

T H E S I S

A STUDY OF FACTORS
INFLUENTIAL IN REDUCING
THE SKINNING OF POTATOES

Submitted by
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In partial fulfillment of the requirements
for the Degree of Master of Science
Colorado
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ENTITLED A STUDY OF FACTORS INFLUENTIAL IN REDUCING
THE SKINNING OF POTATOES

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Chapter I

INTRODUCTION

The loss of periderm from potato tubers due to harvesting and handling operations of both the early and late crop has long been a serious problem. Tender tissue becomes exposed when the protective skin has been broken or scuffed off, and discoloration which ranges from light brown to grayish black in color follows. The length of time the skinned area is exposed to sun, dry winds and organisms determines the color and extent of decay damage. The unsightly appearance caused by skinning the tubers and the entrance of bacteria and fungi which follow are of major importance to growers, shippers, dealers and to the ultimate consumer.

Experimental evidence is available to show that the normal uninjured potato periderm is highly resistant to the penetration of soft rot bacteria and dry rot fungi. There is but little information available to show whether or not cultural practices may be used to toughen the periderm to the extent that losses due to disease and mechanical injury might be reduced. For this reason this investigation was made.

Problem

Is it possible to reduce the amount of skinning which occurs in potatoes during certain periods of harvesting and handling by means of cultural methods?

Problem analysis.--In order to answer the main problem it was found necessary to obtain answers to the following three questions.

1. Can a method for measuring the resistance of potato periderm to rupture, skinning, and slippage be developed?

2. What cultural methods can be used to reduce skinning and what is their relative effectiveness?

3. Are there measurable differences between varieties in their resistance to skinning when grown under similar conditions?

Delimitations.--This investigation has been limited to (1) the use of water pressures for measuring the resistance of potato tubers to skinning; (2) the cultural practices studied have been limited to vine burning, beating, undercutting and spraying with Sinox General and Dow Spray 66 Improved; (3) comparisons of varieties have been limited to the Red McClure, Russet Burbank, Katahdin and Bliss Triumph varieties; (4) the effect of three soil moisture levels at time of harvest (low, medium and high) on skin toughness.

Definition of terms.--Skinning, as used here, includes the trade synonyms, feathering and scuffing and denotes the loss of periderm from the potato tuber.

Slippage refers to the force required to slip the skin when all forces required to tear the skin have been reduced to virtually zero.

Toughness refers to the force required to tear the periderm plus the force required to slip the skin.

Chapter II

REVIEW OF LITERATURE

The studies of the potato skin by early investigators stemmed from the differences in the disease resistance of certain varieties. Thus the natural and effective barrier to infection--the potato skin--was studied extensively by many early workers.

Factors affecting skinning

Artschwager (1), stated that extensive studies of the periderm of several varieties were made by Sorauer, Kreitz and Lutman. In 1868, Sorauer found that deep planting tended to produce a thinner skin than shallow planting; also, fertilization of the soil tended to produce a thin skin. Kreitz, another German worker following up on the work of Sorauer, found that the thickness of the periderm of a given variety was not a constant factor, but varied with changes in environmental condition. Kreitz noted that dryness tended to produce a thin skin, and application of fertilizers caused variable results in that potassium and nitrogenous fertilizers tended to produce a thin skin and phosphoric acid fertilizers a comparatively thick skin.

Lutman, in 1919, noted that the same potato tuber had areas of thick and thin periderm and that the application of fertilizers did not affect the skin thickness.

Maturity of potato tubers is an indefinite condition and rather difficult to evaluate. Potatoes grown in sandy soils with a limited water supply have tougher skin than those grown on heavier soils with adequate moisture. When the soil is moist or the vines green, skinning occurs more readily. If the soil contains excess moisture a few weeks preceding and during harvest, the life of the plants is prolonged, causing the tubers to be more turgid and tender, as well as increasing the difficulty of separating all the tubers from the soil without injury. Tuber development continues until the plant matures. Immature potato tubers have a thin periderm that rubs off easily, (17), (28), (29), (30).

In some potato varieties, particularly Bliss Triumph, injuries which occur during harvest are chiefly due to an unusually tender skin. The thinness of skin has been accentuated by the practice of late planting, (30).

Metzger (14), found that when soils were dry at harvest time the soil sifted through the digger elevator and allowed the potato tubers to bounce on the

unprotected rods. He also noted that the potatoes were somewhat protected from the rods by a layer of soil when the soil was damp.

Westover's (31), investigations have shown that carelessness in handling the potato crop during harvest, in storage and in preparation for market, is the most frequent cause for poor appearance and consequently reduced profits.

Edmundson (5), expressed the opinion that high prices and strong demand are generally the main factors that induce growers to harvest immature or partially grown potato tubers.

Economic importance of skinning

Probably the most serious loss resulting from mechanical injuries is the rotting caused by various organisms, (fungi and bacteria), which gain entrance to the potato tuber through broken areas of the skin. Potato tubers that are harvested immature and placed in storage show a greater amount of decay and shrinkage than mature potato tubers, (2), (10), (12), (13), (18), (21), (28).

Westover (31), stated that at least a third of the potato tubers are usually injured in harvest, storage, and preparation for market. A considerable portion of those with minor injuries are lost due to

the action of decaying organisms.

Walker (27), stated that the chief means of controlling bacterial soft rot in potatoes is the avoidance of skin breakage at harvest time and during the later handling operations.

