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UNIVERSITY of IDAHO

COLLEGE OF AGRICULTURE

*Effects of Mechanical Injury Upon  
the Storage Losses of Russet  
Burbank Potatoes*

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IDAHO Agricultural  
Experiment Station

Department of  
Horticulture

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## Uninjured Tubers Do Not Rot

**C**AREFUL management is the most important, cheapest, and easiest method of eliminating bruising and consequent storage loss of potatoes. Following is a summary of results of a study carried out at the Aberdeen Branch Station on the relation of mechanical injury to storage losses:

1. In two-thirds of all rotten tubers examined in the storage cellar, the avenue of entrance for the rot organisms was a mechanical injury of some kind.
2. Seriously bruised tubers lost more than sound tubers. The more serious the injury the greater the moisture loss during storage. Tubers with digger-cuts lost more moisture than did tubers otherwise injured.
3. The potato tubers did not rot unless injured. The average rot-loss of tubers in each of the injury classes when compared with sound tubers was as follows: Digger cuts, 59.87 percent; serious bruises, 45.17 percent; hard bruises, 20.50 percent; slight bruises, 1.53 percent; and sound, none.
4. With slight air movement, rotting was serious but little water loss took place. More water loss took place with rapid air movement but rotting was less serious.
5. The rot-loss in field-run potatoes was ten times that of graded tubers. The loss due to rot in the graded lots was only 0.42 percent as compared to 4.30 percent for the field run tubers.
6. The rot found in field-run potatoes containing 1 percent water rot was 30 percent greater than for those containing no water rot. Potatoes with water rot lost 5.59 per cent of their original weight.
7. Three bins, which had most of the digger cuts and seriously bruised tubers removed, lost an average of 4.67 percent in total weight while in three bins of the same lots of field-run potatoes 8.01 percent weight was lost during a storage period of about 6½ months.

# Effects of Mechanical Injury Upon the Storage Losses of Russet Burbank Potatoes

WALTER C. SPARKS\*

**I**DAHO potato growers lose as much as 50 percent of their crop in storage—mostly from rots. Ramsey (1) reports that tuber rots usually constitute the principal loss by disease in storage and that most of these rots start in injuries made during harvesting and storing. In Nebraska, Werner (3) points out that minor injuries serve as starting points for more serious situations, such as browning in the field or shed, or rotting in storage or transit. Schrupf (2), in Maine, states that the amount of major injury increased by an average of 2.55 percent the loss in storage. He attributed a large portion of this increase to the development of major injuries from minor injuries during the storage period. The studies reported herein were conducted to determine the effects of mechanical injury and air movement through the tubers upon the amount of rot and other storage losses incurred during the storage season.

## Entrance of Tuber-Rotting Organisms

During the winter of 1948-49, a total of 476 tubers which were still firm were collected from six different storage cellars, carefully washed, examined, and classified as to the source of damage and compared with undamaged tubers. The types of tubers were classified as follows:

**Digger Cuts.**—Any injury caused by the digger point during the digging operation. Tubers illustrating various types and degrees of digger cuts are shown in Figure 1.

**Serious bruises.**—Those bruises which are serious enough to cause the tuber to be classified as a cull by Federal-State inspection standards. These injuries may be caused by the potato hitting against chains, being caught in the digger, smashed by half-sacks, stepped on, or anything else which might cause a tuber to be thrown out, other than by being cut by the digger. Tubers of this type are shown in Figure 2.

**Hard bruises.**—Injuries which are hard enough to break off knobby second-growth, to cause surface cracks greater than  $\frac{1}{2}$  inch in length, or break the skin and remove a small portion of the flesh of the tuber, but which does not cause a pare-away of greater than 5 percent of the tuber. The tubers in this classification were not injured seriously enough to be classed as out of grade for U. S. No. 1 potatoes by the inspector unless for reasons of appearance. Several tubers of this classification are shown in Figure 3.

