APPLE GROWING IN CALIFORNIA

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Section I. The apple industry in the state

The prospective grower is advised to familiarize himself with conditions as they exist in the state

1. The present situation

California produces only about 8 per cent of the country's apples. While this may seem relatively unimportant when compared with Washington's 25 per cent, the fact remains that California's place among apple-producing states usually varies from third to fifth. In several years its production has been exceeded only by Washington and New York, and in most others has been exceeded by these two together with Virginia and Pennsylvania.

During the years 1944–48, the total farm value of apples was scarcely 25 per cent that of peaches and less than 50 per cent that of pears. It was, however, approximately 40 per cent greater than either cherries or plums. California apples meet more competition in marketing than many of the state's other fruit crops, and this, together with other factors contributing toward relatively low returns to apple growers, are discussed in detail in Exp. Sta. Cir. 395, *California Apples: Situation and Outlook—1949*, by B. B. Burlingame.

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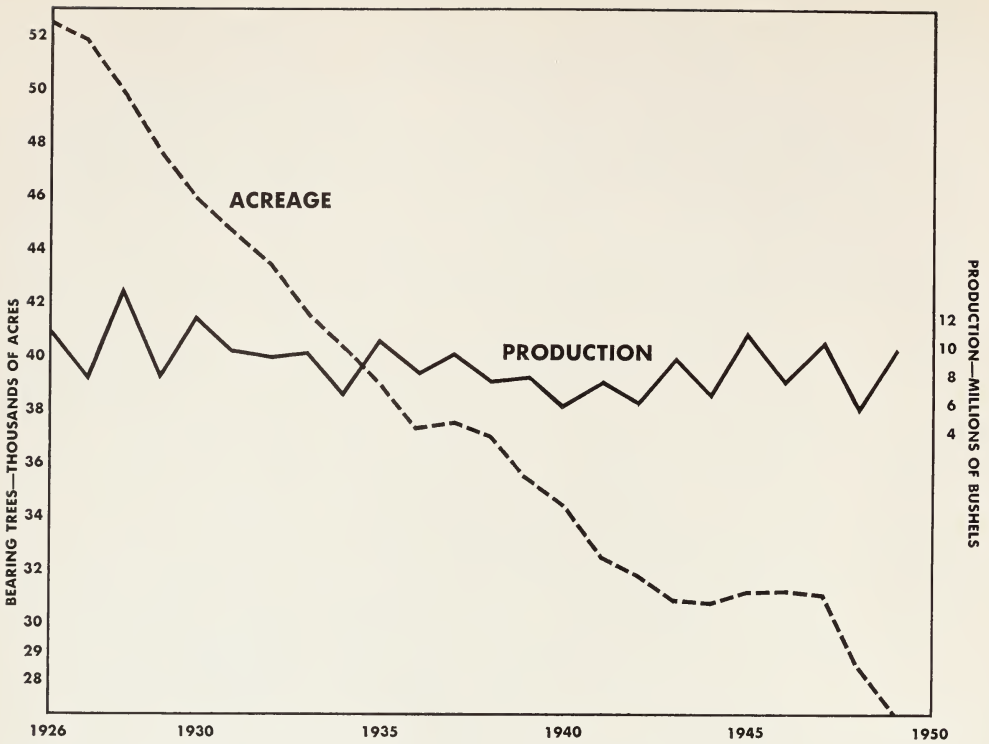
Crop failures in California are practically unknown, and except for alternate bearing, annual yields during the past 20 years have been relatively constant. Crops decreased somewhat between 1930 and 1944, but in comparison with a continuous decline of approximately 50 per cent in acreage of bearing trees since 1926, the drop in production has been relatively small (see graph).

The initial decline in acreage was due primarily to the removal of some 6,000 acres of trees in the Yucaipa district of San Bernardino County, and in the removal of similar acreage in the Pajaro Valley. Further reductions continued in San Bernardino, Inyo, Sonoma, Santa Clara and Tuolumne counties.

Lack of sufficient cold during the winter; lack of or the high cost of irrigation water; the general unprofitableness of apples compared with some other crops; all have been contributing factors in the reduction of bearing acreage.

New plantings in recent years have been confined to small acreages, primarily in Santa Cruz, Monterey, Sonoma, Tulare, El Dorado, Mariposa, and other Sierra foothill counties. In the Pajaro Valley in Santa Cruz and Monterey counties, new plantings have just about offset the older trees removed. Detailed figures on the bearing and nonbearing acre-



This graph illustrates both acreage and production figures for California apples. Note that while acreage has declined rather steadily, production of apples has remained relatively constant.

ages of apples in each county may be obtained from the Agricultural Statistician, State Department of Agriculture, Sacramento.

2. Requirements for apple growing

A commercial apple orchard represents a long-time investment, so while apples may be grown under a rather wide range of conditions, it is well to consider the over-all factors of any given location that will contribute to the success of the venture.

Climatic requirements. Summer and winter temperatures, frost damage, winds, and fog are the elements of weather to be considered.

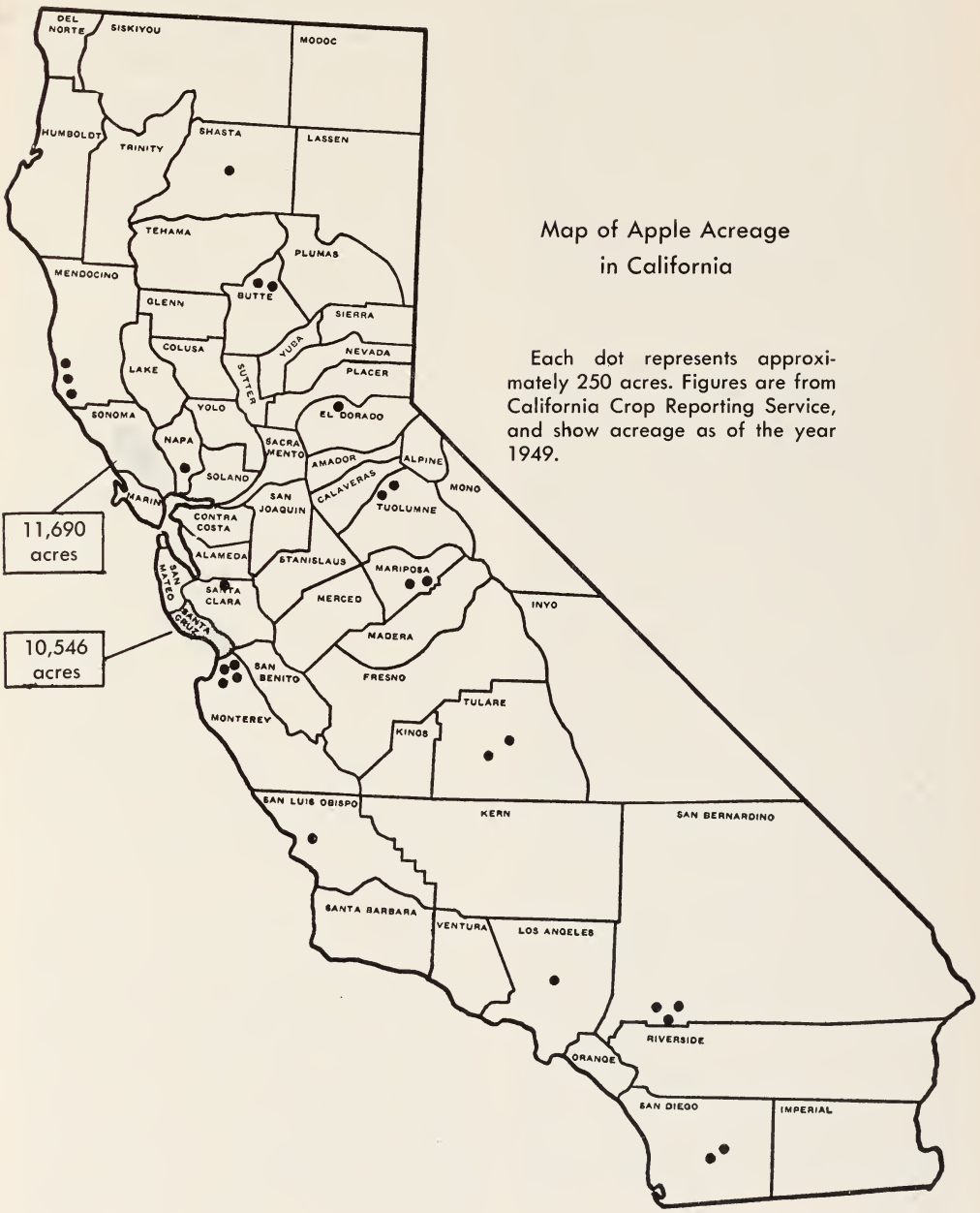
Apple trees thrive and fruit best under a relatively long, cool, slow, growing season. Except for early summer varieties in favorable locations, apples are not being produced successfully under interior-valley conditions. Suitable size and good texture are difficult to secure where high temperatures are combined with low humidity. Furthermore, sunburn damage is often serious on the fruit. In California, therefore, the best apple districts are those where summer temperatures are considered too low for the optimum development of other tree fruits, except perhaps pears. For this reason commercial production is limited to rather definite sections in coast or bay counties with coastal influences or to those in counties of the interior at an altitude of 2,000 to 4,000 feet.

At elevations of 3,500 feet or higher, summer temperatures are moderate and there is usually enough winter chilling to permit satisfactory opening of the buds of most varieties in spring. This is true also for the varieties grown in coastal regions in the northern part of the state. In some southern districts there is very harmful delay in opening of leaf buds and

flower buds in springs following the warmest winters. Temperatures in any part of the state are rarely severe enough to cause winter injury to apple trees; but at altitudes above 3,500 feet the crop is frequently endangered or even lost by reason of late spring frosts. Coastal sections are particularly free from frost damage.

Any location subject to strong winds during the growing period should be avoided. Beside the possibility of blowing the fruit from the trees at harvest time, much damage may occur through limb rubbing.

Fogs may help in coastal sections to break the rest period of trees in the spring. In the growing season, however,



Map of Apple Acreage in California

Each dot represents approximately 250 acres. Figures are from California Crop Reporting Service, and show acreage as of the year 1949.

excessive fog prevents full color development of red or striped varieties and may also cause russeting, which renders the fruit less attractive. For these reasons fruit of highest color and finish is usually produced in fog-free areas at higher altitudes.

Soil. Apple orchards have been planted both on stiff, heavy clay and on sandy soils; but an intermediate type ranging from clay loam to silt or sandy loam is preferable. Such soils are easier to work than those which are heavier; are likely to be more fertile and have a higher moisture-holding capacity than the sandy soils. Good drainage is essential; the tree roots should strike to a considerable depth without reaching the water table. Shallow soils or soils underlaid with hardpan or gravel should preferably be avoided.

Different varieties of apples may show special suitability to certain types of soil. In the Watsonville section the Yellow Newtown does better on heavier soils than the Yellow Bellflower. The Gravenstein, likewise, is apparently well adapted to the fine, sandy loam of the Sebastopol section. With only a few varieties, however, have such soil adaptations been determined with any degree of certainty.

Water supply. Most apple orchards of California depend entirely upon natural rainfall for their water supply. Others receive one or two irrigations. Usually, where the average annual precipitation amounts to as much as 20 inches, that amount has been thought sufficient for satisfactory tree growth. Though it may, under favorable soil and climatic conditions, produce sufficient growth the first few years, it may prove inadequate after the trees reach bearing age. Even where the rainfall is as much as 40 inches, irrigation is sometimes beneficial, either because of an open, porous soil of low water-holding capacity or because all the rain comes at one season and some is lost through surface runoff and by deep percolation.

Bearing trees need an adequate water supply to produce a large crop and bring it to proper size. In most sections, rains are not expected during the latter part of the growing season; hence irrigation facilities will enable the grower to apply water if needed.

3. Popular districts

From the standpoint of apple-producing acreage, two-thirds of the state's total is to be found in Sonoma, together with a small section in Mendocino and Napa counties and in the Pajaro Valley in Santa Cruz and Monterey counties. Some 80 per cent of the state's total commercial production is to be found in the Sonoma County and Watsonville districts. The remaining acreage is in certain smaller districts in a dozen or more coastal and foothill areas from Humboldt and Shasta on the north to San Diego in the south. Although many of these plantings are small and scattered, they produce apples of excellent color and quality.

The Pajaro Valley or Watsonville area is both the oldest and heaviest producing section of the state; the annual production averaging around 4 million 36-pound boxes. At present from 55 to 60 per cent of the apple acreage is of the Yellow Newtown variety; 20 per cent of Delicious; 10 per cent of Yellow Bellflower; and the remaining acreage of mixed varieties, including White Pearmain and Winter Banana. Newer plantings have been largely of the red strains of Delicious, with some 800 acres of nonbearing age.

Because of the climatic conditions, standard red varieties may lack high color. The soils vary from porous sandy loams to clay loams and clays on the terraces and slopes, and from sandy loams to clays and clay-adobes on the valley floors. With an average annual winter rainfall of 20 inches or more, comparatively cool temperatures, and high humidity, most orchards are nonirrigated. Some, however (perhaps 20 to 25 per

cent) receive one 6- to 8-inch irrigation in July or August, the water being obtained from wells. Although there is some alternate bearing, average total yields are high, ranging from 3 to 5 million boxes or 54,000 to 90,000 tons.

Approximately one-half the total crop is used as fresh fruit. Cash buyers purchase much of the crop. Some of the larger growers, having their own packing and storage houses are also packer-shippers who either purchase outright or handle, pack, and market the crop of smaller growers. The district now has storage facilities for over 2 million boxes of fruit and is well provided with evaporators, processing, and by-products plants.

Although fogs are frequent, fungous diseases are relatively few. Powdery mildew does considerable new shoot damage and apple scab is occasionally severe. Codling moth, aphids, and mites are the most important insect pests, but with the orange tortrix or skinworm becoming a problem in recent years. Fruit of the Yellow Newtown variety from this section is subject to internal browning of the flesh.

Sonoma County. The total acreage in Sonoma County is similar to that in the Pajaro Valley but the tonnage produced is not so great. Total shipments of packed apples vary from 700 cars or less in occasional years of short crops, to 2,000 cars in other years. Over a period of years shipments approximate 1,500 cars, or about 35 to 40 per cent of the state's total production. Processing plants and driers each now utilize some 18,000–20,000 tons of fruit.

