RESUME OF THE WASHINGTON POTATO HARVESTER TRIALS

by
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SUMMARY

Potato harvester trials have been conducted in Washington for the years 1970-1972. The tests have clearly demonstrated the need for improved methods of evaluating bruise damage to reduce variability among samples. Catechol and Lye peel methods were found to have no correlation when both methods were utilized in the same tests.

Harvester make and model, ground speed, and harvester chain speeds were not correlated with bruise damage. However, chain speed:ground speed ratios were found to be significantly correlated with damage.

Chain speed:ground speed ratios of 0.35-0.45 for boom and side elevator, 0.50-0.60 for the rear cross and 0.55-0.65 for the secondary chain are suggested for the conditions of the 1972 potato harvester operation workshop.

Bruise damage decreased while field speeds increased over the three years of the trials. Field losses were judged negligible if good operating practices are followed. However, a field loss of over 10% was measured in one instance.

INTRODUCTION

In 1970, Washington State University and the Washington Potato Commission began what was then called the Washington State Potato Harvester Comparison and Demonstration. The first years trials were held at the Othello Branch Experiment Station near Othello, Washington. In 1971, the comparison continued but was moved to a commercial field through cooperation with Chef Reddy Corporation in Othello. In 1972, the trials were changed in concept and purpose and were called the Washington State Potato Harvester Workshop.

The manufacturers of potato harvesters have played an important part in making these trials successful. They have been placed in the difficult position of making their products available for test under, in some cases, less than ideal conditions. Braco Manufacturing and Lockwood Corporation have entered the trials each of the three years. Thiokol Corporation (Hallway) participated two years, while Dahlman Manufacturing and Heston Corporation each participated one year. The support of these manufacturers has been greatly appreciated. Information from the trials does not show a clear difference between manufacturers as to bruise damage and, therefore, company names will not be identified in the remainder of this paper. Participants are listed here because of the part they have played in making the trials possible. By their participation information has been gathered which has and will help the entire industry.

PURPOSE OF THE TRIALS

The trials were held to bring into sharper focus the serious problem of damage at harvest, and to attempt through competition and publication of results, to stimulate growers, processors, and manufacturers to be more aware of the bruise problem and to make a greater effort to correct

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it, to learn how to operate harvesters more effectively, and to improve machines where necessary. The trials were also to be used as a research tool where information would be developed on criteria for optimum harvester operation which could be applied to all harvesters currently in use.

Thus the trials were started with four major objectives in mind.

1. To cause individuals involved with harvesting and handling potatoes to become more aware of the bruise problem and to stimulate an interest in working to reduce harvester caused damage.

2. To develop criteria for optimum harvester operation.

3. To serve as a vehicle of information exchange where everyone participating would benefit including researchers, extension, processors, manufacturers and growers.

4. To improve the quality of the Washington potato.

As the trials developed the basic objectives remained the same but the methods were changed. The competition aspect of the trials was de-emphasized while the learning and teaching aspects of the trials became of primary importance. For example, the difficulty of measuring bruise damage effectively was an immediate problem. Secondly, the long standing recommendations for harvester operation needed modification, and third, it was evident that the operators in most cases, did not fully understand the effect of harvester adjustments on damage. From the experience of the first two years, the trials developed into the concept of a workshop. WSU research and extension personnel cooperated with the manufacturers in adjusting and operating the harvesters using the knowledge gained from the previous trials and other WSU research results.

1970 POTATO HARVESTER COMPARISON AND DEMONSTRATION

The trials were first held in 1970 with participation by four machines. Manufacturers were invited to participate and were allowed the day prior to the test for setting up their equipment. At the time of the trial they were asked to make three runs:

1. optimum ground speed and adjustment for minimum bruise damage.

2. 25 percent over optimum ground speed.

3. 25 percent under optimum ground speed.

Data was collected showing field harvest rate, bruise damage and field losses. Bruise damage was measured using the catechol bruise detection kit. Field losses were measured by digging in small plots behind each harvester. Field speeds were obtained by timing the harvester through a 100 ft. test section. Bruise samples were taken while the harvester was operating in the test section.

Results of these tests are plotted in Figure 1, which shows harvest rate in acres per hour versus bruise damage. Individual harvesters are identified by the letters A, B, C, D. The average harvest rate, bruise damage and field losses are reported in Table 1. Clearly harvest rate is not a good prediction of bruise damage. Two harvesters did have less damage in this trial than the others, however, due to mechanical difficulty one of these harvesters had only one test.

