Interest in growing grapes is rising rapidly in North Dakota. This interest is attributable to several factors, but it primarily is due to American and Canadian universities releasing grape cultivars that are more winter hardy for the northern Great Plains. North Dakota State University is breeding grapes for cold climates and expects to release cultivars in the future.

Commercially, growing grapes and processing them into wine, juice, jams and jellies has proven to be financially lucrative due to the burgeoning demand for local products. Large numbers of North Dakotans purchase grape products at the Pride of Dakota Holiday Showcases across the state. Wine grapes also are contributing to tourism in North Dakota. The recently created North Dakota Beer and Wine Trail features more than 20 wineries and vineyards scattered across the state. To keep up with public demand, the number of acres in North Dakota commercial grape production tripled between 2007 and 2012.

Not surprisingly, interest in hardy grapes is spreading to home gardeners. More and more home gardeners are planting grapes for fresh eating or processing. This publication guides home gardeners through the process of choosing an optimal site for planting, selecting hardy cultivars, and training and pruning the vines. In addition, this guide provides information on managing pests that are common to North Dakota. We hope this guide will demystify the process of growing grapes in the northern Great Plains.
Site Selection

Climate Challenges

When preparing to plant a home vineyard, your success in growing great fruit will depend upon site selection. Protection from the prevailing winds is very important and can be provided by shelterbelts, hedges, fences or buildings. Decreasing the wind velocity on the grapevines will raise temperatures in the vineyard, which accelerates growth and ripening in the fall.

Home vineyards may offer protective opportunities that slightly modify environmental conditions to avoid vine injury from frost and large air temperature drops. However, this micro-climate may not avoid all weather-related grape injury.

Full sun exposure is essential for the success of the vineyard. Whether planting just a few or many vines, locate the vineyard in an area where the plants will receive full sun all day or most of the day. If planting more than two vines, try to place them in a row and orient the row in a north-south direction to maximize sunlight to the leaves and fruit. For those having more than one row of vines, the height of the trellis should be in a 1-to-1 ratio with the row width to avoid shading. If vines are shaded, growth may be weak and spindly.

Supplementing natural rainfall with irrigation should be a consideration when choosing a planting site. As the grape plants mature, they will be less dependent on you for providing water. But in the first few years, having an irrigation option will be very helpful.

Soil Properties

A good understanding of the soil’s properties is essential; plan to have a soil test done. Contact your local office of the NDSU Extension Service for the soil test materials and information on taking samples. Understanding soil properties such as drainage, pH, texture, nutrients and water-holding capacity will play an important role in the success of the home vineyard.

To obtain soil survey data for your site, contact a North Dakota office of the U.S. Department of Agriculture’s Natural Resources Conservation Service (NRCS). The NRCS also has soil survey data available online for most areas in North Dakota. The survey data and your soil test results will be very helpful when determining what kinds and amounts of amendments are necessary before planting.

Good soil drainage is very important and relates to how fast moisture moves from the surface through the soil layers. Clay-type soils have poor drainage, which can reduce nutrient uptake, thereby limiting growth. The other extreme, sandy soils, drain much faster, but because of their low water-holding capacity, they can be a liability for the plants during dry weather. Ideally, a soil that is well-drained but has good water-holding capacity is desired; loams, sandy loams and loamy sands fit this description.

Most North Dakota soils will have a neutral pH or higher and the varieties of grapes that are recommended generally are adaptable to higher pH soils. You must avoid excessively high pH soils because they will stress the vines by manifesting an iron deficiency.
Slope

If the location allows it, choose a south- (or southeast to southwest) facing slope and plant the rows in a north to south direction, or in the direction that is across the slope. South-facing slopes will allow the soil to collect more heat, which will help ripen the fruit in late summer.

Planting on a south-facing slope (or any slope) also allows cold air to flow from higher to lower elevations and out the lowest portion of the vineyard. The downward air flow may lessen the potential for frost damage higher on the slope in the spring and fall.

Avoid low areas where cold air collects because these areas could result in frost injury to buds and young shoots in the spring and make vines more susceptible to winter injury/dieback during late fall and winter. Avoid planting on north-facing slopes because this will not provide enough soil heat for the plants.

Another advantage to planting the vines on a slope is increased water drainage. Grapevines will not tolerate flooded or saturated soils for extended periods. Standing water will deprive the grape plants’ small fibrous roots of oxygen, which could kill them. Any amount of slope will help move water away from the vines.

Avoid slopes steeper than 15 percent because of the difficulty of moving equipment up and down the rows. Another potential problem and reason for staying away from very steep slopes can be soil erosion.

Because most home vineyards will not be in the perfect location, some compromises on the site elements may be necessary. Remember: Avoid north-facing slopes, low areas, excessively fertile soil (can cause too much growth) and wet areas.

Avoiding Herbicide Drift

Grape plants are highly susceptible to damage from growth regulator-type herbicides such as 2,4-D and other homeowner broadleaf weed-control products. Practice extreme care when applying common lawn herbicides near the plants. Spring or summer applications can volatilize and drift to nontarget plants. Fall applications, after the vines have entered dormancy, are safest, but you still need to be careful to avoid herbicide movement in the soil and contact with the vines.

Some of these herbicides also can be taken up through grape roots. If the grape plants will be located downwind from or close to neighbors who regularly use pesticide products that are susceptible to drift, educating them about your home vineyard plans is advisable. The pesticide applicator is responsible for ensuring that drift damage does not occur to the grape planting.
Choosing Cultivars

The grapevine is one of the oldest cultivated plants in the world. However, growing grapes in northern climates such as North Dakota was extremely difficult in the past because few cultivars escaped severe winter dieback. However recently, with breeding efforts by northern institutions and private breeders, hybrid cultivars, hardy to winter temperatures of minus 25 and lower, have survived and even thrived to produce a bountiful harvest.

The keys to successful grape growing are cultivar selection, maintaining good fertility and pest management programs, and proper annual pruning of vines. Once established and properly pruned, these vines will produce an excellent crop for juice, jams, jellies or wine for many years.

