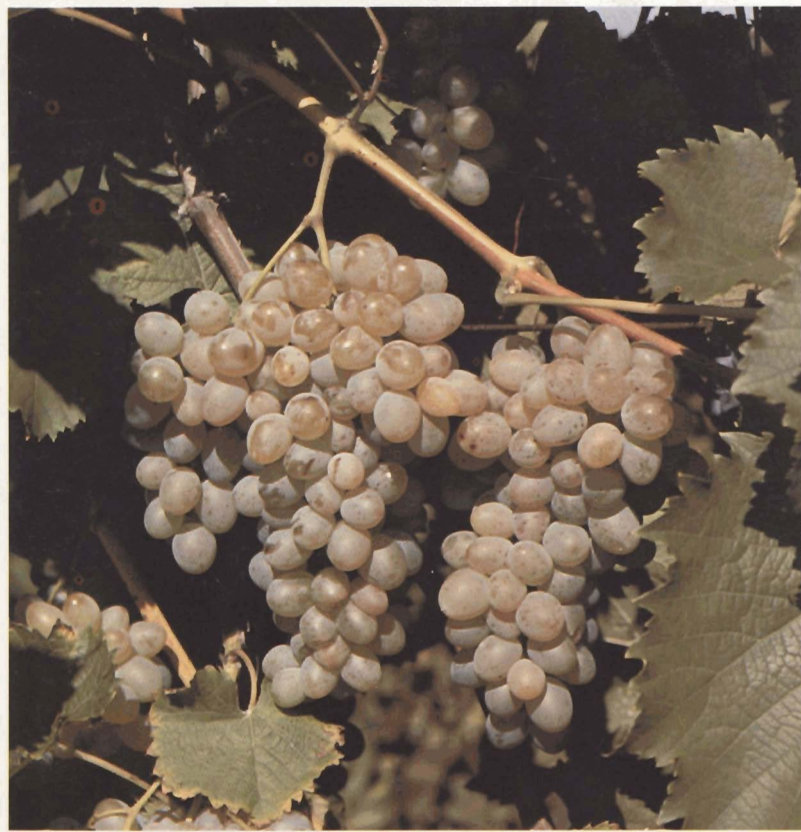


CULTURAL PRACTICES FOR COMMERCIAL VINEYARDS

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This publication for commercial grape growers replaces, expands, and updates Cornell Extension Bulletin 805, *Cultural Practices for New York Vineyards*. That bulletin, first written by Nelson Shaulis in 1950, replaced Cornell Extension Bulletin 375, *Grape Production in New York*, by M. B. Hoffman. Subsequent major revisions of *Cultural Practices for New York Vineyards* were made by N. J. Shaulis and T. D. Jordan in 1960 and by N. J. Shaulis, T. D. Jordan, and J. P. Tomkins in 1966.

The foundation for this bulletin is the experimental results obtained by Dr. Shaulis, his colleagues, and associates during his 34 years of intensive and productive viticultural research in the areas of crop regulation, weed control, nutrition, vine spacing, vine training, vine canopy manipulation to enhance light exposure, and the development of viticulturally sound mechanical harvesting and pruning techniques. Among the many long-time colleagues and associates of Dr. Shaulis in the Department of Viticulture and Pomology, at the Geneva Agricultural Experiment Station, to whom much credit is due are Donald Crowe, John Einset, Gary Howard, Harriet Hubbard, Keith Kimball, Charlotte Pratt, and John Watson.

Recognition is also due the New York State Grape Production Research Fund, Inc., for its 25 years of significant financial support of vineyard research, without which many research projects could not have been initiated or as rapidly completed.

Thus, this publication combines many of the pertinent research findings of the past 3 decades and the more than 60 years of aggregate vineyard observations, experience, and research of the current authors in what should be a useful tool for New York grape producers.

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Grape Industry in New York

New York has the second largest grape production in the United States, with approximately 44,500 acres of vineyard. The average harvested tonnage for the 5-year period from 1975 to 1979 was 150,000 tons. There are approximately 35 commercial grape varieties in New York. The American varieties, French-American varieties, and vinifera varieties represent 88%, 11%, and 1% of New York vineyard acreage, respectively. Seven grape varieties account for approximately 90% of the vineyard acreage in New York State. These 7 varieties and their respective percentages of the total New York vineyard acreage are Concord, 65%; Catawba, 8%; Niagara, 5.5%; Delaware, 5%; Aureore, 4%; De Chaunac, 2%; and Baco noir, 1.5%.

Over the past decade the number of farms in New York producing grapes remained stable at approximately 2,200. During this period total vineyard acreage increased by 10,000 acres, and this increase was about equally divided between the Finger Lakes and Great Lakes (Chautauqua-Erie-Niagara) regions. These plantings were 56% American varieties, 40% French-American varieties, and 2% vinifera varieties. Ten varieties accounted for 80% of the acreage planted during this period. These varieties and their respective new acreage amounts are Catawba, 2078; Aureore, 1293; Niagara, 1100; De Chaunac, 899; Delaware, 803;

Concord, 687; Baco noir, 578; Dutchess, 250; Elvira, 237; and Marechal Foch, 204.

New York grapes are used primarily for juice and wine. Although there has been a revival of interest in fresh marketing of New York grapes in the past 2 or 3 years, this market still uses less than 2% of the total crop. Over the past decade there has been a shift in New York grape use. In 1973, for the first time, more than half of New York grapes (55%) were directly processed into wine. For the previous 3-year period

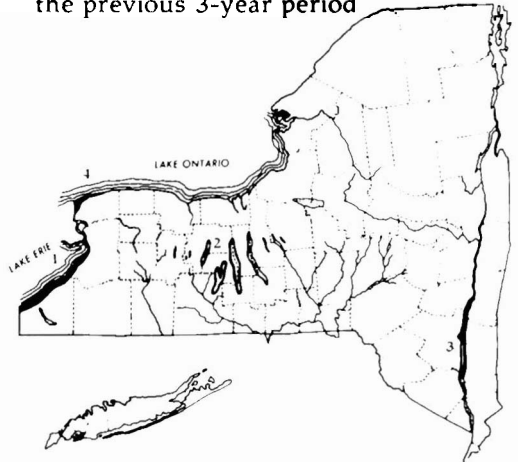


Figure 1. Location of the commercial grape districts in New York State.

District	Millions of bearing vines in 1975
1. Chautauqua-Erie	15.9
2. Finger Lakes	10.8
3. Hudson Valley	0.7
4. Niagara County	2.0

(1970-1972), 56% of New York grapes were processed into juice and 42% went directly into wine. For the 5-year harvest period 1974-1978, the primary uses of New York grapes were for juice, 35%, and for wine, 56%; the remaining 9% went into jellies, preserves, and the fresh market.

As a consequence of the world-wide recession of the mid-1970s and unsettled market conditions, no significant vineyard acreage was planted from 1975-1979. The profitability of existing vineyard acreages has become increasingly dependent upon good management. The purpose of this bulletin is to provide commercial grape growers with information that will help them attain good management in the vineyard.

Vineyard Site Selection

The decision on where to plant the vineyard is likely to be the most important of the thousands of management decisions made during the life of a vineyard. Therefore, great care should be used in selecting the vineyard site.

TEMPERATURE

Temperature is the first consideration in selecting the location of a vineyard. It involves length of growing season, as well as magnitude and frequency of winter minimums. Temperature requirements *must* be satisfied for a site to be considered.

Length of growing season within a given latitude is influenced by elevation, climate moderation by relatively large bodies of water, and sloping ground, which can export cold, dense air to adjacent lower areas. In general, a minimum frost-free period of 165 days is essential

(even for early maturing varieties), and 180 days or more is preferable. This frost-free period must commence early enough in the spring to protect shoots as growth begins, and extend long enough in the fall to ensure maturity not only of the crop, but of the vegetative parts of the vine as well. For example, although the variety *Aurore* matures its fruit earlier than all other commercially important grape varieties in New York, it requires a substantial frost-free postharvest period with functional leaves to adequately mature the vine itself.

Data concerning the magnitude and frequency of winter minimum temperatures at a potential site should be interpreted in light of the proposed variety selection and vineyard management.

Nevertheless, as a general guide the winter-damage hazard of sites can be estimated as follows:

EXCELLENT. Winter temperatures reaching -5° F 3 times or less in 10 years; winter temperatures reaching -10° F no more than once in 10 years, with the long-term minimum temperature not lower than -10° F. Suitable for all current commercial varieties.

GOOD. Winter temperatures reaching -5° F 5 times or less in 10 years; winter temperatures reaching -10° F no more than once in 10 years, with the long-term minimum temperature not lower than -15° F. Suitable for all current commercial varieties, but cold-tender varieties can be expected to sustain severe damage at least once in 10 years and lesser damage more often.

ACCEPTABLE. Winter temperatures reaching -5° F almost

every year; winter temperatures reaching -10°F 4 times or less in 10 years, and the long-term minimum temperature of -15°F or less occurring no more than once in 10 years. The major grape-producing areas of New York fall in this category and, in general, are commercially suitable only for varieties of medium or greater hardiness.

POOR. Winter temperatures reaching -10°F 5 or more times in 10 years; winter temperatures reaching -15°F 3 or more times in 10 years. Not suitable for commercial grape production.

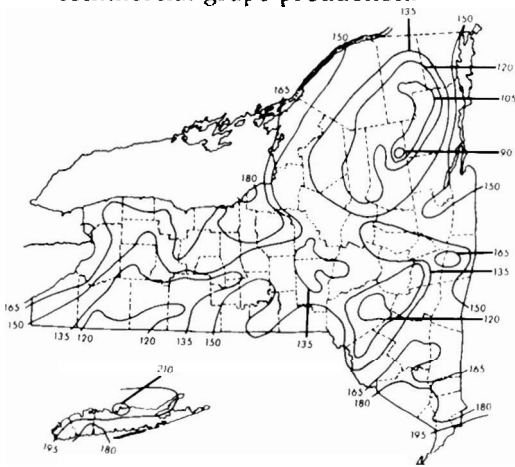


Figure 2. Average length of the growing season in days.

The process of selecting a location for a vineyard also involves a decision about the variety to be grown. A site may be good for a winter-hardy variety like Concord, but unsuitable for cold-tender varieties like Dutchess or White Riesling. *Growing Cold-Tender Varieties in New York* by N. J. Shaulis, J. Einset, and A. B. Pack, N.Y.S. Agricultural Experiment Station at

Geneva, General Bulletin 821, is a valuable reference for evaluating and managing grape varieties in relation to cold-hardiness.

SOIL

If the site under consideration meets the growing-season length and winter minimum-temperature requirements, then the next consideration is soil. Although grapevines will survive and produce a crop under a variety of soil conditions, the establishment of economically viable vineyards is increasingly dependent upon selecting soils that have good internal drainage and sufficient rooting depth. The minimum depth should be at least 30 inches; 40 inches is preferable, with additional benefits likely as rooting depth increases up to 5 or 6 feet.

The general characteristics of the subsoil should be considered when the vineyard site is selected and management practices are chosen. Well-drained soils have bright, uniformly yellowish brown or brown subsoil. Moderately drained soils have some mottling (spots of yellow, gray, and orange) in the subsoil below 15 to 20 inches. Somewhat poorly drained soils have pale-colored subsoils that are highly mottled below 6 to 15 inches. Poorly drained soils have gray subsoils, either mottled or unmottled.

A vineyardist can determine the drainage class of the soil by looking for these characteristics in the subsoil and by studying a soil map of the farm. Soil association maps of most counties are available from



Figure 3. An excellent vineyard site protected by planting on a terrace grade and by a diversion ditch. This young Concord vineyard has already produced crops of 4 tons of grapes per acre.

the Cooperative Extension Service. Detailed maps of individual fields can be obtained through the district soil conservationist.

Good yields of some varieties are common on imperfectly drained soils that have been improved through tiling. However, within the major grape-producing areas of the state, the better the soil drainage, the better the site will be for grape production. Where the option exists, it will usually be false economy to purchase a less expensive site with heavy, imperfectly or more poorly drained soil, because the cost of artificial drainage, which at best is only a partial remedy, may exceed any savings on the original purchase price of the land.

OTHER SITE CONSIDERATIONS

Other concerns in choosing a vineyard site involve long-term management considerations. Does the size and shape of the field lend

itself to long rows and efficient equipment operation? Will surrounding woodlands pose an insurmountable wildlife or insect problem or impair airflow, which will increase the threat of disease as well as frost hazard? If the slope of the land is adequate for frost protection, is it possibly excessive in terms of machine workability or erosion hazard? Modern mechanical harvesters work easily across slopes up to 12 percent and with more difficulty on slopes up to 20 percent.

Planting Stock

Since requirements for the successful propagation of grapevines are rather exacting, most vineyardists purchase planting stock from commercial nurseries. A list of these nurseries can be obtained from the Cooperative Extension Service.

When buying rooted grape cuttings, remember that the quantity of roots determines the grade and is your best guide to quality. One-year-old extra heavy and one-year-old number 1 rooted cuttings are generally most satisfactory. Experience suggests that the one-year-old number 2 and cull grades, even when replanted and grown in the nursery an additional year, may still lag behind vines grown from the better grades. In buying grafted vines, the continuity and strength of the graft union must be considered.

Several grape varieties are now available in virus-tested planting stock and are recommended,

especially for those varieties recognized to be virus susceptible, including Baco noir, Cascade, and De Chaunac.

Purchased vines should be left in the commercial nursery's storage until just before planting, if possible, and must not be permitted to dry out during transport. At the planting site the roots must be kept cool and moist until planting is completed. Usually this can be accomplished by covering them with burlap or other porous material and wetting them frequently. If the vines must be stored more than a few days, heel them in the ground, making sure all the roots are in intimate contact with the soil. It may be necessary to break bundles and line out the vines in a trench.

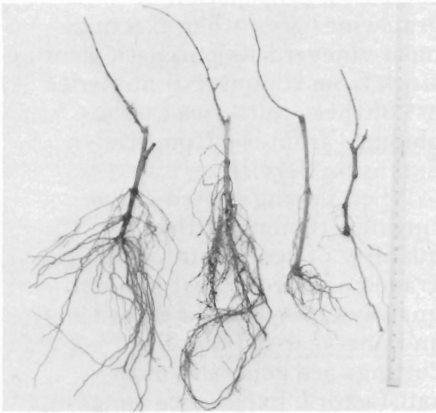


Figure 4. One-year-old Concord nursery stock, from left to right: number 1 extra, number 1, number 2, and cull.

PROPAGATION METHODS

CUTTINGS. Growers who have suitable soil and are willing to follow proper procedures can root their own cuttings. However,

without proper attention, failure is likely and will mean a delay of one or more years in the planting schedule. Steps to be followed in propagating own-rooted cuttings include the following:

Quality cuttings. If virus diseases are present, they can be spread through propagation wood. Therefore, select cuttings from vines that were inspected during a previous growing season and were free of atypical characteristics such as straggly clusters, very short internodes, and malformed or stunted leaves.

Cuttings can be made in late fall or early winter from dormant, well-matured canes. Canes with a 1/4- to 3/8-inch diameter are preferred. Cuttings are usually about 9–12 inches long and include three or more nodes (fig. 4). The bottom cut is made just below the basal bud and the top cut about an inch above the top bud. For convenience in handling and planting, the cuttings should be sorted into uniform lengths, with the top ends together, and tied into bundles. There are fungicides that can be used as a dip before storing cuttings; although not essential, they will give insurance against molding of the cuttings during storage. The bundles should be buried in a trench with the basal ends up and covered with about 3 inches of soil. A well-drained spot should be selected for this purpose. When cold weather approaches, the trenches should be covered with several inches of straw or manure, which can be removed as soon as the weather warms.

Nursery bed. The nursery should contain soil that is light in texture, but to which some organic matter

has been added for moisture retention. Weed control is essential. Successful methods include using an herbicide or black plastic. The soil should be well worked to a depth of 8-12 inches before setting cuttings. Irrigation of the cuttings is highly desirable and, in most years, essential.

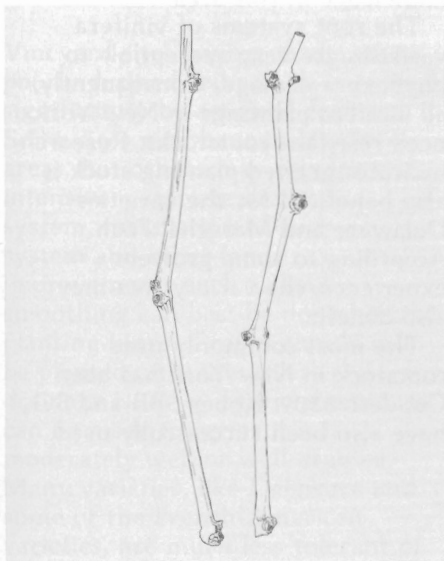


Figure 5. Cuttings for propagation of the grape varieties Concord (left) and Aurore (right).

Setting out cuttings. As soon as the danger of frost is past or by mid-May, set out cuttings in a furrow or trench, spacing them 5-6 inches apart in the row. The soil should be firmly packed around the cuttings as the trench is filled to a point where only the apical bud is above the ground surface. If using black plastic, prepare the soil, mound the soil in ridges, cover each ridge with plastic, and then plant cuttings through the plastic ridge. Throughout the season, keep the

cuttings adequately weeded, watered, and sprayed for insects and diseases. Protection of the foliage is even more important for cuttings than for mature vines, because the development of a large root system is dependent on a limited number of healthy leaves.

Storage. Rooted cuttings can be left in the ground over winter.

However, there is a risk of rodent damage as well as cold damage. Therefore, do not mulch with straw since this will encourage rodents. Rather, hill soil up slightly on rooted cuttings.

Preferably, rooted cuttings should be dug in the fall, graded to size, and then stored either by burying them in well-drained soil (making sure all roots come into contact with soil) or by storing them under moist conditions at about 34° F.

LAYERING. Layering is the surest way to propagate all varieties of grapes, but it is little used except with a few varieties that do not root readily from cuttings. It is, however, commonly used to fill vacancies in established own-rooted vineyards because the young vine, supported by the mother vine, gets a better start than do rooted cuttings.

In layering, a 10-15-inch-deep hole is dug at the location desired for the new vine. A vigorous cane from an adjacent vine in the row is pruned about 3 feet longer than the distance between the vine and the hole. This long cane, or layer, is extended to the bottom of the hole, then bent vertically upward so that two or more buds extend above the soil after refilling the hole. The long cane connecting the new vine to the mother vine should be

stripped of developing shoots when these emerge; shoots should be retained only on those nodes apical to the buried ones. Remove fruit from the layer for the first 2 years.

Do not be overly anxious to cut the new vine from the mother vine. It may take 3 or more years before the new vine is well rooted. One guideline for determining when to sever a layer from the mother vine is to wait until the diameter of the trunk of the new vine exceeds the diameter of the wood leading from the mother vine to the new vine.

TOPWORKING. Recent progress in field grafting of grapevines makes topworking more feasible than in the past. In one trial involving about 15 grape growers, the Kimball process of field grafting had about an 85 percent success rate. Details of this process are available in the publication *Converting Mature Vineyards to Other Varieties*, by Keith H. Kimball, N.Y.S. Agricultural Experiment Station at Geneva, Special Report No. 22. Before attempting any large-scale conversion using this or other exacting techniques, growers should conduct limited trials in their vineyards.

ROOTSTOCKS FOR GRAPES

Although most vineyards in New York are planted with own-rooted vines, grafted vines are sometimes recommended. The primary reason is to provide resistance to phylloxera parasites on the root system. Other reasons for using special rootstocks include nematode parasitism, varietal susceptibility to soilborne virus diseases, an

inadequate fallow period (less than 2 years) before replanting, and varietal susceptibility to lime-induced chlorosis, which is rare in New York viticulture. Additional research on grape rootstocks in progress in New York, other areas of the United States, and foreign countries will expand our knowledge in this area.

The root systems of vinifera varieties are very susceptible to phylloxera damage. Consequently, all vinifera plantings in New York need resistant rootstocks. Research indicates grafted planting stock is also beneficial for the varieties Delaware and Marechal Foch. According to some growers' experience, the variety Ives may also benefit.

