ever, there is research evidence that grow tubes do not increase the rate of vine size development for either above- or below-ground portions of the vine and they do not alter long-term vine productivity. Moreover, the hardness of trunk and cane tissues may be reduced by the use of grow tubes. Presumably this is related to the frequent defoliation of portions of shoots within the grow tubes. One advantage of grow tubes is that herbicides can be safely sprayed around the base of newly planted vines. Some growers feel that this herbicide-spraying capability alone warrants the cost and effort of installing grow tubes. Growers are urged to carefully weigh what can be a relatively high cost per acre for the tubes, their installation, and removal versus the benefits that will be obtained from their use.

The installation of trellis posts and one or more wires at the time of planting grapevines will be helpful in the management of newly planted grapevines. Nevertheless, numerous vineyards are successfully managed in their first year without the installation of a trellis.

**MANAGING YOUNG VINES**

The principal goal of vine management in the first two years of a new vineyard is to develop mature-sized vines (see chapter 5, page 98). Adequate vine size to fill the entire trellis with canopy by the end of the third growing season will be the basis for long-term productivity. Healthy, functional leaf area is the basis for that growth. Promoting the early development of a vine training system by limiting the number of shoots on a newly planted vine to one or two is a traditional, orderly approach, especially if those shoots are meticulously tied to individual stakes at each vine. However, such management limits the leaf area on newly planted vines in comparison to those managed with greater numbers of shoots. If weeds are controlled around vines and vines are fertilized at the time of planting, newly planted vines will support the vigorous growth of several shoots. Shoots should be tied to training stakes or trellis wire(s) in order to keep the foliage protected from fungal pathogens and to encourage straight trunks. If grow tubes are used, the tubes will likely foster a dominant shoot that will suppress development of other shoots within the tube.

Standard vineyard establishment procedures involve defruiting vines in their first year of growth so that cropping doesn’t compete with the vegetative development of the vine. If it seems necessary to verify the variety in the new planting, one cluster per vine can be left on vines in the second growing season. Under optimal conditions, some growers have been able to take a very small crop (for example, 0.5 tons/acre) in the second year of growth in the vineyard; however, this practice is not recommended for inexperienced growers.

Because vine development depends on healthy, functional leaves, disease and insect pests must be controlled on newly planted vines. Diseases of greatest significance in new plantings are typically powdery and downy mildew, which attack the leaf area. Vines should be scouted weekly to detect emerging insect problems. Insects such as Japanese beetles, rose chafer, and potato leafhoppers can quickly become abundant and destructive to new vines. Frequent scouting and the application of appropriate insecticides when needed are part of good first-year vine management. If a trellis is installed at the time of planting of new vines, it will be necessary to tie the shoots loosely on one or more wires. Individual staking of vines is one option for managing young vines. A less costly option is to attach twine to the vine in a way that will not cause girdling (figures 4.20a, 4.20b, page 86). Extend this twine vertically up to one or more trellis wires. Shoots can then be tied loosely to this twine and then on to the trellis wires. All tying in the first year

---

*Figure 4.19* - Grow tubes on grapevines.
Grow tubes on White Riesling grapevines, seven weeks after planting. Although the vines with grow tubes (foreground) are considerably taller than those without grow tubes (background), those in the background developed more leaf area, developed more root growth, and had somewhat harder tissues than those grown with the grow tubes.
Characteristics of an end post anchoring system that uses an external anchor.

Figure 4.27 • End post with external anchor.

Bracing an end post avoids conflict between equipment and external anchors in headlands but is more difficult and costly to install.

