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*College of Agriculture*

# Estimating Hail Injury In Potatoes

WALTER C. SPARKS  
GEORGE W. WOODBURY  
FRANK H. TAKATORI

*Department of Horticulture*

IDAHO Agricultural  
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No defoliation



25 percent defoliation

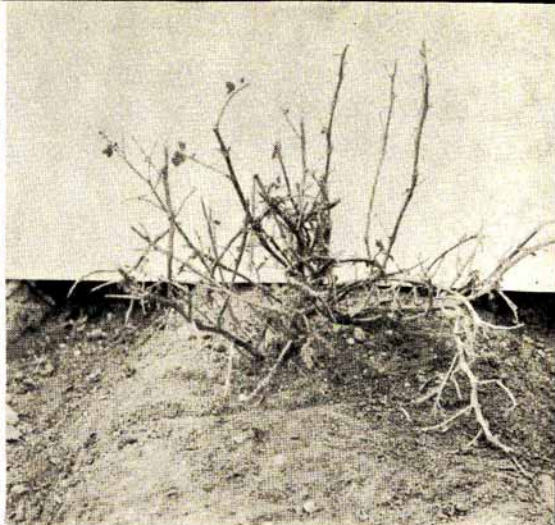
Figure 1.—Russet Burbank potatoes showing various stages of defoliation.

## Summary

1. The loss of 25 percent or more of the foliage reduced the total yield and yield of U. S. No. 1 tubers.
2. As the amount of foliage removed increased, the percentage loss in yield of U. S. No. 1 tubers increased.
3. Defoliation when the plants were in the full-bloom stage of growth caused a greater loss in yield of U. S. No. 1 tubers than defoliation at any other stage.
4. The greatest loss in yield of U. S. No. 1 tubers occurred when the plants were defoliated 100 percent at the full-bloom stage of growth.
5. The percentage loss in yield of U. S. No. 1 tubers increased as the plants developed to the 100 percent full-bloom stage, then decreased as the plants developed beyond this stage.
6. Removal of any amount of foliage at any stage of growth resulted in smaller sized tubers.
7. The later in the development of the plant that defoliation took place, the less the starch content of the tubers, regardless of the amount of foliage removed.
8. Two early varieties, Early Gem and Bliss Triumph, reacted to defoliation in a manner similar to the Russet Burbank variety.
9. Data from the Katahdin and Menominee varieties are variable, and for one season only; therefore, are not considered as being significant.



50 percent defoliation



100 percent defoliation

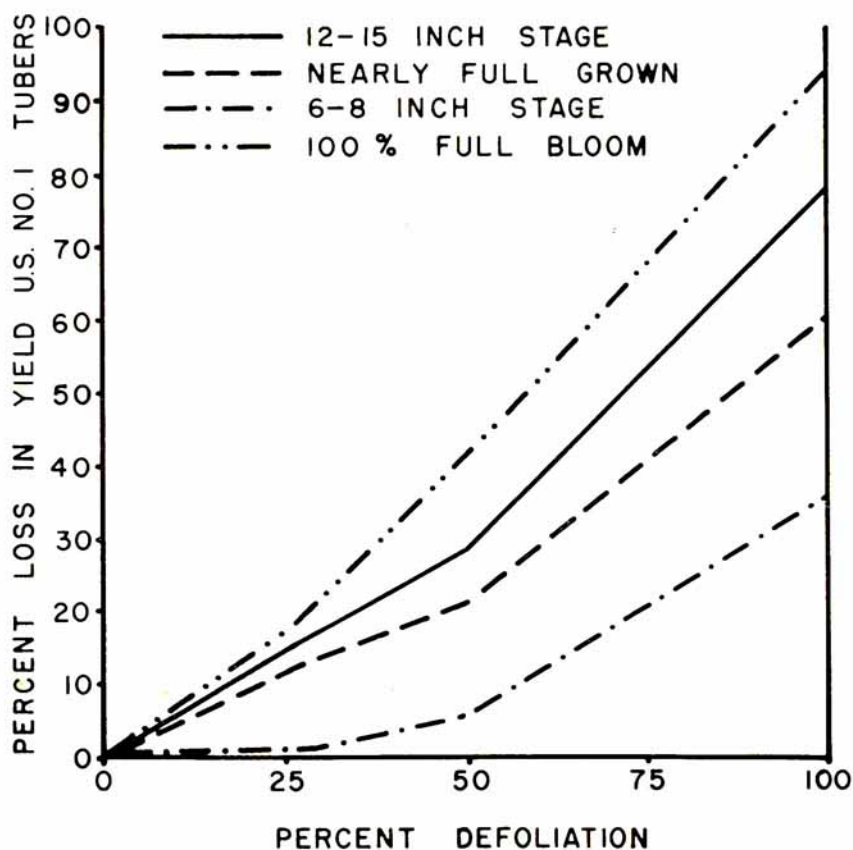


Figure 2.—Percent loss in yield of U. S. No. 1 Russet Burbank potatoes due to simulated hail injury at four stages of growth.

**T**HIS bulletin, the second on this subject from the Idaho Station, reports the results of investigations since 1950 and offers a reliable basis upon which hail loss estimates may be made. The authors believe that careful use of this information will result in general agreement among all parties concerned.

Acknowledgment is made to the Regional Hail Adjustment and Research Association of Chicago, Illinois, for its part in contributing funds for implementation of this work and for publication of the results.



# Estimating Hail Injury In Potatoes

WALTER C. SPARKS, GEORGE W. WOODBURY and FRANK H. TAKATORI<sup>1</sup>

**H**AIL occurs frequently in many parts of Idaho and in some cases causes considerable damage to potato plants by defoliation and mutilation of the stems. Hail insurance has been available for many years as protection against such losses. However, settlement of claims has been a matter of arbitration between the farmer and the insurance company. It is believed that the information presented in this bulletin will provide a systematic method of estimating losses resulting from hail damage.

## Materials and Methods

### Culture

Potatoes for these studies, at both Aberdeen and Lewiston, were grown according to accepted practices for potato production in the respective areas. No special treatments with respect to fertilizers, irrigation, or general management were used which might have biased the data. For all practical purposes, these were commercial potatoes, except that, of necessity, they were divided into plots for treatment and observation. Plots were 50 feet long and one row wide, with some variation in the years 1951 and 1952. At least five replications were used for all treatments. Digging, handling, and grading were according to standard practices. Grading was done according to standards set forth in *Official Grades for the Standardization of Idaho Fruits and Vegetables*; State of Idaho, Department of Agriculture, 1947.