The most commonly used rootstock in New York has been Couderc 3309. Kober 5BB and SO₄ have also been successfully used.

Planting the Vineyard

TIME OF PLANTING

Early spring is the safest time to plant grapevines in New York State. On well-drained soils, however, fall-set Concord vines have grown as satisfactorily as those set the following spring. Fall planting is not advisable on fine-textured, imperfectly drained soils because heaving may damage the

young vines. If vines are set in the fall, it is advisable to plow a 4- to 6-inch mound of soil to the base of the young vines immediately after they are set.

PREPARATION OF SITE AND SOIL

Vineyard sites having moderate to poorly drained soil will be improved significantly by artificial drainage. Some sites may have isolated wet areas, but others may require an intensive, complete drainage system. Installation of such a system and other land improvements such as land smoothing can best be done before planting vines. Grapes should not be planted on a site unless soil drainage is, or by artificial drainage can be made to act as if it is, moderately well or well drained. Many varieties, like Delaware and some of the French-American varieties, are much less tolerant of imperfect soil drainage than is Concord.

If soil tests indicate potassium or magnesium is deficient, incorporation of the needed material should be done before planting the vines. Potassium deficiency is almost always a problem when a vineyard is established on a long-term legume (alfalfa, clover) site, unless potassium is incorporated in the soil before planting.

Before replanting a vineyard that has just been removed, the site should be planted to grass or mixed cover crop for a minimum of 2 years to reduce the population of grape root pests, levels of soil

sterilant herbicides used on the previous vineyard, and perennial weeds. Alternatives include fumigation and the use of vigorous rootstocks, but the economic justification for these has not been documented for most situations and will vary with the variety, site, and market outlook.

Soil preparation should include working the soil to a depth of at least 12 inches in the fall preceding spring planting. This can be done by plowing and disking or using large rotovators or both. Deep rotovating immediately before marking the field improves conditions for machine planting.

DIRECTION OF ROWS

Research at the Vineyard Laboratory, Fredonia, indicates small production superiority of north-south rows over east-west rows with nondivided training, such as Hudson River umbrella, at 10-foot row spacing. However, there was no significant difference with Geneva double curtain trained vines.

The slope of the land is the most frequent determinant of row direction. Rows at right angles to the slope (cross-slope planting) in combination with other erosion control practices are usually adequate to prevent serious erosion. However, for steep slopes or highly erodible soils, rows following a drainage grade laid out by local soil conservation district technicians may be necessary to preserve the site for the long life of the vineyard. Such rows will be difficult to trellis, maintain, and

harvest mechanically. Another important consideration is field shape. A row direction that maximizes row length will result in important equipment-efficiency gains over the life of a vineyard as well as reduced end-structure investment and maintenance costs.

PLANTING DISTANCES

Space needed by harvesters, tractors, and other equipment is the dominant factor governing row width. Rows spaced 9 feet apart allow adequate room for all specialized vineyard equipment now in use even with Geneva double-curtain training. A wider row spacing is more convenient, but is certain to reduce per-acre yield potential. Experimentally, highest yields have been obtained with rows 4 1/2 to 5 feet apart. Geneva double-curtain training permits aerial simulation of this spacing.

It is recommended that vines be set 6-8 feet apart in the row, based on a mature vine size estimate for the variety-site-management combination being considered. If small- to medium-sized mature vines are expected, because of low site fertility, variety growth habit, or management intention, vines should be set closer than 8 feet.

The number of vines per acre at various spacings follow:

<i>Distance between rows (ft)</i>	<i>Distance between vines (ft)</i>	<i>Number of vines per acre</i>
9	8	605
9	7	690
9	6	807

MARKING FIELD

Allow adequate headland at each end of the site when marking the field. Thirty feet outside the end posts will permit external anchoring and enable equipment such as mechanical harvesters to turn. Less headland width will reduce efficiency, and more is wasteful of land. If the field is long, 25-foot cross alleys at intervals of 1,000 feet or less are helpful.

There are many ways to mark the field. If rows are to be laid out along a drainage grade, the curved rows are already marked. A transit is helpful in obtaining straight, parallel rows, especially if the rows are long and involve topographic changes or complex slopes. One method of obtaining straight, equally spaced rows is to drive a long white stake at each end of an outside row of the proposed vineyard. Next, drive additional stakes to mark the rows at 9-foot intervals across each end of the field along lines perpendicular to the staked row.

For planting by hand, a tractor with mounted plow is driven as straight as possible between end stakes of each row to make a deep furrow. Except with a V-plow, the furrows should all be made from the same end of the field, or alternating wide and narrow rows may result. A pole, the length of the desired vine spacing, is convenient for spacing each vine in the row. Here again, it is necessary to start spacing vines from a perpendicular line across the end of the vineyard, if you wish the vines to line up across the vineyard as well as in the row.

If a modified tree-planter is to be used for setting the vines, an outside row is staked after soil preparation is completed. Then, starting with this staked outside row, or staked second row, as shown in figure 6, a simple tractor-mounted row marker is driven as accurately as possible to mark the row between the end stakes. These row markers are usually homemade and consist of two telescoping 12-foot sections of 2 1/2- and 3-inch diameter pipe with three marking teeth (cultivator shovels) attached. When extended to 18 feet overall,

this tool can be used to mark three 9-foot rows and, by telescoping, can be used for 6-8-foot vine spacings. The last row marked with each trip across the field becomes the guide for the next trip. After the rows are marked, the field is generally cross-marked so that the machine-planting crew can more accurately space each vine in the row (fig. 6). Other devices, such as timing buzzers, are sometimes used for spacing vines in the row, but are not as accurate as cross-marking the field.

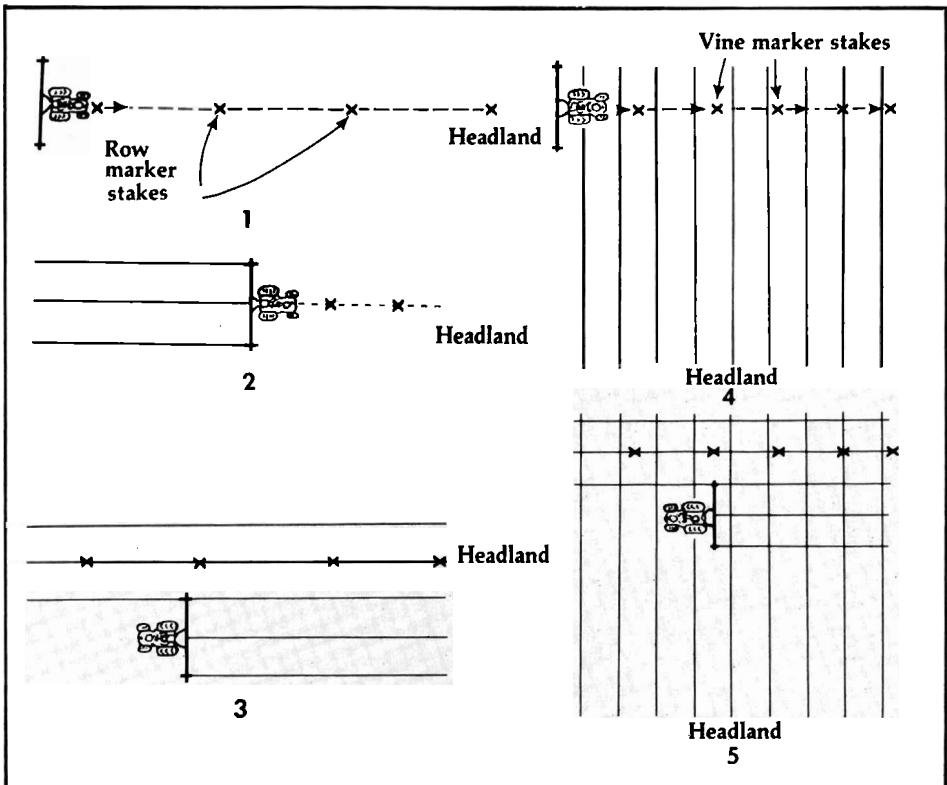


Figure 6. Marking the vineyard. 1, stakes set to determine second row of grapevines; 2, rows 1, 2, and 3 marked as tractor follows row of stakes; 3, other rows marked using last-marked row as a guide; 4, stakes set to determine second vine position in rows; 5, vine positions marked in a similar manner to row positions.

SETTING VINES

Assuming healthy plants with live buds are set, 95–100 percent survival should be routine when three essentials are observed.

- Roots of new vines must be kept moist from the time of removal from the nursery until they are planted and covered with moist soil in the new vineyard. Drying out of the fine fibrous roots due to wind, sun, or contact with dry soil during planting is the most common cause of vine mortality in the first growing season.

All live, undamaged roots on a grape plant should be retained. These roots contain the stored carbohydrates that will start and sustain growth during the first several weeks of new shoot development. Healthy roots should not be pruned off or shortened just for convenience in handling and planting. Top growth can be pruned to the best single cane or to the best two-node spur, depending on the first year's trellising intention.

- All these roots should be set 10–15 inches deep, reasonably spread out, and firmly covered with moist, friable soil. This is possible only if soil preparation has been thorough and deep.

Subsoiling the marked-out rows before planting the vines is beneficial in fine-textured soils with a hardpan within 2 feet of the surface and on sites compacted by prior use or site-preparation activity. Subsoiling not only improves soil drainage and aeration, but also expedites machine planting and the setting of trellis posts.

There are many successful planting techniques. Historically,

and to a limited extent still, planting has been done by hand in a furrow. Vine spacing is measured by a pole or narrow board of the correct length or by a planting wire marked at the appropriate intervals and stretched the length of the furrow. Most planting is now done with commercially available, modified tree-planting equipment. Common features are a tray containing water to hold a small supply of vines; a shoe that opens a narrow, deep furrow; two seats occupied by people who alternate in setting each vine and spreading its roots in the furrow at the correct intervals; furrow-closing discs or hillers; and packing wheels. Planting with this type of equipment is several times faster than by hand in furrows and greatly facilitates keeping the roots moist. Tramping the soil around the new vines immediately after planting is advisable to ensure that the soil is firmed around each plant and that any plant accidentally buried is uncovered.



Figure 7. Modified tree planter showing typical method of planting a vineyard.

MANAGING VINES IN YEAR ONE

Putting fertilizer in the furrow during planting is not advisable because of the danger of injuring roots. It is unnecessary if the soil was properly prepared. If needed, approximately 4 ounces of 10-10-10 fertilizer, or an equivalent, can be applied to the soil surface around each vine immediately after planting. However, the hazard of overfertilization and stimulation of later summer growth with increased susceptibility to winter-cold damage is greater than the hazard of inadequate growth during the first year.

As soon as bud break occurs, the newly set vines, if not pruned before planting, should be pruned to the best single cane. If a trellis is to be constructed early in the first growing season, as recommended, this best single cane should be pruned to a length that will reach the lower wire of the trellis, if possible, to facilitate tying. When the new shoots are an inch or less in length, all but two to four strong shoots near the top of the cane should be rubbed off to promote growth in height.

As the season progresses, the retained shoots should be tied loosely to the trellis for better light exposure, to avoid damage by equipment, and to facilitate pest control. Flower clusters that develop should be removed as early as possible through midsummer. Timely flower-cluster removal, tying, and shoot removal will require two or more trips through the vineyard during early and midsummer, depending on variety.

If no trellis is to be constructed for several months or excess shoot and flower-cluster removal cannot be accomplished in a timely manner, the best cane should be pruned to two buds immediately before or after planting.

Preventing weed competition close to the vines during the first two growing seasons is critical for early profitable vineyard production. Currently there are no recommended vineyard herbicides labeled for use before the fourth growing season.

Cultivation between the rows should commence as soon as weed growth starts; then a 4-6-inch-high mound of soil is pushed up around the vines with a disk or tractor-mounted grape hoe. This soil mound covers and temporarily controls weeds that have already started. When a second crop of weeds germinates, but before the weeds are 4 inches high, a tractor-mounted grape hoe is used to remove the soil mound and weeds growing on it. This "push-up" and "take-away" process may need to be repeated, depending on weed growth and moisture supply; but the growing season should end with a mound pushed up to facilitate weed control the following spring. Hand hoeing close to the young vine may also be necessary.

Trellis

A strong, long-lived, low-maintenance trellis is essential for all training systems used in New York. The trellis is a major long-term vineyard investment. A 1976

New York–Great Lakes Region study showed 2-wire vertical-trellis construction costing approximately one quarter of the total full vineyard development cost, which ranged from \$3,594 to \$4,413 per acre, depending on variety.

All vertical trellises for commercial vineyards in New York are of the same general type: two or three wires, one above the other, stretched tightly on firmly set posts. Two wires are adequate for Hudson River umbrella, umbrella Kniffin, and 4-arm Kniffin, the most common systems; but three wires are necessary for some other training systems. For vine size that is at least average (2–3 lb of cane prunings per 8-ft-spaced vine), the top wire of the trellis should be 5 1/2 to 6 feet above the ground. This permits cane distribution that encourages good exposure to sunlight and facilitates insect and disease control. The bottom wire should be approximately 3 feet above the ground to facilitate mechanical harvest. Yield comparisons between vigorous, large vines on trellises 4 feet high and 5 1/2 feet high have shown higher yields and higher soluble solids from vines on the higher trellises.

Geneva double-curtain (GDC) training requires one trunk support wire plus two horizontal and parallel cordon-support wires, positioned 4 feet apart (for 9-ft rows) and 6 feet above the vineyard floor on metal or wood arms attached to the line posts. The arms are usually bolted to the line posts, inclined upward at about a 35° angle and are free to move vertically up at their outer ends for mechanical harvesting. Row

spacings of less than 9 feet will necessitate reduced space between cordons to permit harvester and other equipment use without excessive damage. GDC arms of various designs are commercially available or can be homemade; however, because of the 35° angle, 26-inch arms are needed, with 3-inch posts, to obtain 4 feet between cordon-support wires.

POSTS

Posts serve two functions. The intermediate or line posts provide vertical support for the trellis wires. Although the end posts support the wire, too, their main purpose is to provide anchor points for tightening and maintaining wire tension.

Cost per year of service is the basis on which posts should be selected; therefore, they should be strong and either naturally durable or treated with chemical preservatives. Steel or reinforced concrete posts may be satisfactory, but are not as commonly used as wooden posts. Wooden posts that have been correctly commercially pressure treated with creosote, †chromated copper arsenate (CCA), or pentachlorophenol are excellent and should last well over 20 years.

Farm-cut posts from some native tree species can also be used successfully in New York vineyards, but most species require preservative treatment to be economically competitive with good

†Restricted-use chemical; permit or certification required for purchase, possession, or use.

commercially treated posts. On-the-farm treatment with pentachlorophenol and fuel oil, according to label directions, will about double the vineyard life of most native species. Nondurable species such as ash, maple, elm, larch, and pine may give a post life of 5 years or less without treatment. Such use is uneconomical, because of frequent installation costs, even if the posts are considered free. Even normally rot-resistant tree species such as red or white cedar and black locust may fail in 7-10 years if fast growing trees with little heartwood are used. In recent years, the preference for round posts, which are more uniform, easier to handle, better adapted to GDC arm installation, and do not require splitting, has encouraged the cutting of younger, smaller-diameter trees with less heartwood. Another possible cause for early failure of a black-locust post is insufficient seasoning before setting in the vineyard. More details on the use of native tree species and preservative treatments can be found in *Vineyards and Posts*, *Conservation Circular*, Vol. 12, No. 2, (N.Y.S. College of Agriculture and Life Sciences, Ithaca, 1974). This is available from your Cooperative Extension office or the Department of Natural Resources, Cornell University.

LINE POSTS

Line posts should be 8 feet long with a minimum top diameter of approximately 3 inches. They should be driven or set 24 to 30

inches in the ground, depending on the trellis height desired. Tractor-powered post-hole augers and post drivers are used for installing posts. Line posts are usually spaced so that there are three or four vines between posts; the exact distance between posts varies, depending on vine spacing, but should not exceed 24 feet, if excessive sagging of the crop-supporting or cordon wire is to be avoided.

END STRUCTURES

End structures should not move when the trellis is subjected to the stress of large crops, wind, and wire contraction in cold weather. If movement occurs, the result will be crooked trunks, sagging cordons, less-efficient mechanical harvest, and the need for retensioning trellis wires. Therefore, end posts should be larger than line posts and, preferably, longer so that they can be set 3-4 feet in the ground, and should be anchored or braced. Eight-foot, round, pressure-treated posts with a top diameter of 4 inches have been satisfactory for single-curtain-trained vines when secured to an external anchor (fig. 8). However, if Geneva double-curtain training is a possibility, larger posts are advised.

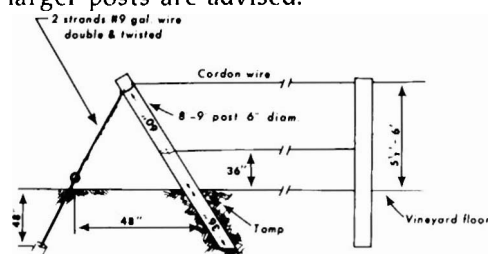


Figure 8. Specifications for a recommended end-post anchoring system.

The stability of an end post is increased by driving or setting the post so that the above-ground part is angled away from the vineyard at about 30° from the vertical, reducing the height of the top wire at the end post, and bracing or, preferably, anchoring it. A common method of bracing uses an extra line post to extend obliquely from a point midway up the end post to the base of the first line post. The outside angle formed by the end post and the brace should be at least 135° to avoid a lever effect, which may lift the end post from the ground when the top trellis wire is tightened. The brace should be spiked or otherwise secured in place, or mechanical harvesting is likely to dislodge it. Braces are advantageous if headland is limited, but will sometimes interfere with mechanical-harvester collector plates.

Anchors are generally superior to bracing, even though they are susceptible to damage by equipment. There are many types of anchors: screw-in anchors, a metal plate welded to a steel shank, and a concrete dead-man attached to a steel shank or heavy wire are all common. Buried railroad ties and old gas or oil line pipe have also been used successfully. Screw anchors, 4–6 inches in diameter, are the most popular and, with a simple adaptor, can be screwed in with tractor-mounted post-hole augering equipment in most soils. Anchors that require augering holes or ditching should be installed before the ground freezes in the fall. The soil is permitted to settle and pack before the connecting guy wire, cable, or rod is attached to the post, and the trellis wire is tensioned the

following spring.

The anchor should be installed 4 feet away from the base of the post. It should be placed at a 45° angle toward the end post and aligned with the row to minimize interference with equipment entering and leaving. The holding resistance of the anchors will vary by type, size, depth, soil type, and other factors. A minimum depth of 4 feet should be the goal and has generally been adequate (fig. 8).

WIRE

The most generally used crop-support wire before about 1970 was No. 9 (steel wire gauge) black annealed wire. However, the development of Geneva double-curtain training and the increased use of it and other cordon training systems, as well as the need to reduce labor, require a more-durable wire. The wire must retain its tension without annual tightening, provided the end structures do not move. New York research found that a No. 11, crimped, high-tensile (210,000 psi) steel wire, with class III galvanizing, most economically met this need. It is now available in all the important grape districts. The larger No. 10 wire of the same type is also available and widely used, but No. 11 is adequate.

The lower wire on the trellis is an aid in maintaining straight trunks, tying up trunk renewal canes and shoots, and securing (tying) the ends of canes to enhance cane distribution on the trellis. The stress on this wire is much less than on the crop-supporting wires;

so it can be of lower tensile strength and cost. No. 9 black annealed wire is satisfactory for the lower wire; however, uncrimped (straight) No. 11 or 12 galvanized fence wire is more durable and is recommended because it reduces wire chafing on 1-3-year-old trunks.

The weight of wire needed for an acre depends on wire size, row number, row spacing, and the amount of waste. For a 9-foot row spacing there is approximately 4,900 feet of wire needed per acre for *each* trellis wire. Thus, a two-wire trellis will require about 9,800 feet of wire.

The weight of wire of various sizes required for one strand per acre is given in table 1.

