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North Dakota State University

Tree Talk

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"I frequently tramped eight or ten miles through the deepest snow to keep an appointment with a beech tree, or a yellow birch, or an old acquaintance among the pines."
Henry David Thoreau

Transplanting Trees with Tree Spades

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Before the development of tree spades in the late 1960s, transplanting large trees was very labor intensive. Two individuals working together and digging by hand could spend a full day to dig, transport and replant two, 3- to 4-inch caliper trees. The introduction of tree spades revolutionized this process by making it much easier and cost effective to move large trees. Those same two trees that previously took two individuals all day to transplant, now can be moved in a matter of minutes with a tree spade and a competent operator. Because of the ease that trees could be planted at homes and other landscape sites, "instant shade" became a favorite phrase for the landscape industry. Moving trees with a tree spade can be a very effective method of transplanting trees, whether it's one or a large number of trees. If you are doing it yourself or planning to hire someone else to move your trees, the moving project will be successful if you follow the guidelines listed below.

Safety should be first on the agenda. When digging, be sure the tree spade will not contact any buried utilities in the tree's original site or its new location. Taking the time to locate underground utilities before digging is an absolute necessity. Phone, cable television, gas and power lines are the most common underground utilities that tree movers will encounter. Tree moving contractors can and are being held liable for damages. Paying for this damage is an expensive lesson that can be avoided, if the tree spade operator takes the time to have the utilities located before digging. Operators also should remember to locate underground sprinkler lines and septic systems. Overhead utilities also should be observed. Most tree spades have large booms that require safe clearance from overhead power and phone lines, trees and other overhead obstructions during the digging process and transport. Tree spades are considered heavy equipment, so the operator needs to know the machine's limitations and have the ability to maneuver in tight spots.

A tree's size and potential for moving is determined by its trunk diameter or **caliper**. Caliper is measured about 6 inches off the ground for trees that are 4 inches or less in diameter. The caliper is measured about 12 inches off the ground for trees with a trunk diameter larger than 4 inches. As trees are selected for moving, it's important to know the capacity of the tree spade. A common mistake is thinking that if the tree spade can dig and lift the tree out of the ground, it is a large enough machine to do the job. Although most tree spades can dig and lift trees much larger than they are designed for, this certainly does not mean that the machine will dig enough soil and roots for successful transplanting.

Tree spades are designed to handle a maximum tree size for a reason. Simply put, moving a tree larger than what the machine is designed for will jeopardize the life of the tree by putting it under additional stress. Worse yet, the tree may not survive the move at all. A high percentage of the tree's roots are lost when the tree spade cuts into the soil to create the rootball. The percentage of roots that are lost during this process increases dramatically if the tree is larger than the rated capacity of the machine. As root loss increases, the survivability of the tree decreases. Staying within the machine's rated capacity is healthier for the tree.

Tree spade manufacturers rate the capacity of their machines differently, but generally, the tree spade diameter should be 10 times the trunk caliper. However, some tree species may require a larger diameter machine. Trees with wide, shallow root systems, such as poplars, will lose a higher percentage of roots than will a deep-rooted tree. Trees that have a deep taproot, such as oaks, are much harder to dig and their chances of survival will be less than that of a non-tap root tree. In both cases, survival probability can be increased by using a machine that is larger than the recommended size. Additional factors that determine the size of the machine to use include the existing soil type (sandy vs. clay) and if the tree has been root-pruned or growing in the wild. Following are some typical manufacturer's recommendations for machine size versus tree caliper size.

Tree Spade Size	Maximum Trunk Caliper
30 inches	3 inches
40 inches	4 inches
60 inches	6 inches
90 inches	9 inches
105 inches	12 inches
125 inches	14 inches
Some trees can be successfully moved if they are slightly larger than the recommended specifications. Other tree species should be smaller than the maximum that the machine is designed for.	

Selecting the right trees to move is an important task. Each tree should be inspected for its overall health. Trees that are not healthy, appear stunted, have a poor structural shape or appear less than desirable should be avoided. Only healthy trees should be considered for moving. The digging and transplanting process can create a great deal of stress, which may cause a less-than-healthy tree to die. Digging and transplanting a tree is an investment in time and resources. Don't jeopardize transplanting success by moving an unhealthy tree.