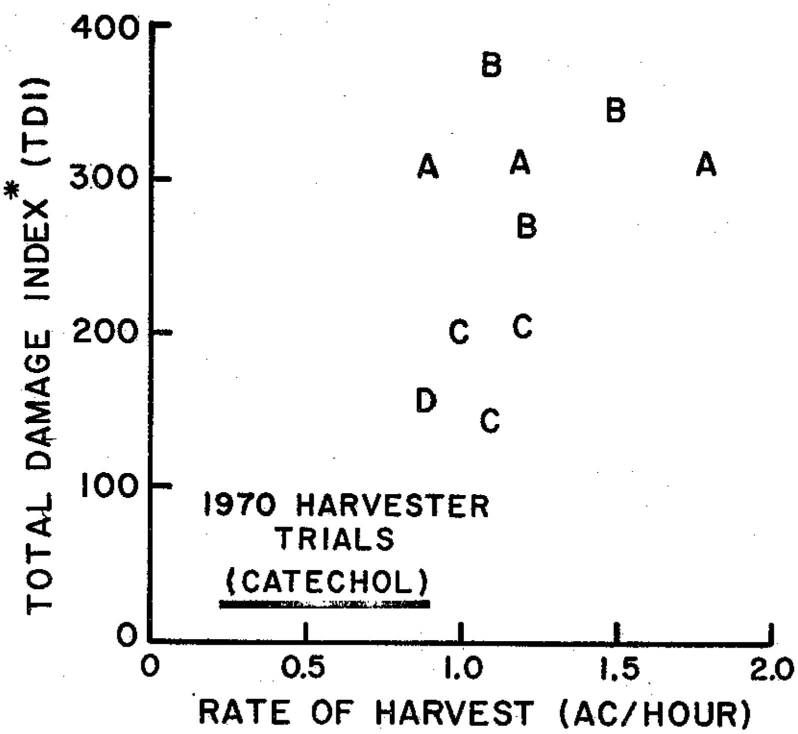

Figure 1.--Rate of Harvest versus Total Damage Index (TDI) as Measured by Catechol for the 1970 Washington Potato Harvester Comparison and Demonstration. The letters A,B, C, D Represent the Individual Machines Tested.

*TDI = % Serious Damage X 7 + % Slight Damage X 3.

TABLE 1.

GROUND SPEED, FIELD CAPACITY, AND BRUISE DAMAGE MEANS FOR EACH HARVESTER IN THE 1970 POTATO HARVESTER COMPARISON AND DEMONSTRATION

HARVESTER	GROUND SPEED, mph	FIELD CAPACITY, AC/HR	BRUISE INDEX, TDI*
A	1.90	1.30	311
B	1.84	1.26	333
C	1.60	1.10	185
D#	1.31	0.9	158
Ave.	1.73	1.19	265

This harvester did not complete the tests due to mechanical difficulty, values reported are for one run only.

* TDI = % serious damage x 7 + % slight damage x 3.

1971 POTATO HARVESTER COMPARISON AND DEMONSTRATION

The 1971 trials were conducted similar to the 1970 trials with a few important changes.

Six harvesters were entered in the trials. The previous trial and other field work had made it apparent that catechol bruise evaluation was not adequately correlated with the lye peel evaluation being used by processors; catechol results, therefore, were not a good indication of the economic value of the damage. Therefore, in 1971 both catechol and lye peel methods were utilized for bruise evaluations. The lye peel evaluation was conducted by the processor who also owned the potatoes.

Table 2 shows the average ground speed, field capacity and bruise damage both by lye peel and catechol measuring methods for these trials. Figure 2 is a diagram of ground speed versus bruise damage as measured by catechol and Figure 3 is a similar diagram as measured by lye peel methods. The letters A, B, C, D, E** again identify individual harvesters. Clearly ground speed or harvester were not correlated with bruise damage.

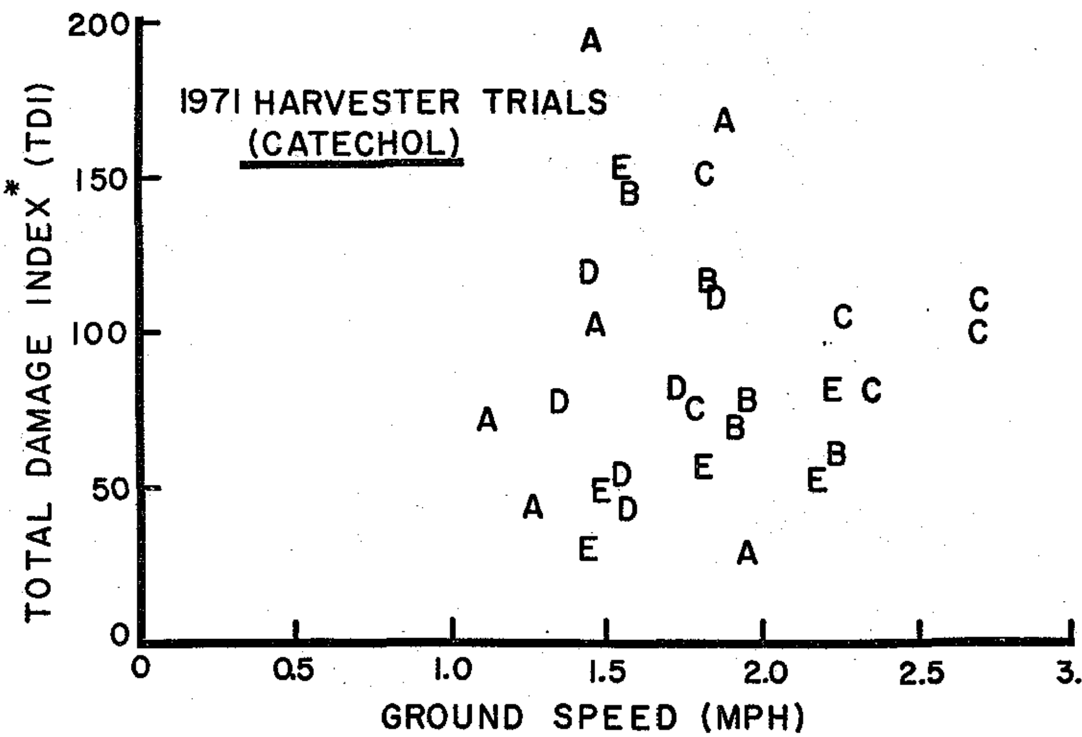

Figure 2.--Ground Speed versus Total Damage Index as Measured by Catechol for the 1971 Potato Harvester Comparison and Demonstration. The letters A, B, C, D, E Represent Each Test for an Individual Harvester.

*TDI = % Serious Damage X 7 + % Slight Damage X 3.

** Similar letters between the years 1970 and 1971 does not imply the same make of harvesters.

TABLE 2.

