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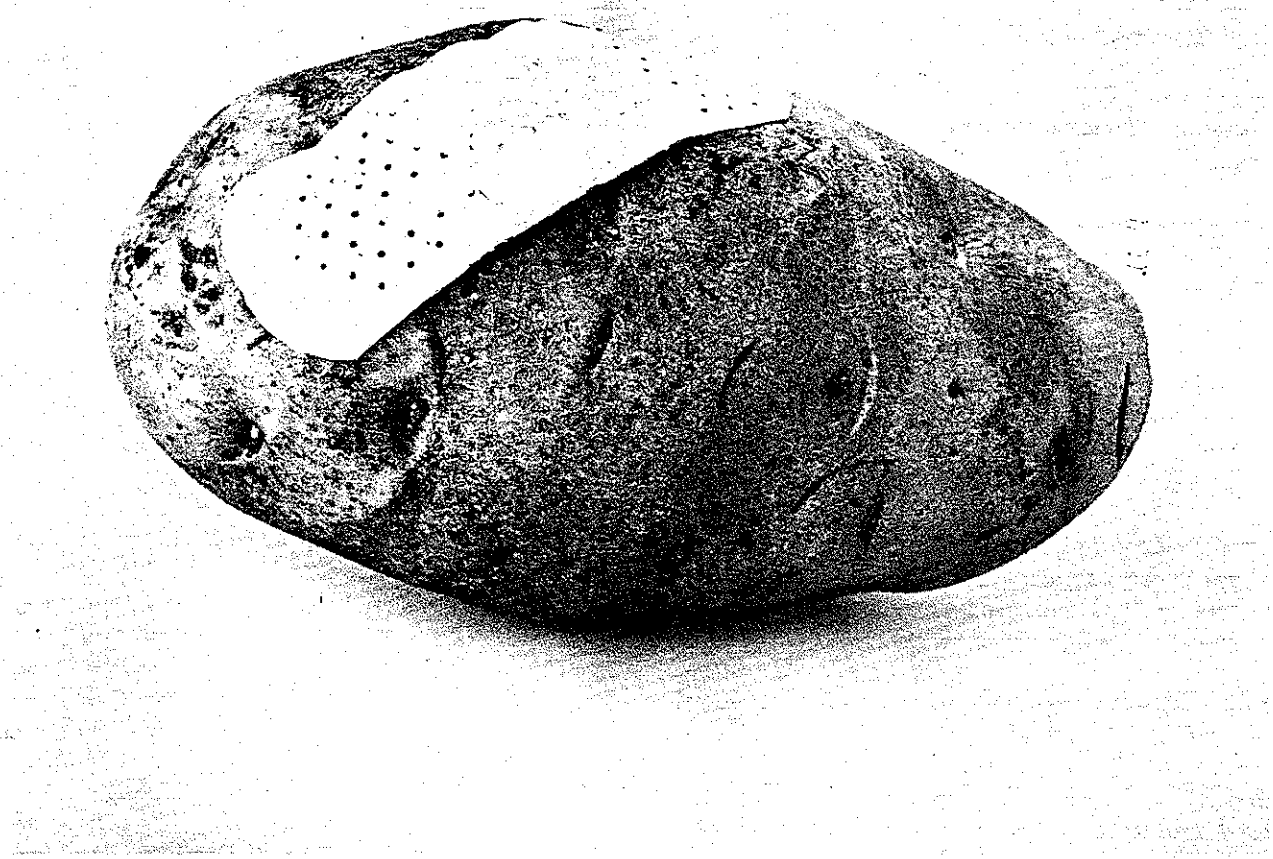

Reducing Potato Harvesting Bruise

G. M. Hyde, Associate Agricultural Engineer, R. E. Thornton, Extension Horticulturist, and R. E. Hermanson, Extension Agricultural Engineer

Field surveys show that more damage occurs after the tubers leave the potato harvester than while passing through it. Much of that damage happens because the equipment that moves the tubers to storage must also remove soil that the harvester failed to eliminate.

