4

Designing the Orchard

THEODORE M. DEJONG AND KEVIN R. DAY

In selecting a particular orchard design there are many factors to consider. Not all are equally important; the importance of any one factor depends on the grower's goals. A goal to maximize yield by sacrificing some management convenience will call for one kind of planting system. A goal to maximize management efficiency, fruit quality, or early returns on investment will require another system. Goals for an orchard are not always mutually compatible.

Design Objectives

Designing a planting system demands efficient utilization of orchard space and other resources. Since all energy for plant growth and development comes from sunlight, the orchard system must capture the greatest amount. To achieve maximum fruit quality and yield, sunlight must be properly distributed within the orchard canopies. Light exposure is directly related to fruit quality, flower bud formation, and fruitwood survival and productivity.

Soil moisture and nutrients are other important resources trees must compete for in proportion to their density. Trees spaced widely apart generally compete less, since they have more soil volume from which to attain these resources. Trees planted at higher densities decrease the soil volume allocated to each and require rigorous management. At higher tree densities, tree-to-tree competition is used to partially restrict vegetative tree growth, but poor management can result in problems. Therefore, as a general rule, the more dense the orchard design, the more horticultural expertise and precision are required.

Also required in orchard design is making it compatible with such management practices as pruning, thinning, harvesting, pest control, frost protection, and irrigation method. Because of the particular tree spacings or framework designs, some orchards are more amenable to ladderwork for pruning, thinning, and picking. Other orchards are developed for mechanization. Similarly, spray coverage or weed control is easier with some planting configurations than with others. These factors often do not affect orchard yields or fruit quality, but they may substantially reduce management costs and increase efficiency.

Finally, orchard design affects economic strategies, such as initial investment costs, timing to first returns, and expected life span of the orchard. One grower may choose to increase orchard establishment costs to obtain early high yields. Another may minimize establishment costs for a slower return on initial investment. The choice could be to emphasize premium price fruit (high quality, large sizes) or to emphasize volume at the expense of quality and size.

Of the numerous orchard design/tree training systems available, no one system is best for all situations. Selecting the "best" depends on the goals previously mentioned and on such limitations as soil fertility, water supply, variety vigor, variety growth and bearing habit, and the availability of size-controlling rootstocks.

What follows are descriptions of several orchard designs, including tree densities and training systems, with some advantages and disadvantages of each.

Fig. 4.1. Open-center or open-vase system of training stone fruit trees.

Low and Standard Density Systems

The open-center (open-vase) system (fig. 4.1) is the low density training system almost exclusively used for peaches, plums, and nectarines. Open-center trees are trained into a bowl (vase) shape by cutting back trees to within 2 feet of the soil surface at planting. Primary, secondary, and tertiary scaffolds that form the bowl's circumference are then selected as the trees develop.

In this system, trees are usually planted from 16 to 22 feet apart in the row and the same distance between the rows, depending on tree vigor, soil fertility, and final, expected tree size. Three planting designs are used in these orchards: square/rectangular, offset square/diamond, and hexagonal/equilateral triangle. Subtle differences exist among them, which may allow for more efficient utilization of space at a given density. The number of trees to be planted per acre is determined by multiplying the distance between rows by the spacing between trees and dividing by 43,560 (square feet in 1 acre).

Square/rectangle

Trees are planted so that a line drawn between a tree and its nearest neighbor in the next row is at right angles to the orchard row (fig. 4.2).

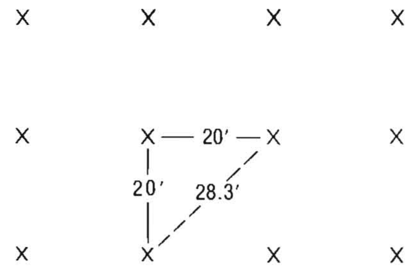


Fig. 4.2. Square/rectangle planting design.

Offset square/diamond

This system is similar to the square/rectangle pattern, but trees in adjacent rows are offset half a tree space (fig. 4.3).

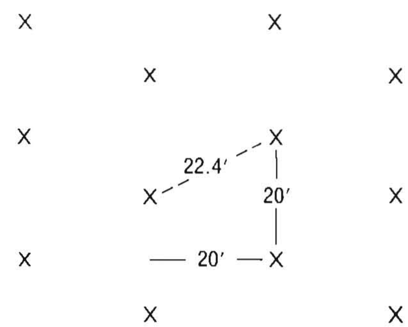


Fig. 4.3. Offset square/diamond planting design.

