

High density apple orchards offer many advantages

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Small, closely planted trees facilitate cultural operations, and they may increase early production and produce better colored fruit. But the grower must be willing and able to make management changes.

Left photo shows young, bearing, central leader apple tree before dormant pruning. Right photo shows same tree after pruning. Central leader and major limbs have been lightly headed (cut) into previous season's growth. Excessive shoot growth, especially upright growth other than the leader, has been removed. Note the wide angles between the main branches and central leader. Such limb angles provide strength to support future crops. Wooden spreaders have been used to position major limbs. (Photos by Jack K. Clark)

Currently, typical California apple orchards have large trees that usually require three operations per year from tall ladders. If ladders could be eliminated or their size reduced, orchard safety could be improved; time could be saved climbing and moving ladders; and a broader spectrum of labor (women, teenagers, and older persons) might be available for orchard operations. Smaller, more closely spaced trees could also produce better colored fruit, allow easier and improved pest control, increase early



production, and provide quicker return on investment.

High density orchards are now used almost exclusively in Europe. Thousands of acres have been planted to high density apples in Washington, Michigan, New York, and other states, and most of these plantings have been successful enough that growers are continuing to plant them. However, until recently, few close-planted apple orchards could be found in California.

A grower must have the willingness

and management ability to make the changes necessary for a successful high density orchard. Merely planting more trees per acre does not ensure success. A size-controlling mechanism, especially a dwarfing rootstock, is usually essential for successful close-set orchards. Spur type apple varieties and chemical growth regulators can also be useful in controlling tree growth. The training system should be relatively simple, easy to teach, and inexpensive.

Tree spacing depends on rootstock,

variety, soil, climate, and training system and must be based on local experience. Test plots to study these interactions have been established in various California apple producing districts.

Changes in cultural operations must be considered, such as irrigation method, orchard floor management, pest control, fertilizer practices, crop control, use of smaller equipment, and other practices. In other words, going to high density plantings of apple trees requires a systems approach.

Rootstocks

For California apples, seedling (standard) rootstock has been the most commonly used. This vigorous rootstock often provides a tree that fills a 30- x 30-foot space and grows to a height of 20 to 30 feet. Trees on this rootstock often take 6 to 10 years to begin significant bearing.

In contrast, the following promising apple rootstocks developed in England offer varying degrees of size control and frequently induce early bearing (precocity).