Approximately three-fourths of the apple crop of the county originates in the Sebastopol area, extending about five miles south of Sebastopol, west to Occidental, and north to Forestville and Trenton. The topography there is naturally rolling, the soil being usually a fine sandy loam with a permeable clay subsoil. From the standpoint of climate this region, though coastal, partakes somewhat of inland valley conditions. Day temperatures are considerably higher than in the Pajaro Valley, while the winter rainfall is about one-third greater—perhaps 37 inches. Irrigation, though not generally practiced, would doubtless be beneficial in orchards on the more shallow soils. Water, however, is scarce and difficult to obtain. Two-thirds of the acreage is devoted to Gravensteins, a portion of which supply the eastern markets in July and August with the first boxed apples of the season. The district is well provided with selling organizations, storage facilities, canneries, evaporators, processing, and vinegar plants.

Other areas of the county include those adjacent to Geyserville and Healdsburg farther north, and the Vineburg and Sonoma districts in the southeastern part. The general climatic and growing conditions in these districts resemble those of Sebastopol. In the Geyserville and Healdsburg areas, somewhat heavier and also more gravelly soils prevail, and the topography is flatter. Irrigation is available in a few orchards. As in the Sebastopol area proper, the Gravenstein is the principal variety.

Mendocino County. Orchards of Mendocino County are somewhat scattered with the main center of production in the Anderson Valley about midway between Ukiah and the coast. From 4,000 to 5,000 tons are produced annually. The orchards are located on cutover redwood lands, and the trees are grown without irrigation. Jonathan, Baldwin, Rome Beauty, Rhode Island Greening, Gano, King, Ben Davis, Delicious, Winter Banana, and Wagener, as well as many less popular varieties, are grown successfully. Much of the crop is dried by individual growers in their own dehydrating plants. In the last few years, however, approximately 500 tons have been sold direct to fresh-fruit markets, San Francisco and local dealers purchasing the fruit at the orchards and doing their own hauling. Although with proper attention to spray-

ing and other orchard operations, excellent apples can be produced, the total tonnage has apparently not warranted a definite general market for packed fruit.

San Bernardino County. Apple acreage in San Bernardino County, which in 1925 was 6,000 acres, is now only a little over 750 acres. Winter temperatures in the Yucaipa district on the mesa lands east of Redlands at elevations of 2,000 to 3,000 feet proved to be too mild for an adequate dormant period of the trees. Largely because of this, apple growing in the county is now confined almost entirely to areas at an elevation of 4,000 to 5,000 feet. Plantings center about Oak Glen, Wrightwood and in the Crestline-Arrowhead area. Except for the possibility of late spring frosts these areas are well adapted for the apple. The main varieties grown are Rome Beauty, Winesap, Delicious, Jonathan, White Pearmain, and King David.

Napa County, adjoining Sonoma on the east, contains some 600 acres of apple orchards nearly half of which are of the Gravenstein variety produced in the Carneros district southeast of Napa.

Butte County. With the exception of a few acres near Gridley the apple acreage of Butte County is located adjacent to Paradise at elevations of 1,000 to 2,000 feet. The principal varieties in order of importance are Red Delicious, Delicious, Golden Delicious and Stayman Winesap. Some Gravenstein, King David, and York Imperial are also produced. Increased attention is being given to grading and packing and several packing houses are in operation during the harvest season. San Francisco and Los Angeles are the principal markets. During the two seasons of 1948 and 1949 some 100 acres of new orchards have been planted.

Tuolumne County. Plantings in Tuolumne County, totaling approximately 500 acres are in the Yankee Hill, Soulsbyville, Ralph Station, and Tuolumne districts in the southwestern part of the county at altitudes of 2,300 to 3,500 feet. The general topography is typical of the Sierra Nevada foothills, rolling to hilly, with many of the orchards on rather steep slopes and surrounded by timber.

The nature and depth of the soil varies with the type of rocks from which it has been derived. Soils obtained from granodiorite are light red in color, sandy loam to loam in nature, well drained, and from shallow to 6 feet in depth. Those from the slates and diabase are somewhat heavier and of a deeper red. All are rather easily cultivated, but such work is often difficult or inadvisable because of the steepness of the slope.

Irrigation water is obtained from the south fork of the Stanislaus River and nearly all orchards receive 2 or 3 irrigations annually.

Tulare County. Apple production in Tulare County is divided between that of early summer apples (mostly White Astrachan, between Visalia and Exeter and in the Cutler district) and that of the fall and winter varieties produced in the foothill areas around Kaweah and Three Rivers. The summer apples, harvested early for cooking purposes, are for the most part trucked to the Los Angeles and San Francisco markets while some of the fall varieties, good for eating out of hand, are often sold in small lots to individual consumers who come to the orchards for them.

San Diego County. Except for a few small scattered orchards in other localities, production in San Diego County is confined to the district around Julian at an altitude of 4,000 to 4,500 feet. Most standard fall and winter varieties are grown, Delicious being perhaps of most importance. With good production methods fruit of high color and fine quality is produced. Most of the crop is marketed locally in San Diego with some truck shipments to Los Angeles. Late spring frosts are sometimes a hazard in this producing area.

Other counties. In addition to the above counties, small scattered plantings,

totaling between 200 and 300 acres, are to be found in Humboldt and Shasta counties in the north and in the foothill sections of El Dorado and Mariposa counties. Climatically these sections are well adapted to apple growing and where the trees receive good care some very excellent fruit is produced. Santa Clara County, better adapted to pears than to apples, nevertheless still produces some miscellaneous varieties in the bay and mountain sections. In the south, San Luis Obispo County contains some 250 acres of apples in the area west of Templeton and south to Arroyo Grande. In Los Angeles County there are approximately 200 acres in the Antelope Valley.

4. Market outlets

Utilization of apples. California apples are marketed as fresh fruit, or are processed in a number of ways.* The relative amount utilized in each form varies somewhat from year to year depending upon market demand and the general level of prices. In recent years the quantity of apples used as fresh fruit has averaged somewhat less than half of the total marketable crop. With limited export demand for dried apples, less fruit is now dried than formerly, about 25 per cent. On the other hand there has been considerable increase in the quantity used for bakery trade, canning, sauce and baby foods, together with that crushed for juice, cider, and vinegar.

Fresh fruit. Limited amounts of early summer and other apple varieties, exempt from the maturity provisions of the Agricultural Code† are on the market in June to supply the demand for cooking apples. Mature Gravensteins follow in July and August, Yellow Bellflower in September, and Delicious, Yellow Newtown and other varieties in September or October.

As fresh fruit, both for eating and culinary purposes, Gravensteins are shipped to eastern markets supplying them with the first boxed apples of the season. The balance of the crop sold fresh and most of that of other varieties used fresh, is distributed by trucks to various local markets loose or place packed in open containers. These apples are on California markets in quantity from November to April. Considerable quantities of both Gravensteins and of Yellow Newtowns were formerly exported—primarily to England, but at present exports are very limited. A small amount of large-sized, well-colored fruit, particularly Delicious, goes into special gift packages which are widely distributed.

Methods of sale vary considerably in different districts. In the smaller districts with limited production, sales may be made at the orchard either directly to consumers or to cash buyers from local markets. Otherwise the grower delivers the apples to some local store or dealer. In either case sales are strictly local, and the apples are sold as bulk fruit with little or no sizing or grading.

Where fruit is produced in large quantities for the general markets, the average grower either sells his crop to some buyer (often a large grower in the district), who handles and ships considerable quantities of fruit or else he markets it through some sales agency, either private or cooperative. Private sales agencies may purchase the fruit outright or sell on commission. In a cooperative, the individual growers composing it receive what the fruit brings less the necessary charges for operation. As mentioned above, an occasional grower develops a special market for extra fancy fruit put up in gift packages. The volume of fruit thus sold is necessarily small, but the returns are large.

The baking trade now takes large quantities of apples which are peeled,

* For statistical data on utilization see Calif. Agr. Expt. Cir. 395—*California Apples: Situation and Outlook 1949*, B. B. Burlingame.

† Alexander, Red Astrachan, White Astrachan, Beitigheimer, Greening, Fall Pippin and White Pearmain in the Fancy and C grades and Gravenstein and Yellow Bellflower in the C grade (but not in combination) when larger than 2¾ inches in diameter and when place packed or loose.

cored, and sliced, all ready for immediate use. The fruit is treated to prevent darkening and is packed and delivered in its fresh state in 50-pound boxes—deliveries being made by truck to the adjoining states of Nevada and Arizona. In some instances the fruit is frozen either with or without the addition of sugar. The Yellow Newtown is the principal variety used for this method of processing.

Another outlet for apples which has expanded rapidly in recent years is the apple sauce and baby food industry. The Gravenstein is particularly desirable for these purposes, but by blending, most varieties may be used. The processing period is now extended over a longer season than formerly through the medium of cold storage.

Fresh apple juice (one of the newer apple products), together with cider and vinegar, utilizes considerable fruit not processed otherwise.

Yields and returns. Differences in soil, climatic conditions, varieties, age of trees, and general care given the orchards cause wide variation in apple yields.

The largest and most uniform yields are doubtless secured in the Pajaro Valley, where the majority of orchards, under good care produce average yields of 400 to 450 (7 to 8 tons) boxes per acre. From the better orchards 600 to 1,200 (11 to 22 tons) boxes may be produced. In the Gravenstein section of Sonoma County the general average yields of full-bearing orchards vary from 250 to 450 (6 to 10 tons) boxes per acre, the size of the yield depending largely upon the season. The more successful growers may secure 500 to 700 boxes (12 to 17 tons) to the acre. In both these sections, individual orchards in certain seasons may give much higher yields, but these are exceptional.

In other sections, individual orchards will doubtless compare favorably with these figures, although because of the lack of proper care the general average of an entire district will probably be lower.

During past years, prices received by California apple growers have varied widely. They have dropped violently since the war years of 1941 to 1945.

In general, apples have returned less to the growers in California than those in other states. Most of the California crop consists of green or yellow varieties which, as a rule, bring lower prices than those of a solid red color. Moreover, in most years one-half or more of the California crop is used for processing, drying, or for juice, and the prices paid for such fruit are considerably less than those paid for graded fruit sold for fresh use. Table 1 (after Burlingame) shows a comparison of prices paid for fruit utilized in different markets.

Average returns in the period 1940–1949, for Pajaro Valley apples (primarily Yellow Newtowns with some Yellow Bellflowers and Delicious) at the ranch, packing house or processing plant have been $1.77 per box or $93.92 per ton for fresh fruit; $43.72 per ton for processing fruit, according to annual reports furnished by the Santa Cruz County Agricultural Commissioner.

During the same period, approximate average returns to growers in the Sebastopol Apple Growers Union were: Gravensteins $1.78 a box; Delicious $1.86; Jonathans $1.99. Averages for the decade are somewhat higher than in previous years because of the relatively high prices during and subsequent to the war years.

5. Costs and income

By Burt B. Burlingame

Production costs vary greatly between individual growers, due mainly to management practices. The apple enterprise management studies conducted in Sonoma and Santa Cruz counties by the Agricultural Extension Service showed that some growers have production costs double those of others. Yield per acre was found to be the most imporant factor affecting costs per box or per ton.

Tables 2 and 3 on pages 10 and 11 were prepared from data obtained in the above studies and a supplemental survey conducted in 1948. These tables are intended to show approximate costs of production for some of the more efficient growers of Gravensteins in Sonoma County, and Yellow Newtowns in Santa Cruz County, under 1947–48 conditions. They are presented here for use by individual growers as a basis of comparison in analyzing their own costs, and to help those not familiar with the costs involved on good apple orchards. These tables should not be construed as representing industry average costs of production in the two counties.

Labor requirements will usually vary from year to year, depending on such factors as weather conditions and size of the crop. The hours of labor for cultural practices shown in the tables should therefore be considered an average over a period of years. Footnotes indicate the hourly rates used in computing costs—these can be adjusted to fit individual circumstances and changing conditions.

General expense, under cash overhead costs, covers miscellaneous expenses not listed elsewhere in the tables, but does not include interest on operating capital, use of the family car in connection with the enterprise, telephone, or other office expenses.

Interest on investment is based on one-half of the original cost of the trees and facilities—this is assumed to be the average value of such items over the entire length of their lives. Both tree and land value figures used are considerably below replacement costs today, and are therefore not intended to represent the amount of capital required to go into the apple-growing business under current conditions.

It should be noted that the total cost per ton figures in the tables are averages for the combined yield of fruit picked off the trees and "windfall" fruit—that which falls from the trees and is salvaged, and which does not bring top prices. Gravensteins have a much larger percentage of windfalls which are harvested at less cost than the tree-picked. After adjusting for this difference, the cost of producing the tree-picked apples would figure approximately the same for both varieties. The net cost of producing apples sold for fresh use may be calculated by deducting from the total cost per acre the income from culls and windfalls and dividing this figure by the tonnage sold fresh.

In the 1947 crop year, windfalls and culls brought little more than enough to pay harvesting costs. On this basis, the net cost of producing Gravensteins for fresh sales (using the data in table 1) would figure approximately $60 per ton, or $1.38 per 46-pound box. The net costs for Newtowns sold fresh (using figures in table 2) would figure approximately $42 per ton, or 76¢ per 36-pound box. (The weights of boxes used in the above calculations are sizes common to fresh sales of the varieties mentioned.)

No allowance for orchard management cost has been made in the tables. Marketing costs, such as grading, packing, box, storage, transportation, and brokerage are excluded from this analysis.

TABLE 1

Prices Paid for Apples Utilized in Different Markets

Years	Sold for fresh use	For drying	For juice	Average all fruit
	(Dollars per ton)			
1936–1941	$21.98	$ 8.40	$ 6.35	$15.88
1942–1947	$83.05	$42.04	$19.31	$62.00

TABLE 2

A Standard of Costs for Production of Nonirrigated Yellow Newtown Apples in a Mature Orchard in Santa Cruz County, California, with an Average Yield of 15.3 Tons per Acre*

Operations	Labor costs				
	Man labor per acre	Tractor work per acre	Truck work per acre	Cost per acre	Cost per ton
	hours	hours	hours	dollars	dollars
Pruning and brush disposal	74.0	2.0	....	76.40	
Fertilizing and covercropping	2.0	1.0	1.0	4.70	
Dormant spray	9.0	3.0	....	12.60	
Other sprays	36.0	12.0	....	50.40	
Cultivation	3.0	3.0	....	6.60	
Thinning	75.0	....	....	75.00	
Propping and bracing	6.0	2.0	....	8.40	
Miscellaneous	6.0	1.0	1.0	8.70	
Subtotal for preharvest operations	211.0	24.0	2.0	242.80	15.87
Picking 760 boxes from trees (at 12 cents)	xxxx	....	....	91.20	6.43
Picking 90 boxes windfalls (at 8 cents)	xxxx	....	....	7.20	
Hauling	21.0	....	14.0	42.00	2.75
Miscellaneous harvesting	4.0	1.0	1.0	6.70	.43
Subtotal for harvesting	xxxx	1.0	15.0	147.10	9.61
Total labor costs	xxxx	25.0	17.0	389.90	25.48

Material costs

	dollars	dollars
Fertilizer and covercrop	12.00	
Dormant spray-oil, dinitro, and fuel for rig	10.00	
Other sprays— for codling moth, aphis, spider, scab, and mildew	34.00	
Miscellaneous material	4.00	
Total material costs	60.00	3.92

Cash overhead costs

	dollars	dollars
General expense, 5 per cent of total labor and material costs	22.50	
County taxes	10.00	
Equipment repairs, excluding tractor and truck	5.00	
Insurance, compensation, and fire	6.50	
Other cash overhead	3.00	
Total cash overhead costs	47.00	3.07

Depreciation costs

	dollars	dollars
Depreciation on trees	12.50	
Depreciation on buildings and improvements	1.88	
Depreciation on equipment—tillage, spray, props, harvest, misc.	16.90	
Total depreciation costs	31.28	2.05

* These data are based upon a minimum family-sized orchard unit of 20 acres with an average yield of 850 36-pound field boxes or 15.3 tons per acre. Labor costs are computed with a wage rate of $1.00 per hour, and a total operating cost per hour of $1.20 for tractor, and $1.50 for truck.

