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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.

I. 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;

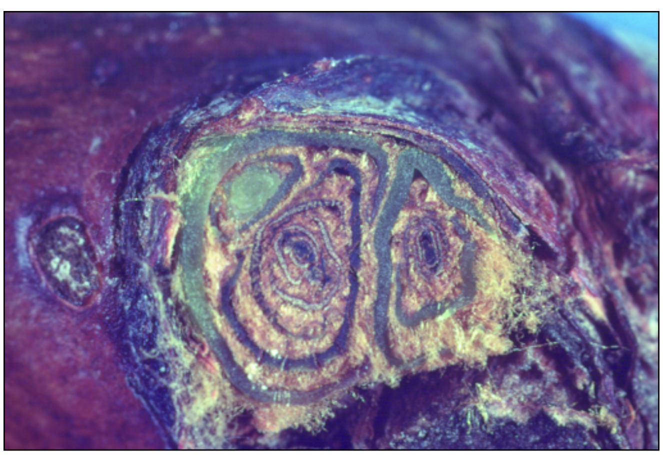

Fig. 1. A cross-section of a compound grape bud showing dead primary and secondary buds and a live tertiary bud.

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

Fig. 2. Macroclimatic ratings for suitability for vineyards based on frequency and extent of winter minimum temperatures for 31 locations in Michigan. E = excellent, G = good, A = acceptable, U = unacceptable.

Table 2. The average number of years out of 10 when winter minimum temperatures of -5 , -10, -15 and -20 degrees F were experienced, the lowest recorded temperature for the 30-year period from 1961 to 1990, and a rating of the macroclimate for grape production for 31 locations in Michigan.

Location	Number of years/10 years that experienced this temperature				Lowest recorded temperature	Site rating[1]
	-5° F	-10° F	-15° F	-20° F	(°F)	
Adrian	10	6	2	1	-21	Acceptable
Alma	9	6	1	0	-19	Acceptable[2]
Alpena	10	10	8	4	-37	Unacceptable
Benton Harbor	6	3	1	0	-20	Excellent
Big Rapids	10	9	7	3	-25	Unacceptable
Bloomingdale	9	6	2	0	-22	Acceptable
Chatham	10	10	8	7	-36	Unacceptable
Detroit	8	4	1	0	-21	Good
Dowagiac	9	7	4	1	-23	Acceptable
East Tawas	10	8	5	1	-26	Unacceptable
Eau Claire	7	4	2	0	-21	Good
Gladwin	10	9	7	3	-26	Unacceptable
Grand Marais	10	8	3	1	-25	Unacceptable
Grayling	10	10	10	8	-42	Unacceptable
Herman	10	10	10	9	-40	Unacceptable
Holland	9	4	1	0	-21	Good
Houghton	10	8	6	4	-26	Unacceptable
Iron Mountain	10	10	10	8	-34	Unacceptable
Ironwood	10	10	10	10	-41	Unacceptable
Lansing	10	8	4	2	-29	Unacceptable
Manistee	6	3	2	1	-22	Good
Maple City	8	4	1	1	-24	Good
Monroe	7	3	1	0	-17	Good
Muskegon	8	3	0	0	-15	Good
Newberry	10	9	7	3	-27	Unacceptable
Saginaw	9	4	1	0	-17	Good
Sault St. Marie	10	10	10	8	-36	Unacceptable
South Haven	5	1	0	0	-13	Excellent
Stephenson	10	10	8	8	-39	Unacceptable
Traverse City	10	9	4	2	-37	Unacceptable[2]
Vanderbilt	10	10	10	10	-43	Unacceptable

[1] Site ratings = macroclimatic rating of the location for grape production as per the definitions in Table 3.
[2] See discussion on pages 8-9.

were applied to Michigan, they would indicate that no excellent or even good vineyard sites exist. That certainly would be true if the classification considered all grape varieties including the **very** cold-tender ones (Table 1) often grown in warm-climate areas such as California. However, if site classification is limited to cold-tender and hardier varieties (Table 1), winter minimum data for several Michigan locations (Table 2) can be used to define and describe vineyard macroclimate classification categories that range from excellent to unacceptable (Table 3). Those definitions have been used to establish macroclimate vineyard site classifications for the locations in Table 2 and Fig. 2.

