr>
<td>(8) Goodwell, Okla.</td>
<td>CT-I, LS-1</td>
<td>10</td>
<td>100</td>
<td>92</td>
</tr>
<tr>
<td>(9) Hereford, Tex.</td>
<td>CT-3, LS-3</td>
<td>9</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>(10) Artesia, N. M.</td>
<td>CT-3+, LS-1</td>
<td>4</td>
<td>100</td>
<td>103</td>
</tr>
<tr>
<td>(11) Moorhead, Minn.</td>
<td>LS-1?</td>
<td>9</td>
<td>100</td>
<td>97</td>
</tr>
<tr>
<td>(12) Mason City, Ia.</td>
<td>LS-1?, Rh-12</td>
<td>9</td>
<td>100</td>
<td>102</td>
</tr>
<tr>
<td>(13) Beltsville, Md.</td>
<td>BR-1, LS-3</td>
<td>3</td>
<td>100</td>
<td>98</td>
</tr>
</tbody>
</table>

Average: 100.0 98.5 99.8 102.5 102.5 101.1 93.6 100.1

---

a Disease exposure considered sufficient to affect harvest results appreciably: BR = black root (*Aphanomyces cochlioides*); CT = curly top (virus); LS = leaf spot (*Cercospora beticola*); Rh = Rhizoctonia root rot. Estimated severity of disease exposure: 1 = mild; 2 = moderate; 3 = severe.

b The local checks, entries 8 and 9, were as follows, respectively (location numbers in parentheses): (1) HH 8; (2) HH 9; (3) GW 674-56C and SL (126 × 128) MS × SP 5822-0; (4) Am 2 Mono and Am 2 Multi; (5) SL (126 × 128) MS × SP 5822-0 and G.W.S. Co. monogerm; (6) Am 2 Mono and Am 2 Multi; (7) same as (6); (8) HH 10; (9) HH 10 and HH 12; (10) HH 10 and Holly 3227-05; (11) Am 3 S Mono and Am 3 N Multi; (12) Am 3 S Mono and Am 3 S Multi; (13) SP 64100-05.

c LSD (0.05) expressed as percent of the sucrose percentage of the standard variety.
Table 5.—Leaf spot resistance comparisons of LSR-CTR sugar beet varieties, Fort Collins, Colorado, and Beltsville, Maryland, 1965.

<table>
<thead>
<tr>
<th>Description</th>
<th>Ft. Collins seed no.</th>
<th>Entry no.</th>
<th>Leaf spot grades&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ft. Collins&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8/23</td>
</tr>
<tr>
<td>SL (129 x 133) MS x SP 5822-0</td>
<td>Acc. 2634</td>
<td>1</td>
<td>3.9</td>
</tr>
<tr>
<td>CT 5 MS x SP 5822-0</td>
<td>Acc. 2635</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>SL (129 x 133) MS x SP 6522-0</td>
<td>Acc. 2636</td>
<td>3</td>
<td>3.7</td>
</tr>
<tr>
<td>FC (502/2 x 503) MS x FC 901</td>
<td>SP 64126H01</td>
<td>4</td>
<td>2.7</td>
</tr>
<tr>
<td>FC (502/2 x 504) MS x FC 901</td>
<td>SP 64126H03</td>
<td>5</td>
<td>2.8</td>
</tr>
<tr>
<td>SP 5822-0; LSR check</td>
<td>Acc. 2626</td>
<td>6</td>
<td>2.1</td>
</tr>
<tr>
<td>US H6; CTR check</td>
<td>Acc. 2633</td>
<td>7</td>
<td>5.7</td>
</tr>
<tr>
<td>GW 674-56C</td>
<td>Acc. 2168</td>
<td>8</td>
<td>2.9</td>
</tr>
<tr>
<td>SL (126 x 128) MS x SP 5822-0</td>
<td>Acc. 2642</td>
<td>9</td>
<td>4.2</td>
</tr>
<tr>
<td>SP 64100-05</td>
<td></td>
<td></td>
<td>2.0</td>
</tr>
</tbody>
</table>

<sup>a</sup> Leaf spot exposure was intensified artificially.

<sup>b</sup> Approximate basis of leaf spot grades: 0 = no leaf spot; 10 = complete defoliation.