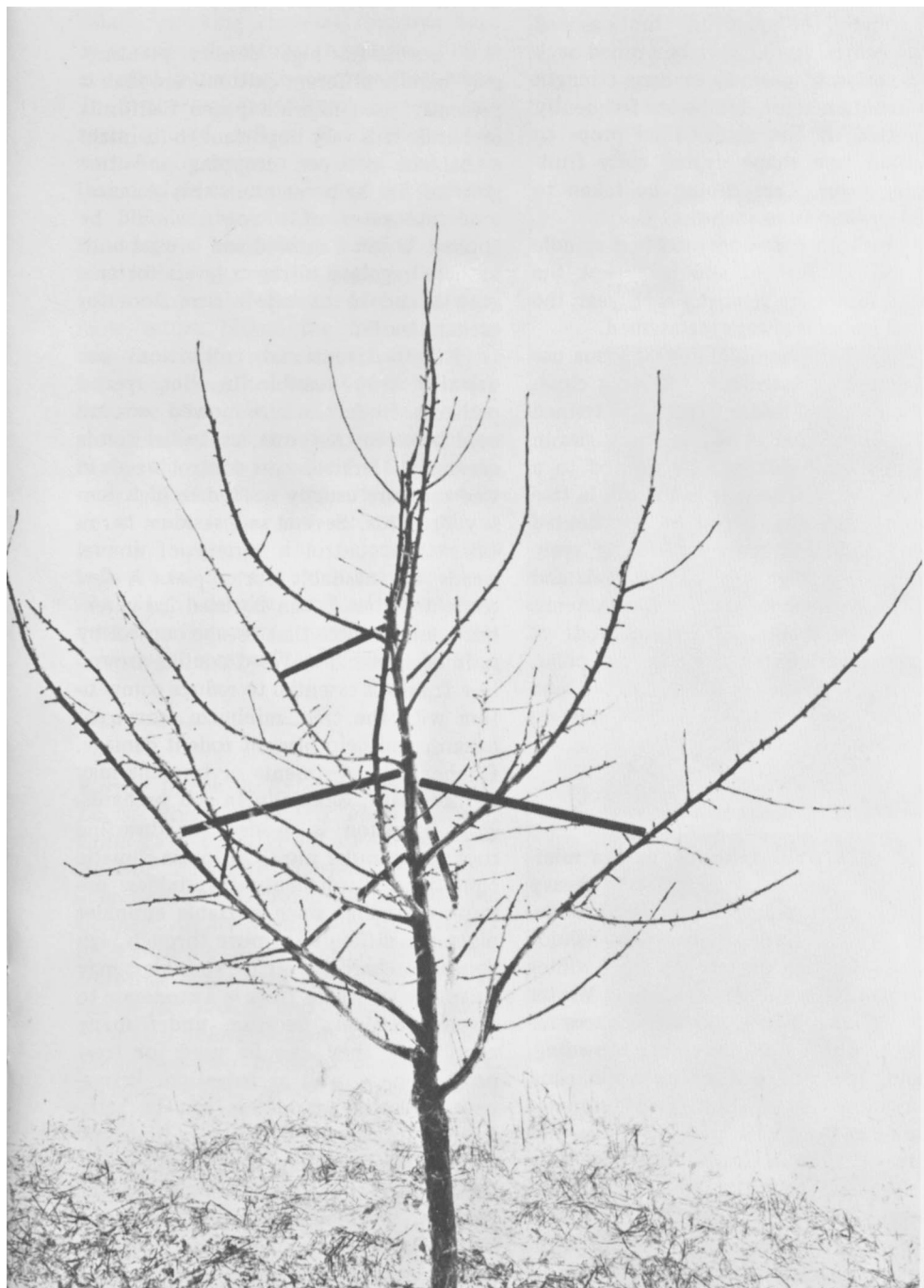
M 111 usually produces a tree about 80 percent the size of that on seedling. This stock is quite tolerant to varying soil conditions, particularly droughty soils, and may be very useful where summer irrigation cannot be provided. M 111 is reported to be resistant to woolly apple aphid. Reports from the state of Washington indicate that spur type varieties may not perform well on this rootstock.

M 106 produces a tree 65 to 75 percent the size of that on seedling and provides more precocity than most apple rootstocks. It also provides good anchorage, is easily propagated, and is resistant to woolly apple aphid.

M 7 produces about a half-size tree. Many plantings of this stock have been made in Washington in recent years, because it appears to be tolerant to high arsenic levels in the soil. This stock tends to sucker badly.

M 26, one of the newer clonal apple rootstocks, provides a tree 40 to 50 percent of the size of that on seedling and is quite precocious. Individual trees on this stock may require support under some conditions.

M 9 is more dwarfing than M 26, giving a tree about one-third the size of that on seedling. It has a brittle root system with poor anchorage and usually requires support by stakes or trellis. It is



very precocious. Good soil conditions are required.

M 27, a new rootstock that should be available soon in the United States, is even more dwarfing than M 9. Little is known about its behavior under U. S. conditions.

Dwarfing interstocks should also be considered, although less is known about these than is known about rootstocks. The use of M 26, M 9, or M 27 interstocks on rootstocks such as M 106, M 111, or even seedling may give good size control, along with good root systems and possibly early bearing. The amount of dwarfing usually depends on the length of the interstock. Such trees are more expensive to produce. More studies are needed to determine the advantages and disadvantages of interstocks under California conditions.

Most apple rootstocks are susceptible to *Phytophthora* crown and root rots. Therefore, apples should not be planted in excessively heavy or poorly drained soils. Trees should not be planted any deeper (after settling) than they were in the nursery.