Workers (16), (19), found that browning caused by the drying out of skinned areas was one of the more serious causes of losses of immature potatoes. Browning can develop on skinned potatoes after 15 to 30 minutes' exposure on warm, clear, windy days.

Methods used to lessen skinning

In order to harvest potato tubers with a minimum of skinning and injury, the harvesting operation should not begin until the vines are dead and the tubers are ripe, (22), (23), (24).

Workers (6), (7), (14), (22), recommend that potatoes be allowed to lie on top of the soil for two to six hours after digging. This permits the skin to toughen and reduces damage in picking and subsequent operations.

The discontinuance of irrigation two to three weeks before harvest has been found to materially hasten the maturity of the tubers and lessen damage in harvesting, (9), (14), (29), (30).

Many workers (3), (8), (10), (25), (26), (29), (31), have maintained that the tubers should be allowed to remain in the ground 10 days to two weeks after the vines have died, (whether by frost or artificial means), so that they will be partially "cured" and can be dug with less skinning and injury.

Potato growers in some sections claim undercutting the potato vines hastens maturity and reduces mechanical injury. Edmundson and others (5), (30), found undercutting two inches below the tubers two to five days in advance of digging in a soil that does not contain too much moisture helped set the skin, but undercutting in moist soil had little immediate effect on the plants.

Various methods have been used to kill the potato vines before they mature so that the crop may be dug early to meet a good market, or to extend the harvest period to meet labor shortages, (4), (11), (15), (17), (18), (20).

Chapter III
METHODS AND MATERIALS

Skin testing machine

It was observed that freshly harvested potatoes could be easily peeled by water squirting from a spray gun. It was reasoned that if a method for readily varying the pressure could be developed, perhaps this procedure could be used to obtain a quantitative measurement of the relative force required to rupture a potato skin and thus make it possible to study some of the factors which might contribute to the reduction in the skinning of potatoes.

A Bean sprayer pump (model No. 64) capable of producing pressures of approximately 200 pounds per square inch was obtained and connected to a series of cylinders, which equalized the pressure, in such a manner that the pressure regulator on the by-pass valve could be used to adjust the flow of water to any desired pressure. The motor and pump were run at a constant speed, and the variation in pressure was obtained by manipulating the pressure relief valve. (See appendix for detailed description and pictures of the machine.)

A pressure gage which registered in pounds per

square inch was connected into the system, and it served as an indication of the force required to rupture the skin. At low pressures of five to 10 pounds, the pointer remained quite steady, the fluctuation being about one fourth of a pound pressure. At pressures over 100 pounds there was a constant fluctuation of about 10 pounds.

Method used in
making measurement

The actual measurements were made by holding a tuber a specified distance (1.75 inches) from the nozzle in such a manner that the stream of water hit the tuber about midway between the stem end and the bud end. The pressure was then increased until the skin ruptured at which time the pressure at the pump was recorded.

In preliminary work it was found that the skin at the bud end of the tuber ruptured easier than the skin at the stem end, and for this reason an area about midway between the two ends was chosen as the place to make the measurements. Care was also taken to test tubers in those areas where no breaks in the skin were present because a pressure of 80 pounds might be required to rupture the uninjured skin, but if a small break existed the tuber could be almost completely peeled by a pressure as low as 10 pounds.

The pressure at the pump was used as an

indication of the pressure required to break the skin. This gave relative values and should not be construed to mean that that was the force in pounds per square inch required to rupture its skin.

Varieties used

The varieties used in the greenhouse were Red McClure, Katahdin and Russet Burbank. The Bliss Triumph variety was used in the field. These varieties were chosen because of their regional importance and relative length of season required for maturity. The close spacing of plants when grown in half-barrel containers and the greenhouse bench made it necessary to use varieties with tubers which could be easily distinguished from each other. Whole seed of foundation grade was used throughout. The tubers were held in approximately 40° F. storage for about 60 days after which they were warmed up at room temperature until definite signs of sprouting were visible. They were then planted directly in a sandy loam greenhouse soil.

1950 greenhouse experiments

Two experiments were conducted during the winter of 1950. The purpose of one experiment was to determine the effect of vine killing on skin toughness, and the purpose of the other was to determine the effect of soil moisture on skin toughness.

In the first experiment, as shown in Figure 1, one plant of each of the three varieties was planted into each of 18 half-barrels (55 gallon oil drums cut in half). The half-barrels were then randomly divided into three groups of six half-barrels each. This made it so that there were six replications for moisture levels and each replication was a three-way split plot for measuring the interactions, if any, between moisture and varieties. Planting all three varieties in each half-barrel made it possible to grow each variety under almost identical conditions of moisture and fertility.

The varieties were planted in their respective barrels on January 5; on April 24, after 110 days of growing at what was considered normal moisture under greenhouse conditions (a tensiometer was placed in each half-barrel to serve as a guide in determining the time to irrigate), the moisture treatments were started. In the low soil moisture barrels no water was applied. In the medium soil moisture barrels no moisture was applied until the tension was 15-18 inches of mercury, and in the high soil moisture barrels water was applied every time the mercury tension reached three to four inches of mercury. The greater the tension the drier the soil.

Fifteen days after the moisture treatments were begun, soil moisture samples were taken from each barrel with a soil auger at the six and 12 inch deep



Figure 1.--Soil moisture plots
(half-barrels) in the greenhouse



Figure 2.--Vine killing
plots in the greenhouse

levels. These samples were oven dried (to constant weight) at 105° C. and moisture percentages determined.

