POTATO HARVESTER PRIMARY CHAIN SPEED, SOIL SEPARATION, AND BRUISE LEVEL 1/

by
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1980

ABSTRACT

This paper discusses the effects of potato harvester primary and secondary chain speeds on soil elimination and tuber damage. First-year results show that increasing primary chain-speed eliminated much more soil without appreciably increasing tuber damage. Second-year results demonstrated the feasibility of an automatic system to control primary chain speed and the importance of slowing down the secondary chain to match the load it receives from the primary.

INTRODUCTION

A primary need in harvesting potatoes is to eliminate more soil from potato tubers on the potato harvester while minimizing mechanical damage to the tubers. A definite economic advantage exists to eliminating more soil because of savings in hauling and handling costs, and the fact that potatoes delivered on some potato contracts may result in a better net return if the grower delivers potatoes with some tuber damage but reduced content.

Current potato harvester chain speed ratio recommendations (Smittle, 1974; Thornton, et al., 1973a, and Thornton et al. 1973b) are summarized in Table 1 below.

Table 1. Harvester Chain-to-forward Speed Ratios

	Yield, ton/acre					
	For Sandy Soil			For Heavy Soil		
Chain	20	25	30	20	25	30
Primary	.90	.90	.90	1.05	1.05	1.05
Secondary	.62	.62	.62	.68	.68	.68
Rear cross	.47	.56	.67	.47	.56	.67
Elevator	.45	.54	.63	.45	.54	.63
Boom	.38	.45	.53	.38	.45	.53

1/ For proceedings, 19th Annual Washington State Potato Conference and Trade Fair, Moses Lake, Wa. January 29-31, 1980.

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Note that, because the load on the primary and secondary chains is mostly soil, potato yield has little effect on the required speeds of these chains. Soil type, however, does influence the optimum speed ratio of the primary and seconday, with sandy, light soils requiring slower speeds than heavier soils.

(The assumptions made in developing Table 1 were 1) an average blade depth of 8 inches, 2) 80 percent of soil removed by primary chain, 3) soil equal to twice the tuber weight carried on the secondary chain, 4) soil equal to 15 percent of the tuber weight carried on the rear cross chain, and 5) chain widths of 60 inches for the primary, 58 inches for the secondary, and 29 inches for the rear cross, elevator, and boom. Table 2 shows the resulting ratios of soil-to-tubers at several positions in the harvester, assuming a potato yield of 25 tons/acre.)

Table 2 shows the percentage by weight of soil in the chain load and the volume flow rate of material per mph ground speed at several points in the harvester, based upon the same assumptions as Table 1.

Table 2. Assumed soil-tuber ratios and volume flow rate for potato harvester (vines excluded).

Location	Percent soil in chain load by weight	Total volume flow, cfm/mph*
Blade (8-inch depth)	97	293
Rear of Primary (80% of soil eliminated)	88	67
Rear of Secondary (soil equal twice tuber weight)	67	28
End of rear cross (soil equal 15% of tuber weight)	13	14

* Assuming tuber yield of 25 ton/acre.

Note that the load moving over the blade is 97% soil and that by the time it reaches the end of the primary chain it is 88 percent soil (12 percent tubers) and the volume has decreased from 293 ft^3/minute to 67 ft^3/minute, or to less than one-fourth what it was at the blade. The volume is approximately halved again by the secondary, and halved once more by the rear cross, at which point the chain load is 87 percent tubers, 13 percent soil.

CURRENT RESEARCH

Note that the values in Table 2 are assumed values based upon calculated predictions. The current research effort was designed to determine actual amounts of soil on the primary and secondary chains at several chain speed settings and to correlate the amount of soil with tuber damage level.

Approach:

In order to measure the output of material from the primary and secondary chains, it was necessary to sample both chains without stopping the harvester.

Figure 1 shows the sampling technique used in the 1978 harvest. Canvas was woven through two sections of the left half of the secondary chain. A sampler was installed on a track so that it could be rolled into place to catch samples at the end of the secondary while the harvester was in operation. Samples caught of the canvas-covered part of the secondary represented the actual output of the primary chain except for vines which were eliminated by the devining chain. Samples caught from the bare secondary represented actual secondary soil and tuber output.

Chain Speed vs. Soil and Bruise:

Results of experiments using this sampling technique (Hyde et al. 1979) are given in Figure 2, which shows the effects of chain speed-to-ground speed ratio on both percent of soil and tuber damage level on the primary chain for two soil types. The Figure 2 curves show that increasing the primary speed ratio can greatly increase soil eliminate with little or no increase in tuber damage.

Figure 1. Two-row potato harvester modified for sampling of primary and secondary chains. (Devining chain not shown).

