



Assessing harvest losses; evaluating
potential damage to sugarbeets caused by
harvesting and piling equipment using an
Impact Recording Device

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Executive Summary

As harvested, topped sugar beets are stored, sugar is lost due to respiration (consumption) by the living beet root. Mechanical injury affects storage losses of beets because of increased respiration rates, as well as providing an entry point for storage rots. In order to reduce tare dirt, sugar beets are exposed to a series of rollers and belts during harvest and piling. If the sugar beet is cracked and bruised, research has shown that respiration rates are higher and sugar loss greater than undamaged sugar beets. Under experimental conditions, severely damaged beets had a respiration rate 4 times that of undamaged beets.

Impact Recording Devices (IRD) are sensors designed to identify locations in fruit and vegetable harvesting and processing equipment which cause damage to produce. They are spherical, self-contained sensors which are similar in shape to the product and are sent through harvesting equipment and processing lines to record locations where high impacts are experienced. These units were sent through sugarbeet harvesters and piling equipment and measured the impacts experienced by the sugarbeets. This enables the operator to make changes or adjustments to the equipment to minimize potential damage.

Sugarbeets left in the field as whole beets missed or dropped by the harvester or displaced by topping equipment can represent significant losses to a producer. Other losses include damaged beets which break up and fall through chains, or "tails" (tips of tap root) which remain in the soil after harvest. Speed of harvest is often blamed for high harvest losses. Losses of over 1 ton/acre are considered excessive and should be addressed.

The largest impacts on pilers are noted at points where beets drop from an elevator to another surface. Generally, the drop to the boom taking the beet to the pile produces the greatest impact.

A beet spends the least time in the Artsway and Tiger harvesters when compared to the Vervaet harvesters. Maximum and average impacts are least for the Tiger, intermediate for the Artsway and greatest for the Vervaet harvester in 2007.

Changes were made to ground speed and cleaner speed on the Tiger harvester to see the effect on the impact on beets. Slow ground speed provided far more impacts of greater magnitude, presumably because the cleaning mechanisms in the harvester were not running at capacity and the beets were subject to more impacts against metal surfaces rather than other beets or dirt. Slowing the rotation of the turbines which clean the beets almost greatly reduced the impacts number and intensity, while running the turbines as fast as possible caused far more impacts of greater intensity. The intensity and number of impacts noted during "normal" conditions fell between these 2 scenarios. While it has been demonstrated that the impacts experienced by sugarbeets in a Tiger harvester can be reduced by decreasing rotor speed and increasing volume through the cleaning mechanisms, the cleanliness of the beet is also a consideration and field conditions also need to be considered when making these adjustments.

Soil conditions at harvest at all sites was dry, which we assumed made harvest more efficient in terms of reduced harvest loss. Fewer root tips were found in the clay soils with all harvesters, but soil type did not appear associated with recoverable harvest losses. High losses (> 1 ton/acre) were found on at least one site with the Artsway and Tiger harvesters. Given that the same harvester demonstrated lower and more acceptable losses on other sites suggest that operation of the harvester made the difference.

Project Results and Milestones

This project had the following objectives:

1. Record and identify points of highest impact on a range of sugarbeet harvesters and determine if they are damaging.
2. If identified, make adjustments and/or modifications to harvesting equipment to minimize damaging impacts.
3. Record and identify points of highest impact on sugarbeet piling equipment and determine if they are damaging.
4. If identified, make adjustments and/or modifications to piling equipment to minimize damaging impacts
5. Assess the harvest losses of different types of sugarbeet harvesters under a range of harvesting conditions to see if improvements can be made.

