PLANNING AND DESIGNING THE ORCHARD

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Pistachio trees are long-lived. Time spent properly designing an orchard saves years of farming frustrations and prevents poor economic returns. The well-designed orchard ensures: the earliest economic per acre return, maximum per acre production at tree maturity and the least management cost.

This chapter discusses the following orchard-planning and design considerations: tree density, row length, planting designs, loading areas, pollinizer placement, and orchard floor management.

TREE DENSITY

Pistachio culture in the United States is relatively new. The most widely planted scion/rootstock combinations in California have only been available to growers since the early 1980's. Scientific experiments designed to determine the relationship between tree density and economic returns have not been done. Planning and design suggestions included here are largely based on observation of productive orchards consisting of trees of 'Kerman' (the female cultivar) budded to a rootstock of *Pistacia integerrima* heritage in the Central Valley of California. Suggestions for pollinizer frequency are based on observation of orchards with 'Peters' (the male cultivar). Other scion/rootstock combinations may have advantages in some environments, but spacing, densities and male-to-female ratios may be different.

Tree and row spacing

A pistachio orchard reaches its maximum bearing potential when space over the soil is completely occupied by nut-bearing surface with sufficient light penetration to keep lower fruit wood productive. An appropriate row spacing is particularly important because pistachio is relatively slow to begin bearing. Five to six years are required between planting and the first nut harvest. The initial number of trees planted per acre is directly related to the orchard's onset of economic production and the time required to reach its maximum bearing potential The closer the trees are planted, the more likely tree thinning or earlier heavy, expensive pruning will be required for an orchard to maintain its maximum bearing potential. Conversely, in a more widely spaced initial planting, the onset of economic bearing is delayed and the longer it will take to reach its maximum bearing potential. Thus, the pistachio grower has two objectives when spacing trees: ensuring earliest economic production and developing an orchard with an economically manageable maximum bearing potential. Where nuts are shaken from the tree and caught before contacting the ground, row and tree spacing is partially governed by size of commercially available catching frames. Frame sizes vary and many are adjustable, but trees spaced less than 12 feet (3.7 meters) apart within the row may make insertion of the frame difficult. Harvesting row and tree spacing greater than 24 feet (7.3 meters) may result in nuts falling outside of the frames' catchment area unless modified equipment is used.

New orchards are not being planted with the assumption tree thinning will be necessary to ensure maximum production at maturity. However, the California pistachio industry is young and many questions remain as to what the eventual size and bearing characteristics of increasingly older pistachio trees will be. The oldest blocks of Kerman on *P. integerrima* rootstocks were planted about 1980. Observations of well-managed trees planted in deep well-drained soils in a rectangular design with 18 - 20 feet (5.5 - 6.1 meters) between rows and 15 - 18 feet (4.6 - 5.5 meters) between trees indicate that crowding, sufficient to reduce

production, does not occur until about the 15th year. Tree crowding has been managed through the use of mechanical hedgers/toppers and hand pruning. Tree thinning has been rare and few growers consider it.

Row width: Row width should be no less than 20 feet to facilitate large harvest and machine pruning equipment (Plate 5A). New pistachio orchards are being planted with row widths not exceeding 22 feet (6.7 meters).

In-row tree spacing: New pistachio orchards are being planted with trees 15 to 20 feet apart within the row. Spacing trees at 16 feet or less leaves little room for tree growth or mechanical cross hedging and more expensive hand pruning will be required to keep trees separated from one another for harvest. If trees are allowed to grow together, shaking will be transmitted to neighboring trees resulting in nut drop outside of the harvester's catch frame

Table 1 lists the number of trees per acre at various row and tree spacings.

Table 1. Number of trees per acre at different square or rectangular tree spacing.

Row x Tree Spacing (ft)	Trees/ Acre	Trees/ Hectare
20 x 17	128	316
21 x 17	122	301
22 x 17	116	288
20 x 18	121	299
21 x 18	115	285
22 x 18	110	272
20 x 19	115	283
21 X 19	109	269
22 x 19	104	257
20 x 20	109	269
21 x 20	104	257
22 x 20	99	245
21 x 21	99	245
22 x 21	94	232

ROW LENGTH

Pistachios are harvested in one direction "down-the-row" with large equipment of limited carrying capability. Rows should not be longer than one-quarter mile without a "break" to change collection equipment and/or minimize time spent traveling to and from the loading site. Leave at least 35 feet (11 meters) from the trunk of the last tree in a row to the edge of the property to turn equipment (Plate 5B).

