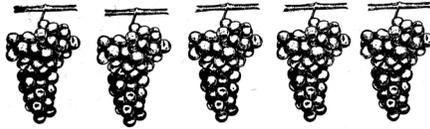


duty free and have a shorter distance to continental markets. Guatemalan and Guatemalan-West Indian hybrids appear to be the only types of avocados adapted to the development of an export trade

from Puerto Rico. However, production of these avocados is still so small that the local market will continue for some time to absorb the entire crop at a relatively high price.



## Let's Take Another Look at Hardiness

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Our knowledge of plant behavior often is advanced materially when some general problem is broken down into specific factors. It seems likely that more rapid progress may be made in the study of winter hardiness, or more particularly cold resistance of woody plants, if a careful analysis of the problem is made to determine what specific factors are involved. A perusal of the numerous contributions on the subject of hardiness in woody fruit plants will reveal that the majority deal only with survival. Over the years these records of survival have been useful, but often they do not explain the difference noted in plant behavior under different conditions. Fortunately some reports have dealt with the effects of specific factors but it is evident that this approach should be used more extensively.

The introduction within recent years of many new fruit varieties has intensified the need for studies to determine the detailed nature of ability to survive winter conditions. Many of these new varieties are the results of fruit breeding programs directed towards superior cold resistance. These varieties usually are considered hardy at their place of origin because there they have survived many winters. But what enables them to survive? And why are these "hardy" plants sometimes severely injured or winter killed? Is it lack of cold resistance or lack of something else which leads to injury? To answer such questions, and to gain a clearer understanding of the reaction of both old and new varieties to winter conditions it is apparent that we should attempt to recognize the specific factors which make up the hardiness complex, and study the role of each relative to

survival or injury. The writer has attempted to attack the problem in this way, but it is recognized that the coordinated efforts of other investigators is needed to determine which factors are valid and important. The factors presented and discussed herein are offered with hope that discussion and improvement may follow.

### Basic Factors

Certain basic factors have long been recognized as affecting winter survival. These include maturity, condition of the plant, exposure, and the variety itself. These factors need not be discussed in detail here. However, we have at times too complacently attributed winter injury to some one of these factors when it has been due to some other factor not recognized at the time. Quite often severe injury to raspberry canes has been attributed to immaturity, but, as shown in the illustration, such injury often is due to rapid loss of cold resistance during a few warm days in winter.

### Winter Drying

Another factor which often is confusing is winter drying, or desiccation. This factor usually is of little importance in eastern localities, but in the Great Plains area and the inter-mountain region it may cause severe injury. In this case, as with immaturity, we need to determine carefully the cause of injury. Drying of woody plants in winter may follow injury from insects, diseases, warm spells, or other causes, and such drying may easily be confused with true desiccation injury. When drying occurs it is necessary to determine if it is the cause of or a result of injury. During winter the

water content of woody plants may fall and rise repeatedly, and slight losses seem to cause no injury. But loss of a large percentage of water may result in material injury unless conditions are very favorable for water replacement during late winter or early spring. Where winter drying occurs it complicates the problem of survival.

### Reaction to Low Temperatures

As mentioned above, most hardiness records deal with the ability of woody fruit plants to survive winter conditions. Studies of "hardiness" often have seemed contradictory because the role of specific factors has not been understood. We need to recognize the possibility that cold resistance is a complex of several specific factors. Some of these factors have been recognized and studied but little is known about others. The several factors which now appear to be related in whole or in part to winter survival will be discussed briefly.

1. **Rest Period.** The resting condition in woody plants usually is considered an internal control which prevents growth at warm temperatures. For the most part it appears to be a function of the buds. It is commonly called the "Winter" rest, but as it begins about the end of the growing season with bud maturity and in northern localities usually is ended by early December it is not truly a "winter" condition. Rest may be broken by heat, anesthetics, or injuries, but most commonly it is broken by low temperatures. With increasing exposure to low temperatures the intensity of rest decreases. The same low temperatures bring about dormancy and resistance to cold. So far as we

know these factors are not directly related but all are responses to declining temperature. However, when rest is broken early in the raspberry plant, warm spells seem to cause a loss of both cold resistance and dormancy and thus result in severe injury during subsequent cold weather.

2. **Dormancy.** Most woody plants are unable to grow at temperatures below about 41°F. and they are then said to be dormant. If the rest is broken some plants begin bud activity very quickly at temperatures above 41°. There are marked differences between the kinds of plants, however, as warm temperatures which start activity in raspberry buds do not seem to affect apple or plum buds to the same extent. Evidently moderately low temperatures, or a "steady" winter is beneficial in maintaining both dormancy and cold resistance.

