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COMMERCIAL APPLE GROWING IN CALIFORNIA

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CONTENTS

Introduction	3
Establishing the orchard	4
Land selection and size of orchard	4
Land preparation	4
Laying out the orchard	4
Planting	4
Varieties	8
Pollination	8
Market demand	9
Variety descriptions	10
Rootstocks	14
Dwarfing rootstocks	14
Pruning and training	16
Management of the bearing orchard	18
Pruning	18
Cultivation	20
Cover crops	20
Fertilization	20
Irrigation	21
Thinning	21
Pre-harvest drop	22
Top-working	22
Frost protection	22
Insect and disease control	22
Harvesting, handling, and storage	23
When and how to pick	23
Handling methods and practices	23
Storage	23
Temperature	24
Controlled atmosphere	24
Storage-caused disorders	25

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COMMERCIAL APPLE GROWING IN CALIFORNIA

INTRODUCTION

California grows about 8 per cent of the nation's apple crop of approximately 135,000,000 bushels. It usually ranks fourth among the states, preceded by Washington, New York and Michigan which together account for about 55 per cent of the country's annual production.

A decrease of about 50 per cent in the national per capita consumption of apples has occurred during the last 50 years. In 1963, 27.0 pounds of apples per person were consumed in the U. S., 18.4 pounds of which were consumed fresh, and 8.6 pounds of which were processed. The con-

tinuing demand for processed apples is of vital importance to the California apple industry, as 73 per cent of the state's crop is processed. Nearly all of California's fresh-market apples are consumed in the state, whose growing population accounts for the almost complete utilization of the state's domestic fresh-market apple crop, despite the declining per capita consumption nationally. The Oak Glen apple district in the San Bernardino Mountains has capitalized on the influx of population by marketing most of its crop at roadside stands in the district.

CALIFORNIA APPLE ACREAGE, 1963

County or district	Bearing	Nonbearing	Total
	Total	acres*	
Watsonville	8,470	2,636	11,106
(Santa Cruz, Monterey, San Benito, Santa Clara)			
Sebastopol	9,871	1,335	11,206
(Sonoma, Mendocino, Napa)			
Sierra Foothills	1,817	517	2,334
(Butte, Nevada, El Dorado, Tuolumne, Kern, Shasta, Tulare)			
Southern California	893	94	987
(San Bernardino, San Diego)			
Other	1,172	243	1,415
Total	22,223	4,825	27,048

* From California Fruit and Nut Acreage, 1963, California Crop & Livestock Reporting Service, June, 1964.

ESTABLISHING THE ORCHARD

Land selection and size of orchard

Deep soils having good drainage are most important for optimum apple production, and soils containing claypans, hardpans, or underlain with gravel should be avoided. Heavy-textured surface soils are more difficult to work than loams or sandy loams, and they create more problems with crown rot.

An adequate supply of good irrigating water is necessary in most apple-producing areas. In certain sections (the Sebastopol district, for example) apples can be grown without supplemental irrigation, but even in good dry-land areas supplemental irrigation will improve yield and tree vigor.

A 20-acre apple orchard is probably the minimum size feasible for profitable production, although 40 acres is even more likely to be commercially practical. Production per acre in relation to the total size of the unit, and the costs of needed equipment, are key factors. A 20-acre unit yielding 10 tons per acre has been considered a marginal enterprise for the past 20 years. The better orchards in full production yield 15 to 25 tons an acre on the average, and some produce up to 40 tons per acre.

Land preparation

Crop land previously under irrigation should require little or no preparation before planting to the orchard. Sprinkler irrigation will reduce the need for extensive soil movement and leveling operations, but grading and leveling is necessary for furrow, rill and border-check irrigation systems. Control of noxious weeds is best accomplished prior to planting.

Where land has been cleared of timber,

stump removal is necessary for efficient use of mechanized equipment.

Laying out the orchard

A well-planned layout is important to all orchard operations. Once the trees are planted changes are almost impossible to make; therefore a good contour map should be prepared locating all proposed trees, pollinizers, roadways, pipelines, water facilities, drainage and other features.

The "square" planting pattern is a most popular and convenient system of planting. The "quincunx" system is actually the square plan with a temporary or filler tree in the center of each square. The "rectangular" or "hedgerow" system is a modification of the square, with interplants in the rows in one direction. In the "hexagonal" (or "equilateral triangle") system all trees are equidistant, thus making more efficient use of space; adequate space should be allowed for mature trees as this system does not permit alternate tree removal in later years, as is possible with the quincunx or rectangular arrangements. On rolling land, cross-slope planting with the orchard laid out in blocks is much more feasible than the contour layout with spike rows.

Planting

Ideally, trees should be planted in December, January, or February, and not later than early April.

Holes for planting need not be larger or deeper than is necessary to accommodate the roots in their natural position. Trees should be set in the orchard at approximately the same depth as they stood in the nursery. This depth can generally be determined by the soil line on the trunks of the trees.

Fig. 1. Typical tree arrangements for an orchard.

All broken or injured roots should be removed before planting. Pulverized soil should be placed next to the tree roots and tamped thoroughly as it is thrown in to firm it about the roots and eliminate air pockets. A small amount of organic fertilizer (such as well-rotted manure) may be mixed with the soil at planting.

Commercial fertilizers should not be placed in the planting hole.

Because feeding roots are often cut when digging out trees at the nursery, tree tops should be correspondingly reduced. At planting, therefore, the main stem is usually cut back to a height desired for scaffold branches. Strong, wide-angled

CONTOUR SYSTEM

CROSS SLOPE

Fig. 2. Planting arrangements for sloping land.

crotches for the scaffold branches arising from the trunk are most likely to be developed if the main stem is headed back in two steps ("double-heading"). At planting, trees are headed about 6 inches higher than the ultimate height of head desired. After the trees are growing, and when the topmost shoots are 4 to 6 inches long, the trees are headed again at about 6 inches below the earlier cut. Branches with the sharpest crotch-angles are usually formed toward the top of the stem near the point at which the tree was first headed. Lower branches normally begin

growth at a wider, more desirable angle to the trunk than do the branches above them. Once started in growth at a wide angle to the trunk, the branches maintain that angle even after the branches above them are removed at the second heading. With double-heading the topmost branches with the sharp crotch-angles are removed, leaving the lower ones with wider crotch-angles from which scaffold branches can later be selected.

