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Training-Trellis Systems and Canopy Management of Table Grapes in California

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Crossarms for foliage support first appeared in California table grape vineyards in the 1930s. Prior to that time, vines were free standing or had a single wire vertical trellis system (1, 10, 14). W. E. Gilfillan (5,6), University of California Farm Advisor for Tulare County, and Dwight Long, a Tulare County grower, discovered that better light exposure improved the color development of Emperor table grapes and that separating the fruit from foliage facilitated fruit thinning and harvest. They evaluated both "T" and "Y" trellis systems and double crossarms arrangements. Because of simplicity and effectiveness, a "T" trellis with a single crossarm with two or three foliage support wires was quickly adopted by most growers in the table grape industry (5,6). This "T" trellis has been the industry standard over the past 60 years with only slight modifications.

The "standard" trellis for California table grape vineyards consists of a "T" trellis with a 0.9 to 1.2 m crossarm (2 to 5 wires) placed at the top of a 2.1 m stake driven into the ground about 60 cm. Cane-pruned varieties use 1.0 m to 1.2 m wide crossarms with four to five wires evenly spaced with canes tied to the center wires (12). Spur-pruned cultivars have cordons located 45 cm to 60 cm below the crossarm, with two or three wires on the crossarm. The standard distance between rows is 3.65 m; the standard distance between vines is 2.4 m.

Objectives for Trellis and Canopy Management Systems

Presently, new trellis designs and canopy management systems are being evaluated in California table grape vineyards with the following objectives.

Maximize light interception by the canopy: The yearly production of biomass and potential economic yield per hectare are reduced when light strikes the vineyard floor rather than the canopy (13). Total biomass production is directly related to light interception by leaves. A trellis should provide the framework for a leaf canopy that maximizes light interception per hectare.

Table grape vineyards with a "standard" trellis and row spacing intercept about 50% to 75% of available light by late May when the canopy is fully developed (17,22). Therefore, there is potential for increasing light interception and, subsequently, yield by expanding the canopy. Expanding the width of the standard trellis or reducing the distance between rows are different approaches that can achieve similar results (13,21,23).

Expanding the width of the "standard" trellis, but maintaining row spacing at 3.65 m, may be most effective in high vigor table grape vineyards. The wider trellis increases light interception per hectare in addition to reducing canopy density. Trellis designs of particular interest are the "T" trellis systems with 1.1 m crossarms or wider, the expanded "Y" trellis systems with arms extended 1.8 to 2.6 m apart, and the overhead gable systems.

Reducing row spacing, without increasing crossarm width, may be the best method to increase yield in medium to low vigor vineyards, especially for cultivars with fruit susceptible to sunburn and heat damage. The smaller crossarm increases canopy density over fruit, reduces light penetration within the canopy, and provides protection for heat sensitive cultivars. The reduced row spacing increases light interception per hectare. Yields are optimized at a row spacing of 3 to 3.3 m using crossarm no wider than 0.9 m: if a wider crossarm is used, then row spacing must be increased to provide for equipment access to the vineyard floor and prevent canopy bridging between rows (F. Jensen, personal communication).

Optimize light distribution within the canopy: In high vigor vineyards, low light levels within the canopy and in the fruit zone can reduce fruit bud formation, particularly with Thompson Seedless (12,15). High vigor vineyards that are inadequately trellised generally have low bud fruitfulness, excessive berry drop, and yield well below capacity. With reduced yields, more assimilates are diverted to vegetative growth which further decreases bud fruitfulness, and the vine settles into a vegetative treadmill (18).

Low light within the fruiting zone can reduce fruit color of red and some black cultivars. The application of ethephon helps to overcome reduced light in the fruit zone necessary for adequate color development of Flame Seedless and other red cultivars, but not Emperor (8).

Trellis designs for table grapes should be developed that reduce labor required for canopy management. On a standard "T" trellis, dense canopies develop with high vigor vineyards. Consequently, the canopy must be extensively managed to improve light distribution within the canopy. This includes labor-intensive activities like positioning shoots, pulling interior and exterior leaves, and cutting canes. Annual expenditures for canopy management can exceed $700/h, which underscores the potential for improving trellis design and reducing these production costs.

Separate fruit from canopy and wires: An effective table grape trellis and canopy management system separates clusters from foliage and wires, and separates clusters from one another. The fruit zone should be located at a convenient height for workers.