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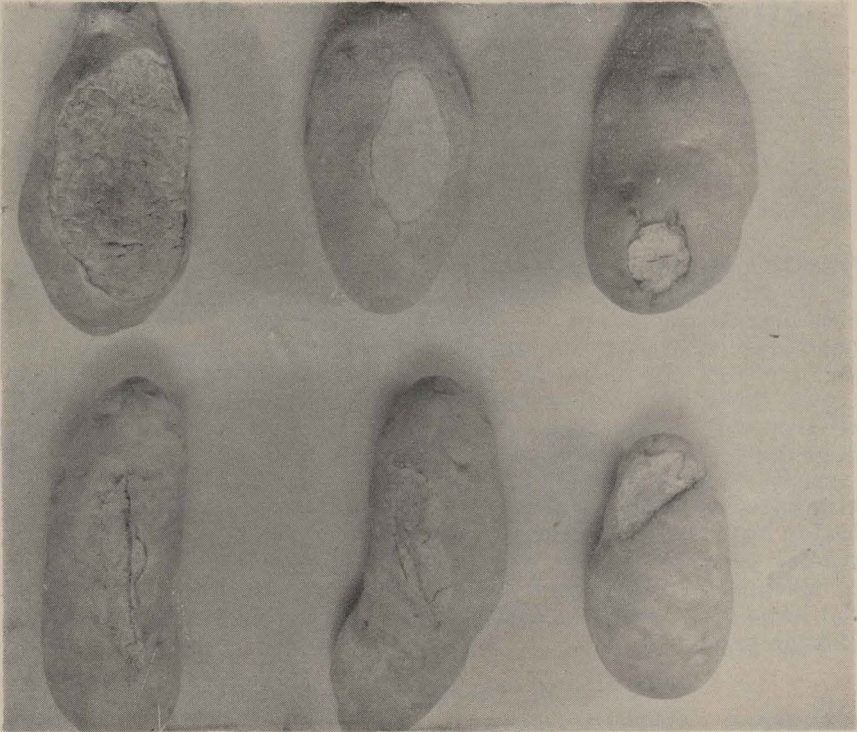


Figure 1.—Tubers showing various types and degrees of digger cuts.

**Slight bruises.**—Those injuries which appear small from the outward appearance and are not scored by the inspector. They consist of surface or “thumbnail” cracks less than  $\frac{1}{2}$  inch in length, small skinned areas, and slight indentations and discolorations. Figures 4, 5, and 6 show some slight bruises.

**Sound tubers.**—Those which have not been bruised or damaged in any way and have a skin which is unbroken.

### Rot Loss

The tubers used in 1948-49 were taken from lots grown under various conditions and harvested by several different methods. Some were harvested by hand, some by mechanical harvesters, and some by combines. In Table 1, the number of rotten tubers in each lot is shown according to the type of mechanical injury which acted as the avenue of entrance for the rot organisms. The rot organisms entered through the digger cuts in 17.4 percent of the cases, through serious bruises in 30.9 percent, hard bruises in 14.5 percent, small bruises in 3.4 percent, stem end in 2 percent, while on 31.7 percent of the tubers the entrance point of the tuber-rotting organisms could not be identified. Cuts and serious bruises, both of which are classified as culls, acted as the entrance for the rot



Figure 2.—Tubers showing injuries which were classified as serious bruises.

organisms in 48 percent of the tubers. Hard bruises acted as the infection court 12 percent of the time. The other types of mechanical injury acted as the avenue of entrance for the rot organisms in only 8.4 percent of the tubers examined. This indicates that the smaller the bruise or injury the less the chance that the organisms can enter the wound and cause rot. Even though in many cases small bruises did not cause an apparent break in the skin of the tuber, they actually did cause 3 percent of the rot.

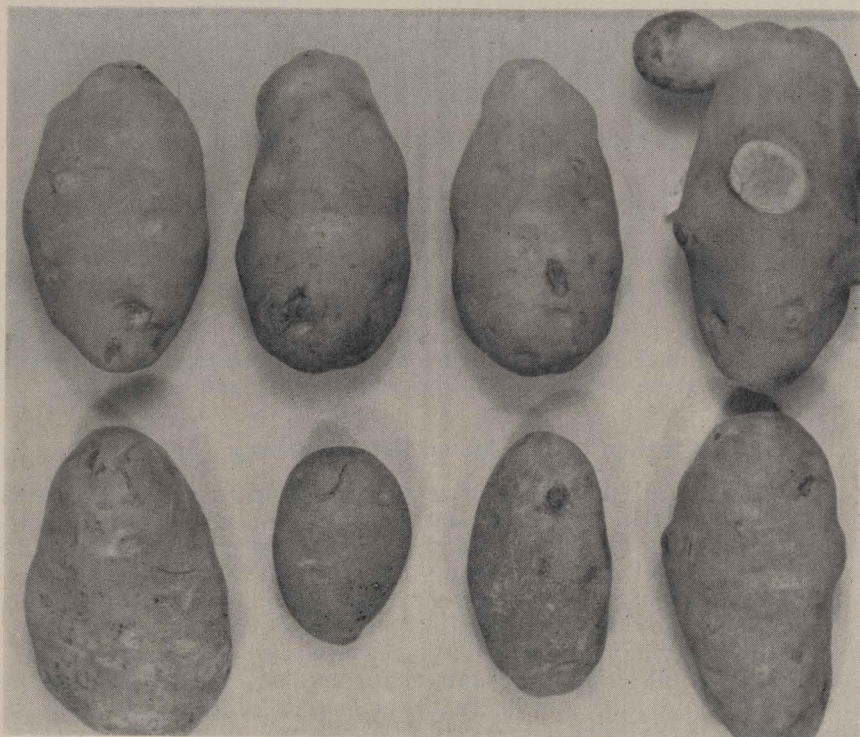
#### **Influence of Air Movement on Storage Loss**