Nursery-grown trees should have been root pruned, which automatically makes them better candidates than trees that are growing in the wild. Though wild-grown trees have not been root-pruned, they can be moved successfully if the tree spade operator takes into account that the root system is not as full as a nursery-grown tree. In this case, it is better to choose trees that are smaller than the design limit of the machine.

Choosing the best time of the year to move trees is important. Spruce and pines should not be moved during the spring when they are sending out new growth. However, they can safely be moved from about mid-summer (after the new growth has properly hardened) until late fall. Many deciduous trees should be moved only during dormancy in the spring or in the fall after their leaves have started to color, but there are exceptions. Deciduous trees in full-leaf can be moved during the summer months, if a few precautions are taken. Watering the tree several days before the move will help prepare it for the moisture loss that will take place during the move. Pre-watering makes digging much easier, though it will result in a heavier rootball. Depending on the weather conditions, an anti-transpirant also may need to be applied to reduce moisture loss through the leaves. Because of the extreme stress that can be placed on the tree, moving a large, fully leafed-out tree on a hot windy day should be avoided. To increase the chances of success, it also is a good idea to dig a larger than normal rootball for trees moved during the warm part of the growing season.

The actual digging process is relatively simple. A hole is dug with the tree spade in the location where the new tree will be moved. If the sides of the hole develop glazing from digging, roots may have a difficult time penetrating it. The glazed area should be roughened with a shovel or rake before the new tree is planted. Next, the tree that will be moved to the new location is dug. With the blades

raised and the back of the machine in an open position, the operator backs the machine up until the tree is centered between the blades.

When the machine is closed around the tree, the platform is lowered to the ground, and the digging process begins. An individual blade is pushed into the soil a small amount and then an adjacent or opposite blade will be worked in the equivalent amount. This digging and root cutting process continues until all of the blades have reached their full depth. It is common practice to apply water to the blades during digging. The water softens the soil and makes it easier for the blades to penetrate the soil. Then the tree, soil and roots are raised and the tree is locked into position for transport. Before leaving the site, it is necessary to inspect the rootball for roots that were not severed during the digging. These roots should be removed in order for the rootball to fit cleanly into the new hole. After transport to the new site, the rootball is lowered into its new location, the blades are carefully pulled up and the machine is moved away.

The maintenance of a tree spade planted tree is very important. The care that should follow transplanting includes watering, anchoring and filling soil around the rootball. Most rootballs don't fit snugly into the new hole, leaving a slight gap. It is important to fill this gap with soil to cut down on root drying, to stimulate new root growth and to help the tree become more adapted to its new location.

Adequately anchoring a newly transplanted tree will ensure that strong winds will not blow it over. Tipping can damage the root system, particularly evergreens. If a newly transplanted tree has tipped because of wind or other reasons, it is important to protect the exposed portions of the root system until the tree can be straightened and re-anchored. Anchoring in three directions usually is sufficient, as long as large enough anchors and cables are used. Don't place the cables directly against the trunk. Instead, use wide straps to cradle the trunk. Large trees in locations that have greater wind exposure require more anchoring. This may mean using more and larger anchors along with larger cables and straps.

Small trees that are dug with a large rootball, and fit securely into the new hole, may not need anchoring. Experienced operators can determine when and if these trees need to be anchored. In addition, it is just as important to allow for some movement of the trunk in order to stimulate root growth. This only can take place if the anchor wires or ropes are gradually slackened through the first season as the tree becomes adapted to its new location. Because of crowded growing conditions, many nursery-grown trees do not develop a good trunk taper. Allowing some slack in the anchoring lines also is necessary for a healthy trunk taper to develop.

Thoroughly watering soon after planting is important to reduce the overall shock to the tree. Several factors determine the proper amount of watering needed for establishment. Typically, a thorough watering once a week provides sufficient moisture for most newly transplanted trees during the first growing season. Too little or too much water during this critical period can cause damage or the transplant to fail. Soil type also plays an important part in the watering regime. Since sandy soil is porous, water can travel through it much quicker than through clay soil. A tree that otherwise might receive sufficient water once a week in a clay may need to be watered twice a week, if planted in a sandy soil. On the other hand, a soil that is heavy clay will not drain well, so a tree planted in clay may need to be watered only once every 10 to 14 days. Tree size in relation to the size of the rootball is another factor that determines how much watering is needed. For example, a 60-inch tree spade digging a 3-inch caliper tree will cut fewer roots than it will from a 6-inch caliper tree. The smaller tree will be able to retain more of the water applied to it than would a larger tree with relatively fewer roots.