TABLE 2 (continued)

Interest costs at 5 per cent	Cost per acre	Cost per ton
	dollars	dollars
Interest on average value of trees: ½ of $500 = $250	12.50	
Interest on average value of buildings and improvements: ½ of $75 = $37.50	1.88	
Interest on average value of equipment: ½ of $194 = $97	4.85	
Interest on normal land value: $500	25.00	
Total interest costs	44.23	2.89
Total all costs	572.41	37.41

TABLE 3

A Standard of Costs for Production of Gravenstein Apples in a Mature Orchard in Sonoma County, California, with an Average Yield of 11 Tons per Acre*

Operations	Labor costs				
	Man labor per acre	Tractor work per acre	Truck work per acre	Cost per acre	Cost per ton
	hours	hours	hours	dollars	dollars
Pruning and brush disposal	47.0	1.5	....	48.80	
Fertilizing and covercropping	3.0	1.0	2.0	7.20	
Dormant spray	4.5	1.5	....	6.30	
Other sprays and dusts	15.0	6.0	....	22.20	
Cultivation	3.0	3.0	....	6.60	
Thinning	40.0	....	....	40.00	
Propping and bracing	5.0	....	2.0	8.00	
Miscellaneous	4.0	1.0	1.0	6.70	
Subtotal for preharvest operations	121.5	14.0	5.0	145.80	13.26
Picking 290 field boxes from trees (at 18 cents)	xxxx	....	....	52.20	6.56
Picking 5 tons windfalls at $4.00	xxxx	....	....	20.00	
Hauling	18.0	6.0	6.0	34.20	3.11
Miscellaneous harvesting	4.0	....	1.0	5.50	.50
Subtotal for harvesting	xxxx	6.0	7.0	111.90	10.17
Total labor costs	xxxx	20.0	12.0	257.70	23.43

* These data are based upon a minimum family-sized orchard unit of 25 acres with an average yield of 11 tons, or approximately 530 field lug boxes per acre. Labor costs are computed with a wage rate of $1.00 per hour for man labor, and a total operating cost per hour of $1.20 for tractor, and $1.50 for truck.

TABLE 3 (continued)

Material costs		
	dollars	dollars
Fertilizer and covercrop	16.00	
Dormant spray-oil, dinitro, and fuel for rig	7.00	
Other sprays and dusts—lime-sulfur, DDT, sulfur, etc.	14.50	
Miscellaneous material	4.00	
Total material costs	41.50	3.77
Cash overhead costs		
	dollars	dollars
General expense, 5 per cent of total labor and material costs	14.96	
County taxes	10.00	
Equipment repairs, excluding tractor and truck	5.00	
Insurance, compensation, and fire	3.50	
Other cash overhead, bees, etc.	3.00	
Total cash overhead costs	36.46	3.31
Depreciation costs		
	dollars	dollars
Depreciation on trees	12.50	
Depreciation on buildings and improvements	1 50	
Depreciation on equipment—tillage, spray, props, harvest, misc.	12.70	
Total depreciation costs	26.70	2.43
Interest costs at 5 per cent		
	Cost per acre	Cost per ton
	dollars	dollars
Interest on average value of trees: ½ of $500 = $250	12.50	
Interest on average value of buildings and improvements: ½ of $60 = $30	1.50	
Interest on average value of equipment: ½ of $136 = $68	3.40	
Interest on normal land value: $250	12.50	
Total interest costs	29.90	2.72
Total all costs	392.26	35.66

Coöperative Extension work in Agriculture and Home Economics, College of Agriculture, University of California, and United States Department of Agriculture coöperating.
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J. Earl Coke, Director, California Agricultural Extension Service.

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APPLE GROWING IN CALIFORNIA

FRANK W. ALLEN

CIRCULAR 178 SEPTEMBER 1951
CALIFORNIA AGRICULTURAL EXTENSION SERVICE
COLLEGE OF AGRICULTURE • UNIVERSITY OF CALIFORNIA

Section II. Apple varieties

The choice of varieties suitable for the location, and those having good market demand, is important

In a commercial orchard, choice of the variety or varieties grown may contribute in large measure to the financial success or failure of the enterprise. Thus the following are:

1. Factors to be considered

Adaptability to the section in which it is to be grown, is a prime requisite in the choice of any given variety. In most districts of commercial importance, there are usually a number of varieties that have been proved by trial to be adapted to the conditions found there. However, since there may be an oversupply of these varieties already growing in such sections, it does not necessarily follow that additional plantings would be profitable. Other conditions might also make the planting of different varieties more desirable.

The Sebastopol district, for example, already produces too many Gravensteins; acreage is decreasing and new plantings are primarily of Delicious, Rome Beauty, and Jonathan.

In the Pajaro Valley, the Yellow Bellflower continues to be in disfavor because of its low market returns. Acreage is decreasing and new plantings are largely of Red Delicious. In the Watsonville area, the Yellow Newtown remains a good variety although the fruit usually lacks the finish of that grown in other districts, and much of it is susceptible to a browning of the flesh when put in storage.

As a rule, at low altitudes in the valleys, where high summer temperatures prevail, only fast growing, early maturing apples are suggested. Late varieties grown in such sections are subject to having their growth checked during the middle of the summer, so that early dropping, small size, and poor texture generally result.

Where strong winds during the late summer often blow a considerable part of the crop from the trees, an effort should be made to secure early maturing varieties, and to avoid those that have a natural tendency to drop. See part 2 of this section for descriptions of varieties.

Growth characteristics. Apple trees do best where winter temperatures are sufficiently low, or of enough duration, to break the winter rest period. In sections of warm winters, varieties having relatively low chilling requirements are likely to do better. Among such varieties are White Pearmain, Winter Banana, and Beverly Hills.

Regularity of crop should also be considered. Weaker growing varieties such as Grimes Golden, or Wagener; those particularly susceptible to prevalent diseases; and those of irregular bearing

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habits such as Spitzenberg and Northern Spy should probably be avoided. While quantity may sometimes be sacrificed for quality, this policy is seldom practical in a commercial orchard.

Good storage qualities are desired in late varieties. With summer varieties, the time of ripening is important.

Pollination experiments have shown that most varieties of apples grown under California conditions are either unfruitful or unable to set satisfactory crops when self-pollinated. Provisions for cross-pollination are usually needed. While it has been shown that solid plantings of Early Harvest, Yellow Transparent, Grimes Golden, Oldenberg, Wagener, Wealthy, and Yellow Newtown will usually set commercial crops, cross-pollination has generally resulted in larger yields from these varieties.

Ben Davis, Gano, Jonathan, Spitzenberg, Rome Beauty, Tompkins King, and York Imperial may be self-fruitful in some years. Golden Delicious is reported to be largely self-fruitful in the Sebastopol and Watsonville areas.

Gravenstein, Yellow Bellflower, Delicious, Red Delicious, McIntosh, Winesap, Stayman Winesap, White Pearmain, and Winter Banana are usually self-unfruitful and should be interplanted with some other variety.

Choice of pollinizers. Except for several cases of unfruitfulness between varieties that are seldom grown in California, the grower need consider only the season of blossoming and the relative amount of pollen produced, in order to choose varieties that will cross-pollinate.

Early summer varieties usually bloom somewhat earlier than fall or winter varieties, and Rome Beauty blooms later than most sorts. With these possible exceptions then, the blooming periods of most varieties are in midseason, and overlap sufficiently for cross-pollination purposes.

Abundant pollen is usually produced by Delicious. This variety, Yellow Newtown, Golden Delicious, and Jonathan are used for pollinating Gravenstein.

In the Pajaro Valley, Yellow Newtown is probably the chief source of pollen for Delicious. Golden Delicious and Jonathan are also suitable pollenizers for Delicious.

Winesap, Stayman Winesap, and Gravenstein produce sterile pollen and therefore are of no value as pollinizers for other varieties.

Market demand is, of course, a primary factor to be considered in the choice of a variety for commercial plantings.

Commercial plantings should be confined to varieties of recognized importance for which there is a good demand. Under certain circumstances a limited quantity of some variety ready for marketing at just the right time—or which may fill some special local demand—may prove more profitable than even some better variety which may already be in overproduction. Limited plantings of such a variety as White Astrachan, for instance (a variety of very mediocre quality), may fill a special early demand on a local market and prove more profitable than either the Gravenstein, so largely grown in the Sebastopol area, or the Yellow Bellflower, grown in the Pajaro Valley.

In the latter district even the Yellow Newtown, long popular as the leading fall and winter apple of California, is rarely being replanted. With all of its market possibilities for use as fresh fruit, processing, or drying, the supply seems adequate.

Because of its attractiveness, its characteristically tender flesh, and mild, pleasing flavor, the Delicious quickly gained popularity for eating out of hand. At present a large proportion of any new plantings are of the red strains of Delicious, such as Richared and Starking. Already, however, some buyers have turned away from the Delicious either because they have found the flesh tough and insipid (because of premature pick-

ing), or else mealy, dry and tasteless as a result of being overripe. Both of these undesirable characteristics may be avoided by allowing the fruit to attain good maturity on the tree before harvesting, and by storing immediately at 30–31° F.

Although well-colored red apples are usually more attractive on the market than yellow ones, Golden Delicious is another high quality dessert apple which is gaining popularity. Like Delicious it should be well-matured, of yellow color, and of good flavor before being harvested.

Numerous varieties are acceptable for general culinary use but for baking as whole fruit the large size, smooth shape, and good cooking quality of the Rome Beauty make it the leading variety.

Since drying and processing have been considered as secondary market outlets, little if any attention has been given toward the production of apples exclusively for these purposes. Yellow Newtowns and Gravensteins, however, are desired for both purposes.

2. Description of varieties

The following descriptions include the most important commercial varieties of the state and several considered valuable for home use. They are listed in their approximate order of ripening, although there will be considerable variation in this respect, according to the section. The season given after each variety represents the period of greatest use.

Yellow Transparent. An important early variety in the eastern states; little grown in California. Fruit of good size, roundish conic, attractive greenish to whitish yellow; skin thin; flesh white, moderately fine-grained, tender, sprightly subacid; excellent for cooking purposes. ***Defects:*** fruit easily bruised; tree subject to blight, though moderately vigorous. Suggested for trial as an early yellow apple under valley conditions. ***Season,*** June 15 to July 15. (Photo page 5.)

Red Astrachan. The variety is widely known and is recommended for early home use and for local markets. Fruit is of medium size, rather irregularly shaped, usually roundish to slightly flattened; skin thin and tender, greenish yellow to striped or deep red, covered with a pale, bluish bloom. Flesh white, juicy, crisp, of good quality for both dessert and cooking. Tree hardy, vigorous, an early and regular bearer. ***Principal defects:*** fruit not uniform in size, often small, inclined to drop, not a good shipper. ***Season,*** July. (Photo page 6.)

White Astrachan. Well adapted to most parts of the state and grown to some extent commercially as a summer variety in the Sacramento and San Joaquin valleys. Fruit large to very large, almost round, flattened at each end; skin greenish white, with faint streaks of red, and covered with white bloom. Flesh white, juicy, crisp, somewhat coarse and acid; primarily a cooking variety. Tree large, vigorous, productive. One of the best early varieties for local market. Fruit too easily bruised to be shipped long distances. ***Season,*** July and August. (Photo page 5.)

Gravenstein. The most popular and most extensively grown summer apple in California. About 1,500 carloads annually (the best of the crop) are packed and shipped to eastern fruit markets as early boxed eating apples. Fruit medium to large, slightly flattened, broad at the stem end, a little one-sided or angular. Stem short, deeply set in the cavity. Skin greenish yellow to orange-yellow overlaid with broken stripes of light and dark red. Flesh tender, crisp, highly aromatic. Of very good to best quality both as a summer dessert and as a cooking apple.

This is a good variety for both commercial and home use. Trees usually large and vigorous, coming into bearing rather early and producing good crops. ***Chief defects:*** tendency to drop badly; high percentage of windfalls; susceptibility to bitter pit; necessity of several pickings because of irregular size and coloring;

difficulty of removing one specimen from a cluster without the others dropping. (Photo page 8.)

Season in Sonoma County, July and August. Some interest is now being manifested in the red bud sports of this variety, which are of practically solid red color. One of these has been named Banks.

McIntosh. Very popular in New York state. Excellent for home use and well adapted to local markets. ***Not recommended*** for commercial planting because of tender flesh, susceptibility to apple scab, tendency to drop prematurely. Fruit medium and uniform in size, roundish to roundish oblate; regular or faintly ribbed. Skin thin, smooth, tender, readily separated from the flesh. Color bright red, striped with carmine to dark purplish red with stripes obscure, overspread with thin lilac bloom. Flesh very tender, usually snow white, fine-grained, crisp, tender, very aromatic. Flavor mild subacid to sweet. Quality very good to best. ***Season,*** September and October. (Photo page 7.)

Yellow Bellflower. One of the oldest and best-known early fall market varieties grown in the state. Because of continued low prices, however, it is no longer commercially popular and acreage in the Pajaro Valley is declining. Fruit large, oblong, ribbed, and tapering toward the blossom end. Skin lemon-colored to yellow, marked with prominent dots and with a pink blush on the exposed cheek. Flesh nearly white, tender, juicy, and crisp, with subacid flavor. Quality not high, but a good fall variety for general use. Tree a strong grower and good producer. Fruit variable in size and quality, requiring careful handling. Prices usually lower than for later varieties. ***Season,*** September to November. (Photo page 7.)