There are several good methods for anchoring end posts. Bracing end posts within the row (figure 4.29) is advantageous because it avoids conflict with equipment in the headlands. However, this approach is generally more complex and costly than external anchoring. Therefore, anchoring externally to the end post is the most common method of constructing an end-post assembly. There are several characteristics of good anchor installation:

- Attach the anchoring wire as close as possible on the post to the main crop-bearing wire. This directly transfers tension from the crop-bearing wire to the anchor and reduces the tendency for the point of attachment of the anchor to act as a fulcrum.
- Angle the anchoring wire to avoid a narrow angle between the post and this wire. If the anchor is installed too close to the post, it may keep the post from rising up but not from being pulled into the row.
- Install the anchor so that its shaft rests in line with the anchoring wire (figure 4.27). Otherwise there will be a tendency to pull or bend the anchor shaft through the soil when tension is applied until it achieves this in-line orientation.
- Install the anchor deep enough and with an anchor plate of adequate surface area. The anchor plate should be at a minimum 30-inch vertical depth and have a minimum diameter of 6 inches. Screw-in anchors may or may not provide a satisfactory shortcut to this procedure.
- Make sure that the anchoring plate is in contact with firm, undisturbed soil. Auger holes for anchors vertically. Then use a crowbar to make a narrow slit in the soil, angling the slit from the bottom of the hole up to the point of anchor attachment to the post. The shaft
Why do we prune grapevines? An unpruned grapevine has hundreds of nodes, most of which may bear fruitful buds and shoots. If left unpruned, the resulting crop would quickly unbalance our "grapevine in a box" to a point where growth and winter hardiness would be compromised. We therefore prune to regulate the crop. There are both immediate and long-term effects of overcropping grapevines. Immediate symptoms are observed in the current year and could include reduced rate of sugar accumulation in fruit, reduced pigmentation in berry skins, and decreased synthesis of flavor and aroma constituents. Rather than maturing into woody canes, the shoots of overcropped vines typically die back completely to older wood or they may mature only one or two basal nodes (nodes towards the base of the shoot). Poor wood maturation occurs because the carbohydrates necessary for wood maturation have been depleted by competitive fruit-maturation processes.

The long-term effect of overcropping is a reduction of vine vigor (rate of shoot growth) and vine size (cane pruning weight). Vine size reduction due to overcropping can occur without a noticeable degree of cane dieback. Although wood might appear to be mature, stored starch reserves in vines stressed by overcropping can be so low that the next year’s vegetative growth and crop will be severely reduced.
The steps in training young vines are reviewed in chapter 5, page 98, and should be reviewed in the context of young-vine canopy management. Diseases, insect pests, and nutrient and water stress may also contribute to situations in which the vine size and leaf area are insufficient to fill available trellis space. Shoot hedging, leaf removal, and canopy division may be completely unwarranted under these conditions. The grape grower should instead investigate the constraints to inferior vine size and work to correct those deficiencies. Drought, nutrient deficiency, and overcropping may be relatively easily corrected; while poor root development, systemic diseases, or chronic cold-injury may be more difficult to deal with. In the latter case, the grape grower may need to make some fundamental changes in plant density, plant material, or vineyard site. Doing nothing is not a profitable option. (For in-depth discussions on nutrient and water stress, diseases, insect pests, and related topics, see chapter 8, page 141; chapter 9, page 169; chapter 11, page 216; and chapter 12, page 241.)

LONG-TERM SOLUTIONS TO VINE IMBALANCE

The canopy modifications described above are intended to improve the microclimate within the canopy and the balance between vegetative growth and crop production of existing vines. Some of these measures offer only short-term solutions, whereas others, such as canopy division, offer more lasting benefits.
(pH 5.6 to 6.9) and “neutral” (pH 7.0) vineyard soils generally have better nutrient balance for plant growth. Calcareous soils—those that contain free calcium carbonate—may be “slightly to strongly alkaline” with soil pH greater than 7.0 or greater than 8.5, respectively. Vineyard soils with a pH greater than 7.5 are rare in eastern North America but will typically exhibit nutrient imbalances where they do exist.