As a tree becomes established during the second through fifth seasons, the frequency of watering should be decreased each year. Reducing the regularity of watering encourages root production, which is important for re-establishment. Re-establishment of transplanted trees takes one to several years. A rule-of-thumb regarding the time for reestablishment is that each inch of trunk caliper requires a growing season to get a tree back to its original vigor. For example, a 4-inch caliper tree will probably take four years before it recovers from a move.

Tree spade owner/operators come from all levels of competencies. Most are experienced and are intent on providing a valuable service for their fees. However, if questions arise regarding the operators skills, ask to see their previous work. Also, be sure the owner has adequate insurance coverage.

By following safety factors, staying within the limits of the tree spade, selecting healthy trees and providing good follow-up care, it is possible to have an excellent tree-moving experience.

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Spring Cankerworm

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The spring cankerworm (*Paleacrita vernata*) is a common insect pest in North Dakota. The name is derived from the fact the female lays her eggs in the spring, in contrast to the fall cankerworm, which lays eggs in the autumn. Common host trees of the spring cankerworm include elm, ash, maple, basswood, oak and apple. The incidence of spring cankerworm defoliation is determined by the abundance of these host species, with periodic outbreaks commonly occurring in community forests and rural tree plantings composed of elm and ash.

The insect has one generation per year. Larvae of the insect overwinter in earthen chambers below host trees. Following pupation, wingless females emerge in early spring (March) and crawl up host trees to deposit loose clusters of eggs in bark crevices. The larvae emerge near bud break and begin feeding on the buds and unfolded leaves, resulting in a "shot-hole" appearance in the leaf (Figure 1). Feeding by older larvae can result in complete defoliation of the tree. The larvae possess two pair of prolegs and range in color from yellow-green to dark brown (Figure 2). When mature, larvae may reach a length of ¾ to 1½ inch. Larvae hanging from silklike strands are often windblown to adjacent trees.

Figure 1. Cankerworm damage on basswood leaves, Bismarck, July 2004.

Figure 2. Spring cankerworm larva. Photo by R. Randell, and used with permission from Texas Cooperative Extension. (http://insects.tamu.edu/fieldguide/cimg293.html)

Generally, trees are tolerant to the damage caused by the spring cankerworm. However, the tree's recuperative ability depends on the size of the tree, its health and the severity of defoliation. Large trees with well-developed root systems possess reserves of carbohydrates (stored energy) that are needed to re-foliate after leaves have been consumed. In contrast, smaller trees, particularly those that have been planted recently, do not possess significant reserves of stored energy and are therefore less able to produce another flush of leaves following defoliation. Similarly, a properly maintained, healthy tree is more resilient to defoliation than a weakened, less vigorous tree.

Lastly, the severity and duration of defoliation influences the extent of stress to the tree. Defoliation caused by the spring cankerworm fluctuates from year to year, depending on the conditions that affect larval survival. Low levels of larval feeding rarely affect the health of the tree. Conversely, several consecutive years of severe defoliation can weaken the trees and make them more vulnerable to other damaging agents.

Banding of tree trunks with a sticky material such as Tanglefoot® was used commonly in the past as a management technique. However, since the larvae can be windblown to banded trees from adjacent unbanded trees, this practice is used less commonly today. Often, treatment of spring cankerworm is not warranted, with the exception of young, recently planted trees or trees that have experienced severe defoliation for several consecutive years. If deemed necessary, insecticide treatments should be directed at the caterpillars in late spring or early summer. Current products registered for spring cankerworm include *Bt*, carbaryl (Sevin®) and permethrin (Astro™).

Ash anthracnose – an annual event …

Joe Zeleznik, NDSU Extension forester

Each year in May and June, I get several phone calls and e-mails asking, "What's killing my ash tree? It's losing its leaves." Chances are that the defoliation is caused by the fungus ash anthracnose. It is a common problem in North Dakota; even though the western part of the state is drier than the east, ash anthracnose still can occur regularly and sometimes severely. Ash anthracnose attacks all species of ash and is an interesting problem. Much of the research describing the ash anthracnose fungus was performed by Teresa Snyder, Scott Redlin, Robert Stack and others from NDSU in the 1980s. A list of references can be found at the end of this article.

