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Vineyard Establishment II

Planting and Early Care of Vineyards

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MICHIGAN STATE UNIVERSITY EXTENSION

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Cover Photo: A Cabernet franc vineyard in its third growing season near Benton Harbor, Michigan. Vines produced a yield of approximately 2 tons per acre after being thinned to allow the development of vine size.

Acknowledgments

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Introduction

The establishment of a productive vineyard is hard work. Too often those who undertake this enterprise do not understand the amount of effort and the need for timely performance of the many tasks required to bring a vineyard into full productive capacity. Frequently, vines are hurriedly planted without adequate preplanting and postplanting care with the expectation that, if one can just get the process started, eventually a beautiful, highly productive vineyard will result. Unfortunately, a poor start can doom a vineyard to mediocrity for a long period — perhaps forever. Therefore, careful planning and timely application of each step in the process of vineyard establishment are important not only to hasten the onset of vineyard productivity but also to ensure its long-term productivity. The information presented here will assist those undertaking what can be a highly economically and personally rewarding experience — the establishment of a vineyard.

I. Preplanting Activities

Preparing the Soil for Planting

Most vineyards are planted after the soil has been tilled completely to provide a loose, workable planting bed for the vines. Plowing, disking, dragging, floating, etc., to prepare a field for planting requires more skill than one might imagine. Laying out the plow patterns to avoid dead furrows in the middle of the field, adjusting the plow so it rolls over the soil properly, cross-disking and dragging to ensure level soils, etc., require planning and skill. Seek counsel from local field crop experts on tillage operations when necessary. Heavy sods, excessively wet soils, excessive growth of cover crops before plowing, etc., can complicate the process. The soil should be not only level but also loose and workable to a depth of 8 to 9 inches so a planter can be readily pulled through the soil to open a furrow for setting the vines. This furrow is typically 12 to 15 inches deep, but some planters can open a trench as much as 24 inches deep. Most soils require only typical surface tillage operations to prepare them for vine planting. Some soils, however, have compacted layers of subsoil, which form either naturally, in the case of a pan soil such as a hardpan or fragipan soil, or through physical compaction by equipment. Because these layers can restrict vine root development, breaking up these layers, either by subsoiling or (less often) through deep plowing, can significantly improve vine size development.

Moldboard plowing works well on fields that have been managed uniformly without woody vegetation, such as those with a field crops history. Many growers prefer chisel plowing on old orchard or vineyard sites. Heavy sods may be killed with a herbicide treatment the previous fall and then rough-plowed so freeze/thaw cycles help break up large clods.

If the field to be planted has considerable slope and the soils are light enough to be erodible, then complete tillage of the vineyard site may be hazardous. In recent years, a number of vineyards with these characteristics have been planted by first rotovating strips of soil into which vines are then planted. Rotovation should be performed as deeply as possible. Placing small marker stakes at the ends of vine rows and at intermediate places in the field will provide a guide for the tractor.

Marking the Field

Marking a field for planting a vineyard is perhaps like brushing teeth — no two people do it exactly the same. Though numerous variations on this step in vineyard establishment are possible, the following guidelines will help focus one's creativity for this task.

The most common situation is a field that has been completely tilled and sufficiently leveled so that 3- to 4-inch deep grooves in the soil will be readily visible. A grid pattern of grooves is made in the soil (Fig. 1)

Fig. 1. Vertical grooves in the soil mark the spacing of rows. Less distinct horizontal grooves mark the vine spacing. This planting was on the Jim and Dan Nitz farm on an April morning near Baroda, Mich.

Fig. 2. This trailer field marker for planting grapevines on the Kerlikowske farm in Michigan uses two cultivating teeth to make grooves in the soil. Meanwhile a hydraulically extended disk marks the location for the next pass of the tractor. (Kerlikowske Farm, Berrien Springs, Mich.)

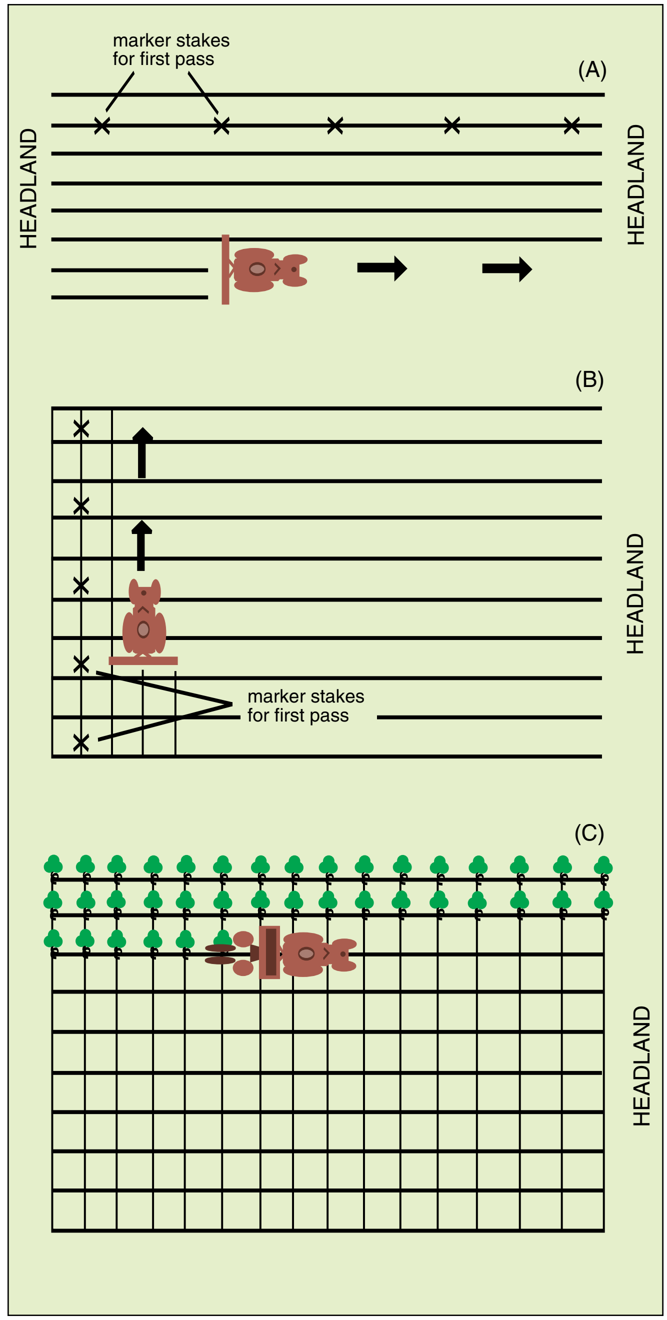

Fig. 3. Steps in planting vines include (A) marking rows, (B) marking vine spaces and (C) planting vines.

and then vines are planted at the intersections on this grid. The marking tools used to make this grid are often fabricated on the farm (Fig. 2) and vary considerably from farm to farm. A common method will be described first and then comment will be made on variations.

The marker is typically a tool bar behind the tractor, either on a 3-point hitch or trailered, on which cultivating teeth are spaced to make grooves in the soil. Three teeth often are used — one in the middle of the tractor and one movable tooth on each side. Begin by placing several stakes along what will be the second row of the vineyard (Fig. 3a). Then set intermediate stakes as needed, either by stretching a wire between end stakes or sighting between end stakes with binoculars to align a 6-foot pole held by one of the crew. Stakes in this row should be about 3 feet tall so the tractor driver can readily sight along them. Lath strips work well. They should be lightly staked in the soil so the tractor can easily push them over during marking. With the marking tool set so the distance between the cultivating teeth is at the desired row spacing, drive down the field along this set of stakes to make the first three rows (Fig. 3a). The third row marked with this first pass then becomes the guide for an outside

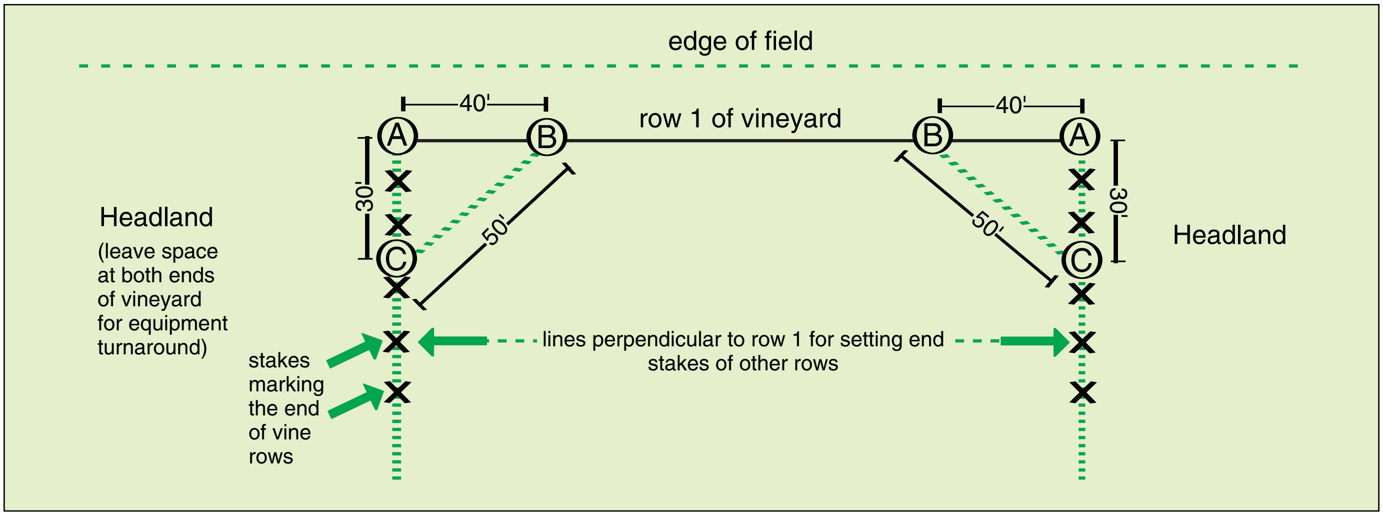

Fig. 4. A method using right-triangle measurements to establish end stakes for vineyard rows in a line perpendicular to the first row of a vineyard (figure adapted from Cahoon *et al.*, 1991).

tooth on the marker for the next pass. This is repeated across the entire field (Fig. 3a). If the marker is stabilized so there is no side-to-side movement, then marking can be performed in both directions. However, even a 2-inch shift on a side slope will make every other row 4 inches too wide or too narrow. Therefore, on small plantings it may be best to take the extra time to mark all rows in the same direction. On large plantings, mark rows on one side of the field in one direction and those on the other side in the opposite direction. This will limit row width variation to possibly one row middle in the center of the field.

The next step is to mark vine spaces. Begin by setting stakes in the second vine space from one end of the vineyard (Fig. 3b). A technique for establishing a right angle to the row markings (Fig. 4) will ensure these stakes are perpendicular to the row markings. Then repeat the process of marking with the cultivating teeth spaced for the desired vine spacing (Fig. 3b).

One ingenious grower variation simply marks the vine spaces. The first row is staked. The other rows are then marked while planting by using a marking pole mounted on the front of the tractor (Fig. 5).

If strip tillage is performed on an erodible slope, begin by placing end stakes for the vineyard rows (Fig. 4). This will often be adequate marking for rotovation of the strips. If the field is very long and undulating, intermediate stakes will be helpful. After the rotovation, place intermediate stakes in the rotovated strips between the end stakes as described above. If it is not

Fig. 5. The person planting vines is looking for the vine spacing grooves in the soil for precise placement of the vine, while a disk on a boom in the front of the tractor marks a groove in the soil for the next row. Others in the crew supply vines and make sure vines are upright and mounded with soil. (Oxley Farm, Lawton, Mich.)

feasible to mark vine spaces perpendicular to these strips as described above, mark vine spaces with spray lime as described below.

On an outer row of the vineyard, lightly tension a wire between the end stakes. Use a 100-foot measuring tape to mark the wire for the desired vine spacing. Begin at an end stake to mark a half-vine space for the first vine and then full vine spaces. Using a bucket of spray lime, put a narrow strip of lime about 2 feet long perpendicular to the wire where each vine space is marked on the wire. When complete, relocate this wire to the other outside row of the vineyard, or at 15-row intervals on large vineyards. Repeat the marking with lime. Then a rope or wire can be stretched temporarily across the 13 or fewer unmarked rows between these marked rows. Beginning at the first vine space at one end of the vineyard, place a 2-foot strip of lime to mark the vine space where the rope crosses the unmarked rows. Repeat the process down the row until all the vine spaces have been marked.

