ECONOMICS OF SOIL REMOVAL ON THE POTATO HARVESTER [1]

by
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ABSTRACT

Delivering excess soil to the potato truck with the tubers results in increased costs in three ways: more fuel, time and labor are required to harvest the crop and; to haul, collect, stockpile, reload, and dispose of the soil; and more tuber damage may result from efforts to eliminate the soil after the crop leaves the harvester.

This paper discusses a preliminary economic analysis of costs of eliminating soil at the storage and gives results of recent experiments to improve soil elimination and reduce tuber damage on the harvester. The harvesting experiments measured the amount of soil elimination and tuber damage occurring on the primary, secondary, rear-cross and side elevator chains at three chain loads with a new automatic load control system on the primary chain. Results show possibility of better soil elimination without increased tuber damage.

INTRODUCTION

Delivering excess soil to the truck with the potato tubers increases costs of crop production (decreases production efficiency) in several ways. These include topsoil losses, soil hauling and handling costs, storage losses caused by poor air distribution that results from soil in the potato pile, and tuber damage caused by hauling and piling equipment that must both move tubers and eliminate soil.

SOIL HAULING AND HANDLING COSTS

Hauling:

The amount of soil hauled out of the field during potato harvest may range from 1 to 12 percent by weight of each potato load, depending on soil type, soil moisture, harvester operation, and other factors. Thus, for a potato yield of 25 tons per acre, the topsoil removed from the field with the crop could range from 0.25 to 3.4 tons per acre. At current ICC rates for a one-way hauling distance of 10 miles, it costs $3.69 per ton to haul that soil to storage (see Table 1).

Table 1. Estimated soil hauling and handling costs.

		Cost per Ton of Soil		Annual Cost For 7000-ton Storage	
Item	Soil Type:	Heavy	Sandy	Heavy	Sandy
Haul to storage		$3.69	$3.69	$2,583	$1,033
Collect & stockpile		1.45	3.62	711	710
Disposal		2.75	2.75	1,348	539
	TOTAL			$4,642	$2,282

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Collection and Stockpiling:

A certain minimum amount of equipment and labor force are required to collect and stockpile soil at the storage, and the cost of those items are not necessarily proportional to the amount of soil. Hence, as shown in Table 1, the collection and stockpiling costs per ton of soil were more for sandy than for heavy soil, because there were fewer tons of sandy soil over which to spread these costs.

The assumptions used to estimate collection and stockpiling costs were as follows:

1. A 50 horsepower tractor with loader, annual use, 1200 hours per year. Costs are $9.47 per hour (Mohasci et al. 1980, except that fuel cost was adjusted to $1.40 per gallon instead of $1.30.

2. The tractor services five pilers, each unloading three loads of potatoes per hour, 10 percent soil in loads from heavy soil fields, 4 percent soil in loads from sandy fields.

3. Half the soil is removed from the tubers by the piler going into storage, another 20 percent coming out of storage, and the remaining 30 percent of the soil (3 percent or less of the total tuber weight) goes to the processor or packer with the potatoes.

4. Labor required is one person at $4.25 per hour to run the loader, one other person half-time to clean out under the piler, plus 10 percent more labor for repairs for a total collection and stockpiling labor cost of $6.80 per hour (Mohasci et al. 1980). (Table 1 gives costs per ton and per 7000 ton storage).

Disposal:

Costs of hauling the soil away from the storage were based upon the 1980 ICC rate of $2.29 per ton for a 5-mile haul (one way), plus $0.46 per ton loading costs for equipment and labor that loads at a rate of 1/2-ton per minute.

Totals:

The total annual costs of soil hauling and handling for a 7000-ton storage amount to over $4,600 for heavy soil and nearly $2,300 for sandy soil (see Table 1). For 10 percent soil in the tuber loads and a 30 ton per acre yield the costs for hauling and handling the soil are nearly $20 per acre.

TUBER DAMAGE, FIELD-TO-STORAGE

Data gathered from commercial grower's harvesters, trucks and pilers showed, over a 2-year average, the tuber damage patterns given in Table 2. Note that while 18% of the tubers are damaged by the time they reach the harvester picking table, another 27% received damage on the trip from harvester-to-storage. The figures indicate a need to reduce tuber damage on trucks and pilers; however, the primary reason that so much damage occurs on these devices is that they currently must do two jobs: move tubers and eliminate soil. If the soil were eliminated on the harvester, the trucks and pilers could be modified to handle the potatoes much more gently. The bruise incentive in the contract determines the value of the reduction in tuber damage.

SOIL ELIMINATION AND TUBER DAMAGE ON THE HARVESTER

The question becomes then, can we eliminate more soil on the harvester without causing more tuber damage? Results of the 1980 harvester experiment indicate we can.