What's in a name? – When naming fungi, mycologists use two different scientific names – one describing the sexual stage of the organism and a different one for the asexual stage. The ash anthracnose fungus is known as *Gnomoniella fraxini* (sexual stage) and also *Discula fraxinea* (asexual, or conidial, state). Some of the older scientific literature lists this disease as *Gloeosporium aridum* (asexual stage).

Symptoms – The classic symptoms of ash anthracnose are brown, dead, distorted leaf tissue (Figure 1), that may or may not be adjacent to the leaf margins. This lesion usually will kill only a part of the leaf, and the rest of the leaf will be distorted. The symptom noticed by most people is premature leaf drop. This occurs when lesions girdle leaf rachises (the leaf-stalks for the ash trees' compound leaves) or the base of young shoots, causing the rest of the tissue to droop and shrivel. This damage may look like frost injury, based on its timing and appearance (Figure 2). If defoliation is severe, there may be stunted growth and dieback of the twigs. Sometimes, the fungus will cause small leaf spots with purple halos instead of blotches (Figure 1). This is related to the weather during the time of infection. Orange to tan lesions may develop on the surface of infected twigs. A tree retaining its leaf rachises over the winter is a symptom consistently associated with the disease.

Figure 1. A green ash leaf showing light infection of ash anthracnose, with necrotic leaf margin and small leaf spots.

Figure 2. Green ash leaves damaged by either ash anthracnose or frost injury. Without a laboratory isolation, it's impossible to be certain what caused this damage.

Biology of the disease

The ash anthracnose fungus overwinters in fallen leaves, twigs, fruit and rachises, and also may overwinter in fruit and rachises that still are clinging to the tree. Asexual spores are released in the spring during wet weather, though it is not clear if these spores overwintered or were newly produced. After release, spores spread to the new leaves, where germination and infection may or may not occur. Several factors are involved, including weather, stage of leaf growth, leaf injury, location within the tree crown and even gender of the tree.

Weather – Germination of spores can begin after only 10 hours at 68 F, and they germinate best between 68 and 77 F. Spores do not germinate at all at 41 F or at 95 F (Figure 3). If infection does occur, the fastest growth rates are achieved between 59 and 77 F. Observations by many of the city foresters throughout North Dakota also indicate that ash anthracnose is more severe when there is a lot of wet weather during the spring flush of leaf growth.

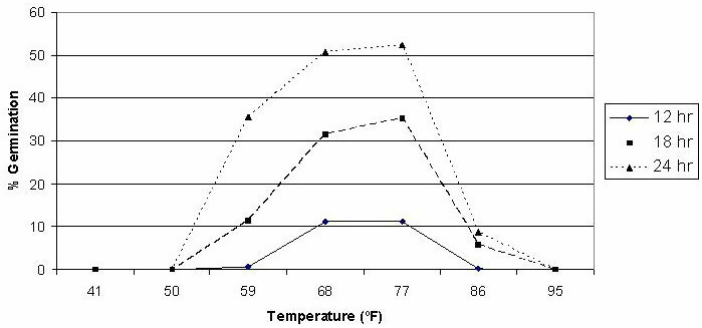

Figure 3. Ash anthracnose spore germination in water agar. Fungal growth rates show a similar dependence on temperature. Adapted from Redlin (1988).

Stage of leaf growth – Most leaves of green ash are fully expanded 21 days from their initial appearance. Redlin's results indicate that leaves are susceptible to infection during this time, and perhaps even up to 25 days after appearance. After 30 days of growth, leaf tissue is less susceptible to infection. However, it is unclear whether this is because the leaves have "hardened up," or if temperatures are simply too high to support continued germination and growth of the fungus.

Leaf injury – Ash anthracnose can infect leaves that have not been injured, though the rate is relatively low (<15 percent). However, leaves that had been injured were infected >80 percent of the

time. This injury perhaps can be due to ash plant bug (*Tropidosteptes amoenus*) or environmental damage such as hail.

Location within the tree crown – Ash anthracnose usually is most severe in the lowest one-third of the crown, and least severe in the top third.

