Characterization of Sugar Beet Varieties on the Basis of Their Internal Structure Together with the Effect of Environment on the Variability of Diagnostic Characters in Inbred Lines

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The material vised in this investigation is represented by 19 inbred lines[2] grown at Fort Collins, Colorado, and in replicated plots at Shelley, Idaho.

The internal structure of a sugar beet root, as seen in cross section, is constant for a given variety and can be used by the breeder for diagnostic purposes, enabling him to discard off types. The type picture of a variety is represented by the type formula (l)[3], and a number of subsidiary characters. Of these, ring number of ring density coefficient are more or less constant while central core and first ring may be disturbingly variable even in pure lines. The size of the core and the diameter of the first ring are variety limited. The core is uniform in some lines and variable in others, and its size is independent of root weight. The diameter of the first ring is more variable and tends to fluctuate with root size.

The characterization of a pure line by the inner structure of the root holds true only for a given environment. The effect of location is most pronounced in the central core and the first ring. With a few exceptions core and first ring were smaller in the Idaho material than in the roots grown in Colorado. Ring numbers were similar for both locations or variable in certain lines (Table 1) .

The type picture delimits a selection more closely than could be done by external morphological characters alone; it w?ould aid in keeping the line pure through the elimination of such mother beets as showed distinct structural differences. Hie type picture will show which characters in the different selections can be relied on to serve as a criterion for purity of type, and for inheritance patterns in making crosses.

The modifying influence of environment on some of the characters has been demonstrated (Table 1), and cognizance of it should be taken. Fortunately only certain lines seem to be affected by environment. For many of the lines the type formula remains essentially the same and the ring density coefficient shows little or no variation.

List of Characters Used in the Construction of the Type Formula General Appearance of the Cut Surface *in situ*

1. Surface mealy white or ivory; zonation faint or absent.

2. Zonation indicated.

3. Zonation pronounced; flesh often gray or translucent.

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[3] Numbers in parentheses refer to literature cited.

Table I.—Mean (M), Standard Deviation (a) and Coefficient of Variablity (CV) of Central Core and Mean (M) of Diameters of First Ring, of Ring Numbers, of Ring-Density Coefficients and Type Formulae of 19 Sugar Beet Selections Grown at Fort Collins, Colorado, and at Shelley, Idaho.

