What is a "Test Winter?"

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HORTICULTURISTS in Minnesota, both practical and professional, are familiar with the term "Test Winter." According to the records, such seasons have occurred at varying intervals. Seasons usually regarded as "test winters" in Minnesota were those of 1872-73, 1884-85, 1898-99, 1917-18, 1935-36, 1940-41 and the past winter of 1947-48. Other regions have had similar test winters but these have not always occurred at the same time as in Minnesota. Also damage may have been more severe elsewhere during the same season recorded as a test winter here, as was seen in Iowa and Nebraska in 1940-41.

The seasons in which severe injury occurred were not all alike. Not all were marked by severe cold nor by prolonged sieges of cold weather. Also it is evident that only moderate injury occurred during some rather cold winters so these were not rated as "Test Winters." So the question arises, "What is a test winter?" What is being tested? It is easy to conclude that we have had a test winter when there has been severe injury or killing, but, because we know that injury may be due to any one of several factors, we need to determine if possible which factor or combinations of factors caused the injury. It is evident that records of survival or injury do not tell us the cause of the injury. If we stop to consider all the factors which enable a woody plant to escape injury, and all which may lead to severe injury or killing, we quickly realize that there are several factors involved in what we call "hardiness." If these factors are favorable there may be little or no injury. If one or more are unfavorable, injury may be very severe.

Condition of the Plant is Important

A woody plant to be best able to withstand winter conditions must be in good vigor. A plant weakened by poor growing conditions, diseases, insect injuries, or by the production of a heavy crop will not be prepared for a severe winter. Also, a young tree usually does not reach the best condition for winter survival. A plant which is not in the best condition may survive a series of moderate winters only to be injured or killed in an unusual season such as the past one. The relationship of the young tree to injury is commonly demonstrated by the behavior of the McIntosh apple. This variety seems to meet with considerable injury during the first four or five winters unless this period happens to be on the mild order. As the trees grow older they seem to become better able to cope with usual winter conditions.

The effects of poor condition are clearly shown by the killing of raspberry canes following severe mildew infection, by the killing of young apple trees following defoliation by insects in late summer, and by injury to "hardy" apple varieties such as Wealthy and Haralson following the heavy crops of 1947.

Maturity Is Very Important

The part played by stage of maturity is well illustrated by the usual behavior of currants and grapes. Although we have not determined the ultimate cold resistance of these fruit plants, experience has shown that currants usually are not injured, largely due to their habit of maturing early. Grapes, to the contrary, tend to grow until a freeze kills the tips of the shoots. Because of this late growth extensive injury is frequent with the grape.

Dry weather in fall often advances maturity as was the case in central Minnesota in the fall of 1940, but a prolonged drouth such as occurred during the late summer and fall of 1947 delayed maturity by interfering with the manufacture and storage of foods. Maturity also seems to be related in some way to the development of cold resistance. Perhaps this is a coincidence or related to the supply of stored foods, but it is quite evident that an immature plant does not harden as quickly or as well as one in which maturity is well developed. Ordinarily our woody plants are well matured by November and have begun to harden. But last fall maturity was delayed by the combination of a short growing season, drouth, heavy crops (in apples), and temperatures too high in October for hardening to progress, so many woody plants were not able to adjust themselves to early cold. In 1947-48 both poor plant condition and immaturity contributed to injury from early cold, and the recent "Test Winter" was not so much a test of ability of our plants to withstand cold, but demonstrated the relationship of plant condition and immaturity to injury.

Winter injury in the Great Plains area often is complicated by the occurrence of winter drying when the soil is frozen deeply and drying winds are frequent. Damage from drying has been very serious at times in Minnesota. In such cases we need to be careful to determine if the drying is in itself the cause of injury, or if drying has followed some other kind of injury such as caused by immaturity, severe cold, varying temperature, or damage by insects or diseases. Winter drying occurred in 1933-34 and contributed to the severe injury during 1935-36 but in each case other factors were involved. Apparently winter drying was not the principal cause of injury during the past season, although it is likely that much of the damage to evergreens and some other nursery stock was due to drying. Possibly drying, complicated by varying temperatures, explains why cuttings of evergreens showed more injury in midwinter than in November.

Cold Resistance Involves Several Factors

Recently we have realized that "hardiness" or resistance to cold is not a simple type of plant behavior, but probably involves several factors all of which are a part of, and contribute to hardiness. As these factors operate both alone and in combination we need to consider each in turn.

1. *Dormancy.* According to the usual horticultural definition a plant is dormant when the temperature is too low for it to grow. So long as winter temperatures remain below freezing a matured plant cannot grow and usually escapes injury from cold. It will escape injury only when the dormant plant also has developed resistance to cold and if this resistance is retained. If dormancy is "broken," even if there is only slight development of buds, hardiness usually is lost and severe injury may follow.

2. *Rest Period.* The winter rest, closely related to, if not a part of dormancy, is an internal control of activity. While the plant is in its rest it cannot grow even when conditions are favorable for growth. Rest is centered in the buds and begins when the buds are fully developed. It continues until some agency, usually low temperature, causes a gradual decline in

intensity of this internal control until sometime in early December it is no longer effective. This explains why there usually is no growth during warm moist weather in late October or November unless there has been enough cold weather by that time to break rest.