Wagener. Relatively unimportant in the state, but often found in Mendocino, Humboldt, Napa, and Sonoma counties. Under favorable conditions, an excellent fall and early winter variety, but not one of good keeping or shipping quality. Trees small, upright in habit of growth, coming into bearing early. Only moderately vigorous, but usually productive of good crops. Fruit of medium size, characterized primarily by its flat or oblate shape and by broad ribbing from stem to blossom end. Skin bright pinkish red, striped with darker red and often streaked with a thin, whitish covering. Flesh whitish, moderately firm, fine-grained, tender, crisp, and juicy. Flavor sprightly subacid. Quality very good to excellent. ***Season,*** October to December.

Jonathan. A seedling of the Spitzenberg and in numerous respects not dissimilar. It is usually successful where fall and winter apples are grown. Similar to Spitzenberg in shape and color but without the conspicuous dots on the skin. Flesh light yellow, tender, juicy, sprightly subacid, of excellent quality for all purposes. A good storage variety for a fall apple. Tree vigorous under good conditions, early-bearing, a good producer. ***Season,*** September to January. (Photo page 6).

Where Jonathan fails to attain a solid red color, planting of the red strains is suggested. One of these listed by nurserymen is given the trade name of Blackjon.

Tompkins King. Grown to some extent in mountain sections, popular in Humboldt and Mendocino counties. Fruit large, round or globular, angular or ribbed, yellowish, shaded with red and striped and splashed with bright carmine; dots numerous and conspicuous. Flesh yellowish, moderately coarse, rich, juicy, tender. Mild subacid flavor; very

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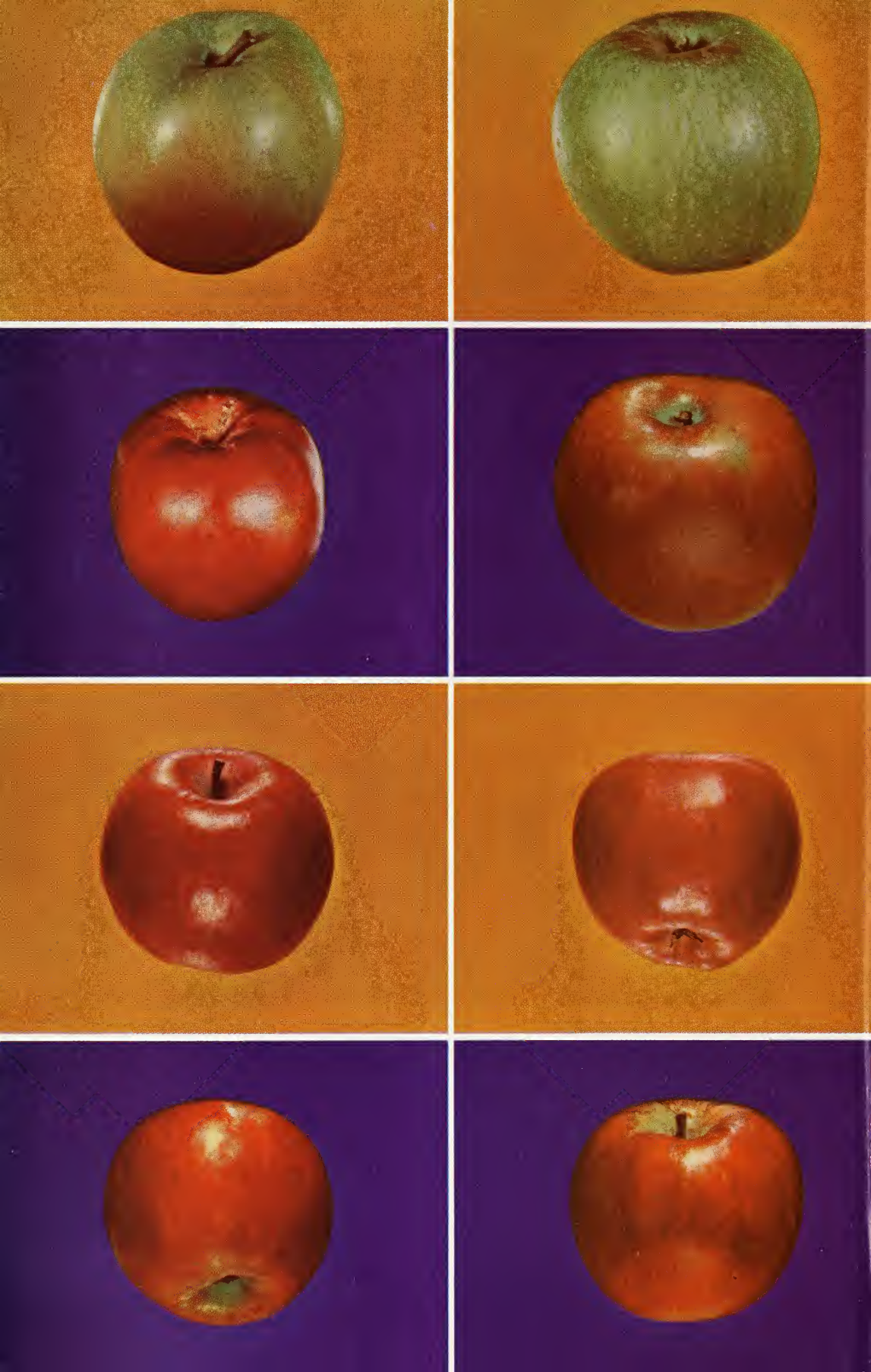
ON THE NEXT FOUR PAGES will be found natural color photos of many of the important apple varieties grown commercially in California. Descriptions of all varieties shown, plus a few that are not shown begin on page 3 of this section.

Winter Banana

White Astrachan

Delicious

Yellow Transparent



(Left to Right)

White Pearmain

Yellow Newtown

McIntosh

Red Astrachan

Stayman Winesap

Rhode Island Greening

Winesap (stem end)

Winesap (blossom end)

Spitzenberg

Jonathan (blossom end)

Jonathan (stem end)

Bellflower

Gravenstein

Rome Beauty

Tompkins King

Golden Delicious

good quality. ***Season,*** September to October.

Grimes. Better known as Grimes Golden. Highly esteemed as both a dessert and a culinary apple but grown to only a limited extent. ***Defects:*** necessity for careful handling; tendency of trees to make a weak growth and produce light crops. Excellent for home use wherever produced successfully. Fruit clear, rich yellow; medium to large; roundish oblong; often flattened or truncated at the ends. Basin or depression at blossom end abrupt, deep, moderately wide. Skin tough, covered with light russet dots. Flesh yellow, firm, tender, crisp. Flavor mildly subacid, rich, aromatic. Quality excellent. ***Season,*** fall and early winter.

Winter Banana. If well grown, one of the most beautiful varieties. Fruit large, shapely, pale waxed yellow, with a decided pink or sometimes red cheek. Usually characterized by a distinct suture line on one side extending from the basin to the cavity. Flesh pale yellow, crisp, tender, mildly subacid, of a distinct musky fragrance. Quality very good. Very easily bruised; not well suited for commercial handling. Grown in both foothill and coastal sections. ***Season,*** October to November. (Photo page 5.)

Delicious. As a dessert apple, widely and favorably known. Found in most apple sections; planting of Delicious and its red sports gradually being extended. Fruit very characteristic in shape, usually decidedly tapering, somewhat irregular, with five very prominent knoblike protrusions at the blossom end. Dull, dark red color, if well grown. Flesh white, fine grained, very mildly acid, aromatic, of delightful flavor and excellent dessert quality. A general favorite on the fruit stands; always sold at a premium. Tree one of the strongest and most vigorous growers, aphid-resistant, blooms late, and is a good pollinizer. ***Defects:*** poor flavor unless well colored; does not cook well; tendency to drop and under ordinary temperatures to become mealy. ***Season,*** October to January.

Because of the lack of color, wide interest is now being shown in the red bud sports of this variety. These may be offered by nurserymen simply as Red Delicious or under such trade names as Richard Delicious or Starking Delicious. The only essential difference between these sports and the original Delicious is in color. (Photo page 5.)

Golden Delicious. Discovered as a chance seedling about 1890 and introduced by Stark Bros. of Louisiana, Missouri, in 1916. An important yellow apple of high dessert quality. Of separate origin and unrelated to the original Delicious. Fruit clear yellow, with small conspicuous russet dots about the stem end. Medium to large, oblong conic, smooth to somewhat ribbed, with a deep acuminate cavity and a rather long slender stem. More uniform and regular in shape than Yellow Bellflower; longer and more conic than Grimes Golden. Flesh is greenish cream in color, firm, crisp, fine-grained, tender, juicy, aromatic, mildly subacid. Good for culinary purposes as well as eating fresh. Keeps well in storage but will quickly show shriveling of skin and flesh unless held in an atmosphere of high humidity. ***Season,*** October to February (Page 8).

Esopus Spitzenberg. Usually known simply as Spitzenberg. An almost unexcelled market variety, of high quality for dessert and cooking. Fruit of good size, uniformly shaped, varying from oblong to conic. Skin smooth, covered with rich red and marked with numerous conspicuous yellowish dots. Flesh yellowish, firm, crisp, tender, juicy, sprightly subacid. One of the most attractive varieties grown. Costly to produce, planting therefore generally on the decline. ***Defects:*** tendency toward shy and irregular bearing; susceptibility (despite general healthiness) to apple scab, aphids, and (in some sections) blight; long, polelike branches, somewhat difficult to control in pruning; planting in California therefore limited. ***Season,*** November to February. (Photo page 7.)

Rhode Island Greening. Often found among the older orchards in the coast counties. Popular for drying because of heavy yields of dried fruit, but never grown extensively in California. Fruit medium to large, roundish oblate, dark green to greenish yellow. Flesh yellow, fine grained, tender, juicy, sprightly subacid. Quality very good. ***Season,*** fall and early winter. (Photo page 7.)

Stayman Winesap. Successful in the foothills, mountain valleys, and at points of higher altitudes in the interior valleys. In many respects similar to its parent, the Winesap; unlike it in possessing less color but growing to larger size. Flesh more tender than Winesap, requiring careful handling, keeping quality poorer. Characterized as medium to large, round conic, with smooth, thick skin covered with dull red and marked with light gray and russet dots. Flesh yellow, fine-grained, very tender, crisp, juicy, pleasantly subacid. Dessert quality very good. ***Defects:*** failure to color properly in certain sections; tendency to drop when mature; necessity of careful handling; susceptibility to scald in cold storage. ***Season,*** Nov. to Dec. (Photo page 6).

Blaxtayman and Staymared, two bud sports of Stayman Winesap, have somewhat more red color.

Rome Beauty. One of the leading commercial apples of the country, with an established reputation in all markets. Not of high dessert quality, but especially attractive for baking. Good for handling and shipping. Because of its late blooming habit, recommended for higher altitudes, especially where late spring frosts make growing of other varieties precarious. Trees of only medium size but, under good conditions, vigorous and early bearing, and producing uniform crops. ***Defects:*** fruit borne especially on the ends of branches, which may whip badly in high winds; variety rather subject to attacks of aphids. Fruit uniformly large, smooth round to round conic; skin thick, smooth, yellow, shaded and striped with bright red to solid red on the exposed cheek, sprinkled with conspicuous yellow dots. Stem set in a very broad, shallow, usually green cavity. Flesh yellow, firm, crisp, mildly subacid, quality fair. ***Season,*** October to February.

Rome Beauty is another variety having one or more red bud sports, essentially the same apple as the parent except that the fruit is mostly of solid red color. (Photo page 8.)

White Pearmain. An old favorite variety of high quality, adapted primarily for home use and local trade. Rather widely adapted, but grown in California primarily in sections having coastal influences where red sorts do not color well. Trees vigorous; regular bearers. Fruit medium to large, oblong conic, pale greenish, often with a decided blush on the exposed cheek. Surface of the skin covered with numerous small brown dots. Flesh yellowish, tender, crisp, juicy, very mildly subacid, of excellent flavor, somewhat resembling Delicious. ***Season,*** October to January. (Photo page 6).

Winesap. One of the oldest and most cosmopolitan sorts, a general market favorite as a late winter variety. Grown in almost every apple section of the country. In California, adapted to most sections other than those exposed to coastal conditions and those of the hot interior valleys. Excellent in foothills and mountain sections. Trees vigorous, productive. Tendency for old trees to overbear and produce small fruit, necessitating thinning of the crop. Fruit of medium size, roundish to conical; skin tough, smooth, bright to dark red, with small scattering dots. Flesh yellow, firm, crisp, sprightly subacid. Good to very good quality for both dessert and cooking. ***Season,*** November to April. (Photo page 6.)

Gano. Probably Missouri or Tennessee. Often called Black Ben Davis; similar if not identical to Ben Davis except in color. Not largely grown in California because it is low in dessert quality. It is, however, excellent for shipping and one

of the best-keeping sorts. Trees similar to Ben Davis, growing rapidly, bearing early, regularly, and abundantly. Fruit medium to large; roundish conic; regular, symmetrical, and uniform in size and shape. Skin smooth, waxy, light yellow, but mostly overlaid with pinkish to dark-purplish red, more or less obscurely striped; prevailing color red. Dots numerous, small, inconspicuous. Flesh white to slightly yellow, firm, rather coarse, mildly subacid. ***Season,*** November to February or later.

Yellow Newtown. Origin, New York. Easily the first commercial winter variety grown in the state, over 1½ million boxes being shipped annually from the Pajaro Valley. Commercial production confined almost entirely to that section. ***Defects:*** a russeting of the skin under Pajaro Valley climatic conditions, detracting somewhat from the general appearance; susceptibility to browning around the core in storage. Trees rather slow-growing but productive and reasonably early-bearing. Excellent for late winter use and probably the most desirable California variety for drying. Fruit large, roundish to slightly flat. Skin green to yellow, often with brownish red cheeks. Flesh cream, firm, crisp, juicy, very good in quality. ***Season,*** December to May. (Photo page 6.)

Crab apples.* Of comparatively small commercial importance, but highly regarded for jelly making and preserving. Grown for home use and for a limited demand on local markets. Most important varieties: Whitney, Transcendent, Hyslop, Montreal Beauty, Large Red Siberian. Of these the first three are perhaps in greatest demand commercially. Red Siberian is reported as being successfully grown in most parts of the state.

* For detailed descriptions of crab-apple varieties see:

Beach, S. A. *Apples of New York,* Vol. 1, p. 251–69. Illustrated. New York State Dept. Agr., Albany, N.Y. 1905.

