A Rapid Method of Making a Non-Bolting Selection in Sugar Beets

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The development of seed stalks in sugar beets has been termed "bolt-ing." Bolting is necessary for reproduction in a seed field, but is highly undesirable in a commercial sugar beet field. Conditions conducive to in-duce bolting in sugar beets are low temperatures followed by periods of long days. Artificial or natural conditions may be used to supply either or both of these requirements. While bolting is largely dependent upon environmental conditions, it is also influenced by heredity. Differences be-tween varieties exist in the amounts of thermal induction required for them to bolt. In the field this appears as different percentages of bolters with different varieties in plantings made early enough that bolting occurs.

In some sections of California there are some advantages in planting sugar beets as early as December or even earlier. Beets planted then receive considerable thermal induction during the remainder of the winter and, with the increased temperatures and day length of spring, many of them bolt during the growing season. If excessive bolting occurs in a commercial field of beets, the disadvantages are threefold: a loss in root yield (l)[2], fouling the ground with beet seed and difficulty in harvesting.

While the inheritance of bolting tendencies is not well understood, selection has been effective in developing varieties which resist, to a con-siderable extent, the conditions which induce bolting. Such varieties are referred to as non-bolting varieties. An example of effective selection for non-bolting might be cited in the improvement made in the highly curly-top-resistant, easy bolting variety U.S. 22/3. Dr. Leroy Powers, formerly of Spreckels Sugar Company, made a non-bolting selection in U.S. 22/3 which produced the Spreckels variety, S-2. From this variety, Dr. J. S. McFarlane (3) of U.S.D.A. made a further selection resulting in the variety U. S. 75. S-2 and U. S. 75, respectively, show a progressive improvement in the non-bolting characteristic over the variety U.S. 22/3.

The normal method of making a non-bolting selection in California is to plant seed of a variety in the fall, overwinter the beets in the ground, and select the otherwise desirable beets that do not bolt the following summer. These selected roots are lifted and reset in an isolation plot or refrigerated for a time and then reset into an isolation plot. In such a plot seed is produced on surviving roots that bolt the next summer. Such a selection requires essentially two years' time from seed to seed. Any method which would reduce this time would speed the process of utilizing improved non-bolting characteristics in commercial varieties.

Efforts have been reported on methods of speeding the time required for seed production by use of artificial light or refrigeration or combinations of both (2) , but information is lacking on the effectiveness of non-bolting selections under such conditions.

[1] Plant Breeder, Spreckles Sugar Company, Spreckles, California.

[2] Numbers in parentheses refer to literature cited.

In November of 1951 a selection for ability to germinate at cold tempera-tures was made in a strain of beets numbered A5116. This is a variety high in curly top resistance and medium in bolting resistance. Germinating seedlings after twelve days at 38°-40° F. were placed between moist blotters for 24 to 36 hours at 70° F. to facilitate selection of only the most rapid germinating seedlings from each seedball. Selected seedlings were then transplanted into 14 x 20 x 3-inch flats of sterilized soil, about 175 plants per flat, and covered with 14 inch of sand. These flats were then kept in the warm greenhouse (60°-65° F.) for seven days to give seedlings a good start. At this time the flats were moved to tables in an unheated green-house under continuous light. These flats were rotated on the tables one position twice a week to minimize any effect of differential light intensity.

Artificial light was supplied from dark until daylight by means of one 100-watt bulb in a reflector placed 42 inches above each table. Minimum greenhouse temperatures during this period ranged from 30° to 40° F. and maximum temperatures ranged from 50° to 65° F. By February 15 some small seed stalks were beginning to appear. With 175 plants in a flat, satisfactory later transplanting to isolation plots could not be accomplished, so, to reduce the number of plants in the flats, the early bolters were re-moved as they appeared. Approximately 80 percent of the plants were removed in this manner.

By April 1 most of the remaining plants were producing seed stalks. Only six plants did not show evidence of producing a seed stalk. The bolt-ing plants were set out in isolation and produced seed harvested in August of 1952 and numbered A5211. Approximately six hundred plants were in-volved in this increase.

The six plants which did not produce seed stalks were refrigerated for an additional month and later allowed to flower and interpollinate among them-selves in the greenhouse. Seed produced from these six plants was harvested *in* October, 1952, and numbered A5240.