Soil pH, CEC, and base saturation values are used together to determine a lime recommendation (the amount of calcium carbonate equivalent needed to raise the soil pH by a desired amount). First, CEC is directly related to soil’s buffer capacity. It takes more lime to raise a soil pH from 4.5 to 6.0 in a soil with high CEC (that is, a clayey soil with a high percentage of organic matter) than it does in a soil with low CEC (that is, a sandy soil with a low percentage of organic matter). Second, there is a positive correlation between soil pH and base saturation, but the relationship is not linear. The chemistry of aluminum and carbonate buffer the soil at low and high pH, respectively. Therefore, it takes more lime to change the soil pH from 4.0 to 5.0 (because of aluminum) or from 6.0 to 7.0 (because of carbonate) than it does to change the soil pH from 5.0 to 6.0 (where aluminum and carbonate are not factors).

Aside from improving the percent base saturation, there are other good reasons to maintain soil pH at optimal levels. In strongly acidic soils, high amounts of free aluminum and iron precipitate phosphorus (P) out of the soil solution, making P unavailable to the plant. Aluminum toxicity can also affect root growth by inhibiting cell division in the root apical meristem. In addition, soil microorganisms, which improve soil fertility through the breakdown of organic matter and metabolism of nitrogen, can be inhibited in acidic soils (figure 8.2).

The availability of micronutrients (for example, Zn, Fe, Mn, and Cu) also changes with soil pH. In general, availability is high in acidic soils and low in alkaline soils. High availability at low soil pH can cause direct toxicity symptoms on the vine or cause indirect deficiency of another element. For example, high availability of zinc and iron may limit phosphorus availability for root uptake. In contrast, low availability of zinc and iron at high soil pH can lead to zinc or iron deficiency. Zinc deficiency is common in California vineyards with sandy, high-pH soils. Some grape varieties are susceptible to

Figure 8.2 • Acidic soil sickness.
Healthy leaves (top row) and leaf symptoms of acidic soil sickness (bottom row). Concord, Traminette, Noiret, White Riesling, and Cabernet Sauvignon leaves are shown (left to right in each row). Aluminum toxicity in acidic soils leads to poor root growth, low phosphorus availability, and decreased cation uptake.
Table 9.2 • Water Management Strategy for Maintaining a Balance between Vegetative Growth and Fruit Development in Current and Following Years

<table>
<thead>
<tr>
<th>Stage of growth</th>
<th>Generally desired water status</th>
<th>Consequences of excess water</th>
<th>Consequences of drought stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bud break</td>
<td>50% or more of plant available water (PAW) in root zone</td>
<td>Temporary iron chlorosis and reduced nitrogen utilization</td>
<td>Delayed budbreak, slow shoot development</td>
</tr>
<tr>
<td>Pre-bloom through bloom</td>
<td>Minimal stress; 50% or more of PAW in root zone</td>
<td>Excessive shoot growth rate and canopy volume with shaded flower clusters; poor fruit set; increased likelihood of powdery mildew infections of clusters</td>
<td>Insufficient leaf area development and/or impaired photosynthetic rates; poor fruit set and poor flower bud development for following year</td>
</tr>
<tr>
<td>Post-bloom to veraison</td>
<td>Sufficient water to allow full canopy development, then mild to moderate stress to slow shoot development; leaves function at full capacity</td>
<td>Shoots require frequent hedging; lateral shoots abundant and vigorous; fungal diseases aggravated by dense canopy</td>
<td>Impaired photosynthetic function, reduced berry size and sugar production; reduced crop in following year</td>
</tr>
<tr>
<td>Post-veraison</td>
<td>Minimal stress; sufficient moisture to retain leaf function but not stimulate shoot elongation; ripening advanced and fruit/wine quality optimized</td>
<td>Shoot growth continues; fruit ripening delayed; disease incidence may be increased; berry splitting may occur</td>
<td>Fruit desiccates, leaves non-functional and fruit ripening impaired; canopy yellows or leaves are shed; winter cold hardness impaired</td>
</tr>
<tr>
<td>Post-harvest</td>
<td>Mild stress, no new shoot development; leaves normally senesce with decreased temperatures; plant cold hardiness optimized</td>
<td>Shoot growth may continue until cold weather or frost; pendicerm maturation is delayed; vines may be predisposed to winter cold injury</td>
<td>Severe stress may impair acquisition of vine cold hardiness.</td>
</tr>
</tbody>
</table>

