JOURNAL OF
ARBORICULTURE

October 1978
Vol. 4, No. 10

THE INFLUENCE OF STRESS ON DISEASES OF NURSERY AND LANDSCAPE PLANTS[1]

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Combatting disease problems has been a difficult and often confusing task in the nursery and landscape industries. The many hundreds of species, varieties, and cultivars utilized as landscape plants can exhibit a tremendous diversity of damage symptoms; some due to disease agents, some to insects, some due to physical or physiological factors. Often damage appears as a result of a combination of factors. Since effective prevention or treatment of plant disease depends on an accurate identification of the cause or causes of damage, a thorough awareness of where disease agents come from, how they enter host plants, and how environmental factors influence disease incidence and severity is essential in order to select effective disease control measures.

Although some disease agents such as fungi, bacteria, viruses and mycoplasmas, and nematodes may be introduced into areas where they were not formerly present and result in disease outbreaks, most of the disease damage encountered on nursery and landscape plants is associated with pathogenic agents that are endemic or have been present in the area for some time. If the disease agents are aggressive pathogens that attack vigorous hosts, if genetically susceptible hosts are present, and if climate conditions are favorable for disease development, disease damage will occur. Many of our most familiar diseases such as leaf spots and blights, rusts, mildews, and vascular wilts fall in this category.

There is another category of predominantly endemic pathogens, however, which are much harder to recognize and about which much less is known. Among them are included the pathogens that cause stem cankers, diebacks, declines, and some root rots. Although a few of these organisms are aggressive pathogens that can attack vigorous hosts, the vast majority are relatively nonaggressive and only attack hosts that are weakened or low in vigor. The amount of disease damage that occurs dependson the relative aggressiveness of the pathogens toward a particular host plant and the state of host vigor. Economically, pathogens of this nature are of great importance in the nursery and landscape industries since they are associated with plant damage that requires pruning or roguing-out of diseased plants, replacement of warranteed plants, and general consumer dissatisfaction.

Weakening or reduction in vigor of landscape plants usually arises from exposure to stresses, the most common ones being drought, flooding, freezing or extreme temperature fluctuation, defoliation, nutrient deficiency, chemical injury, mechanical injury, and transplanting shock. Exposure to any or all of these stresses may cause visible physical injury in the absence of disease organisms. However, the stresses can have a more subtle effect in the absence of visible injury by weakening the host plant and increasing its susceptibility to nonaggressive pathogens.

When landscape plants are placed under stress conditions to the point where damage occurs, what kind of symptoms do we usually find associated with the damage? In many cases, the actual killing of plant tissues is either accompanied by, or a result of infection by disease organisms. Boring insects also attack weakened plants and may cause death of stems, alone or in combina-

[1] Presented to the Ohio Chapter, International Society of Arboriculture in Columbus, Ohio in February 1978.

tion with disease organisms.

Exposure to severe and/or prolonged stress may increase disease susceptibility in plants at almost any time. In general, however, there are two points in the life of most landscape species where exposure to stress is most likely to result in plant damage. The first period occurs during and after transplanting when plants are already weakened due to root pruning and transplanting shock. Exposure at this time to stresses, which may have no effect on established plants, can have serious consequences by inviting disease attack. The second period of sensitivity to stress is after plants reach maturity and begin to decline in vigor. As plants mature, particularly in the case of large trees and shrubs, the balance between the plants and their surrounding environment becomes increasingly delicate and sensitive to change. For example, placing even a shallow soil fill over the roots of a mature white oak may result in decline and increased attack by stem cankers and boring insects.

Nearly all of the disease organisms associated with stress-related diseases normally grow as saprophytes on dead plant tissue, plant debris, or on organic matter in the soil. A microscopic examination of dead twigs and branch stubs or dead roots often reveals the presence of the same organisms that are associated with diseased tissue of plants under stress. Thus a pathogen may be present in or on healthy plants without causing damage unless the plants are predisposed to attack by exposure to stress. The fact that most stem cankers form around a branch stub or wound is an indication that the pathogen causing the canker was present on dead or dying tissue and advanced into the healthy tissues as the plant became weakened.