In the fall of 1949, seventy five sacks of Russet Burbank tubers were obtained from a common source. They had been grown from certified blue-tag seed in which the disease content was low. The tubers were taken from a bin of bulk tubers, the temperature of which had been gradually lowered from 55° F. at harvest time to 40° F. by the middle of November when the various types of injured potatoes were selected and placed in open-mesh cabbage bags. On December 8, 1949, the samples were put into refrigerated chambers where differences in the amounts of air passing into, around and through the bins could be effected while the temperature was held at 38° F. and the relative humidity kept between 90

and 95 percent. The differences in air movement were effected by varying the fan speed in each room as follows: In bin No. 1 the fan was set on high to provide rapid air movement; the fan in room 2 was set on medium which provided a moderate air movement; and the fan in room 3 was set on low which provided air movement which was relatively slow.

**Table 1.**—Decayed tubers found during the 1948-49 storage season, classified by injury type.

Lot Number	Place of entrance of rot organism					Could not be Identified	Total no. Tubers
	Digger Cuts	Serious Bruises	Hard Bruises	Small Bruises	Stem-end		
1	7	20	15	4	—	22	68
2	16	18	21	4	—	17	76
3	1	8	—	—	2	1	12
4	7	48	6	1	1	19	82
5	24	34	9	3	7	47	124
6	28	19	18	4	—	45	114
Total	83	147	69	16	10	151	476
Percent of total tubers collected	17.4	30.9	14.5	3.4	2.1	31.7	



**Figure 3.**—Tubers showing injuries which were classified as hard bruises.



Figure 4.—Tubers showing injuries which were classified as slight bruises.

The 75 sacks of tubers consisted of 15 sacks of each of the five different types of mechanical injury studied in 1948-49. Five sacks of each injury-type were carefully weighed and placed in each of three bins in a 5 x 5 latin square arrangement so that each injury type would have approximately the same surface exposed to the outside and inside conditions. The samples on the border of the stack had no sacks on one side, whereas the sacks inside the stack or pile had sacks of tubers on all four sides. This was done with the expectation that each injury-type would have an equal amount of internal and external exposure and that any difference which might arise due to the different amount of exposure could be determined.

### Moisture Loss

Table 2 shows the summaries of the percentages of moisture lost from the various injury-types at each of the three fan speeds. It shows that there were significant\* differences in the amounts of moisture lost among the various types of injury. There was no significant difference between the amount of moisture lost from

\* As used in this publication, "significant" is a statistical term used to compare averages. It means that the odds are 19 to 1 that the difference is due to treatment and not to chance. That is, if the experiment were repeated 20 times under the same conditions, similar results would be obtained in at least 19 of them.



Figure 5.—A close-up of a slight bruise before peeling.

tubers having digger cuts and serious bruises, but these two types of injury caused significantly more moisture loss than did any of the other injury-types. The hard bruises did not cause significantly more moisture loss than the slight bruises but they did result in significantly more loss than occurred in the sound tubers. The sound tubers did not lose significantly less moisture than those having slight bruises but did lose significantly less moisture than any of the other types of injury.

Table 2 also shows the differences in the amounts of moisture lost at each fan speed. With the low fan speed and accompanying percentage loss of 3.02 percent, least moisture was lost from the tubers. The medium speed with a 4.74 percent loss had the most. The moisture losses were significantly different from each other and varied with fan speed. The rapid air movement (high fan speed) caused a loss of 3.96 percent, which was significantly less than that lost at medium fan speed, but was significantly more than that lost at low fan speed.