GROUND SPEED, FIELD CAPACITY, AND BRUISE DAMAGE MEANS FOR EACH HARVESTER IN THE 1971 POTATO HARVESTER COMPARISON AND DEMONSTRATION

HARVESTER	GROUND SPEED	FIELD CAPACITY	BRUISE DAMAGE	
			CATECHOL TDI*	LYE PEEL (%)
A	1.54	1.06	101.1	28.2
B	1.97	1.35	94.5	31.2
C	2.28	1.57	106.4	18.0
D	1.59	1.09	83.6	22.2
E	1.80	1.24	71.1	24.4
Ave.	1.84	1.26	91.4	24.8

* TDI = % serious damage x 7 + % slight damage x 3.

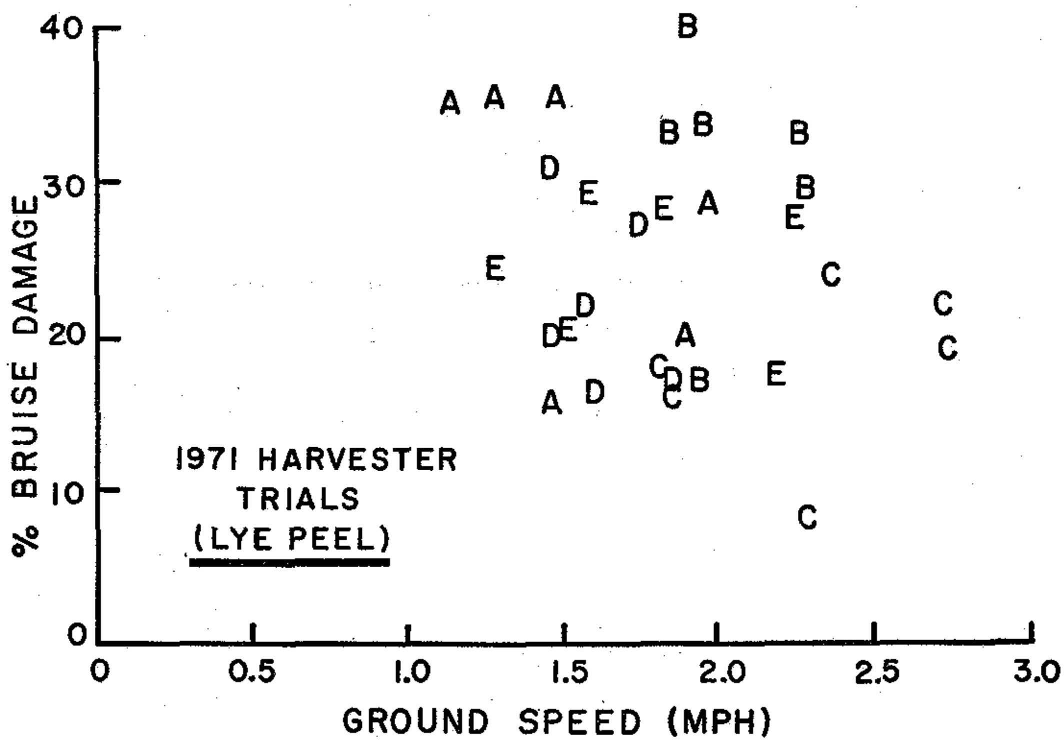

Figure 3.--Ground Speed versus Percent Bruise Damage as Measured by Lye Peel for the 1971 Potato Harvester Comparison and Demonstration. The letters, A, B, C, D, E Represent Each Test for an Individual Harvester.

Figure 4 is a scatter diagram of bruise damage as measured by the catechol method and as measured by lye peel for each of the runs in the 1971 trial. No correlation exists between the two methods of damage evaluation. The lye peel method was evaluated by the processor purchasing the potatoes, therefore, from the standpoint of return to the grower it has to be considered the more valid of the two tests. When comparing the two methods of evaluation it should be remembered that lye peel is primarily an evaluation of internal damage (blackspot or shatter bruise) and catechol is a measure of external damage where the skin is broken. The indication from Figure 4 is that the two types of damage are not necessarily related. This should not detract from the use of catechol as an indicator of trouble spots or damage from a particular machine. But, when using catechol samples should also be taken for later evaluation of internal damage.

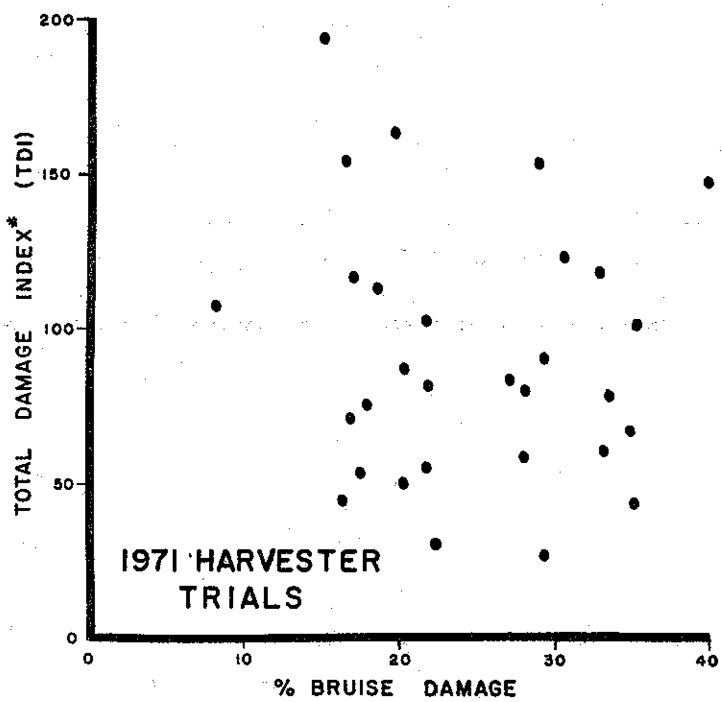

Figure 4.--Relationship Between Percent Bruise Damage as Measured by Lye Peel and as Measured by Catechol at the 1971 Potato Harvester Comparison and Demonstration

*TDI = % Serious Damage X 7 + % Slight Damage X 3.