Tree gender – Green ash trees are dioecious, that is, the male and female flowers are borne on separate trees. A survey of infected ash trees in Grand Forks from 1982 to 1988 indicated that a greater proportion of female trees were in the moderate- and high-severity classes than were male trees. This makes sense, as seeds and seed stalks may remain on the trees throughout the winter and even into the following spring.

If moist weather continues after infection, spore-containing structures called acervuli are formed on the recently-killed tissue. The specialized spores, known as conidia, will continue to cause repeating cycles of the disease, as wet weather permits.

What can be done?

There are a few treatment options that are recommended for ash anthracnose. They are based on common sense, but their scientific validity has not been demonstrated clearly. Fortunately, the disease usually is not severe.

Raking and destroying fallen leaves and fruit may reduce infections in future years. Because retained rachises are a consistent symptom of the disease, removing them also may reduce future infections. However, neither of these approaches has been proven and removing rachises is not that practical.

The use of fertilizers to increase tree health and vigor is an approach that many people would like to use, but it is highly debated within the arboriculture industry. On the one hand, using high-nitrogen fertilizers to promote growth may allow optimum refoliation. Informal observations in Grand Forks indicated that trees receiving high-nitrogen fertilization had relatively little disease during periods of severe infection pressure. On the other hand, high-nitrogen fertilization may make the new growth more succulent and nutritious for leaf-feeding insects. As stated above, feeding by ash plant bugs increases the potential for infection. Also, other studies have indicated that fertilization does not increase the ability of plants to tolerate defoliation either during the year of defoliation or in the year after. Clearly, more research is needed on using fertilizers as a treatment option.

Protectant sprays may be required in areas where disease pressure is consistently high. The timing of fungicide applications is critical, with three applications working best. Lime sulfur should be applied first, just as buds are beginning to swell. The next treatment should be with the fungicide chlorothalonil, just when the buds are showing a green tip. The third application also should be with chlorothalonil, when the leaves are half grown (approximately 10 days later).

Resistant species/cultivars?

There is only one published study on the resistance of ash species and cultivars to ash anthracnose. Jacobs and Danielson (2002) studied several cultivars of green ash and Manchurian ash – both hardy in North Dakota – and several other ash species. Both of these species were rated as relatively highly susceptible. There were three green ash cultivars that can be planted in our climate in this study; both 'Summit' and 'Marshall seedless' green ash (both hardy to Zone 4) were moderately disease resistant, while 'Patmore' (Zone 2) may be disease resistant, although more information is needed. In general, individual trees that broke bud later had less infection than those that began growth early in the spring. The NDSU releases were not part of this study.

Conclusions

Ash anthracnose is a common disease on all species of ash trees that can be grown in North Dakota. Although trees may lose entire leaves or parts of leaves, the damage usually is not substantial and trees survive. Trees are tough!

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Celtis occidentalis

Common hackberry: A tough landscape tree for North Dakota

Allen Lee, Fargo Forestry Department

Common hackberry is an interesting and often forgotten tree in the upper Great Plains. I am approaching this article from my own expertise and personal knowledge gathered while working with this tree in the city of Fargo. As with all plants, its characteristics vary from region to region across the state and throughout the country, and may be different from what I have experienced in eastern North Dakota.

The tree is used extensively across the city of Fargo as a boulevard tree, but it seems to lack appeal to the average homeowner. Its name leaves images of crabapple fruit fresh in a potential buyer's mind, its fall color is a nice dirty brown appearance, and its leaves might develop a condition called nipple gall. With an introduction like that, it is easy to see why property owners might be hesitant to purchase this tree. Throughout this article, we'll take a closer look at the positives and negatives of this tree.

Identification

Common hackberry is quite easy to identify with a little practice. It has alternate, simple leaves that resemble an elm leaf and are 2 to 5 inches long (Figure 1). However, the easiest way to identify the tree is by the texture of the bark. It has a corky appearance with ridges when young, and as it matures, those ridges smooth out to some extent, leaving wartlike protrusions across the trunk of the tree (Figure 2). The bark offers a unique texture and winter interest to the landscape.

Figure 1. Leaf of the hackberry tree. Photo by Joe Zeleznik.