In reality, growers will be highly influenced in their approach to the task of marking a field for planting by the resources available among their grape-growing neighbors. Nevertheless, the very important goal of straight, uniformly spaced rows and vines is universal.

II. Planting Vines

Preparing and Handling Vines

Keep grapevines moist at all times. If the nursery from which you are purchasing vines is storing them well in a moist, cold storage, do not accept delivery of vines until you are ready to use them. Vines that arrive with chlorotic emerging shoots indicate poor storage techniques. Vines should not experience extended periods of shipping. When you receive vines, immediately inspect and water them and place them in a cool, moist environment. If a cold-storage facility is not available, plant as soon as possible. Vines may be kept in a cool cellar for a few days as long as they are watered often and kept covered to prevent their drying out. Check tags on all bundles to make sure they are true to variety and rootstock as per your order. Do not prune the roots of vines. Plant as much of the root system as can be well distributed in the soil (see discussion below). Vines shipped from commercial nurseries often will have had their top portions pruned so that no further pruning is required. Vines that you propagated should have the tops pruned back to 5 to 6 inches. If vine tissues seem dry at planting, soak bundles of vines in water for 4 to 6 hours prior to planting. Vines should be transported to the field under tarps or in covered containers (Fig. 6).

Fig. 6. Grapevines being loaded on a planter. Vines were transported to the field on a hay wagon and kept covered with a tarp to prevent drying. (Jim and Dan Nitz Farm, Baroda, Mich.)

Planting Techniques

Most vineyards are planted with a modified tree planter (Fig. 5). This piece of equipment seats one or two people. When there are two, individuals may alternate planting vines or one may prepare vines for insertion into the furrow while the other plants. While the tractor driver keeps the planter in line with the row markings, the person(s) planting vines places a vine in the furrow each time it reaches a cross marking (Fig. 5). When vines are planted, place roots as deep in the trench as possible (Fig. 7), make a quick swirling motion of the vine, and then pull it up slightly to get good root distribution. Some growers have usefully modified the flanges on a tree planter to open a furrow as much as 9 inches wide and 24 inches deep (Fig. 8). Grafted vines should have the graft union situated approximately 2 inches above the level of the vineyard floor (Fig. 9). This facilitates both hilling and removing soil from around the graft union. If the root systems of vines are so large that they cannot be well distributed in the trench at planting, then modest root pruning may be warranted. Nevertheless, for the health of the vine and to promote its maximum rate of establishment, make the extra effort to plant as much

Fig. 7. A vine being planted in a trench. It is placed as deep as possible, shaken slightly to distribute roots and then lifted to the proper height. Blades attached to the planter are pulling soil into the trench. (Oxley Farm, Lawton, Mich.)

Fig. 8. This planter has been modified to open a trench as much as 24 inches deep and 9 inches wide so that the large vine root systems can be planted with good distribution in the soil. Blades behind the planter fill in the trench with soil. (Oxley Farm, Lawton, Mich.)

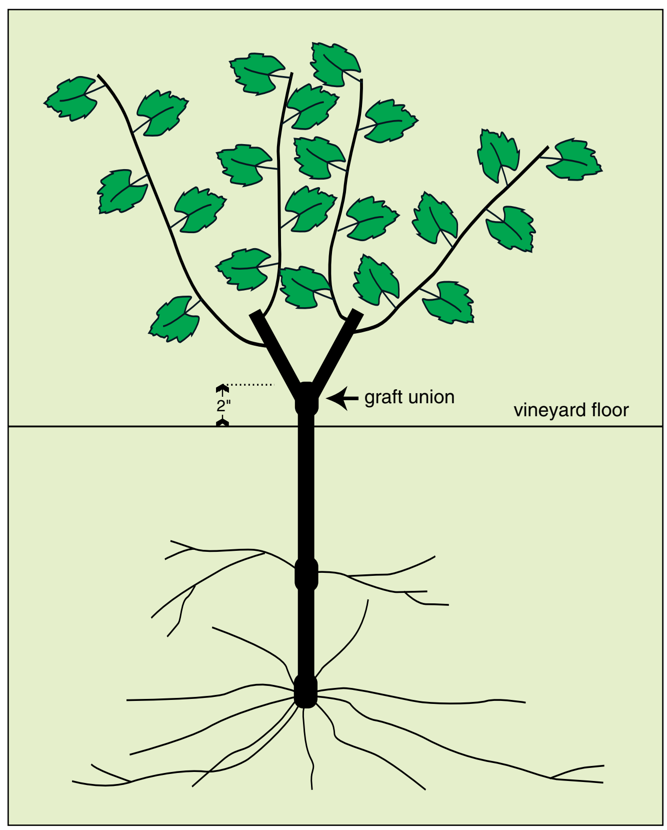

Fig. 9. A young grapevine showing a root system that was well distributed at planting and the proper height placement of the graft union.

well distributed root system as possible. Though tree planters often have wheels or blades to fill in the trench, hand labor should follow the planter (Fig. 10) to straighten vines, make a final adjustment on the height of the graft union on grafted vines and firm the soil around each vine.

When planting by hand, it is helpful to till the soil before planting. One approach is first to rotovate strips for the vine rows. If a V-shaped shovel plow is available, it can then be used to open a trench for planting (Fig. 11). It may be possible to mark vine spaces perpendicular to the rows with a marker, then plant at the intersections of that grid. It is also possible to plant by hand along a wire that has been lightly tensioned between end-row stakes. Placing this wire directly on the row complicates digging holes and distributing root systems. Therefore, it is helpful to offset this wire about 15 inches from where the vines will be planted. Then a 15-inch stick can be used to measure from the wire to the precise location for vine placement. Mark vine positions on the wire, beginning with a half-vine spacing. Do not use a stick to measure the length of individual vine spaces — small errors in vine placement become cumulative as one plants down the row. Holes dug with a shovel should be at least 12 inches in diameter and 12 inches deep. Make sure that the roots are well distributed and that the ends of the roots are at the bottom of the hole, not creeping up the sides to the surface. Mound soil around each vine to hold it upright.

Augers may be used to dig the holes for planting vines by hand. In soils with clay, however, augering may compress soil on the sides of the hole, making it impenetrable to roots. If such soil compression is suspected, chip off soil on the side walls of the hole during planting.

Fig. 10. Members of the planting crew follow the planter to make sure each vine is upright and has a firm mound of soil around it. The marking grid is evident on the soil. (Jim and Dan Nitz Farm, Baroda, Mich.)

Fig. 11. A V-shaped shovel plow has opened a trench for hand planting of vines. The 12-inch ruler next to the vine shows that root systems can easily be distributed 12 to 15 inches deep at the bottom of this trench without any additional digging. A mound of soil is then gathered by hand around each vine and the rest of the trench is filled in mechanically.

III. Steps Immediately After Planting

Hilling Soil Around Vines

The soil around vines immediately after planting is generally level or slightly depressed. Before the introduction of preemergence herbicides in the early 1950s, weed control around vines was accomplished by alternately hilling and removing soil around vines. Though weed control around vines is now accomplished chemically in most vineyards, hilling soil around vines is still desirable for several reasons: vineyards are often planted with rows across sloping ground so that ridges of soil under the trellis interrupt the highly erosive downhill flow of water during heavy rains; depressions in the soil around grapevines may concentrate herbicides at the bases of young vines and lead to vine injury; and hilling soil around graft unions during the winter is the best known method of affording winter protection to those tissues.

Offset plows, disks, cultivators, etc., are commonly used to hill soil around newly planted vines immediately after planting (Fig. 12). Perform this task before applying any herbicides. A ridge of soil 4 to 6 inches above the level vineyard floor is a reasonable goal. If a deep furrow was created during the planting process, a somewhat higher hilling will be necessary to compensate for settling of the soil. Although covering graft unions may initiate scion rooting, it keeps young graft unions moist during the early growth of vines. Scion roots that form should be removed when soil is cleared away from around vines the following spring.

Fig. 12. A new planting of 'Cabernet franc' vines showing hilling of soil in a ridge around vines. (Doug Nitz Farm, Baroda, Mich.)

Hilling soil around grafted grapevines is often considered as protection for the graft unions against winter injury from low temperatures. However, what is really desired is to protect not only the graft union but also the scion tissues 2 to 4 inches above the graft. This affords the opportunity to renew a severely winter-injured grapevine (Figs. 13-A to 13-D). Otherwise, winter injury could occur immediately above the graft union (Fig. 13-E) and prevent any possibility of renewing the vine (Fig. 13-F). Therefore, be sure that hilling of grafted vines is sufficient to provide 2 to 4 inches of settled soil over the graft.

A second strategy uses hilling around new grapevines as a means of weed control. A light cultivation about 3 weeks after the planting begins to fill in furrows and cover any newly emerged weed seedlings. A second and possibly a third cultivation at 2- to 3-week intervals gradually fills in planting furrows and creates a ridge of soil around vines while suppressing emerging weed seedlings.

Controlling Weeds

Weed control is the single most important cultural practice in vineyard establishment. It should dominate site preparation as well as vine management immediately after planting. Without weed control, other cultural practices such as nitrogen fertilization,

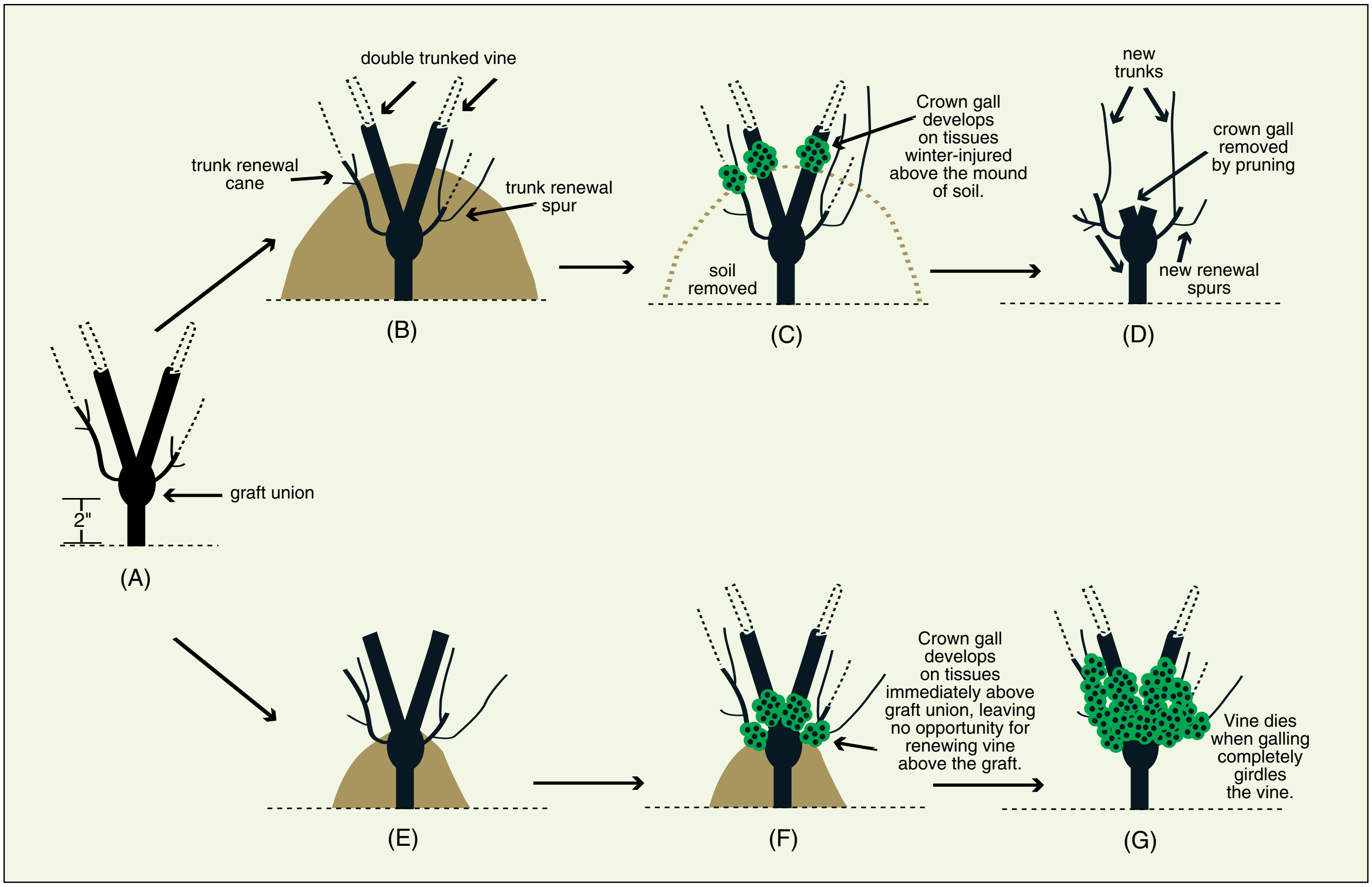

Fig. 13. A schematic of the base of a grafted grapevine (A) showing the progression of crown galling after a winter injury episode, depending on whether hilling of soil covers the graft union and vine tissues several inches above the graft union (B-D) or covers only the graft union (E-G).

irrigation and vine pruning severity will be incapable of promoting vine size development (Fig. 14). When these cultural practices are used in combination with weed control, however, they can have a positive, additive influence on vine growth (Fig. 14).

