

Technology & Product Reports

The Kearney Agricultural Center Perpendicular “V” (KAC-V) Orchard System for Peaches and Nectarines

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Additional index words. *Prunus persica*, pruning, training, high-density systems

Summary. This paper describes a moderately high-density orchard training system (1000 trees/ha) developed at the Univ. of California's Kearney Agricultural Center for peach and nectarine trees grown on standard rootstocks. This two-leader system was developed to increase production during the early years of the orchard while minimizing specialized management operations during orchard maturity. Early selection of two primary scaffolds oriented perpendicular to the tree row is recom-

mended during the first season of growth. During subsequent years, summer and dormant pruning requirements are similar to the standard open-vase system grown in California. Because of the uniform and relatively simple tree structure, individual scaffolds, rather than whole trees, can be used as functional units for crop load management.

As land and labor costs rise, growers are forced to turn to more-intensive farming practices to stay competitive within the market place. One method of doing this is through the use of high-density plantings. Pioneered by the apple industry, high-density plantings have been less used by stone fruit growers because most stone fruit species lack suitable dwarfing rootstocks to aid in overcoming excessive vigor (Walsh, 1991). Managers of high-density stone fruit orchards must rely on cultural practices such as pruning to control tree vigor. Therefore, any successful high-density system must be designed thoughtfully and established so that vigor management can be controlled efficiently. Many high-density systems can produce large amounts of fruit in the early years of the orchard (ages 2 to 6 years), but they are difficult to manage in later years. The key to a successful system is one that can obtain high early yields and sustain yields equal to or greater than standard plantings during the mature life of the orchard, without having to resort to excessively high labor and management inputs. Any new planting system also must be suitable and adaptable to local conditions and practices. With these constraints in mind, the Kearney Agricultural Center perpendicular “V” (KAC-

V) system was developed to fulfill the following criteria:

- 1) Increase production in the early years of orchard development (years 2 to 5).
- 2) Maintain yields equal to or greater than the open-vase system at tree maturity and through the remainder of orchard life.
- 3) Avoid the need for multiple, detailed summer prunings as a management method for controlling tree size.
- 4) Maintain row spacings similar to the standard open-vase systems so that equipment and irrigation pipeline modifications are not necessary.
- 5) Increase the ease of cultural practices, such as pruning, thinning, and harvesting associated with the open-vase system, by maintaining easy tree and orchard access and simplifying the tree structure.
- 6) Maintain or improve upon the canopy light distribution characteristics of the open-vase system.

The KAC-V is a hybrid between the traditional open-vase system and the Tatura trellis (Chalmers et al., 1978), but it requires no trellis. It is used primarily for growing peaches and nectarines, although plums, apricots, apples, and pears also can be adapted to the system.

Each tree is pruned to two major scaffolds (opposite each other in one plane) oriented perpendicular to the row direction. Fruiting wood is renewed annually directly from these scaffolds, which are not allowed to branch. The center of the tree is kept open and free from vigorous watersprout growth so that sunlight can penetrate to the lower portions of the canopy. Some fruiting wood is maintained on the interior side of the scaffolds in the center of the tree to provide both crop production and protection from scaffold sunburn.

The first experimental peach, nectarine, plum, and prune plantings of the KAC-V system in California were established at the Kearney Agricultural Center of the Univ. of California near Parlier, in 1982 (DeJong et al., 1991). In this trial, the performance of KAC-V trained trees spaced 2.0 m in the tree row and 5.5 m between rows (909 trees/ha or 372 trees/acre) was compared with open-vase trees spaced 6.1 m in the row and 5.5 m between rows (298 trees/ha or 121 trees/acre). This trial demonstrated the feasibility

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of the perpendicular V tree structure for supporting heavy crop loads and simplicity of the perpendicular V as an orchard production system.