Another way for stress-related pathogens to enter plants is through fresh wounds and pruning cuts. Few, if any, nonaggressive pathogens can penetrate healthy, intact plant surfaces directly but this is seldom an obstacle to invasion, since nearly all landscape plants have dead branch stubs or twigs and at least minor wounds present. The likelihood of infection through fresh wounds is influenced by weather conditions at the time of wounding. Many stem-infectious fungi produce fruiting bodies which exude spores during wet or damp weather. Bacterial pathogens also ooze bacterial cells from infected tissue under similar conditions. Fungus spores and bacteria are easily spread during wet weather by splashing rains or on pruning and shearing tools. Severe outbreaks of diseases such as juniper blight and bacterial fire blight are common following pruning and shearing operations conducted under damp conditions.

To gain more insight into the various factors causing stress in plants and how these factors influence disease, it may be helpful to look at them individually.

Water Stress

a. Water deficits or drought.

In natural stands of vegetation and in mature landscape plantings, below normal rainfall over a period of years can result in decline and increased disease losses. Outbreaks of several tree diseases occurred following the dust-bowl drought years of the 1930's.

Of more immediate concern for the nurseryman and landscaper are seasonal periods of dry, usually hot weather. For some reason the average homeowner or consumer (and some nurserymen and landscapers) seems to feel that trees and shrubs are drought resistant. It may be true that many woody plants will survive seasonal droughts without showing any readily apparent damage but this does not mean that the plants are unaffected. All too often we find that the effects of drought damage or stress show up as late as one or two years after the drought year. Since most memories ar short, it can be very difficult to convince someone that a drought last year or the year before actually initiated the problem.

Results of recent research have shown that there is usually a threshold level of water stress required to bring about an increase in disease susceptibility in woody plants. In all cases studied, this level is less than the permanent wilting point and the plant may show little or no signs of water stress, yet may become attacked by nonaggressive stem canker fungi. Thus the effect of water stress in such cases is increased disease damage rather than wilting or other physical

drought symptoms.

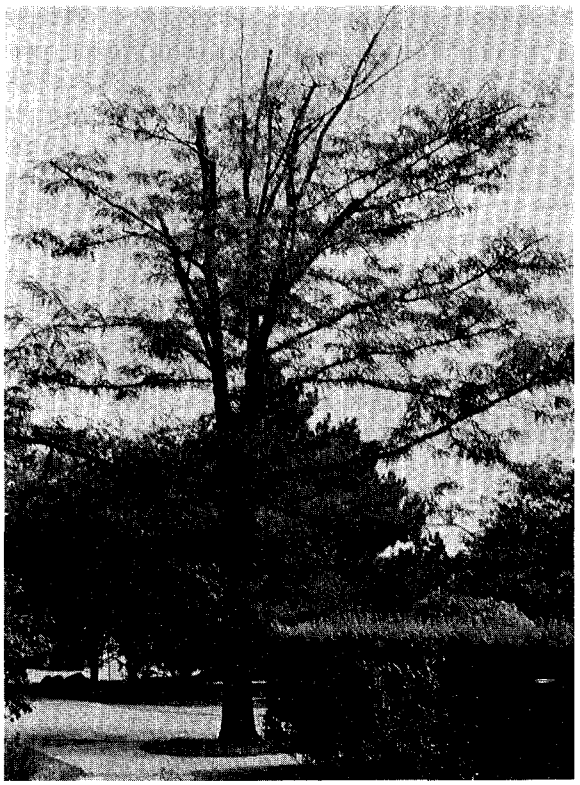

Fig. 1. Honey locust declining from drought stress plus borers and cankers.

b. Excess water and flooding.

Heavy rains, poor drainage, the presence of hard-pan layers, and occasionally extended periods of moderate but frequent rains, increase the soil moisture content and reduce the amount of aeration to root systems. The damaging effects of high soil moisture arise from suffocation of roots rather than an oversupply of water alone. The root systems of nearly all landscape plants require an adequate quantity and exchange of air in the root environment of rhizosphere if the plants are to remain vigorous. If the supply of oxygen in the soil becomes depleted, root absorption of water and nutrients decreases, consequently above-ground symptoms are often similar to drought or nutrient deficiency. Exposure to excess soil moisture, commonly referred to as "wet feet," for extended periods, can result in stress symptoms and increased disease damage. In contrast to other stresses, however, little is known about the duration and severity of flooding stress required to effect disease susceptibility in plants. A good example of flooding stress is the widespread decline and death of mature oaks in northern Illinois following three consecutive years of abnormally heavy spring rains. These declining trees have a high incidence of attack by stem cankers and boring insects.