### Experimental Procedure

Treatments used in these experiments were based upon the logical assumption that losses would result according to the amount of plant damage sustained, the time of such damage, or an interaction between the two.

In each year except 1950, there were at least 13 treatments consisting of a check with no defoliation, 25 percent defoliation, 50 percent defoliation, 100 percent defoliation (Figure 1), and 25 percent defoliation at a given date plus an additional 25 percent

<sup>1</sup> Associate Horticulturist, Horticulturist, and formerly Research Fellow, respectively, Idaho Agricultural Experiment Station.

defoliation two weeks after the first defoliation, each at three stages of plant growth. The first defoliations were made when the plants were between 6 inches and 8 inches high. The date at which this stage of growth was reached varied with variety and season and in these trials ranged from 35 to 55 days. The second treatments were made when the plants were from 12 inches to 15 inches high and were beginning to bloom. This was also the stage of growth at which the tubers were beginning to form and ranged from 48 to 70 days after planting. The third series of defoliations was made when the plants were nearly full grown and past the full-bloom stage, with most of them just finishing blooming. This stage of growth was reached from 72 to 97 days after planting.

The 1950 trial did not include the 100 percent defoliation treatment, but included each of the other 10 treatments.

In each of the two years, 1952 and 1953, two trials were conducted. In 1952, one trial was planted on May 14 and a second on June 3. In 1953, one planting was made at the usual 36-inch row spacing and a second trial including the Early Gem, Menominee, and Russet Burbank varieties was planted in 30-inch rows.

Three additional treatments were included in one series of the 1953 trials. These were 100 percent defoliation when the plants were 50 percent in bloom, 100 percent defoliation when the plants were 100 percent in full bloom, and 100 percent defoliation when the plants were 50 percent past full bloom.



Figure 3.—Type of beater used to simulate hail injury.



In 1954, the defoliation treatments were 25 percent, 50 percent, 75 percent, and 100 percent removal and the stages of growth were at 50 percent full bloom, 100 percent full bloom, and 50 percent past full bloom, or the same as the extra treatments in 1953.

Two trials were carried on at Lewiston, one in 1952 and one in 1953. The planting in 1952 was on April 25 with the variety Katahdin. In 1953, the Bliss Triumph variety was used and planted on April 21. In all, there were seven trials with the Russet Burbank variety of potato and three with other varieties.

In the trials of 1950 and 1951, the foliage was removed by hand and by a beater. In all trials after 1951, the foliage was removed by beater only. The beater consisted of several No. 9 wires welded to a handle. At the ends of the wires, nuts of varying sizes were loosely attached (Figure 3). The plants were flayed with this beater until the desired amount of foliage was removed. The usual procedure of defoliating was to strike across the top and on both sides of the plants. This method provided stem injury similar to that resulting from a hail storm. In many instances portions of stems and sometimes entire branches were broken off.

## Experimental Results

The effects of type of defoliation and speed of recovery have been discussed previously<sup>1</sup> and will not be included here. The results discussed here include: (1) combined data from six trials with the Russet Burbank variety, (2) the data from the 1954 trials which cannot be compared directly with any other year because of the different stages of growth when defoliation occurred, and (3) three trials with other varieties. The data from the six trials on Russet Burbank will be discussed first.

### EFFECT OF SIMULATED HAIL INJURY AT THREE STAGES OF GROWTH ON THE PRODUCTION OF RUSSET BURBANK POTATOES

#### Total Yield

The loss in total yield due to defoliation is shown in Table 1 and Figure 4. The percentage of defoliation increased, the loss of yield increased. At the 6- to 8-inch stage of growth the loss of total yield when 25 percent of the foliage was removed amounted to 7.1 percent, whereas the loss of 50 percent of the foliage at this same stage of growth resulted in a yield reduction of 12.9 percent. The removal of 100 percent of the foliage when the plants were 6 to 8 inches tall resulted in a loss of 36.5 percent of the total yield.

<sup>1</sup> Takatori, Frank H., Sparks, Walter C. and Woodbury, George W. 1952. A Study of Simulated Hail Injury in Potatoes. University of Idaho Agricultural Experiment Station Research Bulletin No. 22.

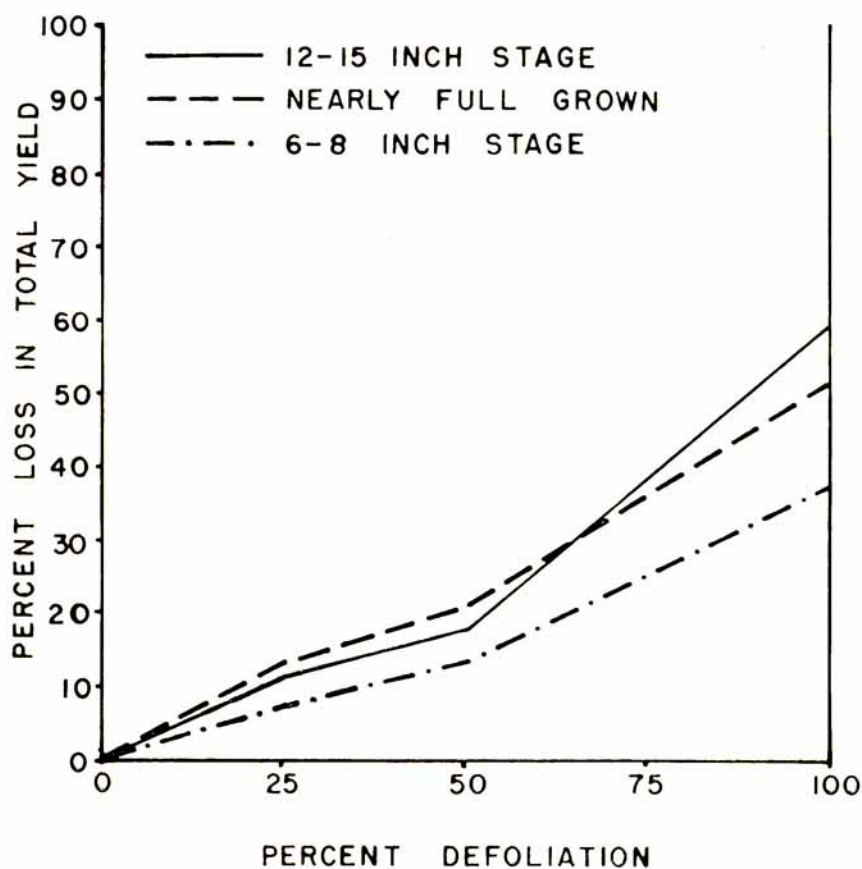


Figure 4.—Effect of defoliation on the total yield of Russet Burbank potatoes.