The tubers were dug May 10, which was one day after the soil moisture samples were taken. Each half-barrel was harvested by hand and care was taken to prevent injury to the tubers. The toughness of the skin was measured immediately after digging.

In the second experiment, as shown in Figure 2, each of the three varieties was planted in its respective place in concrete benches on January 5. There were six replications and each replication contained six plants of each variety, making a total of 36 plants per variety. Each main plot was split into six subplots so that within each replication one plant of each variety was subjected to each of the six vine killing treatments.

The vine killers were applied May 13. Dow Spray 66¹/Improved was applied at a concentration of one gallon of Dow 66 plus two pounds of aluminum sulfate per 100 gallons of water at the rate of 130 gallons per acre with a hand sprayer. Sinox General² was applied at a concentration of one gallon plus 10 pounds of ammonium sulfate per 100 gallons of water with a hand

1/ Dinitro secondary butyl phenol
2/ Dinitro secondary amyl phenol

sprayer at the rate of 130 gallons per acre. When the vine killing treatments were applied the adjacent plots were covered with paper to avoid interplot contamination.

Vine burning was done with a gasoline blow torch, and the flame was applied until a definite wilting of the leaves and stems was observed. The Roto-Beater treatment was imitated by cutting off the vines at the soil surface with a knife. Undercutting was accomplished by inserting a spade under the plants to be undercut and severing the roots. The check was left untreated and undisturbed.

The tubers were harvested, one replication at a time, on May 19 and the measurements for skin toughness were made immediately following the harvesting of each replication.

1951 greenhouse test

Two experiments were conducted in 1951 in the same manner as in 1950 except for three changes.

In both of the experiments which were conducted in 1950 the date of emergence varied so drastically between the three varieties that in 1951 special precautions were taken to obtain uniform plants.

This was accomplished by starting 100 plants of each variety in six-inch pots and permitting them to grow until January 27 at which time 18 uniform plants of

each variety were selected for transplanting into the half-barrels, and 36 were selected for transplanting into the benches.

Only two soil moisture levels were used. They were begun April 6, at which time the vines showed evidence of early maturity probably the result of the high greenhouse temperatures. Soil moisture samples were taken April 13, and the tubers in the half-barrels were harvested and tested on the same day.

In the experiment which was conducted in the benches the main plots were split only once instead of six times as was the case in 1950. This reduced the number of treatments from six to three, but made it possible to incorporate two dates of harvest for the purpose of determining the increase in skin toughness due to allowing a longer period of time between the time the vine killers were applied and the time of harvest.

The vine killers were applied April 11, and one half of each plot was harvested and tested for skin toughness four days later, April 20.

The three treatments used were cutting off the vines at the soil surface, pulling up the vines and an untreated, undisturbed check. The vines were cut off as in the previous year's experiment. Pulling up the vines was accomplished by placing one foot on each side of the vines and then giving them a quick upward jerk

with the hands. This left the tubers in the soil.

Cutting off the vines was used to imitate rotobeating, and pulling the vines as described above was used to imitate the effects of mechanical pulling. These were the only vine killing treatments used because of limited greenhouse space.

1950 Gilcrest field test

This experiment was undertaken to further test the water pressure method for measuring potato skin toughness and to obtain at the same time, if possible, information relative to the changes in skin toughness which occur following rotobeating of the vines.

The potatoes used were of the Bliss Triumph variety. They had been planted April 21 and were considered ready to be harvested for the commercial market by August 5 when the first part of the experiment was begun.

The experiment consisted of three treatments and five replications, and each replication was split to give two dates of harvest. The treatments consisted of beating off the vines with a Roto-Beater August 5, August 7, and the untreated check. One half of each replication was harvested August 9, and the other half was harvested August 11. Soil moisture samples were

taken from each half-plot on each date of harvest. The tubers were harvested by hand and tested for skin toughness immediately following harvest.

Chapter IV
ANALYSIS OF DATA

The water pressure method previously described was used for determining differences in skin toughness due to the effect of vine killers, the effect of soil moisture, the effect of delayed harvest following vine removal and the effect of variety.

Results of soil
moisture tests in
the greenhouse, 1950

The results of this experiment are shown in Table 1. It can be seen that on the Red McClure variety it required a mean pressure of 106.5 pounds to rupture the skin when the per cent soil moisture was 9.6 per cent. When the soil contained 13.4 per cent moisture, 93.0 pounds pressure was required; when the soil was still wetter, 21.1 per cent moisture, it required 77.0 pounds pressure. With the Katahdin and Russet Burbank varieties the trend was the same indicating that the higher the per cent soil moisture at harvest time the lower the pressure required to rupture the skin.

In the case of the Red McClures the difference in pressure required to rupture the skin between any two

moisture levels was highly significant.* In the case of the Katahdin the difference between the low and the medium soil moisture levels was highly significant but between the medium and the high moisture levels not significant. In the case of the Russet Burbank the difference in pressure required at the low and medium moisture levels was significant but nonsignificant between the medium and high levels.

The data also indicates that the Red McClure and the Russet Burbank varieties were about equal in skin toughness when grown under similar conditions. The skin on the Katahdin variety was inclined to rupture more easily than the Red McClures or Russet Burbanks. The comparison between varieties must be accepted with reservation because each variety, though planted on the same day, emerged at a different time and therefore each variety grew for a different number of days. For this reason, no statistical evaluation was made for the differences between varieties.

Results of the vine
killing experiment
in the greenhouse, 1950

The results of this experiment are shown in Table 2. A statistical analysis was made separately within each variety but not between varieties for the

*In all experiments odds of 19:1 or better were considered "significant".

reason given under the previous experiment.