Wickson, E. J. *California Fruits.* 10th ed. p. 215. Pacific Rural Press, San Francisco, Calif. 1926.

Hedrick, U. P. *Cyclopedia of Hardy Fruits.* p. 72–76. The Macmillan Co., New York, N.Y. 1922.

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Section III. Establishing the young orchard

A proper beginning plus early care and training of young trees forms the foundation of a good orchard

1. Preparing the land

If the orchard is to be grown under irrigation the most important factor to be considered in preparing the land is to do what grading or leveling is necessary to make it conform to the irrigation system selected.

Leveling for orchards consists mostly of cutting off the high points and depositing the soil in the low spots. Care should be taken to avoid cutting too deeply and exposing infertile subsoil. Grading for a contour check system of irrigation should be done by an engineering organization, of which there are many in the various orchard sections throughout the state. (See Ext. Cir. 73, *The Contour Check Method of Orchard Irrigation*, by J. B. Brown and J. C. Marr.)

Where the land has been devoted to crops previously, little or no preparation may be required before planting trees. But when weather and other conditions permit, it is usually more convenient to put the soil in good condition prior to planting than afterward. In some instances the land may be disked in the fall and left rough to absorb the maximum amount of moisture during the winter.

In the smaller apple sections at high altitudes, much of the land is heavily timbered. Some growers have simply cut and removed the timber, dug holes and planted apple trees in among the stumps. Due to the high fertility of the soil, the trees have made good growth, but this procedure is not recommended because of the difficulty to be encountered in subsequent cultivation practices. Unless the stumps are of a wood that decays rapidly and will be out of the way in a few seasons, the most economical plan is to remove the stumps by digging or blasting and then dispose of them. Oak and redwood stumps decay very slowly.

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2. Laying out the orchard

To properly lay out an orchard requires considerable care. Mistakes difficult or impossible to correct can often be prevented by first carefully mapping the proposed orchard on paper, spacing the trees according to scale at the distances decided upon, locating roadways and possible irrigation ditches. Such a map enables one to see how many trees of a given variety are needed and how they may be spaced to the best advantage. If properly labeled and preserved, it is also a ready reference as to the location of any given tree.

Of the different systems of planting, the square is the most popular and convenient, except on very rolling land, where contour planting is recommended. The quincunx system—in reality the square method with a tree in the center of each square—is adopted where the orchard is interplanted with temporary or filler trees.

Planting the trees too close together has been a general mistake in most of the early orchards, many trees having been set 20 to 24 feet apart. These crowd badly and need severe pruning, and the fruit is difficult to harvest.

The distance of planting apple trees varies somewhat with the variety and soil conditions. The larger and more spreading varieties such as Gravenstein, Jonathan, and Winesap should be planted at somewhat greater distances than the upright-growing sorts such as the Red June and Rome Beauty. Deep loam or clay loam soils will produce larger trees than the lighter soils. The planting distance may also vary somewhat with the severity of pruning. Usual planting distances recommended for the apple on good fertile soils are 30 to 35 feet.

In laying out an orchard, thought should be given to providing cross-pollination for the trees. The varieties that will provide adequate cross-pollination are discussed in Section II.

3. Selecting nursery trees

Age and grade of nursery trees. Good commercially propagated trees may be purchased from any reliable nurseryman. The trees in greatest demand for planting are those with one-year-old tops. Because the two-year-old tree receives greater injury to its roots when being transplanted, perhaps it does not come into bearing earlier than the one-year-old. The latter also usually possesses enough good buds on the stem to form scaffold branches where desired (see page 5).

Apple trees are graded according to the diameter of their trunk measured at a point 2 inches above the bud union. The approximate height of the trees may also be given. The grades are as follows:

Diameter in inches	Height in feet
11/16 and up	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 price naturally varies with the size and grade. It is doubtful whether the smallest sizes should be purchased if one can secure those that have made a better growth. Regardless of age or size, the main stem of the tree should be reasonably stocky, the bark clean and smooth, and the top well supplied with good buds or well-spaced branches. It should also possess a good union where the bud or the scion was inserted into the stock. If this union has not grown together properly, various fungus troubles are likely to enter at this point and shorten the life of the tree, or it may break off several years after being planted in the orchard.

Trees from a nursery should be ordered well in advance so that the desired varieties may be secured.

When received the trees should be removed from the original package and, unless planted immediately, should be heeled-in in moist soil at some convenient place, preferably one not exposed to the afternoon sun. Where trees ordered from a distance arrive in a dry condition, the roots may be soaked in water for several hours before heeling-in. If the branches also appear dry, the entire tree may be put in the soil and covered for several days.

4. Planting

Where the soil has previously been well prepared the holes for the tree need not be larger or deeper than is necessary to accommodate the roots in their natural position.

Setting the tree at the proper depth and compacting the soil well around the roots are important considerations. Nursery trees usually form their roots at a depth most congenial for their development and

when set in the orchard should stand at approximately the same depth as in the nursery. This depth can generally be determined from the soil line on the trunk.

To avoid air pockets, well-pulverized soil should be placed next to the tree roots and tramped thoroughly as it is thrown in. All injured roots had best be removed before setting. To facilitate planting, the remainder may be shortened back to 6 or 8 inches. Cutting back is considered preferable to bending out of their natural position. Small, fibrous roots, usually dead before the tree is set, may likewise be removed, for they make it difficult to place the soil in firm contact with the larger roots.

As the newly transplanted tree requires some time to become established and as new root growth should precede that of the branches, trees may profitably be planted as early in the season as mature nursery stock can be secured. Where conditions are favorable in December and January, trees set at this time should have considerable advantage over those not planted until March or April. At some of the higher altitudes, however, planting must often be delayed until relatively late. Under such circumstances the trees should be held as nearly dormant as possible so that the buds may not push and utilize all the stored food before the growth of the roots.

As many of the feeding roots are cut in digging from the nursery, the top of the tree should be correspondingly reduced. At the time of planting, therefore, the main stem is usually cut back to a height desired for the scaffold branches. 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: quicklime, 5 pounds; salt, ½ pound; sulfur, ¼ pound. Add the salt and sulfur while the lime is slaking. Allow the whitewash to age several days before use, and dilute to a buttermilk consistency. A whitewash that sticks somewhat better but is more expensive is made from whiting, 6 pounds; casein spreader, 1 pound; and raw linseed oil, ⅓ pint.

Subsequent care. Young trees should get a good start and be kept growing vigorously during the first season. Weeds around the trunk should not compete with the young tree for soil moisture unless there is frequent irrigation.

Where the trees are planted on suitable soil, and where soil moisture is not the limiting factor, the addition of a fertilizer that is high in nitrogen content may be advisable. Usually ¼ to ½ pound of actual nitrogen per tree per year may be applied.

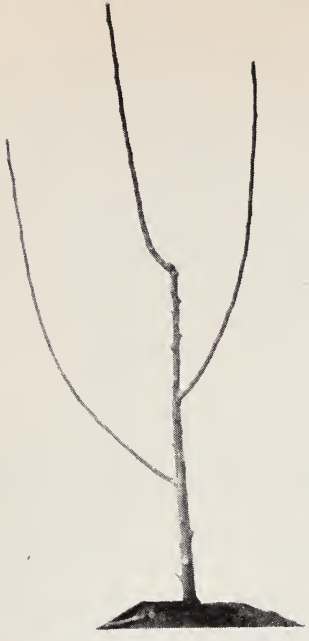
If tree protectors are used instead of whitewash against sunburn, the young trees should be inspected several times to see that these do not interfere with the formation of the scaffold branches at the desired locations. After the new growth starts, better spacing and growth of the main shoots may be obtained by selecting these in the most desirable locations and removing or pinching back the others (see page 6). In addition, the tree should be kept free from all diseases and insect pests that may interfere with its normal growth.

If tree diseases or insect pests appear, consult Sections V and VI of this circular, or see the local Farm Advisor for information on the latest pest or disease control methods to be employed.

5. Intercrops

Intercropping is a possible source of income to the orchardist during the first few years. This practice, however, after the first two or three seasons really becomes double cropping, in that soil fertility and moisture removed by the intercrop are, in some instances, needed for the best growth of the trees. As a rule, intercrops are most successful on fertile soils and on land under irrigation.

Cultivated crops are recommended for young orchards, and annual crops are considered somewhat more desirable than



A young apple tree after the first dormant pruning. Note good spacing of scaffold branches, except that lowest branch is somewhat close to the ground.

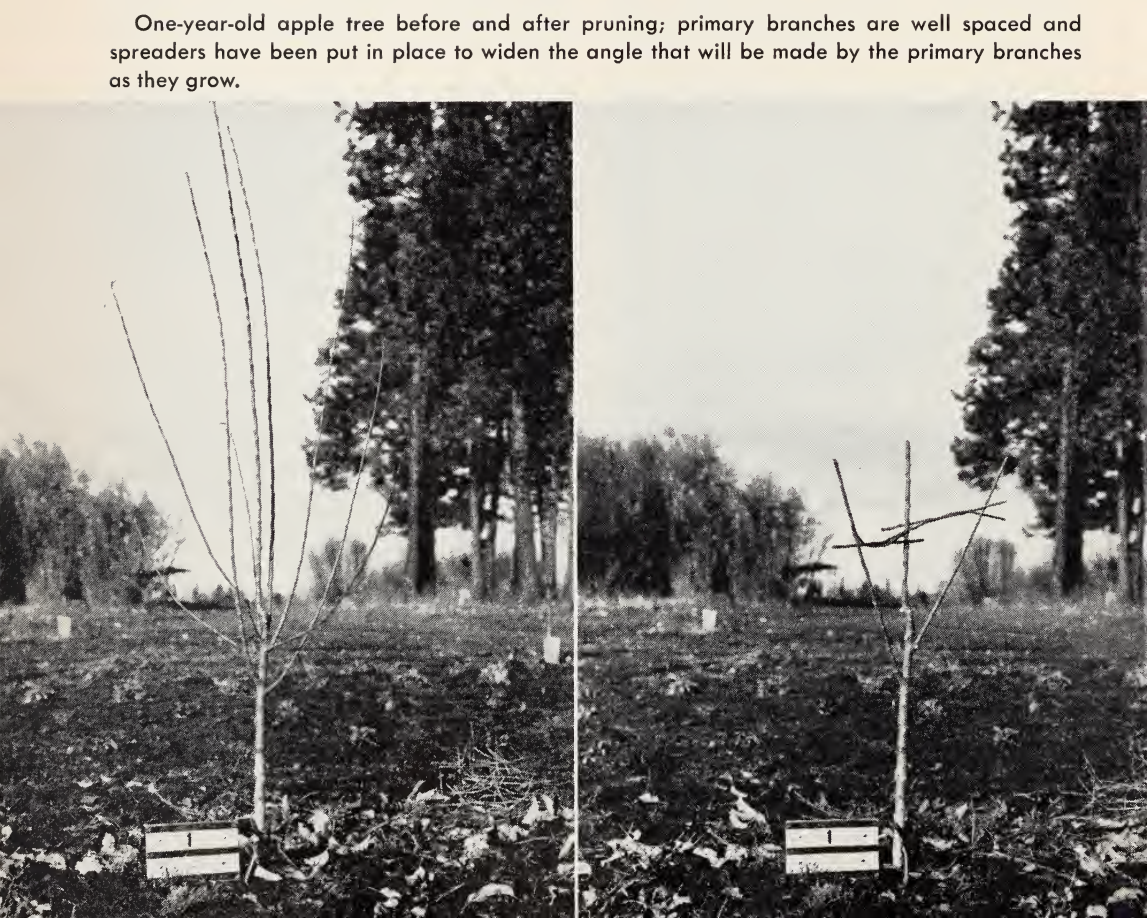
perennial. Among the most desirable, where a market is established, are beans, squash, melons, cabbage, turnips, mangels, potatoes, spinach, beets, peas, tomatoes, and rhubarb. Lettuce is a leading intercrop for young plantings in the Pajaro Valley. Strawberries are also grown. Bush fruits were previously very popular in the Sebastopol area. Since nursery stock, corn, and other grains compete with the trees more than do other crops, their growth is to be discouraged.

It should always be remembered that the apple orchard is the main crop, and when the trees need the space and/or moisture used by the intercrop, the latter should be sacrificed.

6. Pruning and training

During the first few years of a tree's life (or until it starts to bear), most efforts are devoted to giving it a good start in the orchard so that it will develop into a healthy, vigorous plant with strong crotches and an over-all shape that will aid in cultural and harvesting operations. Thus pruning during the first 2 years is aimed at selecting and encouraging certain well-placed branches for a scaffold

One-year-old apple tree before and after pruning; primary branches are well spaced and spreaders have been put in place to widen the angle that will be made by the primary branches as they grow.



on which the fruit-bearing branches will grow.

Young trees are usually trained to one of two systems: the open-center or vase-shaped tree; or the modified leader, sometimes called delayed open-center type. With the open-center system of training, three branches are preferably chosen to form the framework or scaffold. These are all pruned to maintain an equal size as nearly as possible. Any tendency of a branch to outgrow the others and assume the lead is suppressed. The advantages attributed to this system of training are that it forms an open, spreading, low-headed tree, producing highly colored fruits. The principal objection or disadvantage is that the scaffold branches tend to issue from one point, and thus produce a tree structurally weak.

The modified leader or delayed open-center tree results, as the name would indicate, from a system of training intermediate between the open-center and the central-leader type of tree grown in the eastern states. It is started by letting the topmost branch assume the lead for two to five years. Thus one obtains greater spacing of the scaffolds on the trunk, secures strong crotches, and at the same time keeps the tree relatively close to the ground.

Starting the main branches. The height of the trunk is determined when the tree is first headed at planting time. The main stem should be left high enough so that approximately 6 inches will intervene between the main scaffolds and yet the lowest branch will not be too near the ground. A height of 24 to 30 inches is recommended. As a rule, only three main branches well distributed around the trunk as well as up and down are desired. Observations show that at 5 feet from the ground five to seven secondary stems are usually all that the bearing tree can carry without crowding (see photo). If young trees are already branched when planted, the side branches suitably located may be only shortened, rather than cut off. All superfluous branches, however, should be removed.

The same tree shown on page 4, at the end of the second growing season, before and after pruning. Secondary branches on two of the primaries have been selected, and again headed back.

A three-year-old Golden Delicious tree before and after pruning, with branches thinned slightly.

First summer's pinching. Where young trees grow vigorously the first season after planting, summer pinching of the surplus shoots when 3 or 4 inches long is sometimes practiced. Such pinching, done at this time, results in more vigorous growth of the branches selected to form the main framework, in better-shaped trees, and in less cutting at the first winter pruning. Sometimes the trees should be gone over again in about six weeks to suppress any new undesirable growth that may have started after the first pinching.