If vineyard site preparation properly eliminates perennial weed growth, weed control after planting is a matter of preventing weeds that develop from seed. Two fundamental questions relate to that task: how much weed control is desirable around newly planted vines and how can it be accomplished?

Weed control around grapevines typically is established in bands along the vine rows. Vineyard row middles are a separate aspect of vineyard management.

A quarter-century ago, most eastern U.S. vineyards were managed with a 30- to 36-inch-wide weed-free band under the trellis. That width has evolved to approximately 40 to 48 inches. However, even wider weed-free bands — up to 96 inches around newly planted vines — can promote significantly greater vine growth (Fig. 15).

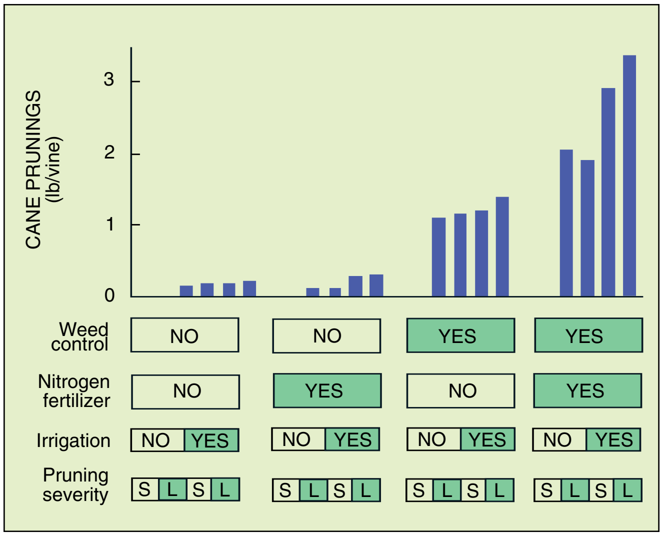

Fig. 14. Weight of cane prunings per vine for 'Niagara' grapevines after two growing seasons. Vines were subjected to combinations of weed control under the trellis, nitrogen fertilization, irrigation and severe (S) or light (L) pruning. (Vineyard near Benton Harbor, Mich.)

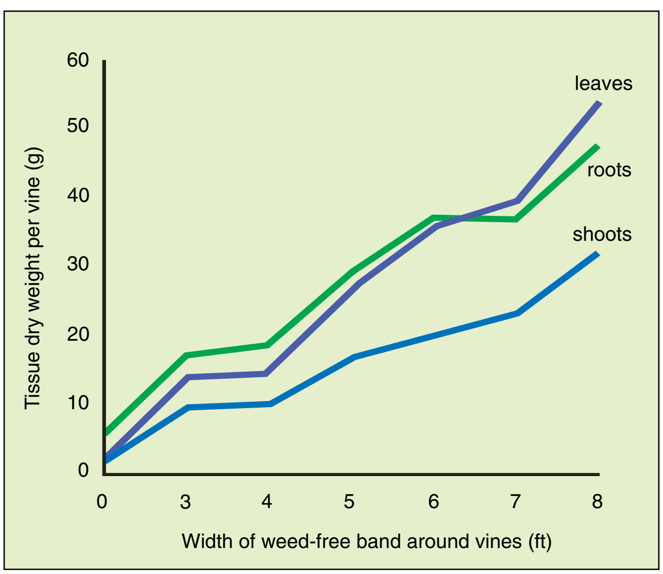

Fig. 15. The dry weight per vine for leaves, roots and shoots of 'Niagara' grapevines at the end of their first growing season. Vines had varying widths of weed-free bands around them. (Vineyard near Benton Harbor, Mich.)

Therefore, a grower needs to consider two opposing factors when deciding how large a weed-free area to manage around newly planted grapevines. The first is the erodibility of the site. When preemergence herbicides first became available for vineyard use, some growers thought that complete control of vegetation on the vineyard floor would be desirable. This strategy often led to highly erosive conditions (Fig. 16), so it was abandoned. However, the wider the weed control band is around new vines, the greater the opportunity for vine growth. Therefore, a grower needs to decide how wide a weed-free band can be established safely around vines. That width can often be enlarged if it is used in combination with erosion control practices such as ridging soil along the vines and maintaining a sod strip in the row middles. A minimum 48-inch-wide weed-free band should be possible in most situations. At times, even wider weed-free bands will be useful.

Fig. 16. A highly eroded vineyard that has lost a large amount of topsoil because sod strips were not maintained in the row middles. Vines are small and unproductive.

The options for weed control around newly planted grapevines are manual, mechanical, chemical, mulching and combinations thereof. Manual weed control with hoeing and hand weeding is an acceptable vineyard practice and can result in good vine size development. However, those who intend to practice manual weed control around more than a hundred vines often grossly underestimate the difficulty of the task. Faithful biweekly weeding throughout the growing season is the key for making this weed control strategy successful. This means marking the calendar so that 2-week periods do not stretch into 3 or 4 weeks!

Mechanical weed control around newly planted vines is practiced with several types of equipment, including hilling-up/taking-out plows, offset rotovating devices, offset cultivators, etc. Although such efforts may control weeds between vines well, they do not control the critically important weed growth immediately around vines. Therefore, supplemental manual weed control around vines is essential. Even if cross-cultivation with disks or rotovators is possible, manual weeding immediately around vines is still critical to promote vine size development (Fig. 17).

Mulching materials used to control weeds around newly planted vines include strips of black plastic mulch, straw, grass clippings, shredded bark, stones and newspaper held down with stones. Commercial use of black plastic mulch typically results in vine growth that is no better than that obtained with herbicides. There are the added complications of managing vineyard row middles at the edge of the plastic mulch and disposing of the plastic at the end of 1 or 2 years.

Fig. 17. This new vineyard was cross-cultivated in the first six weeks after planting. Manual weeding/hoeing was not performed immediately around vines.

Though weed control around most newly planted vines in vineyards is attempted with preemergence herbicides, this is not an easy task. The number of herbicides for this purpose is limited, and many do not control a broad spectrum of weed species. In addition, the grower must obtain and calibrate equipment to ensure proper rate and patterns of herbicide application. Furthermore, adequate rainfall after application is required to activate the herbicides. Too often, some aspect of this combination of factors fails despite the paramount importance of weed control in new vineyards. For this reason, we'll review the steps involved with this task in detail.

Herbicide control of weed growth in a newly planted vineyard begins with the application of a preemergence herbicide. This type of herbicide interferes with seed germination. It will not control existing weeds — this is why control of perennial weeds before planting is so important. Preemergence herbicides are typically highly water-insoluble materials, yet they must penetrate the top 1/4 to 1/2 inch of the soil to be effective. Hence, rainfall after application is important. Because these materials are effective only on a thin top layer of soil, they should be applied after all vineyard tasks that will disturb the soil surface have been completed. This includes hand fertilization of vines and installation of trellis. If a grower waits too long to apply a preemergence herbicide after planting, germination of weeds already may have begun or a late spring drought may occur. Either of these may result in poor performance of the material. Therefore, it is desirable to plant vines as early in the spring as possible and then perform hilling, fertilizing, trellis installation (if one elects to do so) and weed spraying in rapid succession. If trellis installation is deferred, a well managed operation can perform these other tasks in a 2-day period.

Several preemergence herbicides for use on newly planted grapevines have been evaluated at the Southwest Michigan Research and Extension Center and are discussed below. Reference to products mentioned does not imply an endorsement by Michigan State University or bias against those not mentioned. The legal registration of products mentioned in this publication is subject to change. Growers should always check with the local Extension office on the current registration status of herbicides before using them. A complete listing of preemergence herbicides available for use on vineyards can be found in the publication "Fruit Spraying Calendar," Michigan State University Extension bulletin E-154.

Snapshot (oryzalin/isoxaben combination): This material is a combination of the herbicides Surflan and Gallery. It is highly effective against a broad spectrum of weed species. In our trials, the lowest registered rate of 3.75 pounds per acre sprayed was inferior to the full rate of 5.0 pounds per acre sprayed. Therefore, use this product at its full rate. Snapshot provided the best herbicide control of weeds around newly planted vines in our trials.

Surflan (oryzalin): This product is highly effective against many grass and broadleaf weed species but only partially effective against certain other broadleaf weed species, including ragweed and wild carrot. Therefore, it should be used at its full rate of 6 quarts per acre sprayed and weed development should be carefully monitored. A supplemental weed spray, as discussed below, is likely to be required.

Prowl (pendimethalin): This material is effective for many grass and broadleaf weed species at a rate of 4.0 quarts per acre sprayed but is totally ineffective against common ragweed. Therefore, it must be used in combination with the supplemental spray program discussed below.

The cost of weed control strategies in new vineyard plantings varies considerably, with manual weeding generally being the most costly (Table 2).

Table 2. Estimated cost of material, labor and equipment for four weed control treatments in new vineyard plantings.

Treatment description	Materials: Unit price($)	Materials: Rate/acre sprayed	Materials: Rate/acre of vineyard[1]	Materials: Cost/acre of vineyard[1] ($)	Labor[2]: Hours/acre	Labor[2]: Cost/acre($)	Equipment[3] ($)	Total cost/acre of vineyard ($)
Manual weeding	—	—	—	—	30.0	180	—	180
Snapshot	41/lb	5 lb	2.2 lb	91.11	0.5	5	10	106
Surflan	90/gal	6 qt	2.67 qt	60.08	0.5	5	10	75
Prowl & Gramoxone Extra	32/gal 49/gal	1 gal 3 pt	0.44 gal 1.3 pt	14.08 7.96	0.5 2.0	5 20	10 2	59

[1]Assuming 4-foot spray band and 9-foot vineyard row widths.
[2]Manual labor valued at $6/hour and labor to operate equipment valued at $10/hour, including benefits.
[3]Tractor and sprayer valued at $20/hour; backpack sprayer valued at $1/hour.

Weed control planning should begin weeks or even months before planting so appropriate materials and equipment can be readied for a timely application of the chosen strategy. Adequate resources should be committed to this aspect of vineyard establishment in preference to fertilization, irrigation or early establishment of the trellis.

Supplemental Weed Control

Even with good planning and application of any preemergence herbicide, a few weed seedlings often escape control in the treated area around vines. When weed seedlings in the herbicide-treated area around grapevines are freed from competition with other plant growth, they grow rapidly. For example, a common ragweed plant, which might develop normally to a height of 18 inches, can attain a height of 4 to 5 feet by midsummer when it escapes control in a herbicide band. Therefore, a relatively few escaped weed seedlings can compete significantly with the grapevines.

To control those escaped weed seedlings, mark the calendar for inspection of weed control around vines 30 days after planting. Gramoxone Extra herbicide may be applied at this time to newly planted vineyards. Grapevine shoots at 30 days after planting typically have just begun their growth and often will be 6 to 10 inches long. Therefore, it is quite feasible to spot-spray Gramoxone Extra around vines to control escaped weed seedlings without injuring vines (Fig. 18). A person with a backpack sprayer can treat several acres in a day. Gramoxone Extra is a highly toxic restricted-use pesticide. Follow all precautions listed on its label, including use of protective clothing, when using this product.

When a vineyard site has been well managed by eradicating perennial weed problems, applying an appropriate preemergence herbicide after planting and using a supplemental Gramoxone Extra spray as needed, a grower can expect good weed control in a new vineyard until sometime in August (Fig. 19). This situation often is acceptable because the majority of vine growth for the season will have occurred and the onset of weed competition will help slow the vines' growth so that shoots develop into mature canes.