TABLE 1. STATISTICS FOR GAUGES OF WIRE TYPICALLY USED IN TRELLIS CONSTRUCTION

<i>Size of wire (No.)</i>	<i>Approx. ft/100 lb</i>	<i>Approx. lb/A for 1 wire with 9-ft rows</i>
12 straight	3,436	143
11 straight	2,632	186
11 crimped	2,584	190
10 straight	2,079	236
10 crimped	2,000	245
9 straight	1,730	283
8 straight	1,443	340

WIRE INSTALLATION

The high-tensile No. 11 or 10, crimped, crop-support wire should be installed 5 1/2 to 6 feet above the vineyard floor. For nondivided training systems, such as Hudson River umbrella, on well-drained soils where heaving of posts is unlikely, this wire can be stapled

loosely to the top of the line posts with 1-1/4- to 1-1/2-inch fence staples. On more poorly drained soils, alternate freezing and thawing usually cause heaving, which necessitates periodic repounding of the posts. Here wire can be stapled in a groove in the top of the post or should be stapled loosely to the windward side and 2-3 inches below the top of each line post with 1-1/2- to 1-3/4-inch fence staples. Staples should be driven into the posts far enough to hold the wire close, but not so tight as to prevent drawing the wire through the staples for tensioning or retensioning, in the event end structures move or the wire stretches. The lowest wire of a nondivided trellis is similarly stapled to the line posts at a height of 30 to 36 inches from the vineyard floor. If there is a third wire, it is typically located midway between these two.

For Geneva double-curtain (GDC) training, the two cordon and crop-support wires are attached at the ends of the supporting arms by metal clips, hooks, or chain links, depending on arm design. First, however, the arms should be secured to the line posts at a height that will position the taut wires 6 feet above the vineyard floor. A lower wire height will reduce training and pruning options and result in machinery damage to cordons and vertical arms. A higher wire will reduce the harvesting efficiency of current mechanical harvesters. The trunk-support wire should be loosely stapled to the line posts, either just above or just below the point of arm attachment. Vine trunk training for efficient pruning mechanization and vertical

movement of the arms during mechanical harvesting requires this high trunk-support wire.

WIRE TENSIONING

The most common devices for tensioning the wire are the cable or rope and pulley "come-along," and the bumper-jack types.

Taut trellis wires are necessary to minimize sagging cordons, crooked trunks, and excessive vine damage from equipment passage, as well as to maximize mechanical-harvesting efficiency and the potential for pruning mechanization. However, even high-tensile wire can be excessively tensioned, and the yield point of the wire exceeded. If this occurs, wire life will be shortened, and annual maintenance increased. New York research indicates that 250–300 pounds' tension is adequate.

ATTACHING WIRE TO END POSTS

After each wire is tensioned and before the tensioning device is released, the wire must be fastened to the end post. Probably the most common method is to wrap the end of the wire tightly around the end post once or twice and then around the taut wire several times to secure it. Other methods involve drilling holes through the end post and passing the taut wires through the holes, each wire then being secured by a small crank (fig. 9), a washer and splicing sleeve, or other device.



Figure 9. L-shaped cranks made from 1/2-inch steel rods provide a simple, rapid method to tension wires.

Vegetative Growth and Fruiting of Grapes

VINE TERMINOLOGY

The habit of growth and the fruiting of grapevines must be understood to comprehend various vineyard operations. The following terms describe the parts of the vine and related concerns:

Apical. The youngest (last-formed) portion of a vine part, i.e., *shoot, cane, cluster.*

Arms. The major branches of the trunk on which *canes* or *spurs* are borne.

Basal. The older (first-formed) portion of a vine part, i.e., *shoot, cane, cluster.*

Base shoot (formerly referred to as a

watersprout). A *shoot* from a *bud* at the base of a *cane* or previously removed shoot or cane. It may be found on *trunks*, *cordons*, *arms*, and at the base of canes. It is often extraneous and, unless needed for renewal or fruiting, should be removed during the process commonly referred to as "*suckering*."

Bud. A compressed *shoot*. In the axil of each leaf is the compound bud or eye containing the primary, secondary, and tertiary buds.

Calyptra. The petals of a grape flower. The petals are usually green and surround and cover the *stamens* and *pistil*. They are fused together at their tips to form the "cap."

Cane. A mature woody *shoot* after leaf fall.

Canopy. The entire *shoot-leaf* complex of the vine; it can be defined in terms of its height, width, and division.

Chlorosis. Yellowing or blanching of the normally green parts of a plant by causes other than the absence of light.

Cordon. Extension(s) of a *trunk*, usually horizontally oriented and trained along a wire. Fully developed cordons can bear *arms*, *spurs*, *base shoots*, and *canes*. The cordon can be unilateral or bilateral, i.e., it can extend from the trunk in either one or two directions, respectively. Both Geneva double curtain and Hudson River umbrella trained vines have cordons.

Curtain. A length of *canopy* that is shoot positioned. The curtain can constitute a portion of the canopy as for Geneva double-curtain training, or can be synonymous with the canopy as for nondivided *cordon-training* systems (single

curtain).

Floret. Individual flower of a cluster.

Full bloom. When the *calyptras* have fallen from approximately one-half of the *florets* on the *basal* clusters of the *primary shoots*. During warm, sunny, and dry conditions, a grape vine can go from prebloom to full bloom during a 48-hour period; however, under normal field conditions grapes usually bloom over a period of 3 to 10 days. Concord full bloom normally occurs about mid-June in New York.

Head. The top of the *trunk* and short upper *arms*.

Inflorescence. The flower cluster that develops opposite leaves at one or more of the *basal* eight *nodes* of a *shoot*. *Primary* shoots of many New York varieties usually bear fruit opposite leaves at the basal fourth and fifth nodes.

Internode. The portion of a *cane* or *shoot* between *nodes*.

Lateral. A branch of a *shoot*. It may be less than 1 inch long or more than 4 feet long. If mature, it is called a persistent lateral *cane*.

Necrosis. The localized death of plant tissue characterized by brownish or black coloration.

Node. The thickened part of the *shoot* or *cane* where the leaf and its compound *bud* are attached.

Pedicel. The stem of an individual flower or berry.

Peduncle. That portion of the *rachis* extending from the *shoot* to the first branch of the cluster.

Petiole. The stem portion of a leaf. The expanded portion is the blade. Petioles are the tissue of choice for analysis to determine fertilizer requirements.

Phenology. Stages of plant development. See figure 10 for vine phenological stages.

Pistil. Female parts of the flower.

Pollination. Transfer of pollen from *stamens* to the surface of a receptive *stigma*. Cultivated varieties of grapes are normally self-pollinated. Insects are not required for pollination.

Primary. The largest *bud* or *shoot* at each normal leaf *node* of the *cane* or *spur*. *Primary* shoots normally produce most of the crop.

Rachis. The main axis or stem of a cluster.

Secondary. The second largest *bud* or *shoot* at each normal *node* of the *cane* or *spur*. If the *primary* shoot is destroyed, one-third to one-half of a normal crop can be produced by the secondary shoot of most varieties.

Shatter. A period, usually 7–10 days after *full bloom*, when ovaries that will not develop into berries fall from the cluster. Normally only 20–30 percent of Concord *florets* develop into berries.

Shoot. A green growth from a *bud* of a *cane*, *spur*, *cordon*, *arm*, or *trunk*. A shoot always bears leaves and *tendrils*; it may bear fruit.

Soluble Solids. All the dissolved substances in grape juice. For grapes this is frequently measured by a refractometer and is used to approximate sugar concentration.

Sprouting. See *Suckering*.

Spur. A *cane* pruned to four or fewer *nodes*. A renewal spur, of one to two *buds*, is chosen to produce *canes* at a particular location on an *arm* or *cordon*. A fruiting spur is chosen to produce fruiting *shoots*.

Stamen. Male parts of the flower, which produce pollen.

Stigma. That part of the *pistil* to which pollen adheres and on which it germinates.

Sucker. A *shoot* from a *bud* below ground.

Suckering. Removal of *suckers*. Growers commonly and erroneously refer to the removal of both suckers and unwanted *base shoots* as “suckering” or “sprouting.”

Tendril. A long, slender, curled structure at some of the *nodes* of a *shoot*. It can firmly attach the shoot to a support.

Trunk. The relatively permanent above-ground, usually vertically oriented stem of the vine. There may be more than one trunk per vine.

Veraison. The time when grape berries begin to ripen as indicated by color change.

Vigor. Rate of *shoot* elongation.

Vine size. Weight of *cane* prunings on a vine.

FLOWERING AND FRUITING

Grape clusters start to form approximately 15 months before harvest, that is, in June and July of the year previous to their harvest. Cluster initiation begins in the primary and secondary buds in the axil of each leaf. The variety, the climate of the growing season, and the amount of light to which the leaves are exposed will affect the number and size of clusters per shoot the following year. To a large extent, the ability of a given

training system to produce large crops depends on the extent to which the development of these buds is enhanced.

Each primary shoot will bear approximately three clusters of fruit; the number may vary from one to five. A shoot from a secondary bud will usually be less fruitful in both number and size of clusters than a primary shoot. Base shoots on labruscana varieties are usually barren of fruit in contrast with base shoots on French-American varieties and vinifera varieties, which tend to be fruitful.

The flower clusters of primary Concord shoots normally have between 50 and 150 florets depending on the spring climate of the fruiting year and the carbohydrate storage of the previous year. This inflorescence is green and relatively inconspicuous. The Concord variety at Geneva and Fredonia normally blooms around June 15 to 18, depending on spring temperatures.

Grape flowers are shown in figure 10j. Each floret consists of five rather inconspicuous green petals, which are fused at their tips and form the calyptra ("cap"),

surrounding the five stamens and the pistil. The floret blooms when the cells at the base of the petals rupture and the "cap" is shed.

Fruit set in grapes requires the following four steps: (1) pollination—the shedding of the pollen and its movement from the stamens to the stigma of the pistils; (2) pollen germination—the growth of the pollen tube through the stigma and style into the ovules of the pistil; (3) fertilization—the fusion of the gamete (male cell) from the pollen grain with a gamete (female cell) from the ovule; and (4) the start of seed formation in the grape ovary. In seedless varieties the seeds start to form and then abort. One may detect the remnant of one or more seeds in seedless grapes. Seeded grapes require the development of one or more seeds in each berry. The size of a seeded grape is characteristic of the variety and is directly related to the number of seeds per berry.

Fruit set and shatter are not completely understood. The percentage of Concord flowers that set varies widely, but, for balanced-pruned vines, receiving currently recommended viticultural practices,

TABLE 2. COMPONENTS OF YIELD FOR CONCORD GRAPES GROWN IN THE CHAUTAUQUA-ERIE AREA, 1969-79

Component	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Avg.
Nodes/vine	46	44	48	43	46	48	47	55	59	63	54	50
Clusters/vine	84	109	100	86	74	95	89	114	76	120	107	96
Clusters/node	2.35	1.93	2.7	1.9	1.7	2.0	1.9	2.0	1.3	1.9	2.0	2
Berries/cluster	24	36	36	31	35	42	33	35	28	29	37	33
Wt.(g)/berry (30-35 days after bloom)	NA	NA	NA	1.1	1.3	1.0	1.5	1.4	1.5	1.2	1.2	1.28
Seeds/berry	NA	NA	2.0	1.8	2.0	1.9	2.0	1.9	1.5	1.9	1.7	1.86

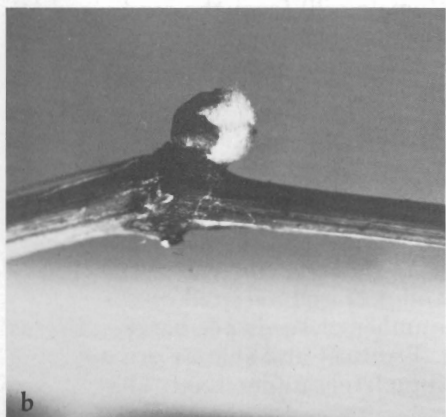
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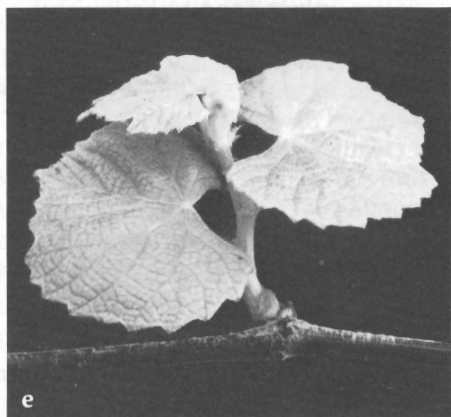
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d



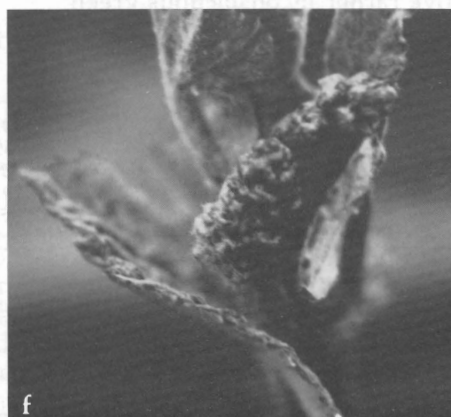
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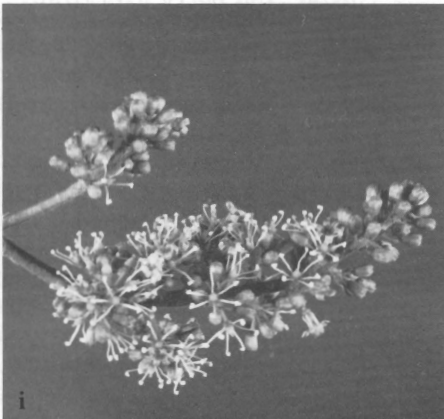
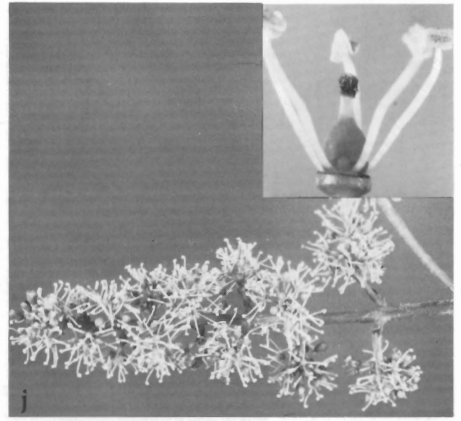
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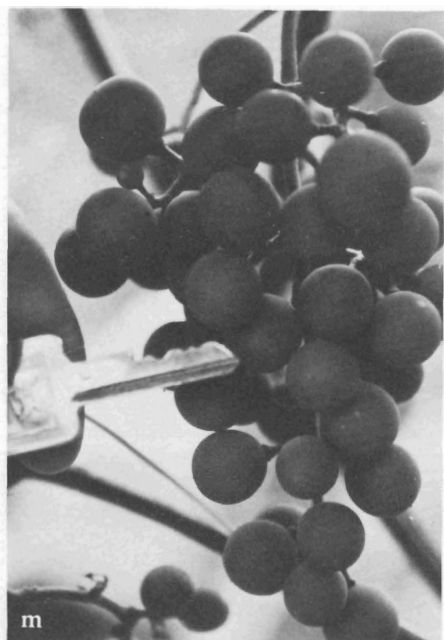
Figure 10. Growth stages of the grapevine.
a, dormant bud; *b*, early bud swell;
c, advanced bud swell;

d, bud burst; *e*, three flat leaves; *f*, visible clusters;



g, separated clusters; *h*, separated flower buds; *i*, midbloom (50% calyptra fall);

j, late bloom (90% calyptra fall); *j*, inset, individual flower without calyptra; *k*, fruit set; *l*, developing berries 2 weeks following bloom;



m. berry touch state; *n.* berries just following veraison.

averages about 30 percent. Factors affecting percentage of set include the environmental conditions before and during bloom, the supply of stored carbohydrates, and carbohydrate competition among florets within the flower cluster as well as between the flowers and elongating shoots. Flowers that are not pollinated will not set, but pollination is not a guarantee of fruit set. Even some berries that have begun to form seeds may shatter.

Substantial annual variability within a variety in grape-cluster number and size may occur, depending on climate, light exposure, and cultural practices during the season previous to harvest, as well as during and after bloom in the year of harvest. These large fluctuations in crop size significantly affect grape marketing and grape-growing profitability.

Since the mid-1960s, processor field representatives in the Chautauqua-Erie district have participated with Cooperative Extension in an annual collection of node, cluster, and berry data from approximately 100 *commercial* Concord vineyards. The objective is to obtain reliable crop-size information by midsummer. These data are summarized in table 2 (p. 21) for the period 1969-1979. For this 11-year period, growers retained an average of 50 nodes per vine when pruning; these nodes produced 96 clusters and set 33 grape berries per cluster. Grape berries averaged 1.28 grams 30 to 35 days after bloom and had 1.86 seeds.

Methods of Training Grapes

DISTINCTION BETWEEN PRUNING AND TRAINING

Pruning is the act of removing parts of a plant. It is done to regulate crop size and quality and also affects the quantity, quality, and location of vegetative growth. In New York viticulture, the term usually refers to the removal of canes during the dormant season and involves consideration of the quality, number, and distribution of the retained buds. It can also refer to growing-season pruning of shoots and root pruning. The degree or severity of dormant-season pruning of canes can be described by the number of nodes retained per unit of vine growth.

Training means shaping the vine, the arrangement of the vine on the trellis. It determines shoot arrangement to the extent that it positions the bud or base of the shoot. Its purposes are to position the annual shoot growth so that leaves receive optimum exposure to light, to position fruit for ease of pest control and harvest, to minimize tying labor, and to maximize dormant-pruning efficiency. On an annual basis, selecting well-exposed canes and using the proper severity of pruning are far more important than the choice of training system. But the choice and maintenance of a desirable training system are the

best long-term means of producing and distributing high-quality fruit buds on the trellis and will significantly influence growing-season labor as well as the mechanizability of the dormant-pruning operation.

MULTIPLE TRUNKS

Two or more trunks are recommended for all New York vineyards because the risk of trunk damage is high from winter injury, eutypa dieback disease, or mechanical injury. Routine trunk renewal is advised at 10–15-year intervals. Figure 11f shows a vine with multiple trunks. The second trunk should originate at or below the ground level on vines grown from rooted cuttings and above the union on grafted vines; it develops from a sucker or a low base shoot of the first trunk. The weight of cane prunings from all the trunks of a vine are included in determining the number of nodes to retain at pruning. When a trunk is removed, the correct number of nodes should be retained on the canes of the remaining trunk(s).

Although the maintenance of healthy vines is a major reason for double trunks, they also aid in cordon renewal and, with head-trained systems like umbrella Kniffin, in distributing the canes and developing shoots over all the available trellis between vines.

To reduce mechanical harvesting losses, double trunks should be trained so as to minimize the opening of the harvester fruit-collecting mechanism around the trunks. Minimum loss will occur

with straight trunks tied closely together to a height of 3 feet above the vineyard floor so that the harvester-collector leaves will open briefly only once for each vine. Above 3 feet, trunks can be spread to aid in cane distribution and trellis utilization.

CURTAIN NUMBER PER ROW

A curtain is formed when the shoots are positioned vertically downward and are suspended from one wire as with shoot-positioned Hudson River umbrella and Geneva double curtain trained vines. In a row of umbrella Kniffin-trained vines, the direction of shoot growth is random; this classical way of training grapes is an acceptable method for vines whose size and vigor is too low to fill the trellis with leaves by mid-August. Because excessively large, vigorous vines with shaded renewal areas do not produce well, their size must be reduced or their light exposure improved by providing more trellis space, by shoot positioning, or both. More space can be afforded by training each row of large vigorous vines to form two curtains, as in Geneva double-curtain training. This relatively new system is effective and, when properly managed, can increase the yield of high-quality fruit on large vigorous vines 2-3 tons per acre. It is especially applicable to rows spaced 9 feet apart and to vines whose cane pruning weight is 3 or more pounds at a spacing of 8 feet or less in the row. More details are available in a later section.

