Quality Losses to Oregon Late Crop Potatoes in Handling Operations at Shipping Point

by

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Foreword

The Oregon Agricultural Experiment Station has conducted and published the results of several investigations relating to the marketing of Oregon late-crop potatoes. For the most part these studies have been concerned with ways and means of preventing quality deterioration after the potatoes leave the producing area.

This study reports results of a survey of quality losses caused by mechanical injuries which occur to potatoes before they leave the producing area. Growers and shippers have control over the handling of their potatoes during harvest and packing operations. Thus, they have the opportunity to minimize mechanical damage. The survey indicated that some growers and shippers are taking advantage of this opportunity. It was found that one-half of the growers were harvesting their potatoes with a third as much damage as the other half. Four of the nine shippers covered in the survey had less than one-half as much warehouse packing damage as the remaining five shippers.

The information included in this report should be useful to growers, shippers, and others in the potato industry as a guide for programs designed to reduce quality losses.

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Dean and Director

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Summary

The purpose of this study was to determine the points of origin and the extent of mechanical damage which occurs to potatoes in harvest and warehouse packing operations in central Oregon. Data were obtained for the 1951 crop from 20 growers and 9 potato warehouse operators.

In determining the amount of damage only mechanical defects such as bruises, cuts, breaks, and wet decay developing in mechanical injuries were considered. The amount and the origin of mechanical defects found were as follows:

Operation	Defects per hundredweight		
	Grade defects	Nongrade defects	Total defects
	Pounds	*Pounds*	*Pounds*
Digging	4.3	7.8	12.1
Hauling from field to storage	0.2	1.4	1.6
Binning	1.6	6.5	8.1
Cellar sacking	1.1	3.2	4.3
Hauling from cellar to warehouse	0.1	0.7	0.8
Warehouse packing	5.8	10.8	16.6
Total	13.1	30.4	43.5

A large variation in mechanical damage among growers and shippers was found. One half the growers had total mechanical damage during harvest operations averaging less than 10 pounds per hundredweight. The other one half of the growers had harvest damages averaging over 30 pounds. Harvest operations include digging, hauling from field to cellars, and bin filling.

Warehouse packing operations caused mechanical damage which varied from a low of 5 pounds per hundredweight to over 40. Four of the operations had damage averaging 9.5 pounds. The average damage for the other five operations was 23.6 pounds per hundredweight.

The cause of the injuries within particular operations was not determined. The study was not designed for that purpose.

Grade defects resulting from mechanical damage in all operations studied reduced the value of the potatoes dug by almost $29 per acre. This was calculated on the basis of estimated yields and prices. If potatoes with mechanical defects not serious enough to affect grade had been reduced in value the above loss would have been even greater.

Some of the losses resulting from mechanical damage undoubtedly was unavoidable. The wide variation in damages suggests that much of it could have been avoided. Those growers and shippers with low amounts of damage had found at least some of the answers to controlling damage.

Quality Losses to Oregon Late Crop Potatoes in Handling Operations at Shipping Point

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A POTATO MARKETING research study made during 1950 showed that 21 to 54 per cent of the graded and packed U. S. No. 1 potatoes examined at shipping point had mechanical injuries.[1] Most of the injuries were small nicks, cuts, and bruises which would not affect grade. These defects, however, did affect the appearance of the potatoes and could have developed into more serious defects by the time the potatoes reached the consumer.

The point of origin of these injuries could not be determined by a superficial examination of the potatoes. Some defects appeared to be relatively fresh while others seemed old and could have occurred during harvest.

The location of the major source of these injuries could be extremely useful to the potato industry as a guide to be used in programs directed toward the reduction of mechanical injuries. If such injuries could be reduced economically the industry would benefit in two ways. First, more U. S. No. 1 potatoes could be marketed because of fewer culls and other lower grades. Second, the pack reaching the consumer would be of higher quality. This should result in growers receiving a higher average price or perhaps it would enable them to sell a larger volume at the same price.