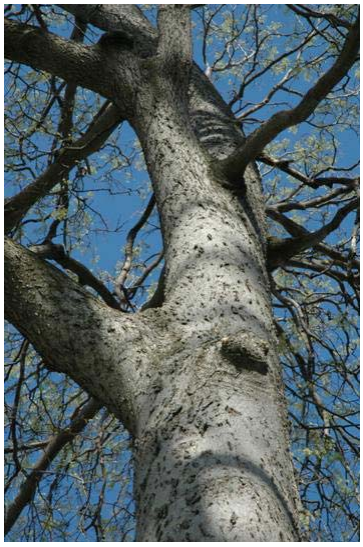

Figure 2. Distinctive bark of the hackberry tree, with wartlike protrusions. Photo by Allen Lee.

Form and Growth Rate

Hackberry can vary greatly in its form. When grown in an open environment, with no competition from other established trees, it seems to lose its central leader quite easily, becoming decurrent (lacking a central leader). Side branches easily compete with the leader and lead to narrow branch attachments on most trees. Its form is generally more upright, and as it ages, it will resemble that of the American elm, although not nearly as grand in appearance.

When grown with nearby trees, resulting in competition for sunlight, its form is much more upright (excurrent) and lateral branches generally have 90-degree attachments. Structurally, this version of the tree is much more sound and requires less extensive pruning when young.

I've seen young trees put on 24 inches of annual growth for the first two or three years here in Fargo. I do not consider this typical, but its rate is generally quite fast when young. As the tree ages, its growth rate will taper off. Due to its fast growth rate, structural pruning should be implemented with a maintenance program when planting this tree.

Establishment

Establishment of this tree shows mixed reviews when visiting with local nurserymen in the Fargo area. A loss rate of 3 to 8 percent during the establishment year is considered normal. Nurserymen seem to stay away from this tree like the black plague. However, most dead hackberry trees that I examine show major problems with planting depth. It seems that if this tree is planted even a few inches too deep in heavy, compacted soils, it will suffer for years before the buried trunk will rot away. It almost seems too easy to determine the cause of death for most cases when working with this tree. Planting depth is absolutely crucial. While most tree species establish better if they're transplanted in the spring, hackberry is one of the few trees that perform equally well when transplanted in either spring or fall.

Figure 3. The above picture shows a hackberry that was planted balled and burlapped and eventually succumbed to its poor establishment procedure. Photo by Allen Lee.

Attributes

Common hackberry is rated routinely as one of the best species of trees to use in compacted urban soils; it tolerates salt quite well and is adaptable to dry or mesic sites. It offers other valuable assets as well. Hackberry is fast growing when young (homeowners like that), offers a unique texture in the winter, and its overall shape and leaf form resembles the American elm. It provides valuable wildlife habitat and its fruits are eaten by many different animals. There are no cultivars used in the nursery trade in our region, though 'Oahe' hackberry, a seed strain cultivar, is used commonly for conservation plantings such as shelterbelts.

The most prevalent negative comment that I've heard is the lack of fall color. "I want a tree that turns bright red" is a comment we all hear, but we need to take into consideration all of the other attributes that a tree has to offer besides fall color. Hackberry is rated down to Zone 2 and has few diseases that can wipe out an established population. Even the "dreaded" nipple gall is not detrimental to the overall health of the tree; it is purely aesthetic.

Conclusion

With the many types of major pest outbreaks occurring across the U.S. – Dutch elm disease, sudden oak death and emerald ash borer – planting a common hackberry should become more frequent every day. A little caution when determining the planting depth will ensure success for years to come. Whoever said that a nice dirty brown fall color was a bad thing, ha!

Get Ready For Rhizosphaera

Rhizosphaera needlecast is a fungal disease that infects spruce trees, especially Colorado blue spruce. The classic symptoms of Rhizosphaera include death of the older needles, with healthy new growth towards the outside of the branches (Figure 1). The other key characteristic of Rhizosphaera is the line of small black dots (fungal fruiting bodies) along the length of the needles (Figure 2). These fruiting bodies are noticeable with a 10X hand lens and are located in the needles' stomates which are normally white (Figure 3).

Figure 1. Spruce tree severely infected with Rhizosphaera needlecast near Walhalla, N.D. Notice that most of the older needles are gone, with only current-year needles remaining.