Fig. 18. Grapevines 30 days after planting showing an occasional weed seedling that has escaped control in a 48-inch wide preemergence herbicide spray band. Spot herbicide spraying to eliminate those weeds is very helpful at this stage.

Fig. 19. This new vineyard has had good weed control around vines, which is just beginning to deteriorate in late August. This weed growth will help to slow vine growth and develop maximum winter hardiness.

Fertilizing

A soil test taken during site preparation may indicate a need for potassium fertilization. If so, applying potassium fertilizer in a band along the vine rows immediately after planting will be more efficient than broadcasting the fertilizer before planting.

Newly planted grapevines almost always respond to nitrogen fertilization. An application of 30 pounds of actual nitrogen per acre is generally recommended for most plantings. This is equivalent to approximately 2 ounces of ammonium nitrate or 6 ounces of a blended fertilizer such as 10-10-10 per vine on typical vine and row spacings. Apply this fertilizer by ringing it around each grapevine in a radius of approximately 1 foot after any hilling operation and before the application of any herbicides. Some growers have obtained impressive early growth of vines by applying as much as twice this amount with 50 pounds actual nitrogen being broadcast at planting and a supplemental banded application of 10 to 15 pounds of actual nitrogen being applied in early July.

Irrigating

Few Michigan vineyards are irrigated. Watering new vines in any manner is not essential for the establishment of a vineyard in Michigan. Research at the Southwest Michigan Research and Extension Center, however, suggests that when newly planted vineyards have been well managed for weed control and nitrogen fertilization, irrigation may further enhance vine development (Fig. 14). If a grower intends to install an irrigation system in a Michigan vineyard, it should be in place at planting because the first 2 years of the vineyard's life are likely to be the most cost-effective time to use it.

Growers occasionally make efforts to water newly planted grapevines. Water has been carried to the field in spray tanks, by a series of hoses or by other creative means. The impact of these efforts is questionable. To be effective, irrigation of young vines should penetrate a minimum of 6 to 10 inches into the ground. A quick application of a few gallons of water per grapevine will result in most of the water either running off or evaporating and not being utilized by the vine. If a temporary irrigation system is considered for a new vineyard planting, then disposable trickle irrigation tape, which can cost as little as 2 cents per foot, should be considered. A relatively low-cost manifold that includes a pressure regulator and a filter can be used with this low-cost trickle tape. Such a system can apply enough water over a period of several hours to percolate into the vines' root zones and be effective. The publication "Components of a Temporary Trickle Irrigation System for New Vineyards" (Zabadal, 1997a) is available to guide growers.

Trellis/Staking

The benefits of supporting grapevines in their first growing season include better pesticide spray coverage, reduced risk of disease and vines that are kept out of vineyard traffic. Therefore, when growers find it economically and logistically feasible, trellis posts and one or two wires should be installed immediately after planting (Fig. 20) (see section V, "Engineering a Modern Trellis").

Fig. 20. A new vineyard managed with the installation of a trellis immediately after planting. String was tied from a shootless spur on each vine to a wire installed on the top of the posts. Vines were then wound around this string as they grew. (Dongvillo Farm, St. Joseph, Mich.)

Fig. 21. This new vineyard was managed without installing trellis after planting. Posts and one or two wires will be installed during the winter between years 1 and 2. (Kerlikowske Farm, Berrien Springs, Mich.)

Nevertheless, many large commercial vineyard acreages are established successfully without the use of any vine-supporting structures in the first growing season (Fig. 21). When vines are managed this way, it often is desirable to reposition shoots out of the vineyard row middles and into the vine rows with a pitchfork or garden rake a few times during the growing season to prevent injury from vineyard traffic.

Growers occasionally place individual stakes next to grapevines for training in their first growing season. Though this procedure can be helpful the first year of vine management, these stakes often have little value in succeeding years. Therefore, the material and labor cost associated with such staking often would be better invested in constructing the permanent trellis. Appropriate vine tying techniques (Zabadal, 1997b) should be used to attach vines to the trellis.

Using Grow Tubes

The use of grow tubes at planting is a relatively new cultural practice. It is well documented that using grow tubes hastens shoot elongation. However, the long-term effects of such rapid shoot growth on winter hardiness and the stability of these tissues in cool-climate vineyards is uncertain. Root development to exploit the soil volume, increase vine size and increase the vine's capacity for fruiting should be the primary goal in the first 2 years of managing a vineyard. Research data indicate that when weeds around vines are controlled and vines are fertilized, unpruned newly planted vines develop more leaf area and roots than severely pruned vines. That strategy is incompatible with the use of grow tubes because a large number of shoots per vine can not be placed in these tubes. Nevertheless, grow tubes provide a sheltered, warm climate for increasing the rate of shoot growth as well as a physical barrier to protect vines from herbicide spray operations. The positive and negative attributes of grow tubes in cool-climate vineyards will be verified over the next 5 to 10 years. For the present, growers should consider them on a trial basis.

IV. Year 1 Vine Management

The primary goal of vine management in the first 2 years of a vineyard is to develop large, healthy vines with large root systems. It is possible, under ideal conditions, for vines to fill the trellis totally with a healthy, functional canopy by the end of their second growing season and to produce significant crops of quality fruit in the third year. To accomplish this goal, all the vineyard tasks in the first 2 years are aimed at reducing or eliminating stresses on the vines. These stresses include pests (weeds, diseases and insects), drought, nutritional deficiencies and cropping stress.

Adjusting the Number of Shoots Per Vine

A basic strategy for developing vine size is to promote the development of as much functional leaf area as possible. Traditional vine management of newly planted vines involves reducing shoot numbers to two to four per vine when shoot growth is 6 to 10 inches long, which is compatible with the contemporary use of grow tubes.

Research on newly planted vines of the 'Niagara' variety at the Southwest Michigan Research and Extension Center indicates that when vines were well managed with regard to weed control and nitrogen fertilization, those left unpruned after planting produced more leaf area and larger root systems than those that were adjusted to two shoots per vine.

Defruiting

It is often surprising to new grape growers that vines can produce fruit the year they are planted. However, producing a crop is detrimental to the development of young vines. Therefore, vines should be defruited at least their first 2 years of growth or until they have adequately filled the trellis. Growers can perform this task with shoot adjustment when shoots are approximately 10 inches long. Retain one cluster per vine when there is a need to check the trueness to variety of vines.

Controlling Pests

Keep the leaves of new vines healthy. Powdery mildew and downy mildew can attack the leaf area of young vines. Fungicide spray programs to prevent these diseases should be part of the first-year management of vines but need not be as rigorous as programs for mature vines with crops. Locally systemic fungicides to control these diseases, applied at spray intervals of 14 to 21 days, generally are adequate. Insect control in new vineyards is a matter of scouting weekly because both traditional grape and non-grape insect pests may attack new vines. Particularly check portions of vineyards that border hedgerows or woodlands. Consult with Extension personnel and refer to current grape pest spray guides to determine pesticide materials, rates and times of application appropriate to your situation.

Managing Shoot Growth

Trellises with one or two wires — one at the top of the vineyard posts and possibly another at 30 inches above ground level — provide a structure for supporting vines during the first 2 years of their growth (Fig. 20). One strategy for supporting shoot growth in a first-year vineyard involves tying twine to a shootless vine spur (Fig. 22), then looping the twine around the lower wire (if there is one) and then tying it to the

Fig. 22. A close-up view of the trunk of a vine at the end of its second growing season. Twine was tied to a shootless spur at the base of the vine and then to the top wire of the trellis. The new trunk was gently wound around this twine to keep it straight.

upper wire (Fig. 23). This provides a structure for attachment of upward-growing shoots. Large bales of twine and boxes of several thousand wire twist ties are common, low-cost commercial tying materials for grapevines. Walk the new vineyard periodically through the growing season to loosely tie shoot growth. Distribute growth over the trellis as much as possible.

If a trellis was not installed (Fig. 21), use a pitchfork or rake to move shoots out of the vineyard row middles before mowing, spraying, etc.

Managing Row Middles

Any growth of weeds or sod in the row middles of the newly planted vineyard is likely to reduce the growth of new vines. Therefore, this growth should be kept to a minimum, especially in the first half of the growing season. If the vineyard site will permit it, a light, trashy cultivation of the row middles works well. Other options include close mowing or arresting growth in the middle with herbicide sprays. The width

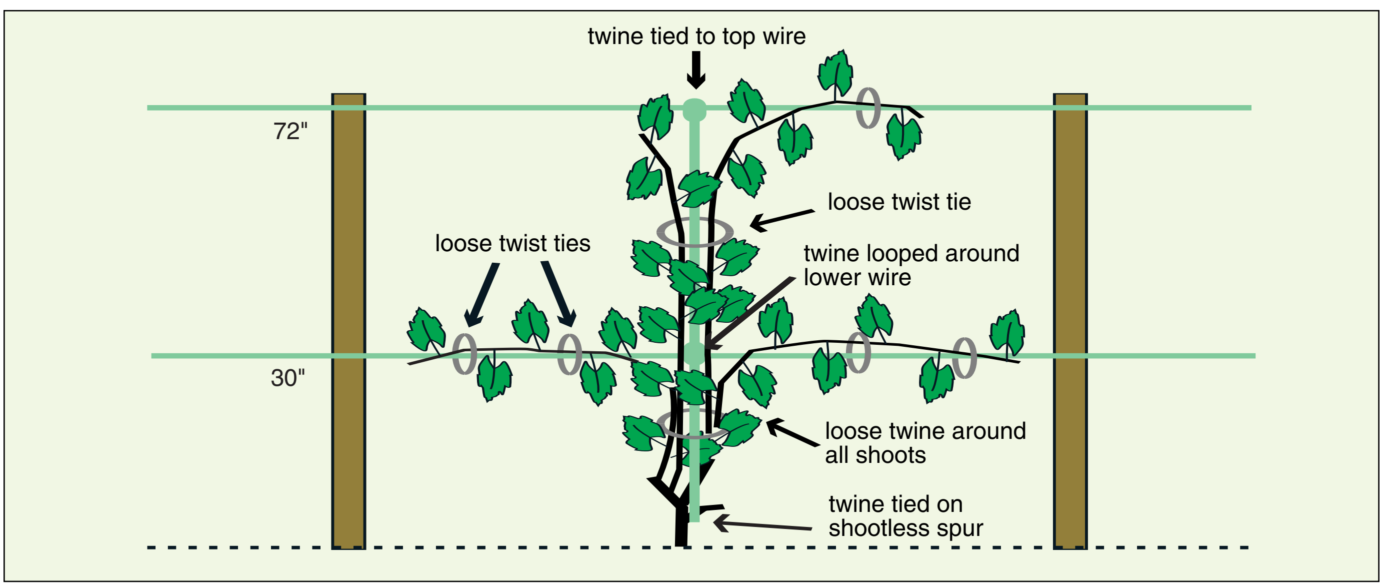

Fig. 23. A piece of twine tied vertically from a shootless spur to the trellis wire. Shoots are then tied loosely around this vertical twine support and the trellis wires with twist ties and other pieces of twine to distribute growth on the trellis.

of the row middle will depend on the width of the weed-free band established in the vine rows. The majority of vine growth should have occurred by early August. Then it is time to establish a cover in row middles to stabilize the vineyard floor against fall-winter erosion and to help slow vine growth so tissues will develop hardiness before winter. Allow weed growth to regrow (Fig. 22) or, if the row middles are cultivated, sow a cover crop in early August. Rye is a good choice if it can be sown precisely in the row middles (Fig. 24). If seed must be broadcast in a less precise manner, then oats are a good choice because they will not overwinter to become a weed problem under the trellis the following spring.

Fig. 24. A well managed vineyard after its first growing season. Rye has been sown in the row middles and trellis posts have been installed in the outer and middle rows. Posts will then be installed in the rest of the rows. (Humphrey Farm, Lakemont, N.Y.)

Controlling Weeds Around Vines

Good weed control should be maintained around newly planted vines until at least the end of July. If all the weed control steps discussed previously were properly applied, no additional effort will be required. Unfortunately, imperfect weed control around newly planted vines is all too common. Options for controlling weeds after vine growth has begun are few, and the task becomes considerably more difficult as the season progresses. Therefore, attend to such problems early in the growing season when they begin. Mechanical approaches such as gas-powered weed whips or cross-disking are not capable of weeding close to the vine. Therefore, hand hoeing and weeding around vines are the last resort. Spot spraying with Gramoxone Extra herbicide must be applied very carefully to avoid injuring young vines.

