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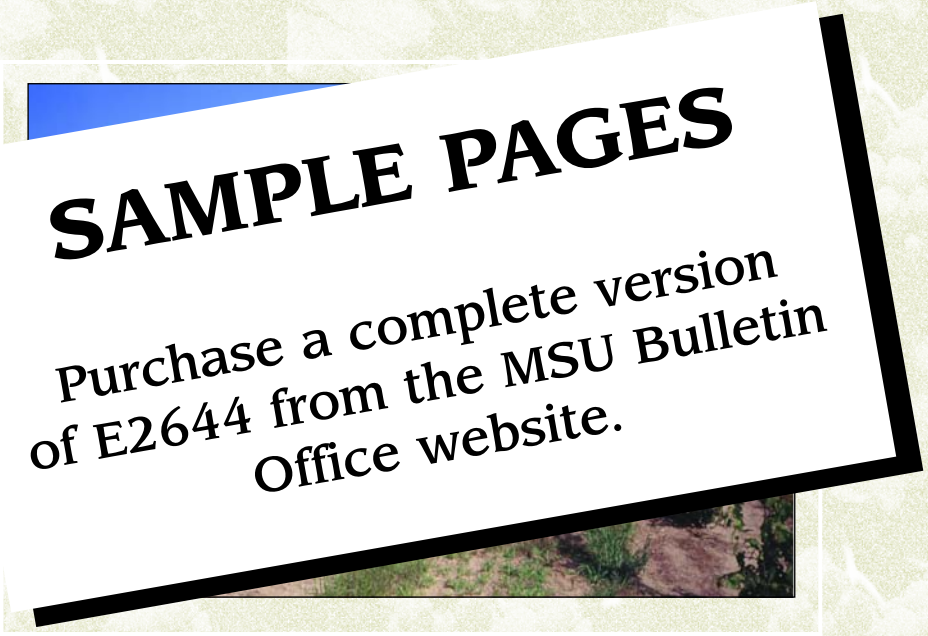
Vineyard Establishment I

Preplant Decisions



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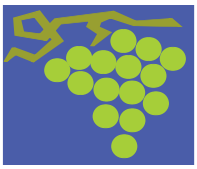
Cover Photo: A Cabernet franc vineyard in its second growing season near Benton Harbor, Michigan.



Acknowledgments

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Introduction

Grape production is increasing in many viticultural areas as consumer demand for wine, grape juice products and table grapes increases. Competition for grapes among processors and marketers is driving the planting of new vineyards. Presuming a reliable market for grapes has been identified, economics is the very first matter to be resolved when planting a new vineyard. Will a new vineyard be profitable? Several publications (Bordelon, 1997; Cross and Casteel, 1992; Kelsey *et al.*, 1989; Varden and Wolfe, 1994; Walker, 1995) can guide individuals in assessing the profitability of a vineyard. If the economics are favorable, then one can begin to establish a vineyard. This publication and its companion, Extension bulletin E-2645, "Vineyard Establishment II - Planting and Early Care of Vineyards," are intended to assist in that process.

1. Selecting a Vineyard Site

Grapevines are relatively easy to grow and can live a very long time. Some Michigan vineyards are more than a hundred years old. The commercial grower's goal, however, is not merely vine survival but production of quality grapes at a profit. The first and most crucial step to achieve that goal when planting a new vineyard is selecting a suitable site.

The climate of a vineyard often is discussed at three levels (Geiger, 1957). The *macroclimate* of a vineyard is the large-scale or regional climate, which is influenced by geographic location (latitude) and proximity to large, climate-moderating bodies of water. Proximity to the Great Lakes, especially Lake Michigan, results in an increase in cloudiness downwind, which in turn moderates daily temperatures — i.e., daily maximum temperatures in a lake-modified climate are lower and daily minima are generally higher. Therefore, the suitability of a given location for grape production in Michigan generally decreases as one moves inland. Because of the prevailing westerly winds, the area of lake-modified climate is much wider on the western side of the state near Lake Michigan than along Lake Huron and Lake Erie on the east side of the state.

The *mesoclimate* is the local climate of a specific vineyard site, which is influenced by the topographic factors of elevation, slope and aspect (direction of slope) as well as close proximity to temperature-moderating bodies of water.

