

Developing Concepts in Low Damage Harvesting of Sugarbeets

Charles L. Peterson, Joseph C. Thompson,
Mark C. Hall and Eldon R. Muller

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INTRODUCTION

Excessive damage to sugarbeets inflicted during harvest and handling has been reported by several researchers (Wyse (1978), Akeson and Stout (1978), Cole (1977) and Wyse and Peterson (1979)). Previous work at the University of Idaho by Parks and Peterson (1979) and Precht (1978) has been concerned with identifying sources of damage and the resulting loss in recoverable sugar. When this project was initiated, very few people in the industry outside of research were aware that damage to sugarbeets was undesirable. Today there is considerably more knowledge of the problem at all levels. While the industry is aware of these findings, serious attempts to actually reduce damage are much less apparent.

The low damage harvest project was initiated as a demonstration to show that modifications can be made which will be effective in reducing damage. The harvester is not represented as being the only way or perhaps even the best way to make a low damage harvester. In fact, when sufficient incentive is provided by the industry many innovations will be forthcoming.

Before the low damage harvester can be a serious consideration, changes in piling equipment will also be necessary. Previous research by Parks and Peterson (1979) has shown that the piler alone contributes as much damage as the remainder of the handling system.

The authors are of the opinion that entirely new equipment either for harvesting or handling sugarbeets should not be re-

*The authors are Professor, Scientific Aide, Scientific Aide, and Graduate Student, respectively, all at the Department of Agricultural Engineering, University of Idaho, Moscow, Idaho 83343. Approved as paper No. 8133 of the Idaho Agricultural Experiment Station.

quired. Modifications to existing equipment can and should be made to reduce the capital expenditures. Sugarbeet handling equipment has a history of long service life. If the industry waits for the natural turnover due to acquisition of new equipment, it could take 30 to 40 years before improvements would be on-line. Therefore, all of the modifications undertaken have been considered for their potential as field improvements. The objective of this project is to stimulate a look at current equipment and procedures and cause steps to be taken to improve existing equipment. When this work started, individuals expressed amazement and disbelief when we mentioned concern for the injury problem. There is more awareness today but now there needs to be action.

Description of the Low Damage Harvester

A sugarbeet harvester is essentially three components (1) lifting wheels (2) cleaning components, and (3) elevator. The beets need to be lifted from the ground, cleaned of dirt and trash, and elevated to a height sufficient to be placed into the truck. Previous University of Idaho harvester work has shown severe damage occurring in cleaning because of the sharp kicker wheels or the high speed grab rolls; during elevating because of the steel chains, sharp edged flights and sliding beets against rough steel edges; and, in dropping into the truck. Most cleaning systems rely on bouncing or rolling the beets to remove the dirt through impact. In the past, reducing damage has given way to designing for high volume. The low-damage harvester gives priority to minimizing damage.

The low damage harvester was constructed in the University of Idaho Agricultural Engineering shop using a 4-row lifter-loader machine manufactured and supplied by Lockwood Manufacturing Company. The machine had 5 high speed grab rolls across the rear of the machine for cleaning and an elevator of steel chain with heavy steel flights carrying the beets beneath a steel pipe stripper grate.

The existing lifter wheels were retained but the machine was reduced to 3 rows so that it could be used with 6 or 12 row planters. The Lockwood harvester had rubber kickers to

carry the beets away from the lifter wheels and these were also retained. The remainder of the cleaning and elevating portions of the machine were totally changed. Even though there is some damage that occurs on the lifter wheels, the existing system was used as that could constitute on area of study entirely separate. And, on-the-other hand, the success of the rest of the machine could not be measured if a newly designed lifting mechanism were to fail or need extensive modifications.

For the low damage harvester the basic concepts are:

- (1) Remove all sharp points and edges where the beets can be damaged. Carry the beets on rubber whenever possible.
- (2) Clean with a brushing action, avoid impact.
- (3) Elevate on rubber.
- (4) Use a truck filler to cushion the fall of beets onto the floor of the truck.

The completed harvester utilizes each of these concepts incorporated into the original Lockwood harvester, Figures 1 and 2. The beets are lifted with the existing lifter wheels and pushed with rubber kickers onto a rubber covered primary elevator chain. A separate chain is used for each row of beets. Since the primary chain carries the beets steeply away from the lifter wheels, rubber fins attached radially to a rotating shaft above the primary elevator prevent roll back. From the primary chain the beets fall across two 10cm trash rolls, one smooth and one with a spirial scroll. These rolls remove some dirt and most of the leaves and weeds that are lifted with the beets.