Objective

The purpose of this study was to determine the amount and kind of mechanical damage which occurs to potatoes during harvest and warehouse packing operations in the central Oregon potato production area.

Origin and Extent of Mechanical Damage[2]

More than 40 per cent of the potatoes examined had been mechanically damaged (Table 1). Warehouse packing, digging, and binning were the major sources and together accounted for approxi-

[1]"Packaging Oregon Late-Crop Potatoes at Shipping Point and at Terminal Market," Oregon Agricultural Experiment Station Bulletin 527, 1952.

[2]See appendix for procedure followed in making the study and for detailed results not shown here.

mately 90 per cent of the grade defects and 82 per cent of the nongrade defects found. Hauling from field to cellar and from cellar to warehouse caused the least damage. Mechanical defects included bruises, cuts, breaks, and wet decay developing in mechanical injuries.

Table 1. AMOUNT OF POTATOES MECHANICALLY INJURED DURING MAJOR OPERATIONS

(Central Oregon production area, 1951 season)

Operation	Number of observations	Mechanical defects per hundredweight		
		Grade defects	Nongrade defects	Total defects[2]
		Pounds	*Pounds*	*Pounds*
Digging	20	4.3	7.8	12.1
Hauling from field to storage	20	0.2	1.4	1.6
Binning	20	1.6	6.5	8.1
Cellar sacking[1]	5	1.1	3.2	4.3
Hauling from cellar to warehouse	5	0.1	0.7	0.8
Warehouse packing	9	5.8	10.8	16.6
Total		13.1	30.4	43.5

[1]Removing from bin and placing in half-sacks ready to be hauled to warehouse for grading and packing.

[2]Analysis of variance shows that these operations, with the exception of hauling from field to storage and from cellars to warehouses, made highly significant increases in mechanical injuries.

Because of wide variability within farms and operations (sampling errors) the hauling operations did not bring about a significant increase. However, a greater degree of control in the sample design (reduction of sampling error) could result in significant increases in mechanical injury due to these handling operations.

Analysis of variance shows that the differences in mechanical damage between farms was highly significant. This means that the variation shown later between farms is a result of the methods and management used and was not the result of chance. Some growers, therefore, were using better methods and better management.

Harvest Damage

Information on the amount of mechanical damage which occurred to potatoes during harvest operations was obtained on 20 farms. All farms were located in Crook, Deschutes, and Jefferson counties.

Digging

Digging caused over one-half of the damage which had occurred to the potatoes by the time they were placed in the bin. Some growers managed their digging operation so that digger damage was less than 5 pounds per hundredweight. Others were not so fortunate. This variation is shown below.

Total mechanical defects per hundredweight	*Number of growers*
Under 5 pounds	5
5 to 10 pounds	5
10 to 15 pounds	4
15 to 20 pounds	2
20 to 30 pounds	3
30 to 40 pounds	1

Bruises were the most important defects caused by digging (Table 2). They caused more nongrade defects, but fewer grade defects than did digger cuts.

Table 2. MECHANICAL DAMAGE TO POTATOES RESULTING FROM DIGGING

(Central Oregon production area, 1951 season)

Kind of defect	Nongrade defects per hundredweight	Grade defects per hundredweight		Total defects per hundredweight
		U.S. No. 2's	Culls	
	Pounds	*Pounds*	*Pounds*	*Pounds*
Bruise	7.7	1.3	0.3	9.3
Cut	0.1	0.7	1.2	2 0
Wet rot[1]	....	....	0.8	0.8
Total	7.8	2.0	2 3	12.1

[1]Includes only those potatoes with wet rot developing in mechanical injuries.