V. Engineering A Modern Trellis

Building a good vineyard trellis is very important, not only because it can be the single largest cash expense in the establishment of a vineyard but also because it can influence significantly the long-term productivity and profitability of a vineyard. Durability is important because the real cost of a vineyard trellis is determined by its years of service rather than initial cost. Considerable annual maintenance of trellises and frequent replacement of trellis components are inefficient and unnecessary with today's technology. A good trellis promotes good canopy management with well exposed leaves and, when desired, well exposed fruit. It facilitates efficient performance of vineyard tasks. The trend toward increased mechanization of vineyard tasks requires precise vine structures, which begin with a proper vineyard trellis. Crooked vineyard rows, sagging trellis wires and bowed vine trunks jeopardize the precise management of vines.

When a trellis is installed in stages for reasons of labor management and/or cash flow, install posts and two wires either at planting or in the fall/spring between years 1 and 2, then install end post anchors and the full complement of trellis wires in the fall/spring between years 2 and 3.

Types of Posts

Selection of trellis post materials will be influenced by the types of posts available, post installation equipment available, choice of a vine training system, cost and personal preference.

Metal Posts

Metal vineyard trellis posts are an attractive option because they are relatively easy to handle and install. Their cost can also be competitive with that of wooden posts. Metal posts specifically fabricated for trellises are in use in some viticultural regions. Those in use in Midwestern vineyards, however, are typically generic fence-type posts. Many types of metal posts have questionable lateral strength. Metal posts have been known to bend when supporting large crops in windy locations, and they may be difficult to use with complex trellis designs. Relatively new specialized metal posts for vineyards may overcome these limitations. However, their durability under Midwestern conditions is unknown. Growers occasionally have installed metal posts in predominantly wooden post vineyards to serve as grounding rods against lightning strikes on vineyard rows. The worth of that strategy is undocumented.

Wooden Posts from Native Tree Species

Vineyard trellis construction a half-century ago was dominated by the use of posts cut from native tree species. These posts occasionally were subjected to on-farm preservative treatments but often were untreated. Because most native tree species are not rot-resistant, random selection of trellis posts from woodlots is likely to result in a high percentage of post failure in 10 years or fewer, with some posts failing in as few as 4 years. The annual cost of a post is its cash cost plus the labor required to install it divided by its years of service. Inexpensive posts with a short life are costly per year of service.

Black locust is the woodlot tree species most frequently used for vineyard trellis posts. Split posts from large black locust trees or slow-growing small trees that contain a very high percentage of heartwood typically provide more than 20 years of service. They have even been documented to be in service more than 50 years! In contrast, locust posts from a suckering second growth that has a very small proportion of heartwood may fail in fewer than 10 years. The sapwood of black locust is very yellow. Some veteran grape growers refer to black locust posts with considerable sapwood as "yellow locust posts." Black locust posts become very hard when they are fully seasoned, so some growers install staples to hold wires on them before that happens.

White cedar is another native tree species that is still used for vineyard trellis posts (Fig. 20). When these posts have 80 percent or more of their cross-sectional area composed of heartwood, they have a life expectancy of 20 years or more. However, white cedar posts with relatively little heartwood, such as those typical from a so-called second-growth woodlot, may fail in as few as 5 years, which is why the reputation of white cedar posts is so variable. On-farm preservative treatments of white cedar were fairly common many years ago. Reference materials from the U.S. Department of Agriculture and other sources provide recipes for this activity, which rarely is practiced today.

Pressure-treated Wooden Posts

Wooden posts that have been commercially pressure-treated with a preservative are the predominant type of trellis post used in Midwestern vineyards today (Fig. 24). Red pine or southern yellow pine is commonly used. Although these posts would fail in 4 to 5 years if they were not preservative treated, with proper treatment they have a 20- to 30-year life expectancy. Characteristics that will influence post life expectancy include the diameter of the post, the type of preservative used, the amount of preservative used per unit volume of wood and the vineyard site. Pressure-treated wooden posts are sold in sizes according to the minimum diameter at the smaller end of the post. The cost of a pressure-treated post increases rapidly as its minimum diameter increases (Table 3). Therefore, important information is presented below to address the question "What minimum diameter is adequate for a trellis post?"

Post Strength and Durability

The strength of a post is proportional to its cross-sectional area. For example, posts 2 and 3 inches in diameter have cross-sectional areas that are only 39 and 56 percent and lateral strengths that are only 25 and 42 percent of those of a 4-inch post, respectively (Table 3).

Post life expectancy is also influenced greatly by diameter. The rate of leaching and weathering of preservative from a post is related to its surface area. As post diameter decreases, the ratio of surface area to volume decreases, a higher percentage of preservative leaks from the wood each year and the rate of post decay increases.

The cost of posts often is related directly to their cross-sectional area (Table 3). Because a post with a 3.5-inch minimum diameter often will be guaranteed for 30 years of service, many growers elect to use this size for line posts.

Four-inch-diameter posts with lateral breaking forces of 970 pounds (Table 3) will be adequate for end posts when they are new and if they are anchored so that tension on load-bearing wires is transferred to the anchor. However, as 4-inch posts decay or if anchoring is inadequate, or both, lateral forces in excess of 970 pounds are likely to cause post failure. Therefore, growers often choose posts with diameters larger than 4 inches for end posts. For example, posts with a 5- or 6-inch diameter will have lateral breaking strengths that are twice or more than three times that of a 4-inch-diameter post, respectively (Table 3).

Table 3. The cross-sectional area, lateral breaking force and percentages of those values compared with a 4-inch-diameter post for pressure-treated pine posts in six diameter classes.

Post	Cost		Cross-sectional area		Lateral breaking force[1]	
diameter (inches)	Per post[2] ($)	Percentage of 4-inch post	Square inches	Percentage of 4-inch post	Pounds	Percentage of 4-inch post
2.5	—	—	4.91	39	238	25
3.0	2.22	59	7.07	56	408	42
3.5	2.87	76	9.62	77	—	—
4.0	3.75	100	12.57	100	970	100
5.0	5.22	139	19.64	156	1,893	195
6.0	—	—	28.27	225	3,268	337

[1] Average pressure applied 4 feet above ground to cause the post to fail. Adapted from "How to Build Trellises with USS Max-Ten 200 High-Tensile Fence Wire", United States Steel Catalog T-111575.
[2] Wholesale price of chromated copper arsenate-treated red pine posts as of April 1996.

The two most common chemical preservatives currently used for pressure treating pine posts are pentachlorophenol (PCP) and chromated copper arsenate (CCA). PCP posts are impregnated with a petroleum base; CCA-treated posts are impregnated with an aqueous solution. The American Wood Preservers Association establishes standards for the minimum amounts of these materials that should be impregnated into wood to ensure long-term resistance to decay. For both PCP and CCA, the standard for vineyard posts is 0.4 pounds of material per cubic foot of wood. Certificates of treatment, service life guarantees or both may be associated with pressure-treated post products. Growers should work with their suppliers to obtain these assurances for this costly part of vineyard establishment. If there is a doubt about the extent of preservation treatment when purchasing large quantities of pressure-treated posts, it is possible to have a post sample analyzed by a private laboratory.

Large knots are a major defect in pressure-treated pine posts. They can cause posts to break during installation or before the end of their projected life expectancy.

Quantities of Posts Required per Acre of Vineyard

How many posts are required per acre of vineyard depends on the row spacing, the distance between posts and the number of rows required to plant an acre of vineyard. The force of gravity causes wires and vines to sag in the middle of a post space. The distance between posts depends on a grower's tolerance for sagging, which can be reduced but not eliminated by increasing tension on trellis wires. Increasing tension on the trellis wires beyond a certain point (see section V, "Installing Wires") will not further reduce sagging and will lead to excessive tension on wires. Therefore, control of sagging is influenced greatly by the distance between line posts in a vineyard, which should ideally not exceed 21 feet and never exceed 24 feet. Table 4 presents values for the number of vines per acre, vines per post space, post spacing and posts per acre for several row and vine spacing combinations. Depending on the choice of row spacing, vine spacing and vines per post space, the number of posts required per acre of vineyard ranges from 196 to 356.

Table 4. Ground area per vine, vines per acre, vines per post space, post spacing and posts per acre for several row and vine spacing combinations.

Row x vine spacing (ft)	Ground area per vine (square feet)	Vines per acre	Vines per post space	Post spacing (ft)	Posts[1] per acre
10 x 8	80	544	3	24	196
10 x 8	80	544	2	16	287
10 x 7	70	622	3	21	222
10 x 6	60	726	4	24	197
10 x 6	60	726	3	18	257
9 x 8	72	605	3	24	217
9 x 7	63	691	3	21	245
9 x 6	54	807	4	24	217
9 x 6	54	807	3	18	284
9 x 5	45	968	4	20	257
8.5 x 8	68	641	3	24	229
8.5 x 8	68	641	2	16	335
8.5 x 7	59.5	732	3	21	259
8.5 x 6	51	854	4	24	229
8.5 x 6	51	854	3	18	300
8 x 8	64	681	3	24	242
8 x 8	64	681	2	16	356
8 x 7	56	778	3	21	274
8 x 6	48	908	4	24	242
8 x 6	48	908	3	18	318
8 x 5	40	1089	4	20	287

[1] Values assume 15 continuous rows per acre of vineyard.

Installing Line Posts

Posts installed within the vineyard rows are called line posts. A typical 8-foot line post is set 24 to 30 inches into the ground so that the top of the post is 66 to 72 inches above the vineyard floor. A measuring stick can be used to guide uniform height installation of posts. Installation of these posts is best accomplished when there is good but not excessive soil moisture. Posts should be installed with their larger diameter end down in the soil because this portion of the post will decay more rapidly than the aboveground portion and ultimately cause the post to fail at ground level. Vineyard posts are sharpened at their bottom end in some viticultural areas, either prior to purchase or on the farm. This is especially useful when pounding posts into heavy soils, either with a hydraulic post pounder or with a post maul. In contrast, vineyard posts are rarely sharpened when they are installed in Michigan's light sandy soils. Hydraulic pounding of posts (Fig. 25) is advantageous because it is relatively rapid (several times faster than augering). The posts can be set to a precise desired depth and they are immediately firm in the ground. Augering of postholes is also common and requires less expensive equipment than post pounding. Light soil tends to backfill around and firm up posts installed in augered holes relatively quickly, but posts on heavier soils can remain loose for long periods. Bucket loaders and other hydraulic equipment have also been used to push posts into the ground.

Fig. 25. Vineyard trellis posts are often installed with a hydraulic post pounder like the one shown here. (Stamp Farm, Rock Stream, N.Y.)

Fig. 26. This post maul has a head with a 3.5-inch diameter. It is used for installing or replacing a small number of posts.

A hand-held posthole digger is the common method of installing posts in small backyard plantings. Another easy method for installing a small number of posts or replacing posts uses a pinch bar and post maul (Fig. 26). Begin with the pinch bar to punch a hole and then use it to "auger" the hole deeper and wider with a circular motion. Put the post in this hole and finish the job with a post maul. A post maul is a specialized sledgehammer with a head face about 3.5 inches in diameter (Fig. 26). When using this venerable tool, stand on a platform such as the trailer that carried the posts into the vineyard.

Installing End Posts

All material preparation and trellis engineering skills will be for naught if the end posts are not installed well. End posts function differently than line posts because they are subjected to a lateral breaking force. Tension that develops in the load-bearing trellis wires is transferred to the end post. An end post that is not anchored or braced will react to this tension by creating a fulcrum at the soil line. Failure to resist this tension may result in curvature of the post or its being pulled through the soil (Fig. 27). End posts that are strong enough and set deep enough into the soil can resist this tension and perform well without additional engineering. For example, large-diameter poles or railroad ties set 4 feet or more into the ground function in this manner. More commonly, however, an end post is chosen for adequate breaking strength when used in combination with an end post anchoring or bracing system. An increase in diameter of 1 inch approximately doubles a post's lateral breaking strength (Table 3). Four-inch-diameter posts should be considered a minimum requirement for an end post, and 5- to 6-inch-diameter end posts are an excellent choice when used in conjunction with a well engineered anchoring system.

Fig. 27. The end posts in this vineyard were not adequately anchored. They have moved after installation to become this random arrangement.

