# Sugarbeet Germplasm Selected From the USDA Collection

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Among the major problems facing sugarbeet (*Beta vulgaris* L.) breeders are the lack of genetic diversity in the commercial crop and the negative association between root yield and sucrose concentration. However, much of the public breeding effort, and probably a significant portion of the private effort, has been concerned with developing resistance to the numerous diseases, insects, and nematodes that prey upon the sugarbeet. Consequently, breeders often have been content with minimal increases in inherent productive capacity and, at the same time, may have reduced the genetic diversity of the commercial crop.

In recent years the economics of sugar processing and the adaptation of electronic technology to the testing of large numbers of grower's samples have resulted in premiums being paid for sugarbeets with superior processing quality (high extractable sucrose content). A producer must attempt to juggle tonnage and sucrose concentration to obtain the maximum profit with this payment system. Hybrid selection and choice of cultural practices influence yield and quality. However, trials involving numerous commercial hybrids grown throughout the Red River Valley (2,3) have demonstrated a strong negative relationship between root yield and sucrose concentration (correlations of approximately -0.60 were observed).

Heterosis or hybrid vigor is the occurrence of increased vigor or productivity of a hybrid resulting from the crossing of two genetically distinct lines. Heterosis for root yield has been widely documented in sugarbeet and justifies the use of hybrids in commercial production. Heterosis for sucrose concentration is less than that observed for root yield. Often the sucrose concentration of a hybrid is intermediate to its parental lines. Heterosis generally increases as the genetic diversity of the parental lines increases (4); therefore, any long-term hybrid development program needs infusions of genetically unique breeding lines with relatively high sucrose concentrations.

The USDA *B. vulgaris* collection apparently has not been used extensively in breeding programs and, thus, may provide unique genetic combinations for increased root yield and sucrose concentration as well as increased genetic diversity. This collection was used as a source population in a selection program with the objective of extracting agronomically desirable germplasm from a previously untapped source. This article describes the resulting germplasm.

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## SELECTION PROCEDURES

One hundred sixty-seven accessions of the *B. vulgaris* collection (NC-7) maintained by USDA-ARS at Ames, Iowa, were evaluated for sucrose concentration. All accessions exhibited biennial growth habit and some were nonsugarbeet types and mixtures. The choice of accessions was limited to entries with sufficient seed for field planting.

The sucrose concentration of each root was determined on a tissue sample obtained by drilling a 1.25 inch diameter hole in the taproot with a power drill. Samples were frozen immediately and subsequently analyzed for sucrose concentration using standard tare laboratory procedures.

Because of limited seed supplies, the original accessions were evaluated in unreplicated field plots with a commercial high sucrose hybrid (ACH-14) in every fifth plot. Field plots for both the initial and all subsequent evaluations were 115 square feet and consisted of two rows 22 inches apart. All evaluations were conducted at Fargo, North Dakota. Plots were harvested manually, weighed and washed before sampling for sucrose and clear juice purity. Root yield and sucrose concentration were expressed on a fresh weight basis.

Thirty individual plants with relatively high sucrose, compared to other plants in the same plot and nearby checks, were identified and randomly interpollinated for form a base population. These 30 individuals were chosen from accessions originating from Turkey, U.S.S.R., Poland, Iran, Afghanistan, Ethiopia, and Burma. Seed were harvested from each plant separately and evaluated the following year as a family in replicated field trials. Subsequent selection was based upon both individual and family performance. Selected plants were interpollinated, seed were again harvested from individual plants, and the progenies of each plant were evaluated as a family. Individuals with the desired traits were selected from numerous families to maintain genetic diversity; however, the number of selections per family was proportionate to family performance. This process was repeated in each of five selection cycles.

Commercial hybrids were included in all evaluations to provide an indicator of the progress resulting from selection and of the sucrose concentration desired. Because of erratic stands, fourth-cycle selection was based solely upon family performance and a sample of 57 individuals from selected families provided seed for the fifth selection cycle. Visual selection eliminated severely sprangled or colored beets.

After the second cycle it became apparent that root size (weight) was decreasing drastically, so individual root weight was added as a selection criterion. In subsequent cycles, the average weight of selected beets was approximately equal to the average weight of the commercial hybrids. Ninety-four plants representing five families were interpollinated to provide the initial seed of the released population designated F1010.

In addition to the individual roots selected to form the breeding population described above, 26 accessions with relatively high sucrose concentrations were identified. Four to six roots with relatively high sucrose concentration from each accession were induced to flower and were interpollination within an accession. Progeny were evaluted in replicated field plots. Individual roots with high sucrose concentration from lines with high sucrose concentration were induced to flower and crossed in pairs within a line. Crossing superior individuals in pairs hastens the fixation of desirable genes while overcoming the self-sterility that likely occurs in some of the plants.