When the plants were defoliated at the 12- to 15-inch stage and just beginning to bloom, the loss in total yield was greater than on earlier treatments. When 25 percent of the foliage was removed there was a loss of 11.3 percent of the total yield. The removal of 50 percent of the foliage at this stage of growth resulted in a 17.5 percent loss in total yield and when 100 percent of the foliage was knocked off, the total yield was reduced by 58.3 percent.

Defoliation of the plants after they had reached full growth and blooming was almost over, caused a reduction in total yield almost equal to the reduction occurring when the plants were just beginning to bloom. The removal of 25 percent of the foliage resulted in a yield loss of 12.4 percent. The loss in yield amounted to 20.3 percent when 50 percent of the foliage was removed and 50.9 percent when the plants were 100 percent defoliated (Table 1).

The double defoliation treatments, 25 percent of the foliage removed and then 2 weeks later 25 percent more removed, resulted in yields similar to those effected by the removal of 50 percent of the foliage at one time.

Table 1 shows that the total number of tubers was reduced by 4.5 percent when 25 percent of the foliage was removed at the 6- to 8-inch stage, but the number of tubers grading U. S. No. 1 actually increased by 2.2 percent. This indicates that even though the total number of tubers was reduced, a greater percentage of the remaining tubers became larger than 2 inches in diameter, thus resulting in more No. 1 tubers than obtained from the no-defoliation treatment. Foliage removal at the 12- to 15-inch stage caused a greater reduction in number of tubers than when foliage was removed at any other stage of growth. The average percent loss in the number of tubers when defoliated at the 12- to 15-inch stage was 13.5 as compared to 9.8 at the 6- to 8-inch stage and 8.5 at the full-grown stage.

### **U. S. No. 1 Tubers**

The greater the amount of foliage removed, the greater the loss in yield of U. S. No. 1 potatoes, regardless of the stage of growth at the time of foliage removal. This is readily shown in Table 1 and Figure 5. The loss in yield of U. S. No. 1's when 25 percent of the foliage was removed and the plants were only 6 to 8 inches high was only 1.8 percent, whereas there was a 7.0 percent loss when 50 percent of the foliage was removed, and a 37.2 percent loss in yield when all the foliage was removed.

When the plants were 12 to 15 inches tall and just beginning to bloom, the reduction in yield of U. S. No. 1 potatoes was 15.4 percent with 25 percent of the foliage knocked off. When 50 percent of the foliage was removed at this stage of growth, the yield of U. S. No. 1 tubers was reduced by 29.3 percent. The removal of 100 percent of the foliage at the 12- to 15-inch stage resulted in a yield reduction of 81.0 percent of the U. S. No. 1 tubers.

Table 1. Effect of various amounts of simulated hail injury at three stages of growth upon the yield, grade, and quality of Russet Burbank potatoes.

Defoliation treatment	U. S. No. 1				Total		U. S. No. 2		Percent	
	Yield		Ave. size		Yield		Yield		Starch	
	Percent loss	Percent decrease	oz.	Percent loss	Percent decrease	oz.	Percent loss	Percent increase	Yield	Starch
No defoliation	0.0	0.0	6.06	0.0	0.0	5.06	0.0	0.0	15.52	
25% 6-8"	1.8	-2.2	6.02	7.1	4.5	4.91	0.4	- .3	15.62	
25% 12-15"	15.4	8.7	5.86	11.3	4.6	4.80	24.6	8.6	15.62	
25% Full growth	13.4	3.5	5.55	12.4	3.4	4.59	12.5	7.8	14.96	
50% 6-8"	7.0	1.9	5.89	12.9	7.8	4.74	-4.9	5.1	15.71	
50% 12-15"	29.3	26.5	5.89	17.5	11.7	4.74	45.0	16.2	14.56	
50% Full growth	22.5	11.2	5.47	20.3	4.5	4.34	3.0	25.8	14.36	
100% 6-8"	37.2	19.3	5.65	36.5	15.9	4.34	1.9	29.9	14.79	
100% 12-15"	81.0	58.8	4.96	58.3	24.5	3.46	79.6	123.3	13.81	
100% Full growth	63.6	27.9	4.94	50.9	17.5	3.82	23.1	87.5	12.08	
25 + 25% 6-8"	7.7	10.2	6.05	12.5	11.1	4.91	3.6	-1.4	15.58	
25 + 25% 12-15"	30.3	42.7	5.54	20.9	13.1	4.50	34.8	25.3	15.00	
25 + 25% Full growth	20.0	31.7	5.06	19.5	8.5	4.00	6.7	17.7	14.90	