The *microclimate* is the climate within and around the vines themselves. This influences important vineyard characteristics such as how well the leaves and fruit are exposed to sunlight, what temperatures the fruit experiences through the day, how long vines remain wet and susceptible to disease infection after a rain, etc.

When a vineyard site is chosen, attention is first given to its macroclimate and then to its mesoclimate. Growers should use the information presented here together with soil surveys, local weather data and local expertise to evaluate the macroclimate and mesoclimate characteristics of a particular vineyard site.

Winter Minimum Temperatures

The most important characteristic of a site for commercial grape production in a cool climate such as Michigan's is the extent and frequency of low winter temperatures. Grape varieties have a genetic limitation for tolerating low winter temperatures. They may be placed into hardiness categories (Table 1), which designate temperatures at which significant injury to vines begins. Very cold-tender varieties may experience significant winter injury at temperatures as high as 20 degrees F (Kissler, 1983) and are not suited for cool-climate locations such as Michigan. Therefore, this discussion focuses on the selection of sites for cold-tender or hardier varieties (Table 1) that do not sustain significant winter injury until -5 degrees F or lower.

Though vine tissues have a genetic limitation for tolerating low winter temperatures, the level of this tolerance is influenced by the rate of temperature drop, cultural practices influencing maturation of vine growth in the previous growing season, cropping history, time in the winter period, potassium nutrition and soil moisture conditions of the vineyard site. Moreover, portions of a vine vary in their hardiness. For example, fruiting buds may be extensively damaged by a low-temperature episode (Fig. 1) while cane and trunk tissues remain healthy. On the other hand, rapid drops in temperatures may injure trunk tissues

Table 1. The temperature at which significant winter injury to tissues begins for five grapevine hardiness categories.

Hardiness category	Temperature at which vine injury begins to occur (°F)
Very cold tender	≥ 0
Cold tender	- 5
Moderately hardy	-10
Hardy	-15
Very hardy	≤ -20

without significantly affecting bud tissues. Therefore, the nature and extent of winter injury are not entirely predictable for any given variety-site-weather combination.

For example, when vines of cold-tender varieties experience -5 degrees F, they may not die or even be unproductive the following growing season. Climatic conditions prior to a -5 degrees F episode may acclimate cold-tender vines so they experience little injury;

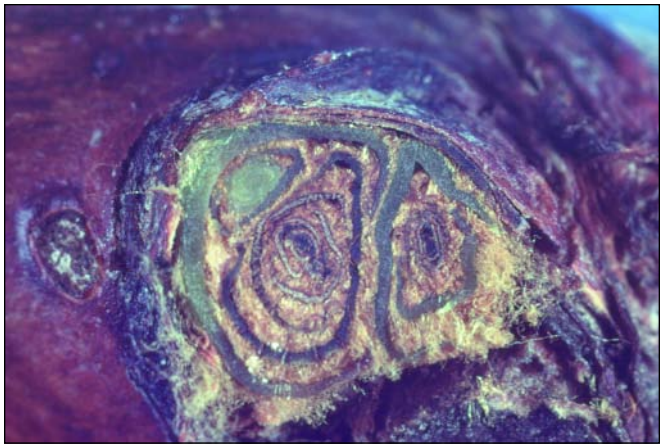

Fig. 1. A cross-section of a compound grape bud showing dead primary and secondary buds and a live tertiary bud.

cultural practices applied by a grower may also compensate for moderate levels of winter injury. Nevertheless, the risk of unmanageable injury to cold-tender varieties becomes greater as temperatures dip lower. Therefore, when vines of cold-tender varieties experience -15 to -20 degrees F, their productivity will often be low the following growing season. Vine survival itself may be jeopardized if the grower doesn't employ special cultural practices. For this reason, a knowledge of the frequency of temperatures of -5 degrees F and lower helps to define the potential of a site for grape production as well as its suitability for varieties within hardiness categories (Table 1).

Low winter temperatures may threaten vine survival itself, but most often the major concern is for the long-term reliability of production. Therefore, it is useful to ask, "How many years out of 10 can one expect highly productive vines with the anticipated levels of winter injury for a specific vineyard site/grape variety combination?" Winter minimum temperature-frequency data to address that question for several locations in Michigan (Fig. 2) are listed in Table 2 (see page 7).