First dormant pruning. At the first dormant pruning, which in California may be given any time after leaf fall and the beginning of activity in the spring, the scaffold branches should be headed back 15 to 30 inches or more from the juncture with the tree trunk. As the primary reason for this heading is to induce more branching, the limbs should be cut at the approximate height where the second branches are desired.

Where necessary, spreaders may be placed between the main branches to obtain a wider angle between the scaffolds (see photos on page 4).

To have started a modified-leader type of tree, the central and uppermost branches selected would have been headed

This close view of a bearing tree shows crowding of the main branches due to poor pruning.

Before- and after-pruning photos of the same Golden Delicious tree shown on the opposite page, but taken the following year when the tree was a four-year-old.

One-year-old tree before and after pruning. To avoid having a narrow, weak crotch, the third branch was removed and the other two were headed at different heights, forming a modified leader type of tree.

back less severely, cutting to an inside bud (see photo on page 7).

As a rule, if the growth is upright and a greater spread is desired, cut to an outside bud; if the variety naturally makes a spreading growth, head the branches back severely, cutting to an inside bud.

Where 3 primary branches originate from approximately the same height on the trunk a bad crotch can be avoided by removing one of the branches, and by unequal heading. One of the remaining branches should be cut back more severely than the other and the longer branch will then assume leadership during the next growing season.

This first dormant pruning is of great importance because it is at this time that the tree is shaped as it should grow. The severity of pruning will also have a marked effect on the age at which the tree will come into bearing.

Second summer's pruning. From the main scaffold branches chosen and headed back at the first dormant pruning, numerous shoots are likely to start. Some of these, if not suppressed, may outgrow those desired for secondary branches. The tree may also become so filled with new wood that severe thinning will be needed the following winter. It may be advantageous, therefore, to go over the trees early in the second summer when the new shoots have attained a length of 6 to 10 inches and pinch back all undesirable growth. If the desired number of well-spaced scaffold branches were secured at the last pruning, two shoots from each of these will be sufficient to leave. If even distribution was not obtained, one or more additional shoots well placed may fill a vacancy and produce a better-balanced tree.

Second dormant pruning. At the dormant season following the second full season of growth in the orchard, the secondary scaffold branches are chosen. These will consist of one or two—usually two—main branches growing out from each primary.

The secondary scaffold branches are selected, then headed back to the height at which additional branches are desired for the formation of the tree head. Other superfluous, misplaced, and interfering branches are removed. Any small branches, however, that may have developed from the primary scaffold may be left to become early fruiting wood.

Subsequent dormant prunings. After the second dormant pruning, the framework of the tree should be established and thereafter, until the tree starts to bear, pruning during the dormant seasons is largely a continuation of thinning out unnecessary branches and perhaps some small branches near the ground that hinder cultivation.

Whether or not additional heading back of framework branches is necessary will depend on the growing habits of the variety and of the individual tree. When vigorous, straight growth is made and more branching is desired; or if more branches are wanted where the limbs become too long and rangy (as in the Spitzenberg) additional heading may be needed. The illustrations on pages 6 and 7 are examples of good pruning of trees 3 and 4 years old.

Pruning of bearing trees is aimed at developing high yields—the tree shape having presumably been determined by this time. This subject is therefore taken up in detail in Section IV.

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J. Earl Coke, Director, California Agricultural Extension Service.

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APPLE GROWING IN CALIFORNIA

FRANK W. ALLEN

CIRCULAR 178 SEPTEMBER 1951
CALIFORNIA AGRICULTURAL EXTENSION SERVICE
COLLEGE OF AGRICULTURE • UNIVERSITY OF CALIFORNIA

Section IV. Management of the bearing orchard

Satisfactory yields and quality production depend on good cultural practices, such as:

1. Cultivation

As recent experiments have shown, the frequent and deep tillage of most western apple orchards is not justifiable; and the earlier idea that intensive cultivation conserves soil moisture, aids soil aeration in the root zone, and increases yields is erroneous. Cultivation has therefore become less frequent and shallower.

Some cultivation, however, does serve "to remove noxious weeds and weed competition; to facilitate subsequent operations such as irrigation, harvesting, and spraying; to incorporate covercrops and manures; to prepare the soil as a seedbed for covercrops; to facilitate the control of certain pests; and to aid in the absorption of water where tillage or other orchard operations have produced an air-impervious condition of the soil." This quotation is taken from Ext. Cir. 50, *Essentials of Irrigation and Cultivation of Orchards*, by F. J. Veihmeyer and A. H. Hendrickson, which covers these subjects more thoroughly than does this circular.

Except on steep slopes in the foothill and mountain sections where danger of soil erosion demands that the orchards remain in sod, most apple orchards of California are maintained under a system of clean cultivation or of cultivation and covercrops.

The exact time of the first spring cultivation depends upon the condition of the soil, the amount and season of rainfall or irrigation, and the amount of covercrop and weed growth present. Tillage of wet soil is never desirable. The surface should be relatively dry. Many of the heavier apple soils must be worked at just the right time; tilling either too wet or too dry results in a hard, lumpy soil, often for the remainder of the season.

In nonirrigated orchards grown under limited rainfall, weed and covercrop growth should be disked down early before it competes seriously with the trees for soil moisture. With late spring rains or in irrigated orchards this operation may be delayed somewhat longer, and a heavier covercrop growth secured.

Disking in both directions of the tree rows in the spring should be sufficient to kill the covercrop or weed growth. Shallow disking is not only less expensive than deeper plowing, but is preferable

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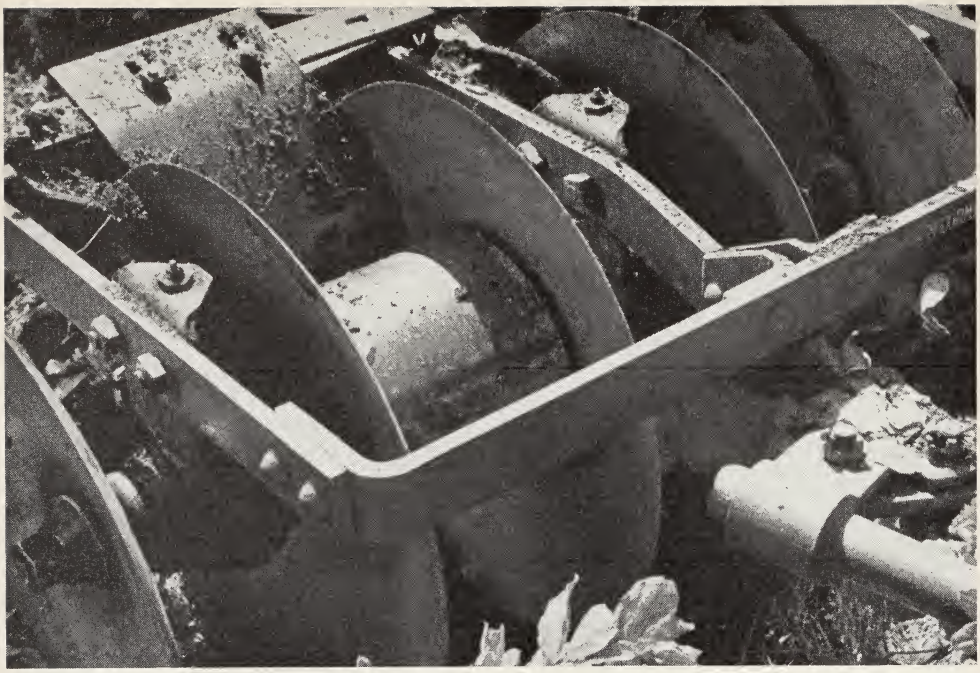

Close view of a section of an orchard disk that has been equipped with depth regulators. When the equipment is used in this way, the soil is cultivated to a depth of only 4 inches when the disks are set to cut at full depth.

(see photo). Since cultivation in the absence of weeds has no influence in conserving soil moisture, the frequency of subsequent tillage during the summer will depend largely upon the amount of weed growth and the frequency of irrigations or of late spring rains. If rains occur and the soil has become too compact to permit the construction of irrigation furrows or levees (in orchards which are irrigated) or if there is a resumption of heavy weed growth, a second cultivation may be necessary before irrigating. But as a rule this is unnecessary. Hence the second cultivation follows any irrigation given, or it may even be withheld until the irrigation levees must be broken down to facilitate harvesting, spraying, pruning, and brush removal or until time to prepare a seedbed for the covercrop.

2. Irrigation

Where bearing trees will produce 8 to 10 inches of new wood each year and a satisfactory annual crop of good-sized fruit, irrigation would seem unnecessary. If, however, wood growth is scanty and the fruit, even when properly thinned, fails to size properly and is of poor quality, lacking in crispness and flavor, irrigation should be considered. The success of many orchards will largely depend upon whether the owner can supply water during the growing season. In other instances the water is probably being applied uselessly.

A supply of available moisture throughout the growing season is the condition desired, and frequent examination with a soil auger is the most satisfactory method of determining the necessity for and the frequency of irrigation.

Sufficient water should be applied to secure thrifty but not excessive or rank wood growth. Light, sandy soils or soils underlaid with a substratum of gravel may require frequent applications, while the heavier clay loams may need only one or two. The latter is the usual prac-

tice in the irrigated orchards of the more important districts. Type of soil, topography, the amount of water available, and the cost will determine the most satisfactory way of applying water. The chief essentials, however, are even distribution and good penetration. The most common methods are the contour-check system of flooding and the furrow system, in which six to eight large furrows 6 inches or more in depth are made between each two rows of trees. (See Ext. Cir. 73, *The Contour Check Method of Orchard Irrigation*, by J. B. Brown and J. C. Marr.) Contour furrows are best adapted to foothill and mountain sections.

3. Covercropping

Covercrops, either planted or natural, are grown in most cultivated apple orchards in California. The amount of covercrop growth that can be obtained depends on the soil, water supply, and temperature during the growing season.

In Sonoma County satisfactory natural growth of covercrop plants is obtained from a fall application of manures and few seeded covercrops are grown. In the Pajaro Valley, some natural covercrops are grown, but many are seeded.

Seeded covercrops may be sown in irrigated sections in August. This will give good growth before the end of the growing season. In nonirrigated sections, particularly the Watsonville area, the practice is to sow the covercrop just before the fall rains (usually September or October) and harrow it in at harvest time.

Plants used. Either leguminous or nonleguminous crops may be planted, but where the former make satisfactory growth they may add nitrogen to the soil. Among the leading legumes are: common vetch, *Vicia sativa;* purple vetch, *V. atropurpurea;* bitter clover, *Melilotus indica;* Canada field peas, *Pisum arvense;* bur clover, *Medicago hispida;* and horse bean, *Vicia faba.*

As covercrops in apple orchards, the vetches and clovers are usually the most widely grown; vetch is recommended in the coast counties and south of the Tehachapi. Bur clover does well in most parts of the state, usually reseeding itself year after year if soil fertility is maintained. As a rule, however, it fails to produce such heavy growth as the vetches or bitter clover.

The grains, barley, rye, and oats, and the mustards are the most widely used nonleguminous covercrops. The cereal crops, often used with vetch, are most effective for controlling erosion.

Rate of seeding. Although they may vary slightly in different sections, the following rates per acre of seeding are recommended: field peas, 60–80 pounds; vetch and horse beans, 40–50 pounds; melilotus, 25 pounds, or if scarified, 15 pounds; bur clover and cereals (where planted with legumes) 20 pounds; cereals planted alone, 50–60 pounds.

Working the covercrop. Unless the covercrop is becoming excessively heavy, it should be allowed to grow as late in the spring as is consistent with maintaining good soil moisture and a sufficient nitrogen supply. With a good supply of irrigation water, the crop can both be started earlier in the fall and allowed to grow later in the spring.

In any event, when the covercrop threatens to use soil moisture needed by the trees, it should be disked in.

4. Fertilization

The addition of nitrogen to the soil has, in some instances, improved the growth of apple trees, and of the fruit; it definitely improves the growth of covercrops.

Animal manures not only add nitrogen but improve the physical condition of the soil, and have long been recommended. Their scarcity, however, limits their use.

Poultry manure, used largely in the Sebastopol area, is usually applied at the rate of 2 to 3 tons per acre, during the dormant season.

In using any manure, the material should be spread well between the rows and kept away from the areas immediately adjacent to the trees.

Commercial fertilizers containing nitrogen, such as ammonium sulfate, ammonium phosphate, calcium and sodium nitrate, also give good results.

They are usually applied at the rate of ¼ to ½ pound of actual nitrogen per tree, for young trees; from ¾ to 1½ pounds per tree for mature trees.

If only one application is used, it is best scattered over the surface of the soil, in late winter but before the last spring rains. If it is to be used to improve the covercrop too, the application may be divided, half being applied in the early fall and the remainder in late winter.

5. Thinning, bracing, and propping

Thinning. The value of fruit thinning is now well recognized and in years of heavy crop yields is one of the most important orchard operations. Removing the surplus specimens aids in increasing the size, color, quality, and uniformity of the fruit, prevents breaking of limbs, assists in maintaining the general vigor of the trees, makes spraying more effective, and decreases the labor of handling the crop at harvest time.

In general, thinning should be practiced sufficiently to produce at least moderate-sized fruit and relieve the overburdened trees. Since the food supply of the fruit is elaborated in the leaves, the size of the fruit is materially influenced by the ratio between the number of leaves (or total leaf surface) on the tree and the number of fruits. For certain important varieties, 40 to 50 leaves per fruit seems most desirable according to Magness *et al.* (1931). To determine the exact number of fruits and leaves on a full-bearing tree (60,000–100,000 leaves on a tree) is, however, obviously impracticable; hence actual thinning recommendations are still based on spacing the fruits at certain distances. A distance of 6–8 inches apart is generally satisfactory. Another method is to remove enough specimens so that when the fruits attain their full size they will be 4 to 6 inches apart on the branch. Unless the set of fruit is very uneven, clusters should be thinned to one apple each.

No definite dates can be given for thinning, because they vary with the variety, the season, and general climatic conditions. In most instances, however, a natural drop of young fruits occurs several weeks after the blossoming period. Immediately thereafter, while the apples are still small and before the seeds develop to any extent, the surplus fruits had best be removed.

Blossom thinning by the use of chemical sprays has been tried in the east and northwest. While some promising results have been obtained, and some sprays are being used in commercial orchards, it is felt that at this writing, the materials and methods used are still in the experimental stage. Any grower wishing to try the materials should consult his local Farm Advisor for the latest available information on the subject.