<sup>c</sup> Plots 2 rows x 20'; 9 x 9 Latin Square design.

<sup>d</sup> Plots 4 rows x 20'; 3 replications; randomized block design.

Figure 1.—Comparison of sugar beet varieties under severe curly top exposure, Artesia, N. M., September 17, 1965; plots 4 rows (2 beds) wide and 22 ft. long. Left, SP 5822-0; right, FC (502/2 x 503) MS x FC 901.
Table 6.—Curly top resistance comparisons of LSR-CTR sugar beet varieties at Thatcher and Logan, Utah, 1965.

<table>
<thead>
<tr>
<th>Description</th>
<th>Fort Collins Entry</th>
<th>Thatcher (field plots)</th>
<th>Logan (greenhouse)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no.</td>
<td>C. T. incidence 9/15</td>
<td>Actual 10/1% US 41</td>
</tr>
<tr>
<td>SL (129 × 133) MS × SP 5822-0</td>
<td>Acc. 2634</td>
<td>76.9</td>
<td>4.0</td>
</tr>
<tr>
<td>CT 5 MS × SP 5822-0</td>
<td>Acc. 2635</td>
<td>76.6</td>
<td>4.0</td>
</tr>
<tr>
<td>SL (129 × 133) MS × SP 6322-0</td>
<td>Acc. 2636</td>
<td>74.8</td>
<td>4.0</td>
</tr>
<tr>
<td>FC (502/2 × 503) MS × FC 901</td>
<td>SP 614204HO1</td>
<td>82.0</td>
<td>4.5</td>
</tr>
<tr>
<td>FC (502/2 × 504) MS × FC 901</td>
<td>SP 614205HO3</td>
<td>78.2</td>
<td>4.0</td>
</tr>
<tr>
<td>SP 5822-0: LSR check</td>
<td>Acc. 2623</td>
<td>95.2</td>
<td>6.0</td>
</tr>
<tr>
<td>US H6: CTR check</td>
<td>Acc. 2633</td>
<td>62.3</td>
<td>3.0</td>
</tr>
<tr>
<td>US 33</td>
<td></td>
<td>82.8</td>
<td>4.8</td>
</tr>
<tr>
<td>US 41</td>
<td></td>
<td>17.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

* Plots 2 rows × 50′; each entry occurred in 2 replications; curly top exposure was intensified artificially.

* Seedling technique; curly top virus culture A1A; 20 plants per variety; 2 caged leafhoppers per plant.

* Basis of curly top grades: 0 = healthy; 9 = death due to curly top. In field plots, the grade represented the combined effects of curly top incidence and reaction of plants to infection. In the greenhouse, plants without curly top symptoms were disregarded.
ance figures for the LSR check (SP 5822-0) and the CTR check (US H6) mean little. Examination of the averages for certain other entries reveals the following important trends or relationships:

1. With SL (129 × 133) MS serving as the female, SP 6322-0 was substantially superior to SP 5822-0 for use as the pollinator. The average gross sucrose yield for entry no. 3 [SL (129 × 133) MS × SP 6322-0] was 107.0 percent of that of entry no. 1 [SL (129 × 133) MS × SP 5822-0], and there was essentially no difference in average sucrose percentage.

2. The outstanding hybrid in the entire series, in yield of gross sucrose, was entry no. 5 [FC (502/2 × 504) MS × FC 901], and its average sucrose percentage also was relatively high. The average gross sucrose yield and sucrose percentage for entry no. 5 were 108.4 and 102.5% of the corresponding averages for the standard variety, entry no. 1. Entry no. 3, described above, was the only close competitor of no. 5 in gross sucrose yield, but it was no better than the standard variety in sucrose percentage. Thus it was concluded that, under the array of conditions represented by these tests, FC (502/2 × 504) MS × FC 901 was substantially superior to the other LSR-CTR varieties (entries 1 through 4) in its combination of abilities to produce high gross sucrose yield with high sucrose percentage.