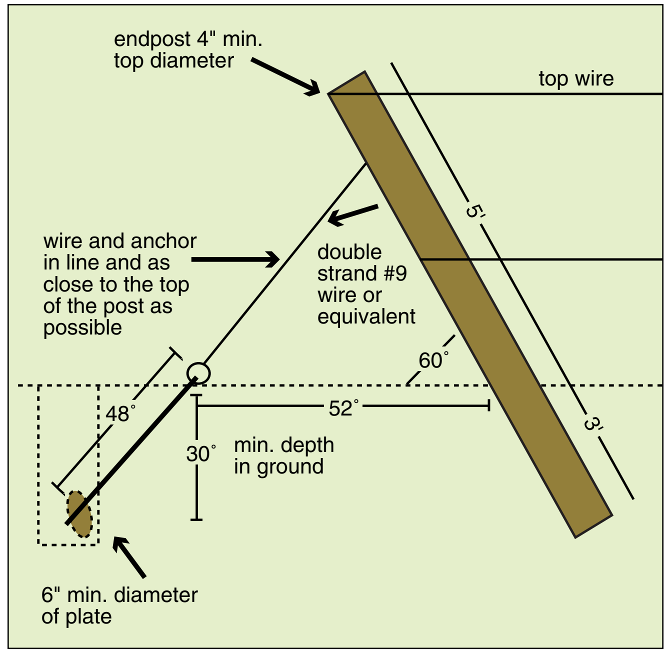

Fig. 28. Characteristics of an end post anchoring system that uses an external anchor.

End posts that will be anchored should be installed at an angle to a depth of 3 feet (Fig. 28), either by augering or post pounding. To ensure that end posts will line up properly, first install the end posts on the outside rows. Then lightly tension two wires between these posts, one at their tops and one at the soil line. These wires guide the installation and angling of end posts for the interior rows. When installing end posts in a large number of rows, first install end posts at 15-row intervals to provide guides for installation on the other rows. Angling end posts 60 degrees from horizontal (Figs. 28 & 29) will transfer tension from load-bearing wires to the anchor at a wider angle than setting posts upright. The more vertical an end post and the closer anchors are placed to the end post, the greater the tendency for the tension on trellis wires to pull the end post inward.

There are several good methods for anchoring end posts. Bracing end posts within the row (Fig. 30) 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.

Fig. 29. This end post was set with a 30-degree angle from vertical. Reinforcement rod connects the post to the anchor and an L-shaped crank is being used to tighten the one wire attached to this post.

Fig. 30. Bracing an end post. This avoids conflict between equipment and external anchors in headlands but is more difficult and costly to install.

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 facilitates transfer of 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 (Fig. 28). 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 verti-

cally. 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 of the anchor is placed in this slit and the plate of the anchor sits firmly against undisturbed soil on the side wall of the augered hole (Fig. 28).

- Use a double-stranded #9 wire or the equivalent for the anchoring wire to ensure that it will not be the weakest point in the assembly. Reinforcement rod (1/2-inch diameter) also has been used very effectively to attach anchors to end posts. A loop is bent and welded in the shop at one end of a 7-foot piece of rod, slid over the post and then held with a staple. The other end is bent with a torch through and around the loop in the anchor (Fig. 29).

End post anchoring systems should be in place no later than the start of the third growing season. Final tensioning of trellis wires is done after anchoring is completed.

Wire Characteristics of Importance for Use in Vineyard Trellises

The purchase of wire for vineyard trellises has often focused on two characteristics of wire: gauge and corrosion resistance. Growers intuitively know that the gauge of a wire determines its ability to support a load. Because most wire used for vineyard trellises is made of steel, it is also readily apparent that galvanized wire is desirable to resist rusting.

Improved materials and technology make it possible to install vineyard trellis wires that are no more expensive than traditional materials but that improve vine management, reduce trellis maintenance costs and lengthen the life expectancy of the vineyard trellis. The following information will assist growers in properly choosing and installing trellis wires.

The tensile strength of a wire, a measure of how much pulling (tension) is required to break it, is determined by the alloy mixture used to make the wire.

Traditional vineyard wire for many decades has been relatively soft, so-called low-carbon wire. Today vineyard trellises are increasingly being constructed with stiffer, harder, high-tensile (high-carbon) wire. Tensile strength is reported as the pounds of tension that would be required to break a wire if it had a cross-sectional area of 1 square inch. Traditional soft vineyard wire typically has a tensile strength rating of about 77,000 pounds per square inch (psi), whereas high-tensile wire has a tensile strength of about 200,000 psi. The ability of a wire to resist breaking is directly proportional to its cross-sectional area. Therefore, the breaking point of a particular gauge of wire is determined by its tensile strength multiplied by the cross- sectional area of the wire. For example, a low-carbon, 9-gauge wire with a tensile strength of 77,000 psi and a cross-sectional area of 0.0172 square inches has a breaking point of 77,000 x 0.0172 = 1,324 pounds. Growers often buy large-diameter (lower gauge number) wires to obtain high breaking-point values for the major load-bearing wires of the trellis.

Wire, however, does not simply resist all tension until it reaches its breaking point. Rather, as tension is put on a wire, it begins to stretch. If a small amount of tension is put on a wire, it will return to its original length when the tension is released. As tension on a wire is increased, stretching continues and eventually a portion of that stretching becomes irreversible. When that happens, the wire has reached its yield point, which occurs at 65 to 85 percent of the tension required to break the wire. The importance of the yield point for trellis wire has been recognized only in recent years. Relatively modest lengthening of trellis wires causes them to sag considerably between trellis posts so that vines sag. When vine trunks bow, it is more difficult to move equipment through the vineyard, prune mechanically, hill and remove soil around vines, and perform other tasks. Trellis maintenance is increased because wires that have stretched need retensioning. Vines with cordon training systems may be so embedded into wires that retensioning may not be possible. Stretching of the wire reduces the cross-sectional area of a portion of the wire slightly, and this lowers its yield and breaking points. Therefore, more irreversible wire stretching will occur at a lower tension, which leads to repeated cycles of wire stretching and eventual wire breakage.

If a wire never reaches its yield point, none of the above problems will occur. Therefore, trellis wires should be installed with consideration of their yield points, not their breaking points. A grower can avoid reaching the yield point with low-carbon, soft wires by increasing the diameter of the wire, but purchasing a large-diameter, soft wire to obtain a higher yielding point wire is not cost effective. High-tensile wires have yield points that are approximately double that of soft wires for the same diameter (gauge) of wire, and their cost per foot is about half that of a soft wire with a comparable yield point (Table 5). Therefore, a grower can use a higher gauge (thinner) high-tensile wire and have the same yield point to resist stretching as a smaller gauge (thicker), soft, low-carbon wire that costs more per foot. For example, a high-tensile 12.5-gauge wire and a soft 9-gauge wire have approximately the same yield points — 1,063 and 1,118 psi, respectively — but their costs per foot are 1.6 cents and 3.5 cents (Table 5).

Table 5. Characteristics and costs of several kinds of wire typically used to construct vineyard trellises.

Wire type	Wire gauge	Dia. (in.)	Cross-sectional area (sq.in.)	Tensile strength[1] (PSI)	Breaking point[2] (lb)	Yield strength[3] (PSI)	Yield point[4] (lb)	Feet/ lb	Cost/ lb[5]	Cost/ foot[5]
Low- carbon	12	.106	.0088	77,000	678	65,000	572	33.7	.60	1.8
Low- carbon	11	.121	.0115	77,000	886	65,000	747	26.3	.60	2.3
Low- carbon	10	.135	.0143	77,000	1,101	65,000	929	20.6	.60	2.9
Low- carbon[3]	9	.148	.0172	77,000	1,324	65,000	1,118	17.1	.60	3.5
High- tensile crimped	11	.121	.0115	210,000[2]	2,415	138,000	1,587	25.8	.65	2.5
High- tensile	10	.135	.0143	200,000[1]	2,860	138,000	1,973	20.6	.55	2.7
High- tensile	11	.121	.0115	200,000[1]	2,300	138,000	1,587	26.3	.55	2.1
High- tensile	12	.106	.0088	200,000[1]	1,760	138,000	1,214	33.7	.55	1.6
High- tensile	12.5	.099	.0077	200,000[2]	1,540	138,000	1,063	38.2	.60[6]	1.6
High- tensile	14.0	.080	.0050	200,000[2]	1,000	138,000	690	58.6	.93[6]	1.6
High- tensile	16.0	.062	.0030	180,000	540	124,200	373	119.6	1.70[6]	1.4

[1]Minimum tensile strength rating supplied by manufacturer.

[2]Breaking point = tensile strength ÷ cross-sectional area in inches.

[3]Values based on yield and tensile strength data from *Mechanical Engineering Design* by J.E. Shigley, 1963.

[4]Yield point = yield strength ÷ cross-sectional area in inches.

[5]Local supplier prices in southwest Michigan as of April 1996.

[6]Supplier price as of January 1997.

Most vineyard wires are made of steel. As they rust, their tensile strength is reduced. Small-diameter wires without corrosion protection can lose more than half of their tensile strength in fewer than five years. Therefore, corrosion resistance of trellis wire is very important to the grape grower. The highest quality zinc galvanization for wire corrosion resistance is a type 3 galvanization, which, according to the American Society of Testing Materials (ASTM Designation A116-57), specifies the ounces of zinc required per square foot of wire surface so that wires may resist the onset of rusting for up to 30 years. When using other types of wire, such as aluminum or plastic, growers should obtain assurances of their durability to resist corrosion and ultraviolet light degradation.

In summary, wire for vineyard trellises should be purchased on the basis of yield point, cost per foot and corrosion resistance rather than breaking point and cost per pound.

Amount of Wire Required

The number of wires required to construct a trellis will range from one to 10, depending on the choice of a vine training system. Trellis wires generally serve two functions. They are either load-bearing wires, which support most of the weight of the vines and crop, or so-called catch wires, which help orient the structure of the vine but do not support much weight. Load-bearing wires should be chosen with emphasis on their yield points. Catch wires have less demanding specifications and can be chosen on the basis of cost per foot of wire and durability.

When purchasing wire, it is often useful to know the number of feet of wire per pound (Table 6) and the quantity of wire required per acre of vineyard (Table 7).

Table 6. Feet of wire per 100 pounds for several gauges of wire used in trellis construction.

Wire gauge	Feet/100 lbs
9	1,724
10	2,070
11	2,617
12	3,300
12.5	3,846

Table 7. The length of trellis per acre and the pounds of wire for one wire per acre for combinations of five gauges of wire and seven vineyard row spacings.

Vineyard row spacing (ft)	Trellis length/ acre (ft)	Pounds of wire for one wire/acre				
		9	10	11	12	12.5
6	7,260	425	352	276	215	190
7	6,223	364	302	237	185	163
8	5,445	318	264	207	162	143
8.5	5,125	300	249	195	152	134
9	4,840	283	235	184	144	127
9.5	4,585	268	223	174	136	120
10	4,356	255	211	166	129	114

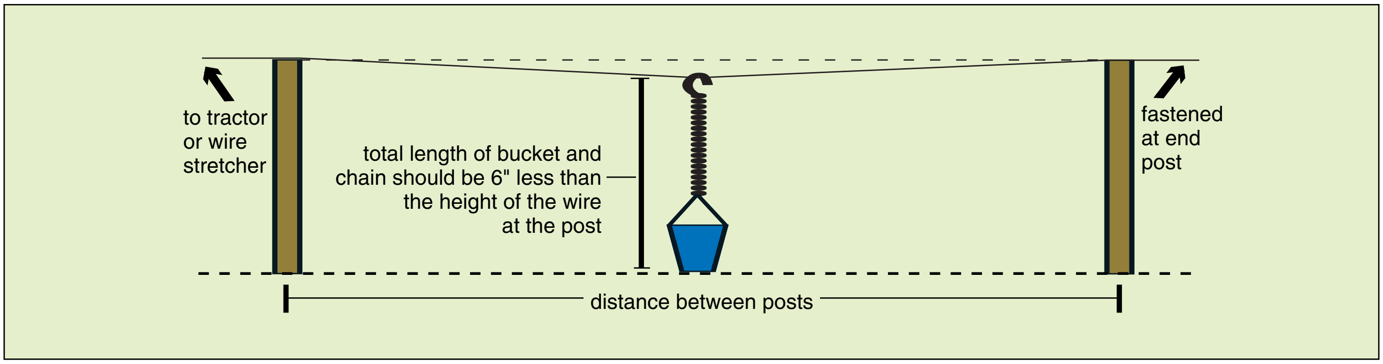

Fig. 31. A technique for tensioning wires to be used in conjunction with information in Table 8. (Figure reproduced courtesy of Washington State University Extension.)