	Fort Collins,		Central Colo. core	Shelley, Idaho			First ring		Number of rings		Ring-density coefficient		Type formula	
							Ft.C.	Shelley	Ft.C.	Shelley	Ft.C.	Shelley		
Selection	MMm.	*a*	CV	M	<i	CV	M	M	M	M	M	M	Fort Collins	Shelley
1	4.2	.58 ~	i7~	1.8	!26™	14	16.6	~ 11.8	10.0	9~.8	2.5	2.0	2-5-8-11/11-14	2-5-8-11/11-14
5	4.4	.81	18	3.7	1.03	28	18.8	17.3	7.8	8.0	2.0	1.9	2-5-8-11-14	2-5-8 11-14
34	5.3	.88	17	3.5	.82	23	19.9	18.7	8.5	9.0	2.2	2.1	2-5-7/8 10/11-14	2-6-7 11-14
37	5.3	.82	15	3.3	.79	24	22.9	24.2	7.2	8.2	1.8	1.7	2-5-7/8-12-13	1-4-8 10-13
50	6.5	.86	13	4.5	1.17	26	20.7	17.4	9.8	11.3	2.3	2.5	2-5/6-7-11-14	2-67 11-14
51	5.6	.86	15	4.0	1.05	26	21.1	19.1	9.8	10.3	2.1	2.4	2-5-7-11-14	1-5-7 '8-12-14
63	5.4	.67	12	2.2	.78	35	15.9	12.7	11.7	11.2	2.8	2.9	1-5-8-12-14	1-5-8 12-14
69	5.5	.75	14	3.0	.97	32	23.1	16.8	8.8	8.7	1.9	1.9	2-5-8-10-13	2-5 8 10-14
83	4.2	.92	22	4.5	1.21	27	18.3	22.9	9.4	10.7	2.0	1.9	2-5/6-7-11-14	2-5-7 12-13
85	3.2	.98	31	3.0	1.34	45	16.2	16.3	12.7	12.0	3.0	2.8	2-5-8-12-14	1-5-8 12-14
101	3.5	.97	28	1.9	.20	10	19.1	16.8	8.2	8.3	1.9	1.8	1-5-8-10-14	2-5-8 10-14
107	7.0	.66	9	6.4	1.17	18	27.3	25.4	7.5	7.0	1.7	1.7	2-5-7/8-10-13	2-5-8 10-13
111	6.3	1.45	23	3.4	.85	25	26.0	17.5	9.4	8.4	2.5	2.1	1-5-8-10-13	2-5-8 10-14
119	7.5	1.35	18	5.3	1.58	30	24.5	20.7	10.5	9.5	2.4	2.3	1-5-8-11-13	1-4-8 10-14
123	3.6	.72	20	3.3	1.66	50	20.1	20.1	7.7	8.4	1.7	1.7	2-5-7-11-14	2-5-7 10-13
131	7.7	1.09	14	5.2	1.34	26	25.5	20.7	10.2	9.5	2.2	2.4	1-5-7/8-12-13	1-4-8 10-13/14
132	8.7	1.45	17	10.5	2.25	21	29.7	31.0	7.4	7.4	1.7	1.6	1-5-7-11-13	1-5-7 12-13
133	7.6	.96	13	5.7	1.42	25	25.9	23.2	10.1	9.5	2.3	2.0	1-5-8-11-13	2-5-8 10-13
142	4.0	.33	8	2.4	.58	24	16.0	16.0	9.9	9.5	2.4	2.2	1-5-8-12-14	2-5-8 10-14
159	4.2	.42	10				16.5		10.5		2.0		2-5-8-12-14	

Appearance of Thin Cross Section Against Black Background

4. Zonation indicated.
5. Zonation pronounced; rings distinctly set off from interzonal parenchyma.
6. Rings very prominent with limits of phloem and xylem clearly defined. Width of Vascular Rings
7. Rings broad.
8. Rings narrow.
9. Rings variable in width; inner rings characteristically broader. Width of Interzonal Parenchyma
10. Parenchyma bands broad.
11. Parenchyma bands narrow.
12. Parenchyma bands of inner rings conspiculously broader. Size of First Ring
13. Ring broad with a diameter of 22 mm. or more.
14. Rings medium large.
15. Rings narrow with a diameter of 12 mm. or less.

General Appearance of Flesh and Inner Structure of Sugar Beet Roots as *Seen* in a Cross Section

Selection 1

Origin Flat Foliage; 11th generation (52-305)*.

Fort Collins: Flat white or ivory with fading bundles; orange cambium lines: gray parenchyma bands; medium thick core and medium-broad first ring.

Shelley: Flat white with fading bundles; orange cambium lines; gray parenchyma bands; thin core and narrow first ring.

Selection 5

Origin U. S. 30297-0. Probably sixth generation (52-307) .

Fort Collins: Ivory cream with fading bundles and deep orange cambium lines; medium thick core and medium broad first ring.

Shelley: fvory or cream with fading bundles and deep orange cambium lines; broad parenchyma bands; variable core and medium-broad first ring.

Selection 34

Origin Flat Foliage. Seventh generation (52-334). Figure 1, A.

Fort Collins: Red-skinned roots with whitish bundle zones and gray parenchyma bands; few-rayed medium-thick core and medium-broad first ring.

Shelley: Red-skinned roots with whitish bundle zones; white cambium lines; dense bundles; small compact core and medium-broad first ring.

Selection 37

Original Flat Foliage. Eighth generation (52-336) .

Fort Collins: Whitish bundle zones with fading bundles; light orange cambium lines; somewhat watery parenachyma bands; medium core but broad first ring.

* This number, and similar ones following, refer to U. S. Department of Agriculture, Fort Collins, Colorado, seed number.