The KAC-V system maintains or enhances several attributes of the standard open-vase system, such as easy tree and orchard access and good canopy light distribution characteristics, but provides an opportunity for early high orchard yields that are the primary goal of most high-density planting systems (Figs. 1 and 2). In the initial trial, the trees were trained with relatively heavy summer and dormant pruning during the first 2 years, but, in subsequent trials, it became apparent that less-severe dormant pruning is advantageous. This initial trial also indicated that, although the system

worked well for plums and prunes, the KAC-V system is particularly advantageous for coping with the growth characteristics, dense canopies, and bearing habits of peaches and nectarines. Therefore, this paper deals primarily with tree training and pruning recommendations for developing and managing the KAC-V system for peaches and nectarines.

Orchard layout

In the central valley of California, appropriate planting distances for the KAC-V system range from 1.5 to 2 m between trees in a row with 4.5 to 5.5 m between rows. The closer spacings are suitable for less-vigorous cultivars and low-fertility soils, while the wider spacings are more appropriate where

high tree vigor is expected. In-row distances between trees should always be large enough to maintain a 30- to 40-cm clear space between tree canopies. This allows good access to the trees and ensures sunlight penetration to lower branches. If distances between rows are <5 m, it is recommended that distances between trees in the row are at least 1.75 m and the rows are offset so that the tops of scaffolds of trees in adjacent rows do not meet at orchard maturity.

Mature tree height can be maintained at 3 to 4.5 m, depending on tree vigor. We recommend that, under conditions that promote high vigor (high fertility, vigorous cultivars), the trees be grown to a tree height that allows a good balance between cropping and vegetative growth. Arbitrarily limiting tree height by heavy pruning on the tree tops promotes vegetative growth and usually reduces yield.

Canopy light distribution is most uniform when orchards are planted with rows in a north-south direction. However, because the trees are maintained with open centers and, in central California, the midday sun during June and July is almost directly overhead, orchards with tree rows oriented east-west should perform satisfactorily. The primary concern about an east-west orientation is the potential for sunburn on the south-facing scaffold, although this problem may not be any more severe than the west-facing scaffold in a north-south-oriented orchard. Care should be taken in either situation to protect highly exposed scaffolds from sunburn.

Training and pruning young trees

The objective in training the KAC-V system is to form a tree that fills its allotted space as quickly as possible without interfering with growth or fruiting of adjacent trees. Because there is little yield difference between high- and low-density systems at maturity, it is imperative that high-density systems such as the KAC-V be managed with the intent of paying for extra trees with early yield. To do this, care must be taken during the first 2 years to optimize tree growth through proper irrigation, fertilization, pest control, and pruning.

First-year summer pruning.

At planting, the trees are headed 0.5 to 0.7 m from the ground, just as with an

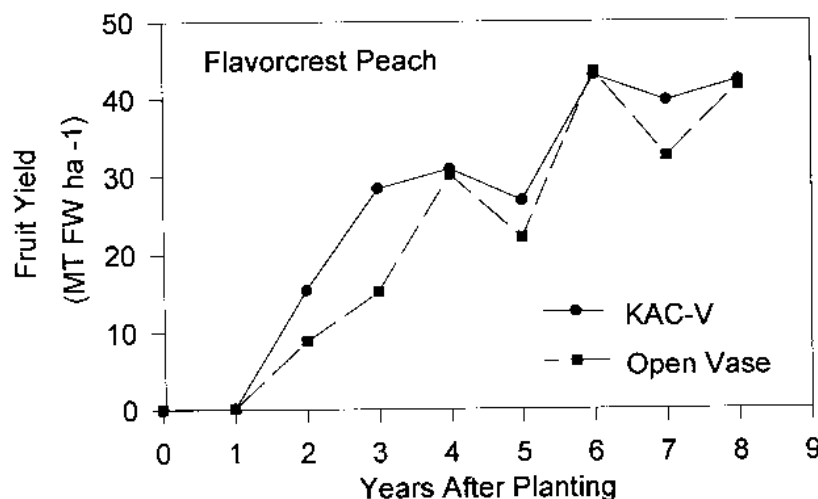


Fig. 1. Annual production pattern of 'Flavorcrest' peach in two pruning/training systems (open vase, spaced 6.1 × 5.5 m with 298 trees/ha and the KAC-V perpendicular, spaced 2.0 × 5.5 m with 909 trees/ha).