Varieties

The growth habits and characteristics of various varieties can also influence high density plantings. Spur type apple varieties are strains that have compact growth habits with more spur and less shoot formation than standard strains of the same variety. Spur types frequently give trees about three-fourths the size of nonspurs of the same variety when both are grown under the same conditions.

Tree vigor and ultimate sizes of various nonspur apple varieties can also differ when grown on the same rootstock under the same conditions. Vigorous varieties, such as Gravenstein and Yellow Newtown, must be spaced farther apart than the moderately vigorous Red Delicious. The less vigorous Rome Beauty, Jonathan, and Golden Delicious can be spaced closer than Red Delicious.

Training

Trees in high density apple orchards usually require a different training system than those in standard orchards. Dwarf trees generally adapt to a central leader system better than to an open center, vase shape. Following are several of the more important and successful systems.

“Freestanding” central leader. The

two major systems in this category are the spindle and the modified spindle.

The true spindle uses the central leader or “Christmas tree” shape. Spreaders or ties maintain the fruiting limbs in a horizontal position, thereby reducing the terminal vigor of the limbs. The major pruning or cutting back is done to maintain the central leader; side limbs are generally not pruned. Control of vigor by choice of variety and rootstock is very important.

The modified spindle also involves the central leader concept but uses spreaders and fruit weight to force limbs about 70° from the vertical. Unlike the true spindle, the main (side) limbs as well as the central leader may be pruned back for a period of years to increase strength and maintain vigor. Limbs are frequently supported by ties rather than props to maintain tree shape during early fruit-bearing years. Care should be taken to avoid girdling from such ties.

In both true and modified spindle systems, all upright shoots except the central leader are removed each year; the central leader is always maintained.

Trellis systems. Many systems use trellises, with essentially all using close-planted, central leader trees; limbs trained to the horizontal or at varying angles in the row; and side growth limited to a narrow hedge. The wire trellis aids in tree support, training limbs to the desired angle, and limb support during early bearing. The high cost of materials and labor may preclude many trellis systems.

Other systems. Other methods of training dwarfed trees, such as vase, pillar, pyramid, Marchand, Lorette, and meadow, have met with varying degrees of success.

Pruning

After fruiting begins, only a minimum of pruning is necessary; heavy pruning only reduces or delays production and induces unnecessary shoot growth. Pruning may be done in winter (dormant), summer, or both. Winter pruning, if too heavy, stimulates excessive growth, which may cause tree crowding, shading out of lower fruitwood, and poor-colored fruit. Conversely, summer pruning reduces vigor and can be used to decrease excessive growth. The high density orchard operator must accept reduced growth as evidence of good management, just as the present California apple grower accepts high vigor as evidence of good management.

All upright shoots should be removed from bearing, central leader trees. The central leader should be the only upright limb in the tree. Enough other shoot growth should be removed to allow light throughout the tree and to balance fruiting and tree growth. Where trees lack sufficient vigor, limbs should be headed (cut) into last season's shoot growth to stimulate vigor. The central leader is normally headed into last season's growth each winter. If the tree becomes too tall, the central leader can be cut back to a weak lateral branch.

Cultural considerations

Successful high density plantings may require different cultural care than is presently used in wide-spaced California orchards. It is very important to maintain a balance between cropping and tree growth. To help maintain this balance, moderate rates of nitrogen should be applied. Often a mowed sod is used both to help regulate nitrogen levels for tree growth and to provide a firm floor for orchard traffic.

Two-directional cultivations are usually not feasible in close-spaced orchards. In fact, where mowed sods are used between tree rows, no cultivation is necessary. Herbicides to control weeds in tree rows are usually needed in high density orchards. Several safe residual herbicides that control a variety of annual weeds are available for apples. A few contact materials can be used for perennials and annuals that escape control by residual herbicides. Weed control around tree trunks is essential to reduce competition with the tree, minimize crown rot hazard, and help prevent rodent damage. Gopher bait treatments or trapping may be necessary, especially in sod orchards.