POLLINIZER PLACEMENT

Pistachio trees are dioecious, with male and female flowers borne on separate trees. Because pistachio pollen is wind blown, males are interspersed around the border of and within the orchard in a regular pattern. The male density within an orchard for optimal production has not been determined. Most new orchards in the Central Valley of California are now planted with males, cv. 'Peters', planted every fifth tree in every fifth row, a ratio of 24 Kerman to one Peters and these appear to yield as well as older orchards planted with a ratio of 8 Kerman to one Peters. Additional male trees are sometimes planted in border rows upwind of the orchard, but solid male rows are not needed. In some instances, in areas where few or no other pistachios are grown, the ratio of Kerman to Peters has been reduced to 14:1 to ensure adequate pollination.

Placing the pollinizers: Place the first pollinizer tree in the upwind corner of the orchard. Then place the remainder in the pattern described above (Figure 5a).

ORCHARD DESIGN

Orchard designs that have been used for pistachio production include square rectangle, offset square/rectangle and hexagonal/equilateral triangle.

Square

Trees configured as a square are equally spaced within and between rows and orchard operations can be carried out in both directions (Figure 5b). However, to maintain the minimum of 20 feet between rows for passage of large harvesting equipment, square plantings will result in relatively low tree densities unless temporary filler trees are used for early productivity.