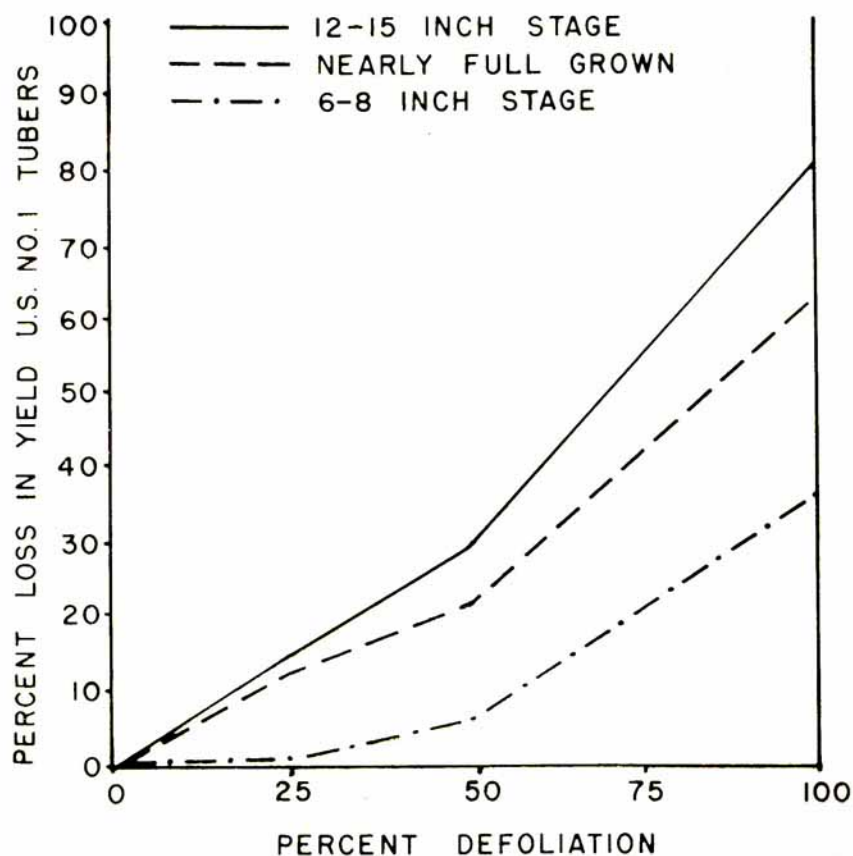


Figure 5.—Percent loss in yield of U. S. No. 1 Russet Burbank potatoes due to simulated hail injury at three stages of growth.

At the full-grown stage, which approximates the cessation of bloom, the reduction in yield of U. S. No. 1 potatoes was not as great as when the plants were in bloom (12- to 15-inch stage) but greater than when the plants were only 6 to 8 inches tall. At the full-grown stage, a foliage removal of 25 percent resulted in a yield decrease in U. S. No. 1 tubers of 13.4 percent. When half the foliage was knocked off, a 22.5 percent loss resulted and when all the foliage was removed the loss amounted to 63.6 percent.

From this it can be seen that if the plants are defoliated when they are in bloom the loss in yield of U. S. No. 1 potatoes is high. It can also be seen that the more foliage lost at any stage of growth, the greater will be the loss in yield.

In one series of treatments, 25 percent of the foliage was removed at the regular time of defoliation and then another 25 percent of the foliage was removed from these same plants 2 weeks later. As can be seen from Table 1, the 25 plus 25 percent treatment resulted in yield losses of U. S. No. 1 potatoes almost identical with the 50 percent treatment and for all practical purposes can be considered as producing the same effects.

Yield, of course, is dependent upon both number and size of tubers and data have been recorded in both of these categories. The results are not the same from all treatments.

Defoliating the plants at the 12-to 15-inch stage, which is at about the beginning of bloom and tuber setting, resulted in the greatest percent decrease in the number of U. S. No. 1 tubers (Table 1). A study of this fact has revealed that when the plants are defoliated, any tubers on these plants which are less than about  $\frac{1}{2}$  inch in diameter are resorbed by the plant. Tubers larger than  $\frac{1}{2}$  inch in diameter do not seem to be resorbed. This can partially explain the fact that the 25 plus 25 percent defoliation resulted in a much greater loss in the number of U. S. No. 1 tubers than did the 50 percent treatment even though the mean yield of the two treatments was almost identical. The 25 plus 25 percent treatment was the only one which resulted in a greater percent decrease in number of tubers than in yield. Even though the 25 plus 25 percent defoliation treatment at the full growth stage resulted in fewer tubers, there was a 40-percent greater mean yield than in the 100-percent defoliation treatment at the same stage of growth.

When the plants were defoliated at the 6- to 8-inch stage there were a few more U. S. No. 1 tubers produced than there were on the non-defoliated plants. The other treatments gave approximately the same curve on number of tubers as they had on the yield. That is, there was a much greater decrease in number at the 12- to 15-inch stage than at either the 6- to 8-inch or full grown stages.

Defoliation of the plants when they were nearly full grown resulted in smaller U. S. No. 1 tubers than defoliation at the other



## EFFECT OF SIMULATED HAIL INJURY AT THREE STAGES OF BLOOM ON THE PRODUCTION OF RUSSET BURBANK POTATOES

### 1953 RESULTS

The results obtained during the 1952 season, with two dates of planting, indicated that the most critical time for defoliation was during the bloom period. In 1953, three extra treatments were included during the bloom period in order to determine more closely the critical period of defoliation. In each of the three extra treatments, plants were defoliated 100 percent, one when the plants were 50 percent full bloom, one when all the plants were 100 percent in full bloom, and the third when the plants were 50 percent past full bloom.