A few online nurseries specialize in propagating grape cultivars. Nursery orders should be placed in the fall to reserve material for spring planting of the dormant vines. Vines also can be purchased from a local garden center, although selection may be limited.

By selecting and planting different cultivars in a home planting, you may be able to spread the harvest or use the grapes for different purposes. However, a single cultivar may be planted because almost all cultivars are self-pollinated or self-fruitful and bees are not required for pollination. The only exception is the St. Pepin cultivar, which produces only female flowers. Suggested hybrid grape cultivars for North Dakota are listed in Table 1.

Table 1. Grape cultivars for North Dakota.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Hardiness Zone</th>
<th>Berry Color</th>
<th>Ripening Season</th>
<th>Principal Uses*</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpenglow</td>
<td>4</td>
<td>Red</td>
<td>Early-mid</td>
<td>W</td>
<td>Good as a blender due to low acid levels</td>
</tr>
<tr>
<td>Baltica</td>
<td>3-4</td>
<td>Blue</td>
<td>Early</td>
<td>W</td>
<td>One of the earliest grapes to veraison</td>
</tr>
<tr>
<td>Beta</td>
<td>3-4</td>
<td>Blue</td>
<td>Early-mid</td>
<td>J</td>
<td>Trailing growth habit</td>
</tr>
<tr>
<td>Bluebell</td>
<td>3-4</td>
<td>Blue</td>
<td>Early-mid</td>
<td>T, J</td>
<td>Iron chlorosis if soil pH is above 7; large fruit; sulfur sensitive</td>
</tr>
<tr>
<td>Brianna</td>
<td>3-4</td>
<td>White</td>
<td>Early-mid</td>
<td>W, T</td>
<td>Semi-upright growth habit</td>
</tr>
<tr>
<td>Edelweiss</td>
<td>Tender-Mod</td>
<td>White</td>
<td>Early-mid</td>
<td>T, W</td>
<td>U of M</td>
</tr>
<tr>
<td>Elvira</td>
<td>3-4</td>
<td>White</td>
<td>Early-mid</td>
<td>T, W</td>
<td>Must have good drainage; trailing</td>
</tr>
<tr>
<td>Frontenac/F. Gris/ F. Blanc</td>
<td>3-4</td>
<td>Blue/white</td>
<td>Late</td>
<td>W</td>
<td>Semi-trailing growth habit; Gris and Blanc are mutations of Frontenac</td>
</tr>
<tr>
<td>Geneva Red</td>
<td>4</td>
<td>Blue</td>
<td>Early</td>
<td>W</td>
<td>Generally used for blending; in cool years, has a vegetative note</td>
</tr>
<tr>
<td>John Viola</td>
<td>3-4</td>
<td>Blue</td>
<td>Mid</td>
<td>T, J</td>
<td>Mild labrusca flavor; sulfur sensitive</td>
</tr>
<tr>
<td>Kay Gray</td>
<td>3-4</td>
<td>White</td>
<td>Early</td>
<td>W, T</td>
<td>Generally used for blending; flavor varies with climate</td>
</tr>
<tr>
<td>King of the North</td>
<td>3-4</td>
<td>Blue</td>
<td>Early-mid</td>
<td>J,T,W</td>
<td>High-acid fruit; trailing growth habit</td>
</tr>
<tr>
<td>LaCrescent</td>
<td>3-4</td>
<td>White</td>
<td>Early-mid</td>
<td>W</td>
<td>Late season fruit drop; trailing</td>
</tr>
<tr>
<td>Marquette</td>
<td>4-5</td>
<td>Blue</td>
<td>Early-mid</td>
<td>W</td>
<td>Semi-upright; accumulates sugars quickly</td>
</tr>
<tr>
<td>Petite Pearl</td>
<td>4</td>
<td>Blue</td>
<td>Mid</td>
<td>W</td>
<td>Rather small clusters</td>
</tr>
<tr>
<td>Prairie Star</td>
<td>3-4</td>
<td>White</td>
<td>Mid</td>
<td>W</td>
<td>Used for blending to add body; semi-upright</td>
</tr>
<tr>
<td>Sabrevois</td>
<td>4</td>
<td>Blue</td>
<td>Mid</td>
<td>W</td>
<td>Ages well, improving after two years in bottle</td>
</tr>
<tr>
<td>Somerset Seedless</td>
<td>3-4</td>
<td>Red</td>
<td>Mid</td>
<td>T</td>
<td>Small fruit with seed remnants</td>
</tr>
<tr>
<td>St. Croix</td>
<td>4-5</td>
<td>Blue</td>
<td>Mid</td>
<td>W</td>
<td>Sister to Sabrevois; semi-trailing</td>
</tr>
<tr>
<td>Valiant</td>
<td>3</td>
<td>Blue</td>
<td>Early</td>
<td>J, T</td>
<td>Highly susceptible to black rot</td>
</tr>
</tbody>
</table>

*J = Juice or jelly, T = Table, W = Wine
Year 1

During the first year, root establishment and growth influence winter survival and should be the focus when caring for the vines. Most nurseries send dormant, bare-root vines for transplanting in the spring after the danger of frost has passed.

Before transplanting, soak roots in water for approximately two hours. Transplant vines at the same depth as they were in the nursery and in a large enough hole so that the roots can be spread evenly. Hybrid grapes tend to be vigorous, so a distance of 8 feet between vines is common.

Most nurseries suggest pruning vines to two or three buds after transplanting to start training the vine to a trellis system. However, research has shown more root development occurs when vines are left unpruned the first year unless moderate root damage occurred before or during transplanting.

Remove all developing flowers because the flowers will divert energy from the plant and the root system. Water vines occasionally if the weather is dry, and control weeds around each vine because weeds compete with the vines for water and nutrients. You also may want to apply mulch around the vines in your home vineyard to conserve moisture and control annual weeds.

Year 2

Even the most well-cared-for vines may die back to the ground after the first winter, especially when little snow cover is available. During the second year, the vine should be trained to a trellis system. If canes did not die to the ground, prune to three or four buds to initiate trunks. As the buds grow, these three to four shoots may be tied loosely to a stake to promote a straight trunk.

