Development of Sugarbeet Germplasms with Low Storage Respiration Rates

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Nearly 75 percent of the sugarbeet (Beta vulgaris L.) crop is stored in large exposed piles for up to 180 days. The stored sugarbeet root is a living organism that obtains needed energy from its own sucrose through normal respiration. Respiration is responsible for 50 to 60 percent of the sucrose loss during post-harvest storage (9). Losses during storage frequently average 0.5 pounds sucrose per ton of beets per day and may reach two pounds per ton under poor storage conditions.

The actual amount of sucrose consumed by respiration is influenced by a number of factors. Figure 1 shows the general effect that temperature has on sucrose loss (7) and provides justification for rather sophisticated attempts to control storage pile temperatures (2,10). Respiration is a heat-producing process and nondissipated heat will result in increased respiration rates and the potential for rapid development of storage rots. Respiration rates of sugarbeet roots are also influenced by the level of mechanical damage during harvest and piling. In general, respiration rates increase each time the beets are subjected to a mechanical operation (3). Scalping at harvest increases both respiration rate and susceptibility to storage rotting organisms.

Varieties differ in storage respiration rate (1,6,8). Rapid screening techniques have been developed and storage respiration rate has been altered by selection (4). This article describes the development of sugarbeet lines with low storage respiration rates.

SELECTION PROCEDURES

Selection for low respiration rate was accomplished by measuring internal carbon dioxide (CO₂) levels of individual sugarbeet roots (5). Carbon dioxide (a by-product of respiration) concentration increases as respiration rate increases. Roots were grown under conditions similar to those used in commercial production, manually harvested, washed, and stored at 40°F and high humidity for one month. Individual roots were sampled by removing a 3/8 by 2 1/2 inch cylindrical core from a smooth surface of the root below the crown (Fig. 2a). The cavity was immediately sealed with a rubber serum vial stopper (Fig. 2b) and the root was returned to storage. After 48 hours an air sample was removed with a needle and syringe (Fig. 2c). The CO₂ concentration of the sample was measured with a differential infrared gas analyzer. Roots with relatively low internal CO₂ concentrations (low respiration rates) were planted in the greenhouse, induced to flower, and produced seed for future selection cycles. Initially, diverse sugarbeet germplasm sources were evaluated for internal CO₂ concentration. The sources included inbred lines from other USDA programs and the USDA Beta vulgaris world collection. Lines selected for low internal CO₂ concentration have been evaluated for vigor, quality, and agronomic performance in replicated field trials.

CHARACTERISTICS OF SELECTED LINES

Two germplasm lines with low storage respiration rates have been jointly released by the USDA and the North Dakota Agricultural Experiment Station. The lines have been designated F1007 and F1008. They provide commercial breeders genetic material for incorporation of low storage respiration rate into their breeding stocks.

F1007 is a multigerm, green hypocotyl line selected from a population formed by interpollinating low internal CO₂ individuals from 31 accessions of the world collection of Beta vulgaris. Progeny of each selected plant were evaluated as a family. Superior individuals from families with relatively low
internal \( \text{CO}_2 \) means were crosses in pairs. Three additional cycles of selection within the lines formed by the pair crosses followed. The mating procedure did not allow for determining if, or to what extent, selfing occurred during selection. Concurrent with selection for low internal \( \text{CO}_2 \) concentration, visual selection was used to eliminate lines with the tendency to produce sprangled or colored roots. The maternal parents of the plants used in the original pair cross were PI 171515 and PI 176872. Both originated from Turkey. Internal \( \text{CO}_2 \) concentrations of F1007 were approximately 40 percent of those observed in the commercial hybrids KW 1132 and Beta 1230. Commercial hybrids did not differ greatly in internal \( \text{CO}_2 \) concentration.

F1008 is a multigerm, green hypocotyl line selected from the same base population and in the same manner as F1007. Internal \( \text{CO}_2 \) concentrations of F1008 were usually slightly higher than those of F1007 but still only about 50 percent of that observed in KW 1132 and Beta 1230. The maternal parents of the selections used in the pair-cross that resulted in F1008 were PI 169016 and PI 181716. PI 169016 originated from Turkey and PI 181716 from Lebanon.

Both lines have been evaluated in replicated trials for two years at Fargo. Root yield of F1007 has been about equal to adapted commercial hybrids; however, the sucrose concentration was only about 70 percent of the hybrids. Purity percent (the percentage of the total sucrose that can be extracted using standard factory methods) was about 4 percent below the hybrids. F1008 yielded about 70 percent of the check hybrids and was slightly lower than the commercial checks for sucrose and purity percent. These lines are intended to be used as pollinators for experimental hybrids, as parents in genetic studies, and as genetic sources for the development of parental lines with reduced sucrose loss due to respiration. Low storage respiration rate is intended to complement other methods of reducing storage losses such as reducing injury to the roots and pile ventilation. Breeder seed of F1007 and F1008 will be maintained by the USDA-ARS sugarbeet research group at Fargo. Germplasm quantities may be obtained from the author.

REFERENCES