It can be seen that with one exception killing the vines six days prior to harvest significantly increased the water pressure required to rupture the skin over that required in the untreated check. The exception was for burning the vines on the Katahdin variety.

It can also be seen that with the Red McClure variety cutting off the vines did not differ significantly from vines which had been burned. The water pressure required to rupture the skins of tubers from the cut-off vines was significantly greater than that required for the Sinox or Dow 66 treatments and for the undercutting treatment. There were no significant differences between the Sinox, Dow 66 or undercut treatments.

With the Katahdin variety, cutting the vines off at ground level produced tubers which required a significantly higher water pressure to rupture the skin than was required to rupture the skin of tubers from the undercut, chemically killed vines. Undercutting produced tubers with skins which were significantly tougher than those produced by vines which had been burned. The differences between the skin toughness of tubers from undercut vines and sprayed vines was not significant.

On Russet Burbank potatoes, all of the vine killing treatments produced significant differences in

Table 1.—COMPARISON OF THE MEANS OF THE WATER PRESSURE REQUIRED TO RUPTURE THE SKIN OF THE RED MCCLURE, KATAHDIN AND RUSSET BURBANK VARIETIES SUBJECT TO DIFFERENT LEVELS OF SOIL MOISTURE. 1950 GREENHOUSE TEST.

| | Low | Medium | High | L. S. D. | |
|-----------------|-------|--------|------|----------|------|
| % Soil Moisture | 9.6 | 13.4 | 21.1 | 5% | 1% |
| Red McClure | 106.5 | 93.0 | 77.0 | 9.1 | 13.1 |
| Katahdin | 90.8 | 70.1 | 63.5 | 11.7 | 16.1 |
| Russet Burbank | 101.7 | 85.5 | 72.7 | 14.8 | 21.2 |

Table 2.—THE EFFECT OF VINE KILLING ON RED MCCLURE, KATAHDIN AND RUSSET BURBANK POTATOES IN RELATION TO THE WATER PRESSURE REQUIRED TO RUPTURE THE SKIN. 1950 GREENHOUSE TEST.

| Variety | Methods of Vine Killing | | | | | | L.S.D. | |
|----------------|--|---------|-------|--------|--------------|---------------|--------|-----|
| | Check | Burning | Sinox | Dow 66 | Vine Cutting | Under-cutting | 5% | 1% |
| | Mean pressure at pump required to break the skin | | | | | | | |
| Red McClure | 65.3 | 78.8 | 76.3 | 76.0 | 84.7 | 75.7 | 6.7 | 9.1 |
| Katahdin | 61.5 | 64.1 | 66.8 | 66.1 | 72.8 | 68.6 | 3.4 | 4.7 |
| Russet Burbank | 67.7 | 75.8 | 77.1 | 76.8 | 81.3 | 76.6 | 6.8 | 9.2 |

skin toughness over the check. There was no significant difference between the vine killing treatments.

Results of the vine
killing experiment
in the greenhouse, 1951

In Table 3 it can be seen that the Russet Burbank required a significantly higher water pressure to rupture the skin than that required by the Katahdin variety.

The effect of time of harvest after the application of the vine killers is shown in Table 4. The data show that a greater pressure was required to rupture the skin on the second date of harvest than on the first date of harvest. In all three varieties, the increase in pressure required on the second and later harvest date was significant. The data also show that the percentage soil moisture decreased from 23.13 per cent to 15.17 per cent between the two harvest dates.

The first order interaction between varieties and dates was not significant.

The results of killing the vines on the pressure required to rupture the skin are shown in Table 5. The data show that pulling or cutting off the vines at ground level produced tubers which required a significantly greater pressure to rupture the skin than was the case when the vines were not pulled or cut. The difference between the pulled and cut off vines was not

Table 3.—COMPARISON OF THE MEANS OF THE WATER PRESSURES REQUIRED FOR SKIN RUPTURING OF THE THREE POTATO VARIETIES GROWN IN THE GREENHOUSE. 1951 TEST.

| | Varieties | | |
|--|----------------|-------------|----------|
| | Russet Burbank | Red McClure | Katahdin |
| Mean pressure required to rupture the tuber skin | 95.2 | 90.0 | 80.8 |
| L.S.D. 5% = 10.2 | | | |
| 1% = 14.5 | | | |

Table 4.—COMPARISON OF THE MEANS OF THE WATER PRESSURES REQUIRED FOR SKIN RUPTURE OF THE VARIETIES GROWN IN THE GREENHOUSE IN RELATION TO TWO DATES OF HARVEST. 1951 TEST.

| | Variety | | | | | |
|---|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| | Russet Burbank | | Red McClure | | Katahdin | |
| | Date of Harvest April 16 | Date of Harvest April 20 | Date of Harvest April 16 | Date of Harvest April 20 | Date of Harvest April 16 | Date of Harvest April 20 |
| Mean pressure required to rupture skin | 91.3 | 99.1 | 85.2 | 94.8 | 74.7 | 86.9 |
| L.S.D. for comparing differences between dates: | | | | | 5% = 6.1 | |
| | | | | | 1% = 8.4 | |
| % Soil Moisture | 23.13 | 15.17 | 23.13 | 15.17 | 23.13 | 15.17 |