In the bin having rapid air movement, the mean percentage of moisture lost from the external sacks in the 5 x 5 latin square was 3.90 and that of the internal sacks was 3.81. In the bin with moderate air movement, the mean percentage moisture lost from the external sacks was 4.84 and the internal sacks 4.46. In the bin having slow air movement, there was a 3.50 percent moisture loss from the external sacks and a 2.88 percent loss from the internal sacks. The internal sacks of all three bins lost an average of 3.72 percent moisture, whereas the external sacks lost an average of 4.01 percent. This difference was not significant.

### Rot Loss

The data on the effects of various types of injuries and the various fan speeds on the percentages of Russet Burbank potatoes developing rot during the 1949-50 storage season at the Aberdeen



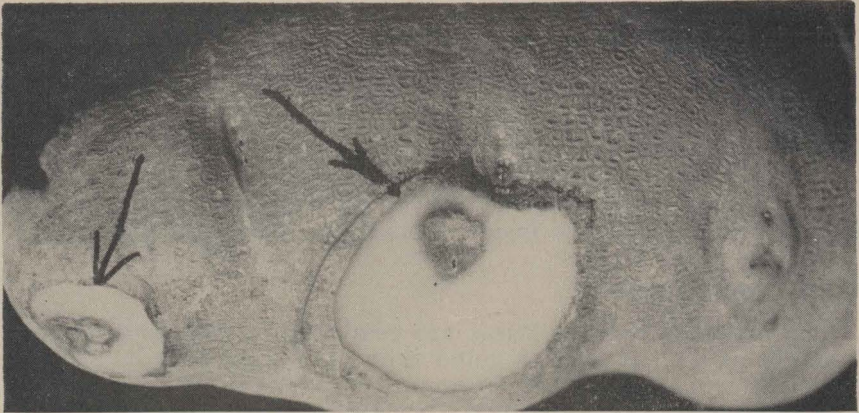


Figure 6.—The same tuber as in Figure 5 after peeling showing the darkened and necrotic tissue under the bruised areas.

Branch Station are shown in Table 3. Nearly 60 percent of the digger-cut tubers developed rot, 45 percent of the tubers having serious bruises rotted, 20 percent of the hard bruises showed rot, and 1.53 percent of the slight bruises showed decay. In all of the 15 sacks of sound tubers not one rotted tuber was found. This

Table 2.—The effect of various types of injuries and various fan speeds (air movement) on the percentage of moisture lost from Russet Burbank potatoes.

Injury type	Percent moisture lost			
	fan speed (air movement)			
	High percent	Medium percent	Low percent	Mean percent
Digger cut	7.01	7.60	4.84	6.49
Serious bruise	5.63	6.81	4.87	5.79
Hard bruise	2.82	3.48	2.06	2.79
Slight bruise	2.35	3.30	1.98	2.54
Sound	1.97	2.49	1.32	1.93
Mean moisture lost at fan speeds	20.79	22.42	33.03	
L.S.D.* 5% fan speeds	0.71	Injury types 0.79		
1% fan speeds	0.95	Injury types 1.06		

\* Difference between means required to be significant at odds of 19.1 (5%) and 99.1 (1%).

demonstrates that if tubers are not injured in any way the loss from rot is nil. It supports the prevailing idea that rot does not enter tubers through a sound, unbroken skin, and also that the more serious the injury the more rot loss can be expected during storage. From Table 3 it will be noted that slow air movement resulted in significantly more rot taking place than did either the rapid or moderate air movement. There was no significant difference in moisture loss between the rapid and moderate air movements.

The percentages of tubers lost by rot in internal and external sacks in the three bins are as follows:

	High	Moderate	Slow	Mean
External .....	18.48	24.45	33.99	25.64
Internal .....	23.33	20.53	31.88	25.25

This shows little difference in the mean percentage of rot loss between the outside and inside sacks at the three fan speeds.

### Total Storage Loss

The moisture and rot losses are combined to give total storage loss (Table 4). It will be noted that the digger cuts had by far the highest percentage of storage loss, slightly over 66 percent. The serious bruises had a mean storage loss of approximately 51 percent, hard bruises 23 percent, slight bruises 4 percent, and sound tubers less than 2 percent. From this it can be seen that the amount and degree of injury in a lot of potatoes have a great deal to do with the volume of good potatoes which are taken out of the cellar.

Rapid air movement (high fan speed) resulted in significantly less total storage loss than did low fan speed but was not significantly different from the medium fan speed. This indicates that even though rapid and medium air movement caused moisture losses significantly greater than did slow air movement, there was significantly less rot in these two treatments and also significantly less total loss.