Temperature Stress

a. High temperatures.

Although landscape plants that are native or adapted to a region are usually tolerant to the range of temperatures that occur in that region, extreme high or low temperatures can cause stress under certain conditions. A sudden period of hot spring weather following a damp period can cause blighting and weakening of very succulent plant tissues, which in turn may become attacked by pathogens. Thin-barked stems that are exposed to bright sun can suffer sunscald, which is actually a form of high temperature injury. Sunscalded tissues often are colonized by stem-canker organisms.

Extreme high temperatures may lead to drying and dessication, which are actually water stresses, but high temperatures alone are seldom injurious to nonsucculent tissues of woody plants. The possible exception may be high temperatures during storage or shipment when the effects of such stress are more complex.

b. Low temperatures.

Frost or freezing injury is quite common on landscape plants but there are several popular misconceptions about how and when this injury occurs and what type of damage symptoms are produced. An extremely cold winter with temperatures well below normal may not produce any significant injury whereas severe damage may occur during a very mild winter. Woody plants that cold-harden during slowly falling temperatures can usually survive temperatures below even the coldest temperatures recorded in the region without damage. However, rapid drops in temperatures to

below freezing before plants have hardened in the fall can result in considerable injury and weakening of plant tissues. Most of our winter injury in the Midwest is a result of hard freezes in the fall. Frost damage which appears as a blighting of succulent shoots usually occurs in the spring following bud break. In addition to fall and spring freezes, a hard freeze following unusually warm weather during the winter can cause injury on plants in which the cold period required to break dormancy has been satisfied. Such plants may lose cold hardiness rapidly when exposed to warm temperatures. Given the wide variety of landscape plants and inconsistencies of weather conditions, it is not surprising that winter or low temperature injury symptoms are highly variable and often difficult to diagnose.

Aside from the actual physical killing caused by freezing temperatures, disease susceptibility can be drastically increased at levels of freezing that otherwise cause no visible injury symptoms. Freezing stress or weakening of woody stems, particularly if it occurs from fall freezes, may show up the following growing season as girdling, wilting, and dieback of shoots. Even stems that have been completely girdled by freezing or frost collars may produce apparently normal shoots, which suddenly wilt and die later in the season. In many cases, the actual girdling is caused by weak or relatively nonaggressive pathogens that have attacked freeze-weakened stems. Results of research conducted in recent years with controlled freezing of dormant but not fully cold-hardened woody stems indicates that susceptibility to stem-canker fungi increases drastically at levels of freezing that have no apparent damaging effect in the absence of the pathogens. Thus the appearance of stem cankers during the growing season may indicate that affected plants were predisposed to disease by freezing stress the previous winter. In some plant species that are not fully cold-hardened, freeze damage appears on younger twigs, whereas in others the bases of larger stems or the main stem are most sensitive to freezing stress.

Defoliation Stress

Dropping of older leaves and needles is a common response of landscape plants to stress conditions. This seldom results in permanent damage but extensive defoliation, whether due to disease or insect attack, weed killers, or other factors can weaken plants and increase disease susceptibility. Larger trees in particular have been known to decline and eventually die following a single defoliation at a critical period during the growing season. Maples defoliated by the gypsy moth in the east have been attacked and killed by Armillaria root rot. Maples in Wisconsin and oaks in Illinois have decined following defoliation by cankerworms.

In tests conducted using artificial defoliation, susceptibility of tree seedlings to attack by certain canker fungi increased markedly if leaves were removed for several weeks, whereas noninoculated plants recovered without ill effects if allowed to refoliate. Although the stresses involved may be complex, defoliation results in slow starvation and depletion of food reserves, weakening the plant.

Fig. 2. Cytospora canker on freeze-weakened red maple.