Figure 3 shows a tree on which double-heading was practiced. Figure 4 shows a single-headed tree. The cluster of sharp-

Fig. 3. Double-headed tree after first season's growth in orchard. Tree was headed at 36 inches at planting, then at about 30 inches to remove topmost shoots (which had formed sharp angles with the stem) after they had grown 4 to 6 inches long.

angled branches near the point of heading is typical of such trees. The lower branches have good angles but are poorly spaced.

Immediately after planting, the entire stem should be protected from sunburn and borers with a coat of whitewash. A good whitewash may be made as follows: whiting, 6 pounds; casein spreader, 1 pound; mix to paste with water and add raw linseed oil, $\frac{1}{3}$ pint.

Young trees should make a good start and be kept growing vigorously during the first season. Frequent irrigations should be applied during the first 2 years

until trees are well established. Applications of nitrogen fertilizer promote tree vigor; usually $\frac{1}{4}$ to $\frac{1}{2}$ pound of actual nitrogen per tree per year may be applied the first few years. Weeds around the trunk compete with the young tree for

Fig. 4. Single-headed tree after first season's growth in orchard. Tree headed at 30 inches at planting.

soil moisture and should be eliminated by hoeing or by chemical treatment. (Some pre-emergence weed killers have been cleared for use and do an adequate job when properly applied.)

Varieties

The variety is of major importance in commercial apple production. A variety must be adapted to the climatic conditions of the district in which it is to be grown, and there should be a good market demand for it. In any district there are usually several varieties which have long been satisfactory, but oversupply, declining markets, and competition from other districts may make additional plantings even of these questionable. Gravenstein, for example, is well adapted to the Sebastopol district, but any increase in its acreage will be dependent on improved processing markets. Plantings in that district in recent years have been primarily of Delicious (or its sports), Rome Beauty, Golden Delicious, and some Jonathan.

In the Pajaro Valley, Yellow Bellflower has nearly disappeared as a commercial variety because of poor market acceptance and a problem of bruising in mechanical grading. There is less acreage of White Pearmain, a high-producing, well-adapted variety, because of decreased foreign-market demand. But the fresh-market popularity of Delicious has encouraged increased plantings of this variety and its red sports throughout California. In the Watsonville district Delicious and its sports bid fair to take the lead from Yellow Newtown as the principal variety.

The increasing acreage of the red Delicious varieties nationally as well as in California is the most striking illustration of the impact of market demand on the growers' choice of variety. At the same time such emphasis on a single variety type must ultimately lead to overproduction, and force growers to consider other

distinctly different varieties to widen their markets and to meet competition from other districts.

Climatically, either high summer temperatures or high winter temperatures may be critical in defining commercial apple production districts in California. Summer temperatures in the great central valley are too high to produce good apples. In coastal districts, or at elevations of 2,800 to 4,000 feet in the Sierra foothills, summer temperatures are suitable for apples.

Apple trees require moderately cold winters to break the rest period of the buds and to condition the trees for normal spring flowering and leafing. The coastal apple districts north and south of San Francisco Bay usually have cold enough winters for all apple varieties except those with the highest chilling requirements. Rome Beauty, for example, suffers from delayed foliation and a prolonged bloom in the Pajaro Valley, whereas Yellow Newtown with its lower chilling requirement is never delayed as much. In the Sierra foothills winter chilling is adequate, except in the occasional year when the winter is open and sunny. In the latitude of Los Angeles or San Diego, both summer and winter temperatures are too warm at the lower elevations for apples but are satisfactory at elevations of 4,000 to 5,200 feet.

The fog and high humidity of coastal districts promote russet development on susceptible varieties. Stem-end russet, for example, characterizes Yellow Newtown grown in the Watsonville area. The finish on Golden Delicious is usually much better in the Sierra foothills than in the coastal districts. Mildew susceptibility of Golden Delicious and Jonathan also is a limiting factor for these varieties in districts such as Santa Cruz County.

Pollination. Most apple varieties need cross-pollination, as they will not set satisfactory crops when self-pollinated. Pollinizers should be provided at inter-

vals no more than two tree spaces from the variety to be pollinated. A practical orchard arrangement consists of four rows of a variety, alternating with two to four rows of a pollinizer. If not planted in complete rows, pollinizers can be located every third or fourth tree in every third or fourth row. However, such an arrangement presents harvesting problems, for if varieties mature at different times the scattered pollinizers must be picked and hauled separately; if varieties mature at the same time and are similar in color, pickers can easily mix them when putting the apples into bins in the field.

Some varieties such as Yellow Newtown are self-fruitful but generally give higher yields when cross-pollinated. Jonathan, Golden Delicious, and Rome Beauty are erratic in self-fruitfulness.

Delicious and its sports, Gravenstein, McIntosh, Winesap, White Pearmain and Winter Banana require cross-pollination.

Good pollinizers produce an abundance of viable pollen, while blooming at the same time as the variety to be pollinated. They should also bear crops of good market value.

Gravenstein and Winesap produce sterile pollen and so are not effective pollinizers for other varieties. Otherwise, among the varieties common in California there are no unsatisfactory pollinizers, except insofar as a difference in time of bloom may be a factor. Rome Beauty, for example, frequently blooms too late to be of value for Gravenstein or Delicious.

Golden Delicious, Jonathan, and Delicious or its sports are used for pollinating Gravenstein; Yellow Newtown, Golden Delicious and Jonathan are used for Delicious and its sports. Growers sometimes graft one branch per tree with Yellow Bellflower or Golden Delicious in an otherwise solid block of Delicious, working the grafts in a regular pattern—every third tree in every third row, for example. Red sports of McIntosh are also

being used to some extent as interplants or as grafts in blocks of Delicious in the Pajaro Valley.