Bracing and propping. Well-pruned and well-thinned trees should need relatively little bracing or propping. In many instances, however, because of weak crotches, extra long horizontal limbs, and light or no thinning, considerable damage may occur. For open-centered trees or others whose main branches are structurally weak, the central wire-bracing system, with wires running from screw eyes or staples in the branches to a ring in the center of the tree, may be used to good advantage. This type of bracing is permanent except for repairing broken or tightening loose wires.

In most apple orchards, however, where smaller outside limbs are most in need of support, wooden props are used. Naturally these must be placed each season and taken down again at harvest time.

A typical Yellow Bellflower orchard in the Pajaro Valley. These trees show the results of heavy crop production. Props from the previous year still remain in place in the orchard.

6. Pruning

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

Although some varieties, such as Rome Beauty, Jonathan, and Wagener, produce much of their fruit on the tips of last year's branches and although on the Pacific Coast a number of varieties may produce fruit laterally on one-year twigs, most of the crop is produced terminally on short branches or on spurs originating from wood 2 years old or older. These spurs normally begin to form after 3 to 5 years, or when the young tree naturally tends to slacken its vegetative growth.

The primary consideration, therefore, 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 and if continued may destroy vigor. The ideal condition during the years of maturity is for the trees to make 6 to 10 inches of new growth each year, and thus increase and maintain the fruiting area while producing large but not excessive annual crops.

With most trees that have received regular pruning previously, there is little necessity for more than a light annual thinning and cutting back of the uppermost branches to laterals. This will prevent the tree from getting too high for economical spraying and picking operations.

The center of the tree should be kept fairly open. Where this has been neglected in past years, it is better to thin out surplus branches over a period of two seasons rather than upset the balance of the tree by removing too much wood in any one year.

Light crops and a large amount of vegetative growth would indicate that previous pruning had been too severe.

Such trees should receive very little dormant pruning.

In districts where mildew is prevalent, it is common practice to remove the tips of infected branches.

A more complete discussion of pruning is given in Ext. Cir. 112, *Pruning*

1. A three-year-old Golden Delicious tree before pruning. The same tree after pruning is shown in the photo below.

2. Tree shown in photo No. 1, after pruning. Summer pinching for the previous two years would have made such heavy heading unnecessary. Secondary branching of this tree is a little low, and the origin of the primary branches from a single point is undesirable.

3. A four-year-old Golden Delicious tree before pruning. The same tree after pruning is shown in photo No. 4 on page opposite.

Deciduous Fruit Trees, by Warren P. Tufts.

Pruning old trees. Old bearing trees, producing heavy crops of small-sized fruit, or those not making 6 to 8 inches of new wood growth annually, require somewhat heavier pruning than

4. Tree shown in photo No. 3 (opposite page) after pruning. In this case, only a very light thinning was needed.

5. A five-year-old Golden Delicious tree before pruning. Here again, only light thinning is needed.

6. The same tree shown in photo No. 5, after pruning. Note that light thinning has been done, and some of the branches have been tipped back to their laterals.

Examples of good pruning on bearing trees

1. A five-year-old Golden Delicious tree before pruning. The same tree after pruning is shown in photo No. 2 on this page.

2. Same tree shown in photo No. 1, after pruning. Light thinning only was required. Note the good development of fruit spurs.

3. A six-year-old Golden Delicious tree before pruning. This tree has been allowed to become too thick during previous years.

4. The same tree shown in photo No. 3, after pruning. Note that only part of the thinning is accomplished. Trees this thick should have their thinning spread over several years. One large center branch and some small ones should be removed at this time.

5. The same tree shown in photos 3 and 4, the following year. Thinning has been completed.

6. This shows typical pruning of a full-bearing Gravenstein tree in the Sebastopol area.

younger trees in order to secure the desirable amount of new growth and to maintain the vigor of the fruiting spurs. Moderately heavy thinning of the smaller branches also reduces the amount of fruit thinning necessary in years of heavy production.

Treatment of pruning wounds. Whenever limbs larger than an inch or so in diameter must be removed, the 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 also employed by some growers in the Pajaro Valley. A more nearly permanent covering, bordeaux powder combined with paint, has given good results. An excellent formula is:

1 gallon paint (formula similar to Fuller's "contour" paint)

1¾ gallons boiled linseed oil

7 pounds of bordeaux powder ("one-package" bordeaux)

According to Cooley (1942), another formula that has been used successfully is:

Rosin (H or I grade), 7 parts by weight

Sardine oil, 3 parts by weight

Copper soap, 3 parts by weight

7. Topworking

Topworking in a commercial orchard is usually limited to a few trees where the existing variety is no longer desired or profitable. If such trees are sound and vigorous, branches may be readily topworked to a more desirable sort, and fruit may be obtained in less time than would be the case if the old trees were replaced by new ones.

SPRAYING

Spraying and other measures designed to control pests and diseases are taken up in detail in Sections V and VI of this circular. In these sections, the major pests and diseases are taken up individually, together with recommended control measures.

General spray programs which will aid in the control of most pests and diseases attacking apple trees may be obtained from the offices of the local Farm Advisors. These programs are made up annually, and embrace the latest approved materials and methods known. They are available free to growers.

8. Other factors to consider

The following are factors that may from time to time affect the relative quantity or quality of the crop. They are not necessarily present in all orchards, but steps should be taken to guard against them.

Preharvest drop. Dropping of apples immediately preceding and during harvest may result in considerable loss. In the case of some short-stemmed varieties such as Gravenstein and Yellow Newtown, the apples may actually push themselves from the spurs as they increase in size. For these varieties the preharvest sprays are likely to be more effective than with other sorts.

With most varieties, however, preharvest drop may be materially reduced by application of one of the numerous growth-regulating substances, or hormones, containing naphthalene acetic acid or its derivatives. These preparations are available under such trade names as Fruitone, Stop Drop, Stayfast, Parmone, Clingspray, Fruit Fix, App-L-Set, etc.

Directions for applying the sprays are given on the package containers. The sprays are usually applied a few days before harvest, or as soon as dropping is evident. The period of effectiveness usually ranges from 5 to 20 days.

Winesap variety is the only one that has responded to applications of 2,4D for stopping preharvest drop. A newer material, now available and apparently of promise, is Colorset 1004 (2-4-5 trichlorophenoxypropionic acid).

Poor pollination may result in failure of the trees to set commercial crops.

Frost protection. Since the larger apple sections of the state are at low altitudes and relatively near the coast, frost danger to the blossoms or young fruit is infrequent, and few growers are prepared to heat their orchards. At altitudes of 4,000 feet or higher, spring frosts may do considerable damage or even destroy the crop one year out of four or five. Even under these conditions, however, the returns from the crop lost would probably not justify the necessary investment in fuel, storage tanks, wagons, heaters, thermometers, and other frost protection equipment that would be of little or no use in most years.

In order that the information in our publications may be more intelligible it is sometimes necessary to use trade names of products or equipment rather than complicated descriptive or chemical identifications. In so doing it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended nor is criticism implied of similar products which are not mentioned.

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APPLE GROWING IN CALIFORNIA

FRANK W. ALLEN CIRCULAR 178 SEPTEMBER 1951

CALIFORNIA AGRICULTURAL EXTENSION SERVICE
COLLEGE OF AGRICULTURE • UNIVERSITY OF CALIFORNIA

Section V. Diseases of apple trees

Diseases may or may not be controlled by spraying. Know the disease before attempting cure

By H. Earl Thomas

The apple, like most other plants, is subject to infectious diseases caused by fungi, bacteria, and viruses; and to noninfectious disorders, usually due to unfavorable action of soil or weather. The fungous and noninfectious diseases discussed here include most of those known to be important with respect to apples, in California.

POWDERY MILDEW. The principal foliage disease of apples in California is powdery mildew, caused by the fungus *Podosphaera leucotricha*, and is particularly prevalent in the Pajaro Valley.

What to look for. A superficial white powdery fungus growth appears on leaves, shoots, and sometimes fruits, and dwarfs and distorts the leaves and shoots if they become affected early.

What to do. Since the fungus hibernates in buds, especially terminal buds, mildewed shoots should be removed at pruning time. The principal control measure consists in spraying at the pink-bud stage with 2 gallons of liquid lime-sulfur or 5 to 10 pounds of wettable sulfur to 100 gallons of water and again with the wettable sulfur at the calyx period (all petals off). If mildew has been permitted to accumulate in the orchard, two or three years may be required to bring the disease under control.

SCAB. Scab, caused by *Venturia inaequalis*, is occasionally important where rainy weather continues after growth of the tree is under way.

What to look for. Superficial velvety dark-olive to black spots are formed on fruits and leaves. The tissues beneath the scab spots are often dwarfed, resulting in misshapen fruits. Older scab spots from which the fungus has weathered away have a russeted appearance.

What to do. In most cases two spray applications at the pink-bud and calyx stages should control the disease. Orchards heavily infested may need an early application when the leaves of the flower buds are about ½ inch long. Either lime-sulfur (1–50) or bordeaux mixture 3–3–50 (3 pounds of copper sulfate, plus 3 pounds of hydrated lime in 50 gallons of water) is effective if properly timed. The latter material is more likely to russet the fruit.

ROOT ROT. In the root rot, caused by *Armillaria mellea*, trees are killed slowly and usually from the center outward in a rather definite area in the orchard. This fungus (often also called oak root fungus) spreads through the roots and crowns, producing characteristic whitish, fan-shaped mycelial mats within and just

IN THIS SECTION

H. Earl Thomas, the co-author responsible for the material in this section, is Professor of Plant Pathology and Plant Pathologist in the Experiment Station.

beneath the bark. Since the apple is less susceptible than certain other of the fruit trees, the progress of the disease may be considerably delayed (though not stopped) by removing the soil from the crowns and larger roots of slightly affected trees and leaving these exposed during the dry season. Some benefit may also result from cutting off affected roots and bark of trees in the initial stages of the disease. Wounds made in this operation should be covered with a fungicide such as mercuric bichloride (1 part in 1,000 parts of 25 per cent denatured ethyl alcohol in water).

A root rot similar in appearance but caused by a different fungus, *Rosellinia necatrix*, has been found in a number of orchards. This may sometimes be distinguished from *Armillaria* root rot by the absence of well-defined fan-shaped mats in the bark and by the presence of loose cottony wefts of fungus mycelium in the moist soil around infected roots. A laboratory test is often necessary, however, to separate these diseases with certainty. No satisfactory control is known.

CROWN GALL (hairy root or woolly knot) is caused by the organism *Agrobacterium tumefaciens*. The most destructive form originates in the nursery, often at the graft union. The apple is less affected than certain other fruit trees, and is usually not severely injured in the orchard.

What to look for. Since the best way to control crown gall is to avoid planting infected trees, nursery stock should be inspected at the time it is delivered. The disease shows up as irregular, spongy tumors on the crowns and roots, with or without an excessive development of fine, fibrous roots.

What to do. Plant only trees with vigorous roots and smooth graft unions, free from visible tumors.

Galls that appear on the crowns in the orchard may be chiseled off and the wounds covered with bordeaux paste (equal parts of copper sulfate and hydrated lime, with enough water added to form a paste). This treatment aids in preventing the entrance of other disease organisms into the tree through the old galls.

FIRE BLIGHT is caused by the organism *Phytomonas amylovora* and affects all parts of the apple tree. The bacteria overwinter in diseased bark and usually invade the tree through the blossoms. Less frequently they enter through the young shoots and cause these to wither and turn brown.

What to look for. The bacteria form cankers (dead areas in the bark) on larger branches, trunks, around the bases of blighted fruit spurs and shoots. A milky or brownish, sticky fluid often oozes from diseased parts. The disease is favored by warm, humid weather, especially at blossoming time, and by vigorous shoot growth.

What to do. When the disease is present in the orchard, the smaller affected branches should be cut off. Cankers on large branches should be cut down to the healthy wood, including a zone of live bark 2 or 3 inches wide surrounding the canker. The wound should then be treated with a good germicide such as that made by dissolving 1 part of mercuric cyanide in 500 parts of a solvent consisting of 10 per cent glycerine in water. (THIS SOLUTION IS A DEADLY POISON.)

This treatment should be applied in the spring, soon after blossoming time.

DIEBACK. Several types of injury to the root system or other parts of the tree may be followed by dying back of terminal shoots and branches. A seemingly small part of the dieback in the state is associated with little-leaf or rosette (which see), and another part is directly related to poor drainage. Some dieback, however, not clearly related to these conditions, but probably due to a boron deficiency in the soil, is sometimes found in the Sebastopol area. The buds fail to start or die soon after growth has begun, and

the shoots die from the tips downward. In severe cases the bark of larger branches and trunks breaks down, sometimes with a sour odor. Although the trunks and larger roots are usually sound in appearance, many of the fine feeding roots are dwarfed or killed outright. This type of injury is almost never found in areas amply supplied with the clay subsoil characteristic of the district. Rather it seems related to the types of subsoils containing little clay but sometimes containing cemented layers (more or less impervious to water) or sandstone bedrock near the surface.

Careful selection of orchard sites and drainage of obviously wet areas are suggested. In the Sebastopol area, repeated covercropping is apparently of value in this connection.

SAPPY BARK. A condition known as sappy bark may be caused by the fungus *Polystictus versicolor*.

What to look for. Bark is soft and spongy during wet weather, loose and papery in dry weather; and the wood beneath breaks down with a punky rot. In vigorous trees the heartwood may rot extensively, with little or no evidence in the bark until later stages. Usually the leathery, bracket-type fruiting bodies of the fungus appear eventually on dead bark or wood.

What to do. The prevention of this disease requires the continuous protection of unhealed wounds. Bordeaux paste is a good fungicide in this connection, though it involves more frequent renewal than certain other materials. Careful pruning early in the life of the trees will later obviate the necessity for large pruning wounds.

When the disease becomes established in a tree, unless the tree is exceptionally valuable, it should be removed and replaced.

LITTLE-LEAF (rosette). Although apples are highly susceptible to little-leaf, most of them in the state are grown in districts where the disease is not prevalent.

What to look for. In mild cases the shoot toward the tip produces leaves progressively smaller, paler, and closer together, giving in the end the appearance of a tuft or rosette. The tip of the shoot is often distinctly thickened. In severe cases the shoots and branches may die back or may survive with little or no terminal growth, the buds developing slowly and the leaves remaining small and narrow.

What to do. Little-leaf is caused by a deficiency of zinc in the soil. Instead of introducing the zinc into the soil, however, the most satisfactory method is to spray it directly onto the trees. Spray during the dormant season with a mixture of 25 pounds of zinc sulfate to 100 gallons of water.

In order that the information in our publications may be more intelligible it is sometimes necessary to use trade names of products or equipment rather than complicated descriptive or chemical identifications. In so doing it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended nor is criticism implied of similar products which are not mentioned.