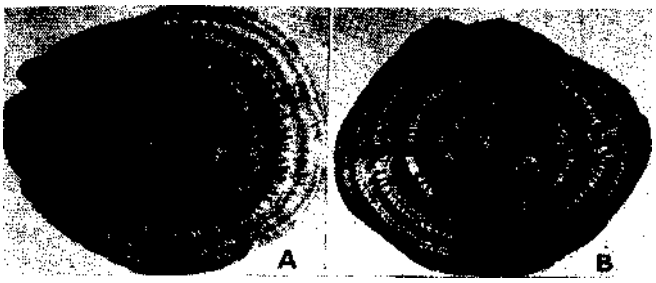

Figure 1.—Selection 34 (left), and Selection 107 (right).

Selection 37 Shelly, Idaho. 1953

	σ	CV
Core = 8.5 mm.	.79	24
First ring = 24.2 mm.		
Ring number = 8.2		
R. D. Coefficient = 1.7		
Formula = 1-4-8-10-13		

Whitish bundle zones with fading bundles; orange cambium lines; gray somewhat watery parenchyma bands; small core and broad first ring.

Shelley: White bundle zones; orange cambium lines; somewhat watery parenchyma bands; small core and broad first ring. Selection 50

Origin sugar variety. At least fourth generation (52-349) .

Fort Collins: Uniform ivory cream; white cambium lines; gray parenchyma bands; sparse xylem; large core and broad first ring.

Shelley: Uniform ivory cream; prominent rings; medium large variable Core and medium-broad variable first ring. Selection 51

Origin sugar variety. At least 5th generation (52-350) .

Fort Collins: Broad white xylem bands alternating with grayish phloem and parenchyma; white cambium lines; long faint bundles; medium core and large first ring.

Shelley: Flat white flesh; often white xylem bands; slender fading bundles; medium, variable core and variable medium-broad first ring.

Selection 63

Origin Pioneer. More than sixth generation (52-364).

Fort Collins: Numerous narrow rings; white bundle zones; gray paren-cheyma bands; medium broad core and medium narrow first ring.

Shelley: Numerous narrow rings; whitish xylem bands; small core and narrow first ring.

Selection 69

Origin sugar Sn x unknown red (52-372).

Fort Collins: Deep red parenchyma bands alternating with white bundle zones; medium large core and broad first ring.

Shelley: Red parenchyma bands alternating with white bundle zones; small dense core; medium-broad first ring.

Selection 83

Origin sugar x garden hybrid. Fifth generation from hybrid (52-388).

Fort Collins: Ivory white with somewhat fading bundles; whitish phloem and white cambium fines; medium core and medium-broad first ring.

Shelley: Ivory flesh; long sparse bundles: white cambium lines; somewhat watery parenchyma bands; variable medium-broad core and broad first ring.

Selection 85

Origin Pioneer. Eleventh generation (52-390). Figure *2, B.*

Fort Collins: Numerous narrow rings; ivory with dark cambium lines; narrow gray parenchyma bands; small core and medium-narrow first ring.

Shelley: Numerous narrow rings; flat white with white cambium zones fading bundles; variable small core and medium-small first ring.

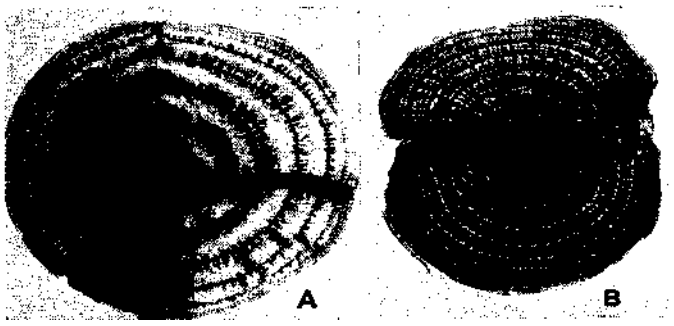

Figure 2.—Selection 101 (left) and Selection 107 (right).

