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WINTER INJURY — AN INTERACTION[1]

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The winter of 1976-77 was the coldest winter in 65 years at Columbus, Ohio. Speculation as to the extent of the winter injury on the part of researchers, arborists and nurserymen alike was widespread even before the winter was over (14). The phenomenon known as winter injury is not something which manifests itself in a predictable pattern within a predetermined amount of time. Winter injury, like all biological reactions, is the result of interactions between the affected plant and its environment. To be sure, winter injury can be as sudden and dramatic as a hurricane with the death of the plant obvious as soon as it is light enough to see. Conversely, damage from winter injury which occurred during the winter of 1977 may not be apparent to the casual observer until the summer of 1980 or later.

The mildest forms of winter injury will be covered first. This is based on the author's subjective view of the severity of various types of winter injury. Rodent damage and salt injury may also be called winter injury, but these and similar associated injuries will not be covered in this report.

Flower bud kill

A mild form of winter injury is the loss of flower buds, resulting in the lack of flowers. Flower buds are often less cold tolerant than the foliar buds. Rhododendron, azaleas, forsythia, viburnums and pyracantha suffered this type of injury in Ohio during the winter of 1977. This injury is marginal and all portions of a plant may not lose flower buds (Fig. 1).

Protection of the flower buds can often be obtained by the use of windbreaks. This type of protection results in a temperature increase of only a few degrees when compared to an unprotected location. Thus we often see flower buds killed on the windward side of a plant and not the lee or protected side.

Fig. 1. Flower buds on the right were protected by another plant which acted as a windbreak. The plants on the left were not protected.

Foliar necrosis

Blanching of foliage is often noted particularly on evergreen plants. This is also a rather mild form of winter injury although the injury may be quite spectacular (Fig. 2). Injury may be confined to the foliage, resulting in leaf abscision. No serious damage to the plants results under these types of conditions, although the homeowner may be quite concerned until the injury is obscurred by new growth.

This type of injury can be caused by foliar dessication as the result of an interruption in

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water movement into the foliage. Rapid drops in temperature can also cause this type of injury (16). The same kind of damage occurs on conifers which are usually more cold tolerant except that blanching usually begins with the tips of conifer needles.

The necrotic lesions caused by injury from cold are often attacked by various disease organisms. Botrytis is frequently associated with this type of injury (11) and while fungicides will control the fungus, the injury could have been prevented by spraying.

Protection from foliar necrosis is often obtained by planting in protected locations or by planting windbreaks. Mulching may also help by making moisture more available, thus reducing dessication.

Laboratories and other professionals are excellent resources to assist in diagnosing plant disorders, but reports can be misleading if the laboratory does not have all the information. For example, foliar lesions caused by winter injury could be identified as a disease problem because of a positive laboratory isolation of *Botrytis*, especially if the laboratory was not privy to the weather history.

Frost cracks

Frost cracks are a more serious form of winter injury than foliar necrosis (Fig. 3). Bark splitting is a mild form of frost crack and can close over rapidly while frost cracks into the xylem tissue can takes years to close over. This type of injury

Fig. 2. Blanching of evergreen foliage caused by a rapid drop in temperature. Leaf buds and apical meristems were not injured.

Fig. 3. *Frost crack on cherry.* This damage is fairly extensive and extends from the first branch to the soil line. Note that the fracture includes a partially closed pruning injury.

also favors invasion of the tree by wood decay fungi (11). Bark splitting may be reduced by nutrient levels which are high enough to prevent stress (13). Old wounds and poor drainage also favor the occurrence of frost cracks.

Cup shakes (Fig. 4) are another form of frost crack. The distinction between frost crack and cup shakes is made by a determination of whether the crack was caused by an expansion (cup shakes) or contraction (frost crack) of the trunk. Both are caused by differential heating and cooling of the trunk as a result of the radiant energy of the sun and low air temperatures. The trunk is heated by the sun rays during the day but at night the temperature at the trunk surface drops rapidly as the radiant energy of the sun drops below the horizon. The surface contracts while the center of the trunk remains expanded, placing the trunk under a severe strain. An old wound may predispose the trunk to this type of injury.