Later in the summer, you will need to select one or two shoots to become trunks for the vine. Do not select shoots with diameters larger than a small finger or with nodes farther than 4 to 6 inches apart because these “bull canes” are very susceptible to winter injury. Remove the shoots you are not keeping. Pruning of these shoots will depend on the intended trellis system.

When canes reach or extend above the desired horizontal wire, bend and tie the canes to the wire or prune the canes so that new, lateral growth can be trained along the wire.
Remove all developing flowers. If utilizing a spur-pruning system, the canes trained horizontally along the wires will become arms, or cordons, and will be as permanent as the trunk.

**Year 3 and Beyond**

By the third year, you should be able to prune according to the selected trellis or training system. Annual and balanced pruning is important because this is the only way to maintain uniform yearly production of high-quality fruit. Research has shown that a properly pruned, mature vine will produce four times as much fruit in one-fourth the space as an unpruned vine.

The best time to prune grapevines is in the spring dormant season after the danger of severe cold weather has passed but before the buds swell and then open. By delaying pruning until the stems “bleed” when cut, you actually delay bud break a bit, which helps avoid frost damage. Maximum vine fruit production will occur only by drastically pruning 80 to 90 percent of last year’s wood (1-year-old canes) each spring. This helps direct the vine energy into fruit production and keeps the vine within its allotted space.

Training a vine to an appropriate trellis system helps maintain good light interception and good air flow through the canopy. Good light interception is important because shading drastically reduces bud fruitfulness and winter hardiness.

Allow a partial crop during the third growing season if vines are developing on schedule and have good vigor. Otherwise remove all developing flowers because flowers will divert energy from the intended plant structure. Remove any shoots developing on the trunk. These shoots will be easy to pinch off if not allowed to grow more than an inch before removal. Suckers developing from the ground should be removed with a hand pruner.

Balanced pruning is the practice of maintaining a balance between vegetative growth and fruiting. A mature vine, on average, has 200 to 300 buds that are capable of producing one to three fruit clusters. If you kept all this fruit, the large crop would not ripen properly, the vine would have reduced vigor, canes would not mature properly and the vine would have delayed acclimation into dormancy. A mature vine treated this way would be extremely sensitive to winter injury and dieback.

The amount of the 1-year-old canes (by weight) determines how many buds you should retain for production during the current year. The base number of buds to retain for the first pound of pruned 1-year-old wood has been established for a number of cultivars based on vine vigor and production characteristics.

For most of the hybrids grown in North Dakota, the base number is 30 buds. If a vine produces less than 1 pound of pruned 1-year-old wood, this number should be reduced proportionally to the weight of the prunings. If the vine has 2 pounds of pruned 1-year-old wood, you should retain an additional 10 buds (30 + 10). If the vine has 3 pounds of pruned 1-year-old wood, you should retain an additional 20 buds (30 + 10 + 10). No more than 60 buds should be retained per vine, even if more than 4 pounds of 1-year-old wood was pruned.

‘La Crescent’ grapes. (Steve Sagaser, NDSU)

‘Frontenac’ grapes. (Steve Sagaser, NDSU)
Trellis System

A grape is a true vine that requires some type of support to keep it upright. In a natural setting, plant tendrils develop along the canes and attach to other vegetation so that the vine grows upward and off the ground. Most home grape growers do not want their grapes sprawling over bushes and trees, so they erect various trellis systems to train and support the vines, and facilitate other management practices.

When a grape is trained, its plant parts are arranged spatially. Most often, this is accomplished with the help of a trellis system to 1) optimize the utilization of sunlight and promote fruit productivity, 2) adapt to the growth characteristics of the cultivar and 3) promote efficient yet sustainable management practices.

Deciding on which trellis system to use depends primarily on the grape cultivar’s growth habit and vigor unless a pre-existing structure such as an arbor is present or the planting is used ornamentally. A good trellis for a home vineyard should: 1) be economical to construct yet long-lived; 2) support the vine structure; 3) provide maximum sunlight exposure to leaves, buds and fruit; and 4) have little need for maintenance yet be easy to repair.

The primary differences among trellis systems are height, number and location of wires, use of horizontal wire spreaders, flexible extended arms and posts for support of wires. Trellis systems generally are considered a nondivided canopy system or a divided canopy system, depending on whether the growth of a plant is split between trellis wires.

The high-wire bilateral cordon, fan, four-arm Kniffin and vertical shoot positioning (VSP) are examples of nondivided canopy systems, while the Geneva double curtain (GDC), Scott Henry, Smart-Dyson and lyre are examples of divided canopy systems.

The most commonly used nondivided (canopy) trellis system for cold-hardy hybrid grape cultivars is the high-wire bilateral cordon (Figure 1) because many American hybrid grapes have droopy, horizontal growth. Eight-foot posts with a minimum top diameter of 3 to 4 inches are buried 3 feet in the ground and spaced 24 feet apart (every three plants). A single No. 9 wire then is placed across the top of the post about 5 feet above the ground. Grapes are cordon trained along this wire in both directions and spur pruned (Figure 1).

This system could be cane pruned, but the cordons would be replaced with two canes each year. During the growing season, new canes are combed downward periodically on both sides of the wire. This system is the least expensive of all trellising systems, but it does not offer full sunlight exposure to foliage and fruit for vigorous cultivars.

The most commonly used divided (canopy) trellis system is the Geneva double curtain (GDC). This system is similar to the high-wire bilateral cordon except it has two curtains or planes of growth that are separated by cross-arms that are usually 4 feet wide (Figure 2). Vines are trained with two cordons on one wire, while the next vine has two cordons on the other wire; with one cordon on each wire; or with four cordons, two on each wire.

On the same vine spacing, this system provides twice the cordon length; thus, it supports more growth and higher yields than the high-wire bilateral cordon system. The GDC system has a high establishment cost due to more trellis

Figure 1. The high-wire bilateral cordon is the most commonly used nondivided (canopy) trellis system for cold-hardy hybrid grape cultivars. (NDSU)
material, but it produces higher-quality fruit and higher yields and it has fewer disease problems, compared with other trellis systems. The system is best for vigorous cultivars or high-vigor conditions of deep and fertile soils.