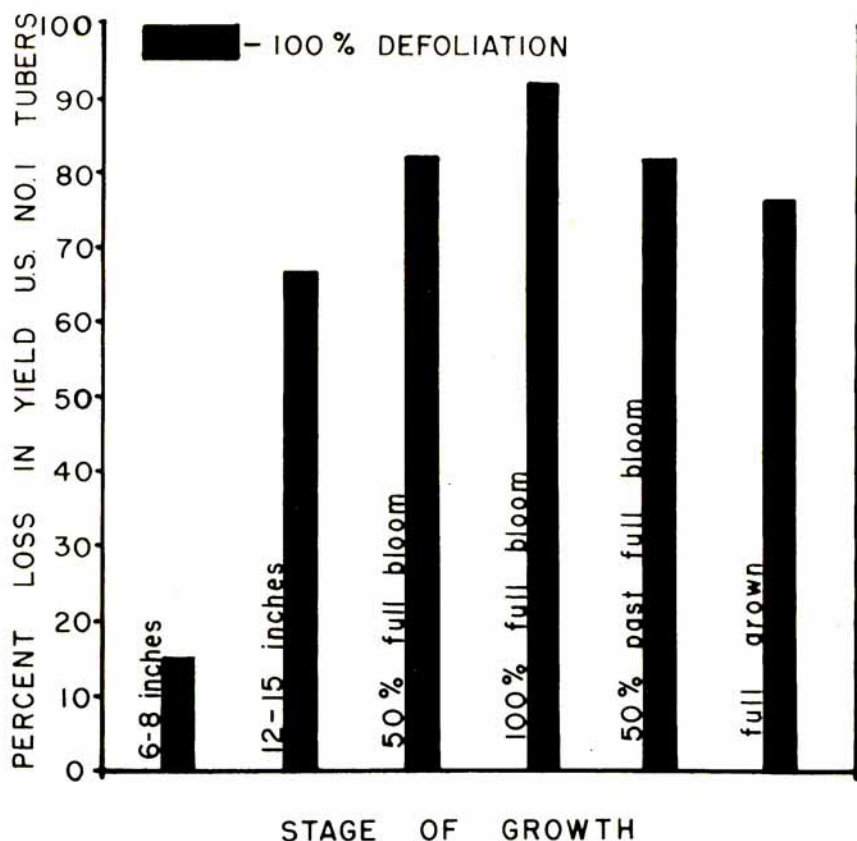


Figure 6.—Percent loss in yield of U. S. No. 1 tubers defoliated at six stages of development.

two stages of growth. The average size of U. S. No. 1 tubers ranged from 4.94 ounces when the plants were defoliated 100 percent at the full grown stage to 6.06 ounces for the non-defoliated check.

## U. S. No. 2

Defoliation when the plants were beginning to bloom caused a much greater increase in the percent of U. S. No. 2 tubers than did the removal of foliage at either the 6- to 8-inch or the full-grown stages of growth (Table 1). This increase in the yield of U. S. No. 2 tubers amounted to not less than 24.6 percent at the 12- to 15-inch stage; whereas the greatest increase in U. S. No. 2 tubers other than the 12- to 15-inch stage of growth was 23.1 percent when 100 percent of the foliage was removed at the full-grown stage.

## Undersize

All tubers under 2 inches in diameter were classed as culls in Research Bulletin No. 22, but are more correctly identified by the term *undersize*. Therefore, they will be designated as such in this paper. Table 1 gives the percent increase in yield of tubers under 2 inches in diameter.

In general, when the plants were defoliated when they were 12 to 15 inches tall and were beginning to bloom and set tubers, they produced more undersize tubers than when defoliated at any other stage of growth. The 100-percent defoliation treatments produced many more undersized tubers than any of the other treatments.

## EFFECTS OF DEFOLIATION UPON STARCH CONTENT IN RUSSET BURBANK POTATOES

The percent of starch in a tuber is a very good measure of its cooking quality. The higher the percent of starch the more mealy the tuber when cooked. The effects that defoliation had on the percent of starch in the tubers are given in Table 1.

Even though the differences were not significant, 4 of the 12 treatments actually resulted in a slightly higher starch content than the check. They were the 25, 50, and 25 plus 25 percent defoliation when the plants were only 6 to 8 inches tall, and the 25 percent defoliation treatment when the plants were 12 to 15 inches high. All other treatments resulted in a decrease in the percent of starch in the tubers.

Removal of foliage when the plants are nearly full grown causes a greater loss in starch content than when defoliation occurs at either of the other two stages of growth regardless of the amount removed. The largest loss in starch content amounted to 22.1 percent of the check if all the foliage was removed when the plants were nearly full grown.



When defoliation occurred with the plants 50 percent in full bloom, the reduction in yield of U. S. No. 1 tubers was 82.3 percent. Removal of all the foliage when the plants were 100 percent in full bloom reduced the yield of No. 1's by 92.2 percent, but when the plants were 50 percent past full bloom the loss in yield was 82.2 percent. A continuous curve to show the loss in yield of U. S. No. 1 tubers from the time the plants were 6 to 8 inches tall until they were nearly full grown can be made by using the 1953 data from the 100-percent defoliation treatments. This is shown in Figure 6. This shows that more loss occurs when the plants are 100 percent in full bloom than at any other stage of growth. Therefore, in 1954 the entire study was concentrated around the bloom stage.

**Table 2.—Effect of various amounts of simulated hail injury at different stages of bloom upon the yield, grade, and quality of Russet Burbank potatoes in 1954.**

Treatment	U. S. No. 1			U. S.		
	Yield	over 10. oz.	Total Yield	No. 2 Yield	Under- size	Starch content
	Percent decrease	Percent decrease	Percent decrease	Percent increase	Percent increase	Percent
No defoliation	.....	.....	.....	.....	.....	16.10
25% 50% bloom	16.7	59.2	6.8	14.3	27.3	16.74
25% 100% bloom	17.1	50.2	9.1	4.7	19.9	15.71
25% 50% past bloom	16.6	76.6	10.5	-26.7	29.0	15.13
50% 50% bloom	35.7	52.8	21.4	26.2	16.9	16.74
50% 100% bloom	42.6	71.9	28.2	- 2.1	23.3	15.33
50% 50% past bloom	37.3	74.6	23.2	-19.4	40.1	14.58
75% 50% bloom	45.9	65.0	26.4	6.3	30.8	15.54
75% 100% bloom	55.2	74.6	30.0	32.0	50.3	15.00
75% 50% past bloom	50.1	89.8	28.6	0.7	52.2	14.81
100% 50% bloom	90.9	100.0	54.6	35.4	75.5	14.73
100% 100% bloom	97.7	100.0	60.5	26.2	58.3	12.33
100% 50% past bloom	62.9	100.0	45.0	-83.5	53.9	12.01
L.S.D.						
5%	12.16	33.13	13.33	14.99	36.12	0.67
1%	16.11	43.93	17.66	N. S.	47.84	1.00

## 1954 RESULTS

### Total Yield

Table 2 shows the effect of various treatments on total yield of potatoes. One hundred percent defoliation at full bloom caused the greatest loss in total yield: 60.5 percent. The same defoliation at 50 percent bloom caused a 54.6-percent reduction in total yield. When plants were defoliated at 50 percent past full bloom there was a total yield loss of 45.0.