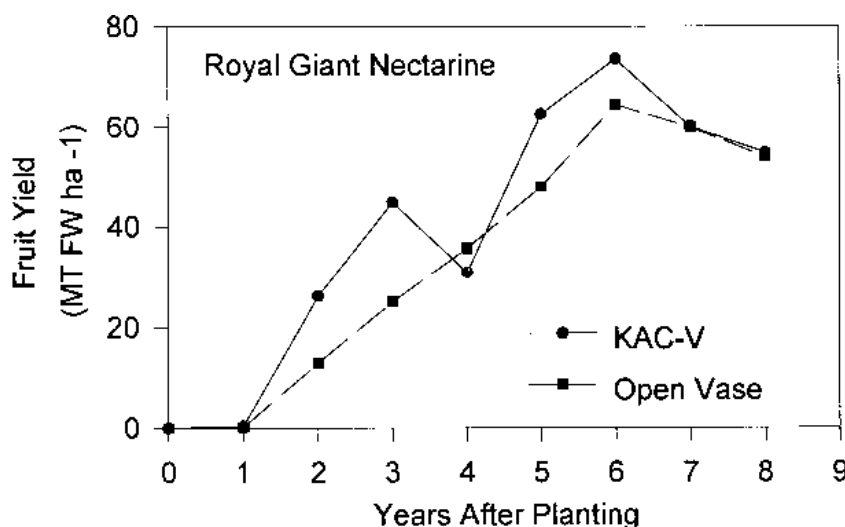


Fig. 2. Annual production pattern of 'Royal Giant' nectarine in two pruning/training systems (see Fig. 1 for details).

open-vase tree. For large nursery trees and those with excessive branching, the trees can be pruned to favor branch development perpendicular to the row direction. Trunks should be either painted or wrapped to avoid damage from sunburn.

In windy areas, scaffold selection should be delayed until shoots have become partially lignified to protect against wind breakage. However, in areas where the probability of wind damage is slight, and the trees are growing vigorously, early scaffold selection can be performed. In these areas, the two primary scaffolds—one on each side oriented perpendicular to the row—can be selected when shoot growth is 0.4 to 0.6 m long (Fig. 3). Competing branches are cut back to less than one-half their original length, or totally removed. Care should be taken to avoid selecting branches that are too horizontal ($>45^\circ$ from vertical), because they are more susceptible to sunburn, or too vertical ($<20^\circ$ from vertical), because narrow crotch angles can be weak and it will be necessary to widen the tree with bench cuts later in the life of the tree. The ideal branch angle for primary scaffolds is 25° to 40° from vertical (Figs. 3 and 4).

Early scaffold selection has a number of advantages over later mid-summer or dormant scaffold selection:

- 1) It quickly directs growth into the two primary scaffolds by reducing competition from other dominant branches.
- 2) It is much less expensive and can be performed quickly because there are fewer shoots to remove and they are easier to see than if performed later in the season.
- 3) It is less stressful to the tree because only a small amount of leaf area is

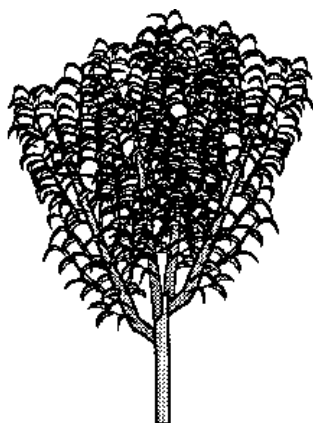


Fig. 3. Illustration of the type of pruning done during the first growing season to select scaffolds for future development. Only large, competing branches are removed.