The trellis design and canopy management system should establish a fruiting zone that is easily accessible to workers for cluster thinning, berry thinning, and harvest. These tasks are difficult and expensive when fruit is buried in foliage and wires. Labor cost to thin and harvest table grapes can exceed $3500/h in California. Trellis designs that improve access to fruit can significantly increase labor productivity.

Fruit scarring can be reduced and packable yields increased when clusters are separated from foliage, wires, and other clusters by a properly designed trellis and canopy management system. Scarring results when berries abrade against foliage, wires, and other clusters. Clusters wedged between wires and shoots are difficult to harvest without excessive damage and are usually not suitable for packing. Separation of fruit from the canopy decreases humidity, increases temperature, and improves ventilation in the fruit zone (4). Separating fruit from the canopy allows sprays to be directed at either the fruit, canopy or both depending on objectives.

Maximize return on investment: The cost of a table grape trellis can range from $4000/ha for a standard "T" trellis to more than $8000/ha for an overhead system. Overhead systems also require considerable skill to install and maintain. Returns on investment over the lifetime of the vineyard must be analyzed to determine if the added cost is justified.

In 1930, the table grape industry adopted the standard "T" trellis for its simplicity and productivity (5,6,10). It has been the industry standard, with very few modifications, the past 60 years. It remains to be seen whether or not the expanded "Y" or overhead trellis systems currently under evaluation will replace the standard "T". Economics and practicality will play an important role in the outcome.

Trellis Designs for Table Grapes

A renaissance in trellis and canopy management systems has occurred in California during the past ten years. Many different ideas are being evaluated in commercial vineyards including open double crossarm systems, various "Y" trellis designs, and overhead trellises, both gabled and flat. Figure 1 shows some trellis concepts of interest for Thompson Seedless and other cane-pruned cultivars. These designs can be modified to accommodate spur-pruned cultivars: quadrilateral cordons are used in place of canes, and the quadrilaterals are lowered to 60 cm (instead of 30 cm for canes) below the canopy support system to allow for future spur growth. These systems include movable wires to help position shoots and establish distinct fruiting zones.

Our research team is evaluating various trellis systems, including those in Figure 1, in combination with various canopy management techniques. Our goal is to develop a trellis and canopy management system that will satisfy the aforementioned objectives for major table grape cultivars.

Managing Table Grape Canopies

Canopy management is an integral part of growing table grapes. Thinning and positioning shoots, throwing and cutting canes, pulling interior and exterior leaves have all been practiced by California table grape growers for the past 60 years (3). The type and extent of canopy work varies considerably and depends on the cultivar, trellis design, and vine vigor.

Shoot thinning: Shoot thinning has two objectives: (1) adjust inflorescence numbers and (2) reduce shoot congestion in the fruiting zone (20,23). Shoots 6 to 12 inches long are thinned on spur-pruned table grape cultivars. Shoot thinning is not required on some cultivars, such as Emperor, which push very few latent buds and rarely require crop adjustment. Redglobe and Calmeria are usually not shoot thinned in low vigor vineyards to increase shading in order to protect fruit against heat damage and sunburn.

Commonly, two shoots per spur are retained, and latent shoots are removed from older wood, arms, and cordons. Only sterile shoots should be removed during light crop years. The position of next year's spurs should be considered when shoot thinning. A fruiting arm that has grown too high can be lowered by leaving a latent shoot, thus allowing the pruner to lower the arm. Fruiting gaps along the cordon can be corrected by leaving latent shoots in appropriate positions. Cane-pruned varieties are sometimes shoot thinned, especially when several canes are wrapped together on a single wire. Normally, only sterile shoots are removed along the canes to space shoots and relieve shoot congestion.

Early basal leaf removal: Basal leaves and laterals are sometimes removed from Flame Seedless, Ruby Seedless, Exotic, Ribier, Fantasy Seedless, Crimson Seedless, and Queen, particularly in high vigor vineyards with standard "T" trellises. The amount of basal leaf removal ranges from none in vineyards with low canopy density to the removal of all primary leaves and lateral shoots beginning at the basal node and continuing to the node opposite the apical cluster on each shoot in vineyards with high canopy density.

In vineyards with dense canopies, removing basal leaves increases light and reduces humidity within the fruit zone, facilitating manual operations such as cluster thinning and harvest (4). However, the benefits of leafing moderate to low vigor vineyards is questionable, and leafing any vineyard can increase fruit damage by heat and bird activity (19).

The cost of basal leaf removal is related to canopy size and the date the practice is performed. Leaf removal is less expensive near bloom, when the vine canopy is relatively small and lateral shoots are easy to remove, compared to later in the season. However, leafing early to reduce expense can have negative effects on fruit set and berry size.