Closely related varieties, such as Delicious and its various sports, are unsatisfactory pollinizers for one another.

Market demand. Varietal selection should be based on market potential. A variety may be marketed fresh or processed, or both. A good red color has become a most important factor in consumer preference of apples sold on the fresh market. Golden Delicious is the only yellow variety that commands general and widespread acceptance.

The importance of red color is well illustrated by Starking Delicious. This variety has shown a strong tendency to revert; this is a condition in which parts of or even whole trees sport back toward the color of the original Delicious and become incapable of producing the highly-colored fruit typical of normal Starking. In Santa Cruz County reversion is particularly noticeable because the color difference between normal and reverted fruit is accentuated under climatic conditions not always the best for red color development. Roughly 20 per cent of the Starking crop in that county shows reversion, and such fruit brings lower prices. Interest has therefore turned to the newer sports of Delicious, some of which appear less likely to revert. Those with solid red or only faintly-striped color are more desirable than those with a distinctly-striped color pattern. Starkrimson, Wellspur, Redspur, Royal Red, and House Red Delicious are examples of types which have shown no marked tendency to revert. Some of these, such as Starkrimson, Wellspur, and Ryan Red develop a dark, almost black-red color in the best coloring years. In some instances the dark color may meet sales resistance on the market.

Along with the higher red color of the newer sports of Delicious goes earlier coloring, so that the fruit appears to be

ready to harvest long before it is actually mature. Consequently, there is a strong tendency to pick the Delicious sports (including normal, well-colored Starking) well in advance of optimum edible maturity. Such fruit usually depresses the market and makes it difficult to move acceptably mature Delicious when it becomes available.

Good quality fruit sold on the fresh market has usually returned more to the grower than has fruit sold to the processor, but development of the apple-pie industry and the use of better-quality apples in canning (sauce, slice and juice) has brought better prices for processing-fruit. Varieties suitable for both fresh market and processing (the dual-purpose varieties) provide the grower with apples that meet a more diverse market situation.

Golden Delicious and well-colored Delicious or its sports go primarily to fresh markets, but much of the poorly-colored Delicious goes for processing, usually at low prices.

Gravenstein and Yellow Newtown are dual-purpose apples. A large part of the Gravenstein crop goes to canneries for apple sauce, canned slices and juice. Yellow Newtown is processed as pie, dried apples, and juice. Both varieties have very good quality as fresh apples when harvested at proper maturity. Much of the fresh-market volume of both varieties is made up of fruit picked enough in advance of optimum maturity to have inferior eating quality. Consequently, consumer acceptance is poor and a potentially good fresh market movement is curtailed.

Rome Beauty is well suited for processing and is an acceptable dessert apple. It is a firm apple that holds its shape well when baked.

Variety descriptions

Gravenstein. The most popular summer apple in California. Matures in August. Fruit medium to large, slightly one-sided

and flattened, with a short deep-set stem. Skin greenish yellow, overlain with broken stripes of light and dark red. Flesh tender, crisp, subacid and aromatic. A good late-summer dessert apple when mature; an excellent sauce apple.

Defects: High percentage of windfalls. Susceptible to bitter pit.

Sports: Several sports with fruit more red than ordinary Gravenstein; some with solid red, unstriped color pattern.

Jonathan. An attractive red, round apple of uniform shape. Flesh yellowish, firm, crisp, tender, juicy and sprightly sub-acid. Excellent quality for both fresh and processing use. Matures in September.

Defects: Highly susceptible to mildew, fireblight, and Jonathan spot.

Sports: Several sports with fruit more highly colored, less striped than ordinary Jonathan; some dark red, nearly black.

Golden Delicious. A yellow apple of excellent dessert quality: unrelated to the red-colored Delicious. Skin clear yellow, with occasional blush and small conspicuous russet dots; medium to large, oblong-conic with a long slender stem. Flesh cream-colored, fine texture, juicy, aromatic, mildly sub-acid. Though primarily a dessert apple, also good for processing. Matures in September.

Defects: Susceptible to mildew and russet. Fruit bruises easily, shrivels unless stored under proper temperature and humidity.

Sports: Golden Delicious spur types are being propagated by nurserymen. Three of them, Starkspur Golden Delicious, Yellospur and Goldspur, are under test in California.

Delicious. The old, common Delicious, a red-striped apple, lost favor with introduction of Starking and Richared, which are sports of a better color than the original Delicious. More recently other sports, many originating from Starking, have provided apple growers with several

highly-colored varieties of Delicious better than Starking or Richared.

The fruit of Delicious and its sports is characterized by a conical, tapered shape with five prominent knoblike protrusions on the blossom end. Flesh is white, fine grained, very mildly acid, aromatic, of good mild flavor and dessert quality. Primarily a fresh market apple. Matures in September.

Defects: Very poor flavor and quality unless picked at proper maturity; does not cook well. Becomes mealy at ordinary temperatures.

Sports: There are two general types of color patterns among the sports of Delicious, one distinctly striped as with Starking, and the other a solid color as in Richared. Some of the newer sports characteristically color earlier with a deeper, darker red than the original Delicious, or even Starking or Richared.

Starking Delicious has lost favor in California, particularly in the Watsonville district, because of the color reversion problem. Among recent introductions, those sports with the distinctly-striped pattern have shown a tendency toward reversion similar to that in Stark-

ing. The solid red varieties, or those with only a faint stripe, have shown little or no tendency to revert, and are preferred to distinctly-striped fruit. Some of solid color may, however, become nearly black in some seasons; at other times (especially when temperatures are high toward harvest) they may become a dull, dun or buckskin color.

None of the Delicious sports observed in California are mature and ready for harvest before the ordinary Delicious or Starking, even though they may color earlier. Indeed, the solid-colored sports may mature slightly later than Delicious or Starking, especially when trees are young.

In addition to having high color, some sports are more prolific spur producers than are Delicious or Starking. The growth habit of abundant spur production results in trees which are smaller at maturity. The spur-type trees may develop apple measles (internal bark necrosis) more readily than do standard trees having more vigorous growth habits.