Tip kill or branch dieback

Another form of winter injury is tip kill. The severity of this type of injury ranges from leaf bud kill to branch dieback to death (Fig. 5). The type of injury is also frequently associated with stress pathogens such as Botryosphaeria (4,11).

Fig. 4. Cup shakes is often more serious and extends into the xylem usually fracturing along an annual ring. Cup shakes occur in the morning as the outer trunk is expanding while the center of the trunk remains contracted.

Tip kill or dieback can be minimized with good cultural conditions. Proper plant selection, adequate soil moisture, nutrition and mulches are important in reducing winter injury (10,8). Placing plants in the proper exposure with good soil and air drainage are also important.

Antidessicants can also reduce foliar burn and tip dieback if applied properly (12). This is one of the few techniques a homeowner has which will allow him to protect plants rather selectively.

Sweetgum, dogwood, redbud, Chinese elm, forsythia, some viburnums and many other plants showed dieback in 1977. Interestingly, a great deal of seedling variation was noted (Fig. 6). The spring of 1977 was a good time to select cold tolerant cultivars for future introduction.

One thing which was quite apparent this past winter was that the green industry as a whole has done a rather poor job of selecting plant materials. We seem obsessed with selecting plants which exhibit some abnormal growth response. Many of these plants could not survive in nature. It seems to be that there is an "implied warranty" which states that when a consumer purchases a landscape plant, that he has a right to expect that the plant will survive under normal conditions with reasonable care.

A case in point is the variation in winter damage suffered by various sweetgum cultivars in the shade tree evaluation plots at Wooster, Ohio. 'Festival' and 'Burgundy' were selected in southern California for fall color. These cultivars suffered severe damage while 'Moraine,' an Ohio selection, suffered little damage under the same conditions. Obviously, 'Moraine' is the best cultivar for use in Ohio where winter temperatures can drop to -20 deg. F. In southern California 'Moraine' may be unsuited for landscape uses for very different reasons. More independent evaluations of plant introductions are needed in order to insure that the consuming public is purchasing adapted plants.

A good example of the interaction which exists between various academic disciplines in nature is also demonstrated by sweetgum. Man, not

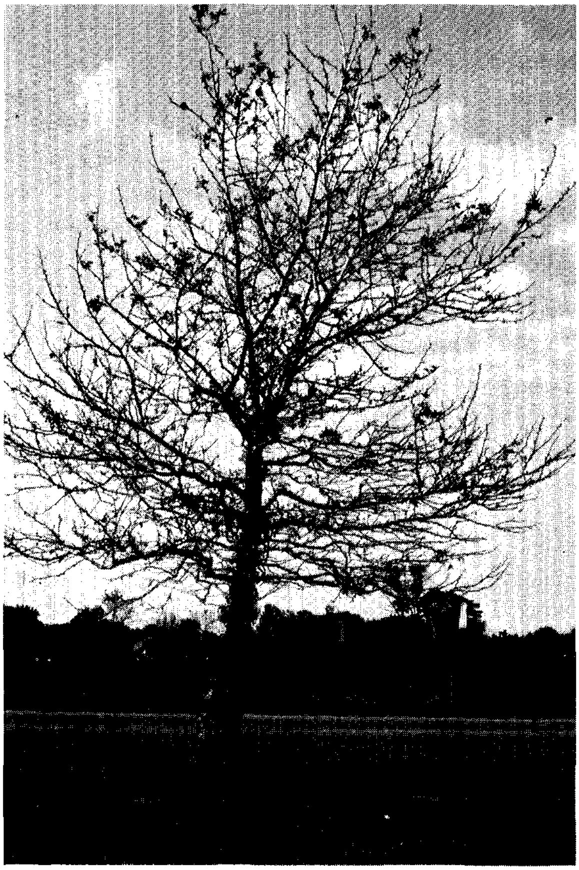



Fig. 5. Tip dieback was common in Ohio during Spring 1977. The degree of severity varied widely depending on the species of the plant. Minor injury was noted on the red-stemmed dogwood (left) while branches several inches in diameter were killed on the sweetgum (right).