Drip systems can include different materials and placement for the laterals along the row of grapevines. A lateral is the drip line that runs along each row of grapes and is attached to a header or manifold at one end of the field. The options for laterals are described below.

**Temporary Laterals**

Drip lines can be placed on the ground next to the row of vine trunks to get plants started before a trellis system is installed. These temporary lines are usually a 1- or 2-year service thin wall vegetable row crop tubing of lighter weight and lower cost than the products installed for the life of the grapevines. A row crop tape is a thin-wall tape with the emitter built in at regular spacing as the tape is manufactured. The tape walls may be 4 to 18 mil thick (1 mil = 1/1000th of an inch); the heavier the wall, the longer the tape is expected to last. The emitter usually is formed of the plastic sheet, but individual emitters are also inserted into thin wall tubes as they are extruded.

Emitters are the small orifices through which the water is discharged. An emitter contains a designed flow path that regulates the flow of water. Some are pressure-compensating, but for many the discharge rate is influenced by the water pressure. Pressure compensating emitters use an internal diaphragm that moves with pressure to vary the water pathway to regulate the flow. Higher pressure causes more restriction of the pathway, but the same amount of water passes through.

With the emitters at regular intervals, the tape or tube can be installed along the row of grapevines quickly to give a wetted strip down the row. The tape can be removed when trellis posts are set. Temporary lines are, however, subject to more mechanical damage from rodents, insects, and people, and may expand and contract significantly during changes in air temperature. These are used when drip irrigation is intended only to establish the planting. Most of these drip tapes are not pressure compensating; however, there are relatively thin-walled tubes with pressure compensating emitters. Pressure compensation is important on slopes greater than 3% to 4%.
“Drift-guard™” nozzles sold by TeeJet are an example of pre-orifice flat fan nozzles.

**Turbo-Teejet**

A turbulence chamber in Turbo™ nozzles produces a wide angle flat spray pattern of 150°. Spray quality is medium-to-coarse at 15 to 90 psi. Nozzles can be set at 15 to 18 inches above the target.

**Air induction nozzles**

Air induction, air inclusion, or venturi nozzles are flat fan nozzles in which an internal venturi creates negative pressure inside the nozzle body. Air is drawn into the nozzle through two holes in the side mixing with the spray liquid. The emitted spray contains large droplets filled with air bubbles with virtually no fine, drift-prone droplets emitted. The droplets explode on impact with leaves and produce coverage similar to conventional, finer sprays. Air induction nozzles work best at higher pressures, in the range of 75 to 90 psi. They are available at 110° fan angles, so boom height may need to be adjusted to 15 to 18 inches. The use of adjuvants will certainly help create bubbles. Air induction nozzles work very well for herbicide application.

**Sensor-Controlled Applicators**

Sensor-controlled pesticide applicators (see figure 10.26) use optical sensors designed to determine where weeds are located. These sensors, coupled with a computer controller, regulate the spray nozzles and apply herbicides only where needed, thus considerably reducing herbicide use. A computer-controlled sensor detects chlorophyll in plants and then sends a signal to the appropriate spray nozzle, applying the herbicide directly to the weed. The operator calibrates the system to bare soil or pavement, allowing the computer to determine when there is a weed present. Sensor-controlled applicators are often mounted on all-terrain vehicles (ATV), John Deere Gators™, and other vehicles including tractors or trucks. Typically, this type of applicator can be used at speeds up to 10 mph. A complete sensor-controlled system consists of a chemical tank, pump, battery power, computer controller, optical sensors and spray nozzles.