3. *Time and Rate of Development of Cold Resistance.* When, and how rapidly do our woody plants harden to cold? We know very little about this factor, but it seems very likely that ability to harden early and rapidly is an important part of what we call "hardiness." Experimental treatments have shown that the Latham raspberry hardens very rapidly when temperatures fall below freezing. It seems likely that most of the woody plants we consider hardy and adapted to northern localities have this ability to harden rapidly. It is possible, also, that the plants we believe are not hardy may lack this important ability.

In northern localities early cold, such as occurred in November in 1940 and 1947, is not unusual. When plant condition and immaturity interfere with hardening, as was the case last fall, we cannot logically attribute the resulting injury to lack of varietal "hardiness." But the rate of hardening last fall may not have been rapid enough under the prevailing conditions. It seems very likely that Haralson, Wealthy, McIntosh and Northwestern apple trees, which differ in "hardiness" escaped severe injury in Minnesota in 1940 because of their ability to harden rapidly. That Jonathan and Delicious were injured at that time may have been due to inability to harden rapidly. All these varieties were well matured at the time and temperatures immediately following the blizzard did not fall below zero in central Minnesota. So the injury to the "tender" varieties apparently was due neither to immaturity nor to severe cold, but probably reflected their inability to harden rapidly. In such cases we cannot properly attribute injury to lack of varietal "hardiness" or to their inability to withstand low temperatures.

4. *Ultimate Cold Resistance.* Ultimate cold resistance may be defined as the lowest temperature a dormant plant can withstand *under the most favorable conditions.* Investigations now in progress indicate that when samples of year-old growth are subjected to gradually lowered temperatures in the laboratory there has been no injury to an assortment of apple, plum and raspberry varieties above —30° F. Even the varieties usually rated as "tender" seem to reach a degree of resistance to cold which is lower than their usual rating. We must keep in mind that many things may interfere with development of this ultimate resistance to cold and that it is not likely that the greatest resistance to cold is reached every year.

Differences in "hardiness" between leaf buds, flower buds, tops and roots are easily recognized, but "hardiness" ratings usually are based upon the behavior of the wood and leaf buds. The several "hardiness" ratings which have been published are based on varietal performance over many years and are useful, but we need to keep all factors in mind if we want to explain why "hardy" varieties sometimes are severely winter injured.

5. *Cold Resistance Not Stable.* We used to think that woody plants once well hardened stayed that way until early spring. Recently it was shown that the high degree of cold resistance usually developed in the Latham raspberry may be lost quickly during a few mild days in winter. Horticulturists in New Jersey have shown that peach blossom buds are less hardy following mild weather than after moderate cold. We need to learn much more about the ability of woody plants to reharden after cold resistance is lessened by mild weather. Indications at present are that cold resistance in the apple fluctuates much as it does in the raspberry but with less marked changes. Thus we may recognize the possibility that poor survival may not indicate either poor maturity or lack of ability to harden, but may show inability to retain cold resistance during mild weather. It is likely that much potential cold resistance had disappeared in many plants before the severe cold spells of early March, thus adding to the extent of injury.

We do not know how readily cold resistance is regained if it is lost. It seems likely, however, that at least a part of injury caused by sudden cold in winter may be due to loss of a considerable degree of cold resistance in a preceding mild spell and inability to regain "hardiness" rapidly enough to escape injury. Here again the variety enters the picture. It seems possible that varieties which are able to develop the same degree of initial cold resistance may differ in their ability to reharden. Possibly those which can regain hardiness rapidly after warm spells are the ones we usually have rated as hardy. It will be interesting to work on that phase of the problem.

Conditions Prevailing in 1947

As we look back over the past year we can recall that the season of 1947 started about three weeks late and ended on November 7, about three weeks early. So the season was an exceptionally short one. In addition to the short growing season there was prolonged drouth during August, September and October which interfered with development of size and color in late apples and also delayed maturity. Weather records for the Twin City area show that there was no frost during October so that influence leading towards maturity and hardening was lacking. In many gardens there still was a fine display of annual flowers on November 6. But on November 7 the weather changed suddenly to snow and freezing temperatures which prevented the usual development of maturity. In the northern part of the state, frosts which occurred before snow came probably served to promote the development of cold resistance enough in many cases to greatly lessen injury.

What Factors Were Involved in the "Test Winter" of 1947-48?

Although injury varied from place to place it was generally severe and appeared in fruit plants, nursery stock and ornamental plantings. As different factors seem to have led to injury in different cases the factors probably involved in different kinds of plants were as follows:

Apple: Short growing season; drouth; immaturity; poor condition due to heavy crop; early cold; late cold.

European Plums: Same as apple.

Grapes: Immaturity; sudden cold; late cold.

Raspberries: Immaturity; diseases; sudden cold; early season injury increased by loss of hardiness in mild weather followed by sub-zero weather in March; failure of canes covered by early snow to harden completely.

Evergreens: Immaturity; varying temperatures; drying during bright days in winter.

Strawberries: Hardening delayed by mild weather; early snow cover prevented full development of cold resistance; temperatures above freezing, and soggy mulch unfavorable; low temperatures in mid-winter when snow cover was lacking; late cold.

Apple Nursery Stock: (Injured at base of trunks.) Failure to harden fully under snow cover; severe cold after snow melted; late cold.