DROUGHT TOLERANCE SELECTION IN SUGAR BEET

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Increased water demands and drought have resulted in a need to determine if drought tolerance exists in sugar beet lines. This study was conducted to determine if drought tolerance existed among a group of genetically diverse sugarbeet hybrids by evaluating sucrose yields over a range of water inputs levels. The study was conducted over three consecutive growing seasons (2008-2010) at the NWISRL in Kimberly, ID on a Portneuf silt loam (coarse-silty mixed mesic Durinodic Xeric Haplocalcid) to assess the production of six KWS breeding hybrids and one commercial hybrid under a range of water inputs [125% (W1), 100% (W2), 75% (W3), 50% (W4), and 25% of estimated crop evapotranspiration (ETc) and rain-fed (W6)] with water applied 3 times a week. Some of the hybrids have been previously tested under drought conditions in proprietary trials. All six were selected for this study based on their known genetic background, preliminary information about variation under drought stress conditions, and a close relationship to actual market hybrids. The experimental design was established based on the use of a line source irrigation system. Impact nozzles (Weather Tec G50V 23 degree; nozzle size and type = 6.5 MPS; flow rate = 12.4 Lpm) were spaced at 6.1 m intervals down the line to provide uniform irrigation distribution for a given perpendicular distance from the line. Water amount treatments were based on applying irrigation to supplement precipitation to match 100% crop water requirement (W2), based on the 1982 Kimberly-Penman Reference Evapotranspiration Model (Wright, 1982) using data from an Agrimet weather station (U.S. Bureau of Reclamation, Boise, ID); the remaining treatments receiving amounts of water based on the distance from the line source. Irrigation depth decreased as perpendicular distance from the line increased. Drought susceptibility index (DSI) is defined as a criterion to evaluate hybrids with more stable performance under water stress (Siahpoosh et al., 2011). The DSI compares yield differences under water stressed and optimum water levels and is calculated as:

$$DSI = \frac{1 - \left(\frac{Xs}{Xp}\right)}{1 - \left(\frac{Ys}{Yp}\right)}$$

Where, Xs is the sucrose yield under water stress, Xp is the sucrose yield under optimum water level, Ys is the average sucrose yield under water stress, and Yp is the average sucrose yield under optimum water level. Sucrose yields at the W2 water level (100% ET) from each sugarbeet hybrid were compared statistically using an ANOVA randomized complete block model in Statistix 8.2 (Analytical Software, Tallahassee, FL). Mean separations were carried out using least significant difference method. Significance was determined at the 0.05 probability level for all analysis. Water application response data defined by the linear portion of the sucrose and root yields versus water input (irrigation level 1-4) were analyzed using SAS Proc MIXED (SAS Institute, Cary, NC). In the model statement, the fixed effects were breeding hybrid and the breeding hybrid by water input interaction. The random effects were block and the block by water input interaction. In the model statement, the denominator degrees of freedom were calculated using the DDFM=KENWARDRODGER option. Confidence intervals (95%) were

established for the comparison of breeding hybrid linear regression slopes and intercepts. Drought susceptibility index values for each sugarbeet hybrid were compared statistically using a randomized complete block model in Statistix 8.2. Mean separations were carried out using the least significant difference (LSD) method. Significance was determined at the 0.05 probability level for all analysis. There were differences in sugarbeet sucrose yield responses to water for the sugarbeet lines used in this study. The differences were demonstrated by comparing sugarbeet lines sucrose yields over the range of deficit water inputs using linear regression slope and intercept comparisons, drought stress index, and near maximum yield at the W2 water input level. Greater drought tolerance or greatest difference in sucrose yield between lines was seen at the lowest water input treatment (intercept difference). Linear regression analysis and drought stress index collaborated to show greater drought tolerance for KWS-05 compared to the commercial cultivar. There were also differences in overall yield potential among lines.

References

Siahpoosh, M.R., E. Dehghanian, and A. Kamgar. 2011. Drought tolerance evaluation of bread wheat genotypes using water use efficiency, evapotranspiration efficiency, and drought susceptibility index. Crop Sci. 51:1198-1204.

Wright, J.L. 1982. New evapotranspiration crop coefficients. Journal of Irrigation and Drainage Division, Proc. ASCE 108:57-74.