POTATO HARVESTER OPERATION FOR REDUCED TUBER DAMAGE [1]

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ABSTRACT

This article discusses the effects of chain speed-to-ground speed ratio on tuber damage, tuber loading, and soil elimination through the potato harvester. Amount of soil carried as tractor gear changes is illustrated. Research results show that for both sandy and heavier soils, keeping the rear-cross and elevator chains full of tubers is more important in reducing bruise than is carrying soil.

INTRODUCTION

A potato harvester moves about 32 tons of soil per ton of tubers, or 800 tons of soil per acre (at a blade depth of 8 inches and a yield of 25 tons per acre). We expect the harvester to eliminate that soil, the vines and any rocks, and deliver the tubers into the truck with a minimum of damage. Indeed, efficient potato production (best net return) requires maximum soil elimination on the harvester and minimum tuber damage, field-to-storage. Surveys show that more damage occurs after the tubers leave the harvester than on the harvester. Much of that damage results because the equipment that moves the tubers to storage must also eliminate soil that the harvester failed to eliminate. In addition to the possible increase in bruise, failure to eliminate soil on the harvester can increase storage loss by causing poor air distribution, and the costs of handling and hauling the soil can be $20 per acre and more.

ELIMINATING SOIL ON THE HARVESTER

The best place to eliminate more soil on the potato harvester is on the primary chain because:

1. Less soil going to the secondary pulls fewer vines through the deviner chain, resulting in fewer vines to be picked out later.
2. Soil elimination early in the machine gives more uniform material flow further back in the machine, allowing more consistent loading of chains with tubers.
3. Increasing primary chain speed-to-ground speed ratio does not increase tuber damage as does increasing the speed ratios of the other chains.

Figure 1 shows tuber damage on the primary chain and flow of soil and tubers to the secondary chain as primary chain speed ratio changes. The data are from experiments in sandy soil. Note that as the chain speed-to-ground speed ratio increases from less than to greater than one, the amount of soil flowing to the secondary decreases drastically; however, the tuber damage increases only slightly. The tuber flow (horizontal lines) remains constant because it is determined not by chain speed, but by yield, rows dug, and ground speed.

If on the other hand we keep the primary chain speed constant and shift the tractor up one and then two gears, the soil flow, tuber flow and damage are as shown in Figure 2. Each full-gear up-shift in the tractor transmission increases ground speed about 30 percent, and so increases tuber flow rate 30 percent. However, because crowding more soil onto the primary

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results in less of it falling through the chain, each up-shift increases soil flow rate by nearly 100 percent, i.e., it doubles the soil flow to the secondary.

Figure 1. Effect of primary chain speed-to-ground speed ratio on tuber damage and soil elimination for sandy and heavier soils at constant ground speed.

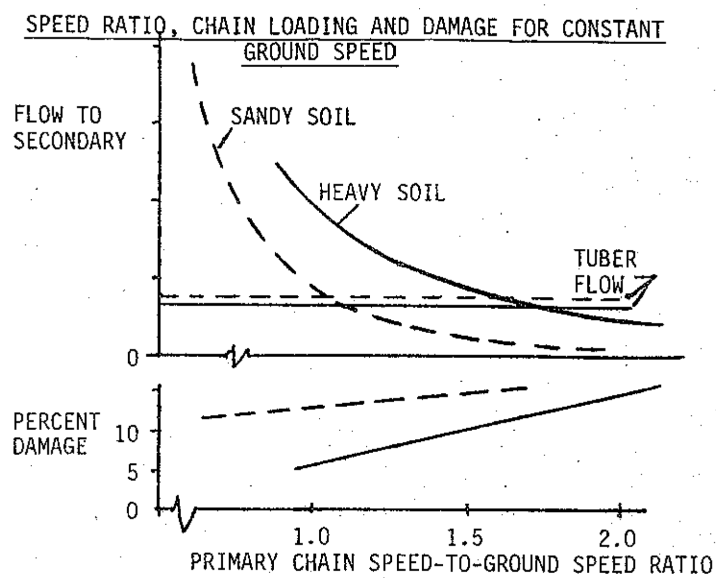


Figure 2. Effect of tractor gear on soil and tuber flow to the secondary chain at constant primary chain speed.