Trends are evident in these classifications. All locations in the Upper Peninsula are rated unacceptable for grape production. Locations along the shore of Lake Michigan have a good to excellent rating. The three locations in the southeastern corner of the state are rated acceptable to good. Locations in the central portion of the Lower Peninsula and those in the northeastern portion of the Lower Peninsula generally are rated unacceptable as sites for vineyards. In general, sites for vineyards in Michigan become more favorable as one progresses south and approaches the Great Lakes shorelines.

Two macroclimate classification anomalies are worth mentioning. The Traverse City location is rated unacceptable, yet there are productive vineyards with cold-tender varieties within this area. The explanation for this apparent discrepancy is that the weather data used for this classification were recorded at the Traverse City Airport, which has a very flat, open exposure that allows cold air to collect near the surface under clear, calm conditions. In contrast, the

Table 3. Vineyard site classifications for Michigan and their descriptions, based on winter minimum temperature data.

Vineyard site classification	Classification description	Occurrence of -5° F (yrs/10 yrs)	Occurrence of -10° F (yrs/10 yrs)	Occurrence of -15° F (yrs/10 yrs)	Long-term winter minimum temperature
Excellent	Suitable for cold-tender and hardier varieties, but cold-tender varieties may experience moderate or severe winter injury in 1 to 3 years and 1 year out of 10, respectively.	≤ 6	≤ 3	≤ 1	≥ - 20° F
Good	Suitable for cold-tender and hardier varieties, but cold-tender varieties may experience moderate or severe winter injury in 1 to 4 years and 1 to 2 years out of 10, respectively.	≤ 9	≤ 4	≤ 2	≥ - 24° F
Acceptable	Suitable for moderate or hardier varieties. These vines may experience moderate or severe winter injury in 1 to 3 years and 1 year out of 10, respectively.	≤ 10	≤ 6	≤ 3	≥ - 24° F
Unacceptable	Not suitable for sustained, commercial production of any varieties.	≤ 10	≤ 8	≥ 4	≤ - 25° F

Maple City location on the Leelanau Peninsula has a good rating and is more indicative of the macroclimate of the Leelanau and Old Mission peninsulas. The Alma location in the central portion of the Lower Peninsula has an acceptable rating because of the relatively elevated, within-city location of the station. The deviation of these two locations from the statewide pattern indicates the importance of mesoclimate at a given location.

Winter minimum temperature data may indicate a potential vineyard site is unsuited for grape production. If vines won't survive the winter, nothing else matters and no further site evaluation is necessary. For example, winter minimum temperatures at Ironwood in Michigan's Upper Peninsula (Table 2) provide no hope for survival of grapevines unless they were buried under snow. If winter minimum temperatures suggest grape production is feasible, they will also indicate hardiness categories of varieties that are suited to that site (Table 3).

Growing Season Length

Grape varieties vary in the length of growing season they require to mature quality grapes, but generally, a minimum 165-day growing season from the last freeze in the spring to the first freeze in the fall will allow most grape varieties grown in Michigan to ripen acceptably. Macroclimatic patterns in growing season length (Eichenlaub *et al.*, 1990) help define the growing conditions of a region. For example, the major fruit production region along the Lake Michigan shoreline has a growing season of 150 to 170 days. This is days or even weeks longer than in locations inland. Good vineyard sites along this shoreline require careful selection of mesoclimates that have a growing season of 165 days or more.

Spring Freeze Damage

Growing season length influences not only fruit maturity but also another important aspect of grape production in a cool climate — spring freezes. The tissues in grape nodes (buds) that develop into shoots and clusters lose hardiness when buds swell and open and shoots begin to grow (Proebsting *et al.*, 1978). Therefore, freezes in the spring after vines have begun to grow severely threaten grape production by killing shoots and clusters (Fig. 3). The probability of such an occurrence increases as one progresses southward and away from large bodies of water. For example, the grape-producing region in the southwestern corner of Michigan is more susceptible to spring freezes than vineyards in the Traverse City area. In fact, the grape crop in southwestern Michigan was severely reduced by spring freezes in 11 out of 31 years from 1960 to 1990 (Zabadal, 1991). Though the frequency of spring freezes in Michigan has not changed appreciably during the past 60 years, the frequency and magnitude of early spring warm spells have increased, resulting in an earlier break of dormancy and an increased risk of spring freeze damage (Andresen and Harman, 1994).