3. To put the above comparisons in proper perspective, it should be noted that the average gross sucrose yield and average sucrose percentage for entry no. 8 (local check), expressed as percent of the corresponding averages for entry no. 1 (standard variety), were 103.2 and 100.1, respectively. Furthermore, it should be recalled (a) that the current standard variety, SL (129 × 133) MS × SP 5822-0, exceeded SL 126 MS × SP 5460-0, in the 1964 cooperative test series, by an average of about 3% in gross sucrose yield; and (b) that the latter hybrid exceeded SL 122 MS × SP 5460-0 by 11% in gross sucrose yield in both the 1962 and 1963 cooperative test series.

---


As shown in Table 5, entries 1, 2, and 3 were approximately intermediate between the resistant and susceptible checks (entries 6 and 7) in leaf spot resistance. Each of the entries, 1, 2, and 3, was an F₁ hybrid of LSR × CTR material—i.e., leaf spot resistant × leaf spot susceptible—and its level of leaf spot resistance was about as expected. Entries 4 and 5 (F₁ hybrids of LSR × LSR-CTR material) were consistently better than entries 1, 2, and 3 in leaf spot resistance. Although not large, these differences are considered meaningful.

All of the entries, 1 through 5, were approximately intermediate between entries 6 and 7 in curly top resistance (Table 6). Since each of the entries, 1 through 5, received its curly top resistance from either the male or the female parent, but not both, an intermediate level of resistance in the hybrids was to be expected.

**Development and Evaluation of LSR-CTR, Monogerm, Type-0, Inbred Lines**

Basic breeding material utilized for the development of LSR-CTR, monogerm, type-0, inbred lines consisted of (a) curly top resistant lines, of both multigerm and monogerm types, furnished by the late Dr. F. V. Owen of the Crops Research Division, Salt Lake City, Utah; and (b) leaf spot resistant lines from the Division's breeding projects at Fort Collins, Colorado, and Beltsville, Maryland. The monogerm gene, where it occurred in this material, had been derived initially from SLC 101 (9). Because of earlier success in transferring leaf spot resistance by means of the backcross method (1), this technique was used as the principal tool for combining resistance to leaf spot and curly top. In this undertaking, the multigerm line, US 201, served as the nonrecurrent parent and the source of leaf spot resistance. Curly top resistant lines served as the recurrent parental type. Of the latter material, multigerm lines were used in matings to produce the F₁ and B₁ generations, and the monogerm, type-0, self-fertile line, SLC 122-0, was used to produce the B₂ generation. Monogerm segregates, selected from the open-pollinated increase of the B₂, were placed in two groups for seed production as follows: (a) SP 611100-0, a seed lot having cytoplasm derived from SLC 122-0; and (b) SP 611101-0, a seed lot having cytoplasm derived from the multigerm, curly top resistant line, SL 202. SP 611100-0 and SP 611101-0 were produced in the greenhouse by means of induced seedlings (2, 4). Selection for leaf spot resistance was performed in the field at Fort Collins in the F₁ and B₁ generations, and subsequently in populations of SP 611100-0 and SP 611101-0.
Leaf spot resistant individuals, selected from populations of SP 611100-0, SP 611101-0, etc., were mated with cytoplasmic male-sterile (CMS) material, for type-0 indexing purposes, and selfed. In contrast with the method reported by Owen (8) in which a CMS annual was used, the CMS material employed for the index matings in this as well as an earlier project (3) was biennial in character. Flowering of the hybrids, required for anther classification, was obtained promptly by means of the seedling induction technique (2,4).

**Observational Screening of Monogerm, Type-0 Lines for Leaf Spot and Curly Top Resistance**

An essential step in the development of LSR-CTR, type-0, inbred lines, is the observational evaluation of $S_1$ and $S_2$ lines for resistance to leaf spot and curly top promptly after indexing. A portion of the selfed seed obtained from each of 33 monogerm plants that had been indexed and rated type-0 or nearly so, was used in 1965 for curly top resistance evaluation in the greenhouse at Logan, Utah, and part was used for leaf spot resistance appraisal in field plots at Fort Collins, Colorado. The greenhouse technique was a modification of a method devised by Giddings (5). Additional details regarding techniques are given in Table 7.

The results of the leaf spot and curly top resistance comparisons are presented in Table 7. The superior resistance to both diseases, shown for three of the four sub-lines of FC 601 (entries 328-334), is of special interest. In addition to the FC 601 material, 11 lines, tentatively classed as type-0 or near-type-0, were at least equal to SP 5481-0 in leaf spot resistance and to US 41 in curly top resistance.