If a selection for non-bolting by the removal of the fast bolters under these conditions was effective, A5211 and A5240, respectively, should show a progressive improvement over the non-bolting tendency of the parent, A5116.

To test this theory a field experiment was designed which included the three varieties, A5116, A52I1 and A5340, together with the non-bolting varieties U. S. 56/2 and U. S. 75 as checks. This test consisted of eight replications of two-row, forty-foot plots of each variety arranged in a ran-domized complete block design. Number of plants per plot and number of beets bolting were counted and the entire plots were harvested for yield determination. A beet was considered to be a bolter if seed stalk develop-ment had been initiated, whether or not seed was produced on it. Counts of plants infected with downy mildew caused by *Peronospora schachtii* were also made and recorded. The test was planted to moisture on December 16, 1952, and harvested October 29, 1953. Mid-December was selected as a planting date, as being early enough that some bolting would occur **but** not early enough to approach complete bolting.

Table 1.—Showing Average Percentages of Bolted Beets, Yields in tons per Acre and Mildew Infection Percentages from a Field Test of Three Experimental Strains and Two Commercial Check Varieties of Sugar Beet s(eight replications).

Variety	% Bolters[1]	Yield Tons/Acre	% Mildew[1] Infection
A5116	18.1	24.33	18.5
A5211	10.7	25.38	13.7
A5240	6.6	21.17	13.0
U. S. 75 (C175)	11.4	22.73	18.8
U. S. 56/2	14.2	20.69	27.0
L.S.D. at P = .05	5.9	2.56	6.4
L.S.D. at P = .01	5.4	3.45	8.4

[1] Analyses of variance on bolting and mildew percentages computed after converting original data to $\sin^2 \theta$.

Table 1 shows a summary of the results of bolting percentages, mildew percentages and yields of the three experimental varieties together with the check varieties, U. S. 56/2 and U. S. 75. It is interesting to note that A5211 is significantly lower in bolting percentage than A5116, and A5240 is significantly lower than A5211. This progressive improvement in the non-bolting characteristics of A5116 indicates conclusively that selection had been effective under these conditions. A comparison of the selections with the check indicates that A5211 is about in the same class as U. S. 56/2 and U. S. 75 in its non-bolting tendency and A5240 is significantly better than either of them. Both U. S. 56/2 and U. S. 75 represent as high a degree of non-bolting as is presently available in commercial varieties, so it ap-pears that this selection was effective even in what is considered at present to be very non-bolting material.

The yield of A5240 was significantly lower than A5211 or A5116. It is believed that this was due to the limited parentage comprising the strain. As was mentioned above, only six plants which were extremely slow to develop seed stalks were interpollinated to produce it. Certainly a reduced yield is not characteristic of this type of selection, because A521I shows no reduction over A5116.

In percentage of infection of downy mildew there is no difference in susceptibility between any two of the three strains involved in the selection. This was as expected because downy mildew was in no way a factor in the selection.

These selections were made, as pointed out above, in material which had been selected for its ability to germinate at low temperatures. Re-sistance to bolting and ability to germinate and grow at low temperatures is a desirable combination of characteristics for a variety to be planted early in California when temperatures are low.

The importance of this method of selection is twofold; it makes possible more rapid commercial utilization of new non-bolting strains by cutting selection time in half, and makes possible a more rapid elimination of undesirable material in any new breeding program in which non-bolting is a desired characteristic.

Some slight modifications have been made in this method since its initiation. Seedlings, when first selected for germination at cold tempera-tures, are transplanted directly into flats covered with 1/4 inch of sand and allowed to grow in a heated greenhouse (60°-65° F.) for four days. Any seedling emerging after that time is destroyed because of the possibility of its being from a locule in the seedball other than the one from which the first seedling emerged. This eliminates the extra step of moving them from the cold germinating chambers to blotters at warm temperatures be-fore transplanting them in flats. This particular problem is eliminated by the use of single germ seed. Because each seed contains only one locule, transplanting from cold germination directly into flats can be made with-out danger of slower germinating seedlings from other locules emerging after transplanting.

Summary and Conclusions

A method of making a non-bolting selection in sugar beets is described which requires less than a year from seed to seed even in relatively non-bolting material. The method described was used to produce a variety equal in bolting resistance to U. S. 56/2 and U. S. 75 and showed possibilities that it might be used to produce varieties possessing even greater bolting resistance. Characteristics other than bolting resistance were apparently not affected by the selection.

Literature Cited

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