**Benefits of sensor-controlled applicators**

These are benefits of sensor-controlled applicators;

- Reduced amount of herbicide applied
- Reduced potential for groundwater contamination
- Ability to apply herbicides in dark or light conditions
- Reduced herbicide drift, if wind-deflecting shields are present
Symptoms and Signs

Lesions on shoots and leaves are the most common symptom of the disease. Infections on shoots result in black, elongated lesions that are most numerous on the first three to six basal internodes (figure 11.13). Cracks or fissures may develop within these lesions, eventually crusting over to produce a rough, blackened appearance by the end of the season. The stem is weakened around these infection sites, occasionally leading to stem breakage in high winds before shoots become attached to the trellis wires. The greater impact of cane infections, however, appears to be the establishment of the fungus within woody portions of the vines, from which it can infect fruit and rachises in subsequent years. During the dormant season, infected canes may become bleached, and numerous tiny, black fungal fruiting bodies (pycnidia) erupt through the surface to produce a speckled appearance.

Elongated, black lesions similar to those on young shoots develop on infected petioles (leaf stems), and these may cause affected leaves to turn yellow and drop if severe. Numerous small, light green lesions with irregular margins develop on infected leaf blades, eventually turning brown to black with yellow margins (figure 11.14). Occasionally, the infected tissue may drop out, causing a “pin-pricked” or “shot-hole” appearance. Heavily infected leaves often become misshapen and crinkled. The impact of such foliar infections is questionable, although they do serve to indicate the presence of fungal inoculum within the vine.

Lesions on the rachises are sunken and black (figure 11.15), causing the rachis to become brittle; clusters may break at these points under the weight of the maturing crop or during harvest operations, leading to a reduced yield. If lesions girdle the rachis, berries below the infection site shrivel and may fall to the ground. A rapidly expanding brown rot develops on diseased berries during the pre-harvest period. The rotten zone is often first apparent where the berry is attached to its supporting stem (pedicel), but this is not always the case. After the berry has become completely rotted, numerous black fruiting bodies (pycnidia) of the fungus erupt through
After perennial weeds are controlled, a ground cover can be established. Glyphosate can be applied in strips in the fall to control the ground cover and grapes can then be planted into the killed strips (see chapter 4, page 71).

**NEW PLANTINGS**

Competition from weeds is most detrimental in the first few years after planting because this will delay vine establishment and full cropping potential. It is therefore desirable to maintain a weed-free strip within the row and, because competition with the ground cover in the alleyways will restrict grapevine root development, a wider weed-free strip, within reason, is beneficial.

**WEED CONTROL OPTIONS**

Weeds can be controlled in vineyards through cultural methods, through herbicide application, or through a combination of these two strategies.

**Cultural Control**

Hoeing and hand-weeding are labor-intensive, but acceptable, options for weed control, especially in small vineyards. Rows will need to be hoed approximately every 2 to 4 weeks during the growing season. Mechanical hoes and cultivators are available and can be used to eliminate under-trellis weeds (figure 13.3). Considerable care is required, however, to avoid trunk and root injury. Additional hand-weeding may be necessary to control weeds growing close to the grapevines.

Cultivation with a grape hoe, rototiller, or other equipment can be used for weed control in the row. If the land is relatively flat and soil erosion is not a concern, cultivation with disks or rotovators is possible. When cultivating, use caution to avoid damage to vine trunks and roots. Cultivated soil is subject to erosion and both soil structure and organic matter content are decreased with cultivation, which are drawbacks to mechanical cultivation. Mixing of soil also brings weed seeds to the surface where they can germinate, so frequent cultivation is needed to maintain a weed-free zone.