Among sports tested under California conditions, the following are most promising:

Varieties with solid or only faintly-striped red skin:

Dieterich Delicious
House Red Delicious
Imperial Delicious
Redspur

Royal Red Delicious
Ryan Red
Starkrimson Delicious
Wellspur Delicious

Varieties with distinctly-striped red skin:

Clarkrich
Evarts Delicious
Hi-Early

Hi-Red
Red King Delicious
Topred Delicious

Other promising sports observed elsewhere, but not as yet thoroughly tested under California conditions, include:

With solid color:

Hardi-Spur Delicious
Morspur
Red Prince

With striped color:

Red Queen
Starkspur Red Delicious
Wayne-Spur Delicious

Normal Starking Delicious (upper left). Reverted Starking Delicious (upper right). Variety with solid red color pattern, typical of Starkrimson, Wellspur, and House Red Delicious (lower left). Variety with a faintly striped red color pattern, typical of Royal Red and Imperial Delicious (lower right).

Yellow Newtown. Grown chiefly in the Watsonville district, it is the leader in production among the winter varieties in California. An excellent processing variety and, when properly mature, a very good dessert apple. The pie and drying industries favor this variety.

Fruit large, round to slightly flat. Skin green to yellow with distinctive grey scarf skin on shoulders. Flesh cream colored, firm, crisp, juicy, high quality. Matures in October.

Defects: Susceptible to stem-end russet; bitter pit and internal browning in storage.

Rome Beauty. Popular late apple in mountain and foothill districts and in Sonoma and Mendocino counties. Because of its fairly high chilling requirement it is not adapted to the Watsonville area.

Fruit large, uniformly round to round-conic, red-striped to solid red, conspicuous yellow dots. Stem long, set in characteristically broad, shallow, usually green cavity. Flesh yellow, firm, crisp, mildly sub-acid. Moderately good dessert quality, excellent for baking. Matures in October.

Sports: Several sports, with fruit more highly colored with solid red or striped pattern than ordinary Rome Beauty. All have strong tendency to revert to poorer color of the parent variety.

Winesap. An old and still popular late variety. In California, it is best adapted to Sierra foothill and other mountain districts.

Fruit medium size, round to round-conic. Skin tough, bright to dark red with scattering of small dots. Flesh yellow, firm, crisp, sprightly. Quality good for both dessert and processing uses. Matures in October.

Other varieties. The following old familiar varieties may be of limited value in some districts but are not of significant commercial importance in California.

Red Astrachan	Winter Banana
White Astrachan	McIntosh (or its sports)
Wagener	Esopus Spitzenberg
Tompkins King	Rhode Island Greening
Smith Cider	White Pearmain
Yellow Bellflower	

New varieties. Since 1920 many new apple varieties have been introduced, some discovered as chance seedlings, others coming out of the apple breeding programs of various experimental stations. Few if any of these have been adequately tested in California apple districts. Grower interest in varieties to supplement Gravenstein, Yellow Newtown, and Delicious has led to tests of both recent and older introductions.

Among the early season varieties maturing in July and August in the Sebastopol district, Wellington, Beacon and Earliblaze have shown promise. All these are red apples, distinctly striped. Wellington matures about 2 weeks before Gravenstein, is large fruited and a regular producer. Beacon is uneven in maturing, beginning ahead of Gravenstein but continuing well into Gravenstein season, thus requiring several pickings; its trees are moderately susceptible to fire blight. Earliblaze matures about with Gravenstein; it is a firm apple and a better keeper than most other varieties of its season.

Promising varieties which mature in the Delicious season or slightly later (September to early October) include Franklin, Idared, Kendall, Melrose, Monroe, Shelred, Spartan, and Webster. Franklin is a red-striped apple of exceptionally fine quality, but it is tender to handle and so is best suited for local or roadside markets. Idared also is a red-striped apple, large fruited, with high quality, valuable for fresh market and for processing; unfortunately its trees are highly susceptible to fire blight, so its usefulness in California may be limited. Kendall produces fruit with an attractive solid-red skin that sometimes may become

nearly black and too dark; it has much of the fine quality of McIntosh, which is one of its parents. Melrose is a striped apple of fine quality, suited both for fresh consumption and processing. Monroe, a moderately attractive, red-striped apple, has good fresh-market quality and fine processing characteristics; its trees are highly susceptible to mildew and scab. Sheldred is a firm bright-red apple resembling Delicious in shape but maturing a little later than Delicious; in preliminary tests in California it maintained excellent quality through several months of cold storage. Spartan, which originated from a cross of McIntosh and Yellow Newtown, bears fruit with an attractive, solid bright red color and fine eating qualities; the fruit tends to be small, so moderately heavy thinning is required. Webster is a large-fruited, red-streaked apple with promising qualities for fresh market and processing; it requires cross-pollination and is unsatisfactory as a pollinizer for other varieties; its trees are susceptible to mildew and scab.

A late variety, Ruby, is an attractive red-striped apple maturing in Rome Beauty season; it generally has better dessert quality than Rome Beauty; it is a prolific annual bearer and is well-suited for areas where Rome Beauty can be grown. Although it appears to have a fairly high winter chilling requirement it does well even in Santa Cruz County, where Rome Beauty shows symptoms of delayed foliation. Another late variety maturing with or a little later than Rome Beauty is Jerseyred; preliminary observations indicate that it will mature too late to be of use in Santa Cruz County, but may have a limited place in Mendocino County or climatically similar districts.

Other promising varieties which have performed well outside of California but which have not yet been fully tested here include Julyred, Blaze, and Tydeman's Early Worcester (Tydeman's Red), which are early maturing varieties: Wayne,

Niagara, and Spigold are recent introductions from New York which have promise as dual purpose, mid-season varieties; Mutsu, a yellow apple of Japanese origin, resembles Golden Delicious but reportedly is less susceptible to russet and to shrivel in storage than is Golden Delicious.