It should be noted that the four $S_1$ lines obtained directly from SP 611227-(001) were given average curly top grades ranging from 108 to 123. In contrast with those lines, one of the seven $S_1$ lines obtained from SP 631103-0 was given an average grade of 104 and the other six ranged from 88 to 98. SP 611227-(001) presumably is segregating for curly top resistance. Apparently, the greenhouse selection of curly top resistant seedlings in that population by C. W. Bennett, giving rise to SP 631103-0, may have improved the general level of resistance of the material.

---

Table 7.—Preliminary evaluation of leaf spot and curly top resistance of monogerm, type-0 and near-type-0, inbred lines of sugar beets, Fort Collins, Colo., and Logan, Utah, 1965.

<table>
<thead>
<tr>
<th>Description and/or source</th>
<th>Immediate parent</th>
<th>Strain no. (seed no.)</th>
<th>No. gen. self</th>
<th>Pol. rating</th>
<th>0.2 rating</th>
<th>Ft. Collins exp. no. 6A</th>
<th>Logan greenhouse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SP 611100-0</td>
<td>SP 622027a</td>
<td>2</td>
<td>4</td>
<td>95/0</td>
<td>301 1 0.5 0.5 5.0</td>
<td>65-1 18 110</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 620009c</td>
<td>2</td>
<td>4</td>
<td>92/0</td>
<td>303 2 1.8 1.8 5.0</td>
<td>65-2 20 104</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 620025a</td>
<td>2</td>
<td>5</td>
<td>96/0</td>
<td>307 2 1.8 2.5 6.0</td>
<td>65-4 20 75</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 620105a</td>
<td>2</td>
<td>5</td>
<td>95/0</td>
<td>311 2 2.8 3.5 6.5</td>
<td>65-5 19 102</td>
</tr>
<tr>
<td></td>
<td>SP 611101-0</td>
<td>SP 622107a</td>
<td>2</td>
<td>5</td>
<td>90/0</td>
<td>311 1 1.0 2.0 5.0</td>
<td>65-6 17 133</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 622101a</td>
<td>2</td>
<td>5</td>
<td>95/0</td>
<td>319 2 1.0 1.0 5.0</td>
<td>65-7 20 112</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 622075a</td>
<td>2</td>
<td>5</td>
<td>90/0</td>
<td>323 2 3.0 4.0 5.0</td>
<td>65-8 19 112</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 622112c</td>
<td>2</td>
<td>4</td>
<td>95/0</td>
<td>322 2 2.3 3.0 5.0</td>
<td>65-9 17 81</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 620064d</td>
<td>2</td>
<td>5</td>
<td>100/0</td>
<td>324 2 1.8 2.5 5.0</td>
<td>65-10 13 117</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 620072d</td>
<td>2</td>
<td>5</td>
<td>95/0</td>
<td>326 2 1.5 2.3 4.5</td>
<td>65-11 17 106</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 620107c</td>
<td>2</td>
<td>6</td>
<td>90/0</td>
<td>324 1 2.2 1.5 6.0</td>
<td>65-12 17 89</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 620105c</td>
<td>2</td>
<td>5</td>
<td>100/0</td>
<td>330 1 2.0 3.0 5.0</td>
<td>65-13 18 100</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 622076c</td>
<td>2</td>
<td>3</td>
<td>100/0</td>
<td>334 2 1.3 2.3 5.0</td>
<td>65-14 17 80</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 622101d</td>
<td>2</td>
<td>5</td>
<td>90/0</td>
<td>340 2 4.0 4.0 5.5</td>
<td>65-15 19 99</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 622075d</td>
<td>2</td>
<td>4</td>
<td>100/0</td>
<td>342 1 1.5 2.0 6.0</td>
<td>65-16 19 106</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 622056d</td>
<td>2</td>
<td>5</td>
<td>100/0</td>
<td>344 1 1.5 2.0 5.0</td>
<td>65-17 20 100</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 622096d</td>
<td>2</td>
<td>6</td>
<td>100/0</td>
<td>344 1 1.5 2.0 5.0</td>
<td>65-18 18 104</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 622044d</td>
<td>1</td>
<td>6</td>
<td>96/0</td>
<td>355 1 1.5 3.0 5.0</td>
<td>65-20 20 131</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 620205d</td>
<td>1</td>
<td>6</td>
<td>92/0</td>
<td>357 2 1.0 2.0 6.5</td>
<td>65-21 19 92</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 620208d</td>
<td>1</td>
<td>6</td>
<td>100/0</td>
<td>361 2 1.0 1.0 6.5</td>
<td>65-22 16 90</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 622098d</td>
<td>1</td>
<td>6</td>
<td>92/0</td>
<td>365 2 1.8 2.0 6.5</td>
<td>65-23 18 98</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 620309d</td>
<td>1</td>
<td>3</td>
<td>88/0</td>
<td>367 2 2.0 2.5 7.0</td>
<td>65-24 16 96</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 612035d</td>
<td>1</td>
<td>5</td>
<td>88/0</td>
<td>369 2 2.5 3.3 5.0</td>
<td>65-25 20 110</td>
</tr>
<tr>
<td></td>
<td>&quot;</td>
<td>SP 612017d</td>
<td>1</td>
<td>5</td>
<td>100/0</td>
<td>371 2 2.5 4.0 6.0</td>
<td>65-26 19 125</td>
</tr>
</tbody>
</table>