Mowing is used to suppress vegetation in the areas between rows but is generally not useful for in-row weed control. However, research in New York suggests that mowing has limited impact in reducing competition from cover crops in the row middles. Growers with small acreage may be tempted to “mow” weeds in the row with hand-held, string weed-trimmers or “weed whackers.” These devices have, unfortunately, caused considerable injury to vines by girdling the trunk and causing long-term vine injury. Their use is therefore not recommended in vineyards.

Mulching has been used in grape production, although it is not widely used. Mulches can reduce soil crusting, conserve soil moisture, and suppress weed growth. Use of mulches is limited by cost, availability, and difficulty in spreading. Organic mulches can serve as a haven for rodents. Mulching suppresses weed growth, which reduces competition for soil moisture and nutrients, increases rainfall penetration, conserves soil moisture, provides nutrients as the mulch decays, and reduces soil erosion. In vineyards where vine vigor is low, mulching can improve vigor. A thick layer of mulch on poorly drained soils should be avoided because this could retain excess soil moisture in the root zone, leading to root diseases. Mulch can also be a fire hazard when material such as hay or straw is used in dry weather.

Most organic materials such as bark, straw, hay, cobs, sawdust, composted grape pomace, or wood chips can be used as mulching materials. The mulch may be applied to the entire vineyard floor or confined to a 4- or 5-foot wide band beneath the trellis. Adding mulch to row middles will reduce soil erosion. The desired depth of
### BERRY SAMPLE ANALYSIS SCORES

<table>
<thead>
<tr>
<th>Date</th>
<th>Sampled by</th>
<th>Flavor</th>
<th>Aroma</th>
<th>°Brix</th>
<th>TA</th>
<th>pH</th>
<th>Tannins</th>
<th>Juice color</th>
<th>Brown seeds (%)</th>
<th>Comments</th>
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</table>

**Figure 16.6 • Fruit scoring and harvest record form.** Adapted from Chateau Morrisette, Floyd, VA.

(figure 16.7). The same juice can be used to test pH and titratable acidity if you are equipped for those measurements. Otherwise the berry samples should be refrigerated and promptly shared with the winery that will purchase your grapes. Each sample should be properly labeled with information about the sampled unit/variety, date and time of sample, and name of sample collector.

**MEASUREMENT OF GRAPE MATURITY AND QUALITY**

Although they don’t tell the whole story, sugar (as soluble solids concentration), pH, and titratable acidity are useful to describe grape maturity and to inform the harvest decision. Despite its limitations, measurement of sugar concentration (°Brix) is a common industry practice. Sugar concentration is important due to its impact on fruit quality (sweet taste) and its role in alcohol formation during fermentation (1.7% sugar =1% alcohol). Actual alcohol yield is 51 to 60 percent and depends on starting sugar concentration, nutrient level of juice, and other winery-controlled factors. Sugar content is a good indicator of quality in cool climates; however, several studies have shown no or poor relationships between sugar levels and accumulation of grape berry flavorants.

Juice pH is important to the fitness of grape must and final wine. The pH affects free SO\textsubscript{2} levels, wine balance (especially the perception of “sourness” or tartness), aroma, as well as the microbiological and physiochemical stability of the must and wine. Wine, particularly white wine, with a pH greater than 3.5 to 3.6 may be flat or unbalanced, while wine with a pH near 4.0 will not age as well, is more prone to microbial growth, and may require acid additions which add to winery costs. Measurement of pH from a field sample can be misleading, as it does not account for crushing and fermentation effects. Titratable acidity is determined by measuring the amount of a strong base (sodium hydroxide) required to neutralize juice or wine to a given endpoint pH. The most common acids present at harvest are malic and tartaric. In the US, titratable acidity is expressed as either percentage or grams of tartaric acid per liter. Sugar measurement can be used with either pH or titratable acidity to yield an index or ratio that can help in the determination of the sugar/
### BORON