Raw winter minimum temperature data for all areas of the United States may be obtained from the National Climatic Data Center in Asheville, N.C. (phone: 704-271-4800). The fee often will be modest, depending on the extent of the data requested. Extension personnel in other states may also be good sources of winter minimum temperatures like those presented in Table 2 for Michigan. Winter minimum-frequency data derived from raw temperature data represent the general climate, or so-called macroclimate, of a region and integrate large-scale climatological factors such as jet stream location and lake-enhanced cloudiness. Because extreme minimum temperatures usually are associated with clear, calm conditions, mesoclimatic features become important contributing factors in describing the low-temperature climate of a given site.

Jordan *et al.* (1981) classified vineyard sites based on the frequency of -5, -10 and -15 degrees F winter minimum temperatures and the long-term winter minimum temperature. If the criteria in that publication

those with at least moderately well drained soils that promote rooting to a depth of at least 36 inches. If a vineyard site is suitable except that the soil is imperfectly drained, it is possible to improve soil internal drainage with drain tiling (see section IV, "Preparing the Site", p. 18). However, such a remedial measure often will not substitute completely for soils with naturally good internal drainage.

If soil survey descriptions are encouraging for a specific site, then the grower should inspect the soil by digging with a soil probe, shovel, posthole digger or backhoe. Layers of soil impervious to rooting, high water tables and other soil deficiencies can then be diagnosed. For example, alternating reddish brown and gray areas of the soil, called mottling, indicate the soil is imperfectly or poorly drained. Michigan State University Extension bulletin E-326, "A Guide for Land Judging in Michigan" (D.L. Mokma *et al.*, 1982), explains the basic physical properties of soil.

The level of soil acidity is the most important aspect of soil chemistry in evaluating a vineyard site because several tons of lime per acre might be required to adjust soil acidity. This might contribute significantly to the cost of vineyard establishment (see "Soil Chemistry", p. 20).

II. Designing a Vineyard

When a site is considered suitable for a vineyard, a design or vineyard layout must be developed. Factors that influence vineyard design include the grape varieties to be grown; the characteristics of the vineyard site, including its dimensions, topography, variations in soil type and equipment access to the site; the type of equipment that will be used to operate the vineyard; the type of trellis that will be constructed; and matters of personal preference. The following topics require consideration.

Row Orientation

As the sun travels through a southern arc in the summer sky of the northern hemisphere, vineyard rows in a north/south orientation provide for the best sunlight interception by grapevine canopies. Therefore, when all other factors are equal, this vineyard row orientation is preferred. However, some situations justify an east/west row orientation, which also can be highly productive. These include planting on north- or south-facing slopes so that east/west-oriented rows run across the slope, thus controlling soil erosion, and planting efficient, long east/west-oriented rows rather than numerous, short north/south-oriented rows.

Row Length

Vineyard row length in most cool-climate vineyards is limited to about 1,000 feet because the tension developed along the entire length of the trellis must be transferred to an end post anchoring system. Shorter rows are often preferable because they provide easy access to vines for manual tasks, and undulating topography may dictate logical places to end rows. Row lengths from 300 to 600 feet are common in Michigan vineyards. Extremely short rows make it difficult to maintain tension on trellis wires. In such situations, springs in line with wires (Fig. 5) or wire-tightening devices that can readily tighten wires in the spring and release tension in the fall are helpful.

Fig. 5. This spring in a trellis wire absorbs changes in the tension of the wire due to temperature changes or crop load so that the wire itself does not exceed its yield point to become irreversibly stretched.

Row Spacing

Vineyard row width should have not less than a 1:1 ratio with the height of the trellis (Smart, 1985). Otherwise, the lower portion of the trellis will be shaded. Because vineyard trellises are typically 5.5 to 6 feet tall, it is theoretically possible to establish vineyard rows on these spacings. Most commercial vineyard equipment in the United States cannot operate between or over such narrow rows, however. Therefore, equipment width often dictates vineyard row width, which in Michigan vineyards ranges from 7 to 10 feet. Most new vineyards are being planted on 8-, 8.5- or 9-foot row spacings, with the narrower spacings made possible by relatively new vineyard tractors that are approximately 60 inches wide and have 70- to 75-horsepower ratings.