The mean percentage of total storage loss for the outside and inside sacks in each of the three rooms is as follows:

	High	Moderate	Slow	Mean
External .....	22.51	29.19	37.29	29.66
Internal .....	27.14	24.98	34.66	28.93

**Table 3.—The effect of various types of injuries and various fan speeds on the percentage of rotten tubers from storage.**

Injury type	fan speed (air movement)			
	High	Medium	Low	Mean
	percent No.	percent No.	percent No.	percent No.
Digger cuts	55.06	58.12	66.43	59.87
Serious bruise	27.93	43.14	64.44	45.17
Hard bruise	20.44	9.63	31.45	20.50
Slight bruise	0.54	1.23	2.82	1.53
Sound	0.00	0.00	0.00	0.00
Mean moisture loss at fan speeds	20.79	22.42	33.03	
L.S.D.* 5% fan speeds	4.89	Injury types 6.23		
1% fan speeds	6.56	Injury types 8.35		

\* Difference between means required to be significant at odds of 19.1 (5%) and 99.1 (1%).

**Table 4.—The effect of various types of injuries and various fan speeds on total storage loss in Russet Burbank potatoes.**

Injury type	fan speed (air movement)			
	High percent wt.	Medium percent wt.	Low percent wt.	Mean percent wt.
Digger cut	62.08	65.72	71.28	66.36
Serious bruise	33.61	49.95	69.31	50.96
Hard bruise	23.26	13.11	33.49	32.29
Slight bruise	2.86	4.56	4.81	4.07
Sound	1.97	2.49	1.32	1.93
Mean	24.75	27.17	36.04	
L.S.D.* 5% fan speeds	5.28	Injury types 6.81		
1% fan speeds	7.07	Injury types 9.14		

\* Difference between means required to be significant at odds of 19.1 (5%) and 99.1 (1%).

This shows that there is very little difference between the mean total storage losses occurring on the inside and outside of the stack.

### Storage Losses of Graded and Field-run Potatoes

#### TRIAL NO. 1

The preceding results show that storage of tubers which have been seriously bruised or cut by the digger blade results in storage losses of 51 and 66 percent respectively, but in these samples all the tubers in any one sack were injured by an equal amount. Since this situation does not exist in the ordinary storage, it was deemed desirable to determine storage loss in a commercial storage cellar where the digger cuts and seriously bruised tubers had been removed. These were compared to field-run tubers containing no water rot and to field-run potatoes which contained 1 percent water rot.

During the 1950 harvest season, 8 sacks of each of 3 lots of tubers were selected from potatoes of a common source. One lot was graded so that all tubers having digger cuts and serious bruises were removed and only U.S. No. 1 tubers remained. The graded tubers were then put into open-mesh bags and weighed at 100 pounds net. Each of the other two lots contained field-run potatoes, one with water rot, the other without. The field-run and field-run plus 1 percent water rot potatoes also were put into open-mesh bags and weighed at 100 pounds net. One sack of each of the three grades was put in the center of eight different bins of potatoes at harvest time and then removed the next April when the potatoes were taken out of storage. The percentage of weight lost because of rot and moisture was determined.

#### Moisture Loss

The data from the comparison between field-run and graded tubers are given in Table 5. Graded tubers lost 3.26 percent moisture while the field-run tubers lost 4.57 percent. This difference was significant. The field-run or ungraded tubers lost significantly

less moisture than the field-run tubers containing 1 percent water rot which lost 5.36 percent.

### Rot Loss

The percentage of weight lost from rot was only 0.42 for the graded tubers and was significantly less than that occurring in the other two classes (Table 5). The field-run or ungraded tubers had 4.30 percent rot and the ungraded tubers containing 1 percent water rot had 5.59. These were not significantly different from each other.

### Total Storage Loss

The total storage loss (rot plus moisture) for the graded tubers was only 3.68 percent while the ungraded or field run lots lost an average of 8.86 percent and the field-run tubers containing 1 percent water rot lost 10.95 percent. Each of these is significantly different from the other, showing that field-run tubers lost twice as much during storage as graded tubers and that field-run tubers having water rot present lost three times as much as graded tubers. Therefore, in order to reduce storage losses to a minimum, all tubers containing serious bruises or digger cuts should be removed before putting the potatoes into the storage cellar.