The fan system, or two-wire multiple trunk system, is useful for training grapes to walls and fences or to a special trellis or arbor (Figure 3). This system also has been used in areas where severe winter damage to grapes commonly occurs and in less desirable sites.

A plant pruned and trained to this system has several upright canes that branch from arms on a very short trunk or multiple trunks. Commonly, the arms and canes are removed from the trellis each fall and covered with soil or laid on the ground where snow will cover them for winter protection.

As a slight modification of this system, the canes serve as flexible trunks. In the spring, the flexible trunks are tied up on the wire or fence for support. This system is ideal for plants that naturally grow upright or for weak vines.

Grape arbors have demonstrated the importance of maximizing sunlight exposure to foliage. Arbors can be constructed as double- or multiple-row arbors with grapes trained from posts to cross-wires. While high yields are obtained from such structures, the structures are expensive to construct and maintain. They generally require a longer unproductive period between planting and harvest as the vines are trained out onto cross-wires and are more difficult to prune.

**Nutrient Management**

No two planting sites are the same. Test the soil before planting the vines to obtain optimal fertilizer recommendations. Less nitrogen fertilizer will be required for soils high in organic matter.

In general, nitrogen will be the limiting factor for North Dakota grapes. Low nitrogen levels may result in light green leaves, poor vegetative growth and lower grape yields.

Two weeks after planting, incorporate ¼ pound of a balanced fertilizer such as 10-10-10 in a ring 18 inches from the main stem. Increase the amount of fertilizer to ½ pound in the second year and finally to 1 pound in the third year.

As the vine grows, increase the radius of the fertilizer ring to 2 to 3 feet from the stem. Fertilizer should be applied
in late April or early May before bud break. Avoid applying nitrogen fertilizer later in the year to prevent overly lush growth in the fall that may be susceptible to winter damage.

Iron deficiencies are also very common in North Dakota’s alkaline soils. Iron deficiencies are manifested by interveinal chlorosis. This is defined as yellowing of leaf tissues between the green veins. Iron deficiencies are more common after cool, wet springs and can be treated with a foliar application of an iron chelate fertilizer.

**Water and Irrigation**

Watering may be necessary in mid to late summer to alleviate summer drought. Water early in the day and avoid overhead watering to prevent fungal diseases. To maximize yields, avoid water stress from the time of bloom until the fruit starts to change color (véraison).

Maintaining even soil moisture also will prevent the grape skin from splitting. Grape splitting is more common when a heavy rain follows a period of drought. In the fall, decrease watering to allow the vines to harden off before winter.

**Harvest and Storage**

When the fruit begins to change color, cover your grapes with netting to keep birds, squirrels and raccoons from eating them. Depending on the cultivar, grapes may turn from green to yellow, red or almost black. However, the color change does not mean the fruit is ripe; the grape clusters won’t be ready for harvesting for several weeks after the color change.

Once grapes are picked, they will not ripen further, so making sure they are at optimum maturity before harvest is important. Determining when to harvest will come from previous years’ experience.

When making grape juice or jelly, the berries can be ripened to taste while considering the factors listed above. However, if making wine, you need to be more particular.

If the above factors seem favorable, then take 50 to 100 berry samples from many clusters in different locations on the vines and on opposite sides of the row. Next, crush the berries and separate the juice from the pulp. When you have a clean juice sample, use a refractometer or hydrometer to measure the sugar content. A good sugar level for white grapes is around 22 degrees brix. Red grapes can be 23 to 25 degrees brix. Degrees brix is the sugar content of a fluid.

A simple means of measuring the pH of your grapes is an inexpensive pH meter. Be sure to calibrate your meter with fresh solutions before each use. Next, using an acid test kit, measure the percent of acid of the juice. This test is not hard to do, but it does take a little practice. When the figures fall within the recommended levels for your varieties, the grapes are ready to harvest.

Do not pull the grapes off the vine. Instead, use a sharp knife or pruner to clip off the clusters.

Try to plan harvest around a cool, dry day because dry grapes will keep longer than wet grapes if they are stored. When harvesting, do not keep clusters that are overripe, shriveled or have diseased berries. Inspect the clusters closely for the presence of the multicolored Asian lady beetle; even one crushed beetle can give products an “off” flavor.

If you are not planning on processing your grapes within a day or two, store them so they are as cool as possible, just above 32 F and with a humidity of 75 to 80 percent. Depending on the variety of grapes and their condition at harvest, you may be able to store them for as long as eight weeks. If the grapes are going to be used for juice instead of fresh eating, but you don’t intend to process them soon after harvest, freezing them is an alternative to refrigerated storage.

Below are additional guidelines for making certain they are ripe:

- Do the berries pull easily from the clusters?
- Squeeze a grape; ripe grapes should crush easily.
- The seeds should be brown, not green.
- If the pulp is still green, the grapes are not ready to harvest.
- Sample a berry or two. If they have a vegetal taste, they’re not ripe; they should taste sweet and have a good flavor.
Common Diseases and Their Control

North Dakota grapes are subject to a number of diseases, and plants having more than one disease is not unusual. Disease pressure will vary with the weather, and most diseases will be worse in rainy years. Grapes are not a low-maintenance crop. Home vineyards must manage diseases actively to produce a crop.

In many situations, good home vineyard hygiene will prevent a number of diseases. However, diseases such as black rot, downy mildew and powdery mildew are so prevalent that periodic fungicide treatments are necessary to prevent crop loss.

The following section describes the most common diseases. To avoid repetition, cultural recommendations to prevent or minimize diseases are grouped at the end of the section. Similarly, fungicide recommendations are grouped in a Grape Spray Guide (Table 2).

Anthracnose
(Elsinoe ampelina)

Anthracnose, also known as bird’s eye rot, is a fungal disease that occurs sporadically in North Dakota vineyards. The disease is more problematic in warm years with heavy rainfall. When present, anthracnose can cause a reduction in fruit yield and quality. Once the disease is established in the home vineyard, control strategies become necessary.