A. Impact Studies

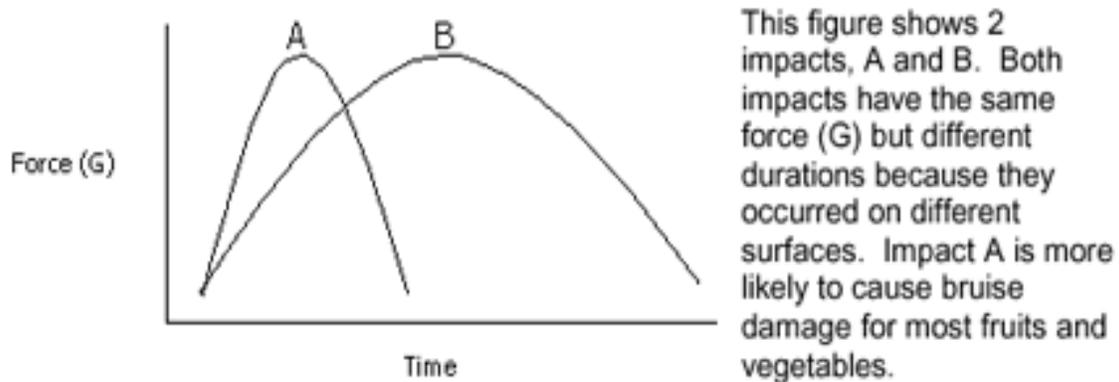
A 3.5" diameter Impact Recording Device (IRD - Techmark Inc, Lansing MI) was borrowed from the Ontario Ministry of Agriculture, Food and Rural Affairs for this study. This instrument was developed to identify locations in fruit and vegetable processing and handling equipment which caused damage to produce. It is a self contained sensor, which records the force of an impact, as well as the duration of the impact. It also records the time of individual impacts, so the location of a specific impact within a machine can be determined. Examples of where IRD's are used are apple and melon packing lines, and potato harvesters.

All three pilers at the Dover Piling Station, as well as an Artsway, Euro Tiger and Vervaet harvester were evaluated. At the piling station, we placed the sensor on the unloading cross conveyor, and retrieved it once it reached the boom going to the piles. For the harvesters, the IRD was placed in a beet row and picked up by the harvester. We retrieved the instrument once it reached the hopper on the Tiger and Vervaet harvester, and on the unloading conveyor on the Artsway.

We intended to run the IRD through all the machinery at least 6 times, which was accomplished for all the pilers except # 1, and all harvesters except for the Artsway. We also have yet to determine the level of force which will cause damage to sugarbeets; we assumed this value to be 80 G for the purpose of this study (based on Techmark data which indicates that potatoes are damaged at forces of 80 G), and did not collect data points below this level of impact.

Impact data can be presented in 2 ways; one approach is to make a graph of force of the impact versus the duration of impact. This is the usual way it is presented in the software which accompanies the IRD; this is because not only the force of the impact must be considered, but also the duration of the force. For further explanation see Figure 1, which comes from the Techmark web site.

Figure 1. Explanation of force vs duration. Source: www.techmark-inc.com.



Sample data collected from the Piler # 1 at the Dover Piling Station are shown in Figure 2. Each point on the graph represents an impact recorded during 1 pass over the piler. Points which are high in force and short in duration (top left side of the graph) are most damaging. From this graph we see that there are no impacts in this range when using Piler 1, which tends to have the greatest impacts. Table 1 is a summary of the data collected from the 3 pilers and indicates that Piler 1 gives the greatest maximum and average impacts.

Table 1: Summary of piler impact data. Ridgetown Campus, University of Guelph. 2007

Piler	Force (g)		Duration (m/s)		Impact #	Time to pass through (sec)	Impacts/second	# of tests
	Max	Avg	Max	Avg				
1	412	191	6.88	2.87	30	28	1.1	5
2	407	179	7.79	2.75	38	35	1.1	6
3	404	160	7.21	2.66	57	26	2.2	6