### U. S. No. 1

The removal of foliage when the plants were in full bloom caused a greater loss in yield of U. S. No. 1 tubers than defoliation at any

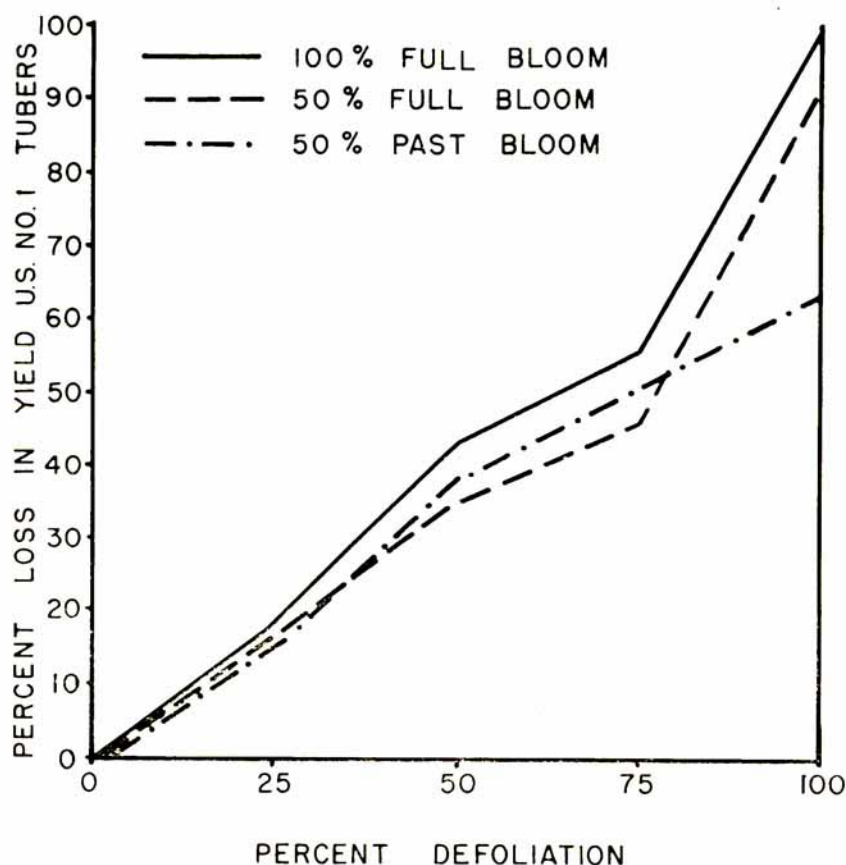


Figure 7.—Effect of simulated hail injury at different stages of bloom upon the yield of U. S. No. 1 Russet Burbank potatoes in 1954.

other stage of bloom (Table 2 and Figure 7). The removal of only 25 percent of the foliage when the plants were in full bloom caused a loss in yield of U. S. No. 1 tubers of 17.1 percent as compared to 16.7 and 16.6 percent for the other two stages of bloom.

When the plants were defoliated 50 percent at 50 percent bloom stage the loss in yield was 35.7 percent, 42.6 percent at the 100 percent full bloom stage and 37.3 percent at the 50 percent past bloom stage.

The removal of 75 percent of the foliage resulted in U. S. No. 1 yield losses of 45.9 percent at the 50-percent bloom stage, 55.2 percent at the 100-percent full bloom stage and 51.1 percent at the 50 percent past full bloom stage.



Knocking off all the foliage, or 100 percent defoliation, caused severe losses in yield of U. S. No. 1 tubers. This loss amounted to 90.0 percent when the plants were 50 percent in full bloom, 97.7 percent when the plants were 100 percent in full bloom, and 62.9 percent when the plants were 50 percent past full bloom.

The percentage of tubers 10 ounces and larger was reduced considerably by any of the defoliation treatments. As shown in Table 2 the defoliation of any amount at any of the bloom stages reduced by 50 percent tubers over 10 ounces in weight.

When all the foliage was removed, there were no tubers produced which were 10 ounces or larger.

### Undersize

As the amount of foliage removed increases, the greater is the

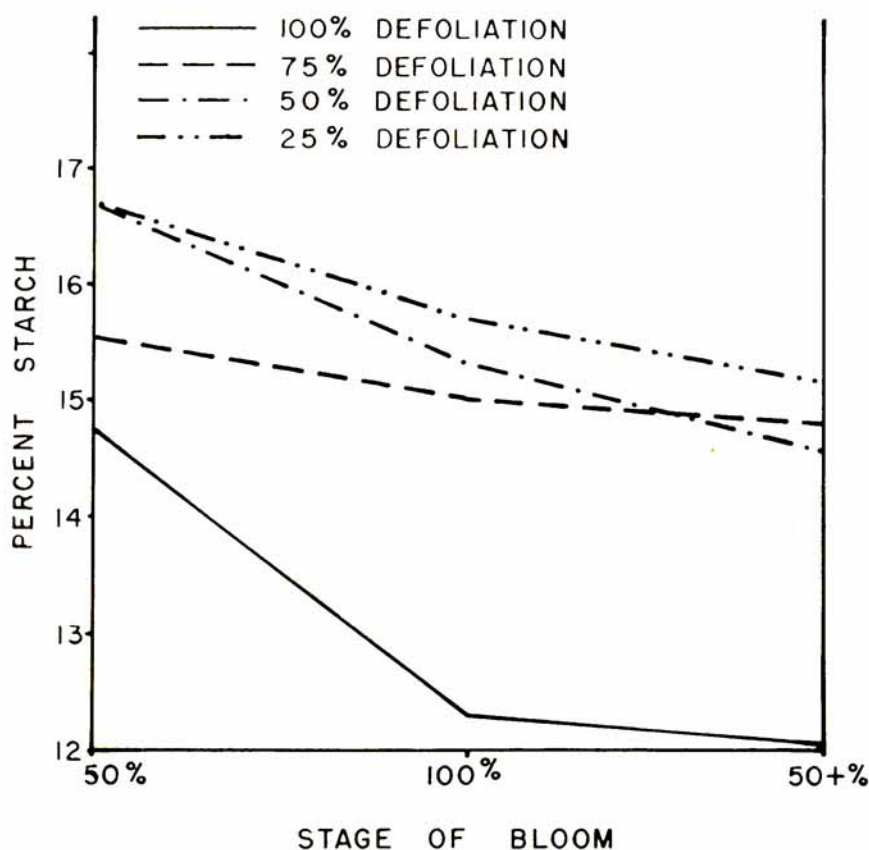


Figure 8.—Starch content of potato tubers as affected by defoliation at four stages of bloom in 1954.

number of small tubers produced. Each of the defoliation treatments significantly increased over the check the number of small tubers produced. The number of small tubers increased to as much as 75.5 percent when all the foliage was removed when the plants were 50 percent in full bloom.