A typical 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. The best net return in potato crop production requires maximum soil elimination on the harvester and minimum tuber damage, field-to-storage.

In addition to the possible increase in bruise, failure to eliminate soil before storage can increase storage loss by causing poor air distribution. Also, the unnecessary handling and hauling of soil can cost $20 per acre or more.

Cooperative Extension College of Agriculture & Home Economics Washington State University Pullman, Washington

This bulletin discusses the effects of chain speed-to-ground speed ratio on tuber damage, tuber loading, and soil elimination as the crop moves through the potato harvester and gives a procedure for tuning harvester chain speeds.

Eliminating Soil on the Harvester

It is important that operators eliminate as much soil as possible on the primary chain of the harvester because:

1. Less soil going to the secondary chain pulls fewer vines through the deviner chain, resulting in fewer vines to be picked out of the crop later.

2. Soil elimination early in the machine gives more uniform material flow farther back in the machine. The uniform flow allows more consistent loading of chains with tubers, which results in less tuber damage.

3. Increasing the primary chain speed-to-ground speed ratio to eliminate more soil has less effect on tuber damage than 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-to-ground speed ratio changes. Note that as the chain speed-to-ground speed ratio increases from less than to greater than 1.0 (moving from left to right on the graph), the amount of soil flowing to the secondary chain decreases drastically, especially in sandy soil. However, the tuber damage increases only slightly. Notice that tuber flow (horizontal lines) remains constant because it is determined not by chain speed, but only by yield, number of rows dug, and ground speed.

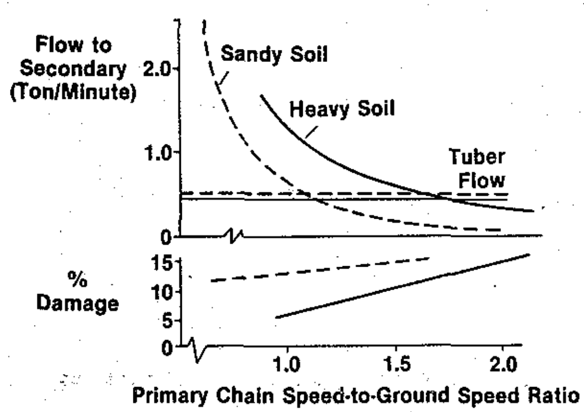

Figure 1. Effect of primary chain speed-to-ground speed ratio on tuber damage and soil elimination for sandy and heavier soils at constant ground speed.

If, on the other hand, we keep the primary chain speed constant and shift the tractor up one and then two gears, the soil and tuber flow are as shown in Figure 2. Each full-gear up-shift in the tractor transmission increases ground speed about 30%. However, because crowding more soil onto the primary results in less soil falling through the chain, each up-shift increases *soil* flow rate by nearly 100%—it doubles the soil flow to the secondary.

Figure 2 illustrates some important aspects of harvester operation. The harvester operator typically does not have enough control over chain loading, first, because 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. Secondly, 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. The only other control currently available to the operator is blade depth adjustment. For optimum machine operation, blade depth should be just sufficient to avoid slicing of tubers and should not be manipulated to control soil loading.

Primary Chain Load Control

To provide the harvester operator with better control over soil loading, WSU agricultural engineers

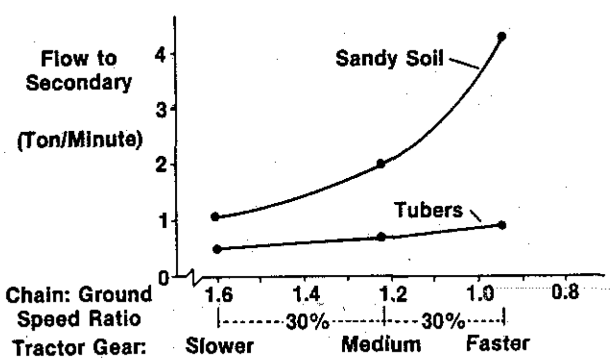

Figure 2. Effect of tractor gear on soil and tuber flow to the secondary chain at constant primary chain speed.

designed a system that weighs the load of material on the primary chain and automatically adjusts primary chain 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, and boom chains.