Installing Wires

Trellis wires are properly tensioned to 270 to 300 pounds. It is quite common to overtension wires to put excessive strain on end posts and stretch wires irreversibly beyond their yield point. A simple, effective technique for proper tensioning of wires involves suspending a bucket containing the appropriate weight from the top wire (Fig. 31). A bucket and chain assembly that is 6 inches shorter than the height of the wire is hung on the wire in the middle of a post space. This chain, bucket and its contents need to be a specific weight in relation to the distance between posts and the desired wire tension (Table 8). As the wire is pulled, the desired tension will be achieved when the bucket is lifted off the ground.

Table 8. The total test weight, in pounds, of a chain, bucket and its contents that will indicate 270 or 300 psi tension on wire for three post spacings when used as indicated in Fig. 31.

Desired wire tension (lb)	Test weight (lb) for 6-inch sag for three post spacings (feet)		
	24	21	18
300	25.0	28.6	33.3
270	22.5	25.7	30.0

This technique for tensioning wires allows a grower to learn the appropriate amount of tension to place on wires so that he can then feel the 270 to 300 pounds of tension on a trellis wire.

It is difficult to properly tension wires on relatively short trellis rows because very little movement of end posts can result in considerable sagging of wires, even when good end post anchoring is installed. Consider two options for vineyard rows 150 feet long or less. The first is to use specially designed springs, which are placed in line with trellis wires to keep them tight year round (Fig. 32). The second possibility is to

Fig. 32. This spring absorbs changes in the trellis wire tension due to temperature fluctuations or crop load so that the wire never reaches its yield point.

Fig. 33. The groove in the top of this vineyard post provides excellent support of the trellis wire and still allows post pounding without damage to the wire.

release tension on wires each fall so they will not exceed their yield point when they contract during the winter, and then retension them in the spring.

Several tips can guide the proper installation of wires on trellis posts. U-shaped, galvanized or otherwise coated staples approximately 1½ inches long are used commonly for this vineyard task. They should be applied on the windward side of the posts for standard trellis wires. When paired catch wires are installed, staples also will be applied on the leeward side of the trellis. Staples should have a slightly downward orientation when nailed into the posts on level ground. Apply staples to posts in knoll and valley areas at a somewhat exaggerated downward or upward angle, respectively. Nail staples so they are not directly oriented with the grain of the wood in the posts, which often means slightly off vertical.

A variation for attaching a load-bearing wire at the top of a line post is to place it on top of the post rather than on the side. If periodic post pounding is anticipated to reset line posts moved by frost heaving, a groove ¾ inch deep can be made with a chain saw in the top of the line posts in line with the vineyard row (Fig. 33). Then place the wire in the groove and place a staple on top of the groove. This permits the post to be pounded without damage to the wire.

Regardless of which of the many ways you use to attach wires to end post assemblies, they should be installed with gentle bends. Abruptly bending or stretching a wire reduces its yield and breaking points and that point becomes the weakest link in the trellis assembly. The simplest method of attaching a wire to an end post is to wrap it around the end post once and then gently bend it around itself several times (Fig. 34). Some prefer to place the staples on each post on the end or back side, while others prefer to place a pair of staples on each side to help maintain the horizontal orientation of closely spaced wires. High-tensile wires may be difficult to attach to end post assemblies. Soft-metal crimps frequently are used in these situations (Fig. 35). Soft wires or small-diameter, high-tensile wires may be attached to end post assemblies with L-shaped cranks, which utilize a wire fed through a hole drilled through the end post (Fig. 29). The crank is made out of a 5/8-inch-diameter and 15-inch-long metal rod. Several excellent in-line tensioning devices are available and will work well as long as they do not cause abrupt bending of the wire.

Movable catch wires are used with some training systems. They are typically installed on upward-slanting nails (or downward-slanting nails in dip areas) on line posts. These wires may be lightly tensioned and permanently attached at the end posts. Some growers have used short (24-inch) lengths of chain on the ends

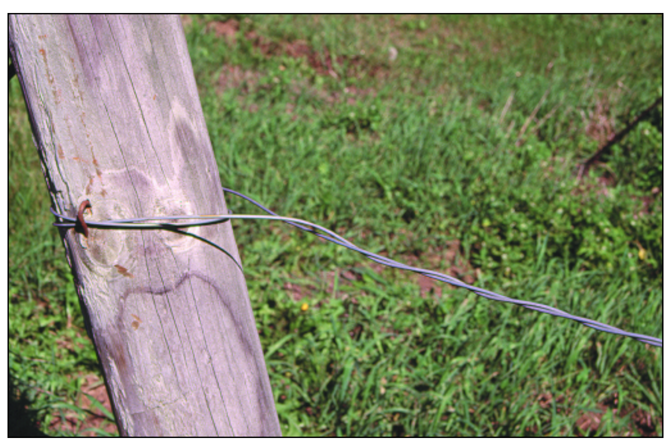

Fig. 34. Low-carbon trellis wire that has been attached to an end post by wrapping the wire around the post and then making a series of gentle bends back on the wire itself.

Fig. 35. A high-carbon trellis wire that has been attached to an end post by wrapping the wire around the post and then attaching the wire to itself with a soft-metal crimp.

of these wires, which are pulled tight and hooked over nails on the end posts to retension wires after they have been moved.

Tools and Gadgets for Installing Trellis Wires

Basic hand tools for installing vineyard trellis wires include fencing pliers for pulling misguided staples and cutting lengths of wire, a standard claw hammer and a ratcheting wire tightener (Fig. 36), which is preferable to a chain grab wire puller. A wire gripper (Klein Tools, Chicago, Ill., model #1613-30F) can be added to the ratchet tightener at one or both ends to hold even high-tensile wire quite well (Fig. 36). A wire reel, which can be purchased or fabricated in several designs, is essential for unwinding rolls of wire. Crimps (Fig. 35) and a crimping tool, a post maul (Fig. 26), a pinch bar and a carpenter's apron to hold staples are also useful.

Fig. 36. A ratcheting wire tightener. A wire gripper has been welded on one end to reliably hold high-tensile wire.

VI. Year 2 Vine Management

Early-season Weed Control

A second-year vineyard should be inspected in early spring for weed control in the vine rows. Before vine growth begins, there is a window of opportunity to control any weed growth around vines that has overwintered with green leaf area. Quackgrass is a common overwintering weed problem (Fig. 37). An application of the systemic herbicide glyphosate can be made over vines before they start to grow to control such weed problems. Because the target for this herbicide is mature leaf area, an application will be most effective if the weed leaf area is allowed to green up in the spring. However, the application must be made before vines start to grow. Therefore, optimum timing for this application can be determined by watching for the first sign of bud swell on vines. A moderate rate of glyphosate in a low volume of water (approximately 10 gallons per acre sprayed) often will be effective. Check the product label for application details.

Fig. 37. This vineyard was overrun with quackgrass at the start of its second growing season. Glyphosate herbicide applied before bud break killed this weed infestation except in the area to the left of the post, which was left unsprayed.

Growers who miss this opportunity will be left to rely on more difficult, more costly, less effective efforts to control these weed problems during the growing season.

Replanting

It often will be necessary to replant a small percentage of vines that either never grew or did not survive the winter, as well as those with extremely weak growth. Plans should be made to obtain the necessary vines. Replant as early as the ground can be worked in the spring and before applying preemergence herbicides.

Year 2 Vine Management

Year 2 vine management continues to focus on the development of vine size. If vine growth in year 1 was exceptionally good, then year 2 pruning may involve the first steps in establishing the permanent vine training system. Information on vine training systems is presented in other publications (Zabadal, 1996a, and Zabadal, 1996b). However, most vines in their second year can be pruned and trained in a standard manner that will permit the grower to select any vine training system in year 3. Retain one or two canes per vine with a maximum length extending to about 4 inches below the top wire of the trellis (Fig. 38). The goal in year 2 will be to approximately triple the number of shoots that grew well in year 1. A shoot will have grown well if it attained a minimum length of approximately 30 inches. A quick evaluation of the vineyard at the start of year 2 will indicate the average condition of vines. For example, if vines average four canes at least 30 inches long, then aim for about 12 shoots to be grown in year 2. Double or even multiple trunking of vines is often desirable in cool-climate vineyards. If growth was good in year 1, it may be possible to establish two trunks in year 2. If the vines are self-rooted, the goal is to have trunks arise independent of each other from the ground (Fig. 38a). If the vines are grafted, both trunks must originate just above the graft union area (Fig. 38b). It often will be possible to obtain enough shoot growth from just one long cane in year 2 so that other canes on grafted vines can be pruned to one- or two-node spurs to create a reservoir of growth near the graft union (Fig. 38c).

If the winter was severe, the variety being grown is relatively cold tender or both, check the nodes on vines before pruning to determine the extent of bud mortality. Compensate for bud mortality by pruning less severely. When winter injury is extensive, delay pruning until after shoot growth has begun.

Tying Grapevines

The second and third years of the vineyard are important formative years for the structure of vines. If the trellis is properly constructed and vines are properly pruned and tied to the trellis, vines with straight trunks will develop. The vineyard task of tying can proceed after pruning and trellis maintenance on days when it is warm enough to work with bare hands.

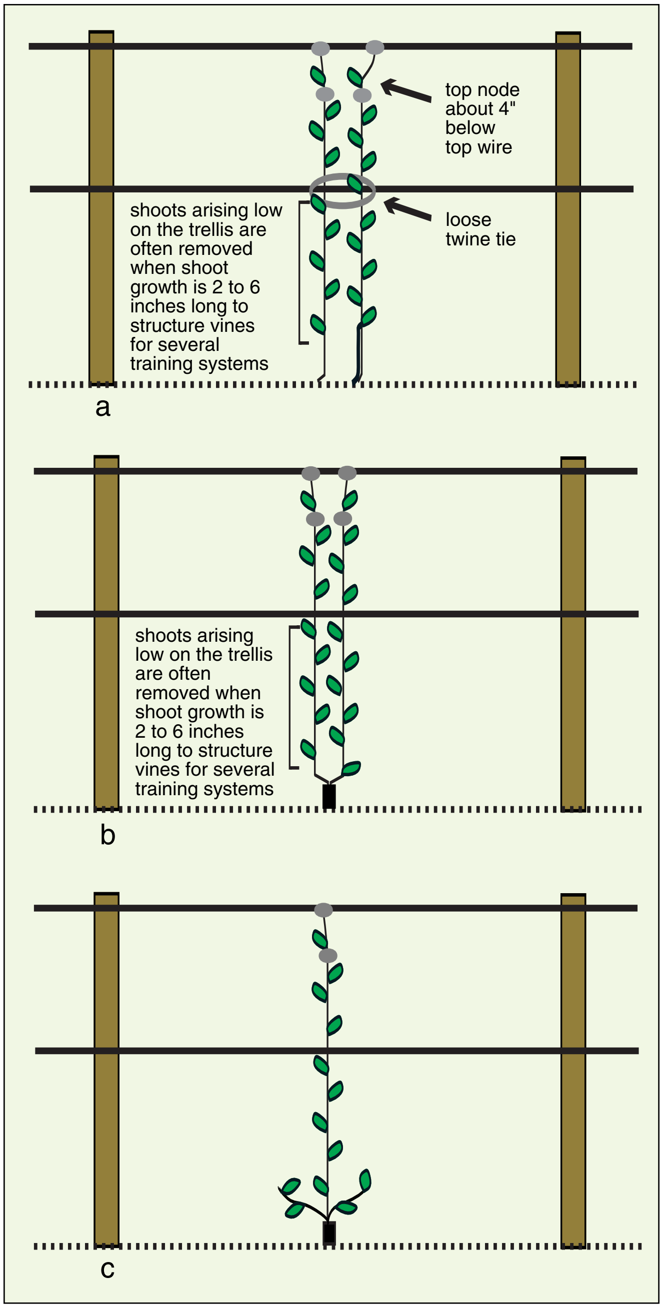

Fig. 38 (a) Two canes originating from the ground for self-rooted vines at the start of year 2; (b) the development of two canes from a single trunk when either two independent trunks from self-rooted vines directly from the ground are not available or when managing grafted grapevines; (c) use of a single cane plus spurs on a grafted vine.