Irrigation is needed for dwarfing rootstocks under most California climatic conditions. Permanent-set sprinklers are most desirable, since portable sprinkler pipes are difficult to move through high density orchards. Overtree sprinklers may be preferred where frost is a moderate to severe problem, because, under many conditions, they can be used for frost protection as well as irrigation. Permanent undertree sprinklers can be satisfactory for irrigation, if lower limbs are kept from distorting the sprinkler pattern. Portable dragline sprinklers, furrows, or flooding may also be used. These latter three irrigation methods require considerably more labor than do permanent sprinklers. Drip irrigation

systems are being tried in some high density orchards.

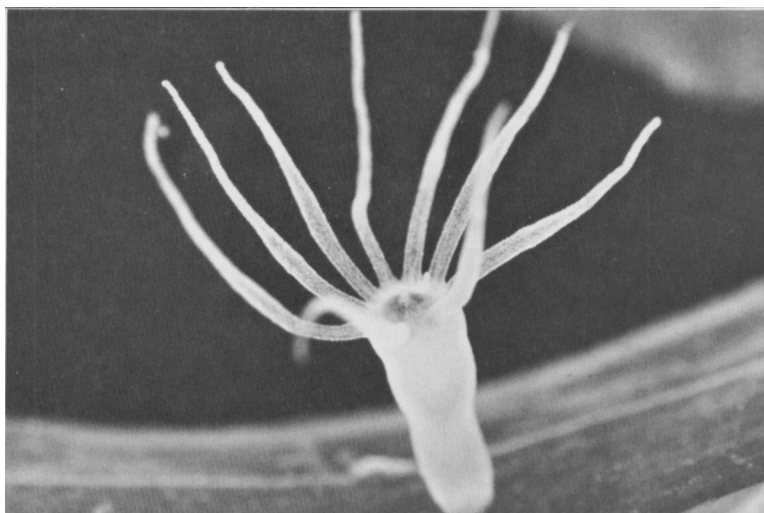
The tree should be grown to nearly its desired size before it is allowed to bear significant fruit. This may mean de-fruiting the trees during the first three years.

Early and annual crops are essential for successful high density orchards. Early cropping, induced by minimum pruning, dwarfing rootstocks, and careful nitrogen management, helps control excessive shoot growth. Crop failures caused by frost, poor pollination, or alternate bearing throw trees into vigorous growth by upsetting the crop-growth balance—making close-set orchards hard to manage. Therefore, frost protection is essential in moderate-to-severe frost areas. To further minimize frost damage, tree rows should follow the direction of normal air drainage on cold nights, so that cold air can drain out of the orchard.

To maintain annual crops, proper thinning is essential. Chemical and/or hand thinning must be done within one to two months following bloom to promote return bloom the following year and to obtain reasonable fruit size at harvest during the current year. A major mistake often made in high density orchards is to leave the first good crop too heavy; the next year there is little or no return bloom. Poor return bloom results in a poor crop and excessive shoot growth, upsetting the balance sought between fruiting and shoot growth.

High density orchards require a normal pest control program, but smaller lightweight sprayers can be used.

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Biological control in action

As mosquito control efforts encounter increasing insecticide resistance, University of California scientists are intensifying their search for biological control agents. One promising prospect is the hydra—a tiny relative of the jellyfish now being field tested in rice fields in Kern County.

These dramatic photos by Jack K. Clark, six times life size, show the hydra in action. Anchored to underwater vegetation (photo 1), the hydra waits for a mosquito larva to venture within range of one of its tentacles, each of which is

armed with thousands of stinging cells called nematocysts. On contact, these cells inject a powerful neurotoxin into the hydra's prey (photo 2), so the hydra can engulf it into its body tube, where the prey is digested (photo 3).

Adding to its effectiveness as a natural predator, the hydra has an insatiable appetite for mosquito larvae and will continue to kill them beyond its food needs. Hydra can be easily mass-produced and dumped or sprayed into rice fields; they do not become an environmental pest and apparently have few natural enemies.