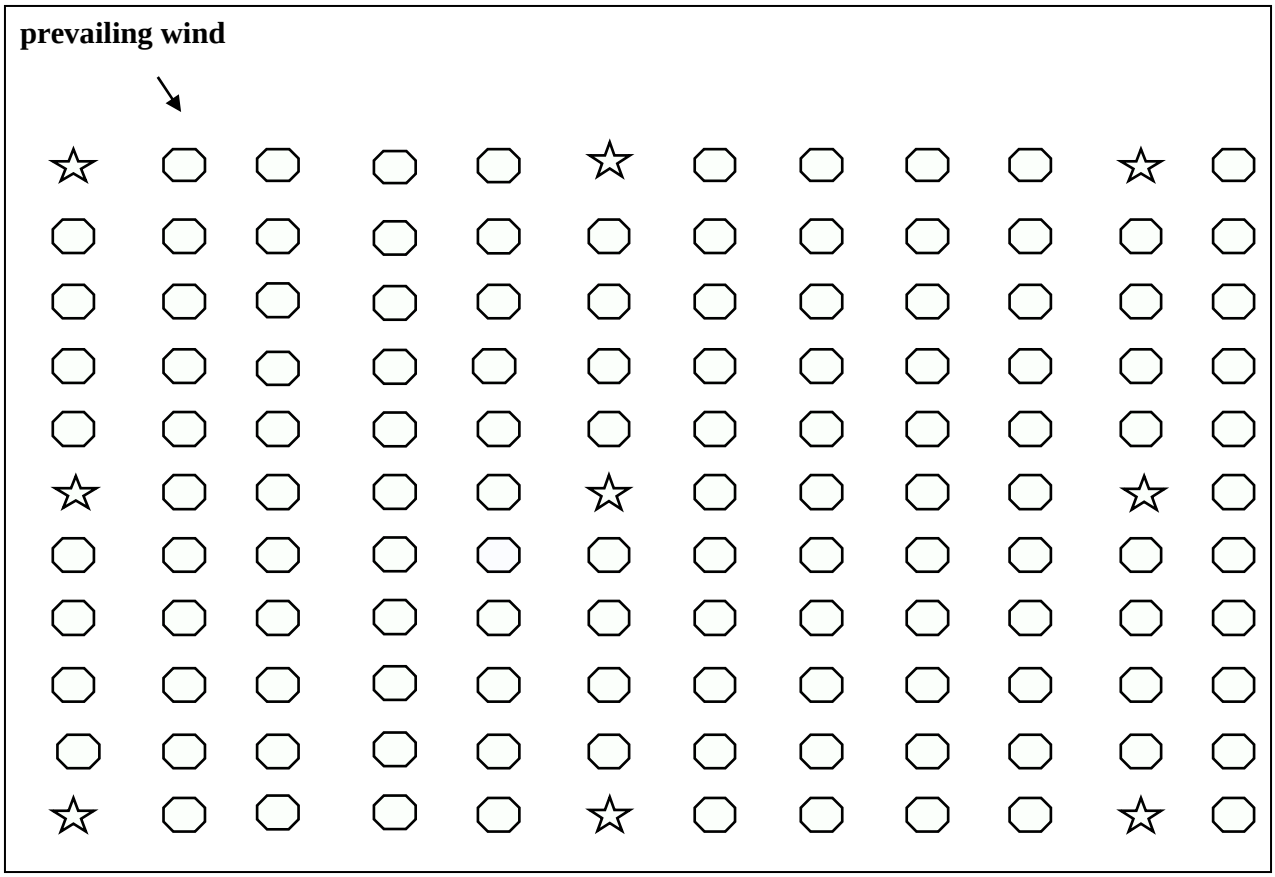

Figure 5a. A rectangular planting system with 24 female trees (circles) to 1 male tree (stars).

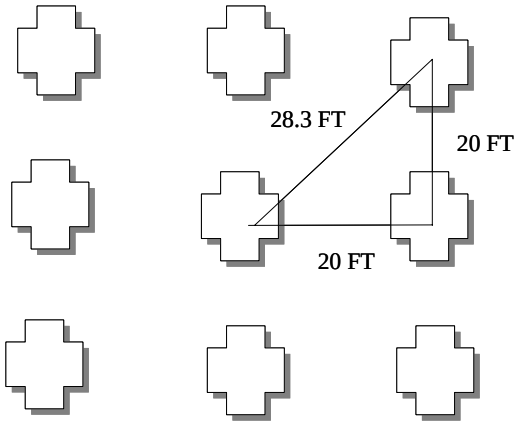

Figure 5b. Square design (109 trees/acre at this spacing).

Rectangle

The rectangular planting configuration is the most common tree design used for pistachio orchards (Figure 5c). It is best adapted to the pistachio trees' slow growth habit by providing high tree densities while accommodating large equipment. Like the square design, it is also suited for mechanical cross hedging and topping.

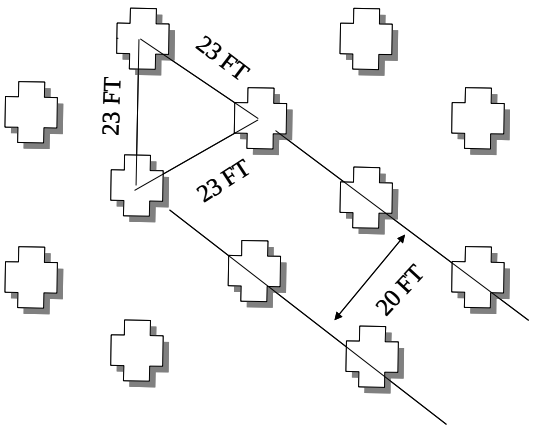

Figure 5c. Rectangular design (121 trees/acre at this spacing.

In most new pistachio orchards trees are spaced in a rectangular pattern with 20 - 22 feet between rows and 15 - 18 feet between trees.

Offset square or offset rectangular

The offset system is a variant of the square or rectangular except trees in adjacent rows are offset (Figure 5d). At any given tree spacing, the square and offset square designs have an equal number of trees per acre.

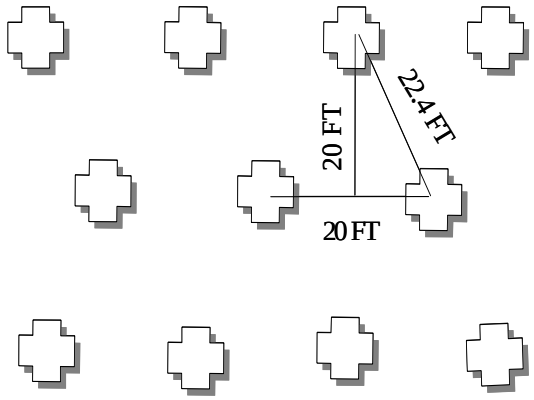

Figure 5d. Offset square design (109 trees/acre at this spacing).