Fruit set is directly correlated with number of mature leaves (3). Research with Cardinal and Ribier, seeded table grape cultivars, showed that when performed just before bloom removing basal leaves and lateral shoots up to the last retained cluster increased shot berries and reduced berry weight and packable yields (9). This response did not occur with the Flame Seedless cultivar (16). Perhaps the application of gibberellin to thin and size Flame Seedless may overcome the impact of early leaf removal. This introduces interesting questions concerning the relationship between vine leaf area and fruit development of seeded and seedless cultivars.

Basal leaves should not be removed before veraison on cultivars susceptible to heat damage or sunburn including Redglobe, Thompson Seedless, and Calmeria.

Leafing after veraison: To develop full color, clusters of red and black table grape varieties require light following fruit softening. Light in the fruiting area is increased by throwing or cutting canes on the north side of the row. With Emperor, leaves in the cluster region may also have to be removed from around clusters (8).

Cultivars differ in their light requirements for berry coloration. Emperor berries color poorly unless exposed to considerable light. The use of ethephon alone does not overcome this requirement (leaves still must be pulled regardless of the use of ethephon). Flame Seedless, Ruby Seedless, Redglobe, Christmas Rose, and Queen also require light exposure to color but not as much as Emperor. With Flame Seedless, ethephon largely substitutes for light, and little leafing is required. Leafing is of questionable value for Ribier and Exotic, black cultivars, to develop full color. The effect of light exposure, with and without ethephon, on color development of several red and black table grape cultivars is shown in the Table 1.

The degree of leafing is based on canopy density and light penetration into the fruit zone. Even with the Emperor cultivar with a high light requirement, weak vineyards with a sparse canopy require little or no leafing since ample light penetrates the canopy to promote full fruit color.

Conclusion

Various trellis systems, row spacing, and canopy management techniques are currently being evaluated for table grape cultivars in California. The objectives are to maximize light interception by the canopy, optimize light distribution within the canopy, separate fruit from canopy and wires, and maximize yield and return on investment.

Table 1. The effect of light exposure, with and without ethephon, on color development of several red and black varieties.

	Treatment			
	No light (bagged)		Light (normal exposure)	
	1 no ethephon	2 ethephon	3 no ethephon	4 ethephon
Red Varieties				
Cardinal	poor	good	good	good+
Emperor	poor	poor	fair	good
Flame Seedless	poor	fair	good	good+
Queen	poor	fair	good	good+
Tokay	very poor	very poor	fair	good
Ruby Seedless	poor	fair	good	good+
Black Varieties				
Barlinka	good	good	good	good
Blackrose	poor	poor	good	good
Exotic	fair	fair	good	good
Ribier	good	good	good	good

Source: Jensen et al. (1980), reference 8.

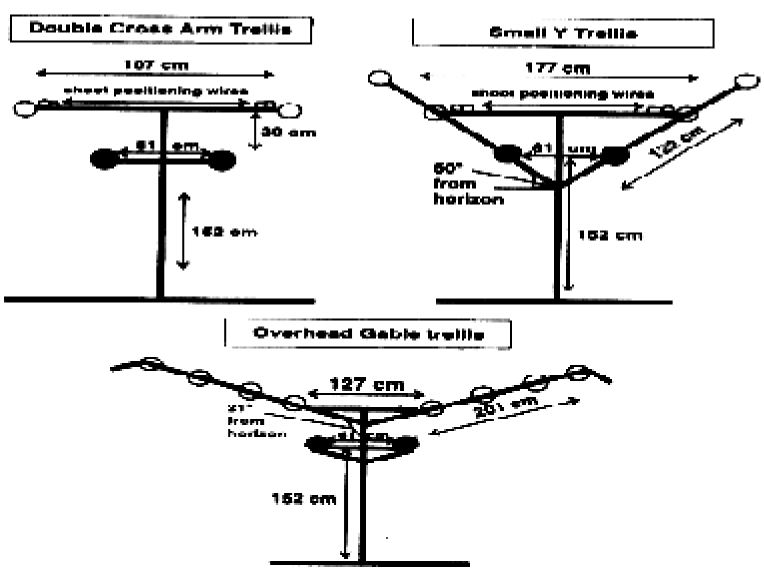

Fig. 1. Location of cane wires (●); canopy support wires (O), and shoot positioning wires (O–) for three experimental trellis systems designed for Thompson Seedless and other cane pruned cultivars.

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