SHOOT POSITIONING

Shoot positioning is a research-developed procedure for increasing the light exposure of leaves on the basal portion of shoots originating from the cordons of top-wire cordon-trained vines, as with Hudson River umbrella and Geneva double-curtain training. This enhanced light exposure of the renewal area increases bud fruitfulness, improves fruit set, and hastens crop and shoot maturation. Shoot positioning is particularly useful with large vines of varieties that have large leaves and a drooping-shoot growth habit. Examples are Concord and Niagara. Shoot positioning has also been used successfully with vigorous Catawba, Delaware, De Chaunac, Marechal Foch, Seyval, and other top-wire cordon-trained varieties. It is essential for Geneva double-curtain training.

The shoot-positioning procedure is as follows: (1) During the 4-week period commencing with grape bloom, all vigorous horizontally growing shoots are placed in a vertically downward position, so that the light exposure of leaves at the basal four to six nodes of fruiting and renewal shoots will be improved. (2) For Geneva double curtain, all vigorous shoots growing into the center area between the cordons must also be pulled down to maintain two separate curtains of foliage and permit light penetration to their inner sides. Although shoots can be positioned so that more than four to six nodes have an enhanced light environment, this excessive

positioning should be avoided since it will result in a loss of vine size and, hence, capacity for high production.

The earlier shoot positioning is accomplished within the bloom to early postbloom period, the greater its effect on fruit-bud initiation and development. Shoot positioning during bloom is not harmful; however, shoot positioning significantly earlier than the start of bloom usually results in excessive shoot breakage, and the effect on shoot direction may be negligible. Maximum benefit from shoot positioning with minimum cost is most likely with an early start and more than one trip through the vineyard. Depending on vine size and vigor, plus timing, shoot positioning may require from 20–30 hours per acre. However, substantial mechanization of this procedure has been commercially accomplished.

TRAINING YOUNG VINES

The primary objectives in training a young vine are the development of a large, healthy root system and straight, semipermanent trunks. The shaping of the above-ground parts of the vine, according to a particular training system, is of secondary importance. During the first and second growing seasons, these objectives can be accomplished by eliminating or reducing the crop and increasing the leaf area. The same treatment rejuvenates very weak vines (pruning weight of 1/2 lb or less) of any age.

First year: Treatment of the vine

during the first year in the vineyard has been discussed under “Setting Vines” (fig. 11a).

Second year: During the dormant period following the first growing season, the best cane should be retained to form one trunk to the top wire if possible (fig. 11b). At the time of bud burst, 6 to 10 shoots should be retained on the upper portion of this single trunk if training systems such as umbrella Kniffin, Hudson River umbrella, or Geneva double curtain are being considered, or at the proper position for arms of other training systems. All other shoots should be removed so that the growth will be concentrated in shoots located in positions most useful for future training.

During the second growing season, all the flower clusters should be removed from the growing shoots as soon as they develop. This, of course, eliminates the crop for that year, but ensures greater development of the vine’s roots and top.

Third year: Vines that have grown enough to produce 3/4 pound or more of prunings during their second year should be balanced pruned, as shown in figure 11c, and fruited in the third year. However, it is important that these immature vines have the flower clusters thinned to prevent overcropping. Balanced pruning and flower-cluster thinning are discussed in a later section under “Controlling Size of Crop.”

A second cane, preferably a sucker, should be pruned to the bottom wire as also shown in figure 11c. All but two or three shoots near the top of this cane should be removed shortly after shoot growth

commences; it will become the second trunk.

When vines produce less than 3/4 pound of prunings in their second or subsequent growing seasons, the second-year treatment should be repeated: flower clusters should be removed to promote a larger growth of the vine.

TRAINING MATURE VINES

There are many different training systems, and no one system is best for all varieties under all circumstances. Research and experience demonstrate that medium to large vigorous vines of Concord and some other varieties

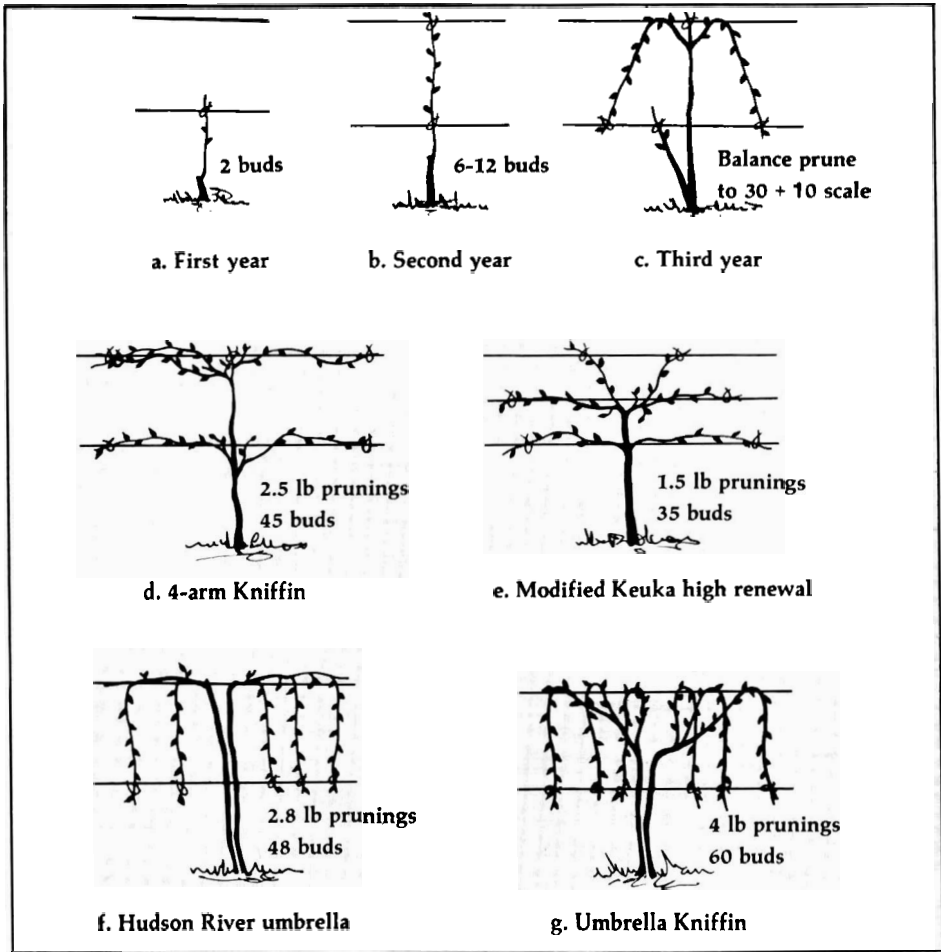


Figure 11. Grape training systems; (a-c) young vine being trained to umbrella Kniffin system with double trunk, mature vines being trained to (d) four-arm Kniffin system, (e) modified Keuka high renewal system on top two wires, (f) Hudson River umbrella, and (g) umbrella Kniffin system.

yield better with Hudson River umbrella or Geneva double-curtain training; four-arm Kniffin and other training systems are acceptable for smaller vines. How should the choice be made?

The following considerations should help evaluate training systems for any variety:

- Systems that place the basal five or more nodes of renewal shoots (next year's fruiting canes) in shaded locations are inferior, except in situations where maximum productivity may be excessive.
- Vigorous vines of varieties with large leaves and drooping shoots, such as Concord, Niagara, and Fredonia, should have the head or cordons (renewal area) of the vine at the top wire; varieties with upright growing shoots and small leaves can better tolerate having the renewal area at the middle wire of a three-wire trellis, as with modified Keuka high renewal, because light penetration is greater with these varieties.
- Cane bending, as with correctly tied umbrella Kniffin, tends to encourage uniform bud break along the cane and thus increase the crop. It is unsuitable for weak vines of any variety, but is good for vigorous vines of varieties such as Concord, Catawba, Elvira, and Fredonia.
- Foliage should be uniformly distributed along the trellis and over its full height to a depth of not more than one and one-half to two layers of leaves for effective exposure to sunlight.
- When, with good cane distribution, the number of layers of leaves exceeds the foregoing criteria, the exposure to light of leaves of nondivided top-wire-

cordoned vines (as with Hudson River umbrella training) and the yield of high-quality fruit from these vines can be improved by shoot positioning and, if cane prunings average more than 3 pounds per 8-foot-spaced vine, by conversion to Geneva double curtain.

- Where vine size is small, that is, less than 2 pounds of cane prunings per vine with 8-foot spacings, or when in doubt about site, variety potential for filling the trellis with shoots and leaves, or variety adaptability to various training systems, modified Keuka high renewal and four-arm Kniffin are acceptable choices. From these the vineyardist can readily convert later to umbrella Kniffin, Hudson River umbrella, or Geneva double curtain.
- Pruning-mechanization research by Cornell University on the variety Concord has found *only* top-wire cordon-training systems adaptable to this procedure.

GENEVA DOUBLE CURTAIN

Geneva double curtain is a relatively new training system developed by researchers of the Geneva Agricultural Experiment Station to increase the number of grape leaves that can be effectively exposed to sunlight. It is primarily useful in vineyards where, because of vine size and spacing, single-curtain training systems, even with shoot positioning, do not adequately expose sufficient leaf area to sunlight for optimum use of vine capacity. Geneva double curtain (GDC) doubles the length of cordon per row and thus the number of shoots that can have the leaves at

their basal four to six nodes adequately exposed to sunlight. Vigorous vines of large-leaved varieties with a drooping-shoot growth habit and annual cane prunings of 3 or more pounds, at 8-foot spacing, may give the greatest economic response. However, somewhat smaller vines, as well as many varieties with an upright-shoot growth habit have also responded to GDC training with economically significant yield increases and improved vine and fruit maturation.

GDC requires a three-wire trellis consisting of two horizontal cordon-support wires, plus a single trunk-support wire (fig. 12). The cordon-support wires should be 6 feet above the vineyard floor and 4 feet apart.

Vines are cordon trained and are short cane (4-6 nodes) pruned.

Once the horizontal cordons are established, the short fruiting canes can be selected from basal nodes located anywhere within the 360° circumference of the cordon (called 360° pruning) or from only the lower 180° (called 180° pruning) or from nodes of very short (1-3 node) vertical arms originating within the lower 180° of the horizontal cordon (fig. 12). To establish the cordons, the elongated trunks of a vine are passed behind and loosely secured to the trunk-support wire with plastic or twine ties. They are then brought up and out to a cordon-support wire and similarly secured. The cordons are formed by extending the trunks in opposite directions along the cordon-support wire. Each 6-8-foot cordon should be secured by two to four wraps around the support wire, plus a tight wire tie at its end. Continuous

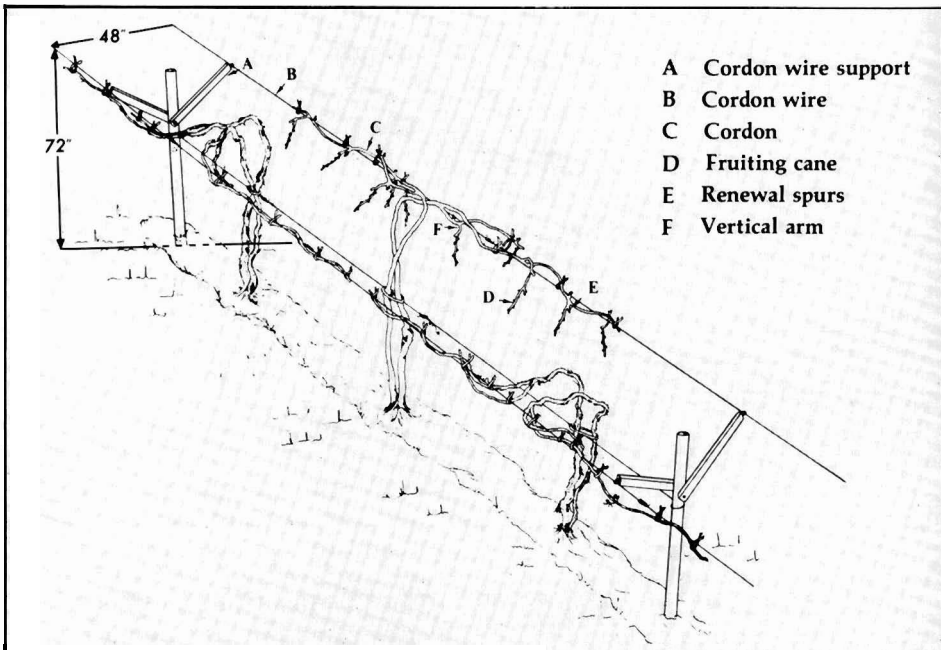


Figure 12. The Geneva double-curtain training system.

contact of the cordon with the support wire is the goal and should be maintained for the entire length of the cordon for maximum mechanical-harvesting efficiency. Though not essential to give the double-curtain effect, it is recommended in New York that vines in the row be *alternated* to the left or right cordon-support wires.

Once the horizontal cordons are established, the development of 10-12 equally spaced, downward growing, *short* vertical arms per vine, from which the fruiting canes will originate, significantly reduces annual shoot-positioning labor and cost. Care must be exercised to maintain taut cordon-support wires and a fruiting-cane renewal area 5-5 1/2 feet above the vineyard floor for efficient mechanical harvesting and the least damage caused by the passage of other essential equipment between the rows.

FOUR-ARM KNIFFIN

The four-arm Kniffin system was formerly used extensively for American varieties. It is used much less today because on vines of adequate size, the lower arms suffer from excessive shade, resulting in weak, unproductive growth. In addition, because canes are tied horizontally along the wires, mechanical harvesting is less efficient and often causes excessive damage to the vine. A two-wire trellis is required. The top wire should be 5 1/2 to 6 feet high, and the second wire should be 3 feet above the vineyard floor. At each pruning, the required node number

is retained on two to six canes, plus renewal spurs (fig. 11*d*). The canes arise from four arms on a single trunk or two arms per trunk on vines with double trunks. The canes extend horizontally along the wires from the trunks and arms toward adjacent vines. Cane length may vary from 8 to 12 nodes, depending on variety, cane vigor, and vine spacing.

If more than four canes are needed to obtain the proper node number, the extra canes should be chosen from those growing along the top wire. On vines with less than 1 pound of prunings, the appropriate number of nodes can be retained on two or three canes, and renewal spurs left at the other arms.

The shoots at the ends of horizontal canes usually make the most growth. To increase the number and the vigor of the shoots originating near the trunk, a renewal spur should be retained near the base of each cane.

To train young vines to this system, a straight cane is brought to the top wire as soon as the vine produces one of sufficient length; this may be at the end of the first, second, or third growing season. This cane becomes a trunk, which should be renewed every 10-15 years. Consequently, it should be tied firmly enough to the top wire for it to remain straight. The trunk ties to the lower wires should be loose.

UMBRELLA KNIFFIN AND HUDSON RIVER UMBRELLA

Since in the four-arm Kniffin system the canes along the top wire

bear most of the crop, the bottom two arms can be removed if enough buds are retained on canes originating below the top wire (fig. 11g). This head-trained system is called the umbrella Kniffin because the shape of the vine, both trunks and canes, when tied, resembles an open umbrella (figs. 11 and 13). It is recommended for Concord, Niagara, Fredonia, and Elvira. The same type of trellis is used as in the four-arm Kniffin system.

A mature vine pruned and trained to the umbrella Kniffin system consists of a single or double trunk headed 6 to 12 inches below the top wire, with one to six

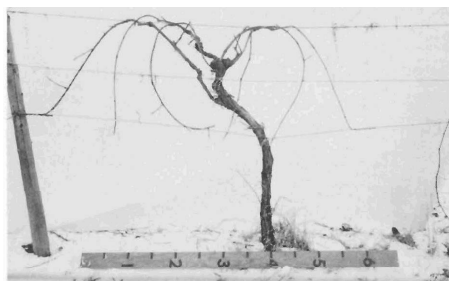
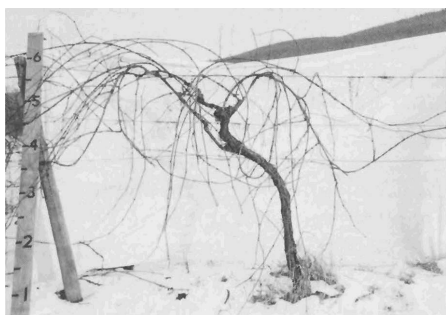


Figure 13. *Top*, an unpruned vine. *Bottom*, a pruned vine trained to the umbrella Kniffin system. The pruned vine had 60 buds; one-year prunings of the lower vine amounted to 4.0 pounds.

canes per vine arising from the head or heads. Each cane may have 8 to 15 buds. The canes are bent sharply over the top wire. They extend down to the lower wire to which they are tied. The shoots that arise basal to the bend are usually vigorous and are excellent to retain for fruiting the following year.

Approximately the same number of renewal spurs as fruiting canes should be left at the head of the trunk. For maximum exposure of leaves of medium to large vines, the canes should be tied to use all the trellis space between vines.

A young vine is trained to the umbrella system by bringing a cane to the top wire as soon as the vine produces one of sufficient length; this may be at the end of the first, second, or third growing season. The following year canes and spurs that originate 6 to 12 inches below the top wire are selected. These canes are bent sharply over the top wire and tied at the bottom wire. The arms at the head of mature umbrella-trained vines are usually less than 1 foot in length.

Hudson River umbrella is a modification of umbrella Kniffin that extends the arms along the top wire halfway to the next vine. From these longer arms, more properly called cordons, arise spurs and canes, which grow or can be bent vertically downward and tied to the bottom wire, if necessary, to obtain good cane distribution over the trellis. This is a productive and recommended training system for medium to large Concord vines and many other varieties. It reduces shading in the renewal area and facilitates full utilization of the trellis. With 180° pruning (fig. 11f)

and shoot positioning, little or no tying of cane ends is needed for good cane and bud distribution on the trellis. Hudson River umbrella is one of the few training systems readily adaptable to pruning mechanization.

MODIFIED KEUKA HIGH RENEWAL

The modified Keuka high-renewal system is a head-training system, typically using relatively short canes for fruiting. This training system uses a vertical trellis with three wires spaced above the vineyard floor as follows: bottom wire, 3 feet; top wire, 5 1/2-6 feet; middle wire, midway between the top and bottom wires.

Vines trained to modified Keuka high-renewal system may have one or more trunks, which reach either the bottom or the middle wire. For small low-vigor vines, the arms and canes are only on the bottom two wires; for larger high-vigor vines, the arms are on the two lower wires, but canes are tied to each of the three wires (see fig. 11*e*). In contrast to classical Keuka high renewal (not recommended), the modified Keuka high renewal has these important characteristics:

- Most fruiting canes are selected from sites other than the bottom wire.
- Summer tying of shoots is not required.

Modified Keuka high renewal is particularly well adapted to varieties that have an upright growth habit and bear heavily from base buds. It is the system of choice for *Aurore* grape vines.

CONVERTING MATURE VINES TO TOP-WIRE CORDON TRAINING

Many growers are currently interested in converting mature vineyards from umbrella Kniffin, modified Keuka high-renewal, or 4- and 6-arm Kniffin training to top-wire cordon systems, such as Hudson River umbrella or Geneva double curtain. There are several reasons, in addition to the potential for improved crop yield and quality by better exposure of leaves to sunlight in the renewal area of large vigorous vines. Experience

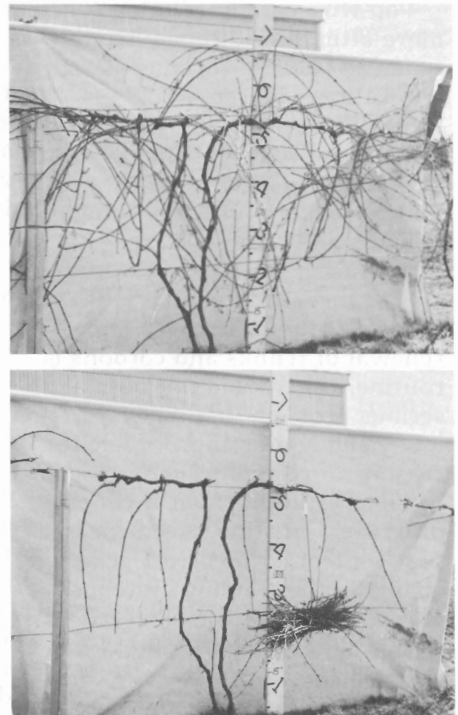


Figure 14. *Top*, an unpruned 8-year-old Concord vine. *Bottom*, the same vine balance pruned and trained to the Hudson River umbrella system. The vine had 4 pounds of one-year prunings, and 60 buds were retained for fruiting.

indicates that top-wire cordon training, *once established*, requires less labor for pruning, brush pulling and tying, and that these operations can be extended later in the spring with less physical damage to tender buds and shoots. Spring frost hazard is also reduced, because this high positioning of canes places the fruit buds farther above the zone of lowest temperature at ground level. Last, but not least, research indicates there is greater potential for a high degree of pruning mechanization, with maintained yield and quality, if vines are trained to a top-wire cordon with 180° pruning and shoot positioning.