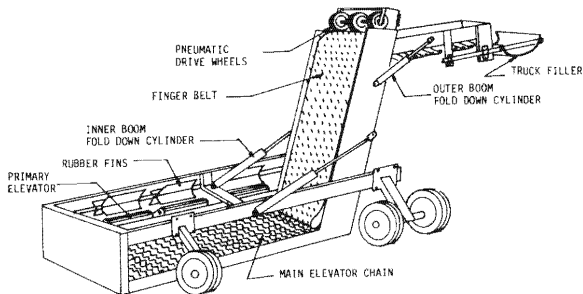


Figure 1. Schematic drawing of the low damage harvester showing the principle components added to the commercial harvester.



Figure 2. The low damage harvester in operation.

Cleaning and elevating are combined into a single operation. The beets are elevated on a draper chain with a special heavy duty rubber covering. The rubber is molded into scraper points on 5 cm centers for cleaning the sutures of the beet, Figure 3. For the vertical lift a heavy duty endless belt with rubber fingers on 10 cm centers runs against the draper chain. The elevator is nearly vertical; approximately 75 degrees from horizontal. Five rollers inside the belt apply pressure to the beets between the belt and draper chain and aid in lifting the beets vertically. The belt is driven by small pneumatic tires running against the head pulley. No tail pulley is used, which allows beets of essentially any size to enter the elevator. A

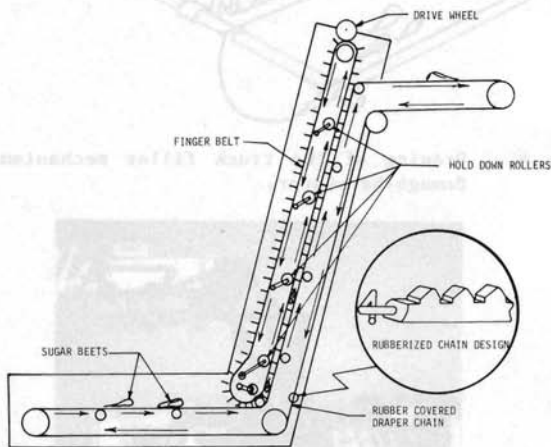


Figure 3. Cut-a-way drawing of the low damage harvester elevator-cleaning system. The belt speed is about 25% greater than the draper chain speed.

truck filler is used at the end of the boom elevator to provide cushion to those first beets falling into the bottom of the truck. The truck filler consists of a rubber belt formed into a trough for rigidity (Figures 4 and 5). In operation, the truck filler accumulates full of beets then automatically dips into the truck by the weight of beets forcing open a sequence valve in the hydraulic circuit (Figure 6). The trough then serves as a slide to finish building a mound of beets in the bottom of the truck. Finally the truck filler can be rotated out of the way by the harvester operator until the truck is filled. Because of the use of flexible belting, neither the truck nor the truck filler are damaged in the event of collision with each other during the truck filling operation.

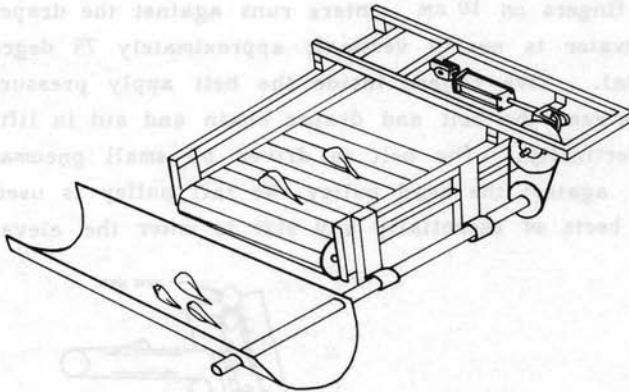


Figure 4. Drawing of the truck filler mechanism on the low damage harvester.



Figure 5. The truck filler in operation.

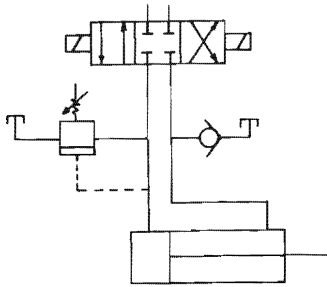


Figure 6. Schematic drawing of the hydraulic circuit for the low damage harvester truck filler.

Because the harvester was to be built for field testing in several locations the entire boom folds down onto the main frame for transport. The unit takes about an hour to unload from the trailer and assemble ready for operation. While the hydraulic fold-up was included for the research versatility of the machine, growers liked the feature because of the possibilities for compactness of storage and transport. The harvester can be backed under a fairly low storage shed when folded down.