FIELD LOSSES

In both 1970 and 1971 field losses were evaluated by hand digging in plots behind the harvester. Table 3 shows the average field losses from each of the two years 1970 and 1971. The conclusion is that field losses from the potato combine need not be a problem. However, in one case a loss of 10.9% or 2 tons per acre was recorded. It may have been due to chance, or the harvester may actually have been poorly adjusted. The harvester trials have been held in fields with green vines which may have increased the losses due to carryover on the deviner chain. In any case, it points out that serious losses could occur and the operator should check the field occasionally and be prepared to make adjustments as necessary.

An occasional potato in the field in often considered unimportant, however, one pound of potatoes in an area 10 ft. square (100 ft^2) represents 4.4 cwt per acre.

The 1970 and 1971 trials gave good indication that losses need not be a problem, and therefore, losses were not measured in the 1972 workshop.

TABLE 3.

FIELD LOSSES FROM POTATO HARVESTERS IN 1970 AND 1971 POTATO HARVESTER COMPARISON AND DEMONSTRATION

YEAR	HARVESTER	FIELD LOSSES TONS/ACRE	FIELD LOSSES % OF YIELD
1970	A*	0.43	1.7
	B	1.33	5.5
	C	0.23	0.8
	D	0.50	1.4
1971	A	0.36	1.8
	B	0.22	1.2
	C	0.36	1.8
	D	0.66	3.5
	E	0.20	1.1

* Similar letter between years does not imply the same make of harvester.

1972 POTATO HARVESTER WORKSHOP

The 1972 potato harvester workshop differed from the previous years in that operating procedures for minimum damage were stressed. Manufacturers were again asked to furnish a harvester, operator and truck. The purpose of the test was to provide information on best operating procedure for each harvester based on what had been learned from WSU research and the two previous years of harvester trials.

The 1972 Potato Harvester Operation Workshop was in no way planned to be competitive between harvesters. The workshop was seeking extremes of adjustments so that the effect of different adjustments could be adequately evaluated.

Data collected included field speeds, chain speeds, and bruise damage. A summary of the data is presented in Table 4.

Each operator was first given an opportunity to operate for one round. He was then asked to select an average operating speed and operate the harvester set-up as delivered. During the tests changes in field speeds and chain speeds were suggested so that the effect of these changes on bruise damage could be evaluated.

Table 5 is a summary of the data collected during all three of the trials. Note that the average TDI* for all harvesters entered in 1971 decreased by 65% below the average of all harvesters entered in 1970. Bruise damage decreased by 26.2% between 1971 and 1972. Ground speeds, on the other hand, increased by 6% between 1970 and 1971 and increased an additional 18% between 1971 and 1972. The net result was that on the average harvesters were digging 29% more acres per hour in 1972 than they were in 1970 (assuming 100% field efficiency) and were doing less total damage. A portion of the decrease in bruise damage is likely attributable to tuber conditioning.

TABLE 4

HARVEST RATE, GROUND AND CHAIN SPEED, AND CHAIN SPEED: GROUND SPEED RATIO MEANS FOR EACH HARVESTER IN 1972 POTATO HARVESTER WORKSHOP. NUMBERS IN PARENTHESIS ARE COEFFICIENTS OF VARIATION.

	MACHINE		
	A	B	C
Harvest rate (Ac/Hr)	1.31 (20.4)	1.75 (32.4)	1.48 (30.8)
Ground Speed (MPH)	1.88 (21.5)	2.52 (31.6)	2.11 (30.7)
Prim Speed (MPH)	2.26 (6.6)	2.18 (11.0)	2.54 (7.3)
Primary: Ground Speed ratio *	1.24 (19.1)	0.91 (18.5)	1.31 (33.3)
Secondary Speed (MPH)	1.91 (6.5)	1.28 (8.2)	1.70 (12.2)
Secondary: Ground Speed ratio *	1.05 (20.7)	0.54 (18.2)	0.88 (36.2)
Rear Cross Speed (MPH)	1.41 (7.0)	1.46 (13.6)	1.25 (8.6)
Rear Cross: Ground Speed ratio *	0.78 (21.0)	0.61 (23.7)	0.63 (27.6)
Elevator Speed (MPH)	1.61 (17.9)	0.90 (11.1)	1.04 (7.2)
Elevator: Ground Speed ratio *	0.90 (28.2)	0.37 (18.0)	0.52 (28.2)
Boom Speed (MPH)	1.29 (17.8)	1.07 (8.2)	0.79 (20.8)
Boom: Ground Speed ratio *	0.70 (19.0)	0.45 (20.4)	0.40 (28.9)
Bruise Damage (%)	22.1 (32.4)	16.2 (42.01)	16.88 (48.6)

* There is a significant correlation with bruise damage at the 5% probability level.

TABLE 5.

SUMMARY OF GROUND SPEED, FIELD CAPACITY AND BRUISE DAMAGE FOR ALL THREE POTATO HARVESTER TRIALS

YEAR	GROUND SPEED, mph	FIELD CAPACITY, AC/HR	BRUISE DAMAGE	
			CATECHOL, TDI*	LYE PEEL, %
1970	1.73	1.19	264.7	-
1971	1.84	1.26	91.4	24.8
1972	2.18	1.52	-	18.3

* TDI = % serious damage x 7 + % slight damage x 3.