Fig. 3. Shoots on 'Concord' grapevines after a spring freeze showing that most of the fruit potential of these shoots has been lost.

Within a grape-producing region, the mesoclimate of a specific vineyard site has a profound influence on susceptibility to spring freezes. When air cools, it becomes denser and heavier, and on clear, calm spring nights, it flows down slopes somewhat like a liquid. Good vineyard sites are typically located on sloping ground because they export cold air (Fig. 4) down a slope. Vineyards on flat ground must rely on convective air flow or frost protection strategies such as wind machines or irrigation to combat spring freeze episodes. Though grape varieties differ slightly in their tissue tolerance to freezing temperatures in the spring, the major difference among varieties is their time of bud break (Howell, 1992). Therefore, as the risk of spring freeze for a vineyard site increases, the incentive to avoid planting early bud-breaking varieties also increases.

Windbreaks or hedgerows uphill from a vineyard can prevent cold air from higher elevations from entering a vineyard. Windbreaks downslope can harmfully trap cold air in the vineyard (Fig. 4).

Growing Season Heat Accumulation

The ability of a vineyard site to ripen a crop is influenced not only by growing season length but also by the heat experienced during that time. Heat summations for various growing regions are measured and compared using growing degree-days (GDD). The GDD concept relates to the physiology of the grapevine, which does not become very active until the ambient air temperature reaches about 50 degrees F. A common method for measuring GDD is to calculate the daily mean temperature by averaging the high and low temperatures for the day and then subtracting 50 degrees F. For example, a day with a high temperature of 80 degrees F and a low temperature of 60 degrees F would have ([80 + 60]/2) - 50 = 20 GDD for that day. Most of the viticultural regions of the world have been compared and placed into five climatic regions according to their GDD summation (Winkler *et al.*, 1974). The coolest regions, Climatic Region I, aver-