The fungal disease attacks all nonwoody plant parts, but its damage is most distinctive on leaves, young stems and berries. Infected leaves and stems display reddish-brown or purple spots with raised margins (Figure 4). The center of the leaf lesions are gray and may fall out, thus giving it a “shothole” appearance.

On berries, the disease manifests itself as ¼-inch dark brown, circular spots with sunken gray centers that resemble a bird’s eye or a bull’s-eye (Figure 5). In contrast to black rot and botrytis bunch rot, berries infected with anthracnose will not shrivel and dry up.

In the past, lime-sulfur spray was applied as a dormant spray in early spring as the leaf buds were starting to swell to greatly reduce anthracnose inoculum. Unfortunately, lime sulfur has become incredibly difficult for home grape growers to purchase, so the fungicide Captan is recommended in Table 2 as a dormant spray. However, lime sulfur is still the preferred product for preventing anthracnose.
### Table 2. Grape spray guide.

<table>
<thead>
<tr>
<th>When to Spray</th>
<th>Disease and Insect Pests Controlled</th>
<th>Pesticide*</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>When buds are dormant in early spring</td>
<td>Anthracnose</td>
<td>Captan</td>
<td>Captan is used as a replacement for lime-sulfur</td>
</tr>
<tr>
<td>At bud swell (before buds show green leaf tissue)</td>
<td>Grape flea beetle (adult stage)</td>
<td>Carbaryl</td>
<td>Apply if more than 4% of grape buds are infested with adult flea beetles</td>
</tr>
<tr>
<td>When new shoots are 2-4” long</td>
<td>Anthracnose, Black rot, Phomopsis, Downy mildew, Powdery mildew</td>
<td>Mancozeb</td>
<td>Most fungicides prevent fungal infections as opposed to curing them. These early sprays are critical. Captan can be substituted for Mancozeb but Mancozeb is more effective against black rot.</td>
</tr>
<tr>
<td>When new shoots are 8-12” long</td>
<td>Black rot, Phomopsis, Downy mildew, Powdery Mildew</td>
<td>Mancozeb PLUS Myclobutanil</td>
<td>Myclobutanil is added to the regimen because it is more effective for powdery mildew</td>
</tr>
<tr>
<td>Just before blossoms open</td>
<td>Black rot, Phomopsis, Downy mildew, Powdery Mildew</td>
<td>Mancozeb PLUS Myclobutanil</td>
<td>Last application of Mancozeb. Mancozeb cannot be used within 66 days of harvest**.</td>
</tr>
<tr>
<td>Just after blossom drop**</td>
<td>Black rot, Phomopsis, Downy mildew, Powdery Mildew</td>
<td>Captain PLUS Myclobutanil</td>
<td>Do not use Mancozeb for the remainder of the season</td>
</tr>
<tr>
<td>First cover through fourth (every 10-14 days)</td>
<td>Grape berry moth</td>
<td>Carbaryl (Sevin)</td>
<td></td>
</tr>
</tbody>
</table>

*Personal safety is of paramount importance when storing, mixing and applying pesticides. Product labels carry important information on environmental and physical hazards, product storage and disposal, necessary personal protective equipment (PPE) and first aid, in addition to mixing directions, application rates and procedures. Be sure to read, understand and follow all product label statements.

**Do not spray insecticides during bloom time because it may kill pollinators such as honey bees.

***Check all pesticide labels for the Pre-Harvest Interval (PHI).

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**Black rot** (*Guignardia bidwellii*)

Black rot is the most important fungal disease of North Dakota grapes and appears to be present throughout the state. This disease can cause serious crop losses unless controlled with a combination of cultural and chemical management practices.

On leaves, black rot appears as round, tan spots that are encircled by a reddish-brown margin (Figure 6). After the spots grow in size, fungal fruiting bodies called pycnidia may appear around the periphery of the spots and resemble small black pins. These black fungal structures may be visible to the naked eye or under a magnifying glass.

The fungal infection is most noticeable on the berries when they are green and immature. First a tiny, white dot appears on the berry surrounded by a brown spot (Figure 7). The brown spot grows quickly in size as the whole berry becomes a dry mummy (Figure 8).

![Figure 6. Black rot causes tan spots surrounded by red margins on leaves. (M. Clerjeau, INRA, Centre de Recherches de Bordeaux, Bugwood.org)](image)

![Figure 7. Black rot lesions on grapes with dried mummies. (Clemson University–USDA Cooperative Extension Slide Series, Bugwood.org)](image)
berry rots and appears deflated. The disease progresses until the fruit shrivels and forms hard, raisinlike structures called mummies that still are attached to the cluster (Figure 7). Fungal fruiting bodies usually are noticeable on the mummies. Multiple berries in a cluster may be destroyed as the disease spreads from berry to berry.

The disease overwinters on infected tissue and in the mummies that have fallen to the ground or still are attached to the plant. Cultural practices are very important to eliminate sources of disease spores in the spring. Appropriate fungicides are described in Table 2.

**Botrytis bunch rot (Botrytis cinerea)**

Botrytis bunch rot, otherwise known as gray mold, is a serious fungal disease that consumes entire grape clusters. Cultivars with tight grape clusters are more susceptible to this disease; however, all cultivars are susceptible to some degree. The damage appears more significant on table grapes than on wine grapes. Fortunately, drier areas of North Dakota will not experience the full force of this fungal disease.

Botrytis is observed first in the foliage. In early spring, shoots and buds may turn brown and necrotic. Leaves may exhibit large, reddish-brown patches. During periods of high humidity, gray mold may accompany the leaf lesions. Botrytis also may affect yield adversely at this stage by infecting the inflorescences and causing flower drop. However, the most common symptom is berry infection in late summer.

Although the fungus can penetrate the skin of healthy berries, the disease usually enters wounds created by hail, birds, insects and powdery mildew. After the onset of ripening, infected berries then start to soften and whitish-gray mold may be visible, depending on the humidity (Figure 8).