Vine Spacing

The appropriate distance between vines in the vineyard row is influenced by two opposing factors. Trellises full of functional grapevine leaves are the basis for a highly productive vineyard. Therefore, vines should be spaced close enough so their leaf canopies efficiently use the entire trellis. However, the closer vines are spaced, the greater the risk of excessive vine canopy development, fruit shading and reduced fruit quality. The ideal grapevine canopy exploits the entire trellis with one to 1½ layers of leaves (Smart and Robinson, 1991). Research indicates that vines with 0.3 to 0.4 pounds of cane prunings per foot of row typically have such a canopy.

Because vine vigor is influenced by numerous factors — including choice of variety, choice of rootstock, characteristics of the vineyard site and many aspects of grower vine management — no standard vine spacing is applicable to all situations. Some Michigan vineyards that were planted with native American varieties on 8-foot spacing have adequate vine canopies, but many do not. Therefore, a vine spacing of 7 feet often would be more productive. Typical vine spacings for the interspecific hybrid and *Vitis vinifera* varieties are 7 and 6 feet, respectively. Accelerated vineyard establishment through high-density plantings with vine spacings as close as 4 feet poses a question about long-term benefits. The merits of this approach have been questionable in other viticultural areas (Smart and Robinson, 1991). Additional years of grower experience and research will be required to resolve the suitability of high-density plantings for Michigan vineyards.

Headlands, Access Roads and Alleyways

A portion of a vineyard site will be unplantable because it is needed for the movement of people and equipment. Headlands, the open areas at the ends of vineyard rows, need to be wide enough to accommodate both end post anchoring systems placed external to the end post and convenient turnaround space for equipment. A minimum headland width of 30 feet is recommended. Placement of access roads often will be dictated by the nature of the vineyard site. They are often located on the edges of the vineyard between the outside vineyard row and a hedgerow rather than

using more valuable space in the middle of the field. Alleyways are systematic breaks in what would otherwise be long, continuous rows in a vineyard. Twenty-foot-wide alleyways are common. Topographic depressions often are natural places to create alleyways. It may also be necessary to reserve some land as a staging area (Fig. 6) for equipment, where trucks, forklifts, etc., operate to load grapes or where a water truck and other components of a portable spray shed are situated. Determining the need for such an equipment staging area is part of the vineyard design process.

Preliminary Layout of the Vineyard

When the above components of a vineyard design have been resolved, it is time to stake the preliminary layout for the vineyard. Materials required are stakes, a sledge hammer, a measuring tape and/or measuring wheel (Fig. 7), a writing tablet on a clipboard and flagging tape. A crew of at least two should stake areas that will be designated for planting, headlands, access roads, alleyways, equipment staging areas, etc. In the most simple design, establish the location of the four corner end posts of a rectangular planting (Fig. 8). The more irregular the site, the more complex the process becomes. As you place stakes in the ground, make a rough sketch to record distances and directions between stakes. This field sketch will be the basis of mapping and calculating how many vines are required for planting.

Fig. 6. This staging area for equipment was part of the vineyard design. Otherwise, there would be no place near the vineyard to load grapes on trucks at harvest.

Fig. 7. This measuring wheel is used to easily measure distances for making a vineyard sketch. It records on a counter in the handle the number of rotations of the wheel as it is rolled along the ground. Each rotation is 6.6 feet.

the vineyard map should accordingly be updated. This makes it easier to communicate vineyard tasks such as placement of picking boxes or repair of wires. Placing numbers on posts may be challenging. Permanent markers and paint are not durable. Stains that penetrate wooden posts are somewhat better. Pieces of plastic with embossed numbers work well. Some vineyard operations use an embossing machine that imprints numbers on a metal tape (Fig. 9). It also may be useful to number line posts so that individual vines can be identified by a three-number system. For example, 14-4-2 would mean row 14, post space 4 and vine 2 within that post space. Whatever system is chosen, make a vineyard map that can be copied readily and distributed.

Fig. 9. The numbers embossed on this metal tape indicate that the post is at row 53 and post space 3 of the vineyard.

III. Obtaining Grapevines for Planting

Vines may need to be ordered as much as one or two years in advance of planting. Therefore, make a plan for obtaining grapevines even before site preparation has begun.