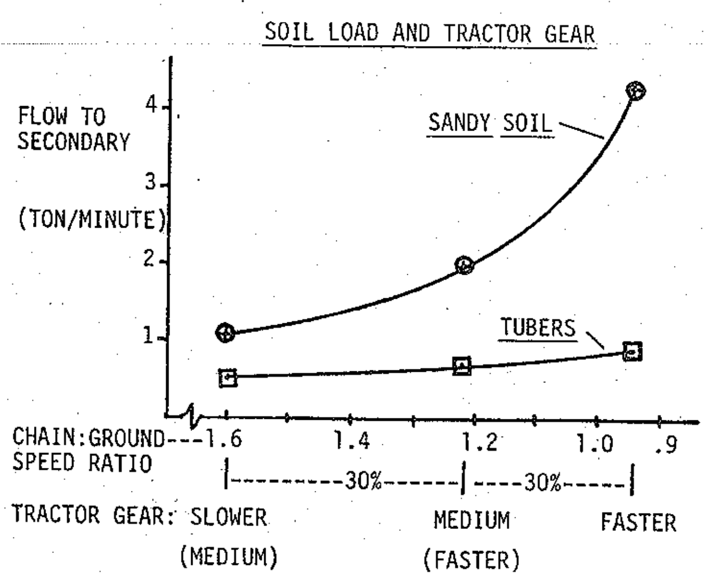


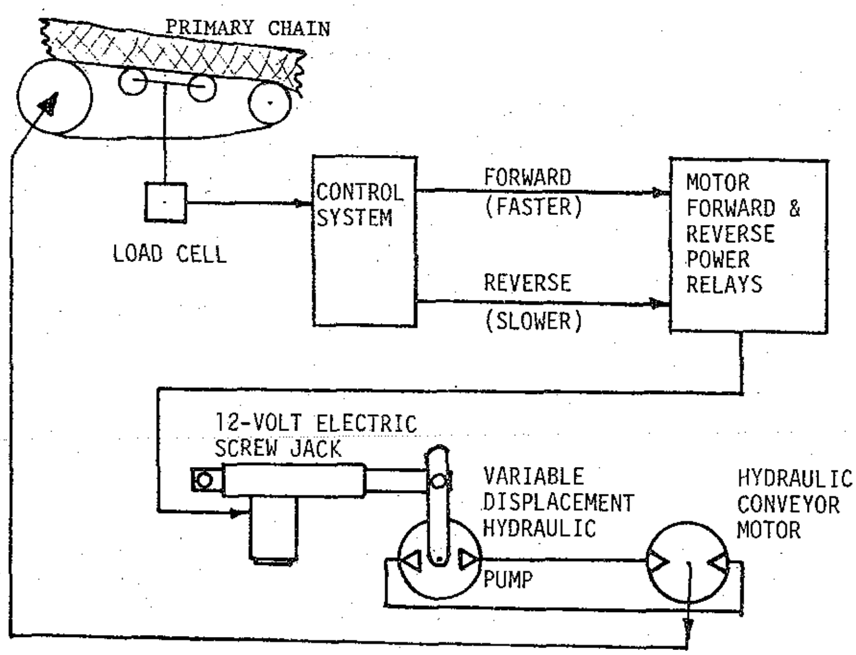
Figure 2 really shows that the harvester operator does not typically have fine enough control over chain loading. Changing engine speed does not change chain speed-to-ground speed ratio and so has little effect on tuber or soil loading on the chains. Changing gears causes a drastic change in soil loading which usually results in carrying either too much or too little soil most of the time.