Other studies show that substantial reduction in digger bruises can be obtained by modifying the digger and by regulating within certain limits the speed of the tractor and digger chain. A recent study of early round variety potatoes in the Southeast shows that " . . . physical injuries can be reduced on the average from 7.0 pounds per hundredweight to slightly less than 1.5 pounds per hundred by protecting the tubers from the link ends of the digger chain and equipping every second link with rubber tubing."[1] Other recommendations have been made in an Idaho report.[2]

The 20 diggers included in this study consisted of 11 two-row diggers, 7 one-row, and 2 one-row combine baggers. Combine bulkers were not included. Neither rubber-covered chains, nor chains which had been turned over so that link ends were turned down, were found on diggers included in the study.

Ground speed of diggers varied between 1 and 3 miles per hour. Six were driven from 1 to 1.5 miles per hour; eight from

[1]Todd, B. J. and Shuler, N. E., "Reduction of Physical Injuries in Digging Early Irish Potatoes," South Carolina Agricultural Experiment Station, Agricultural Economics 106, 1951.

[2]Humphrey, Elmer, "Steps That Can Be Taken to Reduce Mechanical Damage to Potatoes at Harvest Time," Idaho Agricultural Experiment Station Bulletin 278, 1950.

1.5 to 2 and six from 2 to 3 miles per hour. Fewer potatoes were bruised at the lower speeds. Factors other than tractor speed, however, could have accounted for this. Number of shakers, speed of digger chain, condition of soil, and distance that dirt was carried on chains could have been partly responsible.

No attempt was made to determine whether one type of digger tended to bruise potatoes more than another. The study was not designed for that purpose. Furthermore, the way in which the operator uses his digging equipment probably is just as important as the kind of equipment he uses insofar as mechanical damage is concerned.

The damage shown as digger damage also includes injuries received during the picking-up operation. Although digger and picking-up damage cannot be separated, it does appear that picking into wire baskets caused more injury than did picking into sacks alone. In harvest operations where both wire baskets and sacks were used, the total digger- plus picking-up damage was 3 times greater than the damage when sacks alone were used. The baskets used were all bare wire baskets. Baskets constructed of rubber alone or rubber covered wire should reduce this kind of damage.

Hauling to cellar

Hauling from the field to storage was a minor source of mechanical damage. It includes the damage which occurred in the field loading of the truck and the damage resulting from transportation to the cellar. Nongrade defects averaged 1.4 pounds and grade 0.2 pounds per hundredweight.

The most common method of hauling was by flat bed truck with potatoes in half-sacks. The sacked potatoes were loaded on the truck by hand and were hand dumped into the piling equipment in the cellar. Some bulk hauling of potatoes also was included in the study. In this operation the potatoes in half-sacks were mechanically picked up in the field and dumped into a large bin mounted on a truck. An electrically powered conveyor chain in the bottom of the truck bin unloaded the potatoes into the hopper of the cellar binning equipment.

Several of the cooperator growers used low truck beds to reduce the work involved in loading and at the same time possibly reduce loading damage. Very few truck beds were padded on the edges.

Binning

Mechanical pilers generally were used to fill bins and cellars. In a few cases potatoes in half-sacks were dumped by hand into the

bins. The latter method was used for relatively small acreages and small cellars.

Damage in this operation includes that which happened when the potatoes were moved from the truck into the hopper of the piler over the piler chains and the drop onto the potatoes in the bin. The following mechanical damage was found in the 20 operations studied.

Type of defect	*Average number of pounds per hundredweight*
Nongrade defects	6.5
Damage (U. S. No. 2's)	1.4
Serious damage (culls)	0.2
Total	8.1

The variation in binning damage among the growers was quite large. On over one-third of the farms this kind of damage amounted to more than 10 pounds per hundredweight as shown below. However, two-fifths of the growers were able to keep the binning damage under 5 pounds.