Selecting Varieties

The choice of grape varieties to be planted is influenced not only by the market outlook for the crop but also by the characteristics of the vineyard site and personal preference. Several reference materials to assist growers with their selection of grape varieties are listed in Appendix A.

Number of Vines Required for Planting

The number of grapevines required for a new planting is determined by measuring the area to be planted. That information will have been obtained when the preliminary layout, sketching and mapping of the vineyard were done. Exclude areas to be used for headlands, alleyways and access roads. If the planting is oddly shaped, stake out and measure several subareas to be planted. Add together areas to be planted to determine the total area. For example, the vineyard layout in Fig. 8 consists of two rectangular areas that measure 400 by 198 and 300 by 350 feet. The total area of these two sections is 184,200 square feet. Dividing that by the area of one acre (43,560 square feet) indicates there are 4.23 acres to be planted.

The number of vines required per acre of vineyard can be determined by multiplying the chosen row and vine spacings in feet and then dividing 43,560 by that value. For example, if row and vine spacings of 9 and 6 feet were chosen, respectively, then the land area required per vine would be 9 x 6 = 54 square feet. Dividing that value into 43,560 indicates that 807 vines will be required to plant an acre of vineyard. Planting vines at this spacing on the 4.23 acres of vineyard in Fig. 8 would require 4.23 x 807 = 3,414 vines. For convenience, the number of vines per acre for a range of row and vine spacings is presented in Table 4.

Table 4. Area per vine and vines per acre for several row and vine spacing combinations.

Row x vine spacing (ft)	Area per vine in square feet	Vines per acre
10 x 8	80	544
10 x 7	70	622
10 x 6	60	726
9 x 8	72	605
9 x 7	63	691
9 x 6	54	807
9 x 5	45	968
8.5 x 8	68	641
8.5 x 7	59.5	732
8.5 x 6	51	854
8 x 8	64	681
8 x 7	56	778
8 x 6	48	908
8 x 5	40	1,089

In the second year of a vineyard, it is often necessary to replant a small percentage of vines that did not grow well or at all. If one anticipates difficulty in obtaining such replacement vines, consider ordering 1 to 2 percent more vines than necessary for the initial planting. These extra vines can be placed in a nursery or at half-spacing in a corner of the vineyard so they will be readily available the following spring. Adjust the shoot numbers on these replacement vines to a maximum of four after growth has begun to ensure that well developed shoots will mature into strong, hardy canes.

Propagation

A grower may propagate his own vines. This is done rarely for grafted vines but occasionally for self-rooted vines. Propagation typically utilizes hardwood cuttings from mature vines. Propagation of high-quality vines is certainly possible if careful attention is paid to all the steps in the process. These steps are: collecting canes from healthy, mature vines early in the winter; pruning canes into two- to four-node cuttings that range from 10 to 15 inches in length; bundling and storing cuttings so they are kept cool, moist and free from storage molds; preparing a nursery bed; planting cuttings when the top several inches of soil have warmed to at least 50 degrees F; maintaining the nursery in a weed-free, well watered condition throughout the growing season (Fig. 10); maintaining developing vines in a healthy condition, free from disease and insect problems; digging vines either in late fall and storing them under refrigeration or in the following spring before growth begins; grading vines so that only those that have developed large, branched root systems are used; and keeping vines cool, moist and dormant until planting. Details of this process are available from Michigan State University Extension.

Fig. 10. Self-rooted vines being grown in a nursery that is kept weed-free by planting cuttings through plastic mulch.

Purchasing Vines

When purchasing vines from a commercial nursery, seek written certification of their trueness to variety, freedom from viral diseases, and terms of refund or replacement. In the years ahead, grapevines also will be certified to be free of the bacterium causing crown gall. Vines often are placed in grades of declining quality indicated by the designations 1-year extra, 1-year #1 and 1-year medium. Vines graded 2-year #1 have been grown in the nursery for two years and may or may not be of high quality. These grades are applied by the individual nursery and do not represent a standardized grading system across the industry. Generally speaking, grades indicate vine quality in regard to the amount of root system and the extent of branching of that root system. However, the application of a grade to vines is no guarantee of their true quality.