Hexagonal/equilateral triangle

In this system, similar to the offset square, distances between trees (both in adjacent rows and in the row) are always the same (fig. 4.4). Lines drawn between any three adjacent trees form an equilateral triangle, resulting in a closer distance between rows than between trees in the row. Thus, more trees are planted per acre than with the same spacing in a square system.

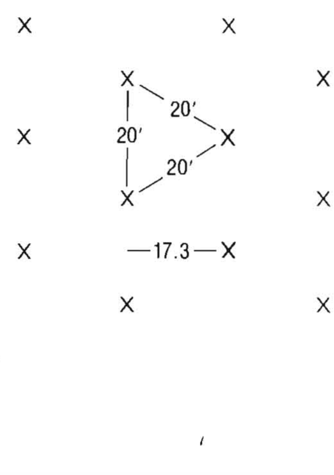


Fig. 4.4. Hexagonal/equilateral triangle planting design.

Medium and High Density Systems

Potential advantages of planting at higher densities are to: (1) increase early yields, (2) increase efficiency of orchard operations (ladderwork, spray coverage, weed control, etc.) through altered canopy configurations and reduced tree size, and (3) increase fruit yield relative to vegetative growth. Primary disadvantages are: (1) high establishment costs and (2) lack of suitable methods (dwarfing rootstocks, dwarf scions, growth regulators, cultural manipulations) to control tree size and vigor adequately under California growing conditions. Future developments in achieving tree size control and reducing nursery production costs may decrease these disadvantages.

Many types of training and spacing systems are used in medium and high density orchards, ranging from simply planting trees at closer spacings and using conventional, open-vase training, to planting hedgerows and training trees on elaborate trellises. Therefore, these systems may be described in three separate categories: (1) medium density using conventional training techniques, (2) hedgerow systems without trellises, and (3) hedgerow systems with trellises.

Medium density; conventional training

Some growers achieve higher initial tree densities and yields by planting trees at twice the tree densities in the row (9 to 12 feet apart) with relatively standard row widths (16 to 22 feet). Trees are then trained to more upright and open-vase systems (fig. 4.5) with the idea of eventually removing alternate trees in a row or interfering limbs within the row. This system can be effective with less vigorous varieties or on relatively low fertility soils. However, with most varieties trees will eventually crowd each other, causing loss of lower fruitwood and thus decreasing the orchard's production. Increased tree densities can also sometimes reduce the efficiency of ladderwork operations when interfering scaffolds make it difficult to reach an area. Trees or major interfering scaffolds must be removed before the canopy becomes too dense.

Fig. 4.5. Open-vase trained trees planted closely together in the row. Every other tree will eventually be removed.

Hedgerow systems without trellises

The most common free-standing hedgerow systems in California are the central leader (fig. 4.6), the California V or parallel V (fig. 4.7), and the perpendicular V (fig. 4.8).

The central leader hedgerow system. Trees are trained to a single, vertical, central scaffold with fruitwood borne on it directly, or on short, horizontal branches coming off the main scaffold. Trees in this system are usually spaced 5 to 8 feet in the row and 14 to 16 feet between rows.

The California V system. Trees are trained with only two opposing scaffolds oriented in the tree row. In this system trees are generally planted 7 to 10 feet apart in the row and 14 to 16 feet between rows. Both this and the central leader system provide advantages offered by high density hedgerow systems such as: (1) use of mechanical hedgers for summer pruning, (2) mechanized platforms for harvest and pruning, (3) more efficient pesticide application, and (4) higher yields during the orchard's early life.

Fig. 4.6. A central-leader trained peach tree after pruning.

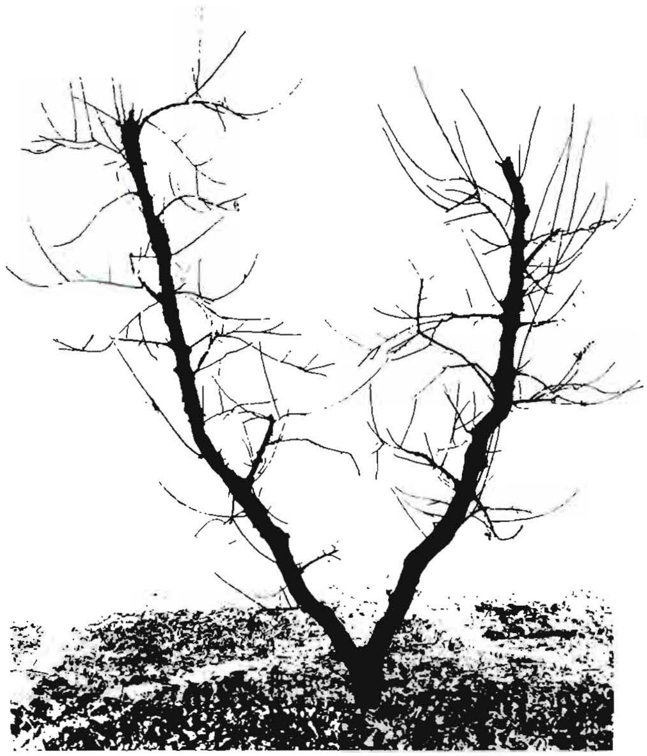


Fig. 4.7. A dual leader or V-shaped peach tree after pruning.