Total mechanical defects per hundredweight	*Number of growers*
Under 5 pounds	8
5 to 10 pounds	5
10 to 15 pounds	5
15 pounds and over	2

It was not determined where the mechanical damage occurred during this operation. Recommendations for reducing bin filling damage based upon a study made in Idaho are:[1]

1. Slow piler chain to 50 feet per minute.
2. Put rubber tubing over each link.
3. Pad the hopper with sheet sponge rubber.
4. Feed the potatoes into the bin steadily.
5. Handle the sacked potatoes with care. Empty sacks carefully.
6. Keep the delivery end of the hopper a short distance above the pile. Do not allow the potatoes to pile up and drag back down with the piler chain.

Damage Caused by Removing from Cellars[2]

Cellar sacking

Mechanical damage resulting from the cellar sacking operation ranged from 0.7 pounds to 8.5 pounds of grade and nongrade defects

[1]Ibid.
[2]See appendix for procedure used to determine this damage.

per hundredweight. The averages for this operation are shown below.

Type of defect	*Average number of pounds per hundredweight*
Nongrade defects	3.2
Damage (U. S. No. 2's)	0.5
Serious damage (culls)	0.6
Total	4.3

Hauling from cellar to warehouse

The amount of grade and nongrade defects from this operation varied from none to 2.7 pounds per hundredweight. The average was 0.8 pounds of which only 0.1 pound per hundredweight was grade defects. The remainder was nongrade defects.

Damage Caused by Warehouse Packing

Warehouse packing damage was obtained for each of the nine warehouses located in central Oregon. Damages shown for this operation do not include any which may have occurred during jigging, weighing, sewing, hand trucking, or car loading.

Grade defects accounted for more than one-third of the total defects occurring during this operation (Table 3). The size B (1½ to 2 inch) potatoes had less total damage, but a much higher proportion of grade defects than did the larger potatoes. This is explained by the fact that a relatively small bruise on a small potato is a grade defect—whereas on a 10-ounce potato this same bruise could be removed with a small percentage of peeling loss and, therefore, be a nongrade defect.

Table 3. MECHANICAL DAMAGE TO POTATOES DURING WAREHOUSE PACKING

(Central Oregon production area, 1951 season)

Extent of mechanical injury	Weight of defects per hundredweight according to size of potatoes		
	1⅜" to 2"	2" and up	Average of all potatoes
	Pounds	*Pounds*	*Pounds*
Nongrade defects	1.1	11.9	10.8
Damage (U. S. No. 2's)	4.0	3.5	3.7
Serious damage (culls)	8.6	1.5	2.1
Total	13.7	16.9	16.6

All but two of the warehouse operations had total defects ranging between 10 and 20 pounds per hundredweight. Of the remaining two, one warehouse had approximately 5 pounds and the other 42 pounds of defects per hundredweight. The specific causes of this variation between warehouses is not known. A major portion of this damage, however, was due to the mechanical features of the operation. The only time the experimental potatoes were moved by hand was in dumping into the hopper and removing filled bags from sack hooks. These handlings were done carefully so any mechanical damage resulting would be slight.

Equipment in the nine warehouses had varying numbers and amounts of drops. The equipment having the least number had six drops which totaled 86 inches excluding the drop into the hopper. The greatest number of drops was 12 for a total of 196 inches. The average number was 8 for a total of about 140 inches. Drops on bare metal numbered 2 or 3 per warehouse. In the case of the other drops the potatoes fell on rubber belts or onto rubber covered chains.

This study was not designed to show where damage occurred within the particular handling operation. It would not be difficult, however, for the warehouse operator to locate where the damage occurs on his own equipment. One way to do this would be to:

1. Remove all potatoes from the packing equipment.

2. Dump enough defect-free potatoes into the hopper so that when the equipment is stopped the potatoes are well distributed between the first hopper and the bagger.

3. Remove potatoes from each of the various places to be checked and place in individual sacks. For example, the operator might wish to check eliminator damage. This would be determined by the difference in damage found in the potatoes removed just ahead of the eliminator and the potatoes removed just after they had passed over the eliminator.

4. Tag the individual sacks with information showing the location on the equipment from which the potatoes were removed.

5. Hold the samples for several days to give injuries an opportunity to discolor and then examine each potato for mechanical defects.