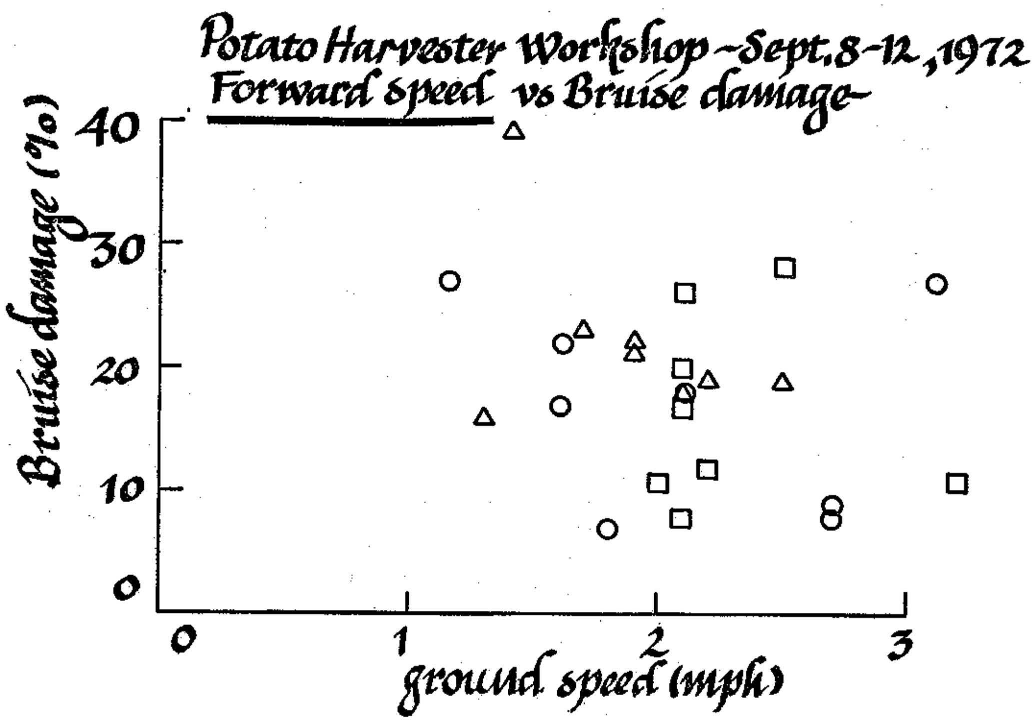

Figure 5.--Relationship Between Forward Speed and Bruise Damage for all Harvesters in the 1972 Potato Harvester Workshop.

Figure 5 again clearly shows that there is no relationship between bruise damage and field speed. Figures 6, 7, and 8 also clearly show that there is no relationship between any of the chain speeds and bruise damage. These three diagrams are for the primary, secondary and rear cross chains; similar diagrams have been plotted for the side elevator and boom with similar results.

There is a significant correlation between chain speed:ground speed ratio and bruise damage for all chains except the primary. (Chain speed:ground speed ratio is found by dividing the chain speed (mph) by the ground speed (mph).)

Coefficients of determination are low ranging from 0.19 to 0.25. Considering that total bruise damage was low, the test was early in the season such that temperatures were high (55-60°F), and the difficulty of obtaining a good representative sample in a manageable size; the low value of this statistic is not surprising. (Coefficient of determination, in this case, indicates the proportion of the variation in bruise damage which is attributed to the change in chain speed:ground speed ratio.)

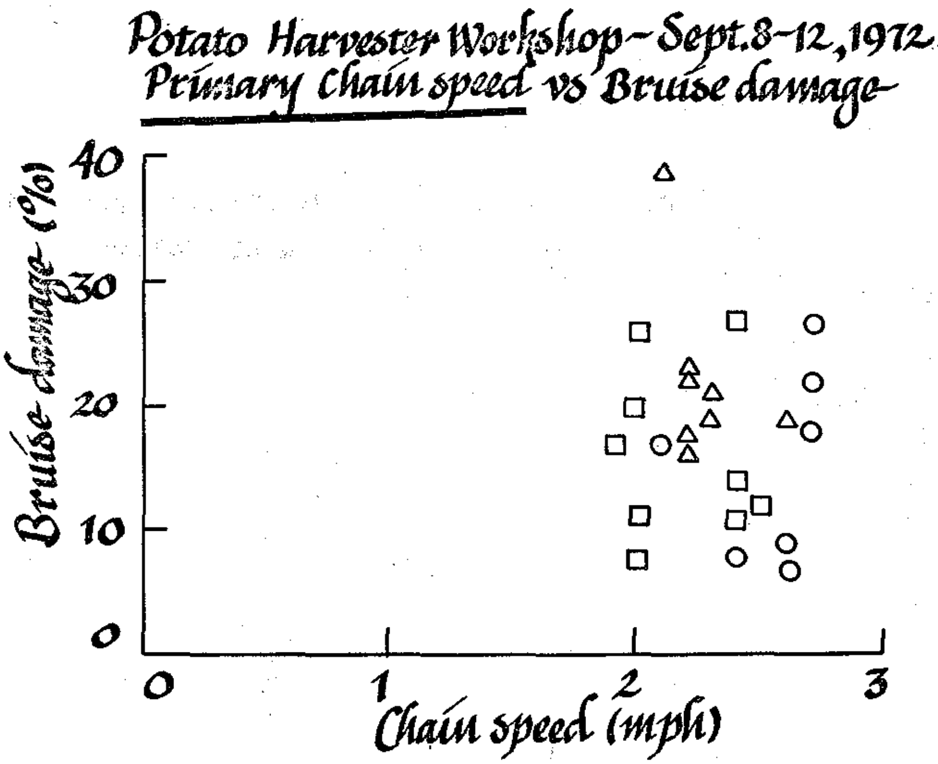

Figure 6. -- Relationship Between Primary Chain Speed and Percent Bruise Damage for the 1972 Potato Harvester Workshop.

