Selection for Cold Tolerance and Low Temperature Germination in Sugar Beets

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Introduction

The development of varieties of sugar beets capable of germination from seed at low temperatures, together with the ability to withstand frost after establishment of the plant in spring and resistance to early freezing damage in fall, now appears to be entirely possible. The apparent advantages of such types in temperate climaxes is fairly obvious, but perhaps will bear repetition: (a) lengthening of the effective growing season in both spring and fall, (b) prevention of replanting or loss of fields due to frost damage in seedling stage, (c) indications of association of cold resistance with greater sucrose content (1)[2]. This latter advantage is probably not too obvious from superficial examination of the problem but if the preliminary evidence is supported by later investigations, the value of such selection is greatly enhanced.

Low Temperature Germination

It was mentioned in a previous publication (1) that preliminary investigations indicated wide variations between sugar beet varieties in ability to germinate from seed at low temperatures. The differences obtained were highly significant statistically and have been substantiated by subsequent investigations. Table 1 gives germination percentages obtained in a later trial and also some information as to whether or not that portion of the

Table 1.—Low Temperature Germination of 16 Varieties of Sugar Beet Seed, 1949.

Acc. No.	Germination at Low Temp.[1]	Residual[1,2] Germination	Total Germination	Original Germination
	(percent)	(percent)	(percent)	(percent)
C453	62.1	22.8	84.9	89.0
C359	62.0	27.3	89.3	81.0
C304	60.8	33.3	94.1	91.5
C381	53.1	30.0	83.1	83.0
C305	50.3	29.3	79.6	67.5
C389	49.7	35.8	85.5	86.5
C452	38.8	47.7	86.5	74.0
C455	32.2	48.5	80.7	75.0
A84	29.7	44.0	73.7	79.3
GW201-48A	29.2	45.7	74.9	97.0
A105	26.2	40.7	66.9	70.0
A101	24.5	51.0	75.5	85.0
A100	23.8	43.8	67.6	74.5
B212	21.3	54.2	75.5	67.0
A53-42	15.8	50.8	66.6	78.0
B379	14.5	55.8	70.3	76.0

[1] Averages of six replications.
[2] Placed in germinator at normal germination temperature after those seeds which germinated at low temperature were removed.

viable seedballs which fails to germinate at low temperatures is damaged by the exposure. Blotter germinations were used throughout the present study.

It is readily apparent from Table 1 that destruction of viable germs by cold and moisture at low temperatures did not take place; actually, in

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[2] Numbers in parentheses refer to literature cited.

the case of variety C452 the combined germination figures might indicate an appreciable percentage of hard seed coats made water-permeable by prolonged exposure to 34° to 36° F. temperature, plus moisture.

Selections, on the basis of germination at low temperature, were made from two commercial types, C304 and C359, extreme care being exercised to destroy locules which did not germinate before planting the sprouted seeds to pots. A comparison of progeny and parents is given in Table 2.

Table 2.—Low Temperature Germination—Progeny Test.

Acc. No.	Description	Germ. Percent[1]
C304	Parent	35.8
B585	Sel. from C304 on basis low temp. germ.	55.1
C359	Parent	29.9
B586	Sel. from C359 on basis low temp. germ.	69.0
LSD 5% point		11.9
LSD 1% point		17.1

[1] As percent of potential.

In each case selection pressure resulted in a marked increase in low temperature germinating ability in the progeny as compared with parent.

A study of low temperature germination of varieties selected on the basis of cold resistance as seedlings failed to show any conclusive evidence that the characters of germination at low temperatures and frost resistance are associated in any way. Further investigation will be required to illuminate this question. Table 3 gives data bearing on the observation above.

Table 3.—Germination of Sugar Beet Seed at Low Temperatures, 1952. 42-day Period at 34°-36° F.

Acc. No.	Desription	Germination percent of potential
C304	Parent	35.8
B573	Cold resistant selection from C304	11.6
B621	Cold resistant selection from C304	31.1
B474	Selection from C304, basis sodium content	17.1
B613	Cold resistant selection from B474	71.9
C359	Parent	29.9
B587	Cold resistant selection from C359	44.0
C455	Parent. (Beta maritima hybrid)	9.0
B588	Cold resistant selection from C455	23.4
A1104	Parent (Sugar x Garden hybrid)	55.7
B612	Cold resistant selection from A1104	47.4
A53-42	U. S. 22 (Curly top resistant)	1.3
Gr. 5125	Inbred (Leaf spot resistant)	42.8
Gr. 5124	Inbred from Beta maritima hybrid	5.5
LSD 5% pt.		17.3

Cold Resistance of Sugar Beet Seedlings

Data and photographs have been presented previously (1) demonstrating that large differences exist between varieties with respect to resistance to frost injury.