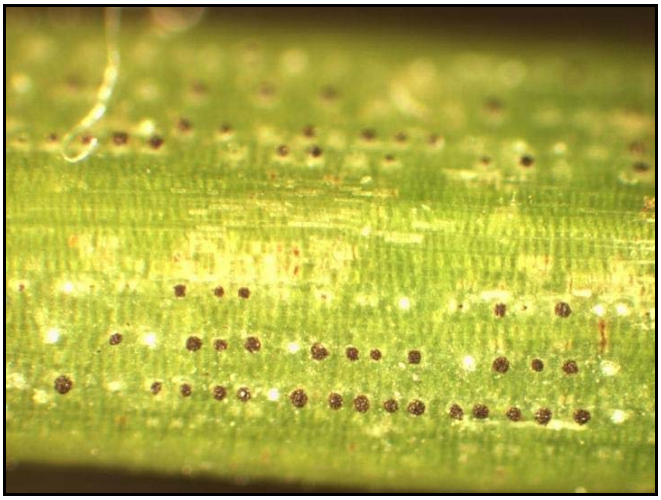

Figure 2. Spruce needle with lines of black dots, indicating the fruiting bodies of Rhizosphaera needlecast. Note that not all of the stomates show this sign.

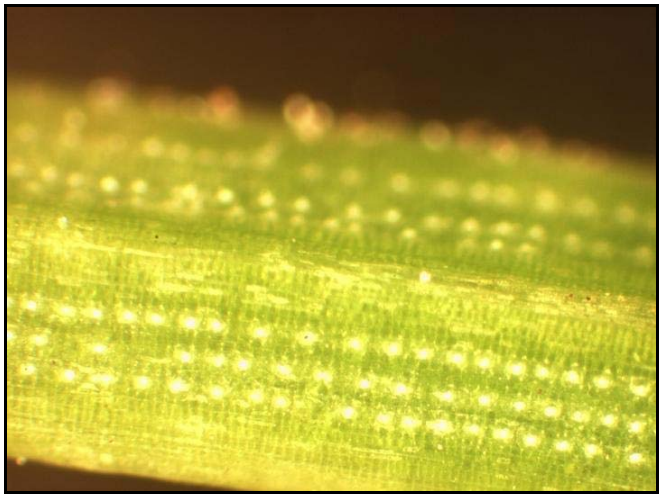

Figure 3. Normal spruce needle with lines of white stomates.

Rhizosphaera can be controlled with fungicides containing chlorothalonil, but it takes a total of four applications over two years. The first application should occur when the new needles are half elongated, approximately Memorial Day. The second application should occur three weeds later. The third and fourth applications follow next year at the same times. For further information on Rhizosphaera and how to tell the difference between Rhizosphaera needlecast and Cytospora canker of spruce, see the NDSU Extension service publication PP-1276, "Spruce Diseases in North Dakota."

Adding Sugar To Irrigation Water To Improve Tree Growth?

A recent article in the Journal of Arboriculture (March, 2005) suggests that adding certain sugars to irrigation water increases tree growth. The authors found that adding sucrose, fructose or glucose at concentrations of 6.8 -10.0 oz/gal resulted in increased root and shoot dry weights 24 weeks after transplanting.

Should we start irrigating trees in North Dakota with sugar water? Not quite yet … This was the first report of using this technique and the authors used only one species – European white birch (*Betula pendula*). Furthermore, the results were tracked for only the first growing season. The long-term effects – such as increased or decreased growth, insect and disease resistance, or winter hardiness – have not been demonstrated.

Symptoms of Frost/Freeze Damage

The weather systems that passed trough North Dakota in late April and early May brought freezing temperatures at the same time that tree buds were opening and leaves and flowers were beginning to expand. The damage was variable, ranging from no visible damage to a loss of most leaves/flowers. Below are three photos of frost/freeze damage occurring on the NDSU campus (all photos taken by Joe Zeleznik).

The expanding leaves of this hackberry tree were completely killed.

Many of the terminal buds and new shoots of this American cranberrybush (highbush cranberry) shrub have been killed and are black. However, buds that opened later have already begun to grow and compensate for the loss of other tissue.

Many of the leaf margins of this Manchurian lilac shrub were killed by April's low temperatures. These leaves will probably lose the necrotic tissue around the edges and may have "crinkled" margins later in the growing season.