The second way to present impact data is to make a graph of force vs time. This allows the location in machinery where large impacts occur to be identified. Figure 3 depicts impact

data over the 28 seconds it takes a sugarbeet to pass over Piler 1. The first cluster of impact points (time = 0) represents the beets falling from the cross conveyor to the belt taking them to the cleaner. The second cluster of impact points (time = 8 seconds) occurs when the beets fall into the roller bed, and we believe the third cluster of impact points (time = 22-26 seconds) are the beets leaving the roller bed and falling to the boom which will take them to the pile. The greatest impacts are noted at the back of the piler, which may be an area which needs modification. Piler 2 shows the same pattern of impacts over time (Figure 4), but the force of these impacts is not as great as Piler 1

Impacts recorded from Piler 3 show a different pattern than the previous 2, since the cleaning mechanism is different (Figure 5). The first set of impacts (time = 11 seconds) occurs when the beets fall from the belt onto the roller bed. The second of impacts (time = 16 to 23 seconds) occurs as the beets fall from the roller bed to the rotary drum, where they stay for 4-6 seconds and fall onto the next elevator. The third cluster of impacts (time = 22) occurs when the beets fall onto the back boom.

Similar graphs are presented for the Artsway, Vervaet and Tigert harvester (Figures 6, 7, and 8 respectively). Clear clusters of impacts are not noted, as was seen in the Pilers, but areas of high impact are noted, and are usually associated with cleaning equipment, either roller beds or rotors. Clusters at the back of the time course are associated with the IRD falling into the hopper (in the case of the Tiger and Vervaet harvester) or falling onto an unloading chain (Artsway harvester).

The impact data for harvesters is summarized in Table 2. A beet spends the least time in the Artsway and Tiger harvesters when compared to the Vervaet harvesters. Maximum and average impacts are least for the Tiger, intermediate for the Artsway and greatest for the Vervaet harvester in 2007.

Table 2: Summary of harvester impact data. Ridgetown Campus, University of Guelph. 2007

Harvester	Force (g)		Duration (m/s)		Impact #	Time to pass through (sec)	Impacts/second	# of tests
	Max	Avg	Max	Avg				
Artsway	363	174	9.84	3.28	24	7.5	3.2	3
Tiger	317	152	4.74	1.98	41	8.6	4.8	5
Vervaet	535	205	6.8	2.56	55	12.2	4.6	6

Changes were made to ground speed and cleaner speed on the Tiger harvester to see the effect on the impact on beets. Slow ground speed provided far more impacts of greater magnitude (Figure 9) than fast ground speed (Figure 10) or “normal” operating conditions (Figure 8), presumably because the cleaning mechanisms in the harvester were not running at capacity and the beets were subject to more impacts against metal surfaces rather than other beets or dirt. Slowing the rotation of the turbines which clean the beets reduced the impact number

and intensity (Figure 11), while running the turbines as fast as possible caused far more impacts of greater intensity (Figure 12). The intensity and number of impacts noted during “normal” conditions fell between these 2 scenarios. While it has been demonstrated that the impacts experienced by sugarbeets in a Tiger harvester can be reduced by decreasing rotor speed and increasing volume through the cleaning mechanisms, the cleanliness of the beet is also a consideration and field conditions also need to be considered when making these adjustments.

B. Harvest Loss Studies

Sugarbeets left in the field as whole beets missed or dropped by the harvester or displaced by topping equipment can represent significant losses to a producer. Other losses include damaged beets which break up and fall through chains, or “tails” (tips of tap root) which remain in the soil after harvest. Speed of harvest is often blamed for high harvest losses. Losses of over 1 ton/acre are considered excessive and should be addressed.

Eight fields were sampled in the fall of 2007 for harvest loss. Three fields were harvested by an Artsway harvester, 2 by a Vervaet harvester, and 3 by a Euro Tiger harvester. Six sections 10 ft long by the number of rows the harvester picks up per pass were randomly selected per field and all beets and beet pieces were picked up. Two rows x 10 ft were dug per site and all tails removed to a depth of 6 inches.

Table 3: Harvest loss evaluation of 3 harvesters. Ridgetown Campus, University of Guelph, 2007.