### Starch Content

Regardless of the amount of foliage removed, the later in the bloom stage that defoliation takes place the greater is the loss in starch content (Figure 8). One-hundred percent defoliation causes a greater reduction in starch content than defoliation by any other amount. This is true at each of the three stages of bloom. One-hundred percent defoliation when the plants were 50 percent past full bloom reduced the starch content of the tubers by 25.4 percent.

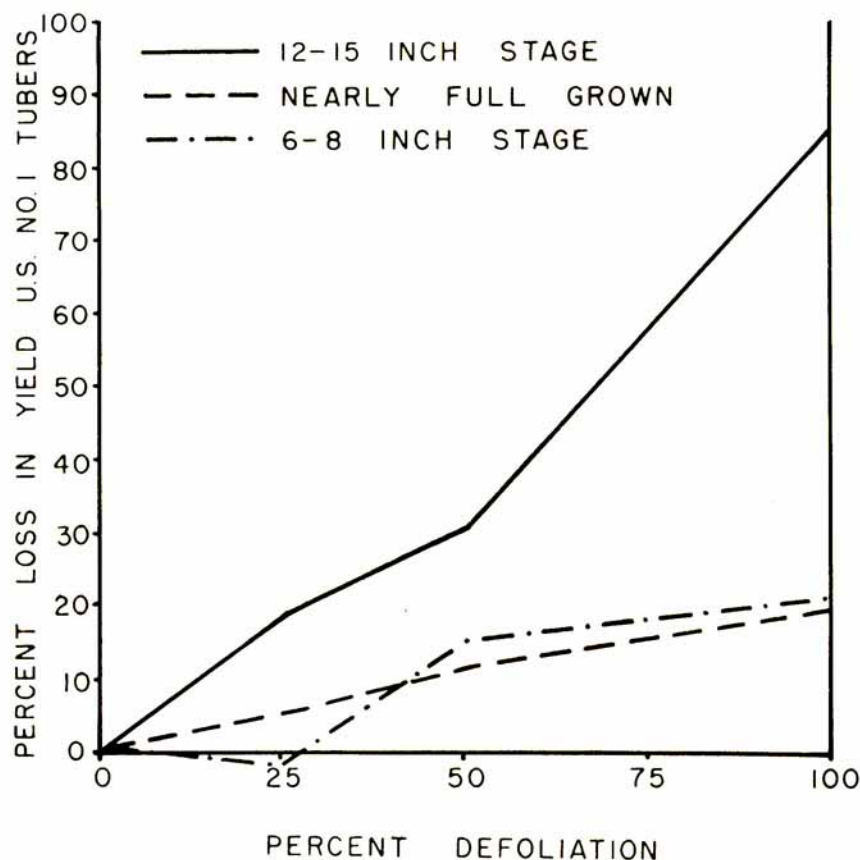


Figure 9.—Effect of simulated hail injury on the loss in yield of U. S. No. 1 tubers from two early varieties of potatoes.



### EFFECT OF SIMULATED HAIL INJURY ON TWO EARLY VARIETIES OF POTATOES

Four varieties of potatoes other than the Russet Burbank variety were defoliated in these studies, two early varieties and two late varieties. The two early varieties, Early Gem and Bliss Triumph, gave results similar to Russet Burbank. Defoliation when the plants were 12 to 15 inches tall caused a greater percent loss in yield than at any other stage of growth. The percent loss in yield of U. S. No. 1 potatoes when these two early varieties were defoliated at the 12- to 15-inch stage was a little larger (Figure 9) than when the Russet Burbank was defoliated at the same stage of growth, but when the two early varieties were defoliated at the nearly full grown stage the percent loss in yield of U. S. No. 1 tubers was less than with Russet Burbank. This indicates that the two early varieties reach their critical period earlier than does the Russet Burbank variety.

As with the Russet Burbank variety, the 25 plus 25 percent defoliation treatment on the two early varieties gave results very similar to those obtained by the 50 percent defoliation treatment.

**Table 3.—Effect of simulated hail injury on two early and two late varieties of potatoes on the loss in yield of U. S. No. 1 tubers.**

Treatment	Early Varieties			Late Varieties		
	L1953 Bliss Triumph	A1953 Early Gem	Early mean	L1952 Katahdin	A1953 Menominee	Late mean
	Percent loss	Percent loss	Percent loss	Percent loss	Percent loss	Percent loss
25% 6-8"	0.6	-2.5	-0.9	-4.0	-1.8	-2.9
12-15"	15.7	21.7	18.7	-2.5	22.2	9.9
Full growth	16.6	-6.2	5.2	0.2	24.6	13.4
50% 6-8"	17.2	12.2	14.7	6.2	9.6	7.9
12-15"	25.4	36.2	30.8	-3.7	9.2	2.8
Full growth	22.7	0.6	11.7	12.9	22.6	17.8
100% 6-8"	22.7	19.9	21.3	6.0	18.2	12.1
12-15"	78.8	90.2	84.5	32.3	53.4	42.9
Full growth	26.4	12.7	19.6	13.2	55.2	34.2
25 + 25% 6-8"	20.5	10.9	15.7	-8.6	-4.4	-6.5
12-15"	29.9	35.1	32.5	18.0	25.5	21.8
Full growth	18.6	13.5	16.1	-4.6	17.0	6.2

## EFFECT OF SIMULATED HAIL INJURY ON TWO LATE VARIETIES OF POTATOES

The two late varieties other than Russet Burbank used in this study were Katahdin and Menominee. The Katahdin variety, grown at Lewiston in 1952, and the Menominee variety grown at Aberdeen gave variable results with half of the treatments producing equal to or slightly better yields of U. S. No. 1 tubers than the check or no defoliation treatment.

Knocking 100 percent of the foliage off the plants when they were 12 to 15 inches tall and just beginning to bloom resulted in a 32 percent loss in yield of U. S. No. 1 tubers, but the other decreases in yield were less than 18 percent of the check. Since these results are for only a single season and are so variable, they are not considered as being significant.

