LAFTA, ABBAS M. and KAREN KLOTZ FUGATE*, USDA-ARS, Northern Crop Science Laboratory, 1605 Albrecht Blvd. N., Fargo, ND 58102-2765. **Metabolic changes associated with elevated respiration rate in stored sugarbeet roots after injury.**

ABSTRACT

Although respiration is estimated to cause 60 to 80% of the sucrose loss that occurs during storage, the mechanisms controlling sugarbeet root respiration rate are unknown. Previous research suggested that sugarbeet root respiration was limited by the availability of respiratory substrates, which are synthesized from sucrose by the combined action of sucrose-degrading enzymes, the glycolytic pathway, and the tricarboxylic acid cycle (TCA). To identify possible restrictions in these pathways that may limit respiratory substrate availability and thereby limit respiration, changes in the concentration of compounds that are substrates, intermediates, or cofactors in the respiratory pathway were determined in roots whose respiration was elevated by injury. In wounded tissue, respiration increased an average of 186%, fructose, glucose 6-phosphate, ADP and UDP concentrations increased, fructose 1,6 bisphosphate, triose phosphate, citrate, isocitrate, succinate, ATP, UTP and NAD^+ concentrations declined, and sucrose, glucose, fructose 6-phosphate, glucose 1-phosphate, UDP-glucose, 6-phosphogluconate, phospho*enol*pyruvate, pyruvate, α-ketoglutarate, fumarate, malate, phosphate, NADH, $NADP^+$, and NADPH concentrations were not significantly altered. In the nonwounded tissue of wounded roots, respiration rate increased 21%, glucose 6-phosphate, fructose 6-phosphate, glucose 1-phosphate and ADP concentrations increased, citrate concentration increased exclusively on the 3rd day after injury, UDP-glucose, pyruvate and UDP concentrations increased exclusively on the fourth day after injury, and isocitrate, UTP, NAD^+, $NADP^+$ and NADPH concentrations declined. Concentrations of sucrose, glucose, fructose, 6-phosphogluconate, fructose 1,6-bisphosphate, triose phosphate, phospho*enol*pyruvate, α-ketoglutarate, succinate, fumarate, malate, ATP, phosphate, and NADH were not significantly altered by wounding in the nonwounded tissues of wounded roots. Correlation analyses and principal component analyses (PCA) were used to identify relationships between respiratory pathway substrates, respiratory pathway intermediates, cellular energy charge, cellular redox status, and respiration rate. In wounded tissues, changes in respiration rate were not correlated to changes in any respiratory pathway substrate or intermediate, cellular energy charge or cellular redox status, although PCA revealed similarities between the effect of wounding on respiration rate and the ratio of NADH:NAD^+, an indicator of cellular redox status. In the nonwounded tissue of wounded roots, changes in respiration rate were correlated with all indicators of cellular redox state. Data from this study suggest that early glycolytic enzymes were limiting in wounded tissues that had a high demand for respiratory substrates. Restrictions in carbon flow due to these enzymes, however, were likely overcome by use of metabolic bypasses that allowed carbon compounds to enter the respiratory pathway at glycolytic and TCA cycle downstream locations. The use of metabolic bypasses such as a phospho*enol*pyruvate carboxykinase-catalyzed production of phospho*enol*pyruvate, the glyoxylate cycle, and amino acid catabolism provides an explanation of how respiration rate could increase two-fold with little or no reduction in the immediate substrates of respiration despite an apparent restriction in carbon flux by early glycolytic enzymes. In nonwounded tissue, glycolysis and the TCA cycle were generally capable of supporting small elevations in respiration rate. Changes in ATP concentrations indicate that oxidative phosphorylation failed to keep pace with ATP utilization in wounded tissue. However,

no evidence was found that alterations in ADP concentration, ATP concentration, the ratio of ATP:ADP or adenylate energy charge had any effect on carbon flow through glycolysis or respiration in either the wounded or unwounded tissues of wounded roots. Although the mechanism by which respiration is regulated in wounded sugarbeet roots is unknown, localized and systemic elevations in respiration were positively associated with one or more indicators of cellular redox status, suggesting that regulation of respiration rate in sugarbeet root by redox status deserves further study. A full description of this research is available online (doi:10.1016/j.phytochem.2010.12.016).