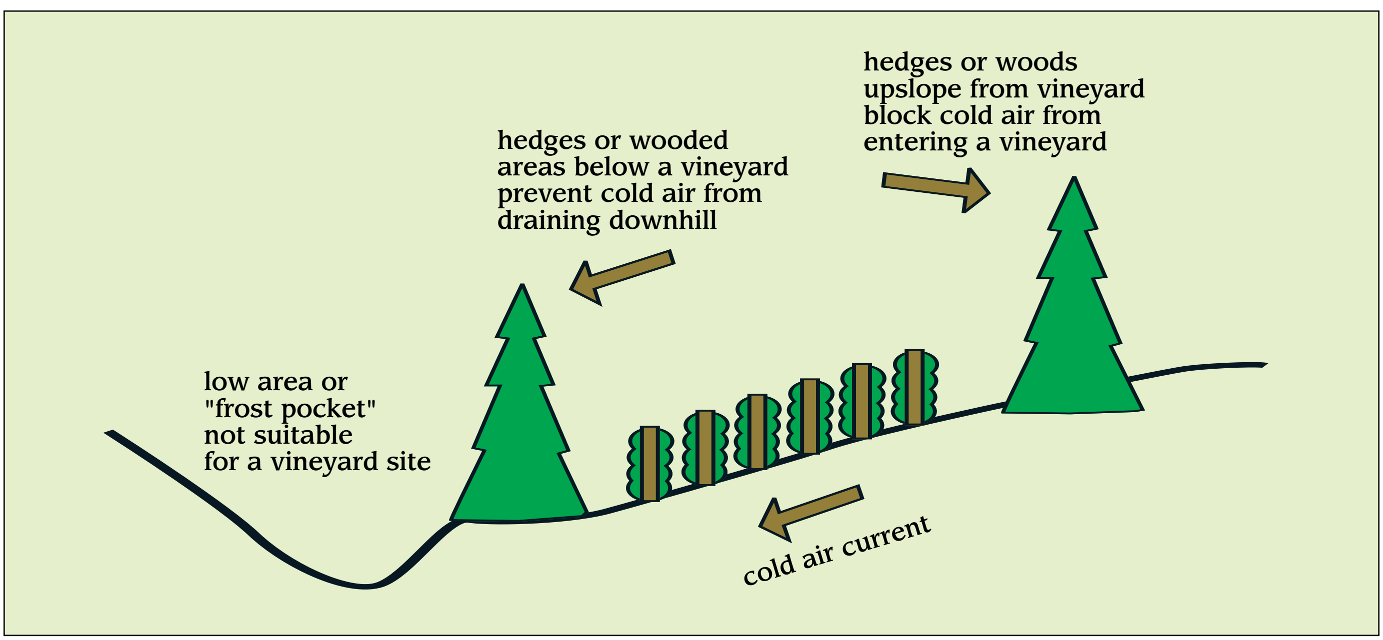

Fig. 4. Topography and adjacent vegetation influence the susceptibility of a vineyard site to spring and fall freeze damage.

age 2,225 GDD. Locations in Climatic Region II average 2,700 GDD. From April 1 to October 31, the two principal viticultural regions in Michigan, the Traverse City area and the southwestern portion of the state, average 2,100 and 2,800 GDD, respectively (Eichenlaub, 1990). Therefore, according to the Winkler *et al.* (1974) classification, these viticultural areas are in Climatic Regions I and II, respectively.

The minimally acceptable level of growing season heat accumulation for a vineyard site is 2,000 GDD. The closer the macroclimate of a region approaches this value, the more important mesoclimatic characteristics become. South and west aspects are desirable for heat accumulation because they have a more direct angle to the sun during the middle and latter part of the day. Elevation also may be a factor because air temperature will decrease approximately 0.5 degrees F per 100 feet increase in elevation. Large bodies of water immediately adjacent to vineyards will also reduce heat accumulation during the growing season. Sites with 1,800 GDD or fewer should not be planted. On that basis, there is a 75 percent probability of excluding 90 percent of the land area of Michigan's Upper Peninsula in any specific year as a suitable vineyard site because of inadequate GDD (Eichenlaub *et al.*, 1990).

Cropping History

Most sites to be considered for a vineyard will have some history of cropping. Site preparation in response to prior cropping history can be critical to the success of a new vineyard and a significant vineyard establishment cost. Therefore, cropping history should be considered a part of the site selection process. Least serious are nutritional matters. For example, land that has been used to grow alfalfa is notorious for having low potassium availability (Mendall, 1960), but the nutritional status of the site can be readily determined and adjusted (see section IV, "Preparing the Site", p. 18).

Biological problems in the soil are more serious than nutritional problems and may include viruses, nematodes, phylloxera and crown gall. Vineyards planted on old vineyard sites always require special management (see the replanting section, p. 21). Many good vineyard sites in southwestern Michigan will have had a history of peach production, which also complicates site preparation (see "Replanting Sites With Cropping History", p. 21).

Soil Characteristics

Though soil testing is often the first vineyard site characteristic considered by a new grower, it is unnecessary until the above-mentioned site requirements are resolved.

Physical soil characteristics are often more limiting than the soil chemistry. Vines grow best in deep, well drained soils. The depth to which vines can establish roots is important for anchoring as well as supplying water and nutrients. Rooting depth will depend on soil aeration because root tissues, like other tissues, require oxygen to respire. Roots cannot develop in heavily compacted or waterlogged soils.

Soil information for proposed vineyard sites is often available in soil surveys published for each county by the U.S. Department of Agriculture (USDA). Copies of this publication may be available from the county offices of the USDA Natural Resource Conservation Service (formerly the Soil Conservation Service). Copies for viewing or loan also may be available in libraries and Extension offices. These publications include detailed mapping to identify soil types for specific fields. They describe not only the physical and chemical characteristics of each soil type but also its suitability for various types of crops and descriptions of the drainage classes of soils. Good vineyard sites have soils that are at least moderately well drained. Soils classified as somewhat poorly, poorly or very poorly drained are also poor candidates for vineyards.