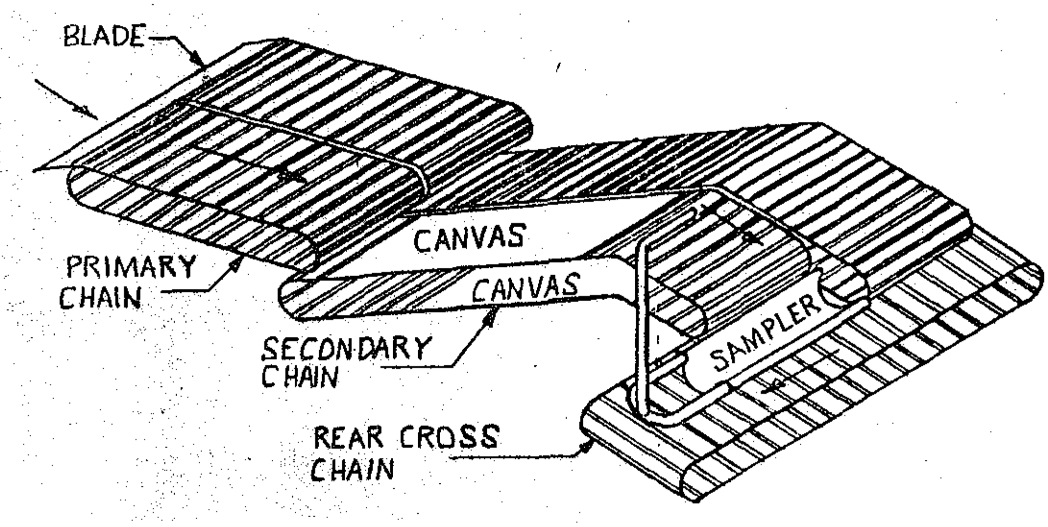


Figure 3 shows results for both the primary and secondary chains for sandy soil. The vertical distance between the two soil curves represents the amount of soil eliminated by the secondary chain. Again the data shows increased soil elimination with little increase in tuber damage for both primary and secondary chains as the speed ratio of the primary chain is increased. However, tuber damage on the secondary did increase more than on the primary (the dahsed bruise curve is steeper than the solid bruise curve, Figure 3). Note also in Figure 3 that, at the lowest speed ratio, the percent of soil on the primary was reasonably close to the Table 2 value of 88 percent. However, the amount of soil on the secondary was 30% or less than half the predicted value of 67% in Table 2. This result means that the secondary chain was running faster than necessary for soil conditions, even though it was set at the recommended speed ratio of 0.62 (Table 1).

These results led to two conclusions:

1. Primary chain speed can be increased relative to ground speed to eliminate more soil, but secondary chain speed must be reduced to minimize damage.
2. A better system might be to control the primary chain so that it would deliver a constant flow of material to the secondary regardless of field conditions.

If the primary always delivered a uniform flow of material, the secondary and subsequent chains could be slowed to cause less damage while still providing better soil elimination.

Figure 2. Bruise damage and soil in primary chain load vs. speed ratio. (Bruise data adjusted for sample handling damage).

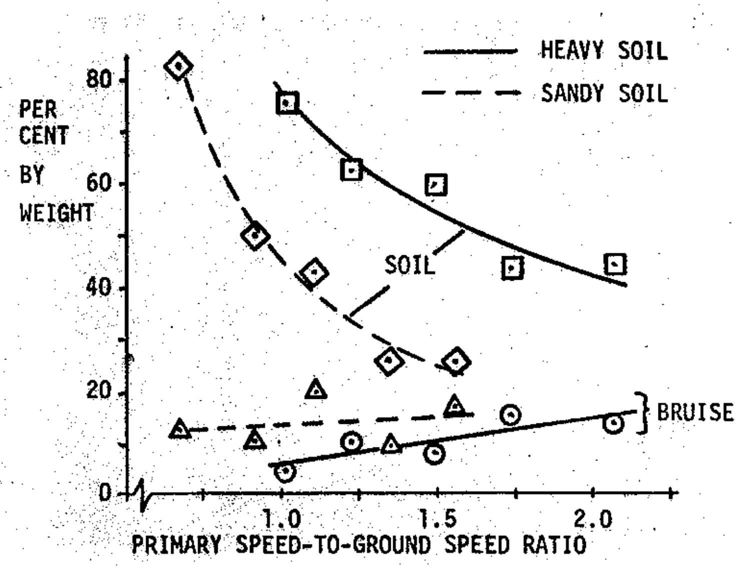
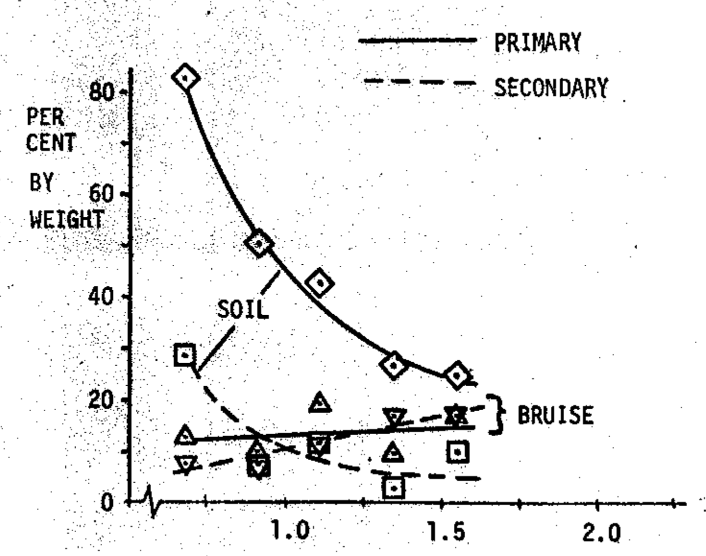


Figure 3. Bruise damage and soil in chain load vs. speed ratio for sandy soil, primary and secondary chains.