Top-wire cordon training requires more attention to timely trunk renewal, because cordons as well as trunks must be renewed.

Depending on the current training system and size of trunks or arms, conversion may increase the number of large fresh pruning wounds and thus, at least temporarily, the opportunity for eutypa dieback infection. However, if double trunks are used and renewal of trunks and cordons is routine, this should not pose a serious problem. If a vineyard is low yielding and unprofitable for reasons unrelated to light exposure or labor efficiency, but involving drainage, nutrition, weed control, pest control, or incorrect pruning, changing the training system *only* will not improve the vineyard.

Top-wire cordons should *not* be established until there is an excellent trellis, including taut, high-tensile cordon-support wires, and well-anchored end posts. These are important because the annual retensioning or replacement of cordon-wrapped wire is difficult and

costly. Permanent sagging of the trellis between line posts, resulting in fewer light-exposed leaves and reduced mechanical-harvesting efficiency, are inevitable with wire that routinely yields or breaks, as with old or soft annealed wire.

CONVERSION PROCEDURE

There are basically two methods of converting to top-wire cordon training. The first involves selection of two long, high-quality canes with live buds to be wrapped securely, one in each direction, on the cordon wire. If more fruiting buds are needed than the two canes afford, additional canes should be tied in such a manner that they do not shade this developing cordon.

The second method uses 2-year-old wood to establish the cordons. Here, two of last year's canes (2-year-old wood), each bearing several well-matured fruiting canes, are wrapped securely, one in each direction, on the cordon wire. The number and length of fruiting canes or spurs to retain are determined by trellis distribution and vine-size considerations.

Frequently, a combination of these two methods must be employed to expedite conversion without crop loss in the conversion year. Many growers prefer the first method if cane-length and bud-number requirements will not cause undue crop loss.

RENEWAL OF DAMAGED OR DISEASED TRUNKS

The trunks of vines may be

damaged by disease, vineyard equipment, or low temperatures. Winter damage is most likely during unusually cold winters, in vigorous vineyards where shoot elongation continues to or after harvest, and following excessively large crops low in sugar. The southwest portions of the trunks, just above the snow level, are most vulnerable. The extent of damage can be evaluated after growth has started by removing a small section of this bark with a sharp knife and examining the phloem and cambium tissue immediately under it. Healthy tissue is nearly white or green, moderately damaged tissue is gray to light brown, and severely damaged tissue is almost black.

Under New York conditions, grape trunks should be replaced when they are damaged or when they are 10 to 15 years old. To renew a trunk(s) of an own-rooted vine, the sucker or shoot originating nearest the vineyard floor is selected and retained. For grafted vines, a new shoot above, but near, the graft union is retained. The first year, the new shoot should be tied to the trellis to protect it from injury by wind or vineyard equipment. In the second year, it can be trained to the height of the old trunk. In subsequent years, balanced pruning to determine the number of buds to be retained for the vine and assigning a bud number to each trunk in proportion to its size are recommended. Removing the oldest or most damaged trunk when the renewal trunk is 2 or 3 years old is the final step in the renewal. It is much easier to obtain a renewal from a young trunk than from one older than 15 years. The use of

multiple trunks of differing ages makes renewal more certain.

Straight trunks are less likely to be damaged by vineyard traffic. When vines are being established or renewed, the young trunks should be tied so that they grow straight.

COLD-TENDER VARIETIES

Some varieties, including those of *Vitis vinifera*, are especially sensitive to damage from winter cold. With these varieties trunk injury is frequent in most areas of New York, and care should be taken to ensure that replacement trunks are available; 3 to 6 trunks per vine are not an excessive number. Many of these varieties have upright growth habits, and training systems that lend themselves to trunk replacement and upright growth should be used.

"SUCKERING"

"Suckering" is the removal of *unwanted* shoots, both suckers from the base of the trunks and base shoots on the trunks, cordons, and arms of the vine. It should be done as early as possible each spring, usually during late May, when the shoots are only a few inches long. Early removal minimizes the loss of leaves and carbohydrates. If suckers are permitted to grow through June, their removal becomes more difficult, costly, and harmful.

When vines over 10 years old or with trunk damage are suckered, one or more shoots should be retained for trunk renewal. These

shoots should be managed as already described.

There are varietal differences in sucker and base shoot production. However, within a variety, vines that are young, winter damaged, or severely pruned produce more suckers and base shoots than those that are mature, undamaged, and balanced pruned. Therefore, excessive development of unwanted shoots, for the variety, frequently indicates that vines are being pruned too severely or that the trunks have been damaged.

Growth and Yield Relationship

Research has shown that growth (size and vigor) of the vine affects the yield of fruit. Conversely, the size and quality of the crop affects the quantity and quality of that year's vegetative growth and, thus, crop potential for the following year. Vine size and vigor depend on both nutritional and nonnutritional factors. The yield of a vine of a given size is controlled mainly by annual dormant pruning, flower or cluster thinning, and using growth regulators. Growth-regulator use should be dependent on variety and shoot vigor during the 2-week period centered on full bloom.

Vineyard management that is a collection of practices applied by formula or calendar cannot compete with vineyard management based on knowledge and understanding. The grower should know both the current and desired size and vigor

of the vines and be aware of practices that will increase or decrease these. In the long run, the vine's growth is determined by the current season's crop, the variety, the supply of nutrients and water, the soil-pest complex, the rootstock, and the weather. The grower can affect the vine's growth by control of diseases and insects, crop regulation, fertilizer choice and use, management of weed and cover-crop competition, and tillage depth. Decisions on rate and placement of fertilizer, for example, need to be made only *after* a decision on whether or not to fertilize, which should depend on vine growth, the presence and identification of symptoms of nutrient deficiency, or leaf-petiole analysis, or all of these.

VINE GROWTH

Leaves constitute much of the dry weight of a vine and produce almost all the sugar of the fruit. The development and protection of a large area of healthy leaf surface, well exposed on the basal half of the shoots, is the primary objective of vineyard trellising; vine training; fertilization; and the control of weeds, oxidant stipple, diseases, and insects. In a weak vineyard, the leaf area is not large enough, but is very well exposed; in a vineyard of adequate vine size and vigor, the leaf area is large and well exposed. In a vineyard of excessively large vigorous vines, the leaf area is very large, but the leaves near the fruit are not well exposed to light and, before harvest, may yellow and fall from the vine.



Figure 15. Weighing the cane prunings. *a*, close-up of the scales;



b, vineyardist weighing the cane prunings of one vine.

MEASURES OF VINE GROWTH

A useful measure of vine size and capacity to bear fruit is the weight of cane prunings (fig. 15). The ideal amount of growth per vine varies with vine spacing, trellis area (length x height) available per vine, training system, and shoot management, that is, whether or not there is to be shoot positioning of large-leaved varieties. However, research has shown there is an optimum weight of cane prunings per foot of canopy. The weight of cane prunings per foot of canopy for a specified situation may be low (0.2 lb), optimum (0.3–0.4 lb), high (0.5 lb), or excessive (more than 0.5 lb). For Concord spaced 8 feet apart in the row, in a nondivided training system on a 5-1/2- to 6-foot-high vertical trellis without shoot positioning, 2 to 3 pounds of cane prunings per vine is adequate or desirable; less than 2 pounds per

vine, too low; 3 to 3.5 pounds, high; and above 3.5 pounds, excessive. For a vine spacing of 16 feet, a pruning weight of 5 pounds is not excessive if the shoots are evenly distributed over the entire 16 feet of trellis.

Another useful measure of the growth of a grape vine is the percentage of the trellis covered by one and a half to two layers of leaves at harvest time: 85 to 90 percent trellis fill is desirable.

CROP EFFECT ON WEIGHT OF PRUNINGS

The vegetative growth of a vine is related to and competitive with yield of fruit. For vines with undesirably low cane-pruning weights, whose growth is maintained with a crop of 2 tons per acre, a crop increase to 4 to 5 tons per acre will seriously reduce the already low cane-pruning

weight; a crop *decrease* to 1 ton per acre can increase the weight of prunings by one-fourth.

In experiments, undercropped vines of high to excessive vine size did not decline in growth when their yield was increased. However, their already high pruning weights were further increased by halving the crop. The best ways to reduce excessive vine size and vigor, in order of effectiveness, are to increase the crop load per vine; reduce the available soil moisture supply by encouraging between-row weed or cover-crop competition, as with sod; and reduce applied nitrogen.

EFFECTS OF VINE SIZE ON THE CROP

In experiments with 8-foot-spaced Concords trained to a standard vertical trellis, increasing the cane prunings to 3 pounds per vine substantially increased the capacity of the vine to bear ripe fruit. Until the crop exceeded 4 tons per acre, with balanced pruning, the increase in yield did not appreciably delay fruit maturation. However, with a crop of 5 tons per acre and 3 or more pounds of cane pruning per vine, further increasing vine size delayed crop maturity; that is, the capacity of the vine to produce *ripe* fruit decreased. This decrease resulted from the increased shading of the leaves on the basal half of the bearing shoots.

Successful grape culture depends on the following:

- Growing a vine of correct size for the available trellis area each year.
- Regulating the crop size to match vine capacity and the quality

requirements of the designated market. This can usually be accomplished by dormant pruning and, where necessary, by flower-cluster thinning, and by managing the vines to avoid an excessive rate of shoot elongation during the period of bloom and fruit set.

- Preventing damage to the crop or the vine. This is mainly a matter of disease, insect and, with some varieties, oxidant stipple control. For current control recommendations, the grower should consult the Cooperative Extension Service.

Management to Control Vine Size

NONNUTRITIONAL CAUSES OF POOR GROWTH

Vines spaced 6–8 feet apart in the row that produce only 1/2 to 1 pound of cane prunings do not have enough leaves to regularly mature a 5- to 6-ton per acre crop of grapes. Ideally, the trellis should be nearly filled with leaves at harvesttime. In weak vineyards, leaves are so scarce that one can see through several rows of grapes in mid-August. Vine vigor and size need to be increased.

Such small vines can be due to one or more causes other than the lack of nutrients (fertilizer) (see chart p. 39).

AIR POLLUTION

Air pollutants are detrimental to

CAUSES OF LOW VIGOR

Shallow, dry soil

Soil that is excessively wet

Overcropping

Root injuries by deep (3- to 5-inch)
tillage

Injuries by root pests

Herbicide injury

Winter injury to trunks

Eutypa dieback lesions in trunk

Oxidant stipple

POSSIBLE REMEDY

Addition of organic materials to
the soil, shallow tillage

Shallow tillage and drainage

Balanced pruning, flower-cluster
thinning

Shallow tillage

None in existing vineyards

Reduce rate; vary rate according to
need; change to different
material; if contact injury, avoid
green tissue

Trunk renewal

Trunk renewal

Maintain high leaf nitrogen, use
protective sprays, improve soil
drainage

many plant species, as well as to human health, and may cause substantial economic loss. Of the many kinds of pollutants that originate from various sources and have different effects on crops, ozone is currently the most prevalent and destructive. Ozone is formed in the atmosphere when hydrocarbons and nitrogen oxides mix in the presence of sunlight. A manifestation of ozone injury, termed *oxidant stipple*, is widespread in New York vineyards. Oxidant stipple first appears as numerous tiny, distinct flecks (stippling) between the veins of the upper surface of the most mature leaves (figs. 16 and 17). These symptoms can be observed as early as mid-June on sensitive varieties and may continue to develop until entire leaves turn brown and drop. This is of serious concern because the first and most severely affected leaves on grape vines are the basal four to six leaves of exposed fruiting shoots—the leaves most essential to

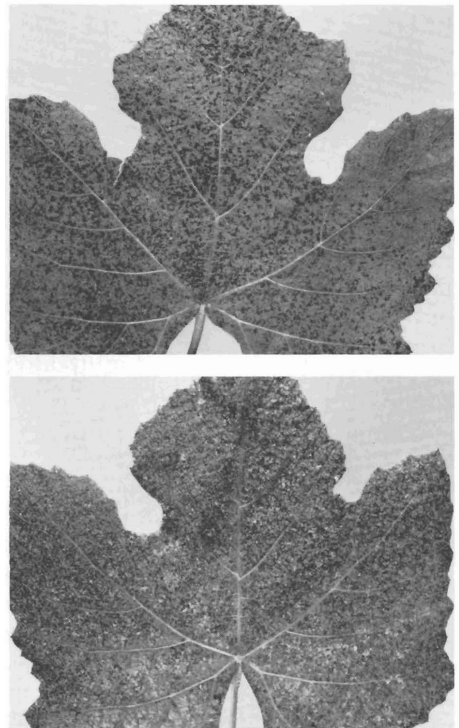


Figure 16. Oxidant stipple symptoms on the variety Ives. *Top*, moderate leaf symptoms; *Bottom*, severe leaf symptoms.

the maturation of the current season's crop and the development of next season's fruit buds.

There is a wide range in varietal susceptibility to current ambient ozone levels. In New York studies to date, the variety Delaware is the most resistant, and Ives, the most susceptible to oxidant stipple damage. Concord, New York's most important variety, is intermediate in sensitivity, but, nevertheless, is seriously affected by ozone; that is, both fruit quality (sugar content) and pruning weights were reduced in these studies. Observations indicate that the varieties Catawba, Niagara, and De Chaunac are also seriously affected by ozone.

VINEYARD MANAGEMENT TO REDUCE OXIDANT STIPPLE. Air-pollutant emissions outside the vineyard boundaries and thus ambient-air quality are beyond the grower's control. However, the severity of oxidant-stipple damage to grape leaves can be influenced by vine management. Research to date indicates oxidant stipple can be minimized by maintaining an optimal nitrogen level (large dark-green leaves), by avoiding excessive soil moisture (soil drainage and cover-crop management), and by applying foliage protective sprays. Oxidant-stipple control by these means is imperfect but helpful. Research is continuing on chemical protectants and physiological factors that predispose grape vines to oxidant stipple and other air pollutants, such as sulfur dioxide (SO_2).

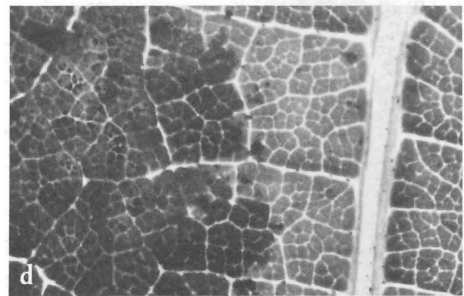
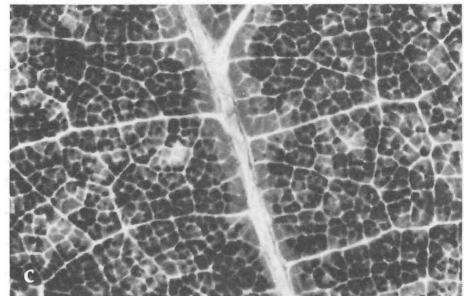


Figure 17. Leaf necrosis caused by ozone or by potassium deficiency. *a*, healthy tissue; *b*, early phase of oxidant stipple development; *c*, advanced stage of oxidant stipple. Note that **both primary and secondary veins are not discolored**. *d*, potassium deficiency symptom. Note discoloration of secondary veins.

NUTRITIONAL REQUIREMENTS OF VINES

The inorganic nutritional requirements of a vine can be met by the root-absorbed nutrients native to the soil or those added by fertilization. The roots can extend 20 feet from the trunk in the surface soil and can penetrate the subsoil to depths determined mainly by the level of soil oxygen as influenced by the water table or hardpan layer or both. The roots are active from early spring until late autumn and thus have a long time to absorb the required nutrients.

The elements taken from the soil and incorporated into leaves and shoots are returned to the soil with the dead leaves and chopped prunings. The crop removes comparatively small quantities of soil nutrients because more than 99 percent of the raw material for the fruit is obtained from carbon dioxide in the air and water in the soil. A 6-ton crop will remove less than 120 pounds per acre of soil nutrients, consisting of nitrogen, potassium, phosphorus, magnesium, calcium, sulfur, iron, manganese, boron, zinc, copper, molybdenum, and perhaps chlorine.

The nutrients found deficient in New York vineyards in order of decreasing frequency are nitrogen, potassium, magnesium, manganese, iron, and boron. Deficiencies may occur in both productive and nonproductive soils. Although usually only one nutrient is lacking at a time, even one deficiency can markedly reduce growth and yield. Economical fertilization depends on correct identification of nutritional

deficiencies; it may have to be varied from farm to farm and even within and between plantings on the same farm. Vines respond to the application of nutrients only when for some reason they are unable to obtain sufficient amounts of them from the soil. Most vineyards in New York State need an annual application of nitrogen fertilizer to maintain vine growth, and other nutrients are added as needed.

Whether fertilizer is needed and, if so, what kind and how much can be judged by vine and crop size, leaf symptoms, and analyses of leaf petioles and soil. The following examples show the wide range of needs possible for one variety in a locality: One vineyard needs no fertilizer because the foliage is symptomless and the cane-pruning weight is more than 4 pounds. Another needs nitrogen and magnesium because the vine size averages only 2 pounds of cane prunings and there are symptoms of magnesium deficiency (fig. 18g). A third needs only nitrogen because it has small low-vigor vines and no other symptoms. A fourth needs potassium because symptoms of potash deficiency are severe (fig. 18). A fifth, because of root injuries, does not respond to any fertilizer.

DIAGNOSIS BY LEAF SYMPTOMS AND VINE SIZE.

Nutrient deficiencies can stunt, yellow, blacken, scorch, or totally kill grape leaves. Symptoms can be used to identify the deficient element (fig. 18). The extent of the deficiency is gauged by the time at which symptoms appear and by their severity.

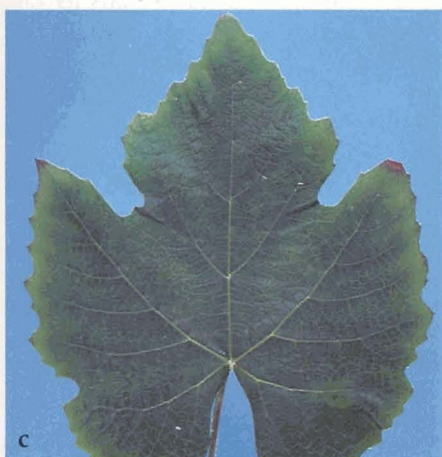
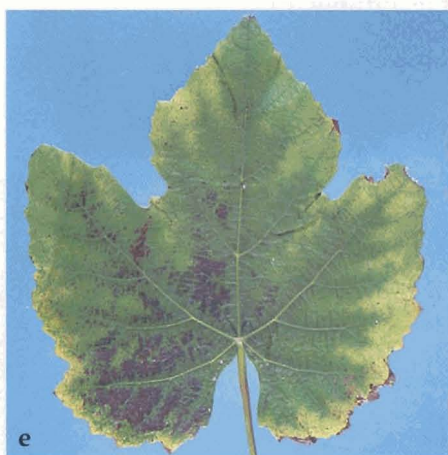
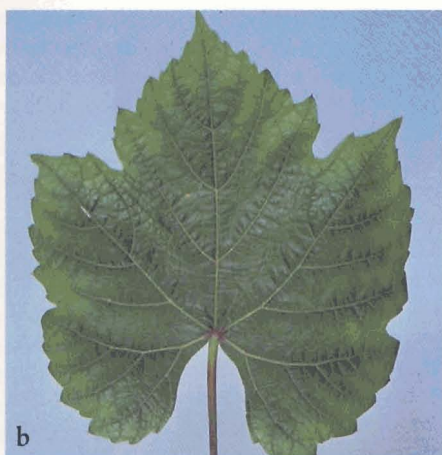
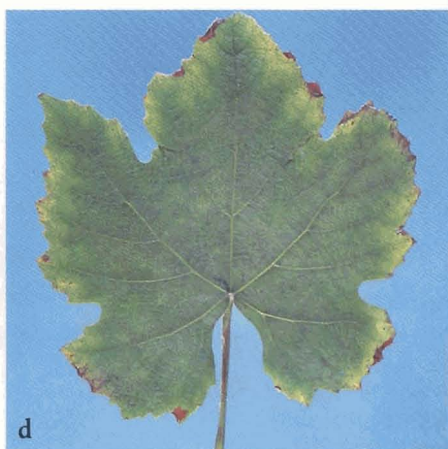




Figure 18. Foliage symptoms of vineyard nutrition. *a*, normal leaf; *b-f*, stages of increasing potassium deficiency; *g*, magnesium-deficient leaf; *h*, manganese-deficient leaf; *i*, terminal portion of iron-deficient shoot; *j*, blackleaf of Concord associated with low potassium. Symptoms are found on leaves exposed to the sun.