Selection 101

Origin doubtful (52-408) . Figure 2, A.

Fort Collins: Uniform white or ivory gray with narrow bundle zones; white cambium lines; small core and medium-broad first ring.

Shelley: Very uniform rings; white bundle zones and orange cambium lines; uniform very small core and medium-narrow first ring.

Selection **107**

Origin "Fredricksen." Sixth generation (52-414) . Figure 1, B.

Fort Collins: Ivory white with dark xylem; broad slightly watery parenchyma bands; broad core and very broad first ring.

Shelley: Very coarse flat white flesh with prominent confluent dark xylem ends; large core and broad first ring.

Selection **111**

Origin Flat Foliage (Strube 20 families) . Fifth generation 52-418) .

Fort Collins: Whitish flesh with fading bunudles; irreguluar orange cambiumu lines; narrow parenchyma bands; broad core with prominent phloem; ver broad first ring.

Shelley: Flat white with fading bundles; deep orange cambium lines; small compact core and medium-broad first ring.

Selection 119

Origin sugar variety. Sixth generation (52-427) -

Fort Collins: Two types represented. Usually narrow white bundle zone with fading bundles and white cambium lines; large core and broad first ring.

Shelley: Two types represented. Usually white narrow bundle zone with slender vanishing bundles; white cambium lines; medium core and medium first ring.

Selection 123

Origin sugar variety. Fifth generation (52-431) .

Fort Collins: Ivory cream with white cambium lines; prominent bundles; small core and medium-broad first ring.

Shelley: Ivory cream with deep orange cambium lines, narrow xylem and prominent phloem; variable small core and medium-broad first ring.

Selection 131

Origin unknown. More than fifth generation (52-439) .

Fort Collins: Flat white with white bundle zone and dark cambium lines; large core and broad first ring.

Shelley: White ivory with fading bundles, dark xylem, narrow phloem and orange cambium lines; variable medium-broad core and medium-broad first ring.

Selection 132

Sisterline of 131. Possibly Flat Foliage x garden cross (52-440). Fort Collins: Whitish bundle zones and white cambium lines; gray somewhat watery parenchyma bands; large core and very broad first ring.

Shelley: Flat white with prominent white cambium lines; long fading bundles; gray watery parenchyma bands; very large core and very broad first ring.

Selection 133

Origin F- root of Flat Foliage x garden cross (52-441) .

Fort Collins: Flat white with white bundle zones and orange cambium lines; gray parenchyma bands; large core and broad first ring.

Shelley: Flat white with white bundle zones, lading bundles; dark cambium lines; variable large core and broad first ring.

Selection 142

Origin sugar variety. Second generation from F1 of Sn x Sn (52-437) .

Fort Collins: White bundle zones with fading bundles and orange cambium lines; uniform medium-small core and narrow first ring.

Shelley: Uniform ivory gray with fading bundles; narrow xylem, broad phloem and broad white cambium lines; small core and narrow first ring.

Selection 159

Sister line of selection 1 (52-474) .

Fort Collins: Ivory cream with fading bundles and orange cambium lines; medium-small core and narrow first ring.

Key

A. Flesh red 69
AA. Flesh white
  B. Mean central core 6.3 to 8.7 mm.
    C. Bundle zones broad
      D. Xylem massive 107
      DD. Xylem not pronounced
        E. Ring number small (+— 8) 132
        EE. Ring number medium (+— 10) 50
    CC. Bundle zones with fading bundles 111, 119, 131, 133
  BB. Mean central core 3.2 to 5.5 mm.
    C. Bundle zones broad
      D. Ring number small (+— 8) 34, 123
      DD. Ring number medium (+— 10) 1, 83, 159
    CC. Bundles zones medium or narrow
      D. Ring number large (+— 11) 63, 85
      DD. Ring number medium, bundles fading
        E. Prominent orange cambium lines
          F. Ring number small (+— 8) 5, 37, 101
          FF. Ring number medium (+— 10) 142
        EE. Prominent white cambium lines 51

Literature Cited

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