[Sp 611100-0, SP 622075d, SP 622106d, SP 622112c, SP 620064d, SP 620072d, SP 620107c, SP 620105c, SP 622076c, SP 622101d, SP 622075d, SP 622056d, SP 622096d, SP 622044d, SP 620205d, SP 620208d, SP 622098d, SP 620209d, SP 621035d, SP 612017d, SP 620208s]
Quantity of pollen shed by the individual plant that was selfed to produce the indicated seed no. Basis of grades: 1-7 in ascending order of abundance (ordinary, open-pollinated, commercial variety usually rated 6 or 7).

2 Pertains to the indexing population (at least 20 plants); left number is percentage classed as male sterile; right number is percentage classed as male fertile; percentage unaccounted for, if any, represents intermediate types.

3 Field plots on Hospital Farm, Ft. Collins, Colo.; inoculation and frequent sprinkling used to promote leaf spot development; plots 1 row x 20', flanked uniformly by rows of a leaf spot susceptible strain.

Curly top resistance evaluation at Logan, Utah, using greenhouse seedling technique with Logan culture A1A of the curly top virus, 20 plants for each code no., and 2 caged leafhoppers per plant.

Leaf spot grades (J. A. Elder): 0 = no leaf spot; 10 = complete defoliation.

Foliation vigor (J. A. Elder): Larger no. = greater vigor.

Curly top severity (C. L. Schneider). The plants were classified individually on a scale of 0-9 (0 = no symptoms, 9 = dead). Plants without curly top symptoms were disregarded. Results for plants with curly top symptoms were averaged by strains, and the averages were converted to percent of US 41. Thus, values less than 100 (shown above) indicate less curly top injury than in US 41, and values greater than 100 indicate more curly top injury than in US 41.

4 FC 601.

Miscellaneous F1 hybrids (LSR X CTR), without US 201 blood, were allowed to interpollinate to produce the seed lot designated SP 611227-(001).

Seed produced at Ft. Collins, using plants selected for curly top resistance, while in the early seedling stage, by C. W. Bennett, Salinas, California.
Agronomic Evaluation of Monogerm, Type-0 Lines

Several monogerm, type-0 or near-type-0, self-fertile, S₁ or S₂ inbred lines, thought to possess some resistance to both leaf spot and curly top, were evaluated in the leaf spot field at Fort Collins and under curly top conditions at Thatcher, Utah. The techniques employed at Thatcher are described briefly in the tables of results.

The tests at Fort Collins were of two types. In one (Experiment 5A), the inbred lines themselves were compared with check material by using a modified randomized-block design with three replications. Plots were four rows wide and 20 feet long, and the two inner rows were harvested for yield and sucrose determinations. Yield data for the inbred lines are considered to have relatively little but sucrose percentages may be indicative of their potential value.