Table 5.--COMPARISON OF THE MEANS OF THE WATER PRESSURES REQUIRED FOR SKIN RUPTURE OF THE THREE VARIETIES GROWN IN THE GREENHOUSE SUBJECTED TO DIFFERENT VINE KILLERS. 1951 TEST.

| | Method of Vine Killing | | |
|---|------------------------|---------|-------------|
| | Check | Pulling | Cutting Off |
| Mean pressure required to rupture the skin. | 81.1 | 91.6 | 93.3 |
| L.S.D. 5% = 2.2 | | | |
| 1% = 2.9 | | | |

Table 6.--COMPARISON OF THE MEANS OF THE WATER PRESSURES REQUIRED FOR SKIN RUPTURE OF THE VARIETIES GROWN IN THE GREENHOUSE IN RELATION TO TWO LEVELS OF MOISTURE. 1951 TEST.

| % Soil Moisture | 24.24 | 13.36 | Variety Means |
|-----------------|-------|-------|---------------|
| | High | Low | |
| Russet Burbank | 76.1 | 88.5 | 82.30 |
| Red McClure | 72.6 | 81.3 | 76.95 |
| Katahdin | 59.4 | 70.8 | 65.10 |
| Moisture Means | 69.4 | 80.2 | |

The least significant difference between moisture required: 5% pt.=4.0
1% pt.=5.7

The least significant difference between varieties required: 5% pt.=3.8
1% pt.=5.1

significant. The first order interaction between the two methods of vine removal and dates of harvest was non-significant. The first order interaction between the two methods of vine removal and date of harvest was significant. The first order interaction between methods of vine killing and varieties was also significant. Pulling up the vines had a greater effect on toughening the skins of the Red McClure variety than on the Russet Burbank or Katahdin varieties. There was no significant interaction between the Red McClure and the Russet Burbank when the vines were cut off. The second order interaction between treatments, varieties and dates was highly significant but also difficult to interpret. The first order interaction between soil moisture and varieties was not significant.

Results of soil moisture experiment in the greenhouse, 1951

The effect of soil moisture on the water pressure required to rupture the skins of potatoes in the 1951 tests is shown in Table 6. There was a mean difference in percentage soil moisture of 10.9 per cent between the high soil moisture and the low soil moisture plots, and the pressure required to rupture the skin on the tubers from the low soil moisture plots was significantly higher than pressure required to rupture the skin of the tubers from the high soil moisture plots. The pressure required

to rupture the skins on tubers of the Russet Burbank variety was significantly greater than that required to rupture the skin on the tubers of the Red McClure and Katahdin varieties. The pressure required to rupture the skin on the Red McClure variety was significantly greater than that required to rupture the skin on the Katahdin variety. These results were similar to those obtained in the 1950 tests.

Field test Gilcrest
area, 1950

The results of the Gilcrest field experiment which compared two dates of harvest and two dates of vine removal are shown in Table 7. None of the differences was large enough to be significant. It should be noted that soil moisture was below 6.5 per cent in all cases.

Table 7.--COMPARISON OF THE MEANS OF THE WATER PRESSURES REQUIRED FOR SKIN RUPTURE OF BLISS TRIUMPH POTATOES SUBJECTED TO ROTOBATER AT TWO DATES AND HARVESTED AT TWO DATES.

| | Check | | Treatments | | | |
|------------------------------|--------------|---------|----------------------------------|---------|----------------------------------|---------|
| | | | Rotobater | | Rotobater | |
| | Harvest Date | | Applied August 5 Harvest Date | | Applied August 7 Harvest Date | |
| | Aug. 9 | Aug. 11 | Aug. 9 | Aug. 11 | Aug. 9 | Aug. 11 |
| Mean pounds pressure at pump | 62.6 | 64.2 | 62.8 | 64.2 | 67.0 | 65.6 |
| Mean % soil moisture | 4.4 | 4.0 | 6.4 | 5.9 | 4.6 | 4.8 |

L.S.D. - Non-Significant

Chapter V

DISCUSSION

This investigation has demonstrated the value of the water pressure machine for obtaining relative measurements of potato skin toughness. It has been possible to obtain definite figures for the evaluation of the effect on skin toughness of such factors as soil moisture, vine killing and variety.

Two years of greenhouse and field experience have shown that moist soil immediately preceding harvest retards the toughening of tuber skin regardless of other cultural treatments or variations. In addition, it has been shown that the lower the per cent of soil moisture at harvest time, other factors being equal, the tougher the tuber skin. These results are in agreement with other investigators (14, 28, 29, 30).

Data gathered in both 1950 and 1951 showed that vine killing or vine removal prior to harvest produced tubers with tougher skins than corresponding controls. The time interval between vine killing or removal and harvest was shown to be a significant factor in greenhouse experiments where the soil was moist at time of treatment. The longer the interval, the tougher the

skin at harvest. In one field test where the soil was relatively dry at time of vine treatment, the interval until harvest was not a significant factor.

Differences in skin toughness between Russet Burbank, Red McClure, and Katahdin were found. All cultural factors being approximately equal, the Russet Burbanks had the toughest skin. This was followed by Red McClure. The skin of the Katahdins ruptured under the lowest pressure.

Suggestions for further study

1. Further development of a simple method of measuring tuber maturity as related to skin toughness.
2. A histological study of the effect of cultural practices, particularly vine treatments prior to harvest, on the skin of a few important commercial varieties.
3. Investigate the possibility of producing new varieties of the desired quality with tougher skin.

Chapter VI

SUMMARY

1. A water pressure machine and a method of using it to measure the relative differences in potato skin toughness was developed.