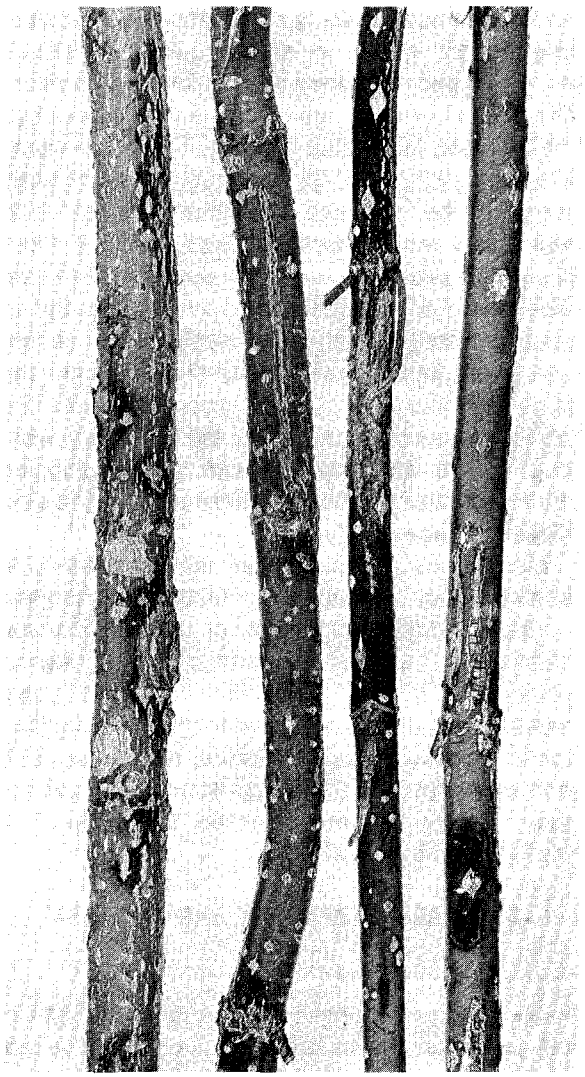

Fig. 3. *Botryosphaeria dothidea* cankers on drought-stressed red ozier dogwood.

Transplanting Shock

As mentioned earlier, the period during and after transplanting is one where plants are under stress from transplanting shock. Whether they are bare-rooted or balled-and-burlapped, nearly all plants are root pruned to some extent when they are transplanted. Root pruning reduces root food reserves as well as reducing the amount of absorptive surfaces for taking up water and nutrients. As a result of this loss, most plants undergo drought or water stress after transplanting until an adequate root system is established. If the water stress exceeds the threshold level that triggers increased disease susceptibility, plants may be attacked by weak or nonaggressive pathogens, resulting in disease damage. A recent work reported on transplanting of container-grown plants, revealed that the container mix became drier after field planting than that of plants remaining in containers. The surrounding soil actually drew water away from the planted container mix. Depletion of nutrients and reduced nutrient uptake may also have an effect on disease susceptibility but valid information on such a relationship is lacking at present.

Since plants are already weakened at transplanting, additional stresses imposed by improper handling and maintenance may exert a much greater effect than they would on established plants. The relatively high percentage of losses from diseases and insects on recently transplanted landscape species is indicative of this increase in stress effects.

Chemical Injury

Although many chemicals are toxic to plants, much of the injury encountered on nursery and landscape plants is due to herbicides. Increasing use of herbicides in the nursery and in combination with lawn fertilizers has resulted in a steady increase in plant damage symptoms. Many herbicides are growth regulating compounds that cause twisting and curling, or epinasty, of succulent leaves and shoots, which are used as diagnostic characteristics. However, herbicides can also cause bleaching or chlorosis of foliage, scorching of leaves, and blighting of shoot tips. Certain landscape species such as redbud, weeping birch, and hackberry are very sensitive to herbicides.

Several reports have appeared of increased disease damage following herbicide injury, but in general the relationship of chemical damage to disease is not well understood. Toxic chemicals undoubtedly cause damage that weakens plants and may have effects similar to root damage or defoliation.