6. Compare the amount of mechanical defects found in the potatoes removed from the different locations. The differences found should show the relative amount of injury occurring in the mechanical operations being studied.

Loss Resulting from Mechanical Damage

Mechanical damage reduces the value of the potato crop in two ways. Potatoes with grade defects are lowered in grade from U. S. No. 1 to U. S. No. 2 or culls by the sorters during the packing operation. This is a direct cost to the grower because he is paid on a packout basis. The more mechanical grade defects the greater the percentage of No. 2's and culls and the lower the return from the potatoes.

The second source of cost is more indirect and is concerned with those potatoes with mechanical defects which have been packed with sound potatoes. This is not an uncommon occurrence. Most mechanical defects are not serious enough to affect U. S. No. 1 grade. Also the grade tolerance permits a limited amount of potatoes with grade defects to be packed with otherwise grade defect-free potatoes. These defective potatoes affect the appearance of the pack, regardless of whether they are grade defects or nongrade defects. It seems reasonable to assume that the housewife will pay more for those free from defects than for those with visible injuries. How much more will be paid, however, is not known. In any case if the

Table 4. REDUCTION IN VALUE OF POTATOES BECAUSE OF MECHANICAL GRADE DEFECTS

(Central Oregon production area, 1951 season)

Operation	Estimated reduction in value of all potatoes dug[1]	
	Per hundredweight	Per acre
Harvesting (digging, hauling to cellar and binning)	$.08	$14.40
Storage to warehouse (cellar sacking and hauling to warehouse)	.02	3.60
Warehouse packing[2]	.06	10 80
Total cost	$.16	$28.80

[1]Costs calculated on basis of following assumptions:

a. Potatoes are mechanically damaged to the extent shown previously in this report.
b. Potatoes average 65 per cent U. S. No. 1, 20 per cent U. S. No. 2, 10 per cent size B, and 5 per cent culls.
c. Potatoes are valued at $3.00 per hundredweight for U. S. No. 1, $2.00 for U. S. No. 2, $1.00 for size B, and 20 cents for culls.
d. All potatoes with grade defects caused by mechanical injuries are correctly lowered in grade to U. S. No. 2 or culls during the warehouse packing and grading operation.
e. Yield of 300 half-sacks or 180 hundredweight of field run potatoes per acre.

[2]This may require some qualification. All potatoes with grade defects are not removed from the U. S. No. 1 potatoes during commercial packing operations. Some are overlooked and are packed with the U. S. No. 1 potatoes. Table 4, therefore, probably overstates the cost of the potatoes reduced in grade at shipping point. On the other hand, the housewife certainly does not wish to pay the same price for defective potatoes as for potatoes free from defects. Therefore, defective potatoes are reduced in value regardless of whether they are lowered in grade at shipping point or are packed with U. S. No. 1 potatoes.

housewife can buy better quality potatoes and is willing to pay a higher price for them, then in time the grower's return will be increased.

Very little information is available to show how consumers will react when offered potatoes with various degrees of injury. This information would be very helpful to all handlers of potatoes including growers. It would serve as a guide to the amount which they could spend to advantage in order to reduce the mechanical injuries resulting from their own handling operations.

Losses resulting from lowering of grade because of mechanical grade defects alone were substantial (Table 4). The estimated loss was 16 cents for each hundredweight of potatoes dug or $29 per acre with a yield of 300 half-sacks or 180 hundredweight per acre. This is approximately one and one-half times greater than the current cost of labor used to pick up the potatoes. For the central Oregon area as a whole, the reduction in value of the crop for 10,000 acres would be over a quarter of a million dollars.

Conclusions

Harvest damage varied from a low of 3 pounds per hundredweight for the grower having the least damage to 56 pounds for the grower having the most. Warehouse packing injuries varied from 5 to 42 pounds per hundredweight. Some of this damage was unavoidable. The wide variation indicates, however, that growers and shippers having low amounts of damage had found some of the answers to controlling mechanical damage.