The Menominee variety was grown at the Aberdeen Branch Station in 1953 in a test which compared the reaction to defoliation of Early Gem, Russet Burbank, and Menominee. The greatest yield reductions in the very late variety, Menominee, occurred when the plants were defoliated when they were nearly full grown rather than when they were 12 to 15 inches tall. This indicates that the very late variety Menominee had not developed as much toward the bloom or tuber setting stage when the plants were 12 to 15 inches tall as had the other varieties.

## Discussion of Results

When this work was inaugurated in 1950, it was hoped that some definite information could be obtained that would provide a sound basis for the farmer and hail adjuster to evaluate more correctly the loss incurred by any hail storm. The results of the first two years of this study, published in Research Bulletin No. 22, indicated that the yield, grade, and quality of tubers were directly influenced by the amount and time of foliage removal. The continuation of these studies not only supported these claims, but added further information as to the most critical time of foliage removal.

The later trials showed that the most critical period in the production of U. S. No. 1 potatoes was the full-bloom stage of growth. Defoliation at this stage of growth caused a greater loss in yield of U. S. No. 1 tubers than defoliation at any other period. Combining this information with the information obtained at other stages of growth resulted in the formation of a graph (Figure 2, page 3) by which both the farmer and the adjuster can evaluate the loss incurred by a hail storm. This graph shows the percent loss in U. S. No. 1 tubers that can be expected from a hail storm at each of four stages of growth when a certain percentage of the foliage has been knocked off.



By interpolating between the "stage of growth" curves listed, the loss in yield of U. S. No. 1's can be closely estimated for any percentage of defoliation at any stage of growth. Figure 2 shows that as the plants develop toward the full bloom stage, greater losses from defoliation may be expected. The effect of tuber production also depends upon the amount of foliage lost. As the plants develop beyond the full bloom stage, the losses become less.

Factors other than foliage loss may inflict damages to the potato crop. One of the important factors contributing to potato damage or loss is that of vines being knocked down into the irrigation furrows and slowing or interfering with the water movement. In order to avoid excessive loss due to water rot when the vines plug the irrigation furrows the length of the rows must be reduced so the water can be run through them in a relatively short time. This might be done by putting cross ditches in the fields; thus shortening the irrigation run. Water must not be allowed to stand in the furrows. This vine problem may be serious only with gravity flow irrigation systems and where there are considerable vines.

When the leaves have been partially removed from a plant, the plant is delayed in maturity and therefore requires a longer season than usual to mature. This should be considered when digging and handling the crop so that care will be taken to avoid skinning and bruising the tubers. Skinned or bruised tubers must be handled and stored with special care and should never be placed in a warm dry storage cellar (see Idaho Experiment Station Bulletin No. 296).

The effects of hail injury upon total yield, yield of U. S. No. 2 and undersize tubers have been minimized because the most important single factor in potato production is the amount of U. S. No. 1 potatoes that can be grown on each acre. But there are some interesting facts about the production of U. S. No. 2 tubers which should be discussed. Defoliation when the plants were just beginning to bloom (12 to 15 inches tall) causes at least a 24.6 percent increase in the percentage of U. S. No. 2 tubers. The greatest increase in No. 2's at any other stage of growth amounted to only 23.1 percent. The 1954 trial shows that defoliation at 50 percent bloom caused a greater increase in U. S. No. 2's than at any other stage of growth. These data seem to indicate that defoliation when the plants are just beginning to bloom and set tubers is by far the most critical as far as production of malformed and off-type tubers is concerned. This is the same stage of growth that was found to be the most critical in the formation of malformed tubers when irrigation was withheld.\* This is the period when the tubers are beginning to form. If growth is retarded at this stage, malformed or U. S. No. 2 tubers frequently result.

The later in the stage of development that defoliation takes place the greater the loss in starch content. This is true regard-

\* L. W. Nielsen and Walter C. Sparks—Bottleneck Tubers and Jelly-End Rot in the Russet Burbank Potato. University of Idaho Research Bulletin No. 23, 1953.

less of the amount of foliage removed. This seems to indicate that some of the starch in the tubers is converted to sugar and is used by the plant to regenerate foliage. Because of the late date at which this takes place there does not seem to be time enough for the plant to replace the starch in the tubers; thus resulting in a lower starch content.

The two early varieties responded in much the same manner as Russet Burbank, but not entirely so. Since tuber development varies among varieties, early and late, it is logical to attribute differences in behavior to the difference in the relationship between plant and tuber development. These data are shown in Table 3 and in Figure 9.





**Other University of Idaho Publications**  
**On Production, Handling and**  
**Marketing of Potatoes**

**Effects of Mechanical Injury Upon the Storage Losses of Russet Burbank Potatoes.** Experiment Station Bulletin No. 220.

**Fertilizer Recommendations for Idaho Soils.** Extension Circular No. 120.

**Consumer Preference for Sized Idaho Russet Burbank Potatoes.** Experiment Station Bulletin No. 208.

**An Analysis of Potato Packing Costs in Idaho, 1950-51 Season.** Experiment Station Bulletin No. 208.

**Storing the Idaho Potato.** Experiment Station Bulletin No. 296.

**A Study of Simulated Hail Injury on Potatoes.** Research Bulletin No. 22.

**Bottle-neck Tubers and Jelly-end Rot in Russet Burbank Potatoes.** Research Bulletin No. 23.

**Producing the Idaho Potato.** Experiment Station Mimeo. No. 121.

**Disease of Potatoes in Idaho.** Experiment Station Bulletin No. 254.

**Potato Tuber Diseases and Defects.** Experiment Station Bulletin No. 274.

**Packing Idaho Potatoes.** Experiment Station Bulletin No. 247.

**Injury to Russet Burbank Potatoes by Different Harvesting Machines.** Experiment Station Bulletin No. 218.

**Selecting and Breeding Potatoes for Resistance to Verticillium Wilt in Idaho.** Research Bulletin No. 30.

**Producing Early Gem Potatoes in Idaho.** Experiment Station Bulletin No. 262.

Copies may be obtained from county agricultural agents; or by writing to the University of Idaho; College of Agriculture, Moscow; or the University Agricultural Extension Service, Boise.