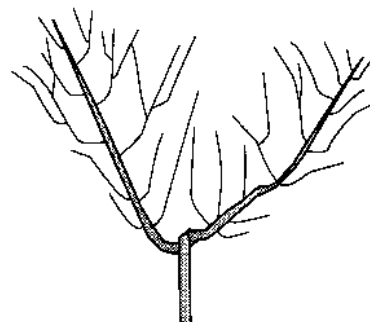
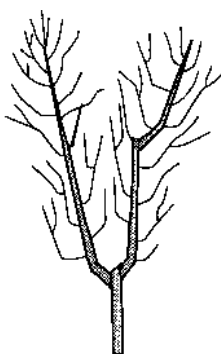


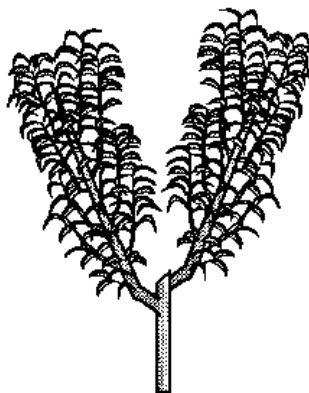
Fig. 4. Selection of branches with proper angles is important. Attempts to spread trees with bench cuts (a) or selecting flat branches (b) should be avoided.

removed and it is performed when temperatures are milder than in mid-summer.

- 4) It minimizes the possibility of selecting scaffolds with poorly formed crotch angles.

If the tree has had early scaffold selection performed in late April to early June, usually little, if any, additional summer pruning will be needed in the first growing season to obtain a properly formed tree. However, some trees growing under vigorous conditions may need to be pruned lightly in mid-summer to eliminate unwanted competing branches.

If early scaffold selection is not performed, the tree should be summer-pruned in late June or July to aid in developing the structure. It is important to remember that summer pruning always reduces total tree growth because of the removal of functional leaf area. When done properly, this is acceptable because summer pruning eliminates competing shoots and directs late-season tree growth into the selected scaffold branches. However, because of this dwarfing effect, summer pruning should never be performed on trees that are weak or under stress.



When pruning first-leaf trees in mid-summer, two primary scaffolds oriented perpendicular to the row are selected. These should be well-formed, strong branches $\approx 25^\circ$ to 40° from vertical. All other strong branches, especially those originating higher on the tree trunk than the two selected scaffolds, should be removed. Weaker shoots below the scaffold branches can be left to provide leaf area to help support the tree. It is very important not to over-prune or over-fertilize the trees at this time because of the possibility of stunting tree growth.

First dormant pruning. If the two primary scaffolds have been selected in the spring or summer, dormant pruning is a simple and rapid process. Vigorous, heavy, non-fruiting wood is removed from each of the scaffolds and then the amount of fruitwood is reduced to a level suitable for the particular cultivar (Fig. 5). The amount of fruitwood left depends on the grower's expectations for a second-leaf tree, keeping in mind that heavy crops will retard tree growth. One-half box of fruit per tree, or 500 boxes/ha (≈ 1000 trees/ha), would require about 36 fruit per tree, or 18 fruit per scaffold (assuming mean fruit size of 175 g or 56 count per box with 25% cullage). That many fruit could be produced on seven to 10 fruiting shoots/scaffold (with two to three fruit/shoot on fruiting shoots 30 to 45 cm long). These calculations assume no significant loss of fruit buds to winter freeze or spring frost.