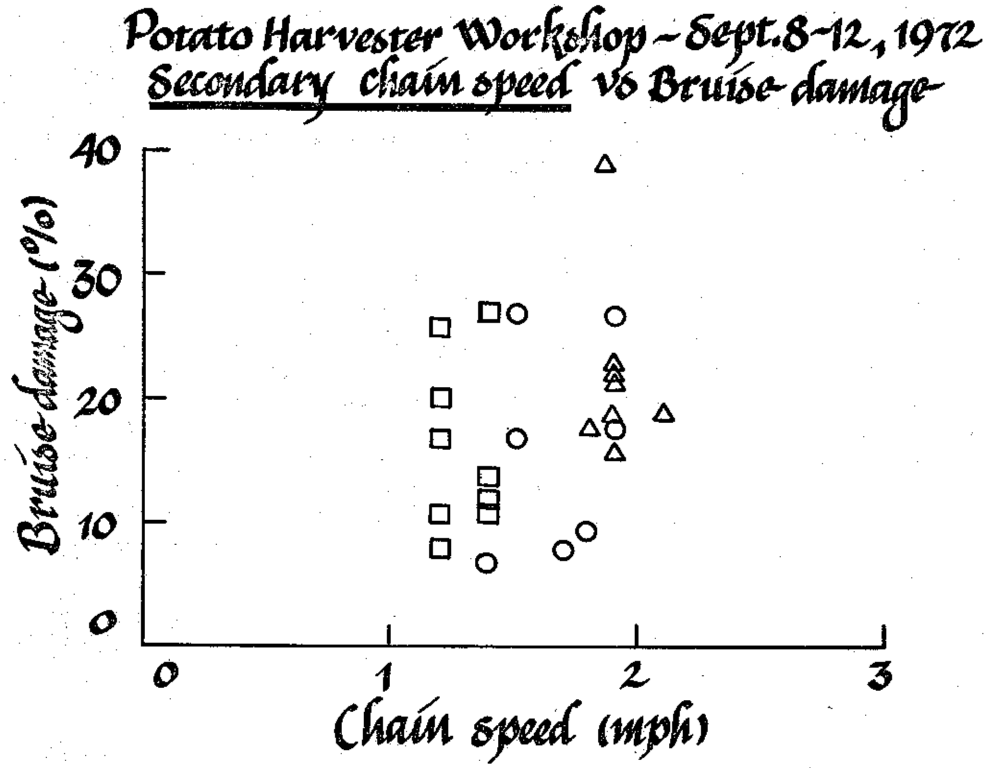

Figure 7.--Relationship Between Secondary Chain Speed and Percent Bruise Damage for the 1972 Potato Harvester Workshop.

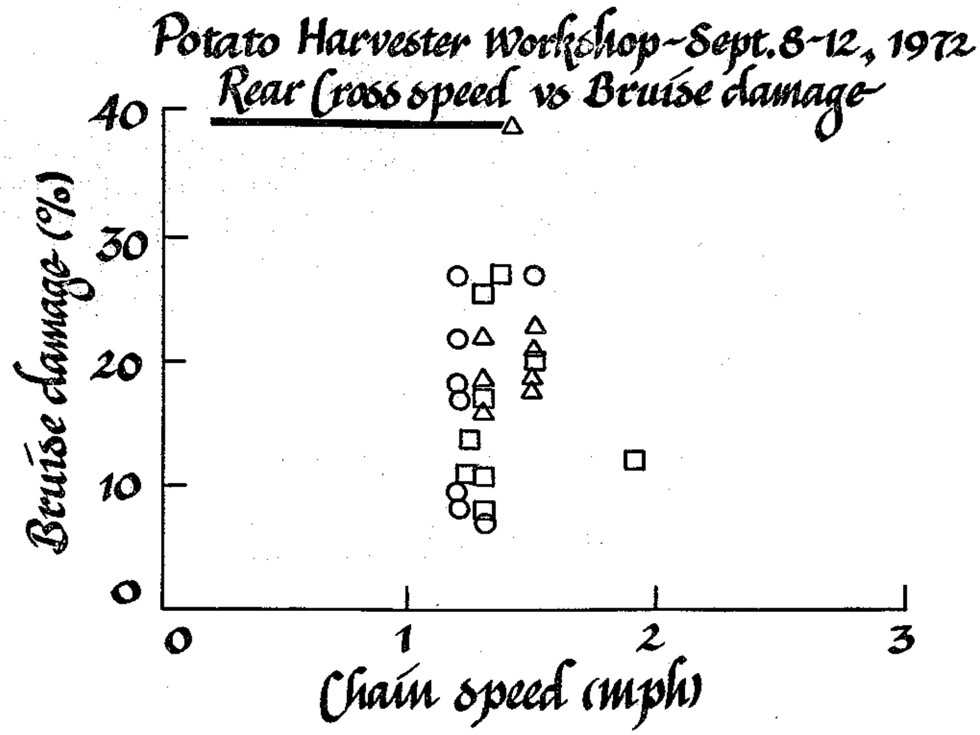

Figure 8.--Relationship Between Rear Cross Speed and Percent Bruise Damage for the 1972 Potato Harvester Workshop.

Figures 9, 10, 11 and 12 show the relationship of chain speed:ground speed ratio for all chains where the regression was significant, this includes the secondary, rear cross, side elevator and boom to ground speed ratios. Naturally, in a linear relationship with positive slope, minimum damage would occur at the point where the chain has 0 speed and a chain speed:ground speed ratio of 0. Since at this speed we would no longer be conveying potatoes, we conclude a higher speed is necessary. Extending these lines beyond the limits shown on the graph would be incorrect as testing has not been conducted in these areas.