Fig. 6. The seedling Chinese elm on the left showed little injury while leaf bud kill and tip dieback was extensive in the plant on the right.

nature, likes to categorize problems. Twig dieback is evident now in Ohio (Fig. 7). Weather conditions for the spread of Botryosphaeria were ideal this past spring. Thus, I predict that in 1980 Ohio will have a serious outbreak of bleeding necrosis (Botryosphaeria). Assuming that my prediction will be correct, would the 1980 problem be a physiological problem (winter damage) or a pathological problem (bleeding necrosis)?

Root injury

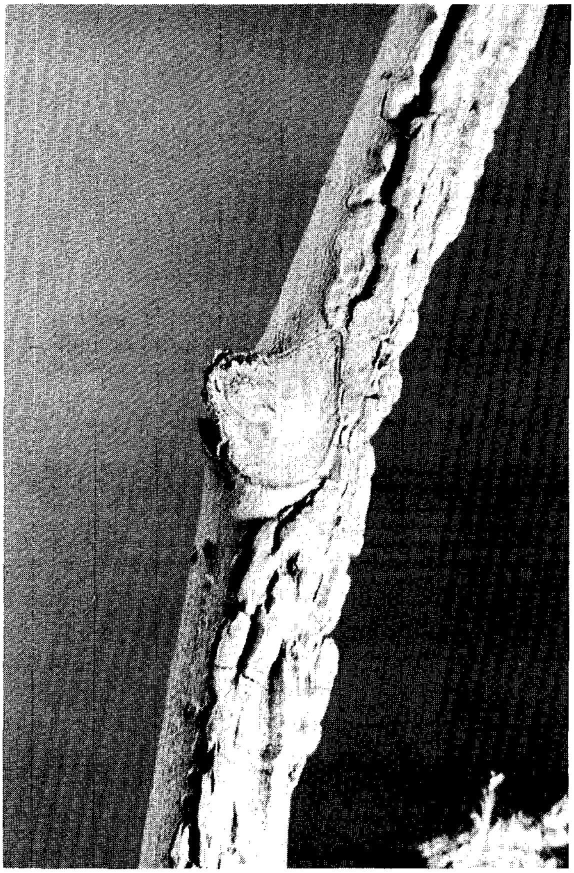
Roots are not as hardy as the above ground portions of the plant (5, 4, 16, 6, 7). Roots are never subjected to the same temperature extremes and variations to which the aerial portions are subjected. A comparison of the 1977 lows for Wooster,, Ohio will give you an example. The 1977 air temperature low was -20 deg. F while the lowest soil temperature at depth of 4" was 26 deg. F.

Injury to roots is more insidious than injury to the twigs because this injury is not visible. Unlike branches which can be acclimatized, feeder roots are normally killed by temperatures just below freezing (12, 16). Nutritional status, photoperiod, hormones and other factors seem to have no effect on root hardiness, as long as the plants are not under stress (12, 16, 9). Thus when the root zone temperatures approach 28 deg. F, severe root pruning of the feeder roots results. Larger roots like branches can acquire a tolerance to low temperatures.

Necrotic roots like necrotic branches are excellent entry points for soil-borne pathogens (Fig. 8).

In addition to predisposing the plant to insect and disease attack, loss of roots during the winter can manifest itself in a vastly different way (Fig. 9). Iron, manganese and zinc deficiencies can be induced by root injury and/or low soil temperatures (3). In this case the foliar symptoms will disappear as the soil warms and roots begin to grow into the surrounding soil again. This assumes that the plant is not attacked by insects or disease which would prevent normal root regeneration.

Reduction of root injury during the winter is accomplished by maintaining the plant in good growing condition. Adequate soil moisture,