The other Fort Collins test (Experiment 10A) was designed to appraise the general combining ability of the lines by using the 1.SR-CTR variety, FC 901, as a common parent. Since fairly representative male-sterile equivalents of the inbreds were not yet available, hybridizations had been made by using Mendelian male-sterile (aa) segregants in FC 901 as the female parent in each of a series of matings with the inbred lines. The resulting hybrids (seed harvested in the greenhouse in the spring of 1965) were compared with check material in Experiment 10A by using a randomized-block design, 1-row × 20-ft. plots, and 9 replications. Both experiments, 5A and 10A, were planted rather late (May 10).

The results of Experiments 5A and 10A are presented in Tables 8 and 9, respectively, together with the curly top resistance data from Thatcher. Three of the type-0 lines (Table 8) were better than SP 5481-0 in leaf spot resistance and approached or equaled US 41 in curly top resistance. Those lines are SP 632028sl, FC 601, and SP 632090sl. The last two were rather low in sucrose percentage, especially SP 632090sl.

The results presented in Table 9 agree with those in Table 8 in showing relatively high leaf spot resistance and high curly top resistance (at least equal to US 41) for the hybrids involving the three inbreds named in the preceding paragraph. In line with the performance of SP 632090sl as an inbred, the hybrid of SP 632090sl was significantly lower in sucrose percentage than the hybrids of SP 632028sl and FC 601. Each of the last mentioned two hybrids (a) approximately equaled FC (502/2 × 504) MS × FC 901 in yield of roots and gross sucrose and in sucrose
Table 8.—Preliminary agronomic evaluation of monogerm, type-0, inbred lines of sugar beet, Fort Collins, Colo., and Thatcher, Utah, 1965.

<table>
<thead>
<tr>
<th>Description</th>
<th>Fort Collins (Exp. 5A), 3-plot averages</th>
<th>Thatcher, Utah&lt;sup&gt;bc&lt;/sup&gt;</th>
<th>Plants</th>
<th>Curly top</th>
<th>Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lbs</td>
<td>Tons</td>
<td>%</td>
<td>No.</td>
<td>No.</td>
</tr>
<tr>
<td>I. Monogerm, type-0 (±) LSR-CTR inbred lines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP 651155HOA</td>
<td>2616</td>
<td>8.81</td>
<td>11.83</td>
<td>2.2</td>
<td>3.5</td>
</tr>
<tr>
<td>SP 652015</td>
<td>2193</td>
<td>8.51</td>
<td>13.20</td>
<td>1.7</td>
<td>1.8</td>
</tr>
<tr>
<td>SP 651152HOA</td>
<td>1505</td>
<td>5.13</td>
<td>14.22</td>
<td>1.5</td>
<td>2.2</td>
</tr>
<tr>
<td>FC 601 (SP 6220718; Si from SP 611101-0)</td>
<td>1916</td>
<td>7.12</td>
<td>13.40</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>FC 601 SP 641156HOA</td>
<td>1916</td>
<td>7.12</td>
<td>13.40</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>II. Checks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC 502/2 (mm; type-0, LSR inbred)</td>
<td>SP 641207HO</td>
<td>3112</td>
<td>9.59</td>
<td>16.23</td>
<td>1.0</td>
</tr>
<tr>
<td>US 201 (MM)</td>
<td>SP 581001-0</td>
<td>1720</td>
<td>6.00</td>
<td>14.38</td>
<td>1.0</td>
</tr>
<tr>
<td>Synthetic Check (MM)</td>
<td>Acc. 2269</td>
<td>2267</td>
<td>8.83</td>
<td>14.23</td>
<td>1.3</td>
</tr>
<tr>
<td>SP 5481-0 (MM)</td>
<td>Acc. 2415</td>
<td>2561</td>
<td>8.58</td>
<td>13.73</td>
<td>4.5</td>
</tr>
<tr>
<td>SP 6054-0 (MM)</td>
<td>SP 631201HO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US 33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US 41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Leaf spot grades (J. A. Elder): 0 = no leaf spot; 10 = complete defoliation.

<sup>b</sup> Foliage vigor (J. A. Elder): Larger no. = greater vigor.

<sup>c</sup> Results at Thatcher were based on a minimum of one 50' row for each line.

