BEAUDRY, RANDOLPH[1*], GREG CLARK[2], DAN ZEMAITIS[1], MATT ALT[1]. [1]Michigan State University, 1066 Bogue street, East Lansing, MI 48824 and [2]Michigan Sugar, 2600 S. Euclid Ave., Bay City, MI 48706. **Assessment of impact severity in handling systems using instrumented sphere technology.**

ABSTRACT

In 2004-2005, the Michigan sugarbeet industry lost approximately $25 million due to losses incurred in field storage piles. Uncharacteristically warm late winter temperatures and larger pile dimensions lead to excessive sprouting and decay with the result that thousands of tons of harvested beet roots were unusable. The unusual 2004 storage season and trends of increasing winter temperatures in Michigan highlight the need to understand factors that lead to sugar losses in the storage campaign.

Earlier research quantitatively described the impact of mechanical harvest and handling techniques and temperature on the severity on sugar losses. From this work, we reported to the Michigan sugarbeet industry that a reasonable return of $1.5 million could be obtained by ameliorating postharvest stresses. This could be done by reducing damage by half or reducing the average pile storage temperature by 5 to 8 °F. Our central hypothesis is that handling abuses at harvest and environmental stresses late in the storage season comprise a stress complex that results in untenable storage losses by the sugarbeet industry.

The ROPA euro-Maus beet loader is an innovative means of handling sugarbeet (*Beta vulgaris*) roots that gives the grower more control and convenience in harvest and transport. In this system, beets are harvested then unloaded at the perimeter of the field and the Maus is used to transfer the beet roots from the perimeter field piles to hauling trucks, which then carry the beets to the piling grounds. The Maus system enables the grower to get roots out of the ground during optimal harvest conditions, avoids delays and potential difficulties brought on by inclement weather, and aids in soil removal from the root. It also makes for more convenient shipment of the harvested beets to processing facilities or piling grounds; the hauling truck no longer needs to be in the field at the time of harvest. However, the Maus system also increases the number of handling steps and has the potential to increase root damage and sugar loss. The current policy of Michigan Sugar is to process Maus-handled beets first and, if possible, avoid long-term storage of these roots at the piling grounds.

The long-term goal of our research program is to develop and implement effective techniques to improve the storability of field-stored sugarbeets. We were interested in determining if the current system of handling compromises root storability. Our objective is to provide a handling analysis of the Maus and other harvest equipment using instrumented sphere (IS) technology and make quantitative measures of root quality loss including respiratory activity, decay incidence, and loss in recoverable white sugar as a function of initial content.

For this study, the severity of impacts during handling by several pieces of harvest equipment was determined using a 4.75-inch diameter Impact Recording Device (instrumented sphere, IS) manufactured by Techmark, Inc. The sphere was run three times through a Ropa beet harvester, a Kringstadt Ironworks beet cart and a MAUS loader. The Ropa harvester picked the IS up from the soil and deposited it onto a field

pile and a beet cart. The beet cart was evaluated dropping into a semi trailer. The Maus was evaluated dropping into a semi trailer. The semi trailer was evaluated (once) as it deposited its load to the ground.

Additionally, a drop-testing platform was calibrated and used to impart impact energies to sugarbeet roots in the range of those encountered in the harvest and handling processes based on data from the instrumented sphere. Roots will be subjected to a range of impact energies using the drop-testing platform and the effects determined as a function of impact severity. Measurements will include descriptions of root injury (e.g., splitting, spalling, and bruising), respiratory activity, decay susceptibility, and recoverable white sugar.

The storability of beets harvested conventionally and via the euro-Maus system was also evaluated. Roots were sourced from two grower field locations after 0, 3, 11, 17, and 32 days in the field pile. Beets were stored at MSU at a sub-optimal storage temperature (7.5 to 12.5°C) to reflect the more severe conditions that might be found at piling grounds and respiration measurements were made after holding the beets at this temperature for 2 months.

The IS recorded hundreds of impacts in the 40 to 100 gravity range, numerous impacts in the 100 to 200 gravity range and several impacts in the 200 to 500 gravity range. Of the three pieces of equipment evaluated, the Ropa harvester imparted far more and more severe impacts then either the beet cart or the MAUS. On average, the Ropa harvester delivered 292 impacts between 40 and 100 gravities, 67 between 100 and 200, and 6 between 200 and 400 gravities. The Kringstadt Ironworks beet cart yielded, on average, 60, 15, and 4 impacts between 40-100, 100-200, and 200-400 gravities, respectively. The MAUS was the least damaging, yielding 40, 12, and <1 impacts between 40-100, 100-200, and 200-400 gravities, respectively.

One must keep in mind that there is no real control over the contact surface on which the IS impacts, so some of these impacts, perhaps most, are sphere-on-beet and some, perhaps only the very highest impact energies, are sphere-on-steel as the sphere wends its way through the harvester and transfer equipment.

In our drop tests, we found that the acceleration experienced by the root increased as drop height increased until the height of the drop reached approximately 32 inches. Above this point, the acceleration experienced by the root did not increase, even when the height of the drop was 100 inches (a little over 8 feet - about the distance the beets fall into an empty beet cart). We interpreted this to mean that the beet absorbed the energy of the impact through elastic (reversible) deformation, much like a rubber ball might, up to a drop height of 32 inches. At higher drop heights, the fact that the beet acceleration did not continue to increase was taken to mean that the beet underwent irreversible deformation, that is, the beets was bruised and tissues inside the beet collapsed, resulting in damage. The assumption is that drops and impacts that have the equivalent energy of a 32-inch drop, damages the beet root irreversibly.

When we measured the respiratory response to impacts (in this case caused by dropping) in the first 10 days, we found drop height and the number of drops affected root respiration. For roots dropped 16 inches, only when the number of impacts reached 40 did we see an increase in respiration relative to undropped roots (controls). This is probably mostly due to surface scuffing and spalling. For beets impacted by a drop height of 32 inches, an increase was evident with as few as 20 drops. For beets dropped 72 inches (6 feet), an increase in respiration was measured following as few as 5 drops. A beet experiencing 20 impacts equivalent to a 6-foot drop has twice the respiratory rate of a gently harvested beet. Importantly, previous work suggests that the response to root damage at harvest only increases in its impact on respiration, largely as a result of decay of the damaged tissue.

The fact that the harvester imparted so many impacts to the beet root, suggests that the harvester, rather than the beet cart or the MAUS loader, should be further evaluated for its impact on respiratory activity. Further, harvesters should be assessed for ways to 'soften the blow' of the handling operations as the beets are lifted, cleaned and transported, perhaps by reducing operation speed and by padding steel surfaces.