Harvester/ site	Soil Type	Total Harvest Loss (t/acre)	Small Beets on Surface (t/acre)	Small Root Tips on Surface (t/acre)	Recoverable Harvest Loss (t/acre)	Root Tips in Ground (t/acre)
Artsway 1	clay	1.11	0.19	0.30	0.62	0.17
Artsway 2	clay	1.81	0.33	0.28	1.20	0.15
Artsway 3	loam	0.75	0.19	0.11	0.45	0.21
Vervaet 1	sandy loam	0.54	0.07	0.03	0.44	0.27
Vervaet 2	heavy clay	0.36	0.10	0.02	0.24	0.14
Tiger 1	clay	0.54	0.22	0.06	0.26	0.11
Tiger 2	black loam	1.01	0.05	0.13	0.82	0.29
Tiger 3	loam	1.68	0.21	0.13	1.34	0.56

The total amount of beet material recovered was weighed and a Total Harvest Loss was

calculated. However, this included small underdeveloped beets (< 1" diameter) and small tails (<1" diameter) which a harvester could not be expected to recover, so these were removed from the total. The Recoverable Harvest Loss is the Total Harvest Loss with these small diameter beets and tails removed and is assumed to be a more accurate measure of harvest loss. Root Tips in Ground indicated the tons of broken tips of beets left buried in the row, which are assumed to be recoverable and are included in the Recoverable Harvest Loss.

Soil conditions at harvest at all sites was dry, which we assumed made harvest more efficient in terms of reduced harvest loss. Fewer root tips were found in the clay soils with all harvesters, but soil type did not appear associated with recoverable harvest losses. High losses (> 1 ton/acre) were found on at least one site with the Artsway and Tiger harvesters. Given that the same harvester demonstrated lower and more acceptable losses on other sites suggest that operation of the harvester made the difference.