2. In the greenhouse, killing the foliage six days before harvest by spraying, burning, undercutting or removing the foliage measurably increased the skin toughness at harvest date in the Red McClure, Russet Burbank and Katahdin potato varieties.

3. Decreasing the percentage of moisture in the soil at harvest, within the limits of the experiment, resulted in tougher potato skins.

4. Skin toughness increased as the length of time after the vines were killed increased and soil moisture decreased.

5. Tubers of the Russet Burbank variety, when grown under the same conditions and for the same length of time as those of the Red McClure and Katahdin varieties, had a tougher skin than those of the Red McClure and those of the Red McClure had a tougher skin than those of the Katahdin variety.

APPENDIX

APPENDIX

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Description of the Machine Used
To Test Skin Rupture of Potato Tubers

A small capacity Bean Sprayer Pump model No. 64, powered by a geared one-horse power electric motor, was used to provide the water pressure in this work. The ratio in inches of the diameter of the pulley on the motor to that of the pulley on the pump was 3.47:1. A V belt was used to reduce slipping.

The pump was originally equipped with a single air chamber in the top of which was screwed a pressure gage which was graduated in pounds per square inch. However, due to the pulsations of the pump, which caused the pointer to fluctuate, three additional air chambers were added and this reduced the magnitude of the fluctuations to almost zero at low pressures.

The air chambers were two inches in diameter, about 25 inches long and made of aluminum. A second more accurate pressure gage was mounted in the top of the air chamber nearest the jet opening where the tubers were measured for skin toughness. The two gages served as checks on each other.

The nozzle was a fan type Tee Jet No. 8004 through which had been drilled a 5/64" sized hole so that

the water was discharged in a stream like a pencil lead. The nozzle was attached to the pump in such a manner that the water was directed toward the floor.

A circular ring was mounted 1.75 inches from the nozzle opening. This made it so that all tubers were held the same distance from the nozzle regardless of size. Details are pictured in Figures 3 and 4.

Machine used to determine tuber skin toughness

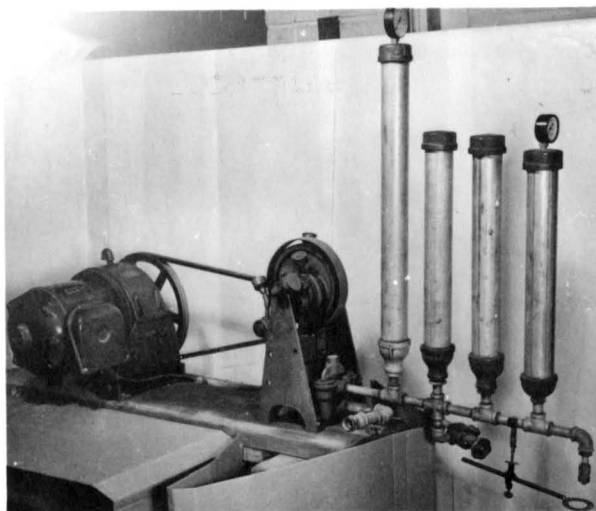


Figure 3
(Side view)

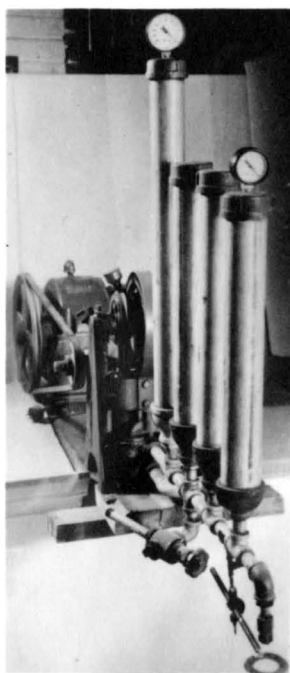


Figure 4
(Front view)

Master Sheet.--THE MEANS OF THE WATER PRESSURES REQUIRED FOR SKIN RUPTURING OF THREE VARIETIES GROWN IN THE GREENHOUSE
1951 IN RELATION TO TWO DATES OF HARVEST AND THREE TREATMENTS.

| Blocks | RED McCLURE | | | | | | KATAHDIN | | | | | | RUSSET BURBANK | | | | | | Block Totals |
|--------|---------------|--------------|---------------|---------------|---------------|---------------|--------------|--------------|---------------|--------------|---------------|--------------|----------------|--------------|---------------|---------------|----------------|---------------|--------------|
| | Check | | Pulling | | Rotobeaer | | Check | | Pulling | | Rotobeaer | | Check | | Pulling | | Rotobeaer | | |
| | Date 1 | Date 2 | Date 1 | Date 2 | Date 1 | Date 2 | Date 1 | Date 2 | Date 1 | Date 2 | Date 1 | Date 2 | Date 1 | Date 2 | Date 1 | Date 2 | Date 1 | Date 2 | |
| I | 80 | 86 | 93 | 117 | 89 | 111 | 74 | 76 | 88 | 87 | 63 | 104 | 86 | 97 | 92 | 103 | 93 | 100 | 1639 |
| II | 74 | 80 | 107 | 103 | 100 | 97 | 76 | 83 | 89 | 105 | 83 | 96 | 85 | 80 | 96 | 100 | 113 | 90 | 1657 |
| III | 86 | 83 | 82 | 93 | 90 | 104 | 71 | 77 | 73 | 80 | 77 | 87 | 91 | 90 | 89 | 104 | 100 | 100 | 1577 |
| IV | 75 | 83 | 86 | 96 | 86 | 100 | 80 | 80 | 73 | 97 | 74 | 94 | 87 | 96 | 92 | 100 | 106 | 110 | 1615 |
| V | 71 | 83 | 83 | 97 | 80 | 106 | 63 | 74 | 70 | 87 | 70 | 89 | 83 | 92 | 84 | 110 | 100 | 103 | 1545 |
| VI | 80 | 80 | 83 | 97 | 89 | 90 | 69 | 75 | 71 | 83 | 80 | 91 | 75 | 100 | 83 | 104 | 89 | 104 | 1543 |
| Dates | 466 77.67 | 495 82.50 | 534 89.00 | 603 100.50 | 534 89.00 | 608 101.33 | 433 72.17 | 465 77.50 | 464 77.33 | 539 89.83 | 447 74.50 | 561 93.50 | 507 84.50 | 555 92.50 | 536 89.33 | 621 103.50 | 601 100.17 | 607 101.17 | |
| Trmt. | 9611 80.08 | | 1137 94.75 | | 1142 95.17 | | 898 74.83 | | 1003 83.58 | | 1008 84.00 | | 1062 88.50 | | 1157 96.42 | | 1208 100.67 | | |
| Var. | 3240 90.00 | | | | | 2909 80.81 | | | | | | | 3427 95.19 | | | | | | 9576 |