Because early shoot growth is weakly attached to canes, tying should be completed before the start of vine growth. Otherwise, it may be preferable to delay this task until shoots have grown several inches and become less susceptible to detachment. Vines that become detached from the trellis during the growing season are very difficult and costly to reattach. Therefore, vines need to be tied well to the trellis to support heavy loads during the growing season. However, if ties are made too tight or in the wrong locations on the vine, girdling can destroy portions of the vine.

Hemp twine and twist ties are the most economical and widely used tying materials. Several types of plastic ties and tools for applying plastic tape are a matter of personal preference and may or may not be cost effective. Whatever the approach, proper tying of vines is very important in year 2 of the vineyard. The fundamental techniques for tying grapevines are presented in the Southwest Michigan Research and Extension Center Report "Tying Grapevines" (Zabadal, 1997b).

Preemergence Weed Control

The same options available for controlling annual weed growth in the newly planted vineyard are available for the second-year vineyard. When vines are three years old or older, other preemergence herbicides are registered for vineyard use. If preemergence herbicides are used, make applications as early as possible in the spring.

Fertilizing with Nitrogen

Most vineyards will exhibit a growth response to nitrogen fertilization. Application of 30 to 60 pounds of actual N is recommended in a second-year vineyard when shoots are 4 to 12 inches long. Band fertilizer along the vine rows or apply by hand in a ring around each vine 2 feet in diameter. Choose the specific type of nitrogen fertilizer on the basis of cost per pound of actual nitrogen. Ammonium nitrate is the most commonly used vineyard nitrogen fertilizer.

Adjusting Shoot Number per Vine, Suckering and Defruiting

If it is necessary to reduce the number of shoots per vine, perform this task when shoots are 6 to 10 inches long. The location of shoots to be retained will depend on the training system to be used. For example, if the chosen training system were the Hudson River Umbrella (top-wire cordon), retain shoots high on the trellis to develop a source of canes with which to establish the cordons (Fig. 39). Many training systems similarly utilize canes high on the trellis, so shoots in that part of the trellis often are retained in preference to those lower (Fig. 38b).

Suckers are shoots that arise from the base of the vines (sometimes also called water sprouts) or from the ground. Some sucker shoots should be retained because they mature into canes that may be used to renew trunks on the vine. However, grapevines can develop as many as 60 suckers per vine. Therefore, reduce suckers at the bases of new vines to two to four per vine. This can be done when the number of shoots is adjusted. Suckers can be loosely summer tied to facilitate their upward growth on the trellis so they are protected from equipment (Fig. 23).

Vines should be defruited in the second year, which is most easily accomplished when shoots are about 10 to 15 inches long and the small, visible clusters can easily be pinched off the vine.

Controlling Pests

The health of the vine must be maintained to promote its growth in year 2. Preventive fungicide sprays and insecticide sprays should be applied as needed to protect leaf area as in year 1.

Fig. 39. This 'Niagara' vine is at the end of its second growing season. Shoots were saved on the upper portion of the vine and allowed to cling along wires. Those shoots matured into canes that were used to establish a cordon along the top wire of the trellis.

Managing the Canopy

Rapidly elongating shoot growth on young grapevines may be highly susceptible to detachment, especially during high winds. It is often useful to attach these shoots to the trellis by a combination of light tying and tucking of shoots. Begin this activity when the shoots are 20 to 24 inches long or about the time of grape bloom — i.e., when shoots are long enough to be reoriented but tendrils have not yet attached themselves to the trellis. Make ties loose so they won't girdle expanding shoots and canes (Fig. 23).

Managing Row Middles

Competition for water and nutrients from weed/sod growth in the vineyard floor middles should be minimized, especially in the first half of the growing season. Row middle management options as previously discussed include cultivation, mowing, mulching and herbicide spraying. Begin in early to mid-August to slow vine growth by ceasing mowing (Fig. 21) or planting a cover crop in row middles that have been cultivated (Fig. 24).

VII. Year 3 Vine Management

Some aspects of vine management in year 3 of a vineyard will be similar to that in year 2. Inspect the vineyard in early spring to determine if over-wintering weed growth under the trellis warrants an early-season spray of glyphosate or if there is still a need to replace a few vines. Trellis construction, including end post anchoring, should have been completed by the start of year 3.

Vines at this stage of the vineyard can vary from being as small as those originally planted to being large enough to fill the entire trellis. Pruning, fertilization and crop adjustment of vines at this time should be based on the size of the vine, which is conveniently determined by its weight of cane prunings, not its age.

Training

Year 3 is often the time to initiate the permanent vine training system. The choice of a vine training system is a major decision in the life of the vineyard. Factors to consider when choosing a vine training system (Zabadal, 1996a) and training system options for cool-climate vineyards (Zabadal, 1996b) are presented in other publications.

Pruning

Vines should be managed in year 3 according to their size. The actual size of individual vines is not apparent after they have been pruned, so as a part of the pruning process in the third year of the vineyard, growers need to determine the average size of vines and employ a strategy to identify vines that are considerably smaller than the average.

To determine the average size of vines, identify sections of the vineyard according to their apparent uniformity of vine size. Prune and weigh the cane prunings of 10 vines in each section.

Vines are considered small, medium, large or extra large when they develop approximately 0.2 or less, 0.3, 0.4 or greater than 0.4 pounds of cane prunings per foot of trellis (per foot of canopy on three-dimensional trellises). For example, vines on a 6-foot vine spacing would be considered small, medium, large or extra large if they developed approximately 1.2 or less, 1.8, 2.4 or more than 2.4 pounds of cane prunings per vine, respectively.

The smaller the vine, the less it should be cropped. However, it is not possible to apply such management if differences in the sizes of vines are not identified in some way during pruning. One strategy is merely to prune small vines as severely as required to reduce the fruiting potential of the vine. If the vine is not much larger than it was when it was planted, prune it to three to four nodes. If the vine matured only four canes that were 30 inches or more in length, prune it back like a second-year vine — i.e., to a 12-node cane. That is the easiest approach.

With such severe pruning, however, winter injury could result in fewer shoots growing out than desired. Regardless of winter injury, severe pruning will limit leaf area development on vines that are already smaller than average. Therefore, a second strategy for small vines is to prune them with the same pruning severity as the other vines in the vineyard but mark them with flagging tape at the time of pruning. In its simplest application, all marked vines are completely defruited to promote their vegetative development. Two colors of tape may also be used to indicate partial or complete defruiting. In this way, small vines can be pruned to develop substantial leaf area without adding crop stress.

Controlling Weeds

Preemergence herbicides that were not legally available for the first 2 years of the vineyard may be registered for use in year 3. Growers should seek counsel from Extension and private consultants on options for preemergence weed control in vineyards 3 years old and older. Nevertheless, the strategy is the same as in previous years — i.e., apply preemergence weed control early in the spring so that the relatively water-insoluble herbicides may be fully activated in the surface of the soil early in the growing season.

Fertilizing with Nitrogen

Nitrogen fertilization in the third-year vineyard will be guided by soil type and the average vine size that has developed in the first 2 years of growth of the vines. Increase fertilizer rates on light soils that have low organic matter and, therefore, release less nitrogen to vines. If vines are already larger than 0.4 pounds of cane pruning per foot of trellis, do not apply nitrogen fertilizer. Large vines (approximately 0.4 pounds of cane prunings per foot of trellis) with good weed control under the trellis should be fertilized with approximately 30 to 60 pounds of actual N per acre. If vine size is less than 0.4 pounds of cane prunings per foot of row, apply 60 to 100 pounds of actual N per acre. A maximum application of 100 pounds of actual N per acre is recommended for all vineyards with a single-curtain trellis.

Controlling Pests

The pest control strategy in most third-year vineyards changes from that in years 1 and 2 because vines will be managed to produce some crop. Diseases such as black rot, *Phomopsis* cane and leaf spot, and *Botrytis* bunch rot, as well as insects such as grape berry moth, may now threaten the health of the fruit itself. Therefore, growers should apply a spray program that also includes control of these potential problems. Pesticide information for these sprays is presented in Michigan State University Extension bulletin E-154, "Fruit Spraying Calendar."

Controlling Crop

Overcropping is the greatest hazard to a vineyard in year 3. Several factors predispose vines to this stress. First, the establishment of a vine training system in year 3 often causes a grower to retain more live nodes with more total fruitfulness on the vine than is warranted. Second, vines in year 3 often have highly fruitful nodes that developed on non-fruiting, open-canopy vines in the previous year. Third, a vineyard in its third year presents the first opportunity for a grower to easily place more fruiting nodes on the trellis than are warranted. Fourth, a grower is often understandably eager to obtain income from a new vineyard. Therefore, even veteran growers too often retain too much crop on third-year vines. Such a large crop may not acceptably mature and, more importantly, vine size may decline rather than increase in year 3. Income derived from heavy cropping in year 3 can be offset in later years by costs required to regain vine size. For all these reasons, crop control is a major focus of good vine management in year 3 of the vineyard.

If large vine size has developed during the first 2 years of the vineyard, then cropping at 4 tons per acre or even more may be fully warranted. For example, it has been possible to crop the 'Niagara' variety at 7 tons per acre in year 3 without any harm to the vines. However, if the development of vine size is lagging going into year 3, then cropping at 1 or 2 tons per acre, or even no cropping, may be the appropriate management for year 3 of the vineyard.

Information on vine size that was obtained at the time of pruning can be used to determine the desired level of cropping for the vineyard in year 3. For juice grape varieties, vines that average 0.1, 0.2, 0.3, 0.4 or more than 0.4 pounds of cane prunings per foot of trellis should be managed to produce no crop, 1 to 2 tons, 3 to 4 tons, 5 to 6 tons or 6 or more tons per acre in year 3, respectively. For vines on a 7-foot spacing, those levels of cropping would correspond to vines with cane prunings that average 0.7, 1.4, 2.1, 2.8 or more than 2.8 pounds, respectively. For wine grape varieties, the upper limit on cropping will be highly influenced by the desired quality of the grapes as well as the average maturity date for the variety. For well developed wine grape vineyards, cropping in the third year is commonly in the range of 2 to 3 tons per acre.

Cluster weight information for a variety can be used to calculate the average number of clusters per vine to retain for a desired level of crop. For example, the 5-year average weight of clusters of the 'Niagara' variety at the Southwest Michigan Research and Extension Center (SWMREC) is 0.3 pounds. The 'Niagara' vineyard is planted on a 9-foot by 7-foot (row x vine) spacing and has 691 vines per acre. The number of clusters per vine required to produce a 1-ton-per-acre crop on this vineyard can be calculated as follows:

$$\text{Clusters per vine} = \frac{\text{pounds per ton}}{(\text{vines/acre}) \times (\text{pounds/cluster})}$$

$$= \frac{(2000)}{(691) \times (0.3)}$$

$$= 9.6 = 10 \text{ clusters per vine}$$

Therefore, in this example, to adjust the crop to 1, 2 or 4 tons per acre, one would retain approximately 10, 20 or 40 clusters per vine, respectively. Be mindful that cluster size is likely to be larger in the third-year vineyard than the long-term average for a variety. Therefore, the number of clusters per vine should not exceed calculations and possibly be somewhat lower. Average cluster weight will decline as more clusters are retained per vine. Therefore, in this example, retaining 60 clusters per vine may not result in a 6-ton-per-acre crop. This general approach to crop adjustment in year 3 will provide only a rough estimate for crop adjustment, but it is a workable method to avoid massive overcropping of vines.

Harvesting

Vines in year 3 are still undergoing vine size development. The crop on these vines should be harvested early enough to allow for a postharvest period with functional leaf area for maturing the vine itself. Leaving crop on the vine as late as possible may enhance fruit maturation but also reduces vine hardiness.

VIII. Summary

The extent to which information in this publication is successfully applied will highly influence whether a vineyard experiences exceptional full establishment in 2 years, is well managed with full establishment in 3 years or is poorly managed with full establishment in 4 years or longer, or perhaps never at all.

The preceding information is useful not only for establishing new vineyards but also for managing aspects of a mature vineyard, which often contains all stages of vine development. There may be blank vine spaces that need replanting or small vines that need to be managed like second- or third-year vines with total or partial crop removal, respectively.

The long-term productivity of a vineyard is best served if the vineyard is fully established before significant cropping begins. The information in this publication was assembled to help reduce the lag time between planting and full cropping of the vineyard, which so often creates severe cash flow problems for the grower.

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