EFFECT OF TEMPERATURE AND VARIETY ON WOUND HEALING OF POTATO TUBERS

by
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The potato tuber is covered with an epidermis (the skin) which is made up of three types of cells. These cells have different functions and appearances which need to be explained in order to understand the wound healing process. The first layer of cells are sometimes referred to as cork cells. These are rectangular, somewhat compressed cells which are arranged in rows (Fig. 1). The cells of this region are coated with lipid materials which give them a waterproof type of covering. The cells of the next layer are dividing cells which produce the cork cells. These cells have weak wall connections and it is this region that is responsible for the skin on the tuber slipping or not. When the tuber is mature and these cells have stopped dividing, the skin is no longer easily removed. The third layer of cells are large and contain significant amounts of starch. The role of these cells in healing is not well understood.

When a potato tuber is harvested, any one of these cell types or all of them may be removed. In order that the tuber may regain resistance to moisture loss and pathogen entry, these wounds must be sealed off by the regeneration of the skin. This process is referred to as suberization.

The process of wound healing involves more than just suberization, however. The following brief explanation of the wound healing process will help deliver us to a common starting place for an understanding of these processes.

1. The act of wounding (scrapes, punctures, cutting) from harvesting of the tubers.
   a) Affected by harvester operation
   b) Affected by skin development or maturity

2. Wound respiration; a rapid increase in the amount of CO_2 respired by the tissue which is wounded.
   a) Affected by temperature
   b) Affected by maturity of the tuber

3. Loss of starch in the region of the wound.
   a) Related to the rate of respiration
   b) Affected by temperature

4. Increase in resistance to pathogen attack.

5. Formation of dividing cells.
   a) Affected by temperature
   b) Affected by gaseous environment

6. Suberin formation and deposition.
   a) Affected by temperature
   b) Influenced by variety
   c) Affected by tuber maturity

7. Increase in resistance to water loss.

Research for more than a century now has investigated the processes listed above. We have a great deal of knowledge as to when some of the events take place, although there are

still questions that have not been satisfactorily answered. We know that resistance to most pathogens is well-developed by 24 hours after wounding, although we still do not fully understand what is the mechanism of this resistance. The formation of the waterproofing material, suberin, and deposition of other lipids begins about 2 to 3 days after wounding and is completed at about 8 days at 72°F. The formation of these waterproofing materials is the area which we have been most actively involved.

Suberin is a polymer of lipid materials. It is formed much like the fibers in synthetic clothing and has wax materials imbedded in it. If we think of a cell as being enclosed with a wall made of cotton (the cell wall) and then add a band of polyester cloth (like a shirt) to the inside of the cotton enclosure, we make it more resistant to movement of water. If we coat the band of polyester cloth with paraffin wax and then apply it to the cotton, we make the enclosure essentially watertight. This is much the same thing that happens during suberization. The cell wall, which is permeable to water, is coated with suberin, a tighter polymer, which is coated with wax-like substances, hydrocarbons.

The amount of suberin and waxes present in the newly formed skin is directly related to its ability to resist water loss. Therefore, this simple non-destructive technique can be used to determine the progress of suberization is the tissue. For this analysis, tissue is weighed, placed on a mesh screen after a given amount of time for suberization to occur, and weight loss is determined after one hour. Through the use of a simple formula, the ability of the tissue to resist water loss is calculated and is reported here as diffusion resistance.

The chemistry and time in which suberin and associated waxes are deposited has just recently become well understood. The factors which affect this deposition are now being studied.

Temperature

Potato tuber tissue is sensitive to temperatures, as in indicated by the buildup of sugars when stored at low temperatures. In order to determine if suberization is also temperature sensitive in the same range, a temperature gradient experiment was performed.

Cores of tissue were removed from the cortical region of the central portion of a potato tuber. The cores were placed in glass jars in an aluminum block to which hot and cold water baths were attached to provide a linear temperature gradient. The jars were connected to humidified air supplies at the same temperature as the tissue. Samples were collected daily for analysis.

Suberization takes place most rapidly at around 20°C, although it occurs equally well at temperatures slightly above and below with a slight delay in time (Fig. 2). There is noticable inhibition of suberization at both high (29°C) and low (less than 15°C) temperatures. This response is very sharp and may suggest that low storage temperature immediately after harvest could interfere with suberization.

It is well to note here that the process of disease resistance is perhaps the most important consideration at this time and that the two processes may be unrelated. Thus compromise storage temperatures are probably in order.