The choice of rootstocks for grafted vines is a major consideration before ordering. Information on that topic is provided in references listed in Appendix A. Some nurseries sell their vines after they have been root pruned. Vines that have been root pruned prior to planting often will not perform as well as those with their root systems left intact.

The demand for grapevines varies considerably by variety and year. Ordering vines a few months or weeks before planting may be hazardous. Order vines at least one year prior to planting. Sources of grapevines for wine grape and juice production are listed in Appendix A. Sources of table grape varieties are listed in Extension bulletin E-2642, "Table Grape Varieties for Michigan" by Zabadal *et al.*

IV. Preparing the Site

Vines with vigorous growth from their time of planting will be more tolerant than weak-growing vines of stresses such as drought, nutrient deficiencies, disease, insects, premature cropping and low winter temperatures. Site preparation should ensure vigorous early growth of vines. Proper site preparation is not a last-minute detail performed just prior to planting and should definitely not be delayed until after planting as a "catch-up" effort. Vines that have poor early growth often will respond slowly to corrective measures. Site preparation is best undertaken at least one year prior to planting. Prepare the vineyard site first and then plant it!

Weed Control

Weed control is the single most important factor in vineyard site preparation. Ironically, it is often also the most poorly managed part of site preparation. Any plant growth within a 5-foot radius of a newly planted

Fig. 12. Overhead irrigation being used to protect a 'Chardonnay' vineyard from a spring freeze in southwest Michigan. Shoots were 1 to 3 inches long.

of good vine management are undertaken. However, the cost effectiveness of irrigation in mature Michigan vineyards is uncertain. Yield increases in mature Michigan vineyards from irrigation have been documented, but the value of the additional crop may not justify the expense of installing and operating an irrigation system.

If irrigation is considered for a new vineyard, then planning the location of main lines, manifolds, control systems, electrical requirements, etc., should take place during site preparation. If irrigation is to be installed, the system should be in place when it is most likely to be cost effective — i.e., the first two years of the vineyard.

Replanting Sites with Cropping History

If a vineyard site has a crop history, additional site preparation may be necessary. Planting grapes after grapes is the greatest concern. The so-called "grape replant problem" is not fully understood. Nevertheless, steps can be taken to minimize the risk of poor vine development. Take soil samples near vine root systems for nematode analysis, then fumigate as necessary. Kill vine root systems when an old vineyard is removed by applying glyphosate to vines in abandoned vineyards in late summer or immediately after harvest in a cropping vineyard. Research has shown that crown gall can exist on dead vine tissues for several years (Burr *et al.*, 1995). Therefore, remove as much vine tissue from the site as possible. Fallow the site a minimum of one and up to three growing seasons. Consider using phylloxera-resistant rootstocks for all varieties when replanting after one year of fallow. Plant new vineyard rows so they are not directly on top of the old ones. Grow new vines aggressively with good weed control, fertilization and pest control.

A potential problem also exists if the vineyard site has a history of peach production. Certain grape varieties are susceptible to peach rosette mosaic virus (PRMV), including the native American grape varieties 'Concord' and 'Catawba', certain interspecific hybrids such as 'Aurore', 'Baco Noir' and 'Vidal blanc', and several rootstocks (Ramsdell, 1988). Examine peach trees for evidence of PRMV before they are removed. Collect samples of soil near tree roots for nematode analysis to determine the concentration of dagger nematodes, which transmit this virus. Nematode analysis may indicate a need for soil fumigation.

After the site has been prepared properly, it is ready for planting. Planting and management of early vine growth are discussed in the companion, Extension bulletin E-2645, "Vineyard Establishment II: Planting and Early Care of Grapevines in Michigan Vineyards."

Appendix A:

Grape varieties, rootstocks and sources of grapevines

Selecting Wine Grape Varieties for Planting

Bordelon, B. 1995. Grape varieties for Indiana. Bul. HO-221. West Lafayette, Ind.: Purdue University.

Cahoon, G., M. Ellis, R. Williams and L. Lockshin. 1991. Grapes: Production, management and marketing. Bul. 815. Columbus, Ohio: Ohio State University.

Cattell, H., and H.L. Stauffer. 1978. The wines of the east: I. The hybrids. Lancaster, Pa.: L.C.H. Photojournalism.