### TRIAL NO. 2

To further test the effect of grading tubers upon the percentage of loss occurring during storage, 54 sacks of graded tubers were selected, weighed and placed at 18 different positions in each of three different type bins containing graded tubers. These were compared with 54 weighed sacks of ungraded or field-run tubers which were placed at comparable positions in duplicate bins filled with ungraded potatoes.

### Moisture Loss

Table 6 shows the mean percent moisture, rot, and total storage losses of the graded and ungraded tubers. The graded tubers stored significantly better than did the ungraded tubers. The graded tubers lost an average of 0.8 percent less moisture than did the ungraded lots.

### Rot Loss

The difference between graded and field-run tubers in the amount of rot occurring during the storage season was very marked. The graded lots had an average of only 1 percent rot whereas the ungraded lots had an average of 3.62 percent. This included both wet and dry rot. Eleven of the 48\* sacks of graded tubers had no rot at all while each of the 48\* ungraded sacks contained some rot.

\* Tubers were lost from 6 of the 54 pairs of sacks; therefore, only 48 pairs were used in the analysis.

**Table 5.—The average percent storage loss in Russet Burbank potatoes as influenced by grading.**

Grading Procedure	Moisture	Rot	Total
	Percent wt.	Percent wt.	Percent wt.
Graded	3.26	0.42	3.68
Ungraded	4.57	4.30	8.86
1% water rot	5.36	5.59	10.95
L.S.D.*5%	0.63	1.81	2.07
1%	0.87	2.52	2.88

\* Difference between means required to be significant at odds of 19.1 (5%) and 99.1 (1%).

### Total Storage Loss

In total storage losses, the ungraded tubers lost an average of 8 percent while the graded lots lost only 4.67 percent. These differences are far greater than that required for significance (Table 6).

### Discussion

These data point out that the more serious the mechanical injury inflicted upon the tubers at harvest time, the greater the loss during the storage period. They show that more than 48 percent of all the rotten tubers examined had digger cuts or serious bruises. Almost 18 percent of all rotten tubers would have graded U.S. No. 1, but, because of the small bruises present, they rotted during the storage period. This means that even though care is used in digging and handling, rotten tubers may occur because of the amount of mechanical injury which is present in the tubers at the time they are put in storage. Even though the "stem-end" of the potato was the court of infection in 3 percent of the rotten tubers it is not listed as a mechanical injury.

All lots of injured potatoes lost a large percentage of their original weight through rot, whereas sound tubers had no rot. The more serious the injury the greater the rot loss. For instance, slightly bruised tubers lost 1.5 percent of weight due to rot while digger-cut tubers lost almost 60 percent. The data on the effect of fan speed upon the total storage loss show that, even though slow air movement resulted in lowest moisture losses, the greatest total storage loss was encountered here because of the large numbers of tubers that rotted during the storage period. A partial explanation of this is that the low fan speed resulted in the highest relative humidity, whereas at the medium and high speeds, it was difficult to keep the relative humidity up to 85 or 95 percent. Even with automatic humidifiers in the bins, the relative humidity varied considerably among bins. If it had been possible to control relative humidity more accurately the percentage of rot loss at the three fan speeds might have been different. The fact that the sacks on the outside of the pile lost very little more moisture than the inside sacks indicates that the relative humidity was high enough to reduce moisture loss to a minimum.

**Table 6.—The average percent storage loss of Russet Burbank potatoes as influenced by grading.**

Type of tubers	Moisture loss	Rot loss	Total*
	Percent wt.	Percent wt.	Percent wt.
Ungraded	4.36	3.62	8.01
Graded	3.56	1.00	4.67
L.S.D. <sup>1</sup> 5%	0.35	1.49	0.57
1%	0.46	2.00	0.76

\* Includes moisture, rot, and sprouts.

<sup>1</sup> Difference between means required to be significant at odds of 19.1 (5%) and 99.1 (1%).

Because of the increased speed in modern methods of harvesting, it would seem advisable to place a person in the cellar to remove all badly damaged tubers before they go into the storage bin. This would be particularly good business if any water rot were present. As pointed out in Table 5, graded tubers lost an average of only 3.68 percent of their weight during storage, whereas field-run or ungraded tubers lost 8.86 percent, or more than twice as much in the same period of time. This difference of 5.18 percent storage loss would easily pay the wages of a person to remove tubers with digger cuts and serious bruises. If a person harvests 1000 sacks of potatoes a day, he could save as much as 50 sacks of potatoes a day by having someone in the cellar removing the badly damaged tubers.

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