The location and extent of germ plasm carrying such frost resistance characters has been investigated. Eighty differing strains, inbred lines and varieties, representing as many different sources as were available at the Agricultural Experiment Station of the Great Western Sugar Company at

Longmont, Colorado, were tested and indexed for low temperature reaction in seedling stage. Percent survival and hardened plants after exposure to —6° to —8° Centigrade for 2.5 hours ranged from zero to 96. The relation of resistance to ecological source was not clearly defined; however, North Sea types in general appeared somewhat better in survival.

Selections in seedling stage on basis of frost resistance were made and seed produced. Progeny testing is underway at the present time and only preliminary data are available.

Table 4.—Comparison of Parent and Progeny in Cold Resistance Selections of Seedlings.

Acc. No.	Description	Percent Survival	Number Plants tested
C304	Parent, Com'l. G.W.	17.8	477
B573	Easy bolting plants from C304 selection for cold resistance[1]	27.3	452
B621	Normal bolting plants from C304 selection for cold resistance.	34.7	300

[1] Bolted as result of cold exposure when frozen.

The differences shown in Table 4 Only approach statistical significance at the five percent level. Considerable difficulty has been encountered in getting uniformity of growth of the seedlings in greenhouse flats; however, later plantings have shown improvement and it is felt more precise and conclusive tests will be completed soon.

Cold Resistance in Fall Period

Previous observations (1) have indicated that large differences may exist between varieties in their reaction to cold in the fall season. Further observations were made possible in the fall of 1951 as result of a temperature of 15 degrees below zero Fahrenheit on the night of November 2, while approximately one-half the commercial beet crop was still unharvested in some northern Colorado areas. The recovery of individual beets compared with destruction of others, after such a shock, gave a very striking comparison indeed.

Sugar Loss Following Freezing

As result of the low temperature (—15° F.) mentioned in the last paragraph above, some indication was obtained as to what happens to sugar content following such exposure. This information is given graphically in Figure 1.

From this figure it appears that a decline was taking place in sugar content before the freeze occurred; actually, this is accounted for by the dates of sampling, as the last sampling prior to the freeze was accomplished two or three days ahead of that time. The dotted line would seem to give a good projection of actual conditions. Growth of the beet was apparently not affected to any great degree since weight increase was almost over for the season; this is indicated by a fairly flat tonnage curve.

The greatest interest then is centered around what happens to the sugar already manufactured and stored in the root. It is, of course, very well known that defoliation with the resulting production of new leaves uses up sugar for the growing of new parts, with the result that actual sugar content of the root is diminished; further, respiration, due to enzymatic action and rot organisms, after harvest gives a measureable sugar loss; probably there are other normal losses, but none which would seem to account for a sharp

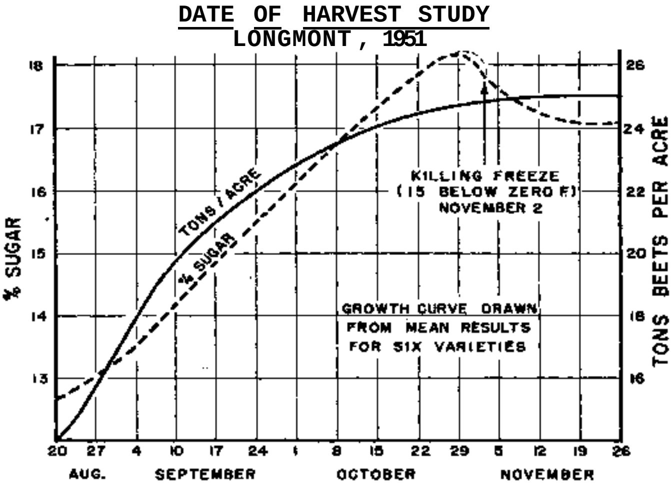

Figure 1.

drop of the magnitude demonstrated here. It should also be emphasized that in this instance production o£ new foliar tissue could not have been a factor in lowering sugar content.

These observations on sugar loss following frost are very well in agreement with those of Peto (2), who studied factory records at the Raymond, Alberta mill. It seems quite evident then that some other mechanism not presently explained must be involved to account for the drastic loss in sugar in beets following severe frost.

Summary and Conclusions

1. Data are presented to show that ability of beet seed to germinate at low temperatures is probably heritable and improvment should be accomplished by selection pressure.

2. Preliminary data indicate resistance of beet seedlings is also heritable in nature and can be improved by breeding.

3. Some mechaaism or mechanisms appear to be involved in sugar losses, in beets in the field following severe frost, other than those at present accepted and evaluated.

Literature Cited

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