The Experiment:

The experiment used three load levels on the primary chain as controlled by an automatic system. The system continuously weighed the load on the primary chain and adjusted chain speed to maintain one of the three load levels.

The harvester was also run at three different ground speeds (1.6, 2.1 and 2.6 mph) for each of the three primary load settings. For all of these treatments, samples of soil and tubers were caught from the output ends of the primary, secondary, rear-cross, and elevator chains without stopping the machine. (Actually, samples from the primary chain were taken from a canvas-covered portion of the secondary chain as described in Hyde et al. 1980a).

The speeds of the secondary, rear-cross, and elevator chains were constant throughout the experiment. They were set at ratios for the slowest ground speed as recommended by Thornton et al. (1973) for sandy soil and 30 ton per acre yield. Thus, as ground speeds increased, the chain speed-to-ground speed ratios of these chains decreased, resulting in heavier tuber loads on them. Table 3 shows the approximate ground speeds, chain speeds, and speed ratios used in the experiment for the secondary, rear-cross, and elevator chains. The width of the secondary was 58 inches; rear-cross and elevator chain widths were 29 inches between sprockets. (For wider chains, chain speeds would be set proportionately slower.)

Table 2. Tuber damage, field-to-storage.

Sampling Location	Damage Increase*	
Harvester Picking Table	18%	
Truck Conveyor	11%	27%
First Piler Conveyor	6%	
Storage Pile	10%	
TOTAL Damaged Tubers	45%	

*Averages for 6 machines each of 2 years

Table 3. Chain speeds and ratios for secondary, rear-cross, and elevator chains used in the experiment.

Ground Speed (mph)	Chain Speed-to-ground Ratios and Chain Speeds (mph)					
	Secondary		Rear-Cross		Elevator	
	Ratio	mph	Ratio	mph	Ratio	mph
1.6	0.62	1.01	0.67	1.09	0.63	1.03
2.1	0.48	1.01	0.52	1.09	0.49	1.03
2.6	0.39	1.01	0.42	1.09	0.40	1.03

Figure 1. Soil and damage levels through the potato harvester for three primary chain load levels.

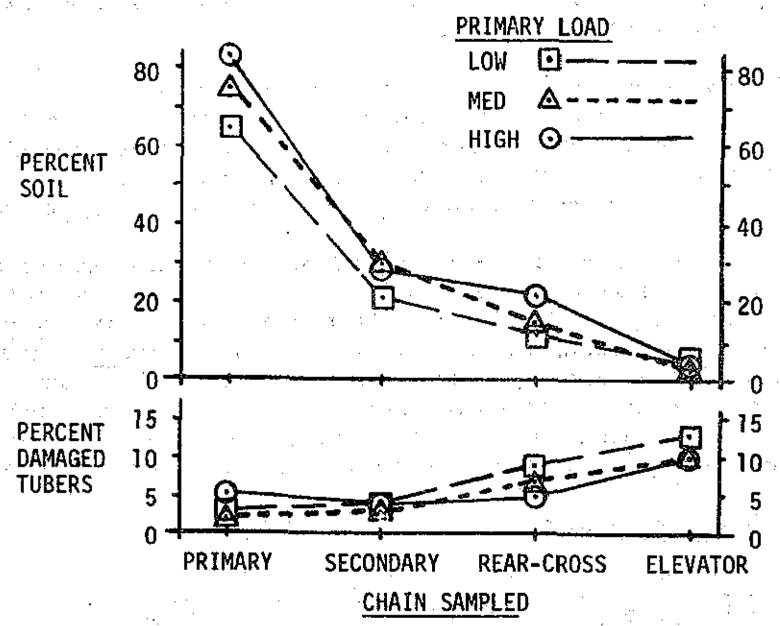


Figure 1 shows soil and damage levels through the potato harvester for the three primary chain load levels. The three load levels (upper left circle, triangle, and square in the figure) were maintained by the control system at 83, 75, and 65 percent soil, corresponding to approximate chain-to-ground speed ratios of 0.9, 1.2, and 1.6 respectively for the high, medium and low control settings. The graph shows that tuber damage on the primary and secondary chain was not affected by soil load on the primary. Tuber damage begins to increase on the rear cross and is slightly affected by soil level, but at the top of the elevator there were no significant differences in damage levels for the three soil loads.

Figure 2 shows soil and damage levels through the harvester for the three tuber load levels on the secondary and subsequent chains caused by the three ground speeds. Note that the soil levels on the primary were essentially the same for all three ground speeds, demonstrating that the automatic control system on the primary did compensate for changes in ground speed.

Also note that tuber damage on the primary and secondary was unaffected by tuber load level, but was significantly affected on the rear cross and elevator chains. Underloading of the chains resulted in nearly 9 percent tuber damage at the rear-cross and 14 percent at the top of the elevator, while keeping these chains loaded more heavily with tubers (not soil) resulted in about 4 percent and 8 percent damage, respectively, at these two locations.