The berries also may display a color change. Light-skinned berries will start to brown while purple-skinned berries will turn reddish. The shriveled berries eventually will fall off the vine and become hard and mummified.

For home vineyards, cultural practices alone largely can reduce the effects of this disease. See the cultural practices section for more information.

In some situations, the fungus *Botrytis cinerea* can be beneficial for professional vintners. Producers of botrytised wines intentionally use this fungal pathogen to increase the sugar levels in grapes. Essentially, the fungus causes the grapes to rot and dehydrate. Expensive late-harvest dessert wines such as Sauternes are made from these rotted grapes. The timing of infection and specific relative humidity levels are crucial. This is a risky endeavor and most professional vineyards do not attempt it.

**Crown gall (Agrobacterium vitis)**

Crown gall of grape is the only bacterial disease covered in this publication. The bacterium *Agrobacterium vitis* is specific to grapes and lives systemically within the plant until a significant stress or injury, such as freezing, hail, pruning, grafting or mechanical injury, occurs. The bacteria travel in the sap and are attracted to chemicals produced by injured tissue. North Dakota grapevines are particularly susceptible to crown gall because freezing injury to the vines provides a regular opportunity for the bacterium.

The symptoms are unusual and recognizable. Upon infection, the bacterium genetically engineers the host plant's cellular DNA and essentially takes over the infected plant cells. The bacterium induces the plant cells to produce plant hormones that cause plant cells to grow and divide uncontrollably. This process results in a tumor (gall) formation on the trunk.

Usually, the gall appears on the lower trunk near the soil line, although galls may occur higher up the trunk. The galls first will appear to be fleshy and light colored, but they will turn darker and hard with time (Figure 9). If the galls are extensive, they may girdle the trunk and prevent water and
nutrients from reaching the upper portions of the plant.

If a plant develops crown gall, renewing it from buds that are below the point of the tumor is possible. Cultural measures are best for preventing infection because chemical options are not effective on grapes. Choose cultivars that are less susceptible to winter injury, and plant disease-free-certified grapevines if they are available.

**Downy mildew (Plasmopara viticola)**

Downy mildew is the second most important fungal disease of grapes in North Dakota. While the fungus certainly can ruin the fruit, even leaf infections are detrimental because the disease can cause vines to defoliate. The loss of leaves can lead to increased winter injury in North Dakota’s harsh climate due to the plant’s decreased production and storage of carbohydrates.

The disease first appears on leaves and affects the upper and lower surfaces. Yellow spots with diffuse borders develop on the top of the leaf. These spots are conspicuous among otherwise green leaf tissue (Figure 10). The spots eventually will turn brown.

On the bottom side of the leaf, a white, cottony or “downy” fungal growth appears during humid conditions and provides the name for the disease (Figure 11). As the disease progresses, the leaf may fall off the plant prematurely. The disease overwinters on fallen leaves and provides the source for the following year’s disease outbreak.

Infected berries may appear gray and cottony due to the presence of fungal spores on the surface. These berries fall off the cluster very easily. Cultural and chemical strategies are required to control this devastating disease (see Table 2).

**Powdery mildew (Erysiphe necator)**

Powdery mildew is a common fungal disease in North Dakota that differs significantly from other diseases. While most fungal diseases require water for infection, powdery mildew does not. New powdery mildew infections can occur during dry weather as long as the relative humidity is above 40 percent. In fact, rainfall can be damaging to the fungal spores. The disease can affect plant vigor and yield if not managed.

Powdery mildew infection is easy to detect. Symptoms include white or grayish-white patches on the upper and lower surfaces of the leaves and on the berries (Figure 12). If the disease is severe, entire leaves may be engulfed in a powdery covering and the leaves may curl. Berries may lose their shape, develop red spots and split open. Cultivars with normally red or purple berries may appear blotchy at harvest. On dormant canes, powdery mildew appears as dark brown spots.
Cultural Practices to Manage Diseases

Site selection is extremely important for managing diseases. Full sun exposure and well-ventilated sites will prevent or minimize many fungal diseases. Good sanitation also is important for controlling all of the above-described diseases. Prune out diseased portions of the plant during the dormant season and rake up diseased berries. Dispose of the clippings and mummies off the property or else burn or bury the material to reduce disease inoculum for next year. Do not compost this material.

Proper pruning and training of vines to maximize air flow is essential to promote rapid drying of the foliage and berry clusters. Removing leaves surrounding the grape cluster before bunch closing also improves air circulation around the grapes.

Finally, fungicides can be used as an effective control measure. See Table 2 for fungicide recommendations and timing and Table 3 for common pesticides and their brand names.

Table 3. Common pesticide brand names.

<table>
<thead>
<tr>
<th>Pesticide Active Ingredient</th>
<th>Type of Pesticide</th>
<th>Common Trade Names*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Captan</td>
<td>Fungicide</td>
<td>Bonide Captan-50% WP Fruit &amp; Ornamental, Hi-Yield Captan 50W Fungicide</td>
</tr>
<tr>
<td>Carbaryl</td>
<td>Insecticide</td>
<td>Complete Fruit Tree Spray, Gordon’s Liquid Tree Fruit Spray, GardenTech Sevin</td>
</tr>
<tr>
<td>Mancozeb</td>
<td>Fungicide</td>
<td>Dithane 75DF Rainshield, Dithane F-45 Rainshield, Manzate Flowable, Manzate Pro-stick</td>
</tr>
<tr>
<td>Myclobutanil</td>
<td>Fungicide</td>
<td>Spectracide Immunox Multi-Purpose</td>
</tr>
</tbody>
</table>

*There are many formulations of these pesticides. Please read the label to make sure that it can be applied to grapes.
Common Insects and Their Control

Many insect pests attack grapes in North Dakota. Fortunately, most of them are simply minor nuisances that can be minimized through cultural management practices.

Grape flea beetle and grape berry moth appear to be the most serious pests, and we have incorporated insecticide spray recommendations into the Grape Spray Guide (Table 2). Grape phylloxera raises the alarm for many home vineyards because the protruding insect galls look serious. However, phylloxera usually does not merit treatment.