Hexagonal/equilateral triangle

Trees configured into a hexagonal/equilateral triangle design are equal distances apart when measured in any direction (Figure 5e). This design is the most efficient use of land and light as it allows 17.5% more trees per acre than the square at any given tree spacing. It has two disadvantages: 1) Trees placed in an equilateral/hexagonal design must be placed as permanent trees. This design does not allow for temporary trees because their eventual removal results in inefficient tree and row distances for optimal productivity and 2) row widths are 87% of the distance between trees which must be considered with use of large equipment in the orchard.

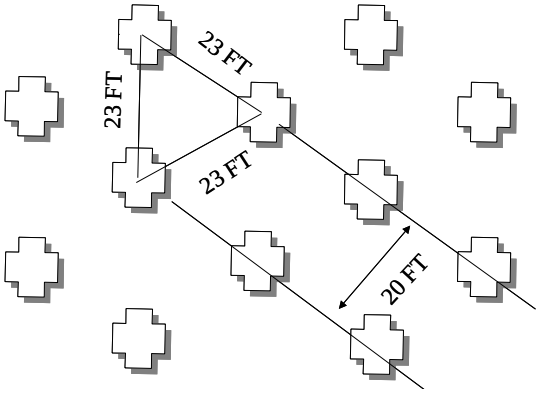

Figure 5e. Hexagonal/equilateral triangle design (97trees/acre at this spacing). Note that at a 23 ft. tree spacing a row is 20 ft. wide.

USE OF FILLER TREES

Inter-planting temporary, or "filler" trees, between the trees that will be permanent, can increase early yield. The initial expense of filler trees, and continuing costs of their culture (e.g. tree training), adjustments to irrigation systems and cost of their eventual removal must be weighed against their contribution to early productivity. In California, at the present time, no pistachio orchards are being double planted with filler trees.

Filler trees are planted far enough apart so that they are harvestable with conventional equipment, but close enough so that when removed the spacing of the remaining permanent trees would be optimal to sustain the orchard's maximum bearing potential. No formula is available for calculating when filler trees should be removed. At some point, added cultural costs such as pruning and yield reductions associated with competition for light and nutrients are greater than any additional yield provided by a greater number of tree per acre.

LOADING AREAS

Growers should include a loading area when planning the new orchard (Plate 5C). Most California acreage is planted to a single producing cultivar (i.e. 'Kerman') resulting in a crop that matures at the same time in the same district producing an acute demand for harvesters, especially in the "on" crop years. A loading area, 50 feet (15.2 meters) by 500 feet (152.4 meters), facilitates harvest and improves safety by providing space for passing equipment and efficient crop loading operations. Enough area should exist for a typical nut elevator, truck and passing vehicles. The loading area's length should be sufficient for truck turning and, if necessary, an area for additional

trucks to get off access roads and into line for loading. A loading area should be contiguous to every 40-acre block of pistachios. If positioned properly, a loading area should serve up to 160 acres.

ORCHARD FLOOR MANAGEMENT

When planning a pistachio orchard, growers must consider the orchard floor management system that will be used for both the young and mature trees. Choices include: complete weed control, complete vegetative cover, strip chemical weed control, and intercropping. Further information related to orchard floor management is found in other chapters on weed management, irrigation systems, improving water penetration, and foliar and fungal diseases, respectively.

COMPLETE WEED CONTROL

Complete Cultivation

Orchards using this system are cultivated in both directions. The primary objectives are weed control to prevent competition with trees for water and nutrients, water penetration and frost protection. Complete cultivation does not use herbicides so is a viable soil management option for organic growers. For complete cultivation to be a practical option, trees must be spaced at sufficient distance to accommodate discing equipment.

Complete cultivation can be adapted to level and non-level land and is often used when flood or furrow irrigation systems exist. It is not well adapted to solid-set irrigation systems because cross cultivation is difficult.