Figure 2: Recorded Impacts vs Velocity Change
Piler #1

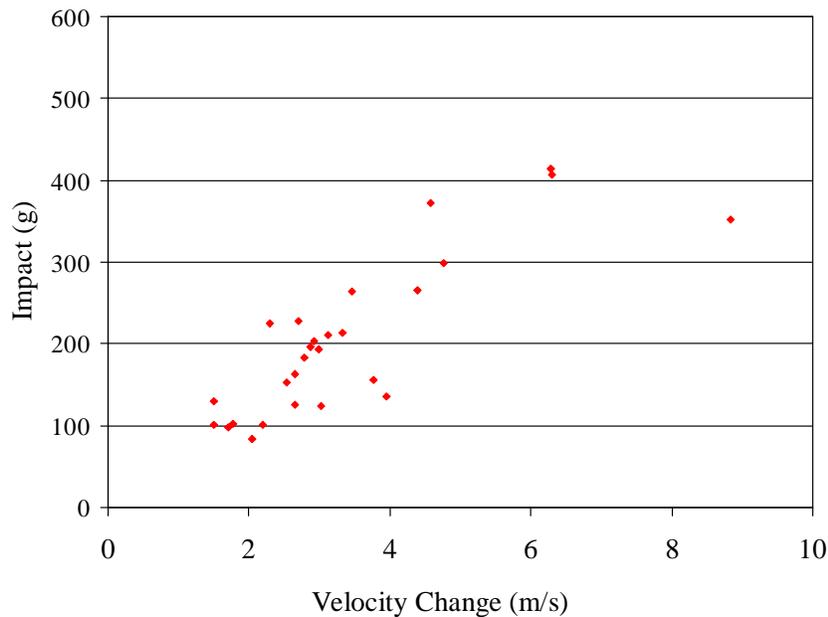


Figure 3: Recorded Impacts vs Time
Piler #1

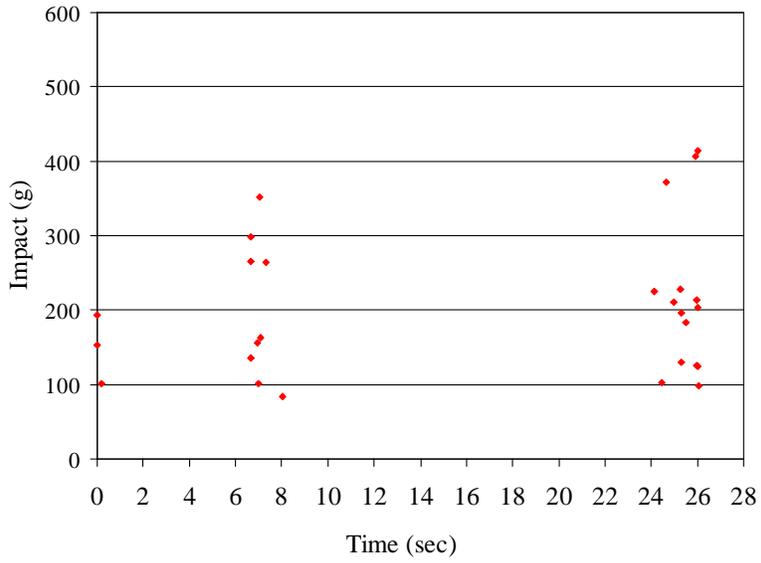


Figure 4: Recorded Impacts vs Time
Piler #2

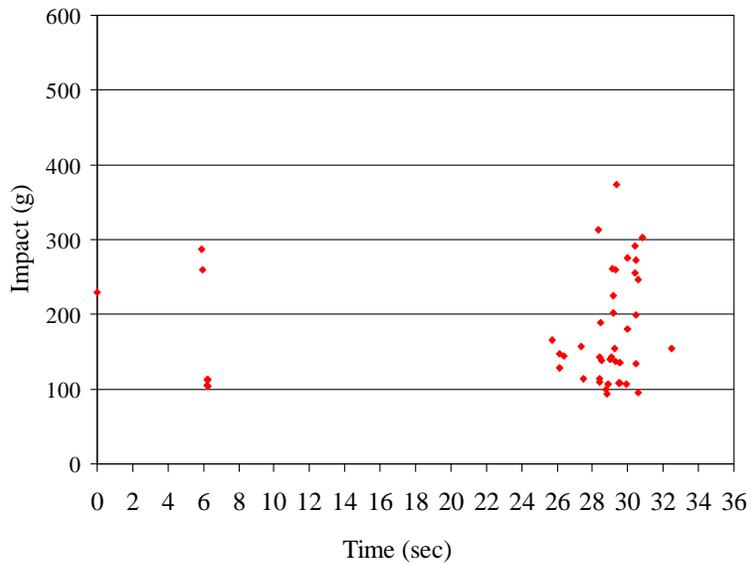


Figure 5: Recorded Impacts vs Time