<sup>d</sup> Curly top grades (A. M. Murphs): 0 = healthy; 9 = death due to curly top.

The preceding generation (SP 631170HO), evaluated under leaf spot conditions in 1964, was found to have excellent leaf spot resistance and acceptable sucrose percentage, root size, and foliage vigor.
Table 9.—Agronomic evaluation of experimental, LSR-CTR, sugar beet hybrids, Fort Collins, Colorado, and Thatcher, Utah, 1965.

<table>
<thead>
<tr>
<th>Description</th>
<th>Fort Collins</th>
<th>Fort Collins, Colo. (Exp. 10A) 9-plot avs.</th>
<th>Thatcher, Utah</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>seed no.</td>
<td>Acre yield</td>
<td>Leaf spot&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lbs</td>
<td>Tons</td>
</tr>
<tr>
<td>FC 901 a × SP 652086</td>
<td>SP 651134HO2</td>
<td>3369</td>
<td>11.10</td>
</tr>
<tr>
<td>FC 901 a × SP 652595</td>
<td>SP 651132HO2</td>
<td>3073</td>
<td>10.78</td>
</tr>
<tr>
<td>FC 901 a × SP 652576</td>
<td>SP 651134HO2</td>
<td>2720</td>
<td>8.97</td>
</tr>
<tr>
<td>FC 901 a × SP 652529</td>
<td>SP 651153HO2</td>
<td>2640</td>
<td>9.04</td>
</tr>
<tr>
<td>FC 901 a × FC 601 (SP 622074)</td>
<td>SP 651156HO2</td>
<td>3175</td>
<td>10.49</td>
</tr>
<tr>
<td>FC (502/2 × 503) mm MS × FC 901</td>
<td>SP 641204HO1</td>
<td>3398</td>
<td>11.02</td>
</tr>
<tr>
<td>FC (502/2 × 504) mm MS × FC 901</td>
<td>SP 641204HO3</td>
<td>3221</td>
<td>10.62</td>
</tr>
<tr>
<td>SL (129 × 133) mm MS × SP 5822-0</td>
<td>Acc. 2634</td>
<td>2434</td>
<td>8.52</td>
</tr>
<tr>
<td>SP 5481-0</td>
<td>Acc. 2483</td>
<td>84</td>
<td>5.5</td>
</tr>
<tr>
<td>SP 6051-0</td>
<td>SP 631210HO</td>
<td>63</td>
<td>4.0</td>
</tr>
<tr>
<td>US 33</td>
<td>84</td>
<td>4.8</td>
<td>86</td>
</tr>
<tr>
<td>US 41</td>
<td>45</td>
<td>3.3</td>
<td>98</td>
</tr>
</tbody>
</table>

General mean | 3004 | 10.67 | 14.90 | 5.0 | 3.2 | 115 |
S. E. of var. mean | 94.50 | 0.3123 | 0.1179 | 0.17 | 0.17 | 3.02 |
S. E. of var. mean as % of gen. mean | 3.14 | 3.10 | 0.79 | 5.87 | 2.61 |
L.S.D. (05) | 267 | 0.88 | 0.83 | 0.5 | 9 |
F (varieties) | 14.58** | 11.14** | 15.01** | 11.61** | 17.23** | 0.83 |

<sup>a</sup> Lines are multigerm (MM) except where otherwise indicated. MS and as denote cytoplasmic and Mendelian types of male sterility, respectively.

<sup>b</sup> Leaf spot grades (J. A. Elder): 0 = no leaf spot; 10 = complete defoliation.

<sup>c</sup> Results at Thatcher were based on a minimum of one (but mostly two or more) 50' rows for each variety or hybrid.

<sup>d</sup> Curly top grades (A. M. Murphy): 0 = healthy; 9 = death due to curly top.

<sup>e</sup> F exceeds the 1% point.
percentage; and (b) exceeded the standard variety, SL (129 × 133) MS × SP 5822-0, by highly significant amounts in each of those three attributes. Evaluation of the type-0 character of SP 632028sl and FC 601 has not been completed, but each line appears to be bona fide type-0 or nearly so.