PRIMARY CHAIN LOAD CONTROL

To provide the harvester operator with better control over soil loading, we designed a system that weighs the load of material on the primary chain and automatically adjusts primary speed to keep the soil load at the desired level. The system automatically compensates for changes in soil moisture and tractor gear, and thus allows the operator to concentrate on adjusting ground speed for best tuber loading on the rear-cross, elevator end boom.

Figure 3 shows the chain load control system schematically. The hydraulic drive for the primary chain allows continuously variable speed control and can also be operated manually if the operator wishes.

Figure 3. Automatic chain-load control system developed at WSU. Chain loading is sensed by the load cell and used to control chain speed so that the load remains constant.



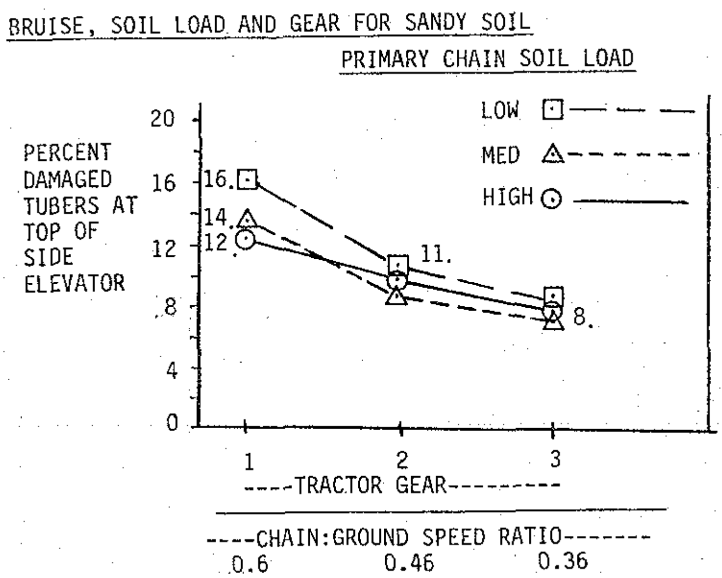
OPTIMUM TUBER LOADING

With automatically-controlled soil elimination on the primary chain, the flow of material to the secondary will be much more uniform. With uniform flow and most of the soil eliminated on the primary, the secondary and subsequent chains can be slowed down (relative to ground speed) to keep them fully loaded with tubers. Or alternatively, these chains can be left at current speeds and the tractor can be shifted up until ground speed is fast enough to fill the chains with tubers. The important point is that the chain speed-to-ground speed ratios of the secondary and subsequent chains must be reduced in order to keep the chains full. For yields of 25 to 30 tons per acre and two-row harvesting, these chains can be run at half the ground speed or possibly slower. However, the absolute speed of the secondary, rear-cross and elevator chains must not be less than about 1.1 mph (96 feet per minute) or the tubers will not be thrown far enough to properly load the next chain (especially the rear-cross). Looking at the problem the other way around, if the secondary, rear-cross and elevator chain speeds are all set at 1.1 mph, then to get a chain speed-to-ground speed ratio of 0.5 or less the ground speed should be 2.2 mph or greater.

REDUCING TUBER DAMAGE THROUGH THE HARVESTER

Experiments in both sandy and finer textured soils in Washington show that proper tuber loading reduces harvester bruise more than does carrying more soil. Figure 4 shows tuber damage at the top of the side elevator for three primary chain loads and three tractor gears in sandy soil (1980 experiment). Increasing primary-chain soil load reduced damage from 16 to 12 percent, but shifting the tractor up to third gear to keep chains full of tubers reduced damage from 16 percent to 8 percent. The rear-cross and side-elevator chain speeds were kept constant at a rate to give just adequate tuber loading at the slowest ground speed.