Figure 3 is a schematic drawing of the chain load control system. The hydrostatic drive for the primary chain allows automatic infinitely variable speed control as well as manual control if the operator wishes.

Optimum Tuber Loading

With automatically controlled soil elimination on the primary chain, the flow of material to the secondary chain becomes much more uniform. With uniform flow and better soil elimination on the primary chain, the secondary and subsequent chains can be slowed (relative to ground speed) to keep them fully loaded with tubers. Or, as an alternative, 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 to keep the chains full.*

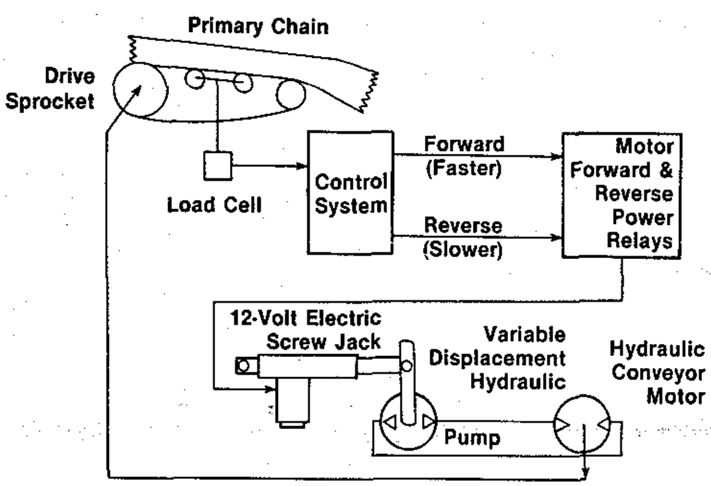

Figure 3. Automatic chain-load control system developed at WSU. Chain loading is sensed by the load cell and used to control chain speed so that the load remains constant.

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 chain). 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 bruising 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%, but shifting the tractor up to third gear (to keep the chains full of tubers) reduced damage from 16% to 8%. 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.

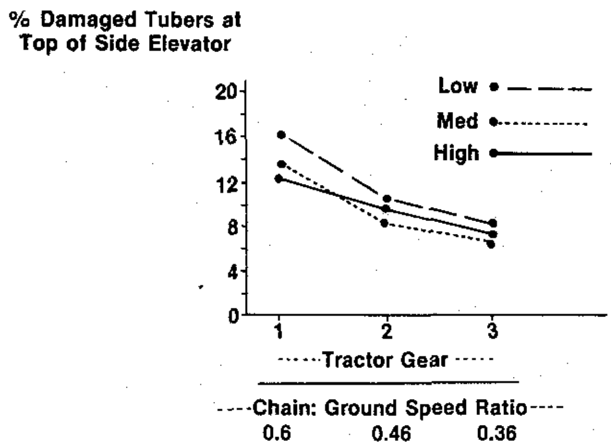

Figure 4. Effects of both primary chain soil loading and tractor gear on tuber damage at the top of the side elevator for sandy soil.

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% down to 25% at the top of the side elevator, but that shifting the tractor up to third gear to fill chains with potatoes reduced damage levels from 33% all the way down to about 13%.

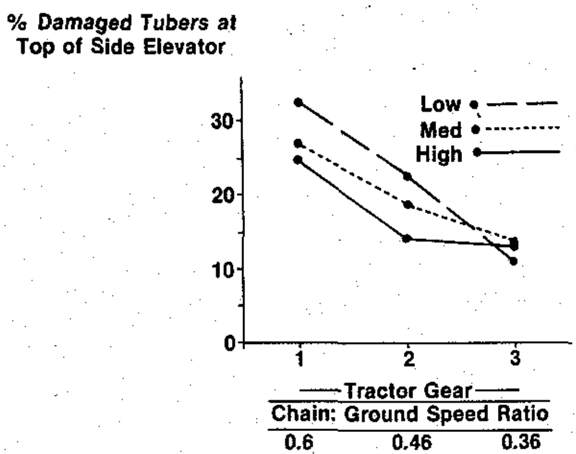

Figure 5. Effects of primary chain soil loading and tractor gear on tuber damage at the top of the side elevator for heavier soil.