Automatic Control of Primary Chain:

For the 1979 harvest an automatic control system was designed and installed to control load of material delivered by the primary chain to the secondary chain. A device was installed to continuously weigh the load of material on the primary chain. The electrical signal from the weighing device was used to control the amount of output from the hydraulic pump that powered the hydraulic motor which drove the primary chain. The result was that as the harvester moved across the field, the primary chain speed would change automatically to maintain a constant load on the primary chain as field conditions varied.

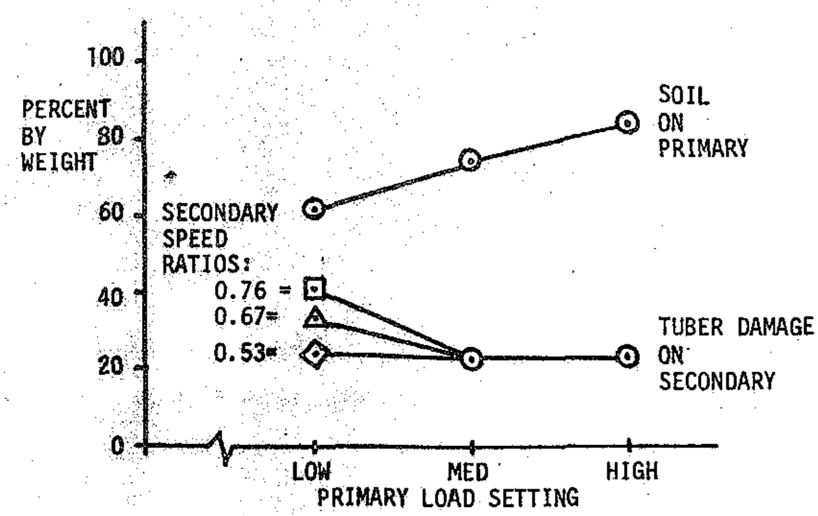
The operator's control box provided a gage to indicate the relative load on the primary at any moment and a means for setting the desired load level.

Experiments during the 1979 harvest used the automatic primary chain control system. The sampling procedure was similar to that used in 1978. Three primary chain loads as controlled by the automatic system were used. Because secondary chain speed is important in minimizing tuber damage, three different secondary chain speeds were also used in the experiments. Harvester ground-speed was constant throughout the experiments.

Figure 4 shows soil on primary and tuber damage on the secondary for three primary load settings (low, medium and high), and three secondary-chain speed ratios.

The upper curve (Figure 4) shows that the amount of soil was greater for higher load settings, so the control system did its job in spite of some stability problems at slow chain speeds. The lower curves show that secondary chain speed had an effect on bruise for the low primary load (least amount of soil carried), but no effect appeared at medium and high chain loads. The relatively high bruise level for the entire graph is partially due to sampling technique.

Figure 4. Primary-chain load effects on soil elimination and tuber damage.



Conclusions from the automatic chain load control experiment are that:

1. The control system concept worked satisfactorily.
2. It may be possible to reduce primary soil load from 83 percent down to 74 percent without greatly increasing bruise damage at the rear of the secondary if secondary speed is kept sufficiently low to keep that conveyor fully loaded. This primary chain load reduction would reduce the volume delivered to the secondary by nearly 1/3 (from 50 to 34 cubic feet per minute per mph).

In other words, it may be possible to reduce primary chain load from 83 percent soil to 74 percent or even less which reduces soil volume delivered by the primary by 1/3. This reduction will reduce energy requirement and ultimately the amount of soil delivered to the storage, all without significant increase in tuber damage.

REFERENCES

Hyde, G. M., R. E. Thornton, and W. M. Iritani. 1979. Chain speed effects on tuber damage and soil elimination. ASAE paper No. 79-3014. ASAE, P. O. Box 410, St. Joseph, Mi.

Smittle, D. A., R. E. Thornton, C. L. Peterson, and B. B. Dean. 1974. Harvesting potatoes with minimum damage. Amer. Potato J., Potato Assoc. of American, Orono, Maine. 51(5):152-164, May.

Thornton, R. E., D. A. Smittle, and C. L. Peterson. 1973a. Reducing potato harvester damage. Proceedings, 12th Annual Washington State Potato Conference, Washington State Potato Commission, Moses Lake, Wa. Feb.

Thornton, R. E., D. A. Smittle, and C. L. Peterson. 1973b. Reducing potato damage during harvest. Extension Bull. 646, Coop. Extension Service, College of Agr., Washington State University, Pullman. August.