Piler #3

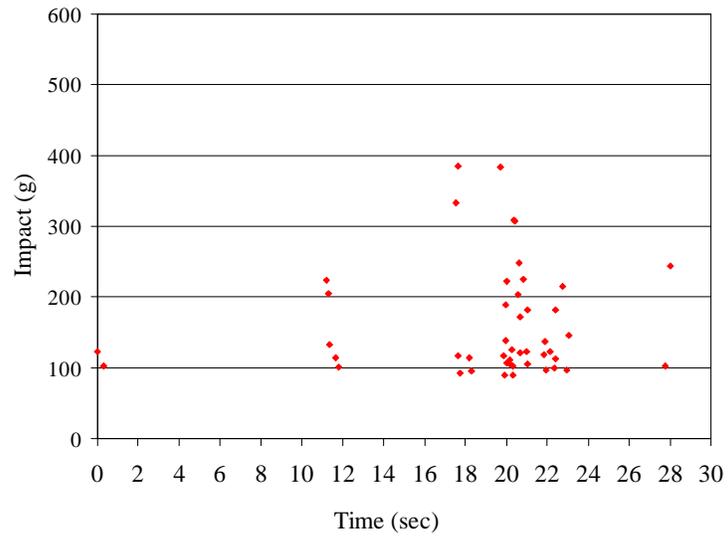


Figure 6: Recorded Impacts vs Time
Artsway Harvester

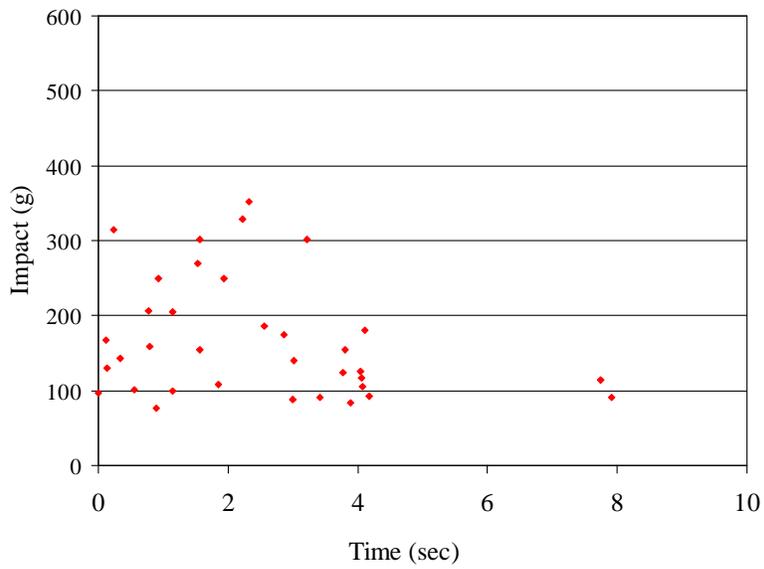


Figure 7: Recorded Impacts vs Time
Vervaet Harvester

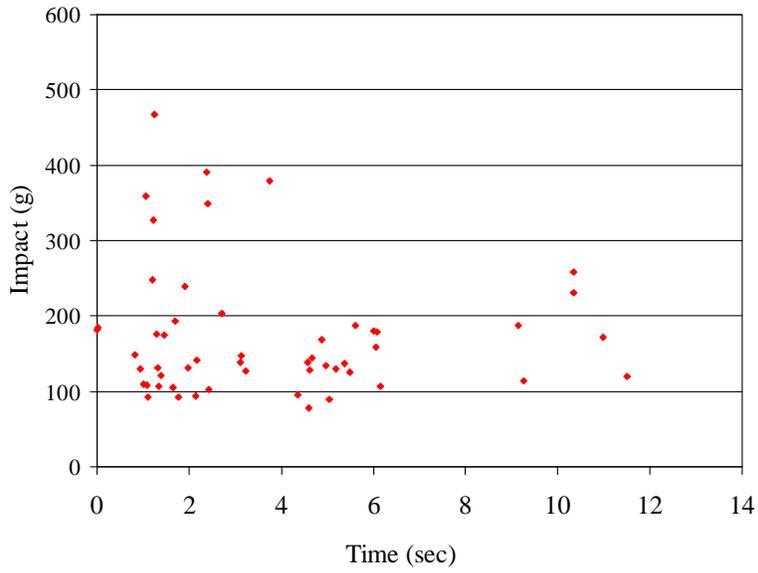


Figure 8: Recorded Impacts vs Time
Euro Tiger Harvester (Lambton Beet)