If the scaffolds are growing at the proper angle and have sufficient caliper to maintain that angle with a crop, it is not necessary to head them. Unnecessary heading causes excessive watersprout growth below the heading cut (Mika, 1986). This increases shading and summer-pruning costs,

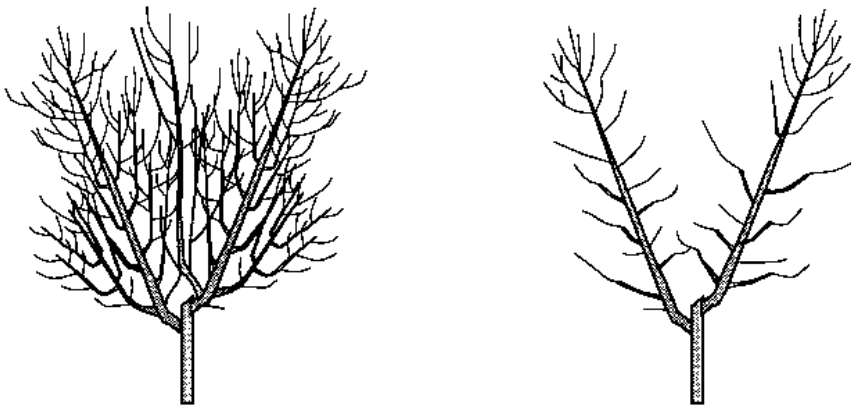


Fig. 5. Pruning during the first dormant season reinforces the dominance and proper direction of growth of the two scaffolds selected previously. Competing vigorous shoots (watersprouts) in the middle of the tree and below the scaffolds are removed and fruitwood is thinned to prevent over-cropping.

and can decrease fruit color. Heading cuts also increase the likelihood of forming flat areas (bench cuts) on the scaffolds that are very prone to sunburn. Heading should be performed primarily to redirect the growth of an improperly oriented shoot. If the diameter of the scaffold is too small to support heavy crops, it is best to use thinning cuts rather than heading cuts to decrease the potential fruit load.

If the trees were not summer-pruned during the first growing season, the two primary scaffolds must be selected during the first dormant pruning. The same procedure outlined for summer selecting of these scaffolds is appropriate. Once selected, they are pruned as discussed previously, emphasizing thinning cuts to select fruit wood. Pruning should be kept to a minimum to avoid reduced early bearing.

If tree growth the first summer was poor, then one should consider short-pruning the tree. This is done by selecting two branches oriented perpendicular to the row direction and cutting them back to a length of 20 to 40 cm. Generally, only one or two "hangers" (fruit-bearing shoots) are left on each of these branches, thus very little crop is produced in the second year. Short pruning a weak tree will result in vigorous regrowth the following spring. This will provide many strong shoots from which to select scaffold branches during the second growing season. If a tree is pruned this way, it is essential that the tree be summer-pruned during the second growing season to select proper scaffolds, direct growth, and prevent shading.

the second dormant season will severely restrict productivity the third year.

Summer-pruning second-leaf trees. Development of tree form continues during the second growing season. The basic shape of the tree was established the previous year (unless the trees were short-pruned during the dormant season) and training consists primarily of keeping tree growth directed properly. Summer pruning is necessary during the second growing season to maximize scaffold growth, but it is usually quite simple and rapid when performed properly. With the basic tree form established, summer pruning involves little more than eliminating vigorous watersprouts that compete with the desired extension growth of the scaffolds (Fig. 6). Few, if any, fruiting shoots should be removed. Summer pruning is performed best in early to mid-May, while shoots are

growing rapidly and before temperatures are high. Usually pruning can be done quickly, because only a few shoots are removed and they are generally <1.0 m long. Waiting until mid-summer to perform this operation often results in more costly pruning because much greater amounts of wood are removed.

Even if trees are pruned in May, some very vigorous orchards may benefit from a second summer-pruning in July or August. Again, this pruning should be kept to a minimum, removing only water sprouts and vigorous vertical shoots that are competing with the extension growth of the permanent scaffolds. Pruning late in the growing season on young, vigorously growing trees often will stunt tree growth if this pruning is severe. Severe pruning at this time also can stimulate lateral-branching and late-growing shoots, which will not be productive the following year. Most orchards do not need this second summer-pruning.