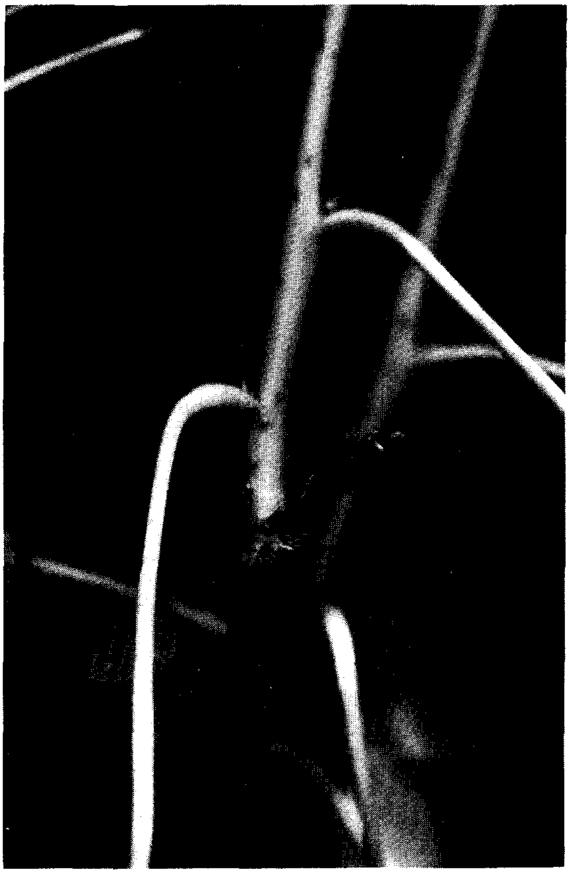


Fig. 7. Many twigs were killed back to the branch. These dead twigs are an excellent entry point for fungi such as Botryosphaeria. Note the cut made through the juncture of living and dead tissue on the left. Regrowth later in the season confirms that tip dieback and not foliar bud kill has occurred in the photograph at the right.

Fig. 8. Root injury on this Norway spruce seedling resulted from freezing in transport. Aerial portions of the plant were not damaged.

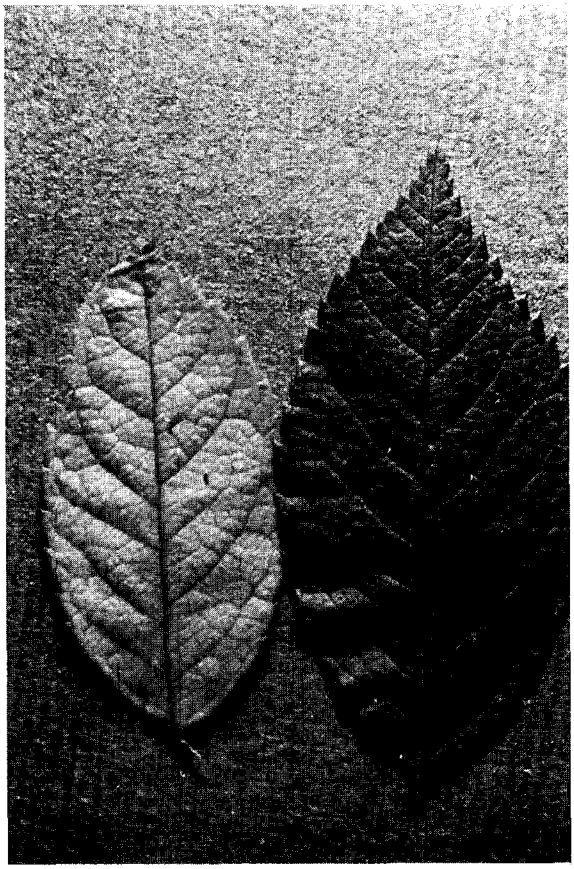


Fig. 9. Iron chlorosis on this rose was the result of root injury and low soil temperatures. Foliar analysis confirms a lower Fe content in the sample on the left.

nutrition and mulches will help to minimize injury and to reduce recovery time.

Storm damage

Winter storms carry wind, snow and ice which can cause physical injury to exposed plants. The weight of ice and/or snow and the force of the wind can cause serious injury. A number of plant species are particularly prone to this kind of injury (Fig. 10, 11). American and Siberian elms, zelkova, Russian olive, willows and pecans are susceptible to injury (1, 2). Plants with evergreen foliage or plants with an upright habit of growth are also a problem as evergreen foliage intercepts more ice and snow and upright plants which have narrow crotch angles are not capable of holding the weight which a 90 deg. crotch angle will hold (1).