The rest of the insects discussed below can be treated as needed and recommendations are discussed. In the future, insect pests may be a more serious issue in North Dakota as invasive insects such as the brown marmorated stink bug and Japanese beetle move into the state.

Foliar Pests

Grape Flea Beetle (*Altica chalybea*)

The first significant grape pest to appear in the spring is the grape flea beetle. The flea beetle is approximately 3/16 inch long and has iridescent bluish-black wing covers (Figure 13). The adults overwinter and emerge in April. The adult beetles feed on swollen leaf buds before the leaves have expanded. The worst damage occurs during cool springs because shoot growth is slowed. Once shoots reach 3 inches, they are less susceptible to flea beetle damage. Adult flea beetles and larvae will feed on full-grown leaves, but this kind of damage is less significant. Home vineyards next to wooded areas will have more pest damage.

Scouting the vines for signs of the grape flea beetle during bud swell is important. If one out of 20 buds is damaged, then insecticides should be applied. See Table 2 for insecticide recommendations.

Grape Phylloxera (*Daktulosphaira vitifoliae*)

Grape phylloxera is a destructive pest native to the eastern U.S. This microscopic yellow pest is closely related to aphids and has two distinct forms that feed exclusively on the leaves or roots of susceptible grape varieties.

In the late 1800s, phylloxera was introduced unintentionally into Europe from the U.S. The tiny insects attacked the roots of susceptible European grapevines and almost destroyed the French grape industry. The French grape industry was saved by grafting European grapevines onto American rootstocks that tolerate phylloxera root feeding.

In North Dakota, one form of phylloxera will feed on the roots, but the damage is inconsequential. The foliar form of phylloxera is more problematic. Cultivars that are highly to moderately susceptible to foliar phylloxera include Frontenac, Frontenac Gris, LaCrescent, Marquette, St. Croix and St. Pepin.

Phylloxera has a complex life cycle; only the foliar form will be discussed in this publication. Eggs are laid in bark crevices in the fall and hatch in spring as leaves are unfolding. The immature nymphs feed on the leaves and encase themselves in wartlike galls on the bottom side of the leaves (Figure 14). When they mature, the adults also lay their eggs in the protected galls. Two or three generations occur each year. Usually the foliar damage is minor and does not merit insecticidal treatment.
Hornworms
(*Manduca quinquemaculata, M. sexta*)

Hornworms are one of the more intimidating-looking grape insects. These large caterpillars can measure up to 4 inches in length. Even more impressive, tomato hornworms and tobacco hornworms carry a hornlike projection on the ends of their bodies that resembles a sword (Figure 15). These massive caterpillars turn into moths that commonly are called sphinx or hummingbird moths.

Typically, hornworms prefer tomatoes and potatoes, but they also will eat grape leaves. Not surprisingly, the caterpillars can consume a large amount of leaves in a small amount of time. Fortunately, hornworms are not a serious grape pest because they have natural enemies that keep their populations in check. The easiest way to get rid of hornworms is to simply brush the caterpillars into a pail of soapy water. Insecticidal treatment is not necessary.

**Potato leafhoppers (Empoasca fabae)**

Potato leafhoppers do not overwinter in North Dakota. They migrate on wind currents from the southeastern U.S. and arrive in June. These 1/8-inch leafhoppers are pale to lime green with slender bodies (Figure 16). The nymphs lack wings and feed on the youngest shoots using their piercing-sucking mouthparts. When disturbed, the nymphs move backward or sideways.

Leaf damage consists of yellowing margins, and the leaves will start to curl downward. This usually is not a significant pest in North Dakota grapes. No insecticidal treatment is necessary unless you find more than 15 leafhoppers per leaf. An insecticide with carbaryl as the active ingredient is effective against leafhoppers.

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**Pests that Attack Fruit**

**Grape Berry Moth (Paralobesia viteana)**

The grape berry moth is a major pest east of the Rocky Mountains. The adults are mottled brown and 3/8 inch long (Figure 17). They emerge from pupas in the leaf litter before bloom and lay their eggs near flower clusters. The first generation of larvae feed on tender shoots, flower buds and, finally, the green berries. Webbing may be seen on the grape clusters, and the larvae may be apparent just under the grape skin.

The second generation of larvae feed exclusively on the berries, and the entrance sites look like rips in the grapes. The larvae consume the fruit from the inside, and they also vector rot fungi into the berries.

This insect usually has only two generations of larvae in North Dakota. Infestations can be variable among different home vineyards. Infestations can be minimized by raking up dead leaves and disposing of them in early spring. This may get rid of the pupas that overwintered. If the grape berry moth is an annual problem, consult Table 2 for insecticide timing and recommendations.
Multicolored Asian Lady Beetle  
(*Harmonia axyridis*)

Multicolored Asian lady beetles are a variable insect. Some will be orange while others are red. Some beetles will have no black spots while others will have up to 19 spots. The best way to positively identify this variable beetle is to look for a black “M” or “W” marking immediately behind its head (Figure 18).

In the fall, these beetles are attracted to ripening grapes that are split or damaged by yellowjackets and other pests. Multicolored Asian lady beetles cannot pierce the grape skin. While these beetles are more of a secondary pest, the main problem occurs at harvest. If these beetles are trapped in the grape cluster at harvest, they can be incorporated into the juice or wine, and even one beetle will impart an off flavor.

Insecticidal treatments are not recommended because grape growers must comply with the insecticide’s preharvest interval — the time after insecticide application during which harvesting the fruit is not safe. Instead, grape growers should avoid insecticide application and pick their grapes late in the day when beetles are not present. Then give the cluster a little “shake” just to make sure. Shaking the grape clusters will allow the beetles to fly away.

Another method for eliminating beetles is to submerge the clusters briefly in cool water, then just skim the floating beetles off the water with a mesh strainer. Alternatively, a portable air pack can be used to blow the beetles off the clusters.