Reduction in avoidable damage in some cases may be accomplished at no additional cost by more careful handling and a better adjustment of equipment. Other damage, however, may be reduced only by increasing some costs. For example, remodeling or altering digger equipment can reduce damage, but at a cost. Operation of equipment at lower speeds has been shown to reduce damage and thereby increase revenues. Fewer potatoes are dug per day at slower speeds. Reducing speed, therefore, could result in costs which would be greater than the value of the additional potatoes saved. Such questions as these were not within the scope of this study. They must be considered, however, in any damage prevention program.

APPENDIX

Method of Determining Damage

Harvest

Twenty potato growers from the central Oregon potato-producing area were selected at random from a list of all growers in the area. Each cooperating grower was visited during his digging operation. Four half-sacks, each weighing approximately 60 pounds, were randomly selected from one area in the field immediately after the potatoes had been picked up and placed in burlap sacks by the pickers. Another four half-sacks were removed from the truck which had loaded in the section of the field from which the field samples were obtained. Truck samples were taken off the truck in the storage cellar before the potatoes had been unloaded. While the potatoes were being dumped into the equipment which fills the bins another four half-sacks were removed by hand from the potatoes already in the bin. All the experimental potatoes were obtained under normal operating conditions.

The samples were hauled in a padded truck from the farms to commercial potato storage, where they were held for 5 days to permit mechanical defects to discolor and become more visible. A federal-state shipping point inspector then examined the potatoes to determine the kinds and amounts of mechanical defects present.[1] Mechanical defects only were considered. Shape, growth cracks, wireworm, scab, and other nonmechanical defects were disregarded. Defects were classified as grade and nongrade defects. Potatoes with grade defects had been mechanically damaged to the extent that the potatoes would grade either cull or U. S. No. 2. Potatoes with nongrade defects had been mechanically injured but not seriously enough to affect U. S. No. 1 grade.

Results of the inspection showed the amount of mechanical defects caused by digging, hauling from field, and binning. The amount attributed to each operation was determined by the differences found between operations. For example, the amount of all mechanical defects found in the samples taken from behind the digger averaged 12.1 pounds and off the field truck 13.7 pounds per hundredweight. The difference, 1.6 pounds per hundredweight, was attributed to loading on the truck and transporting to the cellar.

[1]The experimental potatoes were inspected a second time a month after digging. Results of the second inspection were almost identical to those obtained from the first inspection. There did appear to be a tendency for wet rot to change to dry rot. Whether or not this is to be normally expected is not known.

Removing from cellars

A different procedure was followed in determining the amount of mechanical damage occurring during cellar sacking and hauling from cellars to warehouses for packing and grading. Potatoes free from all mechanical defects were used for these operations. Four half-sacks of injury-free potatoes were hauled to a cellar sacking operation and carefully dumped on the cellar floor. The potatoes were forked onto the sacker and sacked by the regular crew. Mechanical damage found afterwards in these potatoes was attributed to this operation.

Damage resulting from transporting the sacked potatoes to the warehouse from the cellar was obtained also by using potatoes free from defects. Four partly filled burlap sacks of injury-free potatoes were placed on the truck while it was in the cellar and these same bags were removed at the warehouse before they had been unloaded.

The experimental potatoes were held in commercial potato storage for a period of 5 days and then were inspected under the same procedure used to obtain harvest damage.

Warehouse packing

The procedure followed was similar to that used in the cellar sacking and cellar to warehouse hauling operations. Approximately 500 pounds of potatoes free from all mechanical defects were dumped from field bags into the warehouse hopper. This was done after all other potatoes had been removed from the packing equipment. The test potatoes moved over the equipment and into bags at the head end of the sorting table and at the end of the "Size B" belt. Potatoes were not picked off the belts. After a holding period in commercial storage, the potatoes were inspected under the same procedure followed for the other tests.