As shown in Table 8, SP 632028sl, FC 601, and SP 632090sl were derived from the basic line, SP 611101-0. As previously indicated, this and another basic line shown in Table 8 (SP 611100-0) are segregating, monogerm populations, developed by means of a backcrossing program in which curly top resistant material served as the recurrent parental type and US 201, the non-recurrent parent, was the source of leaf spot resistance. The LSR-CTR, multigerm line, FC 901, is a product of a similar backcrossing program with the same nonrecurrent parent. It was developed primarily for use as a source for the selection of superior pollinators. As a shortcut for preliminary evaluation of certain type-0 lines, however, FC 901 was used as the female parent in the hybridizations shown in Table 9.

The relatively high yields of roots and gross sucrose, shown for three of the hybrids having FC 901 as the female parent (Table 9), are of special significance in light of the fact that the male and female parents of each hybrid were related at least as indicated by the following: (a) their leaf spot resistance was derived from the same source, US 201; and (b) the curly top resistant material, used in the production of the F1 and B, generations in the backcrossing program leading to the development of the inbreds, was nearly identical to that used at the corresponding steps in the development of FC 901. The curly top resistant lines, used to produce the final backcross (B2) in the two backcrossing programs (SLC 122-0 and SL 932, respectively), were presumed to be only distantly related.

Summary

1. Cooperative evaluation tests of a set of five, monogerm, hybrid, sugar beet varieties, carrying some degree of resistance or tolerance to both leaf spot and curly top (so-called “LSR-CTR” varieties), were conducted by various agencies at 15 locations in 10 states in 1965. At two locations, disease resistance, only, was evaluated. At the other 13 locations, the tests were agronomic in character. Harvest results, in terms of root and gross sucrose yield and sucrose percentage, were expressed as percentages of the corresponding values for the standard variety, SL (129 × 133) MS × SP 5822-0. High lights of the results follow:
a. With SL, (129 $\times$ 133) MS serving as the female, SP 6322-0 was substantially superior to SP 5822-0 for use as a pollinator. With the average gross sucrose yield of SL, (129 $\times$ 133) MS $\times$ SP 5822-0 expressed as 100, the gross sucrose yield of SL, (129 $\times$ 133) MS $\times$ SP 6322-0 was 107.0. Differences between the two hybrids in sucrose percentage and in resistance to leaf spot and curly top were negligible.

b. The outstanding hybrid in the entire series, in yield of gross sucrose, was FC (502/2 $\times$ 504) MS $\times$ FC 901, and its sucrose percentage also was relatively high. The average gross sucrose yield and sucrose percentage, for that hybrid, as percent of standard, were 108.4 and 102.5. FC (502/2 $\times$ 504) MS $\times$ FC 901 was about equal to the standard variety in curly top resistance and higher than the standard variety in leaf spot resistance. Average gross sucrose yield and sucrose percentage for the local check (entry 8), as percent of standard, were 103.2 and 100.1, respectively.

2. Backcross programs in which US 201 served as the nonrecurrent parent and curly top resistant material served as the recurrent parental type have led to the development of the following:

a. FC 901, a multigerm variety with high resistance to curly top and moderate resistance to leaf spot; considered a promising source for the selection of superior lines for use as pollinators.

b. Basic, LSR-CTR, monogerm material (SP 611100-0 and SP 611101-0), segregating for type-0. Three type-0, or near-type-0, S, inbred lines (SP 632028s1, FC 601, and SP 632090s1), derived from SP 611101-0, were crossed with FC 901, using the Mendelian male-sterile (aa) phase of the latter as the female parent. Each of the hybrids, FC 901 aa $\times$ SP 632028s1 and FC 901 aa $\times$ FC 601, in comparison with FC (502/2 $\times$ 504) MS $\times$ FC 901, was: 1) about the same in yield of roots and gross sucrose and in sucrose percentage, under leaf spot conditions at Fort Collins; 2) at least as high in leaf spot resistance; and 3) higher in curly top resistance, being about the same as the curly top resistant check, US 41.

3. The results of this study showed conclusively: (a) that the backcross method is a useful tool for combining leaf spot and curly top resistance; and (b) that US 201 is suitable for use in such a program as the nonrecurrent parent and the source of leaf spot resistance.
Literature Cited