Master Sheet.--THE MEANS OF THE WATER PRESSURES REQUIRED FOR SKIN RUPTURING OF THREE VARIETIES GROWN IN THE GREENHOUSE IN 1951 IN RELATION TO TWO DATES OF HARVEST AND THREE TREATMENTS. (continued)

| Source | Analysis of Variance | | | | | | |
|-----------------------|----------------------|-----------|--------------|---------|---------|------|------|
| | DF | DF | ΣX^2 | M^2 | F | 5% | 1% |
| Varieties | 2 | 2 | 3822.722 | 1911.36 | 31.00 | 4.10 | 7.56 |
| Blocks | 5 | 5 | 650.111 | 130.02 | 2.11 | 3.33 | 5.64 |
| | | Error (A) | | | | | |
| V x B | 10 | 10 | 616.50 | 61.65 | | | |
| <hr/> | | | | | | | |
| Total for whole plots | 17 | 17 | 5089.33 | | | | |
| Dates | 1 | | 2620.592 | 2620.59 | 35.50 | 4.54 | 8.68 |
| D x V | 2 | | 94.57 | 47.28 | --- | | |
| D x B | 5 | Error (B) | | | | | |
| D x V x B | 10 | 15 | 1107.51 | 73.80 | | | |
| <hr/> | | | | | | | |
| Total for half-plot | 35 | 35 | 8912.00 | | | | |
| Treatment | 2 | | 3111.72 | 1555.96 | 72.4376 | 3.15 | 4.98 |
| T x D | 2 | | 211.57 | 105.79 | 4.9250 | 3.15 | 4.98 |
| T x V | 4 | | 217.56 | 54.39 | 2.5321 | 2.52 | 3.65 |
| T x V x D | 4 | | 954.30 | 238.58 | 11.1071 | 2.52 | 3.65 |
| T x B | 10 | | | | | | |
| T x V x B | 20 | Error (C) | | | | | |
| T x D x B | 10 | 60 | 1288.85 | 21.48 | | | |
| T x V x D x B | 20 | | | | | | |
| <hr/> | | | | | | | |
| Total | 107 | 107 | 14696.00 | | | | |

Master Sheet.—THE MEANS OF THE WATER PRESSURES REQUIRED FOR SKIN RUPTURING OF THREE VARIETIES GROWN IN THE GREENHOUSE IN 1951 IN RELATION TO TWO LEVELS OF MOISTURE.

| BLOCKS | HIGH MOISTURE LEVEL | | | LOW MOISTURE LEVEL | | | BLOCK TOTALS |
|--------|---------------------|-------------|----------------|--------------------|-------------|----------------|--------------|
| | RED McCLURE | KATAHDIN | RUSSET BURBANK | RED McCLURE | KATAHDIN | RUSSET BURBANK | |
| I | 72 | 48 | 80 | 72 | 55 | 83 | 410 |
| II | 84 | 52 | 76 | 71 | 68 | 85 | 436 |
| III | 80 | 60 | 84 | 78 | 73 | 91 | 466 |
| IV | 72 | 60 | 73 | 86 | 71 | 95 | 457 |
| V | 67 | 58 | 68 | 87 | 78 | 87 | 445 |
| VI | 70 | 60 | 70 | 92 | 73 | 83 | 448 |
| VII | 70 | 63 | 83 | 76 | 73 | 93 | 458 |
| VIII | 69 | 63 | 68 | 80 | 69 | 95 | 444 |
| IX | 64 | 70 | 87 | 85 | 73 | 90 | 469 |
| X | 78 | 60 | 72 | 86 | 75 | 83 | 454 |
| | <u>726</u> | <u>594</u> | <u>761</u> | <u>813</u> | <u>708</u> | <u>885</u> | <u>4,487</u> |
| | <u>72.6</u> | <u>59.4</u> | <u>76.1</u> | <u>81.3</u> | <u>70.8</u> | <u>88.5</u> | |