Picnic beetles (*Glischrochilus quadrisignatus*)

Picnic beetles, also known as sap beetles, are ¼-inch-long black beetles with four orange spots on the wings (Figure 19). The antennae have rounded knobs at the end. Picnic beetles are attracted to overripe and fermenting grapes, but they also may consume healthy grapes. Insecticide applications close to harvest are not recommended because of safety concerns. Instead, the best management strategy is to pick the grapes before they become overripe and to dispose of grapes that have fallen to the ground.

Spotted wing drosophila (*Drosophila suzukii*)

Spotted wing drosophila, a 2- to 3-millimeter-long vinegar fly, first was detected in grapes in North Dakota in 2014 (Figure 20). This new invasive pest prefers raspberries and tart cherries but also will lay its eggs in grapes.
Unlike native vinegar flies, the spotted wing drosophila does not require cracked skin to enter a grape. The spotted wing drosophila uses its sawlike egg-laying mechanism (ovipositor) to cut a hole in grape skin and lay its eggs (Figure 21).

Typically, this pest does not begin to lay eggs until the grape starts to turn color. The eggs hatch within days, and the larvae start consuming the grape from the inside. The grape then will shrivel and rot.

Although this pest is well-distributed throughout the state, what is unknown is whether this pest will be anything more than a minor nuisance for North Dakota grapes. Thicker-skinned cultivars may avoid injury.

If spotted wing drosophila is a concern in your home vineyard, begin scouting and trapping for the pest just before véraison. The NDSU Extension publication “Integrated Pest Management of Spotted Wing Drosophila in North Dakota” provides detailed information on pest identification, simple trapping methods and insecticide recommendations. This publication and a more complete list of insecticides can be obtained from your Extension agent.

Please keep in mind that insecticides are ineffective once eggs have been laid in the grapes, so early scouting and trapping is extremely important. Also, rotation of insecticides is necessary to prevent insecticidal resistance.

Cultural control is important in controlling spotted wing drosophila. To prevent breeding, promptly harvest ripe fruit and rake up grapes lying on the ground.

**Yellowjackets (Vespula spp.)**

Yellowjackets are familiar residents of home vineyards in the fall. With alternating yellow and black stripes, they resemble honey bees without hair (Figure 22). However, they are much more aggressive than honey bees and can sting multiple times because their stinger remains intact. In the fall, their populations dramatically increase and they seek sugary foods such as grapes.

Yellowjackets typically live in underground rodent burrows or papery nests in trees or woodpiles. If yellowjackets have nested in the home vineyard, finding the nest to eradicate the problem is important. To avoid being stung, treat the nest at night or before daybreak when the yellowjackets are sluggish. Do not use a flashlight because the yellowjackets will be attracted to the light.

A nest can be treated with an aerosol wasp killer that contains pyrethrin or pyrethroids. These sprays easily can reach 20 feet. Generously soak the nest and check it the following day to see if any yellowjackets have survived. A second treatment usually is necessary. Once yellowjackets are dead, remove all aerial nests to prevent re-establishment.

**Pests on the Horizon**

**Japanese beetle** (*Popillia japonica*) has been detected in North Dakota on nursery stock that was shipped from out of state. It likely will become established in this state in the near future because the pest is present in Minnesota.

While the Japanese beetle feeds on more than 300 host plants, grapes are one of its preferred host plants. The insect has an iridescent green head with coppery-brown wings (Figure 23). The damage that the Japanese beetle does is very distinctive. It feeds on leaf tissue and avoids consuming the veins. The leaf will appear “skeletonized” (Figure 24).
Protecting Your Grapes From Animals

Protecting your grapes from devastating diseases and insect pests is not enough. Almost overnight, animals can devour the crop that you have nurtured. Birds and raccoons are attracted to the ripening berries as the sugar content increases.

Netting is the most efficient way to protect ripening fruit from these pests. Different styles of netting exist, and you will have to select a mesh size that works best for the pests you are trying to deter. Netting should be in place before véraison. Noisemakers such as cannons can work temporarily to scare away the birds. However, birds may become used to noisemakers through time.

Other pests such as deer will inflict damage in more than one season. Besides consuming ripe grapes, deer will nibble on young shoots throughout the growing season. Homemade repellents such as human hair, scented soap and garlic generally are not effective.

As for commercial repellents, most of them cannot be sprayed on edible crops such as grapes because they will impart an offensive taste or odor. Therefore, an 8-foot fence around the home vineyard is the most effective solution to thwart hungry deer. The fence also will protect the grapes from rabbits that may girdle the stem in the winter.

Voles, also known as meadow mice, tunnel under the snow and can girdle a grapevine during the winter. If voles are a problem, getting rid of their preferred habitat is important. Tall grasses and brush should be trimmed to eliminate habitat. Woodpiles should be moved. Do not use hay or straw to mulch the grapes because voles like to burrow in the mulch. As a last resort, contact your Extension agent for rodent bait recommendations.

Brown marmorated stink bug (Halyomorpha halys) is another invasive pest that may invade North Dakota in the near future (Figure 25). While the stink bug feeds upon a wide variety of ornamental and edible plants and crops, it can cause a unique problem for wine and grape juice producers.

As its name implies, it exudes an unpleasant odor when disturbed. If brown marmorated stink bugs are incorporated into the juice, their odor can taint the flavor. Fortunately, grapes are not a preferred host for this pest. However, feeding on grapes can introduce rot pathogens such as Botrytis or inflict wounds that will allow Japanese beetles, multicolored Asian lady beetles and yellowjackets to feed.

The brown marmorated stink bug can be distinguished from native stink bugs by distinctive striped antennae and banding along the edge of the abdomen (Figure 25).

If you discover either pest, contact NDSU Extension Entomology or the North Dakota Department of Agriculture.

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**Figure 23.** Japanese beetle with coppery-brown wing covers. (Pest and Diseases Image Library, Bugwood.org)

**Figure 24.** Japanese beetle skeletonizing damage on linden leaf. (Steven Katovich, USDA Forest Service, Bugwood.org)

**Figure 25.** Brown marmorated stink bugs have striped antennae and banding along their abdomen. (David R. Lance, USDA APHIS PPQ, Bugwood.org)
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Citations


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