Varieties and age

The genetic makeup of a potato tuber dictates much of the tissues' ability to form suberin. Little attention has been paid to this process in variety development or evaluation. If a tuber is wounded in the harvest operation, its wound must be healed in order for it to store well. When a tuber is cut for seed, the cut surface must heal in order to provide protection for the seed piece which is responsible for plant growth. It is essential, therefore, that we understand the difference between breeding materials in their abilities to wound heal.

We collected 35 different breeding lines, hybrids, and plant introductions from the potato breeding project at Aberdeen, Idaho. These genotypes were evaluated for their ability to suberize by the diffusion resistance technique. From those 35, 6 were selected and used for further study with Russet Burbank as the control.

Each genotype responded differently in their ability to suberize under our conditions (Fig. 3). Russet Burbank and Fred A-1 were consistently good in their ability to suberize, whereas genotypes such as AHD 43-2, 146-12, ADX 287-23 and LS 2943-3 were good sometimes and poor other times. PI 225703-A1 seems to be a consistently poor performer in our studies.

There seems to be little consistency in the ability of the tubers to suberize with time of storage. Spring analyzed samples were not always high or low relative to fall analyzed samples. We can therefore conclude that temperatures below 15°C may be inhibitory to the proper healing of wounds of potato tubers. It is also obvious that some genotypes (potential varieties) have significant differences in their ability to heal and this data should be considered when hybridizing for future variety development.

Figure 1.

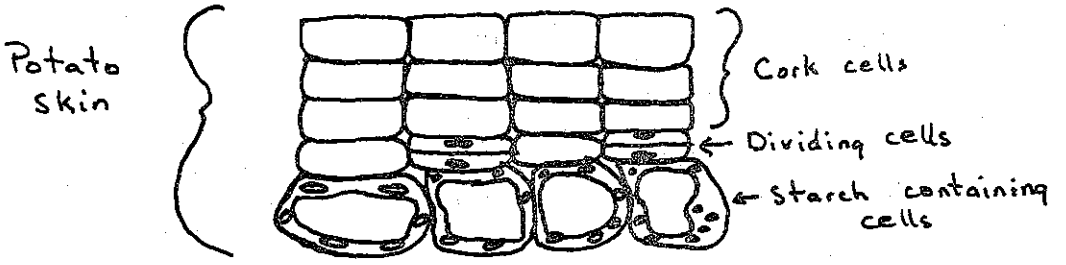


Figure 2.