Four additional cycles of mass selection within each line formed by a pair-cross followed. High sucrose individuals from desirable lines were selected in all selection cycles except the fifth. Fifth cycle selection was based soley upon line performance and a random sample of individuals from selected lines provided seed for the sixth cycle. Approximately 10 plants per line were increased for each cycle. Root yield was added as a selection criterion in the last three selection cycles. Visual selection eliminated severely sprangled or colored roots. Four germplasms, F1011 to F1014, were selected in this manner.

## GERMPLASM CHARACTERISTICS

The maternal parentage of the families that formed F1010 can be traced to the following accessions: PI169025, PI179174, PI220506, PI220645, and PI274393 ("PI" numbers identify accessions in the USDA-ARS collection). Average sucrose concentrations of F1010 was 110 percent of the average of the hybrids Ultramono and ACH-164. Average root yield was 80 to 90 percent of the two commercial hybrids, and clear juice purity was 106 percent of the hybrids. F1010 is heterogeneous for numerous traits. All plants were diploid and produce multigerm seed. All roots have white skin and flesh and the characteristic sugarbeet shape. Details of the selection procedure and observed progress have been reported previously (1).

Both F1011 and F1012 were selected from PI266100, an accession from Poland. F1013 was selected from PI169025, an accession that originated from Turkey, and F1014 from PI355959 from Russia. F1012, F1013, and F1014 segregate for pink and green hypocotyl color. F1011 has pink hypocotyls. All four lines are diploid and produce multigerm seed. In the initial screening the original four accessions were from 1.5 to 2.2 percent lower in sucrose concentration than ACH-14. Also, comparisons of the parental accessions with F1013 and F1014 indicated that selection had increased sucrose concentration approximately 2.5 percent. Average sucrose concentration of the four germplasms was equal to the sucrose concentration of the commercial hybrids used as checks (Table 1). Yield differences were not significant in all cases but, in general, root yields were about 75 percent of that observed for the hybrids.

F1011 and F1012 originated from the same parental accession but exhibited contrasting performance throughout the selection and testing process. F1011 had consistently high sucrose concentration while F1012 was consistently one of the higher yielding lines. F1013 and F1014 appeared to be intermediate in both root yield and sucrose concentration.

Purity, a measure of extractable sucrose, of all the germplasms was not substantially different than that observed for the commercial hybrids. Purity increased as the sucrose concentration was increased so purity was not included as a selection criterion. The low root yields in 1986 were the result of waterlogged soil conditions shortly after emergence.

These germplasms make readily available a portion of the genetic diversity within the USDA **Beta** collection. All are intended to provide unique genetic sources for the development of populations and parental lines with enhanced performance. Preliminary combining-ability tests that are under

**Table 1. Performance of sugarbeet germplasms, Fargo, North Dakota, 1985-1988.**

| | Sucrose | | | Root yield | | | Purity | |
|---|---|---|---|---|---|---|---|---|
| Designation | 1985 | 1986 | 1988 | 1985 | 1986 | 1988 | 1986 | 1988 |
| | % | | | tons/acre | | | % | |
| F1011 | 17.3 | 15.3 | 15.1 | 13.7 | 6.3 | 11.7 | 94.5 | 93.0 |
| F1012 | 16.5 | 14.4 | 13.9 | 15.8 | 8.3 | 16.3 | 94.7 | 91.5 |
| F1013 | 16.5 | 14.0 | 12.6 | 15.0 | 7.1 | 14.7 | 93.0 | 89.2 |
| F1014 | 16.0 | 13.9 | 13.3 | 15.6 | 5.4 | 8.4 | 92.3 | 91.5 |
| Mean | 16.6 | 14.4 | 13.7 | 15.0 | 6.8 | 12.8 | 93.6 | 91.3 |
| ACH-164 | 16.4 | 14.6 | 13.9 | 14.5 | 10.4 | 17.2 | 94.4 | 91.2 |
| Ultramono | 16.3 | 14.1 | 13.8 | 19.4 | 10.2 | 16.9 | 94.4 | 91.0 |
| Beta 1230 | 16.1 | 13.8 | 13.4 | 17.8 | 10.2 | 19.8 | 93.7 | 90.0 |
| Monohikari | — | — | 13.8 | — | — | 16.2 | — | — |
| Mean | 16.3 | 14.2 | 13.7 | 17.2 | 10.3 | 17.5 | 94.2 | 90.7 |
| $LSD_{0.05}$ | 1.1 | 1.0 | 0.6 | 2.6 | 2.7 | 1.6 | 3.0 | 1.0 |

way will provide insight into the potential value of these germplasms. Commercial breeders will combine them with their unique male-sterile lines to determine how they might benefit their specific hybrid development programs. Since selection was almost exclusively for sucrose concentration and root yield, commercial breeders likely will need to introduce genetic resistance to the pests unique to their regions by combining their elite breeding populations and these germplasms. The described germplasms were developed and released jointly by the Agricultural Research Service, USDA and the North Dakota Agricultural Experiment Station. Breeder seed will be provided in quantities sufficient for reproduction upon written request to Sugarbeet Research, USDA-ARS, Northern Crop Science Laboratory, Fargo, N.D. 58105-5677.

## REFERENCES


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