Rootstocks

Most apple trees planted in California are propagated by commercial nurseries. Seedling trees are grown from seed generally obtained from an apple-processing plant. The seedlings are budded to a desired fruiting variety and sold as 1-year-old whips or 2-year-old trees. Nursery trees are graded for sale according to the diameter of the trunk 2 inches above the bud union. The approximate height may also be listed:

Diameter (inches)	Height (feet)
11/16 and larger . . .	6 to 8
1/2 to 11/16 . . .	4 to 6
3/8 to 1/2 . . .	3 to 4
1/4 to 3/8 . . .	2 to 3

The 1-year-old whips are preferred to 2-year-old nursery trees. Growers can make a better selection of scaffold branches and develop a better framework from whips than from 2-year-old nursery stock, as primary branching on whips will be initiated in the orchard rather than in the nursery row. Branches on 2-year-old stock are frequently deformed or poorly developed because trees are crowded in the nursery. The larger whips (1/2- to 11/16-inch diameter) usually perform better than smaller ones, growing more vigorously and developing a better selection of laterals from which to form the framework.

Dwarfing rootstocks. There has been an increasing interest in the use of dwarfing rootstocks to reduce labor and bring orchards into earlier commercial production. With smaller trees the primary saving in labor is the result of the reduc-

tion in ladder work for pruning, thinning and picking.

Two major groups of dwarfing rootstocks, both of which were developed in England, are being used. They are the

East Malling, or EM series, and the woolly apple aphid resistant Malling-Merton, or MM series. The most important of these rootstocks have been classified into four vigor levels:

Vigor level	Rootstocks	Typical planting intervals, in ft.	Trees per acre
Standard.....	Standard seedlings, EM XVI, EM XXV, MM 109	25 × 25 to 30 × 30	70 to 48
Semi-standard.....	EM II, MM 104, MM 111	21 × 21	96
Semi-dwarf.....	EM VII, MM 106	17 × 17	150
Dwarf.....	EM IX, EM 26	15 × 8	363

Research work with these rootstocks has been carried on extensively in many apple areas of the world, but in California observations have been limited primarily to small trial plantings established by

growers. Because vital factors can vary with areas, further evaluation of these rootstocks under California conditions is needed before any firm recommendations about them can be made.

Dormant pruning. Fig. 5. (Below, left.) Tree before first dormant pruning. Fig. 6. (Below, center.) Same tree as in figure 5 after first dormant pruning. Fig. 7. (Below, right.) Same tree as in figure 3 after first dormant pruning. Scaffold branches are well distributed vertically and around the tree. Shoots not selected as scaffolds were merely stubbed to provide additional leaf surface in next growing season.

Pruning and training

During the first 4 years of the orchard the primary aim in pruning is to develop a tree shape that will lend itself to economical culture. The ideal tree should have three primary scaffold branches originating from the trunk, and two secondary scaffold branches arising from each primary. These six secondary branches are the main framework from which fruiting branches will grow.

First year summer pinching. Growth of well-placed shoots for use as scaffold limbs may be encouraged by depressing the growth of other shoots. Removing the tip inch or two of shoots not well located for permanent limbs is called "pinching." It should usually be done from about mid-April to mid-May, or when shoots are 4 to 8 inches long. Pinching shoots on weak trees is not recommended.

The first dormant pruning is done in winter following the first summer's growth. Three primary scaffold branches are selected at this time, and these should be spaced about equally around the trunk, preferably with a vertical spacing of 4 to 6 inches between them. Good vertical spacing promotes strong crotches which are less likely to develop pockets of rot later on or to split out from heavy crops and wind. The primaries generally need not be headed back, except to achieve a balance in growth among them.

Three well-spaced primary branches cannot always be obtained the first year. If two good limbs are available, they may be headed back to about 18 inches from the trunk to suppress their development until a third scaffold can be selected at the end of the second growing season. With an occasional tree it will be necessary to cut laterals back to one bud and defer scaffold selection until the next year. Such trees will generally grow vigorously and will benefit by summer pinching during the second growing season.

Second year dormant pruning. Five

to seven secondary branches per tree, usually two on each primary scaffold, should be selected in the second dormant season. Well-chosen secondaries should be directed partially outward. New growth from such branches will fill in laterally, giving the tree a well-shaped framework. Secondary limbs should be left full length and not headed back, unless it is necessary to maintain balance with the primaries or other secondaries. Any forked tips may be thinned out to a single terminal. If a primary scaffold branch is overly vigorous it can be retarded by heading back to balance with the rest of the tree. Upright-growing sucker shoots should be removed. Most trees will produce short

Fig. 8. Tree after first dormant pruning, with scaffolds headed back for balance and spreaders holding branches apart.

Fig. 9. Tree prior to second dormant pruning.

laterals and spurs during the second year, and these should not be immediately removed as they provide shade and some early fruit.

Third and subsequent dormant season pruning. Third-year training consists of thinning out unwanted branches and cutting others to desirable side limbs. Secondary branches often form fruit spurs during the third growing season, but on young trees fruit buds may form at the tip of unpruned shoots.

By the fourth dormant pruning, tree training has been largely completed. From here on pruning should be done in such a manner as to permit the best development of the crop. The tree should be thinned out and the remaining branches cut to side limbs, as was done in the third dormant pruning. A moderate number of small shoots should be left in the center of the tree for fruit-bearing wood. Adequate thinning out of branches and fruiting wood will maintain a well-distributed bearing area throughout the tree and reduce excessive spread and breaking of branches.

Fig. 10. Same tree as in figure 9 after pruning, with spreaders in place to separate scaffold limbs and direct them outward.

Fig. 11. Same tree as in figures 9 and 10, but branches lightly headed to shorten unusually long or vigorous secondaries and to maintain balance among them. Light heading may also be needed to remove tips of shoots infected with mildew.

Fig. 12. Tree before third dormant pruning.

MANAGEMENT OF THE BEARING ORCHARD

By about the fifth summer after planting most apple varieties produce enough fruit to be considered a bearing orchard. The cultural practices recommended in the following sections are a means of maintaining satisfactory crop yield and quality.