The primary disadvantage of the central leader hedgerow system is the tendency of the tree to self shade. Because the central scaffold is vertical, the tree's top is essentially the only part exposed to direct sunlight at midday. This stimulates vegetative growth in the top (creating an umbrella effect), which, as the season progresses, shades lower portions for greater lengths of time, causing decreased fruit yields and color in lower branches. To counter self shading, trees may be trained to a pyramid or Christmas tree shape. However, lower branches tend to obstruct ladder work. The California V system is less subject to self shading because the two scaffolds are brought up at an angle from the vertical. Because this angle is still less than in conventional, open-center trees, particular care must be taken not to let the center of the V fill in or an umbrella effect occur. Other disadvantages of these two systems are high initial tree costs and, in some cases, the need for specialized equipment to operate in more narrow tree rows.

In most hedgerow systems, rows should be oriented north to south to achieve maximum sunlight distribution on both sides of the hedgerow. The clear alley width between canopy walls should be 3 feet less than the tree height. More narrow row widths will substantially decrease light incidence in the lower part of the canopy, thereby adversely affecting fruit yield, size, and color, as well as causing loss of fruitwood.

Fig. 4.8. The perpendicular V system of training stone fruit orchards.

The perpendicular V. This system is similar to the California parallel V, except that the two scaffolds are oriented perpendicular to the row. Trees are planted 5 to 7 feet apart in the row and row widths are similar to conventional plantings (16 to 22 feet). This system has the high early yield capacities of high density plantings with maintenance of open-tree centers and row widths comparable to conventional open-center trees. The potential for using mechanized hedgers or picking platforms is limited; however, the uniform scaffold distribution does potentially increase the ease of ladder work. North to south row orientation for this system may help prevent sunburn on exposed scaffolds.

Trellis systems

Of the many trellis designs for tree crops, few are suitable for stone fruits, primarily because of their extreme vigor. Most common are the vertical, espalier-type trellis and the V-shaped, tatura-type trellis.

Vertical, "espalier-type" trellis. Trees are usually trained with a central leader and horizontal fruiting branches tied to the trellis wires (fig. 4.9). The system is more suitable for less vigorous, spur-bearing varieties of plums than for peaches and nectarines that require annual renewal of fruitwood. Since forcing fruitwood to grow more horizontally can stimulate spurs to form and increase fruitfulness, this system does offer greater potential for extensive manipulation of the tree canopy. However, successful manipulation is costly and requires considerable

Fig. 4.9. Plum trees trained on a vertical trellis.

Fig. 4.10. Tatura-type trellis training system.

knowledge of tree responses to manipulation. In some varieties, tying branches horizontally to wires stimulates excessive water sprout development and actually reduces shoot productivity. This often can be alleviated by tying branches so that branch angles are 45° to 60° from the vertical instead of 90°.

Generally, vertical trellis systems offer potential for rapid canopy development, more uniform sunlight distribution throughout the canopy, and maintenance of a narrow fruiting wall.

Tatura-type trellis. This V-shaped system is similar to the perpendicular V except that trees are usually planted more closely together (2 to 4 feet in the row) and fruiting scaffolds are supported by the trellis (fig. 4.10). The canopy, which is established rapidly, was initially intended to accommodate mechanical hedging and harvesting of processing fruits. This system has potential for high yields because sunlight is distributed efficiently over the entire system and the wide canopy angles tend to stimulate fruitwood development.

The primary disadvantages of all trellis systems are the high cost of establishment and replanting, and the necessary commitment to extensive, detailed canopy manipulations.