For trees short-pruned at the first dormant pruning, it is vital that a proper summer pruning program be followed. Short-pruned trees will have a large number of shoots arising below the heading cuts made in the dormant season. Unless the two main scaffolds are selected during the growing season, most of the energy of the tree will be spent on the growth of branches that will eventually be removed. Accordingly, these trees should be summer-pruned when shoot growth is 50 to 60 cm long by selecting two main scaffolds oriented perpendicular to the tree row and eliminating all others. These trees also may need to be sum-

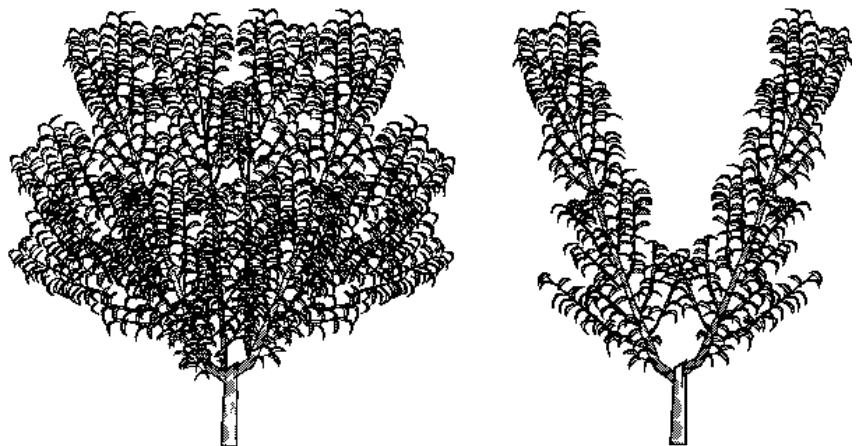


Fig. 6. Summer pruning in the second and subsequent growing seasons again reinforces the dominance of the scaffolds. Vigorous shoots are removed, but minimal pruning is done to select the next year's fruitwood.

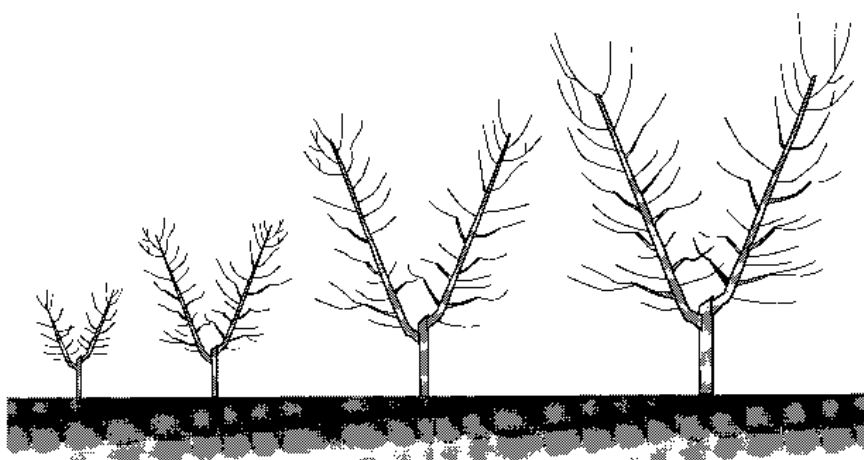


Fig. 7. *Dormant pruning after the second and subsequent growing seasons continues to reinforce the dominance and orientation of the two unbranched scaffolds that have been selected previously. Developing long perennial fruiting hangers is discouraged. Selecting renewal fruitwood arising directly from or close to scaffolds is preferred. Fruitwood is thinned to adjust potential crop load.*

mer-pruned a second time in mid-summer to maintain the dominance of the selected scaffolds. Again, this pruning should be kept to a minimum by removing competing watersprouts only.