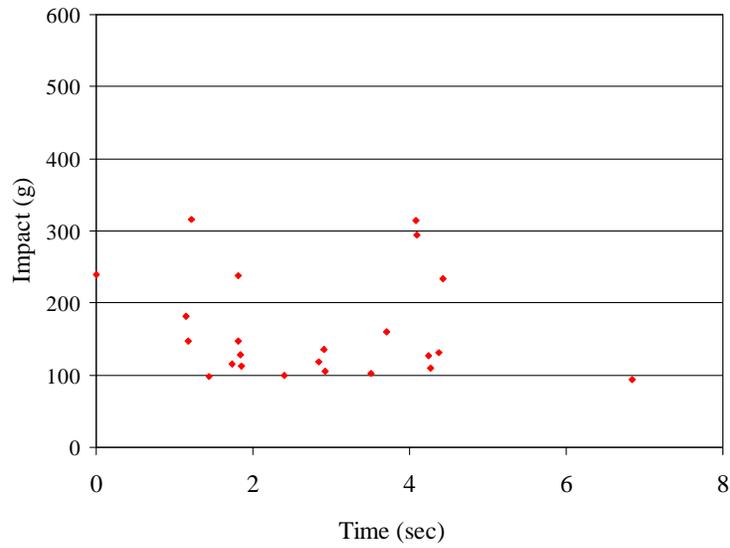


Figure 9: Recorded Impacts - Slow Ground Speed
Euro Tiger Harvester (Lambton Beet)

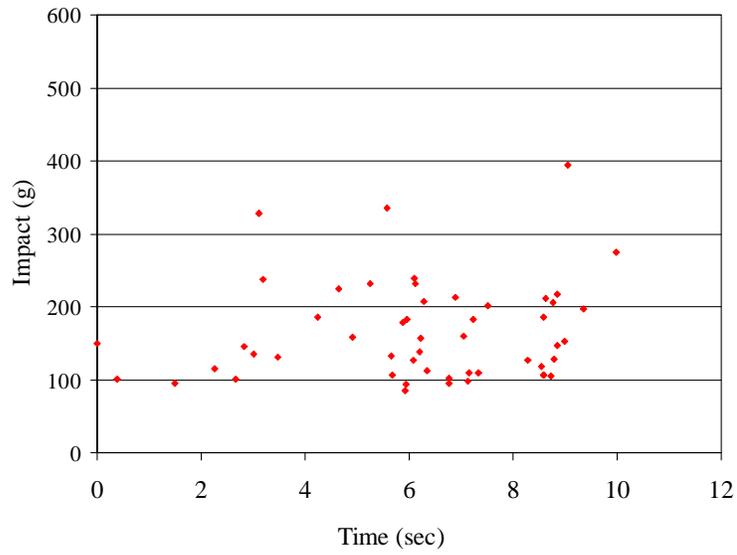


Figure 10: Recorded Impacts - Fast Ground Speed
Euro Tiger Harvester (Lambton Beet)

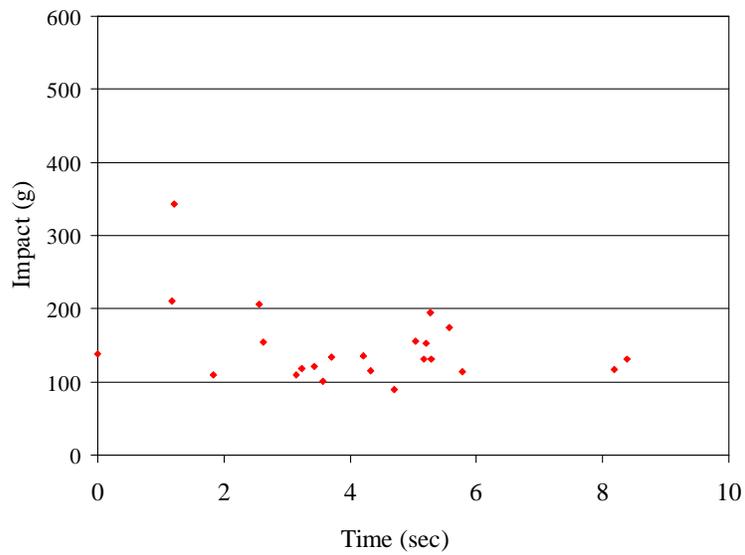


Figure 11: Recorded Impacts - Slow Turbines
Euro Tiger Harvester (Lambton Beet)