Ultra-High Density Systems

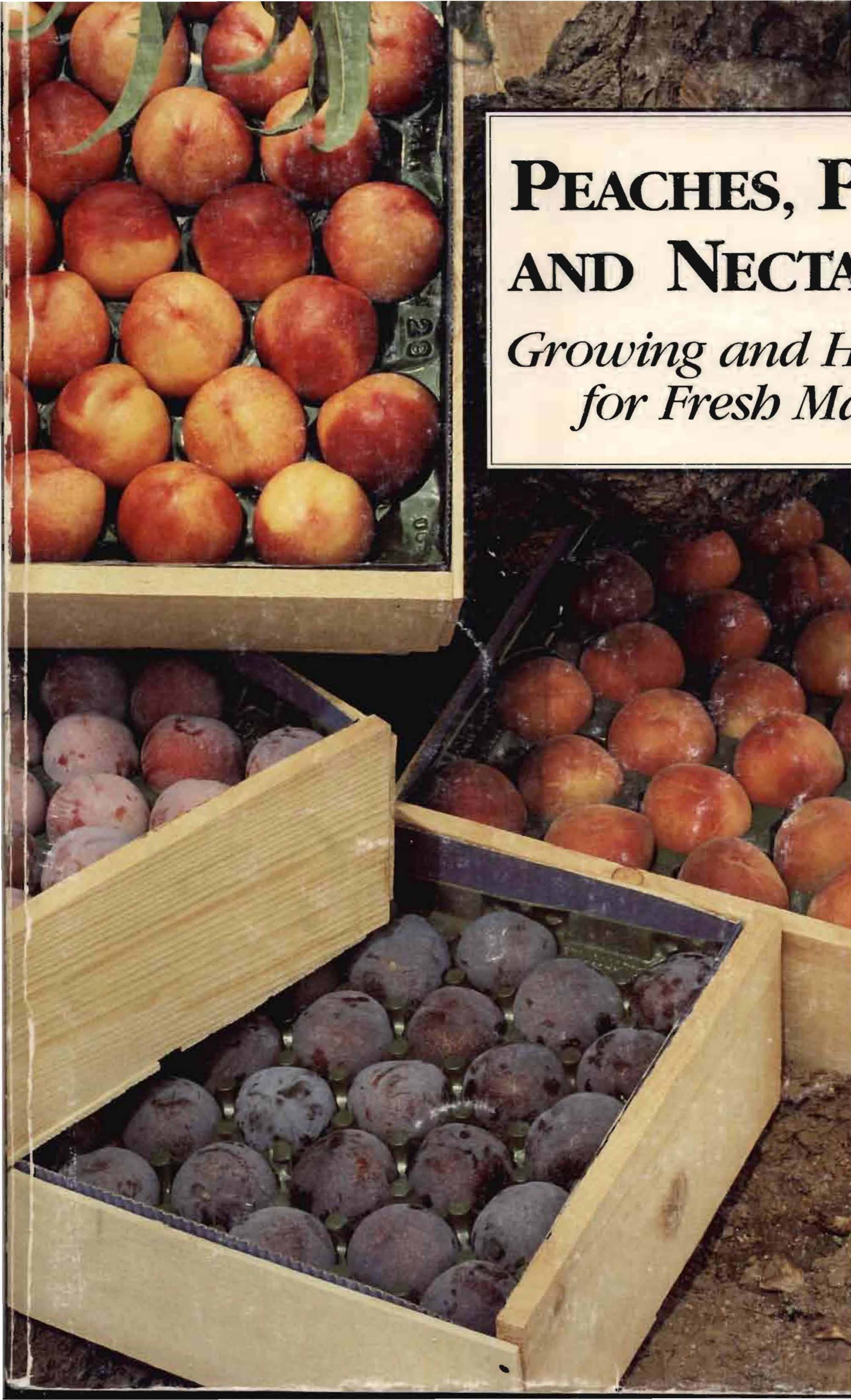
A few ultra-high density systems (bed and meadow-orchard systems) have received experimental attention, but they are basically unsuitable for stone fruits in California.

Bed-system trees are planted 3 to 6 feet apart in 2- to 6-row beds bordered by 12- to 14-foot alleys. These systems are used in northern Europe for apples on dwarfing rootstocks, but they are not suitable for stone fruits on nondwarfing rootstocks in California due to extreme vigor and large tree size.

The meadow-orchard system involves annual mowing of shoots at harvest time similar to using a commercial tomato harvester. This system relies on the extreme vigor of early maturing peach and nectarine varieties to regrow and set a new crop of fruit buds between harvest and leaf fall. Preliminary experiments in California indicate its potential is limited because of the excessive heat that may occur during regrowth and the poor quality of fruit produced.

Additional Reading

Jackson, J. E. 1980. Light Interception and Utilization by Orchard Systems. Horticultural Reviews 2:208-267.



PEACHES, PLUMS, AND NECTARINES

Growing and Handling for Fresh Market

Technical Editors:
James H. LaRue
R. Scott Johnson

Cooperative Extension

University of California

Division of Agriculture and Natural Resources

Publication 3331