Chain speed:ground speed ratios were significantly related to each other (correlation coefficients = 0.63** - 0.91**) which means that during the Potato Harvester Workshop changes were obtained by varying all the ratios at once such as would occur if the tractor transmission were shifted with the pto speed held constant. As a result, the effect on damage due to varying one chain alone cannot be determined from the data of the workshop and, although individual charts have been prepared for each chain, what is actually known is the effect on bruise damage when all of the ratios are varied together. Additional testing should be done where each chain is varied from a high to a low ratio while holding all other factors constant. In that way, the effect of one chain on the damage level could be evaluated. Even so, since the chains are alike in concept, it is reasonable to assume if chain speed:ground speed ratio is important for one chain it would be important for the others. By looking at each chain separately we are assuming the effects are additive.

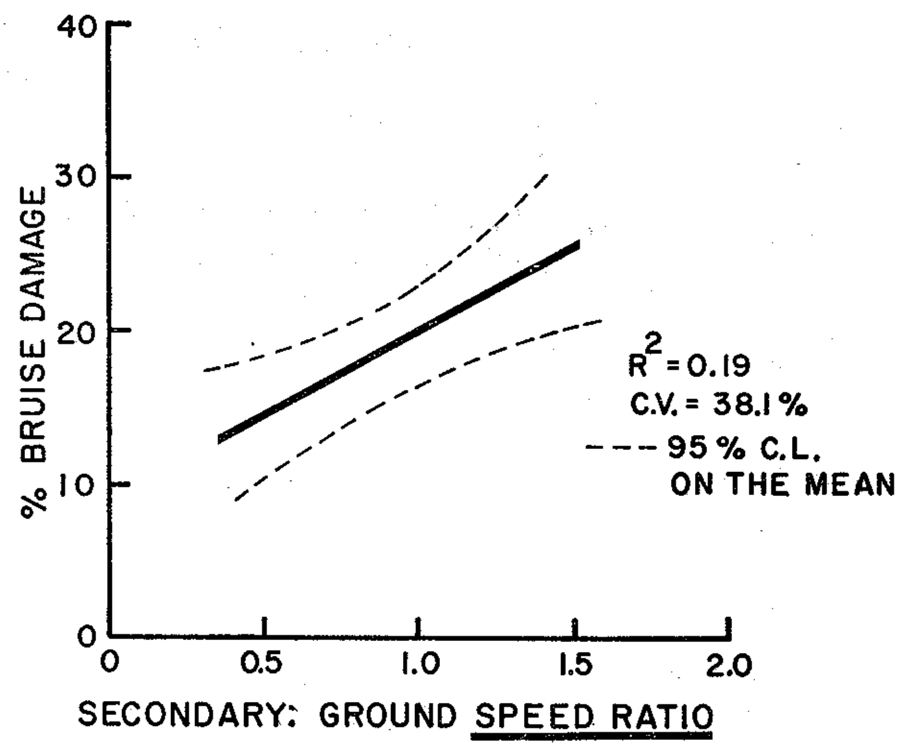

Figure 9.--Relationship Between Secondary:Ground Speed Ratio and Percent Bruise Damage for the 1972 Potato Harvester Workshop.

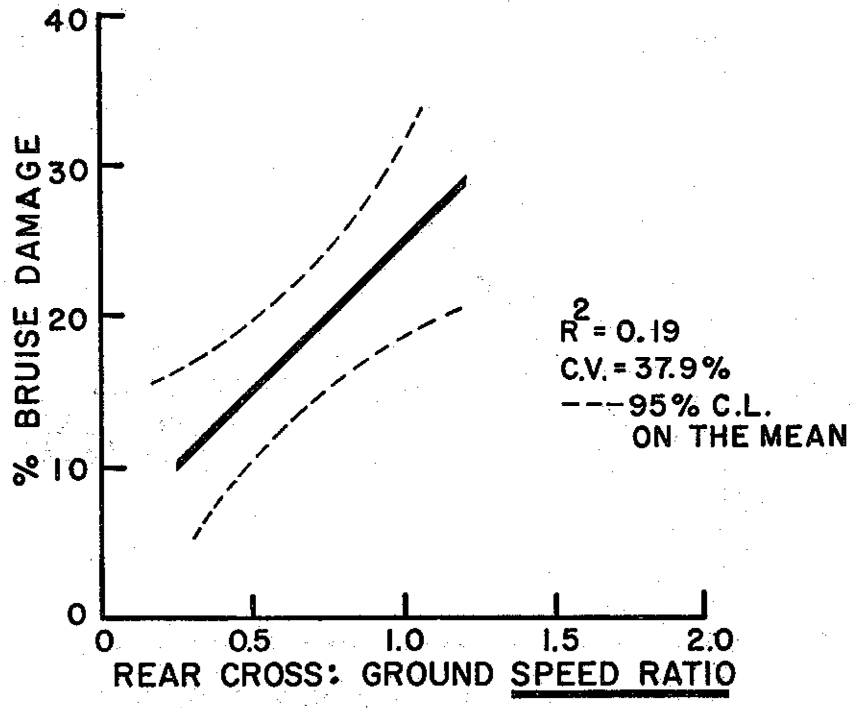

Figure 10.--Relationship Between Rear Cross:Ground Speed Ratio and Percent Bruise Damage for the 1972 Potato Harvester Workshop.