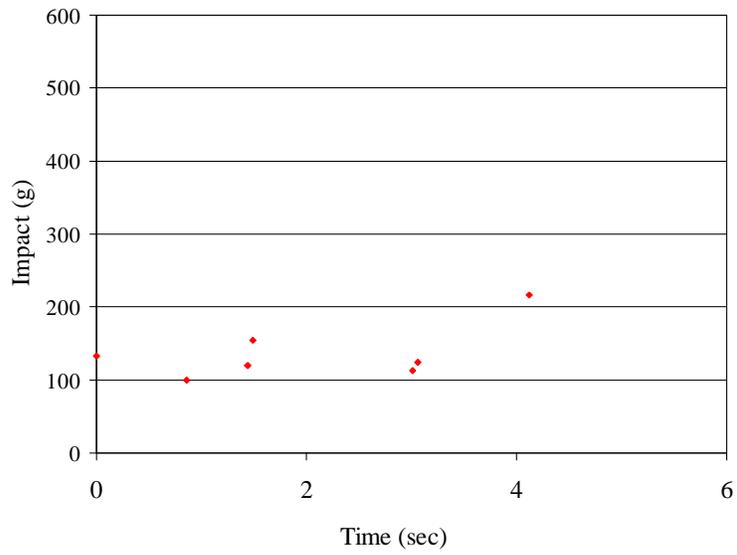
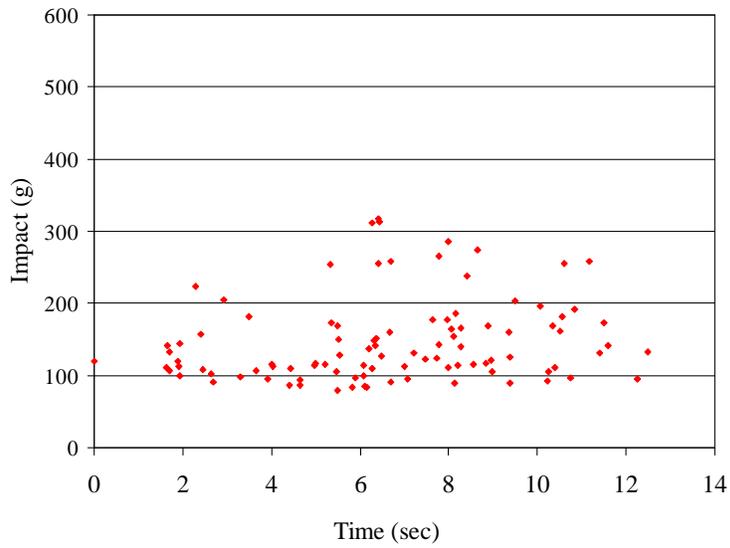


Figure 12: Recorded Impacts - Fast Turbines
Euro Tiger Harvester (Lambton Beet)



Milestones

1. Record impacts on harvesters and pilers - November, 2007
- completed
2. Compile, analyze and report data - 01 December, 2007
- completed

All milestones were completed as indicated.

Communication Plan

The Michigan Sugarbeet Advancement committee has an annual meeting in January of each year; it is anticipated that this project will be reported on at this meeting

Reports are usually made at the annual Ontario Sugarbeet Growers Association meeting, which is held in January of each years. It is anticipated that this project will be reported on at this meeting

Conclusions

1. Pilers differ in the impacts they generate, and provide greater impacts than harvesters.
2. Drops cause the greatest impacts in Pilers
3. Harvesters differ in the degree of impact they impart
4. Harvest losses do not appear associated with soil type, but rather with the operation of the machinery.

Acknowledgements

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- Wayne Martin and his group at the piling yard
- Mark Lumley (Tiger harvester)
- Brian Fox and his harvest group (Artsway harvester)
- George Bos, Dwayne Ferguson (Vervaet harvester)