Growers should be familiar with the leaf symptoms of deficiencies of nitrogen, potassium, magnesium, and manganese and should closely inspect their vineyards in late August or early September to determine whether symptoms are present. If they observe symptoms, but need identification assistance, they should promptly consult their Cooperative Extension agent or specialist or their processor's technical field representative.

The first *potassium*-deficiency symptom of grape leaves is usually interveinal or marginal chlorosis or both. With increasing severity, marginal necrosis (scorch) develops. Symptoms of potassium deficiency are illustrated in figures 18*b-f*. When this deficiency is most acute, these symptoms appear early (just after bloom) and become extensive, at both the margin of the leaf and between the veins. Potassium-deficiency symptoms are first

observed and most severe on leaves in the midportion of the shoot. Another symptom that can be decreased by potash applications is blackleaf (fig. 18j). With a serious potassium deficiency, vine vigor and size, crop, and berry size are all reduced, and maturity of both crop and vine is decreased.

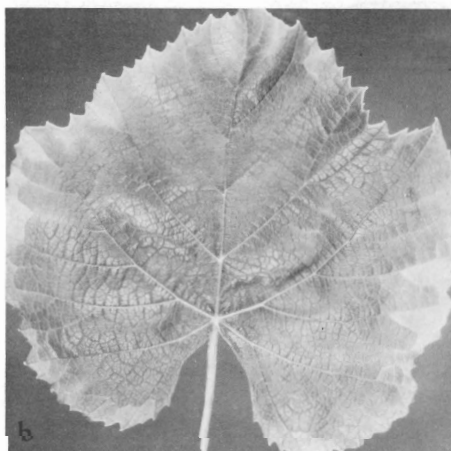
Magnesium deficiency (fig. 18g) appears first and is most severe on basal leaves of the shoots. Magnesium deficiency is usually indicated by chlorosis between the large veins. However, the veins remain green, and there is usually a thin line of green tissue at the margin of the leaf. When the deficiency is severe, the tissue between the veins can become necrotic (scorch), and the symptom may be confused with potassium deficiency by an inexperienced observer. Magnesium deficiency is most common under New York conditions in very acid soils and is rare in soils with a pH of 5.0 or above, unless there has been excessive potassium fertilization.

Manganese deficiency (fig. 18h) is found mainly on high-lime soils and often in poorly drained areas. It is indicated by a characteristic (intermittent) interveinal chlorosis, which is usually more severe on shaded leaves than on those in full sunlight.

Iron deficiency, usually found on high-lime soils, causes a whitening of the apical leaves in May or June (fig. 18i). The large and small veins are conspicuously green, and the tissue between the veins is pale green to white.

The need for *nitrogen* is determined by vine size and vigor as follows: during the growing season, by the size and color of

leaves; during August and September, by the amount of trellis filled or covered by foliage; during the dormant season, by the weight of cane prunings per vine. A vineyard has adequate vine size and vigor if 90 percent of the available trellis is covered with dark green leaves by mid-August and if the cane prunings are at least 3 pounds



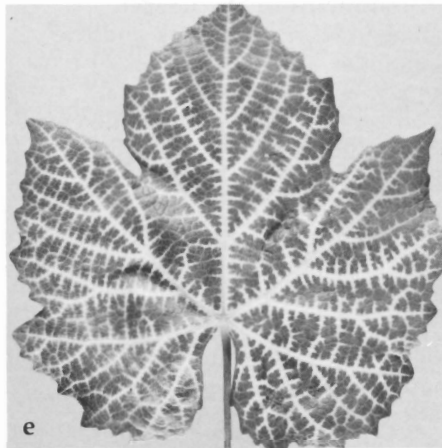
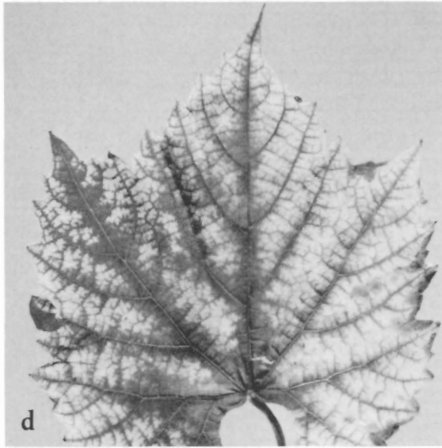
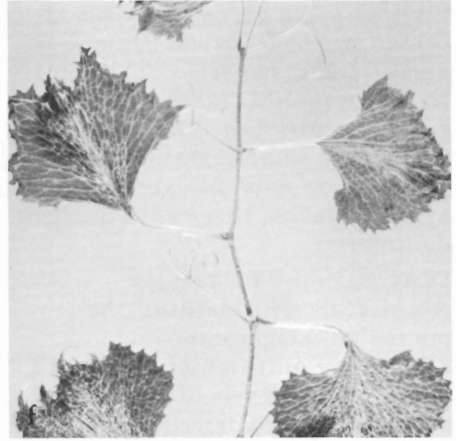
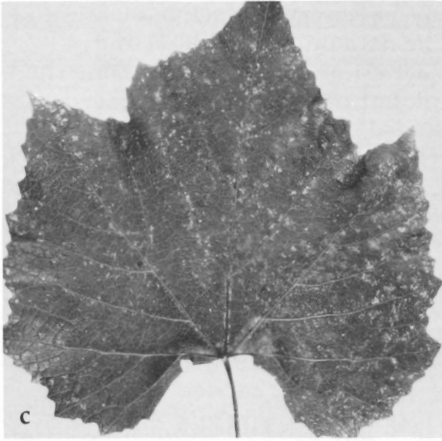


Figure 19. Nonnutritional leaf disorders caused by (a) *Eutypa* dieback, (b) potato leafhopper, (c) grape leafhopper, (d) systemic simazine (Princep) herbicide injury, (e) systemic diuron (Karmex) herbicide injury, (f) 2,4-D herbicide injury, (g) glyphosate (Roundup) herbicide injury.

per vine space of 8 feet. Such vineyards gain nothing by nitrogen applications to *increase* vine size unless trellis area can also be increased to permit exposure of the additional leaves to light. However, insufficient vine size is a more common problem in New York vineyards than is excessive vine size.

Other types of leaf chlorosis are caused by shade, ozone (figs. 16 & 17), drought, sun scald, "wet feet," leafhoppers (figs. 19*b,c*), mildews, eutypa dieback (fig. 19*a*), winter injury, and some pesticides (figs. 19*d-g*). Care must be exercised to avoid confusing these with nutrient deficiencies.

DIAGNOSIS BY PETIOLE ANALYSIS. The status of the potassium, magnesium, and manganese nutrition of a vineyard, as well as the levels of minor elements, can be determined by chemical or spectographic analysis of petiole samples. These samples are collected from the youngest *mature* leaves of exposed bearing primary shoots during late August and early September (about 70 days after grape bloom). The sample should be made up of petioles from either typical symptom-showing *or* symptomless vines in a problem area or typical vines in a nonproblem area where data on the current nutritional status are desired. Petiole analyses can show which nutrient elements are or *may become* deficient, as well as where an excess exists; thus, the use of unneeded fertilizer is avoided. However, the sample must accurately reflect the situation in the sampled area, or the analyses will be useless or even misleading. The grower should contact the Cooperative Extension agent or specialist for further information on collecting petiole and soil samples.

DIAGNOSIS BY SOIL ANALYSIS. When a site is to be planted to grape vines, it is advisable to test top soil and subsoil samples for pH, phosphorus, calcium, potassium, and magnesium levels and to take

any necessary corrective measure. The data on pH, calcium, and magnesium can help determine the amount of potassium fertilizer needed.

For producing vineyards, soil tests are *not* a dependable method of *identifying* a nutrient deficiency. However, after a deficiency has been identified by foliage symptoms or petiole analysis or both, a soil test may help determine the extent of treatment needed and the choice of the nutrient carrier.

TIME OF FERTILIZER APPLICATION. To obtain optimum leaf size, shoot growth, and fruit set, sufficient nitrogen should be in the plant tissues before growth starts. Thus, a nitrogen fertilizer suitable for the vineyard should be applied 2 to 3 weeks before the anticipated date of bud break. Some growers in areas subject to late spring frosts prefer to apply nitrogen after frost danger is past. Obviously, in seasons with a frost, they save fertilizer; but in the other growing seasons, the nitrogen gets into the plant tissues too late to be most effective. A split application, that is, applying two-thirds to three-fourths of the needed nitrogen *before* bud break and the remainder after the danger of frost is past, is a common practical solution to this dilemma. However, where spring frosts are rare, a single early application is more efficient; that is, less energy and equipment use are required for application, and less atmospheric loss of nitrogen occurs.

If a vineyard is deficient in potassium, magnesium, or manganese, the sooner the deficiency is corrected, the better

TABLE 3. AMOUNT OF FERTILIZERS NEEDED TO SUPPLY VARIOUS AMOUNTS OF NITROGEN

Actual N (nitrogen)	Ammonium nitrate (33% N)	Urea (46% N)	Ammonium sulfate (21% N)	A mixed fertilizer with 10% N (like 10-20-10 or 10-10-10)
		pounds		
30	91	65	143	300
40	121	87	190	400
50	151	109	238	500
60	182	130	286	600
70	212	152	333	700
80	242	174	381	800

will be the growth and yield. If the fertilizer is applied during the growing season, the severity of the deficiency symptoms should determine the rate of application. Fertilizer applications made after grape bloom may show little effect in that year, but these nutrients will remain either in the soil or in the vine to reduce or eliminate the deficiency during the following growing season.

FERTILIZER MATERIALS. *Nitrogen* should be chosen mainly on the basis of cost per pound of actual nitrogen. However, ammonium sulfate is a better nitrogen fertilizer for high-lime soils on which vines show manganese or iron chlorosis or both.

In a well-drained, shallow-cultivated vineyard, nitrogen that is broadcast will be available to the vine. However, grower experience indicates that in vineyards where excessive soil moisture or deep tillage or deep rutting by harvesting equipment has caused feeder-root damage between the rows, applying the nitrogen in a 2-3-foot band centered on the vine row may increase vine growth. An annual application of 40 to 60 pounds of actual nitrogen per acre usually is

adequate for *maintaining* vine vigor and size with nondivided training. Heavy producing vines trained to Geneva double curtain (GDC) may need 100 to 120 pounds of actual nitrogen per acre to maintain growth.

To *increase* vine size, these maintenance rates may have to be increased 30 to 50 percent and competition by cover crop or weeds eliminated. To increase vine size by fertilizer additions is generally impossible if the vine stunting is due to overcropping or other nonnutritional causes.

To *decrease* vine size, the nitrogen application rate should be reduced or possibly eliminated for a year or more (unless oxidant stipple is a problem); and a cover crop should be maintained as a sod between the rows to compete with the vines for moisture and nutrients. Such competition may require close mowing or even eradication to prevent *excessive* water stress during drought.

Potassium. The two major potassium carriers are potassium sulfate (sulfate of potash), which contains 50% potash, and potassium chloride (muriate of potash), which contains 60% potash. There is some evidence, both in New York and in

Europe, that potassium sulfate is preferable to potassium chloride, possibly because of chlorine toxicity, which is well documented on some crops. However, this finding is not of significant concern for grape vines in New York at normal application rates, particularly since the current cost of potassium sulfate is approximately double that of potassium chloride per unit of potash. Certainly, if a vineyard has severe potash deficiency and the grower has a limited number of dollars with which to buy potassium fertilizer, he or she should purchase the product that will provide the most potash for the available dollars.

Sulfate of potash magnesia, a fertilizer containing 22% potash and 11% magnesium, is a potassium carrier that is occasionally used when both potassium and magnesium are deficient and soil pH is too high to permit the use of dolomitic limestone as a source of magnesium.

Stable manure and grape pomace (including stems) are low-analysis potash fertilizers. The approximate analysis of grape pomace is 2% nitrogen, 0.5% phosphorus, and 2% potassium. Manure and pomace are most valuable in the vineyard when used at rates of 5 to 15 tons per acre to increase the soil organic-matter content or reduce erosion or both. Waste hay and straw at rates of 2 to 3 tons per acre are similarly useful. These organic materials also improve soil tilth and water-holding capacity.

Leaf symptoms, petiole and soil analyses, soil texture, and the magnesium status of the vines all affect the decision on the frequency

and rate of potash application. Vineyards free of potassium-deficiency symptoms throughout a growing season, with a normal or large crop, are unlikely to respond to any applications of potash in that year or the following one.

The amount of potash (as K_2O) needed in a vineyard deficient in potassium may range from 150 to more than 1,000 pounds per acre (300 to more than 2,000 lb of potassium sulfate), depending on the severity of the deficiency and the base exchange capacity of the soil. With less than 2 percent of the leaf area chlorosed by potassium deficiency in early September, more than twice as much potassium fertilizer is needed for a clay soil of pH 7 as for a sandy soil of pH 5.0 to eliminate the deficiency.

Potassium fertilizers tend to be fixed in the surface of the soil and, hence, to be unavailable to the vines. By reducing the area of application, the percentage of potash fixed in the soil is reduced. For this reason, potassium-deficient vines respond much better when this fertilizer is concentrated beneath the trellis in a band about 2 feet wide, instead of broadcast.

If leaf symptoms of potassium deficiency appear before September, an immediate application of potassium fertilizer is suggested at the rate of 200 pounds K_2O per acre for sandy or gravelly loam soils and at the rate of 300 to 400 pounds K_2O per acre for loam to clay loam soils. However, with coarse-textured, very acid soils (below pH 5.0), the addition of potassium fertilizer and the resultant decrease in the percentage of magnesium in the soil solution may cause a magnesium deficiency. Such soils

should be tested for magnesium level to determine if magnesium fertilizer will also be needed.

Magnesium is most frequently deficient where the soil is very acid or where excessive amounts of potassium fertilizer have been applied. Dolomitic limestone is high in magnesium. It can be broadcast in the vineyard at rates from 1/2 to 1 ton per acre to supply magnesium if the soil pH is below 5.5. Where soil pH is 5.5 or above, some other source of magnesium, such as fertilizer-grade magnesium oxide or magnesium sulfate, should be selected to avoid increasing the soil pH and reducing the concentration of potassium in the leaves. Severe magnesium chlorosis can be reduced, on an annual basis, by the use of 15 pounds of Epsom salts (magnesium sulfate) per 100 gallons of dilute spray (10 lb per acre if concentrate spraying) in each of two or three postbloom sprays.

Manganese deficiency occurs most often on soils whose pH is near 7. The cure, aside from the suggestions for ammonium sulfate on page 47, is to apply fertilizer-grade manganese sulfate in a band beneath the trellis at the rate of 1/2 to 1 pound of the carrier per vine. Annual applications need to be made only as long as manganese-deficiency symptoms persist.

Iron deficiency appears as a whitening of the leaves near the tip of the shoot; it is most evident in early June in high-lime (pH 7.0 or greater) vineyards, where drainage is poor. No corrective measure is suggested except the regular use of ammonium sulfate as a nitrogen source and improved drainage.

Phosphorus and calcium. Concord and other eastern-grown grapes have

not responded favorably to applications of phosphorus or calcium to the vineyard. The phosphorus applied to mature vineyards in a complete fertilizer does not affect the grape vines in any detectable way and is not recommended except as needed for cover crops. Calcium added in the form of lime does not harm high-potash vineyards, but does harm low-potash vineyards.

TRACE MINERALS AND MICRONUTRIENTS. Various trace minerals and micronutrients are frequently promoted to improve grape production. Zinc, iron, manganese, chlorine, boron, copper, and molybdenum have all been proved essential for growth of higher plants. However, these elements are rarely needed in amounts greater than those naturally supplied by New York soils.

Manganese, as discussed earlier, is deficient in an occasional vineyard.

Boron deficiency has also been identified in perhaps a half-dozen very unusual situations in New York. However, the risk and consequences of boron toxicity are so great that accurate diagnosis and precise treatment are essential. Boron toxicity can result from annual applications of as little as 2 pounds of borax per acre. A boron deficiency should be confirmed, *before* boron fertilizer is applied to the vineyard, by analyzing a petiole sample collected at time of grape bloom.

LIMING THE VINEYARD.

Vineyard fertilization is usually less expensive and less complicated with soils of pH 4.5 to 5.5 than it is with soils of pH above 6.0. In

experiments, potash deficiency was increased by the application of 1 ton of dolomitic limestone per acre to a loam soil of pH 5.4. Manganese deficiency can also be increased by liming. Therefore, liming is recommended in the vineyard only as a source of magnesium and only if the pH is below 5.5. It may also be useful for nonlegume cover crops if the soil pH is below 5.0 because of its effect on phosphorus availability. Only dolomitic (high-magnesium) limestone is recommended, at not more than 1 ton per acre per application.

Soil Covers

WEED CONTROL

The intensity and the duration of weed control needed vary with the season, the site, and the vigor and size of the vines. The least vigorous vineyards require the most complete, and longest period of, weed control in any season. Weed control is the major justification for cultivation. Cultivation should never exceed 2 to 3 inches in depth, or it will damage the feeder roots of the vines. Because *excessive* cultivation lowers the organic matter in the soil and increases the likelihood of erosion, it can reduce profits.

BETWEEN THE ROWS.

Competition by weeds or cover crops between the rows is usually reduced in the spring by cultivation, mowing, or an herbicide. This reduction should be completed early

enough on frost-susceptible sites to afford a maximum exposure of firm, bare ground during periods of possible spring frost. Where spring frost is not considered to be a hazard, the timing of weed or cover crop reduction between the rows can be viewed as a tool for either increasing or decreasing the soil moisture available to the vines, according to whether the vineyardist wishes to slow or stimulate shoot growth. The exact timing depends on soil moisture and vine size and vigor. With the same weather conditions, dry sites or vineyards with small low-vigor vines, from causes other than poor drainage, require earlier and more prolonged control of weeds than sites where moisture is adequate and vine size is large or excessive. Where maximum vine growth is desirable, elimination of competition between rows should usually be started during May. Weed control should be maintained as long as moisture competition is undesirable, usually until mid-August but occasionally until early September. UNDER THE TRELLIS. Weeds under the trellis can be controlled with a tractor-powered hoe or by herbicide sprays. Before 1957, more than 95 percent of the vineyards in New York were mechanically hoed; since 1964, more than 75 percent have been sprayed.

To prepare for mechanical hoeing, every August or at the last cultivation, 4-7-inch-high ridges of soil must be pushed up along the row around the bases of the vines with a tractor-mounted hoe. This procedure, of course, covers and controls many weeds. In late May or early June of the next year, these ridges and the growing weeds can

be hoed away with the tractor hoe. If weeds are removed too early by hoeing away or covered too early by pushing up, weed competition under the trellis will be excessive. Tall weeds at harvest may also slow hand harvest and (or) contaminate mechanically harvested fruit. Hoeing, at best, cuts some grape roots and occasionally removes entire vines. However, vine damage can be minimized by careful operation, a large soil ridge to permit shallow hoe operation, straight trunks to reduce the hazard of mechanical injury, and cover-crop seeding and fertilizing only between the rows.