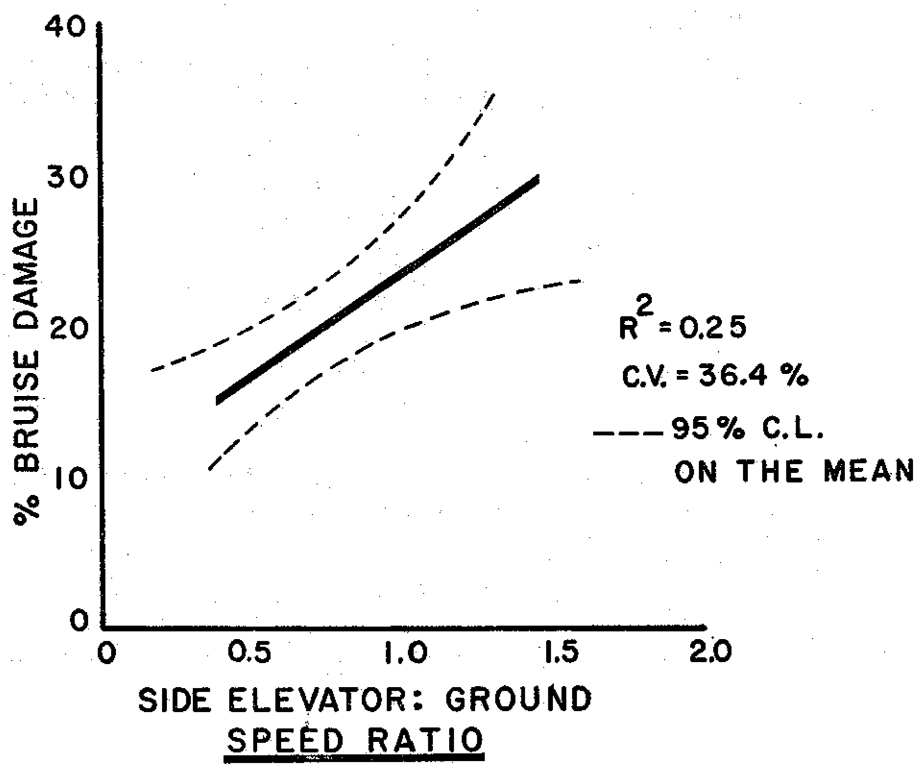

Figure 11.--Relationship Between Side Elevator:Ground Speed Ratio and Percent Bruise Damage for the 1972 Potato Harvester Workshop.

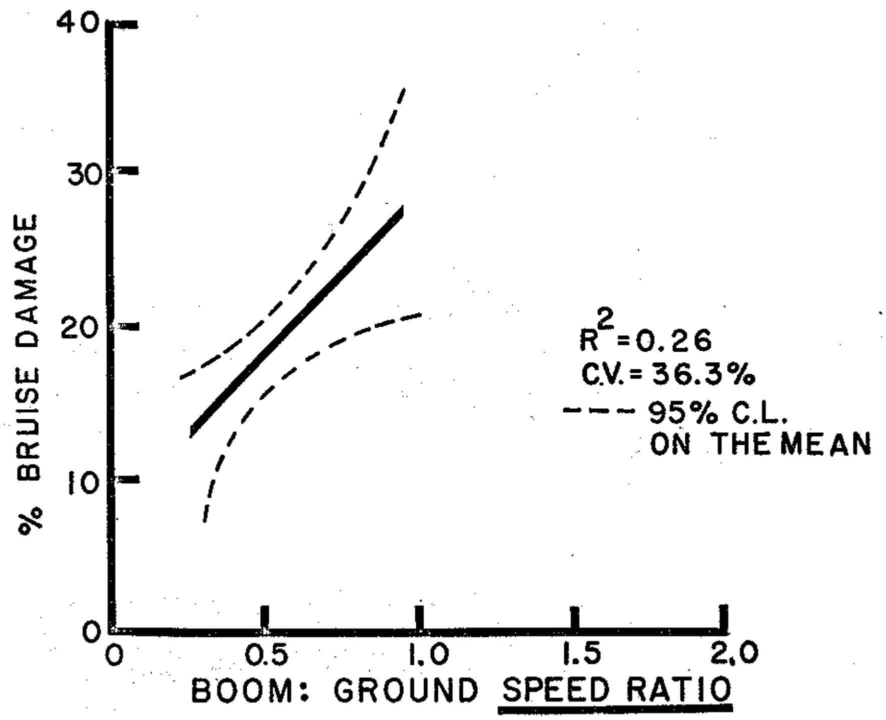

Figure 12. --Relationship Between Boom:Ground Speed Ratio and Percent Bruise Damage for the 1972 Potato Harvester Workshop.

The charts of chain speed - ground speed ratios would suggest the following ratios were best for the conditions of this test (25 tons per acre, adequate moisture and light soil, temperatures of 55-60°F).

Chain	Ratio
Secondary	0.55-0.65
Rear Cross	0.50-0.60
Side Elevator	0.35-0.45
Loading Boom	0.35-0.45

Example: For a yield of 3 mph and 25 ton yield, a rear cross speed of 3 x 0.55 = 1.65 mph is indicated; which is the speed recommended for the rear cross in the harvester operation rate tables presented by Thornton and Peterson (1973).

For the side elevator, a speed of 3 x 0.40 = 1.20 mph is indicated.

The best setting of primary chain speed is still dependent on soil conditions.

CONCLUSIONS

1. Properly adjusting the harvester chain speeds can have a significant effect on reducing damage.

2. Results of these tests have given no justification for reducing harvester field speeds if other adjustments can be properly maintained.

3. The effect of field speeds, beyond those encountered in these trials have not been evaluated. It is reasonable to assume that excessive field speeds would increase bruise damage.

4. Harvester models from different manufacturers were not different in the amount of bruise damage produced.

Proper adjustment of a particular harvester appears to be more important than make or model.

5. Bruise damage decreased while field speeds increased by nearly 30% during the year of the tests.

6. Field losses from potato combines were found to be less than 2% in nearly all cases. Generally the problem causing field losses can be corrected by the operator.

REFERENCE

Thornton, R.E. and C. L. Peterson. 1973. Reducing Potato Harvester Damage. Proceedings of the 12th Annual Washington State Potato Conference. Moses Lake, Wash.