Mechanical injury of this sort must be removed by pruning. Removal of the snow or ice can also provide relief. If the temperature is at or above freezing, water can be used to remove ice or snow, however, care must be taken to insure that this does not complicate the problem. Using plants which are structurally sound and not weak wooded will also reduce injury which is incurred during an ice storm.

Frost injury

Frost injury differs from cold injury in that frost injury is a sudden drop in temperature in the spring or fall. The temperature drops below

Fig. 10. This live oak is holding a heavy ice load. No breakage was noted although the branches were often bent double from the weight.

Fig. 11. Pecan has narrow crotch angles and was virtually destroyed in the same ice storm as seen in Fig. 10.

Fig. 12. Frost injury is unusually severe on conifers which have only one growth flush per year. Pine, fir and spruce lose a year's growth when the expanding shoot is killed.

freezing then normally climbs above freezing within a few hours. Frost injury also occurs at temperatures which the plant would tolerate during the winter months. While the severity of the damage varies greatly (Fig. 12), rarely is it fatal to woody ornamentals.

Plants are most sensitive to frost injury when the leaf buds are rapidly expanding in the spring. At this time injury occurs at or just below freezing temperatures.

Frost injury is often quite localized (Fig. 13). Exposed branches on one side of the plant may be the only injured tissue. Injury is more severe on conifers than on deciduous plants. Holes in leaves may also result from frost injury which occurs when the leaf tissue is expanding. As a general rule, frost injury on deciduous plants is usually cosmetic and rarely causes any real damage because the tissue is normally aborted which reduces the chance for secondary infections.

All of the various kinds of winter injury and the various cultural environmental and genetic differences combine to make each case somewhat different. However, if you keep your eyes open and remember the various interactions which can

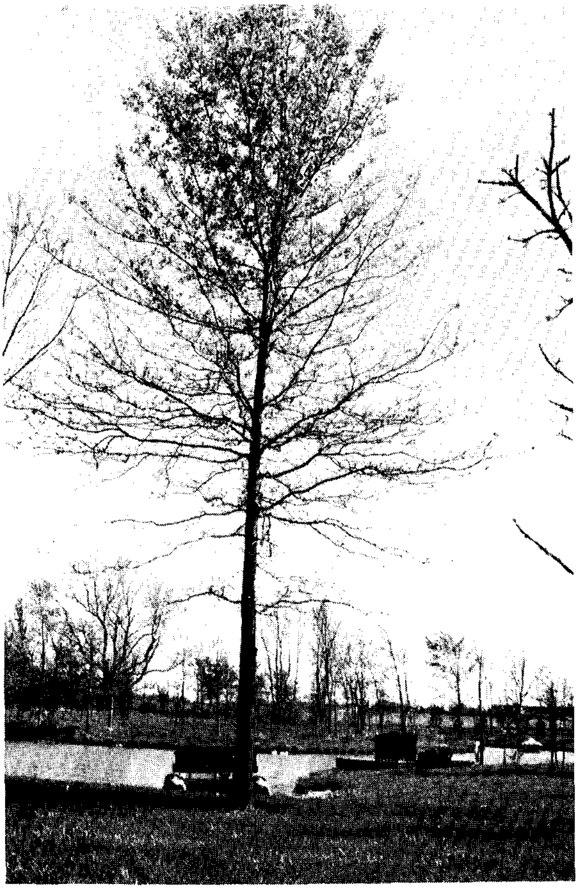


Fig. 13. This pin oak shows a classic pattern of layered injury. Cold air is denser than warm air. Thus, we see increasingly severe injury as we move down the tree.

occur, it becomes easier to identify winter injury. In addition, a knowledge of the weather history of the plant which has been injured is essential.

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ABSTRACT

Kozelnicky, G.M. 1977. **Using plant protectants economically.** Weeds, Trees and Turf 16(2): 42, 44, 46.

Plant protectants are generally divided into herbicides, fungicides, and insecticides. The EPA includes in its definition of pesticides other compounds such as certain surfactants and growth regulators. Regulations and laws always seem to increase costs. Before we use a plant protectant we need to have a reason for its use. Armed with this foreknowledge, you are now ready to introduce into your program the plant protectants you need. Don't buy more than you need. Acquaint yourself with the common namees of the chemicals you will be using. Your application equipment must be in proper operating condition.