Vineyards to be weed sprayed must also have a 4-7-inch-high ridge of soil around the bases of the vines if herbicides are to be used safely (fig. 20). This ridge tends to deteriorate after several years and must be renewed periodically.

CHEMICAL WEEDING

Many vineyard weeds can be controlled with annual applications of herbicides (fig. 20). The popularity of chemical weeding stems from its economy, effectiveness, and safety when properly done. Three basic types of herbicides commonly used in vineyards at the time this bulletin was prepared include those with residual activity such as diuron or simazine, contact herbicides such as paraquat, and systemic herbicides such as glyphosate. Consult your Cooperative Extension specialist or county agricultural agent and the herbicide label for details of procedure and current recommendations.

Grapes are especially sensitive to 2,4-D and MCPA. The use of sprays or dusts of these chemicals in or near vineyards is extremely hazardous. In 1964, the use of sprays or dusts of 2,4-D was regulated in certain areas by executive order of the New York State Department of Agriculture and Markets. The current status of these regulations can be learned from either the Department of Environmental Conservation in Albany or the Cooperative Extension Service.

COVER CROPS

VINE RESPONSE. Cover crops that grow when the vine is growing compete with it for water and nutrients. If nutrients are abundant or if vine vigor and size are high or excessive, this competition does no harm and may be useful in reducing vine growth. If vine size and vigor are low, the competition is undesirable because it reduces vine growth. The competition of cover crops will be greater on shallow soils and in dry seasons than on deep soils and in wet seasons.

The hazard of spring freeze damage to shoots is increased by the presence of a dense cover crop, because it acts to elevate the zone of coldest air to the top of the cover crop. Therefore, the taller the cover crop, the greater the risk of damage to shoots.

SOIL RESPONSE. A soil cover, whether dead or alive, is superior to bare soil for controlling erosion and preventing runoff (fig. 20). Vineyard sites have been ruined by erosion caused by a combination of bare soil and sloping rows. Early

spring and fall growth of cover crops tends to remove excess water and makes vineyard travel with equipment easier and less damaging to vines and soil.

RECOMMENDATIONS. The amount of growth made by the cover crop and the period and duration of its growth are more important than the kind of cover crop. Vineyardists must consider vine size and vigor, soil fertility, drainage and moisture, and frost hazard in their vineyards and then tailor their use of cover crops accordingly.

Cold-hardy covers such as rye, wheat, ryegrass, or barley usually afford more soil protection than cold-susceptible ones such as oats or millet. If a cover crop is sown under the trellis, certain perennial cover crops such as rye may become a weed problem. Therefore, winter-cold-susceptible covers may be useful in these situations. Legumes are not useful as *annual* cover crops for vineyards in New York. Seeding the cover crop by drill or broadcast when tillage is completed in mid-August to mid-September is suggested. Six to 10 pounds of domestic ryegrass or 1 1/2 bushels

of rye, wheat, or barley per acre are suggested. This cover can be disced under or treated with an herbicide about the time shoot growth of vines starts in the spring and can be 80 or 90 percent destroyed by early June.

For vineyards of high to excessive vine vigor and size, continuous cover (sod) mowed close to the soil is appropriate. For vineyards where erosion is a problem and soil is low in organic matter, organic materials such as manure, waste hay, straw, and pomace plus stems can be added to the chopped prunings and cover crop. A brush chopper is useful in spreading such material (fig. 21).

For vineyards on steep slopes where soil erosion is a serious



Figure 20. A typical New York vineyard in April. Note under-the-trellis ridge for weed control and the rye cover crop to prevent erosion.



Figure 21. Vine prunings from two rows have been pulled together, *top*. *Bottom*, they are being chopped with one of several effective types of choppers.

problem, but vine size and vigor preclude continuous sod, alternate row culture is suggested. With this system every other row is cultivated to eliminate weed competition, and the noncultivated rows are either mulched or left in sod and mowed. The following year the treatment of the rows is reversed. This system minimizes unwanted weed competition and greatly reduces the danger of soil erosion. In addition, the sod or mulched area makes a better driveway for vineyard equipment during the early spring and harvest seasons.

Controlling Size of Crop

Crop size per acre is the product of cluster number per vine \times cluster weight \times vine number per acre.

The importance of controls on the size of the crop can be understood only if the hazards of overcropping and undercropping are known. In *overcropping*, usually too many buds are retained at pruning; so many clusters result that fruit and vine maturity plus vine vigor and size can all be seriously reduced. An example is the unpruned vine with small clusters, immature fruit, and low-vigor shoots, which, after leaf fall, appear as short, immature canes with buds and wood very susceptible to damage by low temperatures. Above-average bud fruitfulness or fruit set, as well as unusually adverse growing-season conditions, or any combination of these can also result in overcropping.

In *undercropping*, usually too few fruitful buds are retained. So crop size is inadequate in relation to vine capacity; vine vigor and size increase and become too great for the available trellis space (above 3 lb of cane prunings per vine with a spacing of 8 feet or less in the row, a nondivided canopy, and no shoot positioning). The results are increased shading by leaves on vigorous shoots and reduced bud fruitfulness (i.e., cluster number and cluster size), delayed fruit and vine maturity, and increased susceptibility of buds and canes to damage by low winter temperatures.

The number of clusters per vine is controlled by light exposure of the leaves at the basal four to six nodes of renewal shoots during bloom and the early postbloom period, fruiting cane selection, the number and quality of buds retained, flower-cluster thinning, and removal of base shoots and, in some cases, secondary shoots.

Two major reasons for controlling the grape vine's production are to increase the quality of the current season's crop and to favor the development of a large, well-exposed leaf area, which maintains or increases the vine's bearing capacity. Dormant pruning, which must be done each year, is usually the only practice used to achieve both goals with the traditional American varieties such as Concord, Delaware, Niagara, and Catawba. However, many table-grape varieties and several of the American and French-American varieties, now being grown for wine making, require flower-cluster thinning or shoot thinning or both, in addition to dormant pruning to

adequately control crop size and quality and the subsequent ripening of buds and canes. Flower-cluster thinning is also used when vines are young or weak to increase vine vigor and size.

PRUNING

Pruning is the single most important, costly, and skill-requiring vineyard operation. Several studies have indicated that depending on variety, training system, vine spacing, and vine size, an experienced skilled person requires about 24 hours to commercially balance-prune an acre of vineyard. Because of its importance, pruning has been the subject of much research; and because of its cost, many attempts have been made to mechanize it. Pruning-mechanization research has been in progress at the Vineyard Laboratory in Fredonia for many years and now shows promising results under specified conditions.

At this writing, however, the equipment and techniques researched have had only limited large-scale field testing. A 1978 report entitled "Mechanical Pruning of American Hybrid Grapevines" is available from your county Cooperative Extension office or the Department of Agricultural Engineering, Cornell University.

TIME OF PRUNING.

Commercially, grapes in New York State are pruned throughout the dormant period, extending from the first hard freeze, usually in early November, to bud break, about May 1. Pruning is also easier and faster, thus more economical, in the

milder weather of late fall and early spring as compared with pruning in midwinter when deep snow, wind, and severe cold usually slow the operation. However, research indicates that winter cold damage to buds and canes is more likely on pruned vines than on unpruned vines. So to the extent acreage and available time permit, it is recommended that pruning be delayed as late as possible in the dormant period, not only to minimize the risk of winter cold damage, but also to provide some opportunity to compensate for any bud kill that may have occurred during December, January, and February. (See p. 58.)

It is not harmful to prune a grape vine during the spring when the sap is flowing even though there may be "bleeding" from some fresh pruning cuts. However, brush pulling, that is, the removal of prunings from the trellis and the manipulation of long canes, as in tying umbrella Kniffin or converting from single-curtain training to Geneva double curtain, should be accomplished before bud swell (usually by late April) if significant shoot breakage, with the resulting reduction in crop potential, is to be avoided.

Since varieties differ in cold-hardiness, pruning the hardiest varieties first and the more cold-tender varieties last is good viticultural practice. *Growing Cold-Tender Grape Varieties in New York* by N. J. Shaulis, J. Einset, and A. B. Pack, N.Y.S. Agricultural Experiment Station at Geneva, General Bulletin 821, is available from the Cooperative Extension Service and provides more details and a ranking of commercially

important varieties.

SELECTION OF FRUITING

CANES. Much variation exists in the fruitfulness of the buds on a cane, and even wider variation when all the buds on a vine are considered. The following conditions are associated with high fruitfulness of a bud:

- *Full exposure of the leaf to sunlight the previous year as the bud developed in the axil of the leaf.* The best light-exposure positions for buds are generally located on the exterior of the canopy, canes in the interior of the canopy being the most shaded. Cane color and internode length are indicative of the light-exposure status of the leaves on the shoot during the preceding growing season. Characteristic cane color and internode length vary by variety and vigor, respectively, but for each variety the darker-colored canes with shorter internodes will likely have had superior light exposure. For example, a Concord cane that is bright dark-mahogany brown and has 4-6-inch internodes has had better light exposure and will have more-fruitful buds than a yellow brown cane with 7-inch or longer internodes.

- *Location at a node from which the lateral growth, if any, is weak.* When the lateral growth is ample, it should be retained and pruned to a 1- or 2-node fruiting spur, because these spur buds are more fruitful than the buds at the node from which the vigorous lateral developed.

The largest fully exposed canes should be chosen, provided any large persistent laterals are spurred as indicated. However, large canes of inferior exposure or with large

laterals removed will be less fruitful than exposed pencil-size canes.

The point of origin of the cane is much less important than the conditions already mentioned. Canes that develop from the preceding growing season's base shoots or suckers can be used for fruiting to the extent that they meet these conditions.

Selecting buds and canes for best light exposure is much more important than maintaining the typical form of any training system.

LENGTH OF CANE. The appropriate length for fruiting canes differs with variety, training system, trellising, vine size, vine spacing, and whether or not shoots were positioned. There are three fruiting unit lengths known as short pruning, half-long pruning, and cane pruning. These use 3-node spurs, 4-7-node short canes, or 8-15-node long canes, respectively. All mature vines of American and French-American variety grapes grown on the standard vertical trellis, without shoot positioning, are normally pruned 8 to 15 nodes per cane. The longer cane is used with large vigorous vines trained to systems that shade the renewal area so as to increase the proportion of exposed buds retained. For Concord trained to umbrella Kniffin, the use of 10- to 15-node canes is recommended vineyard practice. For Catawba, Delaware, and the French-American varieties, 8- to 10-node canes are normally used. Research on vines trained to Geneva double curtain and Hudson River umbrella has demonstrated that with *shoot positioning* to improve light exposure, basal buds *are* fruitful. This procedure permits the use of 4- to

7-node canes and thus affords better cane distribution on the trellis, plus increased potential for pruning mechanization with these high-cordon training systems.

NUMBER OF NODES (BUDS)

The most-important decisions in pruning grapevines are the selection of high-quality fruiting canes as discussed and the determination of the number of nodes containing fruitful buds to retain on each vine for the coming crop. These decisions will largely determine the quality and quantity of the crop and have a major influence on vine growth and the capacity of the vine for fruiting in the following year.

The number of fruitful buds to retain should be based on each individual vine's capacity. Every good pruner attempts to gauge this, usually by retaining buds or canes in proportion to the *quantity* of vegetative growth made during the preceding summer. A vine that could mature the fruit on 50 shoots is overpruned if only 30 nodes are retained; it is underpruned if 70 nodes are retained. Accurately gauging each vine's capacity and retaining the correct number of fruitful nodes require considerable skill.

BALANCED PRUNING. Balanced pruning is a research-developed technique that uses measurement—the weight of canes (the preceding summer's shoot growth)—node counting, and a pruning formula for estimating vine capacity. It assumes the selection of well-exposed canes with fruitful buds. Each pruning formula (nodes per pound of cane

prunings) is based on the growth and fruiting characteristics of the variety and has been researched for the major commercial varieties under New York conditions. However, balanced pruning alone is not sufficient crop regulation for some varieties or for small weak vines of any variety.

Vine capacity can, and does, vary greatly between vines in a vineyard and even between adjoining vines in a row. Balanced pruning, with an appropriate formula, avoids either overpruning or underpruning these vines of differing capacity and is the first step in achieving the annual goal of a maximum crop of the desired quality, with maintained or improved vine capacity for the following year's crop.

Table 4 shows *pruning severity*, which is the number of nodes to retain per pound of cane prunings for New York's major varieties. For Concord this is 30 + 10, which means 30 nodes for the first pound of cane prunings and 10 nodes for each additional pound. Consider an unpruned Concord vine whose estimated weight of canes is 4 pounds, with 600 nodes: severe pruning would remove 570 or more nodes and retain 30 or less; light pruning would remove only 520 or fewer nodes and retain 80 or more; balanced pruning at 30 + 10 would remove 540 nodes and retain 60. For Delaware the recommended pruning severity is 20 + 10, which means 20 nodes for the first pound of cane prunings and 10 nodes for each additional pound.

PROCEDURE FOR BALANCED PRUNING OF MATURE VINES. The only special equipment needed by the pruner other than pruning shears and a saw is a small pocket

TABLE 4. SUGGESTED PRUNING SEVERITY FOR BALANCED PRUNING OF MATURE VIGOROUS VINES OF SOME MAJOR VARIETIES

Grape variety	No. of nodes to retain for fruiting per pound of cane prunings		
	First pound of cane prunings	Each additional pound of cane prunings	Maximum number of nodes per vine at 8-ft spacings
Concord	30 plus	10	60
Fredonia	40 plus	10	70
Niagara, Delaware, Catawba	25 plus	10	60
Ives, Elvira, Dutchess	20 plus	10	50
French-American varieties — all of these require severe "suckering" of the trunk, head, and cordons during spring and early summer for satisfactory growth, plus crop and vine maturity, with the formulas suggested below:			
Small-clustered varieties such as Foch and Leon Millot	20 plus	10	50
Medium-clustered varieties such as Aurore, Cascade, Chelois	10 plus	10	40
		Weak vines will need flower-cluster thinning and careful "suckering"	
Large-clustered varieties such as Seyval, De Chaunac, Chancellor	20 plus	10	45
		Must supplement with flower-cluster thinning and careful "suckering"	
Viniferas and other cold-tender varieties*			

*See p. 59.

scale for weighing the cane prunings. The pruner first estimates the weight of cane prunings on the vine. Suppose the estimate is 3 pounds and it is a Concord vine; he or she then selects the 4-6 most fruitful canes, counts the nodes, and retains a few more than the 50 (30 + 10 + 10) nodes needed (table 4). Next, the remaining canes and any other superfluous wood are pruned off; the cane prunings (last summer's growth only) are then cut into 3- to 4-foot lengths for ease in handling, and weighed. If the weight is only 2 pounds, the number of nodes retained on the vine is adjusted to 40. If the weight is 3 1/2 pounds,

the retained node number is adjusted to 55. Commercially, not every vine can be weighed, but most pruners need actually weigh only a few vines initially and an occasional vine thereafter to develop considerable skill in closely estimating the weight of cane prunings and thus the node number to retain for balanced pruning. The selection of canes with the most fruitful buds is, of course, critical to the success of balanced pruning.

COLD-KILLING OF BUDS AND PRUNING SEVERITY. Concord is considered a cold-hardy grape variety; however, midwinter temperatures at or below -18° F usually result in commercially

important damage to Concord buds, canes, or trunks or all of them.

After overcropping or a season in which, for climatic or other reasons, the vine fails to mature properly in the fall, damage may be caused by temperatures well above 0° F in November or December. Warming periods of several or more days' duration, that is, temperatures of 50° F and above, in late winter or early spring, followed by a sudden resumption of severe winter temperatures, may also cause damage. Other American varieties, many French-American varieties, and most vinifera varieties are likely to be damaged at somewhat higher temperatures than are Concord.

In the commercial grape-growing districts of New York where the climate is generally satisfactory, immaturity of vine tissues in the fall is more commonly associated with winter damage than are extreme winter minimums. The extent of damage can be seen by cutting through dormant buds (fig. 22*c*); when damage is severe, the middle of dead primary and secondary buds is blackened. Bud mortality should be evaluated on good-quality canes suitable for retention for fruiting. The canes should be held at room temperature for at least 24 hours, and damage assessed by making careful sequential cuts through each bud with a sharp razor blade. If 10 percent or more of the primary buds are dead, the number of buds retained at pruning should be increased to compensate for the loss.

Tissues other than buds are also subject to winter-cold damage. Damage to internodes and trunks

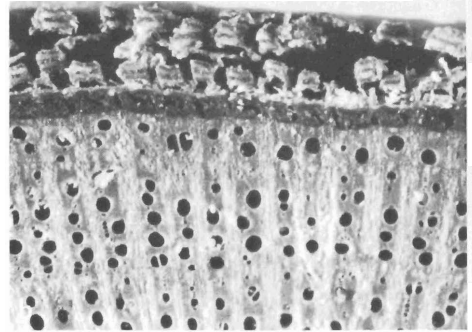
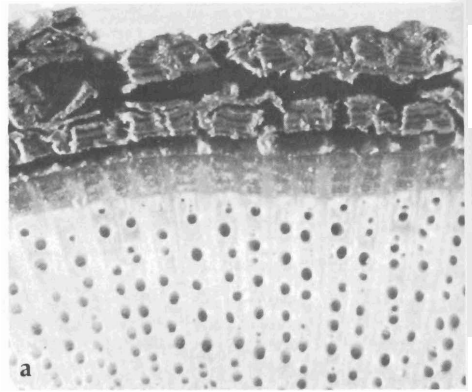


Figure 22. Winter damage to grapevines. *a*, cross section of undamaged trunk; *b*, cross section of cold-damaged trunk; *c*, cross section of grape buds showing dead primary bud and undamaged secondary and tertiary buds.

(fig. 22) can affect the percentage of bud break and shoot development. Therefore, such damage should also be taken into consideration when assessing cold damage and the need for adjusting pruning severity.

PRUNING COLD TENDER VARIETIES. When growing cold-tender varieties in locations where appreciable bud kill can be expected, the concept of balanced pruning should be modified. If vines must be pruned during the dormant season, they should be pruned lightly, with approximately twice as many canes and nodes, as dictated by balanced pruning, being retained. Once growth commences, shoot number, if excessive, should be adjusted to the number called for by balanced pruning. Vinifera wine varieties commonly planted in New York should be pruned in this fashion, a 20 + 20 formula being used, coupled with flower-cluster thinning to one cluster per shoot. No more than 60 nodes, with developing shoots, should be retained on vines spaced 8 feet in the row.

DOUBLE PRUNING. Because of apical dominance, the buds on canes break dormancy in an apical to basal pattern; that is, the buds at the end of the cane commence growth first and briefly suppress the growth of basal buds. The double pruning technique attempts to use this phenomenon to reduce the risk of shoot damage by a late spring freeze. This technique increases the cost of crop regulation, but may be useful for high-value varieties or on sites with a higher than normal incidence of spring freezes or with early budding varieties such as Ives. Double pruning involves retaining the full length (or a minimum of several additional nodes in length)

of each fruiting cane and then re-pruning each cane to the desired number of shoots after growth has started and the risk of spring freeze is past.

PRUNING NEGLECTED VINES.

Vines unpruned for a year or more are usually low in vigor and contain a jumble of dead or poorly ripened canes, many of which are badly located. Such vines can be rejuvenated to bear good crops within 2 to 3 years by pruning, flower-cluster thinning, adequate fertilization, and weed control.

A vine overcropped and unpruned for several years has a low reserve of carbohydrates in roots and trunks. To restore these reserves requires a large, healthy leaf surface and no crop. In the first year, 40 to 80 nodes on the best available canes, plus renewal spurs at desired locations, should be retained. All flower clusters should be removed before bloom. In the second year, the vines should be balanced pruned; at least half a normal crop can be obtained. Because trunks of neglected vines are likely to be injured, one or two suckers for renewal should be retained in the year in which they appear. Good weed control and liberal fertilization with nitrogen and other nutrients, if deficient, speed the recovery of neglected vines.