Injury from highway salt is also a common form of chemical injury. Landscape plantings along ex-

pressways and heavily travelled roads that are salted during the winter often exhibit severe injury and decline. In many cases stems of salt-injured plants are attacked by canker and decline pathogens.

Construction Damage

Although most reputable nurserymen and landscape contractors know that established trees and shrubs, particularly mature specimens, are highly valuable and should be protected during construction operations, the same is not true for the building trades. It is tragic to go into an area of expensive new homes recently constructed in a native white oak woodlot and see so many damaged and declining trees. As mentioned previously, mature landscape plants attain a rather delicate balance with the surrounding environment. Trenching, excavation, changes in grade or drainage, soil compaction, mechanical breakage and wounding, and burial of excess mortar, plaster, and other debris are all too common practices in construction operations. The stresses imposed on plants in such areas are obvious and it is no wonder the losses due to plant damage are so great, particularly since the home buyers usually pay dearly for properties with large trees.

Often damage due to construction injury does not begin to show up for several years after the construction is completed. In the typical syndrome, trees begin to decline and staghead, and show increasing attack by cankers and boring insects. Suckers appear on the trunk and larger branches and limbs begin to die. As long as plant vigor remains low, decline and dieback continue and the value of the plants as landscape specimens erodes accordingly. It makes little difference whether the damage is due to disease, insects, or purely mechanical injury but it should be kept in mind that the problem was initiated by stress and treating it as an insect or disease problem which can be controlled by spraying will seldom produce satisfactory results.

Storage and Shipping

Many changes have occurred over the years in the size and mobility of the landscape industries. Nursery stock that used to be propagated, grown, and consumed locally is now often propagated in one region, grown in another, and sometimes even shipped to a third region for consumption. Storage of planting stock before and after shipment is also increasing steadily. The more plants are handled, stored, and shipped, the more likely they will be exposed to stresses, particularly water and temperature stresses, and the more likely that problems will arise with stress-related diseases. For example, extensive losses due to stem cankers have been experienced in recent years on shade tree liners shipped into the Midwest from west coast growers. Either the plants were not hardened at the time they were dug or the stresses imposed during shipping and/or storage and planting were sufficient to alter disease susceptibility.

Many landscape plants are either produced in containers or planted in containers at shopping centers, industrial plantings, or urban landscape plantings. The root environment of container-plants can be quite different from field-grown plants and is usually exposed to more drastic fluctuation in temperature, moisture, and nutrients. If container-plants are not constantly maintained, they quickly become stressed and subject to disease and insect attack.

DISEASE PREVENTION AND THERAPY

Prevention

There are so many types and combinations of stress which plants are subjected to, it is not possible to give control measures to fit each situation. The main point I would like to emphasize is that the appearance of stem cankers, diebacks, declines, and some root rots is quite often a sign that plants which are not normally attacked when vigorous have become susceptible as a result of exposure to stress. Just as wilting, stunting, and chlorosis are signs of stress, so are many disease infections. Since the organisms associated with stress-related diseases are usually present in plant tissues before healthy plants become susceptible to attack, it is not reasonable to expect to control such diseases with fungicide sprays, which are usually protective barriers that prevent disease organisms from entering host

plants. Even systemic fungicides that move within the plant are not likely to be effective once stem tissues have become infected.

How, then, can we approach the problem of preventing damage from stress-related diseases? Perhaps we should take a clue from the medical profession which has dealt with similar problems for many years. Often pathogenic bacteria and viruses are present in the human body without causing illness unless we become overly tired and rundown. Many of the deaths associated with the influenza epidemic early in this century were actually due to weakened bodies succumbing to the pneumonia bacteria already present in the body. Taking two aspirins and going to bed may not solve our plant problems but promoting plant vigor and hardiness is the best way to avoid stresses and their effects on disease susceptibility.