<table>
<thead>
<tr>
<th></th>
<th>Target Values</th>
<th></th>
<th></th>
<th>THEN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil</strong></td>
<td><strong>Bloom</strong></td>
<td><strong>70–100 DAB</strong></td>
<td><strong>AND</strong></td>
<td><strong>THEN</strong></td>
</tr>
<tr>
<td>IF &lt; 0.3 ppm</td>
<td>20 ppm</td>
<td>20 ppm</td>
<td></td>
<td>Apply boron as recommended in notes.</td>
</tr>
<tr>
<td>IF = 0.3–2.0 ppm</td>
<td>25–50 ppm</td>
<td>25–50 ppm</td>
<td></td>
<td>No action necessary; repeat sampling in two years.</td>
</tr>
<tr>
<td>IF &gt; 2.0 ppm</td>
<td>50 ppm</td>
<td>50 ppm</td>
<td></td>
<td>Monitor for Boron toxicity.</td>
</tr>
</tbody>
</table>

**Sources:**
Solubor (20% B), most common; can be applied to soil or to foliage
Borax (11% B)
Borate-46 (14% B)
Borate-65 (20% B)

**Rates:**
Soil application rates of 1 pound B/acre in medium to coarse textured soils to 2 pounds B/acre on heavy clay soils are recommended. Blending with other fertilizers (such as N) for broadcast application is suitable. Soluble B products can also be applied to the soil with an herbicide sprayer. Calculate sprayer rate based on actual area sprayed, as opposed to total vineyard acres sprayed. For example, assume we want 1 pound B per planted acre, or 5 pounds Solubor (20% B) per planted acre. If only spraying 1/3 of a planted acre (for example, a 36-inch herbicide band of 9 foot rows), use 1.7 pounds Solubor per planted acre.

Foliar applications of 0.2 pounds B/acre (1 lb. Solubor) are recommended and no more than 0.5 pound B/acre (2.5 lb. solubor) in one application. Spring foliar sprays are timed at 6–10 inch shoot growth and 14 days later. In California, fall (immediate post-harvest) foliar sprays have been more effective than spring foliar application in eliminating cluster and berry disorder.

To reduce the risk of foliar burn, do not apply boron sprays at less than 14-day intervals or tank-mixed with water-soluble packages, oil, or surfactants.

### IRON

<table>
<thead>
<tr>
<th></th>
<th>Target Values</th>
<th></th>
<th></th>
<th>THEN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil</strong></td>
<td><strong>Bloom</strong></td>
<td><strong>70–100 DAB</strong></td>
<td><strong>AND</strong></td>
<td><strong>THEN</strong></td>
</tr>
<tr>
<td>IF &lt; 10 ppm</td>
<td>10 ppm</td>
<td>10 ppm</td>
<td>10 ppm</td>
<td>Alkaline soil and/or visual symptoms of Fe deficiency. Lower soil pH to improve long-term iron availability and apply Fe foliar spray to correct current foliar deficiencies.</td>
</tr>
<tr>
<td>IF = 20 ppm*</td>
<td>30–100 ppm</td>
<td>30–100 ppm</td>
<td></td>
<td>Improve soil drainage to improve long-term iron availability and apply Fe foliar spray to correct current foliar deficiencies.</td>
</tr>
<tr>
<td>IF &gt; 50 ppm</td>
<td></td>
<td></td>
<td></td>
<td>No action necessary; repeat sampling in two years.</td>
</tr>
</tbody>
</table>

**Notes:**
*Soil values between 11–19 ppm should be monitored for possible developing deficiency.

Iron deficiency is often associated with calcareous soils (high soil pH), low soil oxygen (waterlogging), and variety (V. labrusca more susceptible). Tissue standards for interpreting iron levels are not well defined. In the absence of visual deficiency symptoms, no corrective action is indicated.

**Common deficiency treatments:**
Lower soil pH by trenching in soil sulfur or using acidifying nitrogen fertilizers.
Improve soil drainage
Apply foliar iron sprays (only effective for existing foliage)
Apply iron chelates (expensive and short-lived)