Though grapevines are capable of rooting to a depth of more than 20 feet (Seguin, 1972), vine roots typically are concentrated in the upper 36 inches of the soil (Seguin, 1972) or even the upper 18 inches of soil (Perry *et al.*, 1983). Therefore, good vineyard sites are 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.

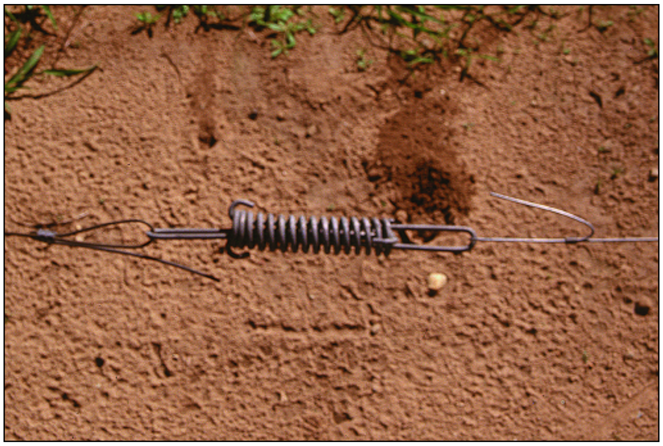

Fig. 5. This spring in a trellis wire absorbs changes in the tension of the wire due to temperature changes or crop load so that the wire itself does not exceed its yield point to become irreversibly stretched.

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. 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.

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.