In the nursery, a careful program of pruning, watering, and fertilization will usually maintain plants in a vigorous condition. Since these plants will eventually be sold as landscape specimens and transplanted, periodic root pruning to promote a compact, efficient root system will help the plants survive the stresses of transplanting with a minimum loss of vigor. Root pruning, however, is a shock to the plant and additional maintenance at this time may be advisable. When new tree and shrub liners are planted out in nursery rows, they often become subjected to rather extensive stresses, particularly water stress due to a reduced root system. If they are not conscientiously pruned and watered at this time, they may become susceptible to some of the stress-related pathogens discussed previously. An outbreak of stem cankers in the nursery can often be traced to careless handling or maintenance of newly planted stock. When stem disease damage becomes excessive on liners in spite of good maintenance, the grower should inquire about the condition of the plants at the time they were dug and how they were stored and shipped. Plants can be quite stressed yet appear healthy at the time they are unloaded at the nursery, particularly if shipped over long distances. If he continues to experience severe disease losses after planting out, he may wish to change his source of supply and use liners produced within his own region. In some cases it may be advisable to modify his own storage and planting procedures to ensure that his stock is in a vigorous condition at the time of planting.

I have already discussed the importance of stresses at the time of transplanting but one further remark may be appropriate. With the high costs of shipping and handling, there has been a tendency of some wholesalers and retailers to cut costs by specifying or accepting smaller than recommended balls on B and B stock, thus saving weight. This practice increases the chances that stresses imposed on the plants will be severe enough to influence disease susceptibility. Any savings in cost may be made up later in replacing disease damaged plants.

Pruning and shearing are common practices in the nursery and landscape trades. These operations, however, produce fresh wounds which may be invaded by disease organisms, particularly if done during damp weather when fungal spores and bacteria are being released. Therefore, pruning during damp weather should be avoided and pruning or shearing tools should be disinfected as often as possible in alcohol or bleach solution. The common practice of applying wound dressings to larger cuts to prevent infection has come into question lately and results of recent research indicate that wound dressings not only do not prevent infection, they often enhance it. They also have no apparent beneficial effect on wound healing. Therefore, this practice is now seldom recommended.

All growers should know how to produce vigorous, healthy plants and when to dig and transplant them. Diseases that attack vigorous plants can best be avoided by selecting disease resistant varieties or cultivars. Diseases that only attack weakened plants can be avoided by insuring that plants are exposed to as little stress as possible. Neglected plants become sick plants, which become dead plants. The important thing to keep in mind is that susceptibility to many relatively nonaggressive pathogens may increase in stressed plants before any physical stress symptoms appear. Thus waiting to water until a plant is wilted may be too late to prevent infection.

Therapy

Fortunately, increases in disease susceptibility

due to exposure to stress are often reversible if the stress is relieved before disease damage becomes too severe. For example, stem cankers that appear following a drought but have not girdled affected stems may cease to expand after the plants receive proper irrigation. Callus tissue forms around the canker margins and the cankers may eventually heal over. In controlled experiments with water stressed European white birch, inoculated with a stem canker fungus, the rate of canker expansion began to decrease four days after the plants were watered and callus formation was initiated three days later. The same is true with most other stresses. Once the vigor of a plant is restored, it again becomes resistant to attack by weak or nonaggressive pathogens, although there is usually a lag period between removal of the stress and restoration of disease resistance.

It is obvious then, that one of the most effective treatments for diseases associated with plant stress is to restore the vigor of the host plant. Pruning, watering, and fertilizing are the common practices recommended to help plants recover from this type of disease. Selective pruning of the top growth can help restore the balance between the top and an injured or stressed root system. In addition, diseased stems should be removed wherever possible. Many stem pathogens can survive in stem tissues for long periods, even years, without causing disease damage, until the plant is exposed to stress. Since pathogens are not necessarily present in all plants, it is a good practice to eliminate any known source of infection, such as cankers and dying stems. Branch stubs may be colonized by weak pathogens, therefore, pruning cuts should be made flush with the stem.

Fig. 4. *Tubercularia ulmea* canker on freeze-weakened tall hedge.