3. **Time of Development of Cold Resistance.** Considerable evidence has been presented to show that mature woody plants harden as the temperature declines, but not enough is known about the time when cold resistance is fully developed in fruit plants. It seems likely that woody plants adapted to northern regions develop cold resistance early. But there may be marked differences between kinds and varieties in this respect. It may be that some cases of injury attributed to immaturity possibly are due to delayed hardening. If injury is so caused, it would not necessarily indicate inability to harden eventually under more favorable con-

ditions. More information is needed on this item.

4. **Rate of Development of Cold Resistance.** Available information relating to this factor deals largely with herbaceous plants. Some recent studies have shown that the Latham raspberry is able to harden rapidly. We may assume that similar behavior enabled the "hardy" apple varieties Haralson, Wealthy, McIntosh and Northwestern to escape serious injury in Minnesota during the Armistice Day storm of 1940 whereas the less "hardy" varieties Jonathan and Delicious were severely injured. All these varieties appeared to be well matured and temperatures in the locality during and immediately following the storm did not fall below zero, so injury could be attributed neither to immaturity nor severe cold. Sudden cold may be a cause of injury at times but it is doubtful if it causes much injury to hardened plants particularly if hardiness is retained. Differences in the rate of hardening have been noted in some reports but we need to learn much more about the role of this factor.

5. **Ultimate Cold Resistance.** This can be defined as the lowest temperature a variety can withstand without injury under the most favorable conditions. To a large extent published hardiness ratings are expressions of this factor as they show the average behavior of varieties over a period of several years. However, as these ratings are not always based on exposure to controlled low temperatures

they may not show the ultimate degree of resistance. Our information could be improved by more studies carried on under controlled temperatures.

#### 6. Variations in Cold Resistance.

We long have known that cold resistance is developed as temperatures decline in late fall and early winter. We have assumed that such resistance is retained throughout winter and lost rapidly towards early spring when temperatures rise. It may be that this regular behavior does occur in some fruits. We also know that roots and tops, leaf and fruit buds differ in their degree of cold resistance. But only recently have we begun to learn that cold resistance may rise and fall as winter temperatures vary. Present indications are that failure of some plants to survive certain winters may be due to loss of cold resistance rather than failure to develop it. Retention or loss of a high degree of cold resistance possibly may explain why some plants are injured by fluctuating winter temperatures while others escape injury. Loss of part or all of the ultimate cold resistance of a plant possibly can explain some cases of injury from sudden cold. It is evident that our information relating to this factor is incomplete.

#### 7. Ability to Regain Cold Resistance.

This factor is directly related to the preceding one. If cold resistance is lost can it be regained? To what extent is it lost? How rapidly can it be regained? A few recent reports show that some plants or their parts readily reharden if conditions are favorable. That so little is known



Matured and hardened Latham raspberry canes may be injured by cold if exposed to warm temperatures prior to the cold period.

No. 1. No exposure to warm temperatures.

No. 2. 2 days at  $+45^{\circ}\text{F.}$ : 24 hours at  $-8^{\circ}\text{F.}$

No. 3. 4 days at  $+45^{\circ}\text{F.}$ : 24 hours at  $-8^{\circ}\text{F.}$

No. 4. 8 days at  $+45^{\circ}\text{F.}$ : 24 hours at  $-8^{\circ}\text{F.}$

Injury in the field similar to that of numbers 2, 3, and 4 generally has been attributed to immaturity.

about ability to reharden reflects our lack of information relative to loss of cold resistance. Obviously such information is

needed before the problem of winter survival can be fully understood.

If the problem of winter survival can be broken down into some such specific

factors of the hardiness complex, it seems likely that we shall materially advance our knowledge of the winter behavior of woody fruit plants.



## The Baldwin Apple

### 1740 To The Present

By J. H. Waring

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The Baldwin clon is fully 200 years old. S. A. Beach, in *The Apples of New York*, gives as its origin a farm in Wilmington, near Lowell, Massachusetts "soon after 1740." Its dissemination and popularity did not come at once, but William Kenrick wrote of it in 1833: "No apple in the vicinity of Boston is so popular as this at the present day." F. C. Bradford, in his Master's thesis on *Maine Apple Varieties*, placed Baldwin as the leading commercial variety of Maine from 1850 through 1910. This leadership was held until 1933, but the following severe winter killed or severely injured some two-thirds of the Baldwin trees in Maine orchards and gave impetus to a decline that had already set in and has continued since.

#### Many Unfavorable Reports

Contributing to *Agriculture of Maine* about 1867, Calvin Chamberlain of Foxcroft cited the experiments of a "Mr. A." in one of the eastern counties, who reported: "I have tried some 100 varieties, and thrown away about 50 recorded in the books as worthless in this soil and climate. Among them is the Baldwin. I cut down a tree of that variety this fall that had been living and dying for ten years and produced about a barrel of imperfect apples." This is an extreme case because the tree was probably located near Oldtown, Maine, which was too far north for this variety. Ultimately Baldwin was adjudged to be out of place throughout much of New England.

In 1873, Z. A. Gilbert of Androscoggin County wrote that the Baldwin fruit