Cattell, H., and L.S. Miller. 1979. The wines of the east: II. The vinifera. Lancaster, Pa.: L.C.H. Photojournalism.

Cattell, H., and L.S. Miller. 1989. The wines of the east. III: The native American grapes. Lancaster, Pa.: L.C.H. Photojournalism.

Elfing, D.C., A. Dale, K.H. Fisher, N. Miles and G. Tehrani. 1992. Fruit cultivars: A guide to commercial growers. Pub RV-5-92. St. Catherines, Ontario, Canada: Ontario Ministry of Food and Agriculture.

Howell, G.S., D.P. Miller and T.J. Zabadal. 1997. Wine grape varieties for Michigan. Bul. E-2643. East Lansing, Mich.: Michigan State University.

Reisch, B.I., R.M. Pool, D.V. Peterson, M.H. Martens and T. Henick-Kling. 1993. Wine and juice grape varieties for cool climates. I.B. 233. Ithaca, N.Y.: Cornell University.

Wolf, T.K., and E.B. Poling. 1995. The mid-Atlantic wine grape grower's guide. Raleigh, N.C.: North Carolina State University.

Selecting Rootstocks

Howell, G.S., D.P. Miller and T.J. Zabadal. 1997. Wine grape varieties for Michigan. Bul. E-2643. East Lansing, Mich.: Michigan State University.

Sources of Grapevines for Wine Grape Production

Reference to nurseries on this list does not imply endorsement by Michigan State University or bias against those not mentioned.

Bailey Nurseries, Inc. - 1325 Bailey Road, St. Paul, MN 55119. Phone: 800-829-8898

Bear Creek Nursery - P.O. Box 411, Northport, WA 99157.

Concord Nurseries, Inc. - 10175 Mile Block Road, North Collins, NY 14111-9770. Phone: 800-223-2211

Congdon & Weller Wholesale Nursery - Mile Block Road, North Collins, NY 14111. Phone: 716-337-0171

L. E. Cooke Co. - 26333 Road 140, Visalia, CA 93292. Phone: 800-845-5193

Double A Vineyards - 10275 Christy Road, Fredonia, NY 14063. Phone: 716-672-8493

Euro Nursery - 3197 Culp Road, Jordan, Ontario, Canada LOR1SO. Phone: 905-562-3312

Evergreen Nursery - 17 Southwinds Circle, Suite 7, Washington, MO 63090. Phone: 314-390-2301

Grafted Grapevine Nursery - 2399 Wheat Road, Clifton Springs, NY 14432. Phone: 315-462-3288

Gurney's Seed & Nursery Co. - 110 Capital Street, Yankton, SD 57079. Phone: 605-665-1930

Indiana Berry & Plant Co. - 5218 W. 500 South, Huntingburg, IN 47542. Phone: 800-295-2226

J.W. Jung Seed Co. - 335 S. High Street, Randolph, WI 53957 -0001. Phone: 800-247-5864

Lake Sylvia Vineyard Nursery - 13775 51st Avenue, South Haven, MN 55382.

Miller Nurseries - 5060 West Lake Road, Canandaigua, NY 14424. Phone: 800-836-9630

Mori Nursery - RR 2, Niagara on the Lake, ON, LOS 1J0 Canada. Phone: 416-468-3218

Pense Nursery - 16518 Marie Lane, Mountainburg, AR 72946. Phone: 501-369-2494

Rambo's Wholesale Nursery - 10495 Baldwin Road, Bridgman, MI 49106. Phone: 616-465-6771

Sonoma Grapevines Inc. - 1919 Dennis Lane, Santa Rosa, CA 95403. Phone: 707-542-5510

Turnbull Nursery, Inc. - 10036 Versailles Plank Road, North Collins, NY 14111. Phone: 716-337-3812

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Geiger, R. 1957. The climate near the ground. Cambridge, Mass.: Harvard University Press.

Hanson, E. 1996. Fertilizing Fruit Crops. Bul. E-852. East Lansing, Mich.: Michigan State University.

Howell, G.S. 1992. Spring frost injury: Factors that influence damage to developing grape buds. *Vintage and Vineyard View,* 7(3):5-8.

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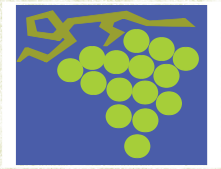

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