SUMMARY TABLE

| SOURCE | DF | SS | MS | F | 5% | 1% |
|---------------|-----------|---------------|---------------|--------|------|-------|
| MOISTURE | 1 | 1760.4 | 1760.4 | 38.079 | 5.12 | 10.56 |
| BLOCKS | 9 | 431.7 | 47.97 | 1.038 | 3.18 | 5.25 |
| M X B Error A | 9 | 416.1 | 46.23 | | | |
| WHOLE PLOTS | <u>19</u> | <u>2608.2</u> | <u>137.27</u> | | | |
| VARIETIES | 2 | 3099.3 | 1549.65 | 43.924 | 3.26 | 5.25 |
| M X V | 2 | 36.6 | 18.30 | | | |
| V. X B. | 18 | Error 1270.1 | 35.28 | | | |
| V. X B. X M. | 18 | B | | | | |
| HALF PLOTS | <u>59</u> | <u>7014.2</u> | | | | |

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Artschwager, Ernst. Studies on the potato tuber. Journal of Agriculture Research. Vol. XXVII, No. 11: p. 829-30, March 1924.
2. Babcox, E. L., Jr. Irish potato studies and commercial growers. Market Growers Journal. Babcox Publications, Inc., Akron, Ohio, December 1950.
3. Callbeck, L. C. Current results with potato vine killers in Prince Edward Island. The American Potato Journal, 25:225-33, June 1948.
4. Davis, G. B. Quality loss in marketing Oregon early-crop potatoes. Oregon Agricultural Experiment Station. Bulletin, 468. October 1949.
5. Edmundson, W. C., Landis, B. J., and Schaal, L.A. Potato production in the western states. United States Department of Agriculture. Bulletin, 1843. April 1945.
6. Grubb, E. H., and Guilford, W. S. The potato. New York. Doubleday, Page and Company, 1912.
7. Hardenburg, E. V. Potato growing in New York. New York State College of Agriculture. Bulletin, 239. August 1932.
8. Hardenburg, E. V. Potato production. Ithaca, New York. Comstock Publishing Company, Inc. 1949.
9. Harrington, F. M., Iverson, V. E., and Pollinger, W. E. Potato yields and quality as affected by commercial fertilizers. Montana Agricultural Experiment Station. Bulletin, 392. June 1941.
10. Kraus, J. E. Progress report of potato research. Idaho Agricultural Experiment Station. Circular, 88. June 1944.

11. Kunkel, R., Edmundson, W. C., and Binkley, A. M. The effect of chemical vine killers on yield and quality of Red McClure and Bliss Triumph potatoes. *The American Potato Journal*, 25:371-76, October 1948.
12. Kunkel, R., and Binkley, A. M. People pick their potatoes by looks. *Colorado Agricultural and Mechanical College News*: 12-13, July 1951.
13. LeClerg, E. L. Potato production in the southern states. United States Department of Agriculture. *Bulletin*, 1904: August 1942.
14. Metzger, C. H. Growing better potatoes in Colorado. Colorado Agricultural Experiment Station. *Bulletin*, 446. June 1938.
15. Moll, A. C., Bushnell, J., and Keirnes, V. E. Potato growing in Ohio. Ohio Agricultural Extension Service. *Bulletin*, 309, January 1950.
16. Nielson, L. W. Solar heat in relation to bacterial soft rot of early Irish potatoes. *The American Potato Journal*, 23:41-56, February 1946.
17. Otis, C. E. The killing of potato tops with chemicals in Oregon. *The American Potato Journal*, 23:33-36, September 1946.
18. Peacock, W. M., Wright, R. C., and Whiteman, T. M. Controlling the shrinkage of skinned potatoes in storage. *Proceedings of The American Society of Horticulture Science*, 29:415-19, 1932.
19. Ramsey, G. B., Lutz, J. M., Warner, H. O., and Edgar, A. D. Experiments on shipping washed potatoes. Nebraska Agricultural Experiment Station. *Bulletin*, 364. June 1944.
20. Rich, A. E. The effect of various defoliant on potato vines and tubers in Washington. *The American Potato Journal*, 27:87-91, March 1950.
21. Rose, D. H. Handling and shipping early potatoes. United States Department of Agriculture. *Circular*, 744. January 1946.

22. Sandsten, E. P. Potato growing in Colorado. Colorado Agricultural Experiment Station. Bulletin, 220. January 1917.
23. Sandsten, E. P. Potato culture in Colorado. Colorado Agricultural Experiment Station. Bulletin, 243. March 1918.
24. Sandsten, E. P. Potato growing in Colorado. Colorado Agricultural Experiment Station. Bulletin, 314. January 1927.
25. Schrupf, W. E. Practices, costs, and tuber bruising in digging potatoes in Aroostook County, Maine. Maine Agricultural Experiment Station. Bulletin, 472. June 1949.
26. Stuart, William. The potato. Philadelphia and London. J. B. Lippincott Company, 1928.
27. Walker, J. C. Plant pathology. New York. McGraw-Hill Book Company, Inc., 1950.
28. Werner, H. O. The cause and prevention of mechanical injuries to potatoes. Nebraska Agricultural Experiment Station. Bulletin, 260. August 1931.
29. Werner, H. O. Wound healing in potatoes (Triumph Variety) as influenced by type of injury, nature of initial exposure, and storage conditions. Nebraska Agricultural Experiment Station. Bulletin, 102. July 1938.
30. Werner, H. O. Commercial potato production in Nebraska. Nebraska Agricultural Experiment Station. Bulletin, 384. June 1947.
31. Westover, K. C., and Leach, J. G. Growing potatoes in West Virginia. West Virginia Agricultural Experiment Station Circular, 78. July 1943.

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