Miscellaneous Information

The following information relates to the potato enterprise on the 20 farms included in the study.

Acreage of potatoes

Acres potatoes per farm	*Number of farms*
Under 10	2
10 to 20	8
20 to 30	5
30 to 40	3
40 and over	2

Fertilizer application

Information on fertilizer application was obtained on 18 of the 20 cooperating farms. Nine growers used a straight nitrogen fertilizer, usually ammonium sulfate, in addition to a more complete fertilizer. The rate of application of nitrogen for those who used it varied from 200 to 300 pounds of 21-0-0 per acre. A 200-pound application was the most common.

All 18 of the growers used a fertilizer which contained the three common elements, nitrogen, phosphorus, and potash. The heaviest application was 1,000 pounds per acre of approximately 12-12-10. The lightest application was 500 pounds per acre of 6-10-4. The most common formula used was 10-16-8 at a rate of 400 to 500 pounds per acre.

Vine elimination

Six of the 20 growers used mechanical vine beaters to eliminate vine growth. None of the growers used chemicals for vine removal.

Depth of digging

The variation in digging depths measured from the top of the row to the digger blade level was as follows:

Depth of digging	*Number of growers*
Under 7 inches	2
7 to 8 inches	8
8 to 9 inches	5
9 to 10 inches	2
10 to 11 inches	3

Distance soil carried on chains

This represents an estimate of the point on the digger chain at which most of the soil, except clods, had fallen through the chain. It varied as follows:

Distance soil carried on chain	*Number of growers*
¼ way	10
½ way	9
¾ way	1

Shakers

The number of sets of shakers or kickers used, without regard to their size or location on the equipment, is shown below.

Number of sets	*Number of growers*
1	6
2	11
3	3

Ground speed of tractor

The ground speed of the tractor was recorded at the location in the field from which the experimental field samples were obtained. Tractor speeds observed for the different types of diggers used were as follows:

Speed of tractors in miles per hour	*Number of 1-row diggers*	*Number of 2-row diggers*	*Number of 1-row combines (sackers)*	*Total number of diggers*
1.0 to 1.5	2	3	1	6
1.5 to 2.0	2	5	1	8
2.0 to 3.0	3	3	0	6

Temperature

Temperatures of the tubers were recorded immediately following digging and at time of bin filling. In addition, the outside air temperature at time of digging and cellar temperature at time of bin filling were taken.

Temperatures of tubers recorded immediately after digging were as follows:

Tuber temperature	*Number of growers*
40 to 45 degrees	7
45 to 50 degrees	7
50 to 55 degrees	3
55 to 60 degrees	2
Unknown	1

The temperature of tubers taken in cellars at time of bin filling was as follows:

Tuber temperature	*Number of cellars*
40 to 45 degrees	1
45 to 50 degrees	5
50 to 55 degrees	5
55 to 60 degrees	3
60 to 65 degrees	4
65 to 70 degrees	----
70 to 75 degrees	1
75 to 80 degrees	1

The temperature of the outside air at time of digging varied as shown below:

Air temperature	*Number of growers*
40 to 45 degrees	3
45 to 50 degrees	8
50 to 55 degrees	4
55 to 60 degrees	1
60 to 65 degrees	1
65 to 70 degrees	----
70 to 75 degrees	----
75 to 80 degrees	1
80 to 85 degrees	1
Unknown	1

The variation in temperature of the air in the cellars at time of bin filling was as follows:

Air temperature	*Number of cellars*
45 to 50 degrees	3
50 to 55 degrees	6
55 to 60 degrees	7
60 to 65 degrees	2
65 to 70 degrees	1
70 to 75 degrees	1

Length of time between digging and picking up

The variation in the time between digging and picking up of potatoes is shown below.

Time	*Number of growers*
None (combines)	2
15 minutes	2
30 minutes	9
45 minutes	1
1 to 2 hours	4
2 hours or more	2