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.*

Chain Speed Tuning for Minimum Bruise

The following sequence of steps is for 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 one-half of your slowest ground speed—if you plan to dig at 2.5 mph (220 feet per minute), set the speeds of these chains at about 1.25 mph (110 feet 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 five complete revolutions, measure the distance traveled in feet, divide by five, and you have the 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:

$$\text{mph} = \frac{\text{circumference} \times 3.4}{\text{seconds for 5 revolutions}}$$

For example, if wheel circumference is 11.5 feet and the wheel makes five complete revolutions in 18 seconds, the ground speed is 11.5 × 3.4 ÷ 18 = 2.18 mph. 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. For example, the total length of a 1.88-inch pitch chain with 83 links is 83 × 1.88 ÷ 12 = 13 feet.)

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 chains.

   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% 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%. Minor adjustments may be needed to get good tuber loading, but *the important point is to keep the rear-cross and side-elevator chains 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 affects 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 of material on the chain (chain loading). The harvester should be set up as above under wet 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.

Other Modifications

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).

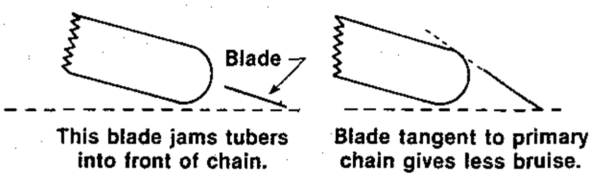

Figure 6. Blade positioning for reduced tuber damage.

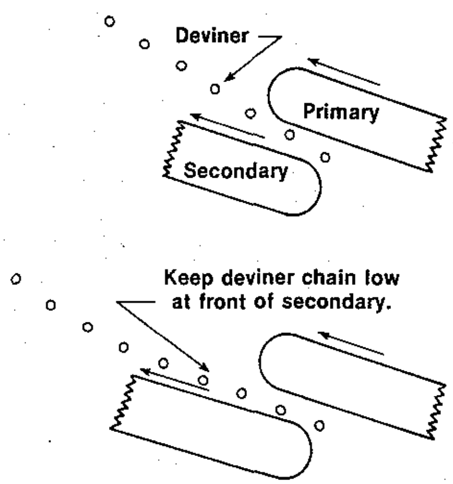

Figure 7. Deviner chain positioning for reduced tuber damage.

Another item is positioning of the deviner chain at the beginning of the secondary. There is some evidence that keeping the deviner chain 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 an unflighted secondary chain and lays the deviner on the secondary chain for the first two-thirds of its length. The deviner acts as flighting for the secondary chain, and because 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 chain.

Summary

Reducing drop heights, setting the best blade angle, and keeping conveyors adequately loaded with tubers all help to reduce tuber damage. Going slowly and reducing engine speed does not help unless done so 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.

Further Reading

Some of the information presented in this publication comes from these three reports. They are available from the authors.

Hyde, G. M., R. E. Thornton, and W. M. Iritani. 1979. Chain speed effects on potato tuber damage and soil elimination. ASAE Paper No. 79-3014, ASAE, St. Joseph, MI.

Hyde, G. M., R. E. Thornton, and G. K. Cuillier. 1980. An automatic conveyor load control system for handling potatoes and similar commodities. ASAE Paper No. 80-1559, ASAE, St. Joseph, MI.

Hyde, G. M., R. E. Thornton, and D. W. Woodruff. 1980. Potato harvester performance with automatic chain-load control. ASAE Paper No. 80-1537, ASAE, St. Joseph, MI.

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