Pruning

Trees properly cared for during their formative period will be well shaped and mechanically able to support heavy crops.

Apple trees normally produce their

crop on long-lived spurs originating as laterals from shoot wood at least 2 years old. Some varieties such as Rome Beauty, Golden Delicious, and Jonathan may produce additional fruit on the tips of last year's shoots.

The primary consideration in pruning bearing trees is to maintain a proper balance between vegetative growth and fruit production. Excessive growth by the young tree is usually produced at the expense of fruit production, while overbearing is accompanied by less growth

Fig. 13. Same tree as in figure 12 after pruning.

and, if continued, loss of vigor. On the ideal mature tree, shoots average at least 10 inches of new terminal growth per shoot each year. Thus the tree increases and maintains its fruiting area while producing satisfactory annual crops.

With most trees that have received regular pruning previously there is little necessity for more than a light thinning and cutting back of the upper branches to laterals; this will prevent the tree from getting too high for economical spraying and picking operations. It is desirable to provide ladder spaces for pruning, thinning and harvest operations.

The center of the tree should be kept fairly open with varieties for which fruit color is an important factor; if this has

Fig. 14. Same tree as in figure 13 after a few additional light thinning-out cuts. Any advantages of the additional thinning are debatable, particularly in relation to the time required to do it. Spreaders at this age of tree are of limited value, except when used to help force a scaffold outward (as illustrated by the branch on the left turning inward in figure 13).

been neglected for several years it is best to thin out surplus branches over a period of two or more seasons. Heavy removal of branches can upset the balance of the tree and expose scaffold branches to sunburn damage. Any heavy pruning will encourage a large amount of vegetative growth. Old bearing trees producing small fruit will benefit from heavy pruning, which stimulates new shoots and fruiting spurs.

In the Pajaro Valley and with the Yellow Newtown variety particularly, mildew infection is reduced by pruning out infected tips in the dormant and even in the growing season.

Whenever a limb larger than an inch in diameter must be removed, the cut should be made as close as possible to the branch from which the limb arises so as not to leave a stub. Large pruning wounds should be protected with some covering in order to exclude rot-causing fungi. For this purpose commercial preparations may be used. Bordeaux paste is a good temporary covering. A more permanent covering consists of combining Bordeaux powder with paint. An excellent formula is: 1 gallon "orchard contour" paint or similar formula, $1\frac{3}{4}$ gallons boiled linseed oil, and 7 pounds of Bordeaux powder ("one-package" Bordeaux).

Cultivation

Orchards are cultivated to (1) reduce noxious weeds and plant competition; (2) facilitate subsequent orchard operations, such as irrigation, harvesting, brush removal or spraying; (3) incorporate cover crops and fertilizers; (4) prepare seedbeds for cover crops; and (5) to aid in the absorption of water where certain orchard operations have produced an impervious soil condition. Cultivation should not be any deeper than is necessary to accomplish the various objectives listed above. Tillage does not reduce water loss, except by killing weeds which use water. Unnecessary cultivation, especially when the soil is wet, increases the costs of operation and may cause definite injury through soil compaction and damage to soil structure. (See University of California Agricultural Experiment Station Extension Service Circular 486, *Essentials of Irrigation and Cultivation of Orchards*.)

Cover crops

Cover crops are used to (1) improve water penetration; (2) fix nitrogen (leguminous cover crops only); (3) improve the general physical condition of the soil; and (4) reduce soil erosion on sloping land. Non-leguminous cover crops such as mustard, rye, oats and barley are planted alone or in combination with a legume; vetch and Canadian field peas are two of the most common leguminous species, and either can be used alone. Where volunteer covers of weeds and grasses are adequate, growers would be wise to fertilize this natural cover rather than to spend money in purchasing cover crop seed.

Planted cover crops are fall seeded and disked under in the spring. They should not be allowed to grow late in the spring because they will compete with the trees for nitrogen and water. In non-irrigated orchards, it is advisable to disk in the cover crops as soon as possible toward the end of the rainy season.

On the steeper slopes in the foothill and mountain areas where there is danger of soil erosion, most apple orchards are maintained under a system of sod culture or trashy cultivation.

For more detailed information on cover crops in orchards, see University of California Agricultural Experiment Station Extension Service Circular 466, *Fertilizers and Covercrops for California Orchards*.

Fertilization

A statewide recommendation for the fertilization of apples cannot be made because of variations in soil, moisture and temperature within and between the various districts. As a general rule, however, trees will show a response to nitrogen; this should be applied annually at the rate of $\frac{3}{4}$ to $1\frac{1}{2}$ pounds of actual nitrogen per mature tree.

Phosphorus deficiency has not been found in California apple orchards to date. Phosphates are used with nitrogen to stimulate cover crop growth.

Occasional trees and some orchards have been found deficient in potassium, and correction may sometimes be made by heavy applications of potassium sulfate, which should be trenched or drilled into the soil about 6 inches deep, using 10 to 25 pounds per tree. It may require a year or two for tree response to become evident.

Minor element needs must be determined on a local basis and treated accordingly. Your local Farm Advisor should be consulted when a deficiency is noted or suspected.

Irrigation

Good irrigation replaces moisture removed from soil by growing plants before they show stress. Thus, satisfactory irrigation for apples requires some knowledge of the amount of water the trees remove from the soil. The relation between soil type and climate affects the amount and frequency of irrigation. Apples have been raised successfully under dry-land conditions in the cooler coastal areas of California on good, deep soil. Optimum yields, however, are closely associated with optimum soil-water relations.

Medium-sized trees growing in the warm section of the Sierra foothills use nearly twice as much water annually as do large trees growing in the cool coastal belt, and differences in summer temperature and humidity contribute to these variations. Approximately half of the total seasonal water consumption occurs during July and August.

Factors which tend to limit depth of root distribution will also affect the need for more frequent irrigations. Texture of the soil is also important: sandier soils, which have lower water-holding capacity, require more frequent irrigation than do

heavier loams. Sharply stratified surface soils and subsoils, impervious layers of hardpan or rock, or shallow water tables, limit root activity and create difficult problems in orchard management.