HANDLING THE VINE

PRUNINGS. After pruning and before the start of shoot growth, all the prunings, except trunks infected with *Eutypa* dieback disease, should be pulled from the trellis and placed between the rows where they can be shredded with brush-chopping equipment (fig. 21). Trunks and stumps infected with *Eutypa*

dieback should be carried from the vineyard and burned or buried. In removing the prunings, care should be taken to avoid breaking the retained canes. Tying is easier if it is done after the prunings have been chopped.

FLOWER-CLUSTER THINNING

Flower-cluster thinning is the removal by hand of some (usually all but one) of the flower clusters on each shoot and is most efficiently done when the clusters first appear. The purpose is to reduce an excessive crop so that the remainder will mature or to increase the vigor and size of very weak vines or both.

In 1950, 1956, 1958, 1971, and 1976, most vines in Chautauqua County were exceptionally fruitful. In 1956, 30 + 10 pruned Concord vines in one experimental vineyard yielded 8.5 tons per acre; the fruit reached only 13% soluble solids in 107 days after bloom. Similarly pruned vines from which two-thirds of the flower clusters had been removed produced 4.1 tons per acre, and the fruit reached 13% soluble solids in 91 days, more than 2 weeks earlier. Comparable results have been obtained experimentally in other years of exceptionally large crops. New York growers cannot afford to prune so severely every year that these unusually large crops are always avoided. So, in these exceptionally fruitful years, the recommended 30 + 10 pruning *plus* flower-cluster thinning can be a useful combination.

PLANT-GROWTH REGULATORS. Certain chemicals can alter the

growth and development of vines or fruit or both. These compounds are called plant-growth regulators. Two of these, Alar and gibberellic acid, are registered for use in New York vineyards. *Alar* is a growth retardant, which can increase fruit set and cluster size by reducing the rate of shoot elongation and, thus, competition for carbohydrates during the critical grape-bloom and fruit-set period. It should only be used in those cases where vine size is large (greater than 2 lb of cane prunings per 8-ft-spaced vine) and the rate of shoot elongation is excessive. It should not be used where the increased set will lead to overcropping, excessive cluster compactness, or delayed maturity. It is applied as a bloom-time spray at a rate not to exceed 1 pound per acre. Although labeled for several varieties, it is currently recommended only for the Concord variety. It is generally not recommended for shoot-positioned, Geneva double curtain trained vines. Consult your Cooperative Extension office and the label for up-to-date recommendations.

Gibberellic acid is a natural plant hormone. Seedless grapes respond to gibberellic acid with an increase in berry size. Most seedless varieties will respond favorably to the treatment. With some varieties, however, caution is urged. For example, with Canadice increased berry size can result in excessive compactness and berry cracking. Concord seedless also reacts unfavorably. Gibberellic acid is applied at fruit set, usually about 7-10 days after bloom.

Application of gibberellic acid to seeded varieties at the time shoots are 4 to 6 inches long can result in

reduced cluster compactness and, therefore, a reduction in bunch rot in varieties with excessively compact clusters. However, seeded varieties vary considerably in their response to gibberellic acid, and the label should be consulted for the recommended rate of application.

Misapplication of gibberellic acid can result in increased winter damage and reduced bud fruitfulness in the year following application; so recommendations on the label should be strictly followed.

Fruit and Vine Maturation

Early maturity of the fruit and the vine is more certain in New York vineyards if—

- an early maturing variety is grown;
- grape bloom is earlier than June 15;
- the mean temperature for the 100 days following grape bloom is above average;
- the crop is somewhat less than the “capacity” of the vine;
- there is enough trellis space for all-season exposure of the leaves at the basal 4–6 nodes of the fruiting shoots;
- the leaves are free of damage by diseases, insects, air pollutants, and nutrient deficiencies;
- the first fall freeze does not come before late October.

The ripeness of the fruit and of the canes is closely related. On a vigorous vine the ripest fruit is found on the well-exposed shoots that mature into canes; the least-mature fruit is found on the shaded

shoots that are frost-killed for half or more of their length.

Concord berries usually show the first pink coloration in mid-August; at this time the soluble solids content is about 8 percent. The maturation period extends from this color change, or veraison, until harvest. Figure 23 shows the increases in soluble solids, berry weight and color, and the decrease in acids during a growing season. Soluble solids of grape juice are mainly sugars. Because the concentration of soluble solids gives reliable indication of juice color, it is an excellent measure of grape maturity for ConCORDS that will be pressed for juice. The date for harvesting grapes for processing is generally determined by the degree of maturity the processor desires.

Bird Damage in Vineyards

Much damage can be caused by birds feeding on ripening grapes from mid-August until end of harvest. The birds may either eat the entire berry or damage the fruit by pecking or clawing, causing punctures, which expose the sweet juice and flesh to attack by bees, infestation of fruit flies, dehydration, and various fruit rots.

The severity of damage is related to variety, degree of ripeness, lack of foliage covering the fruit, and proximity to bird roosting sites, such as a hedge or woods or power line. The bird species most troublesome in New York vineyards are starling, robin, oriole, blue jay,

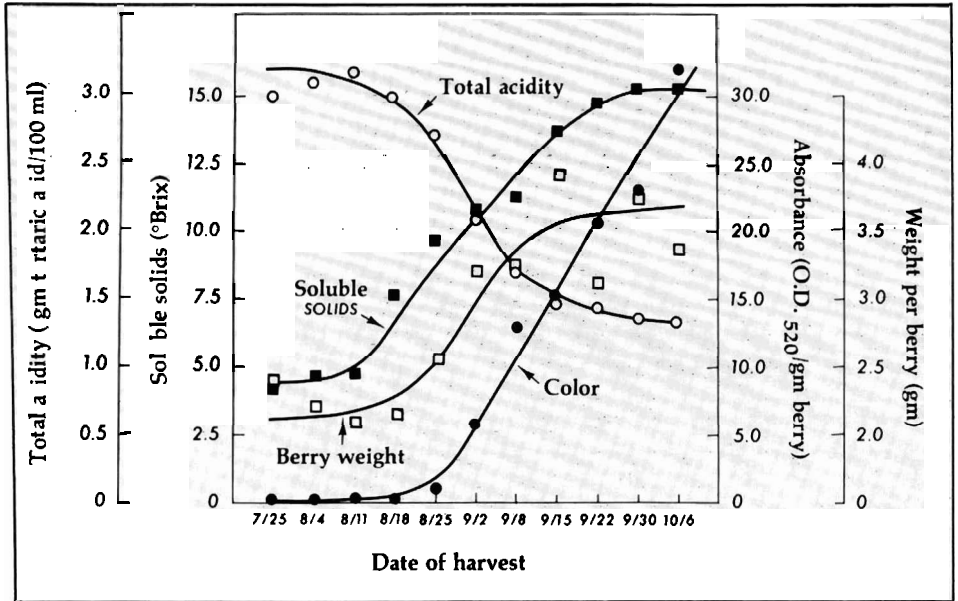


Figure 23. Changes in Concord fruit composition during a growing season. (Source: Dick Kluba, Ph.D. thesis.)

flicker, mourning dove, gold finch, several species of field sparrow, and, occasionally, red-winged blackbird.

Varieties most often damaged by birds are Aurore, Baco noir, Marechal Foch, Verdelet, Cascade, Himrod, Interlaken, Rosette, Leon Millot, Colobel, Chelois, Pinot noir, and Delaware.

Many procedures have been tried to avoid or reduce the amount of bird damage. The use of an electronic noisemaking device called the Avi-Alarm has been generally helpful, as has the use of propane- and acetylene-gas-operated exploders. Frequently growers have reported that the combination of electronic noisemakers with gas exploders has been most helpful. The use of a coarse netting with 3/4- to 1-inch mesh openings gives

complete protection, but is expensive, cumbersome to install, and difficult to remove.

Research with bird repellants in New York and elsewhere has shown promising results. In 1979 the N.Y.S. Department of Environmental Conservation was granted a section 18 exemption by the U.S. Environmental Protection Agency for vineyard use of the repellant Mesurol. Consult your Cooperative Extension specialist or county agricultural agent for the current status of and use recommendations for repellants.

Much damage from birds can be prevented if one avoids growing those varieties especially attractive to birds. If a variety attractive to birds is chosen, then damage can be minimized by doing the following: avoid isolated sites—set the

planting in the middle of a grape area and preferably near the house so that the vineyard can be frequently patrolled; remove all hedge rows or woods, including large solitary trees, near the vineyard; use a training system that keeps the fruit on the trellis well covered by foliage so that the ripe fruit is not readily apparent to birds; and use noisemakers or a labeled repellent or both from about the time the fruit starts ripening (but before the birds start extensive feeding on the fruit) until harvest is completed.

Varieties (Cultivars)

The success of a vineyard depends to a large extent upon the varieties it contains. In choosing a variety, vineyardists should consider all the available facts about its vine and crop characteristics; they should consider its adaptability to the locality and site, the uses that can be made of the fruit, and the available market outlet. When a commercial vineyard is planned, the processor who will purchase the fruit should be consulted.

As with other fruits, hundreds of varieties of grapes have been named and introduced, but only a few have assumed commercial importance in New York. New varieties are still being originated; vineyardists should test a few vines of the more promising ones under their conditions.

Only in areas with long growing seasons should varieties that ripen

later than Concord be planted. Using varieties that ripen earlier is a more practical way to lengthen the commercial grape season in New York State.

LEADING COMMERCIAL VARIETIES

AMERICAN VARIETIES. The relative importance of major grape varieties in the principal grape districts of the state is shown in table 5. *Concord*, the leading commercial variety in New York State, constitutes approximately 65 percent of the acreage.

The many ways in which the fruit is used gives Concord a larger market outlet than any other American grape variety. Concord bunches and berries are of fair size and the abundance of bloom that covers the blue berries makes a handsome fruit. Concord also is the variety most in demand for grape juice; it is used for wine production more than any other variety grown in New York; it is a popular table grape and is widely used for grape jelly and grape preserves.

Concord also succeeds on a greater number of soils and under a wider range of climatic conditions than do most varieties.

Concord has some faults. Although many people like its fruity taste, others consider it objectionable. It is susceptible to *Eutypa dieback* disease. For growers who would like to market Concord-type table grapes, Alwood and Price are suggested for early marketing and Sheridan for marketing after Concord.

Catawba is a standard red grape of the American type. Except in areas

TABLE 5. NEW YORK GRAPE ACREAGE BY VARIETY AND AREA, 1975

Variety	Chautauqua- Erie	Niagara	Finger Lakes	Hudson Valley	Other
Concord	19,626	1,342	5,743	681	176
Catawba	749	294	2,341	35	58
Niagara	690	522	809	21	313
Delaware	680	20	1,356	36	31
Aurore	152	99	1,441	21	14
DeChaunac	166	92	583	30	28
Baco noir	48	—	572	—	23
Ives	46	—	545	—	5
Elvira	86	—	430	—	22
Dutchess	21	133	192	—	—
Misc.	476	317	1,362	237	47

SOURCE: Suter, G.W., *New York Orchard and Vineyard Survey 1975*, N. Y. Crop Reporting Service, Dept. of Agriculture and Markets, State Campus, Albany, NY 12235.

with long growing seasons, Catawba may fail to ripen satisfactorily. The vines are vigorous, hardy, and productive, but the foliage and fruit are susceptible to fungus diseases. The wine industry is the important outlet for Catawba. It makes a high-grade, white juice that is used in champagne and other wines.

Niagara is a leading white grape of the American type. It can be grown in any of the grape districts of New York, although it is not as cold-hardy as Concord. It is useful for the fresh market, wine, and fresh juice. *Niagara* is moderately susceptible to the major grape diseases.

Delaware is a high-quality wine variety. The vines are not as hardy as Concord. *Delaware* fruit matures about 2 weeks before Concord. The skin of the mature pink berries is tender and subject to cracking, and fruit and foliage are susceptible to attack by fungus diseases.

This variety requires a deep, fertile, well-drained soil for good vine growth. For other soils it should be grafted to a phylloxera-resistant rootstock. The berries are

smaller than in most other varieties, and the cluster is compact. On good sites and under good management, yields of *Delaware* may approach those of *Concord*.

COMMERCIAL VARIETIES OF LIMITED ACREAGE

AMERICAN VARIETIES. *Cayuga White* was named in 1972 by the Geneva Agriculture Experiment Station. It resulted from a cross between *Seyval* and *Schuyler*. It produces a fruity, European-type white wine, which has received excellent ratings in tastings at the Geneva Station. It is vigorous, productive, and moderately winter-hardy. Its growth habit is relatively upright, and its shoots are somewhat subject to wind breakage.

Dutchess is a green grape with high quality. It ripens between *Concord* and *Catawba* and apparently has a large proportion of *Vitis vinifera*, the European grape, in its makeup. The vine is susceptible to diseases and is often damaged by low temperatures.

Elvira is a white wine grape with *Vitis riparia* parentage. It is productive, hardy, and somewhat resistant to diseases. It ripens with Concord. The thin skin and crowding of the berries in compact clusters may cause the berries to crack. A new variety, *Ventura*, has been released by the Horticultural Research Institute of Ontario, Canada. It has fruit and vine characters similar to *Elvira*, but its fruit resists cracking. It is under trial in several New York vineyards as a replacement for *Elvira*.

Ives is a black, *Vitis labruscana*-type grape used for making red wine. It is very sensitive to the air pollutant, ozone, and may be weak growing and unproductive. In some cases grafting to a phylloxera-resistant rootstock such as C.3309 has improved vine size. Other cultural practices will partially alleviate the effects of ozone.

Moore's Diamond produces a strong-flavored white wine. It is hardy and productive and moderately susceptible to powdery mildew. It ripens just before Concord.

Vincent is a dark blue grape from the Horticultural Research Institute of Ontario, Canada. It is vigorous, productive, and moderately winter-hardy. It produces a dark-colored red wine, which has rated very well in tests at Geneva.

FRENCH-AMERICAN GRAPE VARIETIES. French-American varieties were introduced by French grape breeders who produced them by crossing the European varieties with certain wild species grown in America. They are used primarily for wine, and plantings should be made only of varieties

recommended by the processor who will purchase the crop. Hundreds of French-American hybrid varieties exist, and many are just now being evaluated in New York. Those currently of major importance in New York follow:

Aurore (Seibel 5279) is the most widely planted French-American variety in New York. It is vigorous, medium hardy, and productive. It is the earliest maturing wine grape of importance in New York. The thin skin and medium-large, compact clusters may cause the berries to crack, especially if there has not been adequate control of powdery mildew. Birds may be serious pests.

Baco noir (Baco 1) is a widely planted red French-American variety in New York. It is very vigorous; but because of its small clusters and berries, its productivity may be somewhat reduced compared with other varieties. It ripens 2 weeks before Concord. The trunks of *Baco noir* are subject to damage from winter cold. Own-rooted vines are susceptible to infection by soilborne viruses.

Cascade (Seibel 13053) is a vigorous, hardy, red wine grape, which ripens well before Concord. Own-rooted vines are susceptible to infection by soilborne viruses. It is rarely planted now and not recommended for New York for both viticultural and enological reasons.

Chancellor (Seibel 7053) ripens with Concord and makes a red table wine of high quality. It is vigorous and productive, but extremely susceptible to downy and powdery mildews. Only growers who will give careful attention to their spray

program should attempt to grow Chancellor. It is generally winter-hardy, but overcropped or diseased vines have suffered trunk injury.

Chelois (Seibel 10878) is a red wine grape and matures just after Concord. It is vigorous, but susceptible to winter damage and fungus diseases. Its fruit may crack in some years.

De Chaunac (Seibel 9549) is hardy, vigorous, and productive. It is the most-prevalent red French-American variety growing in New York and ripens with Concord. This variety will overbear and lose vigor and winterhardiness unless its crop size is controlled.

Marechal Foch (Kuhlmann 188-2) is an early ripening red wine grape with small clusters and berries. It is hardy and more productive when grafted on a phylloxera-resistant rootstock.

Rougeon (Seibel 5898) is hardy and vigorous. In some years Rougeon will bear little crop because of a failure to set fruit. This problem is not understood and is presently under study.

Seyval (Seyve-Villard 5-276) produces a white wine of high quality. It is very productive with large, compact clusters. If allowed to overbear, vine size will be reduced, and the vines will be less winter-hardy. Properly cropped vines ripen 2 weeks before Concord.

Vidal 256 is a white grape which ripens shortly after Concord. It has large vine size and large, compact clusters and is moderately hardy. It has produced high-quality white wines.

Vignoles (Ravat 51) is a white grape

and has a moderately hardy vine and small, compact clusters, which frequently crack and rot during inclement weather around harvesttime. It ripens with or before Concord and produces white wines of high quality.

VITIS VINIFERA VARIETIES. In recent years there has been much interest and some commercial success in growing European (*Vitis vinifera*) grape varieties in New York. These varieties are less winter-hardy; as a class their production will be more erratic and smaller in most regions in New York as compared with our native varieties. In general, they are also more subject to fungus diseases. Successful culture requires the best vineyard management and should only be attempted on superior vineyard sites. The vines should be grown on resistant rootstocks when planted in soils that are or may become phylloxera infested. This property is true of most vineyard sites in New York. Only the earliest maturing varieties should be grown. Generally, in New York, the white varieties have produced higher-quality wines than have the red varieties.

Chardonnay is the variety from which the white Burgundy and champagne of France are produced. It has produced some outstanding wines when grown in New York State.

White Riesling is the grape from which the best wines of Germany are made. It has made outstanding wines with good varietal character in New York.

Gewurztraminer will produce a wine with a spicy, aromatic character. It generally has been more subject to winter damage in New York than

have the previously named vinifera varieties.

Pinot noir is the red wine grape from which Burgundies are made. Its fruit tends to crack in wet weather; as a result the variety is difficult to mature properly in New York.

Cabernet Sauvignon can produce outstanding red wines. It matures later than do the other listed varieties, and so the quality of its wine has been variable in New York.

DESSERT VARIETIES

Commercial production of grapes for fresh market sale is currently a small part of the total grape production in New York, but there is much interest in expanding this area. Many varieties are suitable for dessert grape production; those listed represent some of the most promising.

Seedless varieties are much preferred by customers for dessert grapes. Four white seedless varieties have been bred for New York growing conditions. In order of ripening, from early to late, they are *Interlaken*, *Himrod*, *Lakemont*, and *Romulus*. These were all produced from crosses with the winter-tender, European seedless grape *Sultanina*; and as a consequence, none is fully hardy except on the best grape sites in New York. They are also somewhat susceptible to powdery mildew. *Interlaken* and *Himrod* have relatively small clusters and berries and should be treated with gibberellic acid to improve appearance. The other varieties will also benefit from gibberellic acid treatment. In 1977 a

new, cold-hardy, seedless variety, *Canadice*, was named by the Geneva Experiment Station. The fruit of this early ripening variety is red and is likened to Delaware. Gibberellic acid treatment is *not* recommended on *Canadice*.

Seneca is an early ripening white-seeded grape of high quality. It is only moderately winter-hardy and is susceptible to powdery mildew.

Buffalo has the best dessert quality of the early ripening black grapes. The vines are large and moderately winter-hardy.

New York Muscat is a dark red grape with a rich muscat flavor. The vines are moderately winter-hardy, and the fruit ripens 1 week before Concord. The vines are subject to powdery mildew and will lose vine vigor and size if allowed to overbear.

Steuben is a blue grape that ripens with Concord. It has very attractive fruit and rich flavor, stores well, but will overbear and lose vine vigor and size without flower-cluster thinning. If not overcropped, the vines are hardy.

Yates is a hardy red grape with juicy, sweet flesh and a tough skin. It ripens about 10 days after Concord and has an exceptionally long storage life.

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APPROXIMATE CONVERSIONS TO METRIC MEASURES

Symbol	When you know	Multiply by	To find	Symbol
LENGTH				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
A	acres	0.4	hectares	ha
MASS (WEIGHT)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
TEMPERATURE				
°F	Fahrenheit temperature	5/9 (after sub- tracting 32)	Celsius temperature	°C

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Cooperative Extension, the New York State College of Human Ecology, and the New York State College of Agriculture and Life Sciences, at Cornell University, Ithaca, N.Y., and the U.S. Department of Agriculture, cooperating. In furtherance of Acts of Congress May 8, June 30, 1914, and providing equal opportunities in employment and programs. Lucinda A. Noble, Director.

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