Dormant-pruning second-leaf trees. The second dormant-pruning is very similar to that performed the previous year. Because the scaffolds already have been selected, pruning consists of removing vigorous upright shoots that may have developed following summer-pruning and thinning out fruit-bearing shoots to regulate cropping to a level desirable for the cultivar (Fig. 7). The tops of the scaffolds should each be thinned to a single leader. These leaders do not need to be headed because they are not allowed to branch. However, if necessary, they may be headed to redirect growth in desired directions. This is performed by heading the leader so that the uppermost remaining shoot is oriented in the direction or angle in which the scaffold should grow. Again, severe heading cuts of this type should be avoided whenever possible to reduce the risk of creating flat branches (bench cuts, Fig. 4), which are susceptible to sunburning.

Training third- and fourth-leaf trees. As the trees enter their third and fourth growing seasons, they have the capacity to produce large amounts of fruit when grown properly. For the most part, they can be treated in a manner similar to second-leaf trees. In most orchards, only one summer pruning will be necessary, although very vigorous orchards may benefit from

being summer-pruned twice to prevent shading of fruitwood and to continue directing tree growth and main scaffold extension. Summer pruning is performed similar to the previous year, primarily by removing watersprouts. As trees reach this age, a greater proportion of the watersprouts originate in the center of the tree (inside the V), rather than throughout the tree, as is the tendency of younger trees. It is important to remove these watersprouts early, keeping the center of the tree open so that light can penetrate through to lower fruitwood.

Dormant-pruning these trees is similar to that of previous years. Large competing branches and strong side-shoots should be removed entirely. Fruiting wood then can be reduced to the amount suitable for the particular cultivar. As trees approach their permanent height, the scaffolds should be cut back to an upright fruiting shoot, just as with a standard vase-shaped tree. In California, tree height is generally held to 3.5 to 4.5 m.

Care and maintenance of mature trees

Summer pruning. Summer-pruning mature KAC-V trees is only slightly different than pruning young trees. Because the final tree size and form have been established, summer pruning is used to maintain a proper light environment rather than train the tree. The basic summer pruning of the KAC-V can be performed quickly and easily by removing watersprouts. These watersprouts should be removed totally unless doing so would leave the

scaffold bare and susceptible to sunburn. If this is a problem, and adjacent fruiting wood and shoots fail to provide adequate sunburn protection, these watersprouts can be headed (stubbied) to a length of 15 to 30 cm. The remaining basal shoots and leaves will provide enough shade so that the chance of sunburn will be reduced. These stubs then can be removed during dormant pruning, or left and pruned to provide additional fruit-bearing surface. Flat areas (due to bench cuts) or bare areas on scaffolds exposed to afternoon sun should be whitewashed *before* sunburning occurs. Proper training and avoiding bench cuts during the early years of the orchard will minimize this problem.

Mature KAC-V trees should be summer-pruned before the interior of the V begins to fill in with excessive growth. Early season varieties often require more than one summer pruning. Preharvest pruning 2 to 3 weeks before harvest may be needed to open the center of the tree to get light to the fruit for proper coloring. Following harvest, these varieties usually undergo a period of rapid shoot growth that is stimulated by the removal of the fruit. If this regrowth is severe, it can necessitate another summer pruning in mid-summer (late June to mid-July) to prevent shading and death of lower fruiting wood (DeJong and Day, 1991). Generally, mid- and late-season varieties can be pruned about 3 to 4 weeks before harvest. This will open the tree, reduce shading and shoot death, and increase fruit color and quality. If trees, especially mid-season varieties, are growing under excessively vigorous conditions, they also may need to be summer-pruned following harvest to prevent excessive shading and to guard against shoot death.