Irrigation programs vary according to orchard location and soil type, and each grower must learn the requirements of his own land. Diligent use of a shovel, soil auger or soil tube is a highly recommended method of determining the moisture conditions surrounding the tree roots. Soil moisture measuring instruments, such as tensiometers and gypsum blocks, are also helpful.

On fairly flat land, apple orchards may be irrigated by the use of furrows, contour checks, strip checks, square checks, or sprinklers. On rolling foothill lands the sprinkler system, while expensive to install, is far more efficient than contour furrows and results in better distribution of water. Sprinkler irrigation has become a common practice in most apple-growing areas of the state because it does not interfere with the propping necessary for trees producing heavy crops. On heavy soils any irrigation system which tends to result in a wet-soil condition around the trunk for extended periods may promote crown rot. On such soils furrow irrigation may therefore be preferred to sprinklers.

Thinning

Fruit thinning is well recognized as one of the most important orchard operations. It results in improved fruit size and uniformity, promotes regular bearing, reduces limb breakage, assists in maintaining general tree vigor, and decreases the labor of handling the crop at harvest time.

Historically, apples have been thinned by hand, usually following the natural June drop, when the fruits are between the size of a cherry and a walnut. With most varieties, the small apples are removed from their stems, leaving the stems attached to the spurs. Growers generally

strive to thin their crop to one fruit per cluster, with 6 to 8 inches between fruits. If the crop is light to begin with, it is practical to leave two fruits per cluster with most varieties.

In recent years the advent of chemical thinning agents has provided growers with an economical means of partially thinning their crop. In the Watsonville district, Yellow Newtown and red Delicious can be thinned using naphthylacetamide (NAAmide) at 40 parts per million at 70 to 80% petal fall. In the Sierra foothills, Golden Delicious and Stayman Winesap can be thinned with NAAmide at 50 parts per million at 80 to 90% petal fall. NAAmide is not used on red Delicious in the Sierra foothills due to the fact that it tends to produce pigmy apples. Naphthaleneacetic acid (NAA) sometimes causes overthinning and some flagging of the foliage and stunting of the shoot growth; it is used in the Sierra foothills on Golden Delicious and red Delicious at 15 parts per million 2 to 3 weeks after full bloom. Recently the insecticide, 1-naphthyl N-methylcarbamate (Sevin®), was found to act as a thinning agent. It has been used successfully on most varieties in California at 1½ pounds 50 per cent wettable powder per hundred gallons of water 10 to 20 days following full bloom. Sevin® and NAAmide have not caused overthinning on healthy trees.

It is usually necessary to do some supplemental hand thinning following chemical thinning, but the total cost of thinning is still greatly reduced. Apples may be left in clusters of two during the

supplemental thinning and still attain satisfactory fruit size.

Pre-harvest drop

Dropping of apples immediately preceding and during harvest may result in considerable loss. With most varieties, this drop may be materially reduced with hormones containing naphthaleneacetic acid or its derivatives. These preparations are available under a number of different trade names (directions for their use and application are printed on packages and should be followed exactly). They are applied a few days before harvest or as soon as dropping is evident. The period of effectiveness usually ranges from 5 to 20 days.

Top-working

Grafting or budding is commonly used to establish a variety on seedling rootstock by nurseries. Growers may use the same techniques to convert an orchard to a new or more desirable variety, or to provide additional pollinizers.

Frost protection

Since the larger apple-growing areas of the state are at low altitudes and relatively near the coast, frost danger to blossoms and young fruit is infrequent, and few growers are prepared to heat their orchards. At altitudes of 3,000 feet or higher, spring frosts may do considerable damage or even destroy the crop one year out of four or five. With such a frequency of loss it is seldom economically sound to attempt to provide frost protection.

INSECT AND DISEASE CONTROL

Information on insects and diseases of apples is available at your Farm Advisor's Office. Good control of these pests is vital to the health of the tree and the production of marketable fruit. Spray schedules for such control prepared annually by the Agricultural Experiment Station and the Agricultural Extension Service of the University of California are also available at your Farm Advisor's Office. Five to seven sprays are generally required throughout the season.

HARVESTING, HANDLING, AND STORAGE

When and how to pick

Statewide minimum maturity standards have been established for most commercial varieties. Flesh firmness, soluble solids in the juice, and ground color of the skin are criteria that may be used to set a standard. The County Agricultural Commissioner in each county enforces maturity standards in his particular county, and in apple-growing sections he is equipped with refractometers, pressure testers, and color guides for determining fruit maturity. He will on appointment test fruit for growers. If a variety complies with the standards for two of the three maturity criteria the commissioner releases it for harvest.

The standards require that fruit ripen to reasonable dessert quality, have a satisfactory appearance, and be free from excessive shriveling during storage and marketing. However, being minimum standards, they permit apples at the beginning of the season to be harvested considerably in advance of optimum maturity for top quality. Such early harvest can adversely affect their acceptance as dessert apples, resulting in lowering of the early-market price in most seasons.

When apples are harvested at minimal maturity, the total tonnage from any given orchard is less than if harvest is delayed until a more advanced maturity is reached. Apples of low maturity are still growing, and a delay in harvest of 2 or more weeks can result in a gain in tonnage of as much as 20 per cent. (Brown, Dillon S. and Edward C. Koch, *Yield Gain by Delayed Harvest*. California Agriculture 11(9):6, 1957.)

More Gravenstein and Yellow Newtown apples are canned or otherwise processed than are sold fresh. Standards for fresh apples do not apply directly to those sold for processing. However, top

quality in processed apples or apple products comes only from fruit harvested at optimum maturity, so processors desire fruit of more advanced maturity than is required for the fresh market.

Picking should be done in such a way as to avoid bruising and stem punctures. Apples should be grasped in the palm of the hand and removed from the fruit spur with a quick, upward turn of the wrist. A straight pull will usually result in pulling the stem out of the fruit or the spur from the tree. Apples should be transferred carefully from picking containers into boxes or bins. Varieties such as Golden Delicious and Bellflower require extra careful handling.