FIELD TESTING

The first tests of the low damage harvester were in Twin Falls, Idaho during the 1979 harvest season. That year a number of mechanical difficulties were overcome but sufficient data were collected to show the value of the harvester in reducing damage compared to other beets being delivered to the Twin Falls piling ground.

During 1980 the low damage harvester was operated for three weeks in southern Idaho with testing at three locations: Paul, Nampa and Weiser.

1979 Testing

Three tests were conducted in 1979:

- (1) A point-to-point analysis of the low damage harvester for both damage and cleaning ability, Figure 7.
- (2) An analysis of the truck filler's ability to reduce damage, Figure 8.
- (3) A comparison of tare and damage between the low-damage harvester and other harvesters delivering beets to the same piling ground, Figure 9.

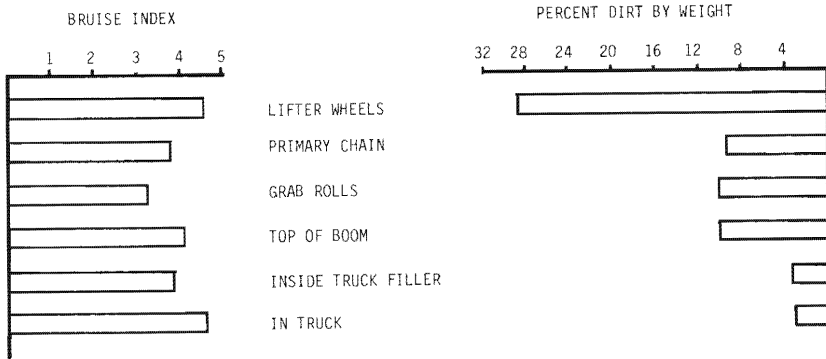


Figure 7. Point-to-point damage and tare dirt evaluations within the low damage harvester, Fall 1979.

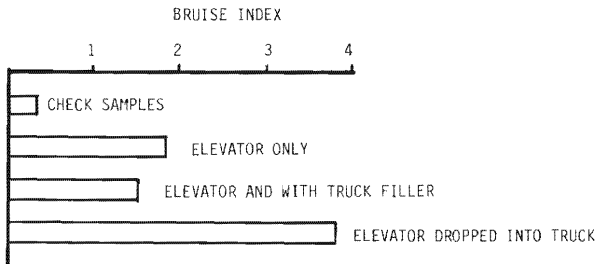


Figure 8. Evaluation of truck filler effectiveness in reducing damage, Fall 1979. All samples were hand harvested and introduced in the low damage harvester at the main elevator.

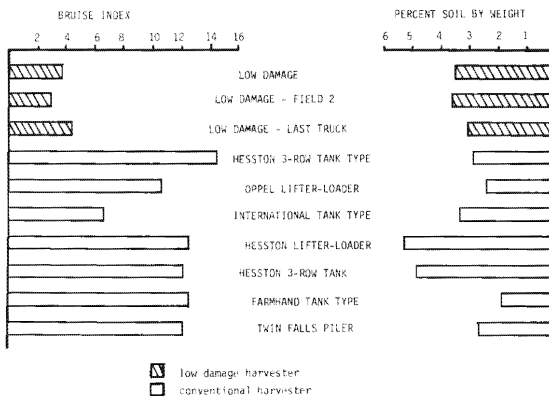


Figure 9. Damage level and tare dirt comparison of low damage harvester and conventional harvesters at Twin Falls piling ground, Fall 1979.

1980 Testing

In 1980, a diversity of soil conditions and beet yields was desired. For this purpose the harvester was operated in three selected areas. Because of the pleasant fall, harvest conditions were good in all three areas. Moisture was adequate but not muddy. Root yield was about 54 mg/ha at Rupert, 63 mg/ha at Nampa 1, 67 mg/ha at Nampa 2, and 74 mg/ha at Weiser. Very large beets were encountered at Nampa 2. One beet weighed 11.3 kg, and was handled adequately by the elevator.

The only serious mechanical problem encountered in the 1980 tests was the main drive clutch, which began slipping when the harvester was operated for several loads in succession. Changing the clutch to a larger model had been considered earlier but testing had not shown a problem until it was put under continuous load in the field. The clutch had operated normally in the continuous tests operations at the shop.