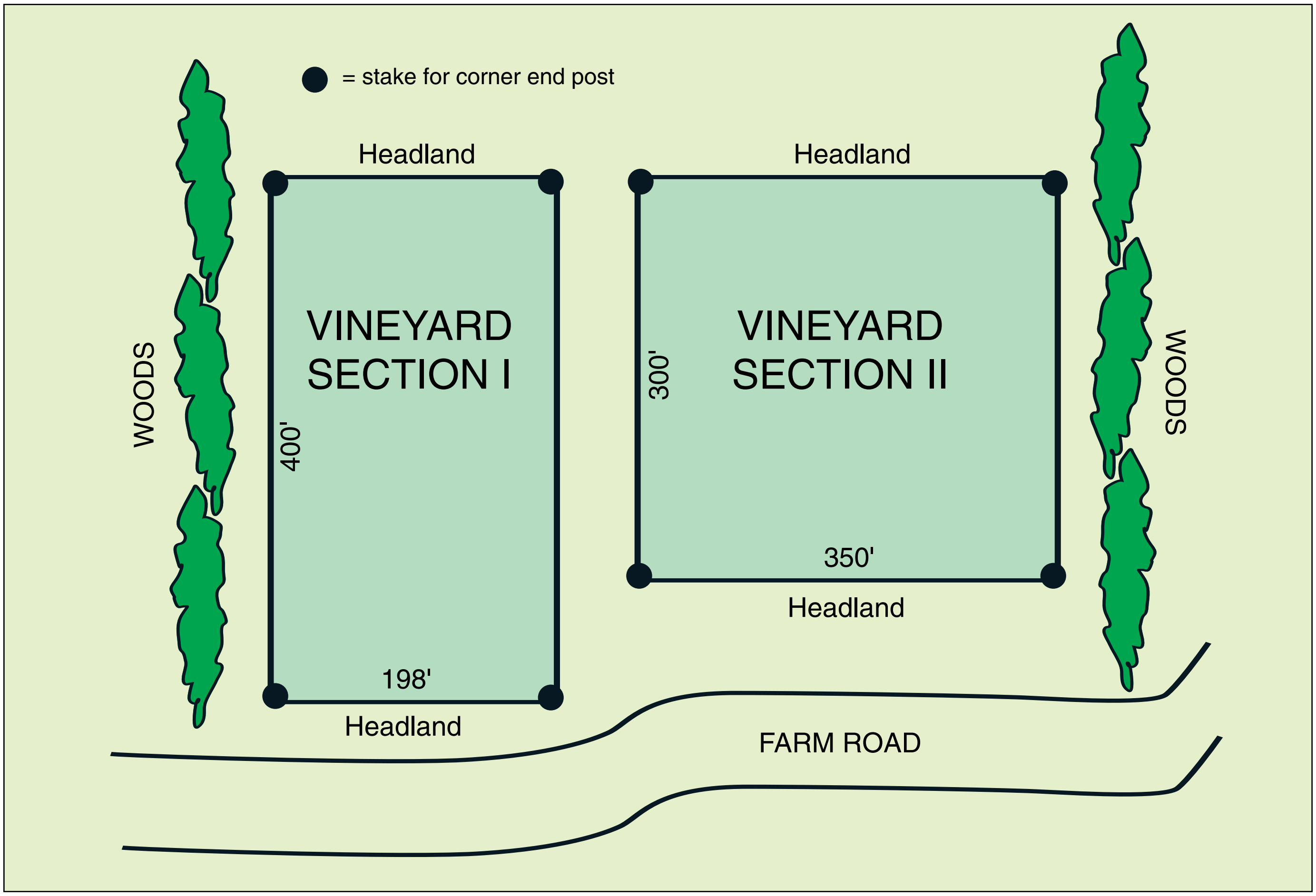

Fig. 8. Schematic drawing of a field to be planted to a vineyard in two rectangular areas. The combined area of the two sections equals 4.23 acres.

Mapping the Vineyard

When all the components of the vineyard design have been determined, it is time to map the vineyard. A simple sketch on a sheet of paper may suffice. The larger the vineyard operation and the more people involved with various vineyard tasks, the more valuable a scaled, detailed map of various vineyard blocks will become. Computer-assisted drawings (CAD) of vineyards gradually are replacing drafting of maps on graph paper. At our horticultural research farm, we generate an overview map of all vineyard blocks on a cover page that identifies individual vineyard blocks. Each vineyard block is then mapped in detail on succeeding pages. Vineyard maps should include a system for numbering rows and indicating where varieties change and where sod waterways, diversion ditches, soil tiling systems and irrigation systems are located.

After the vineyard has been planted and the trellis installed, row numbers should be placed on the end posts, preferably at both ends of the vineyard row, and 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 grapevine may reduce the growth of the vine. A common problem is that the perennial plants we desire to grow (grapevines) are often planted among other perennial plants (weeds). When that happens, control of those weeds becomes very difficult. Therefore, eradicate all perennial weeds on the vineyard site before planting vines.

Cropping the vineyard site for one or more years before planting vines can greatly reduce perennial weed populations. If corn is grown on a vineyard site, carefully choose the herbicides used and their rates so there will be no herbicide carryover when vines are planted. When the field has been used to produce hay or consists of perennial weed growth, a late summer mowing followed by an early fall glyphosate application will control many perennial weed problems (Fig. 11). If a heavy sod poses a problem for tillage the following spring, rough-plowing in the fall will allow freeze-thaw cycles to break up clumps. Do not completely plow and disk a field in the fall because the soil may erode in the winter. Buckwheat sown on heavy ground not only suppresses perennial weed populations but also helps loosen heavy clay soil.

Rye is a common cover crop. It should not be allowed to grow very high in the spring when vines will be planted because a tall stand of rye makes plowing, disking and planting difficult.

Fig. 11. This vineyard site was sprayed with glyphosate in the fall to kill perennial plants and then left in that condition over the winter in preparation for planting in the spring.

If control of perennial weeds on the vineyard site has been ignored in the one or two growing seasons before planting, one can follow a much less desirable "catch-up" approach: delay tilling the soil in the spring when vines will be planted. Wait until weed growth greens up — i.e., about the time vine growth begins — then make an application of a non-selective, systemic herbicide such as glyphosate, wait 48 hours, and then begin tillage operations.

A last-minute decision to plant vines in the late spring on a site with considerable perennial weeds is hazardous. It would often be better to delay planting for a year and use that time to prepare the site properly.

Tree/Shrub Removal

Remove all woody plants from the site. Vines require full sun to produce quality fruit. Solitary trees in the midst of a vineyard are potential roosting sites for feathered intruders on your grape crop. It is especially important to remove hedgerows downhill from a vineyard when spring or fall freezes are a concern (Fig. 4).