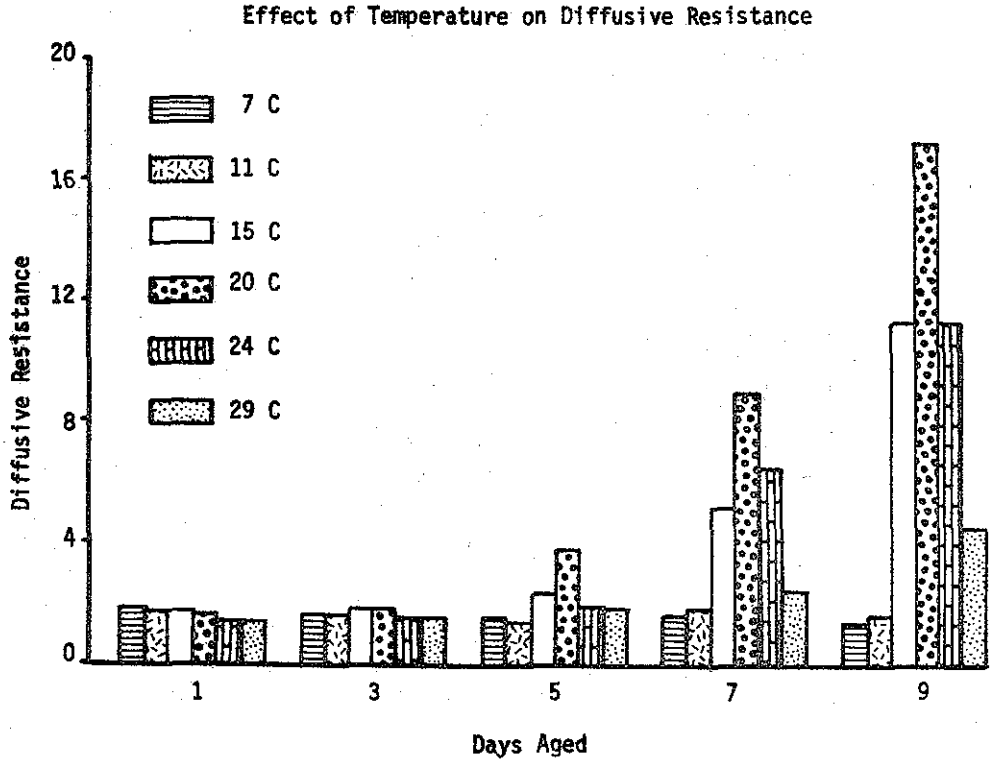
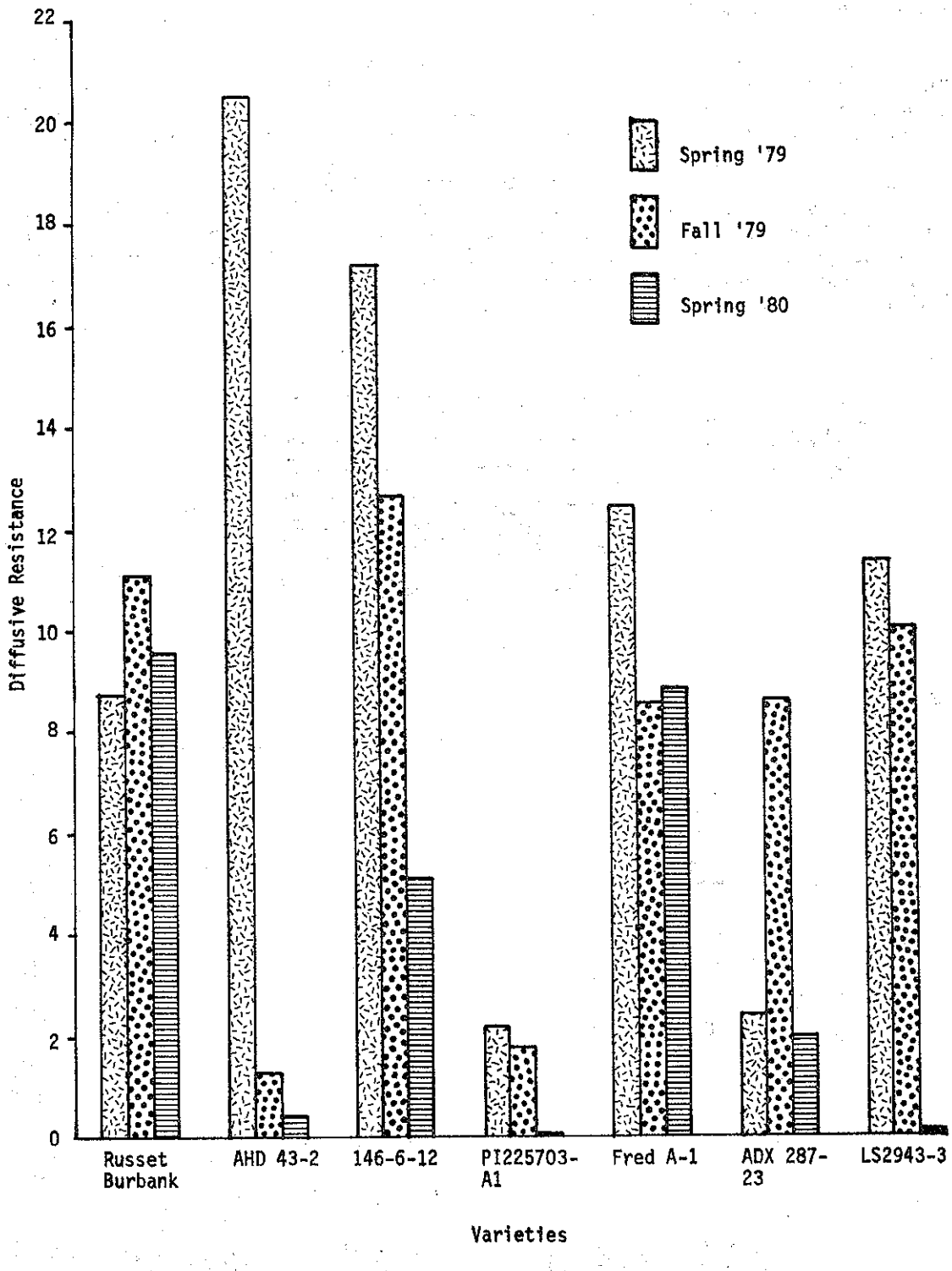


Figure 3.


Diffusive Resistance
22
20
18
16
14
12
10
8
6
4
2
0
Spring '79
Fall '79
Spring '80
Russet Burbank
AHD 43-2
146-6-12
PI225703-A1
Fred A-1
ADX 287-23
LS2943-3
Varieties