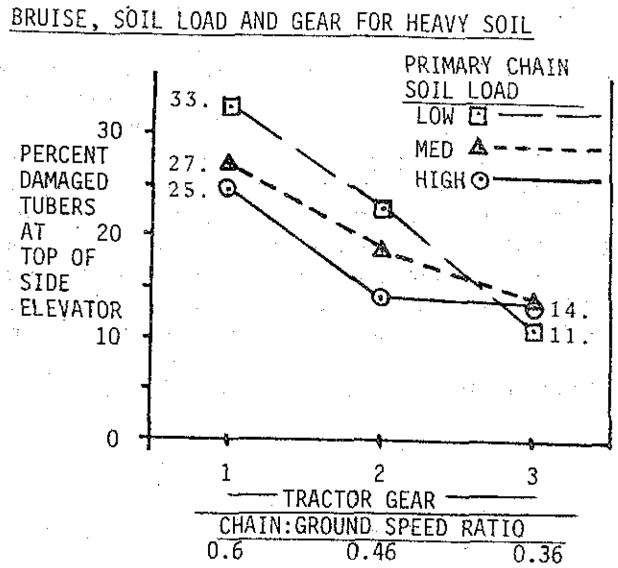
Figure 4. Effects of both primary chain soil loading and tractor gear on tuber damage at the top of the side elevator for sandy soil.



In finer textured soil (1981 experiments) the effect is more dramatic. Figure 5 shows that increasing primary chain soil load reduced tuber damage from 33 percent down to 25 percent at the top of the side elevator, but that shifting the tractor up to third gear to fill chains with potatoes reduced damage levels all the way down to about 13 percent.

We can conclude from these results that keeping the rear-cross and side-elevator chains fully loaded with tubers will do more to reduce tuber damage (black spot and shatter bruise) than will attempting to carry soil all the way through the harvester. Tubers can cushion tubers, and consistent tuber loading is easier to achieve and more cost effective than using soil for cushioning.

Figure 5. Effects of primary chain soil loading and tractor gear on tuber damage at the top of the side elevator for heavier soil.



CHAIN SPEED TUNING FOR MINIMUM BRUISE

Below is the sequence of steps to use in adjusting chain speeds for proper loading, based upon yields of 25 to 30 tons per acre. For lower yields, slow down chains to keep them full or shift tractor up.

1. Set secondary chain speed at 1.1 mph (96 feet per minute) at the slowest tractor engine rpm that you will use when harvesting.

2. Set rear-cross, elevator and boom chain speeds at approximately 1/2 of your slowest ground speed; e.g., if you plan to dig at 2.5 mph (220 ft. per minute), set the speeds of these chains at about 1.25 mph (110 ft. per minute). Remember that your tractor tachometer may not show true ground speed, especially if you are not using normal-size tires for that tractor. To check ground speed, mark an unpowered wheel with spray paint. Move the machine ahead so that the wheel makes three complete revolutions, measure the distance traveled in feet, divide by three and you have wheel circumference in feet. Then run the harvester in the field and measure the number of seconds required for the wheel to make five complete revolutions. Assuming negligible slip, the ground speed is:

$$\text{mph} = \frac{\text{circumference in feet} \times 3.41}{\text{seconds for five wheel revolutions}}$$

   Check chain speeds by the same method, but use total chain length in feet instead of wheel circumference. (Measure chain length, or multiply number of links by pitch in inches and divide by 12 to get feet of chain length).

3. Set primary chain speed at 1.0 to 1.2 times normal ground speed for sandy soil or 1.3 to 1.5 times normal ground speed for heavier soil.

4. Run harvester in typically yielding potatoes in the wettest field condition that you would normally expect and observe tuber and soil loading on the rear cross, elevator and boom.

a. If tuber loading is too low, shift the tractor up one gear. Then check soil load at top of elevator and increase primary chain speed 15-to-30 percent if needed to reduce soil load.
b. If tuber loading is good but too much soil is going into the truck, speed up the primary chain by 15 to 20 percent.