Soil Erosion Control Measures

Vineyards in cool climates such as Michigan's are highly susceptible to soil erosion because they typically are situated on sloping ground to minimize spring/fall freeze hazards. One acre-inch of rain is 27,154 gallons of water. Runoff patterns during episodal heavy rains can concentrate many thousands of gallons of water into a highly erosive force. Very large quantities of soil can be lost. Just 1 acre-inch of soil weighs approximately 170 tons. Even in relatively young vineyards (4 to 6 years old), it is possible to find highly eroded soils with root systems protruding several inches from the soil. Topsoil is a key vineyard resource, both as a nutrient reservoir and for its water-holding capacity. Therefore, planning and implementing soil erosion control measures before planting vines is critically important to the long-term productivity of the vineyard. Strategies to control surface drainage on vineyard sites include diversion ditches to intercept water from uphill areas, sod waterways to channel water safely through vineyard areas, standpipes to drain depression areas through underground tiling, hilling soil under trellises and various patterns of permanent sod strips. Remedial efforts to correct soil erosion problems after the vineyard is planted are often more difficult, more costly and less effective than those performed during site preparation.

Soil Internal Drainage

Evaluation of the vineyard site during site selection may reveal the need to improve the internal drainage of the soil. If the problem is an impervious layer of soil that perches water above it, then deep ripping or plowing of the soil may be a suitable corrective measure. However, if the soil texture and topography create generally poor internal soil drainage, tiling may be the solution. A well conceived soil drainage plan covers not only the vineyard site but also the surrounding acreage. Expertise for such planning may be available from soil conservationists and companies that install drain tiling. Vineyard problems resulting from inadequate internal soil drainage include reduced accessibility by equipment, small vine size, reduced productivity and increased hazard of winter injury to vines.

Soil Chemistry

Two aspects of soil chemistry require attention during site preparation. The first is potassium status. Michigan State University recommends that soils to be planted for a vineyard have a minimum potassium level of 200 lb/acre (Hanson, 1996). A soil test will indicate if potassium fertilization is necessary. Soil sampling procedures are described in Michigan State University Extension bulletin E-498 (Shickluna and Robertson, 1988). A large percentage of the potassium in soils is tightly bound to soil particles and unavailable for plant growth. Therefore, apply potassium fertilizer in strips along vine rows to increase efficiency of fertilizer utilization.

Soil acidity also should be checked during site preparation (Shickluna and Robertson, 1988). Many nutrients in the soil are most available for uptake when the soil is relatively neutral — i.e., it has a pH of about 7.0 (Christenson *et al.*, 1983). Therefore, most crops grow better when relatively acid soils are neutralized with lime. However, a few crops, including the three types of fruit native to North America — cranberries, blueberries and grapes — grow well under acid conditions. For example, the native American grape variety 'Concord' can be highly productive on acid soils. Excess liming of 'Concord' grapes can be harmful (Smith *et al.*, 1972). Therefore, when necessary, vineyard sites to be planted to native American varieties should be limed to raise soil pH to 5.5. Vineyards to be planted to interspecific hybrids and *Vitis vinifera* varieties should be limed, when necessary, to raise soil pH to 6.5. Liming is discussed in Michigan State University Extension bulletin E-471, "Lime for Michigan Soils" (Christenson *et al.*, 1983). Lime should be applied and plowed/disked into the soil profile as deeply as possible during site preparation.

Irrigation

Irrigation may be used to protect vines from spring freezes (Fig. 12) or to provide supplemental watering of vines during the growing season. Overhead irrigation for frost is being used successfully at the Southwest Michigan Research and Extension Center. It requires close monitoring during freeze episodes, adequate rates of water application to generate sufficient heat of fusion as water freezes on tissues, uniform distribution of irrigation on the vines and continuous irrigation until ice on the vines is obviously melting.

Experience with drip irrigation in Michigan vineyards indicates that it may be cost effective during the first two years of the vineyard **providing** that other aspects

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.

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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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Other Extension bulletins in this series:

E-2642, Table Grape Varieties for Michigan
E-2643, Wine Grape Varieties for Michigan
E-2645, Vineyard Establishment II: Planting and Early Care of Vineyards

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