The harvester was evaluated for damage, percent tare dirt delivered to the truck, and speed of operation. Samples were taken by holding a catch frame under the boom; similar in both size and approach to the tare samples taken at the piler. The tare data reported is that measured by the Paul Tare Lab of Amalgamated Sugar Company. The samples were processed in the same manner as their other samples. Damage was evaluated by visual grading, using the Bruise Index employed in previous tests at the University of Idaho.

Criterion for damage was based on bruise depth. A slight damage is up to 10mm, a moderate damage from 10 to 20mm, and severe damage deeper than 20mm. In all classifications, a damaged area was considered a single damage if it was less than one-quarter face area of the root. If the damaged area was larger, the number of damages was the number of one-quarter face areas affected. A root was said to have a broken root tip if the diameter of the root at the point of breakage was 25mm or more.

A total damage score for each root, called a bruise index is given by the following equation:

Bruise Index = No. of slights + (3 x No. of moderates) + (8 x No. of severes) + (2 x No. of broken root tips).

The Bruise Index for the four locations are shown in Figure 10. Tare in Figure 11, and the Point-to-Point damage study in Figure 12.

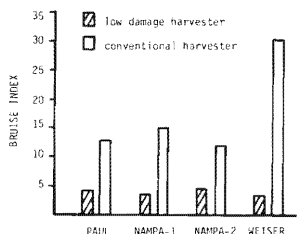


Figure 10. 1980 damage comparisons of low damage harvester and conventional harvesters at four locations. Samples collected off the end of harvester elevators.

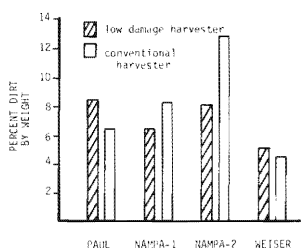


Figure 11. 1980 tare dirt comparisons of low damage harvester and conventional harvesters at four locations. Samples collected off the end of harvester elevators and evaluated by the Amalgamated Sugar Co., Paul tare lab.

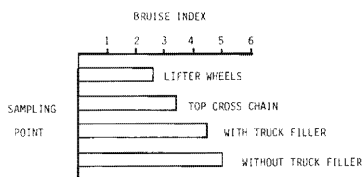


Figure 12. Point-to-point study of damage within the low damage harvester, Fall 1980.

Discussion

It is easily seen that the low damage harvester reduced damage by approximately 65 percent in 1979 and from 62 to 88 percent in 1980. Tare dirt delivered to the truck was the same for the low-damage harvester as for the conventional harvesters used for comparison both years. Considerable difference in damage is seen even in conventional harvesters. In 1980, two identical conventional harvesters were encountered. One had a bruise index of 12.9 and the other 30.4. Thus, operator care and procedures are important. Root temperature, variety, field

speeds, and soil conditions also can affect damage levels.

At this point the low-damage harvester has operated successfully up to 5.2 km/h in 74 mg/ha beets. The comparison harvester operated at 6.4 km/h and even up to almost 8 km/h. Some of that difference is inherent in the original basic machine, some due to the limiting capacity of the clutch drive on the elevator.

Pilers

Tests at the University of Idaho have shown that when undamaged, hand harvested beets are run through a commercial piler the damage level is nearly the same as the level measured on beets going through all of the harvesting and handling steps. Part of this may be that when a certain level of damage is reached, the evaluation system does not detect additional damage. Even so, the damage from the piler is quite high as shown for pilers evaluated by Parks and Peterson (1979). Pilers are operated in a start-stop manner to facilitate handling tare by individual trucks. They also rely on severe impact of the roots to remove dirt. Large drops are encountered to facilitate tare sampling and often heavy steel cleated belts are used to elevate the beets. Metal gates are often used to regulate the flow. Trucks drop the first part of their load long distances into an empty hopper. Time and motion studies have shown as much as 10 percent of the available operating time of a piler may be lost as a result of the intermittent operation. Past loss evaluations have shown that from 1.0 to 2.5 percent of the total beet weight may be returned with the tare dirt in the form of broken root tips and beet chips. Growers have commented on the discouragement of carefully harvesting root tips only to have them returned by the piler. One study showed 42 percent of the root tips were broken off going across the piler.

Future Work

1. Continue demonstrations and increase the hours of use with the low damage harvester.
2. Correct some of the remaining problems on the low damage harvester to improve its operation. One major improvement would be spreading the beets uniformly across the rear elevator to improve its capacity.

3. Reduce damage at the piler by suggesting changes in operation procedures and machine modifications. This is regarded as a much more difficult problem than the modification of the harvester reported in this report. Pilers handle a huge volume of product. Any modifications must be consistent with standard piling procedures and they must be designed to operate continuously under adverse conditions for the length of the harvest season.

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