Minor adjustments may be needed to get good loading of the rear cross and elevator, but the important point is to keep these conveyors full without spillage, roll-back, or back-feeding under the previous conveyor. Bare chain on the rear cross and subsequent chains means bruise. Bare chain on the secondary is much less important. Note that changing engine speed alone only effects how far tubers are thrown from one chain to the next. Changing engine speed changes chain speed and ground speed in proportion, and so does not affect chain speed-to-ground speed ratio or depth or material on the chain (chain loading). The harvester should be set up as above under field conditions so that as the field dries out the operator can shift up a gear to make sure the harvester has adequate chain loading.

Figure 6. Blade positioning for reduced tuber damage.

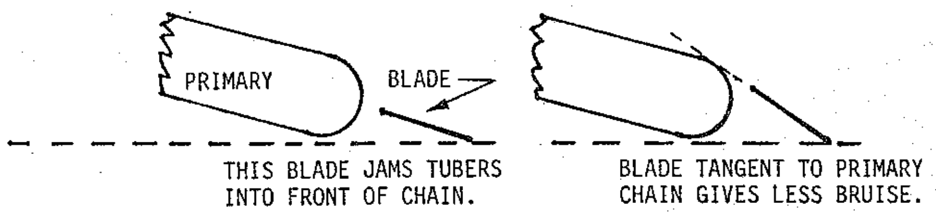
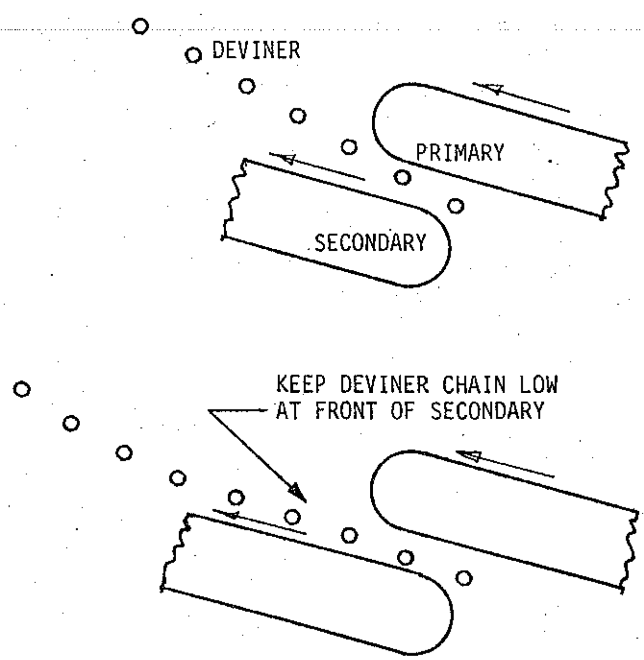


Figure 7. Deviner chain positioning for reduced tuber damage.



OTHER MODIFICATION

Under many conditions, adjusting blade angle so that tubers flow up onto the primary chain rather than jamming into the front of it can reduce tuber damage (See Figure 6).

A second item is positioning of the deviner chain at the beginning of the secondary. There is some evidence that keeping the deviner down close to the front section of the secondary and then gradually lifting it as the chains move toward the rear of the harvester will reduce tuber damage at the drop from the primary to the secondary chain (Figure 7). One Idaho grower uses unflighted secondary chain and lays the deviner on the secondary for the first two-thirds of its length. The deviner acts as flighting for the secondary, and since the secondary chain has no flights to clear, the rear-cross chain can be raised up to reduce the drop height at the end of the secondary.

SUMMARY

In summary, reducing drop heights, setting best blade angle, and keeping conveyors properly loaded with tubers all help to reduce tuber damage. Going slowly and reducing engine speed does not help unless they are done such that the chains are kept as full as possible without roll-back, spillage, or back-feeding under the previous conveyor. Bare chain on the rear-cross and subsequent chains means bruise.