Handling methods and practices

Most commercial apple growers have replaced field boxes with pallet bins in recent years. The bins are used for harvesting and for storing of fruit until ready for final packing and shipment.

After picking, apples should be put under cover immediately. Picked apples left in the orchard ripen faster than those remaining on the tree, and uncovered fruit is subject to heat injury. Because apples at harvest time seem to be hard, there is a tendency to handle them in a rougher manner than more perishable soft fruits. While not particularly visible at packing time, injuries resulting from rough handling do show at marketing time—or on the retail shelves. Such injuries detract from eye appeal at the time of purchase and may make the fruit distasteful.

Storage

All fresh fruits are alive and remain so during storage and marketing. Being alive they respire, combining sugar and

other constituents stored in them while on the tree with oxygen from the air to produce carbon dioxide and energy (heat). The reactions are extremely complex and lead ultimately to fruit deterioration.

Cold storage is used to retard these deteriorating effects and to reduce decay from pathogens and shrivel from water loss. The best storage temperature is generally the lowest the fruit will withstand without freezing, though certain apple varieties such as Yellow Newtown will not tolerate storage temperatures quite that low.

Deterioration may also be retarded by controlled-atmosphere storage, in which carbon dioxide, oxygen, and temperature and humidity are controlled in gastight rooms.

Apples are one of the most important fruits stored on a tonnage basis, and the average time of storage is considerably longer than for other fruits. Cold storage is critical to proper handling and marketing, although storage time may be short for an early variety like Gravenstein.

Temperature. For most varieties, 30° to 31°F is the recommended storage temperature. This is 1.5° to 2.5°F above the average freezing point (28° to 28.5°F) of most apples and is normally safe for modern storage rooms. In older rooms with limited air distribution, 30°F is unsafe because of variability of temperature at different locations within the room. Some apple varieties such as Yellow Newtown develop physiological disorders that impair storage life and marketability if held at the above temperatures. At 38° to 40°F, however, such storage disorders may not be an economic factor; unfortunately, such an elevation in temperature results in faster deterioration which greatly shortens storage life and marketability time. Because the raised temperature may have almost as serious consequences in relation to marketability as does the physiological

disorder, a storage temperature of approximately 36°F is often used.

The storage life of apple varieties largely depends on harvest maturity, elapsed time and temperature between harvest and storage, rate of cooling in storage and, sometimes, cultural factors. Mature apples usually have the greatest storage potential. Essentials for rapid cooling and good cold storage are adequate refrigeration capacity, rapid air circulation, and proper stacking to permit good exposure of fruit to cold moving air.

Controlled atmospheres. Controlled-atmosphere storage may offer important gains in extending the market life of certain apple varieties. Only apples of good quality, proper maturity and high storage potential should be placed in controlled-atmosphere storage.

Yellow Newtown and McIntosh varieties were the first to receive controlled-atmosphere storage because of their susceptibility to low temperature disorders. By elevating their storage temperature to approximately 40°F, and altering the composition of the atmosphere, chilling-injury symptoms were avoided. Recently, attention has been given to varieties such as Delicious that can be stored at low temperatures.

Some of the construction requirements—in addition to those called for in conventional storage rooms—are: (1) gas tightness, (2) provision for removing excess CO₂ from the atmosphere, (3) provision for ventilation to control oxygen level, (4) adjustment to changing atmospheric pressures, and (5) provision for maintenance of very high relative humidity required by the longer storage period.

Precautions in the operation of controlled-atmosphere rooms are highly important as the atmosphere in them will not support human life. The size of a controlled-atmosphere room is also important: once the room is opened, its

APPROXIMATE REQUIREMENTS FOR CONTROLLED- ATMOSPHERE STORAGE OF APPLES*

Variety	Per cent CO ₂	Per cent O ₂	Temperature, F
McIntosh	2 to 5	2 to 3	38
Delicious and Golden Delicious	1.5 to 3	2.5 to 3	30 to 32
Baldwin, Jonathan, Rome Beauty, Stayman Winesap	1 to 5	2 to 3	30 to 32
Yellow Newtown	5 to 8	2 to 3	38 to 40

* From p. 614, chapter 51, *Storage of Apples, Pears and Grapes*. (Prepared by Claypool, L. L. and Nelson, K. E., University of California, Davis.) ASHRAE Guide and Data Book, 1964. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 345 East 47th Street, New York 17, New York.

contents should be marketed or utilized within a few weeks.

A service is now available in which a generator delivers an atmosphere of desired composition to a storage room which need not be as gastight as those rooms in which fruits lower the atmospheric oxygen by respiration. Economic considerations determine the commercial use of different controlled-atmosphere methods.

Storage-caused disorders. *Scald* is a serious disorder affecting apples in storage. It first appears as traces of light mottling on the greener surfaces of the fruit. Darkening becomes more severe with elapsed time and will extend to red colored surfaces. Ordinarily, scald affects only the skin, but in severe cases may extend into the flesh. It develops rapidly at warm temperatures, and apples with light scald in storage may be severely scalded during marketing. Immature fruit is susceptible to scald.

Bitter pit is characterized by small

sunken spots on the fruit surface. They are most prevalent near the blossom end and usually near the surface. At first, they show as small water-soaked areas that shrink and turn brown as water is lost from them, and end up as brown localized areas of dead tissue. Yellow Newtown, Delicious, Golden Delicious and Gravenstein are susceptible. The problem is most severe when apples are picked on the immature side, and may be worse in light-crop years when fruits are large.

Internal browning is associated with the Yellow Newtown apple grown in the coastal area of California and is characterized by brownish streaks radiating into the flesh from the core. Susceptibility varies between years and orchards. It can be controlled by storage at 40°F, but because of the short storage life at this temperature a compromise temperature of about 36°F is ordinarily used. With controlled-atmosphere storage, however, the higher temperature can be used.

To simplify the information, it is sometimes necessary to use trade names of products or equipment. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

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