Dormant pruning. Dormant pruning mature KAC-V trees is generally a simpler procedure than pruning open-vase trees of equivalent age. Due to the regimented structure of the system, each tree is virtually identical. As a result, pruning can be performed quickly and efficiently because only a single ladder position is needed to prune each scaffold. In many instances, scaffolds on adjacent trees can be pruned from a single ladder position by placing the ladder between the trees. On a per-acre basis, this reduces the time spent moving ladders, which translates into more-economical pruning.

The uniform tree structure also contributes to decreased pruning costs by reducing the amount of time a pruner spends deciding which cuts to make on a particular tree. Once the two scaffolds have been selected, they are not permitted to branch. The pruner then needs only to regulate the amount of fruiting wood rather than develop additional structural components of the tree.

When pruning mature KAC-V peach and nectarine trees, we recommend using a system of renewal pruning in which the previous season's fruiting shoots (hangers) are cut back to the main scaffold as closely as possible and "replaced" with new fruiting wood arising from as close to the main scaffold as possible. In this type of pruning, the highest-quality fruiting wood (20 to 50 cm long and 3 to 6 mm in diameter) is selected for fruit production in the upcoming season and new fruiting wood is stimulated for the following year. This also helps to keep the in-row space between trees open to direct light exposure.

Tree support

With heavy cropping on late-maturing cultivars, it may be advantageous to prevent excessive spreading of the scaffolds by looping tree rope around the two scaffolds at about three-fourths the height of the tree. Because the scaffolds are unbranched, they tend to be much stronger than in a standard open-vase tree and one tree rope is adequate. Only rarely are additional supports, such as tree props, needed.

Crop-load management. Because of the uniform tree structure, fruit load can be estimated and regulated relatively easily. Because the tree consists of two very similar scaffolds with fruiting shoots coming directly off of them, each tree can be pruned accurately to have a specific number of fruiting shoots, and later the fruit on

each shoot can be thinned to a specific fruit load. For instance, if a grower expects to have a yield of 3000 boxes (10 kg/box) per hectare and has 1000 trees per hectare, then three boxes are needed per tree. If the average fruit weight is 175 g (equivalent to size 50 to 56), then about 200 fruit (100 fruit per scaffold) are needed per tree (assuming 25% cullage). If, on average, the grower believes that four fruit can be carried per shoot given their average length, then each tree will need about 25 shoots per scaffold assuming no significant loss of shoots or fruit buds to freezing or spring frost damage. At thinning time, the grower can instruct the thinning crew to leave about four fruit per fruiting shoot. At harvest, the grower can note if fruit size is smaller or larger than expected and unless there is some environmental explanation for a deviation from expected production (such as drought or excessive heat), the grower can adjust the pruning and thinning practices during the next year.

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Evaluation of Products to Enhance Tree Stump Decay

Gary W. Hickman¹ and Ed Perry²

Additional index words. potassium nitrate, stump removal

Summary. Three commercially available tree stump removal products: Dexol Stump Remover, Cooke Stump Remover & Potassium Nitrate, and Lily/Miller Stump Remover and Potassium Nitrate, as well as three nitrogen-containing fertilizers—potassium nitrate (13-0-45), ammonium nitrate (34-0-0), and ammonium sulfate (21-0-0), were evaluated for their ability to hasten decomposition of the stumps of two tree species [*Eucalyptus camaldulensis* Dehnh. and *Paulownia tomentosa* (Thunb.) Steud.]. None of the products accelerated decay in either species after 8 weeks.

Various tree stump removal products on the market claim that they stimulate the decomposition and decay of tree stumps. The primary ingredient in these products is potassium nitrate. Rockwell (1944) recommended using potassium nitrate on stumps "to make them rot quicker." Metcalf (1944), however, disagreed, stating that no chemicals available at a reasonable cost could quickly accelerate decomposition of tree stumps.

The original purpose of adding potassium nitrate was to facilitate burning of the stump, as indicated on labels of commercial products containing potassium nitrate (Wray, 1992). A review of published literature found no scientific studies related to chemical enhancement of tree stump decay.

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