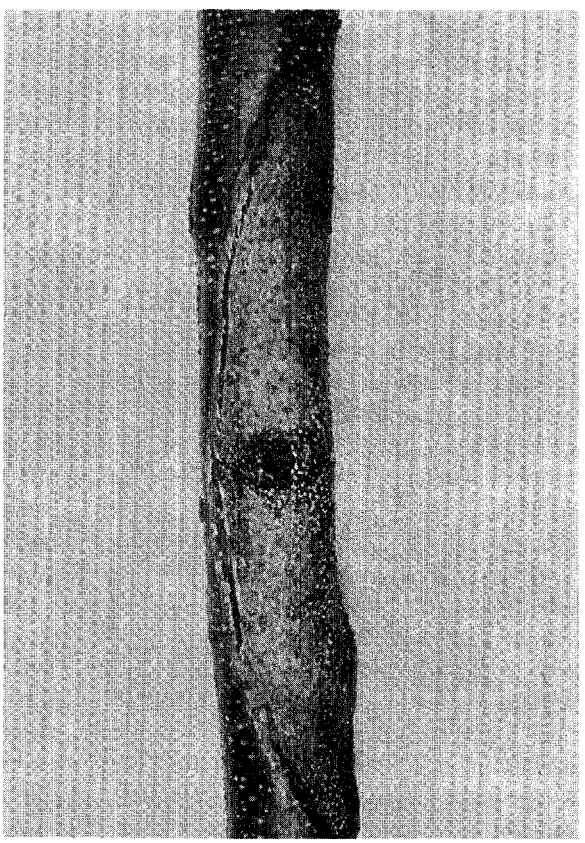

Fig. 5. *Tubercularia vulgaris* (Nectria) canker on drought-weakened honey locust.

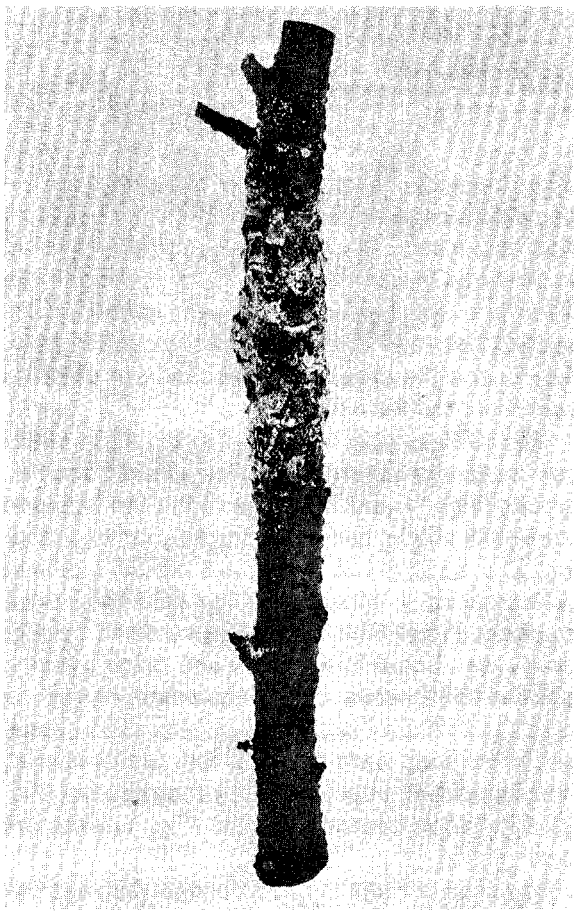

Fig. 6. Cytospora canker on blue spruce possibly stress-related.

Older trees and shrubs that are declining in vigor may be restored, at least temporarily, by the same procedures outlined above. If the soil has become compacted or depleted of nutrients over a long period of time, aeration and fertilization of the root system may be advisable. This can be accomplished either by injecting water and fertilizers under pressure with a root needle attached to a power sprayer, or by boring or punching holes in the soil under the plants then adding dry fertilizer to the holes and watering it in. Any practice which promotes plant vigor should help plants recover from infection by stress-related disease pathogens.

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ABSTRACT

Chapman, D.J. 1978. **Crab apples can be both beautiful and tough.** Weeds, Trees and Turf 17(3): 27, 30.

Crab apples are an extremely popular small tree, filling a unique place in the landscape, with outstanding flower color in the spring and good fruiting during the autumn. There are some 200 cultivars available in the trade, but due to susceptibility to apple scab and fire blight, the list of actively-grown cultivars should be drastically adjusted. The following 15 varieties of crab apples show a high degree of resistance to apple scab and fire blight while being aesthetically outstanding.