Figure 3 summarizes the soil and damage levels at the top of the side elevator for the three soil loads and the three tuber loads. The curves show that primary chain soil load had a minor influence on tuber damage through the harvester (top curve) but that increasing tuber loading on the secondary and subsequent chains reduced tuber damage levels far more than did carrying more soil on the primary.

Figure 3 also shows that, at the high tuber load level, tuber damage was approximately 8 percent and soil level was only about 5 percent at the top of the elevator. (Note that these experiments were conducted with the Washington State University Agricultural Engineering harvester which has an anti-roll-back belt on the side elevator.)

Figure 2. Soil and damage levels through the potato harvester for three tuber load levels (ground speeds) or secondary and subsequent chains.

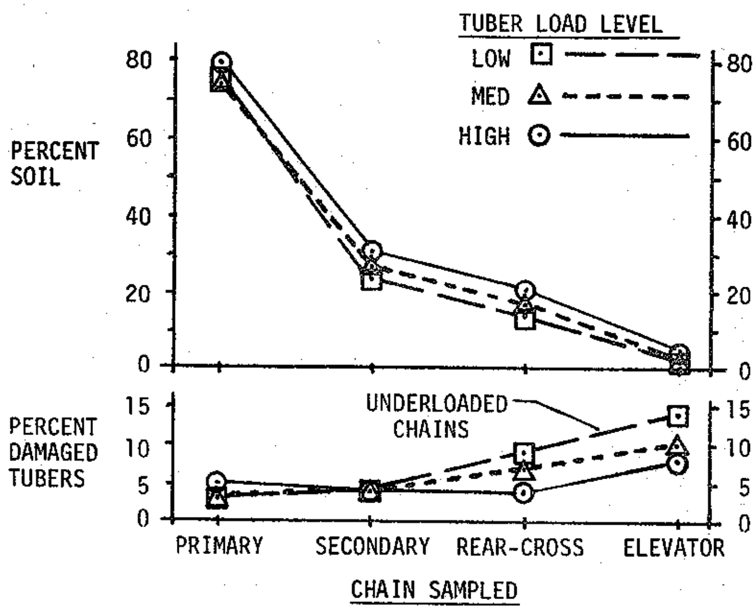
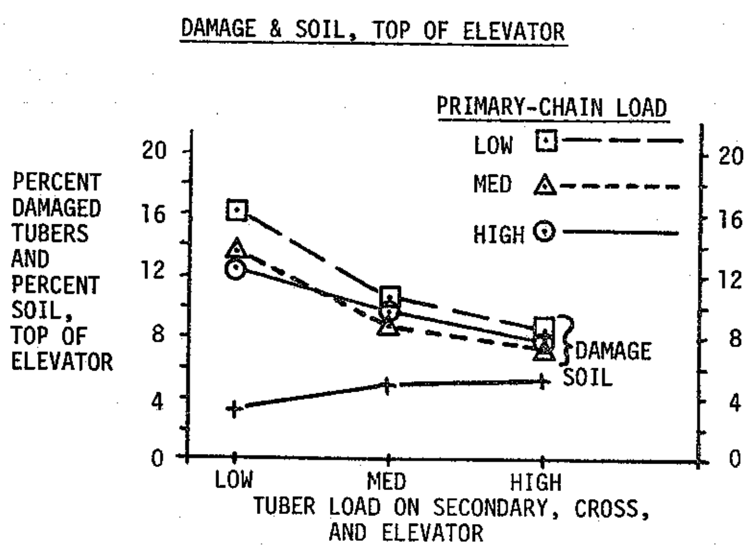


Figure 3. Soil and damage levels at top of side elevator for three tuber loads (ground speeds) and three primary chain soil loads.



CONCLUSIONS

The results of this experiment in sandy soil with Russet Burbank potatoes indicate that keeping the secondary and especially subsequent conveyors fully loaded with tubers (without roll-back, spillage, or snatching of tubers under the ends of chains) will reduce tuber damage more than carrying heavy soil loads on the primary chain. Damage levels on the primary and secondary remained at or below 5 percent for all treatments, but reach only about 8 percent at the top of the side elevator if the rear-cross and elevator are kept fully loaded with tubers. Soil content at the top of the side elevator could be kept as low as 5 percent with 8 percent tuber damage. For further information, see Hyde et al. (1980b, c).

The results of the economic analysis of soil hauling and handling indicate that for tuber loads from the harvester containing 10 percent soil by weight and crop yields of 30 tons per acre, the soil hauling and handling costs can be nearly $20 per acre. This figure does not include the value of the 3 tons of soil per acre that may be lost or the increased harvesting fuel cost resulting from carrying more soil on the harvester.

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