Complete cultivation is an expensive orchard floor management system because of operational costs associated with frequent use of heavy equipment. Heavy equipment compacts soils, impeding water infiltration, and creates dust that may encourage mite pests. On rolling land, cultivation increases potential for soil erosion and in areas of high rainfall may not always be done in a timely fashion.

Complete chemical weed control

The orchard floor can be kept free of weeds with use of chemical herbicides. This orchard floor management system can use both low-volume sprinklers, and flood systems (if land is "dead level").

Where weeds are completely controlled with chemicals, land preparation for irrigation or harvest is not required. Dusty conditions are reduced, as cultivation equipment is not used.

Orchards using this system tend to be warmer than those with cover crops, which is an advantage in areas of the state where late frosts occur or in colder areas during the first winter following planting.

Water penetration can be a problem on a clean orchard floor and is particularly evident where the impact of droplets from high-volume sprinklers destroys the surface soil structure.

COMPLETE VEGETATION

Here, a complete cover of native or planted vegetation is maintained on the orchard floor throughout the year. The plant cover is mowed regularly to prevent interference with irrigation or harvest. This system is adapted to both flat and rolling land.

Native or planted vegetation minimize soil compaction and has been shown to improve water penetration. Vegetative ground covers allow quicker reentry of equipment, including harvesting equipment, after a rain or irrigation, allowing better traction, which is especially important in rolling terrain. Ground covers reduce dust and erosion compared to complete cultivation but may increase rodent populations, especially gophers. Mowing is less costly than discing, as it can be done faster with lighter and less expensive equipment. Vegetation in the orchard results in a colder orchard than where vegetation is eliminated, but since pistachio trees bloom in April, increased frost hazard associated with complete covers is of less concern than with other crops. Actively growing vegetation increases water use by as much as 25% and fertilizer use may increase as well. Irrigation emitters may also interfere with mowing. Flood or high-impact sprinklers, often necessary for maintaining vegetation that covers 100% of the orchard floor, can result in high orchard humidity increasing the incidence of fungal disease, such as Alternaria late blight and Botryosphaeria panicle and shoot blight.

STRIP CHEMICAL WEED CONTROL

With Cultivation of the Row Middle

Weeds in row middles are controlled by cultivation while weeds in the tree row are controlled with herbicides (Plate 5D). This system of orchard floor management is commonly used in conjunction with low-volume irrigation systems located in tree rows but also by growers using, furrow or flood irrigation systems.

Continued discing in row middles may result in a raised berm within the tree row that will interfere with cross hedging. On rolling ground, use of a disc can result in terracing of the orchard. An elevation difference of 12 inches between adjacent terraces can create problems during nut harvesting, as uneven ground complicates shaking of trees and rapid movement of equipment.

With vegetation in the row middle

This orchard floor management system combines chemical weed control in the tree row with mowed planted sod or native vegetation in the row middle (Plate 5E).

Strip chemical weed control with vegetation is also often used in conjunction with low-volume irrigation systems that do not irrigate the row middles. In the drier parts of the state, native vegetation is allowed to grow in the row middles. This vegetative cover is not irrigated and dies or becomes dormant in late spring greatly reducing management requirements. Where late precipitation is greater or irrigation water is more available and cheaper, the middles may be planted to sod or other cover crop and mowed to control growth throughout the season.

Little information exists on how native or other planted ground covers either positively or negatively influence insect, mite, nematode and plant diseases and effects may vary depending on species of plant, pests and weather.

INTERCROPPING

Relatively slow early growth and required heavy wood removal associated with early tree training extends: 1) the time period before middles are shaded and 2) the length of time before economic bearing occurs in pistachios. To provide income before the pistachios begin producing, some growers have planted a row crop, such as watermelons, beans, or other crop between the rows of young trees. Care must be taken in choosing the intercrop to ensure that chemicals used on the intercrop and pistachios are compatible and registered for both crops. Intercrops, like weeds, may compete with the pistachios for water and nutrients and provide habitat for harmful insect and mite pests. Additionally, cultural and harvest practices required for producing an intercrop may cause damage to trees The manager must always remember that the trees are the main crop and must never suffer because of the intercrop.