Coöperative Extension work in Agriculture and Home Economics, College of Agriculture, University of California, and United States Department of Agriculture coöperating.
Distributed in furtherance of the Acts of Congress of May 8, and June 30, 1914.
J. Earl Coke, Director, California Agricultural Extension Service.

A SPRAY SCHEDULE, designed to give adequate control of the diseases and pests found most commonly in California apple orchards, is given on the next page For control of individual diseases or pests not mentioned in the general schedule, the measures outlined on the other pages of sections V and VI should be applied.

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Seasonal spray schedule for control of the most common insects and diseases of the apple

Note: These general recommendations apply for the 1950 season. Spray programs differ somewhat in different sections and are subject to annual changes. For the latest information consult your local Farm Advisor or agricultural commissioner.

Time of application	Pest or disease to be controlled	Spray materials to use per 100 gallons
Dormant period (Jan.–Feb.) before buds open	San Jose scale and mite eggs	5 gals. dormant oil emulsion (86% oil) or 4 gals. emulsive oil (98% oil)
	Oyster-shell scale and mealy bug	3 gals. dormant oil emulsion (83% oil) plus 4 gals. lime sulfur solution*
	Green and rosy apple aphid eggs	2 gals. dormant emulsive oil (98%) plus 1 pound dinitro-phenol or 1 quart dinitro-cresol (30%)
Delayed dormant: buds in green tip stage	Scab	2½ gals. lime sulfur solution
Cluster or pink bud stage (before petals open)	Scab and powdery mildew	2 gals. lime sulfur solution plus 5 to 10 pounds wettable sulfur
	Blister mite, scab, mildew	2 gals. lime sulfur solution plus 5 pounds wettable sulfur
All petals off	Codling moth, scab, mildew Tussock moth larvae Leaf roller larvae	1½ pounds 50% wettable DDT plus 5 pounds wettable sulfur (except in Monterey and Santa Cruz counties) plus ¾ pt. nicotine sulfate† or
	Orange tortrix (skinworm) Aphid	2 pounds 50% DDD plus 1 pound 25% wettable parathion‡
21–27 days later	Codling moth Mildew Leaf hopper	1 pound 50% wettable DDT plus 4 pounds wettable sulfur (except in Monterey and Santa Cruz counties) or
	Orange tortrix (skinworm) Woolly apple aphid	2 pounds 50% DDD plus 1 pound 25% wettable parathion
July—only on late varieties	Codling moth Mites	1 pound 50% wettable DDT plus one of the new organic miticides as recommended by manufacturer†

* Lime sulfur solution is not generally compatible with emulsive oils (98%) but is compatible with oil emulsions (83%).

† In the near coastal counties sulfur applications may injure the foliage unless the trees are preconditioned for its use—consult your Farm Advisor or agricultural commissioner.

‡ Within the past few years a number of new organic compounds have been introduced that are most promising as insecticides. Parathion is apparently very effective against mites, woolly apple aphid and other insects at very low dosages. It is a very toxic material and the precautions for handling this chemical as given on the package should be carefully followed.

APPLE GROWING IN CALIFORNIA

FRANK W. ALLEN CIRCULAR 178 SEPTEMBER 1951

CALIFORNIA AGRICULTURAL EXTENSION SERVICE
COLLEGE OF AGRICULTURE • UNIVERSITY OF CALIFORNIA

Section VI. Insect pests

Insects may ruin the apple crop.
Follow the latest spray recommendations
for controlling them

By A. D. Borden

The more important insect pests attacking apples in California are the codling moth, scale insects, spider mites, and the aphids. Other insects are of minor importance, or only of local or seasonal interest.

In the following discussion, the insects and control measures are described. While the control measures are given individually, it is often possible to combine chemicals in one spraying operation and control more than one insect at a time.

Then too, local conditions will enter into any spray schedule so it is recommended that growers contact their local Farm Advisors for the latest information on spray materials and methods to use. Such schedules are made up annually and are distributed free by the Farm Advisors in most counties where apples are grown.

THE CODLING MOTH, *Carpocapsa pomonella* (Linn), has been troublesome for years, is now relatively simple to control with DDT.

There are two definite broods of codling moth each season: the first develops from overwintering larvae and emerges as adults from March to June; the second develops from larvae that enter the maturing fruit, and emerge as moths from June to October.

IN THIS SECTION

A. D. Borden, the co-author responsible for this section, is Lecturer in Entomology and Entomologist in the Experiment Station.

What to look for. These pests are difficult to locate in the moth stage as they only fly about sunset. The damage they do to fruit can be detected in the early stages by observing the small holes in the fruit made by the newly hatched larvae. These holes will be surrounded with a mass of frass.

Control of the first brood is important, and will largely prevent the second brood attack.

On early varieties of apples, use a spray consisting of 1½ pounds of wettable DDT in 100 gallons of water—spray after all petals are off the blossoms. Follow this with a second application of 1 pound of wettable DDT per 100 gallons of water, 27 days after the first application.

For late varieties, the above applications should be made, plus 1 pound of wettable DDT in 100 gallons of water, put on in late June or early July, to get the larvae of the second brood.

If DDT is used as recommended above, there should be no problem of spray residue on the fruit. However, spraying with DDT on waxy varieties, late in the season, should be avoided as it makes spray residue removal difficult.

Warning. Applications of DDT generally result in increased populations of spider mites (see page 4) and woolly

apple aphid (see below) which require additional spray chemicals for their control.

SAN JOSE SCALE, *Quadraspidiotus perniciosus* (Comstock), is the most important scale insect attacking apples in California. It frequently infests the fruit and causes it to be unmarketable. It also causes dying out of whole limbs following heavy infestations of the bark.

What to look for. The circular, cone-shaped, gray scale may readily be recognized by the characteristic red stain it leaves on the fruit and under the bark.

What to do. San Jose scale is controlled with an application of dormant oil emulsion (4 per cent actual oil) or 11 gallons of liquid lime sulfur solution per 100 gallons of spray. Apply in January or February, while trees are dormant.

Annual applications for the control of this scale are not always necessary—in many orchards spraying every other year is sufficient.

OYSTER-SHELL SCALE, *Lepidosaphes ulmi* (Linn.), rarely infests the fruit, but may cause dead branches by feeding on the bark.

What to look for. This scale resembles half an oyster shell encrusted in the bark of the tree. It is light to dark brown in color and overwinters in the egg stage with pearly white eggs encrusted under the scale.

What to do. The adult scale is controlled by dormant applications of 3 gallons of dormant oil emulsion plus 4 gallons of liquid lime sulfur per 100 gallons of spray. The small, immature scale appearing during the summer months is controlled by summer sprays of oil emulsion (light or medium grade), 2 per cent—or by some of the new organic materials.

ITALIAN PEAR SCALE, *Epidiaspis piricola* (D.G.), rarely infests the fruit, but old or heavy infestations may kill limbs or the entire tree.

What to look for. This scale is nearly circular, and dark reddish purple. It is frequently found under the moss on the trunk and main limbs of the trees.

What to do. It is important to destroy the protective covering of moss and to remove loose bark on the trunk and limbs. Spray while dormant with oil-lime sulfur, or oil-caustic soda. Wet the bark thoroughly.

GREEDY SCALE, *Aspidiotus camelliae* Sign., is common on apples in the coastal area but is usually held in check by the annual dormant spray of oil emulsions or lime sulfur. It rarely infests fruit except where there has been no efficient control.

MEALYBUGS, *Pseudococcus* spp., also infest apple trees and fruit.

What to look for. These are flattened, oval, soft-bodied insects covered with white wax. They not only secrete a honeydew which covers the foliage and fruit, but frequently cluster at the stem end of the fruit and make it unsightly.

The oval, pale yellow eggs are deposited in cottony masses. The females overwinter on the bark of the tree and then attack the fruit and foliage in the late spring.

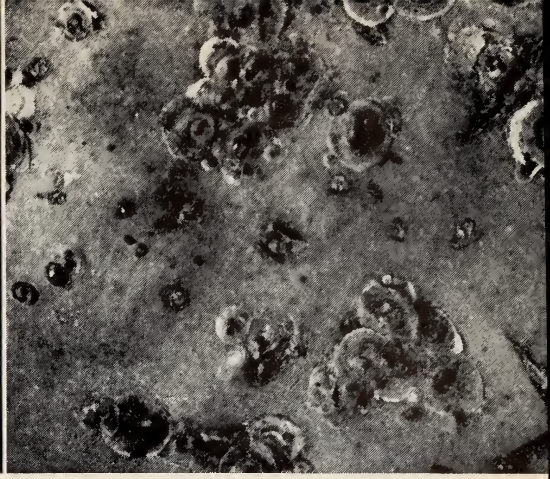
Control of the overwintering mealybugs may be obtained by spraying during the dormant season with 3 gallons of dormant oil emulsion and 4 gallons of lime sulfur per 100 gallons of spray.

To control the migrating forms in June or July, spray with foliage oil emulsion (light-medium grade)—2 gallons per 100 gallons of water, or with 1 pound of 15 per cent wettable parathion per 100 gallons of water.

APHIDS. Three species of aphids are important in California apple orchards. They are the rosy apple aphid, *Anuraphis roseus* Baker; the green apple aphid, *Aphis pomi* De Geer; and the woolly apple aphid, *Eriosoma lanigerum* (Hausmann). All attack the foliage and fruit, causing deformations and leaving fruit and foliage smutty with the honeydew they drop.

Aphids increase rapidly in population following applications of DDT, so special attention should be given to their control.

Woolly apple aphid infestation on apple twig. Photo courtesy of E. O. Essig.



A close view of San Jose scale. Photo courtesy of E. O. Essig.

What to look for. As the names imply, aphids are small insects either green, reddish, or whitish (in the case of woolly types) insects. They are usually present in groups (see photo).

Control of aphids is best obtained by a dormant spray of 2.5 gallons of dormant oil emulsion plus 1 pound of dinitro phenol (or 1 quart of 30 per cent dinitro cresol) per 100 gallons of water. This spray destroys the rosy and green apple aphid in the egg stage, and reduces the overwintering colonies of woolly aphid.

To control woolly aphids that attack the roots a different method is used. In the fall, when the soil is dry and warm, level the soil around the base of the tree. Apply from ¾ to 1 ounce of paradichlorobenzene (PDB) around the tree in a circle about 2 inches wide, with the inside of the circle 2 to 4 inches from the trunk. Cover the PDB with soil to a depth of 2 to 4 inches, and pack it down with a few pats of the shovel. The PDB crystals will give off a vapor that will penetrate the soil and kill the aphids.

FRUIT TREE LEAF ROLLER, *Archips argyrospila* (Walker), attacks the foliage and young fruit soon after the buds open in the spring.

What to look for. These insects may be identified by their characteristic method of tying leaf clusters together and feeding on immature fruit and foliage. In the winter their presence may be noted by the smooth, flat, grayish egg masses found on the bark and limbs.

Control is obtained with DDT spray. The first codling moth spray (see page 1) will also control leaf rollers.

TUSSOCK MOTH, *Hemerocampa vetusta* Bdv., is more commonly known as the horned caterpillar. It is in the caterpillar stage that it does damage to both foliage and fruit.

What to look for. This pest is brilliantly colored, clothed with tufts of black and white hair. White, felty egg masses may be found during the winter on the trunk and limbs of the trees.

Control is obtained with the DDT spray used against codling moth.

ORANGE TORTRIX (skinworm), *Argyrotaenia citrana,* is seasonally serious in the coastal areas where it feeds on the surface of the fruit and at the stem and blossom ends.

What to look for. The adults deposit flat, yellowish egg masses on the trunks, limbs, and foliage. The larvae tie clusters of leaves together with silk and feed on the fruit and foliage under the protection of this covering.

NOTE: The DDT spray recommended for codling moth, as described on page 1, will also give good control of fruit tree leaf rollers, tussock moth and leafhoppers. Substitute DDD in the spray to control orange tortrix.

What to do. The orange tortrix can be controlled by using a dosage of 2 pounds of 50 per cent wettable DDD (Rhothane) per 100 gallons. Another effective agent against this pest is a dosage of 1 pound of 25 per cent wettable parathion per 100 gallons of spray.

TENT CATERPILLARS, *Malacosoma* spp., occasionally attack apple trees in the coastal counties. Their damage to the trees may be rather severe unless they are controlled early.

What to look for. These pests may be gray, or brown, or hairy and may have white spots on their backs or pale bluish lines on their sides.

Control. The rather large nests of larvae may be pruned out or burned out with a torch. Spraying with lead arsenate or DDT will also destroy them.

WESTERN FLAT-HEADED BORER, *Chrysobothris mali* Horn, deposits eggs in sunburned or other dead areas of the trunk and the larvae later burrow into the wood, doing serious damage.

What to look for. The eggs hatch into larvae with flattened bodies, greatly enlarged at the front end. The larvae feed under the bark.

What to do. Since the borers lay their eggs only in dead or sunburned areas of the trees, control consists of preventing sunburn by the use of tree protectors, or whitewashing the trunks. The borers themselves may be dug out of the wood or the trunks may be sprayed with DDT (2 pounds to 100 gallons) in late summer.

The APPLE LEAFHOPPER, *Typhlocyba rosae* L., not only damages the foliage, but spots the fruit with excrement. It has been particularly serious in the coastal counties on Gravensteins, Yellow Newtowns, and Bellflowers.

What to look for. These pests resemble tiny grasshoppers. They are usually light yellowish green and about ⅛ inch long.

Control of leafhoppers is gained by the DDT spray applied for codling moth control.

MITES (red spiders, spider mites). Three species of mites are known to attack apples in California. These are the brown mite, *Bryobia praetiosa* Koch; the European red mite, *Paratetranychus pilosus* (C. & F.); and the two-spotted mite, *Tetranychus bimaculatus* Harvey.

These mites often build up populations large enough to cause leaf injury and defoliation, especially after DDT applications. This is thought to be caused by the killing of the mites' natural enemies which permits the mites to increase rapidly.

What to look for. Their presence may sometimes be noted by a yellowing and dropping of the leaves. They can be seen with the aid of a handglass, on the undersides of the leaves. When in great numbers the overwintering eggs may appear as a reddish mass.

Control. The brown and European mites overwinter in the egg stage and may be controlled with dormant oil sprays (4 gallons of actual oil per 100 gallons of spray). The two-spotted mites overwinter in the ground and appear in midsummer. The addition of a miticide to late cover sprays or special applications of a miticide are sometimes required.

PEAR LEAF BLISTER MITES, *Eriophyes pyri* (Pagen), attack the leaves and fruit when the buds open, having overwintered under the fruit bud scales.

What to look for. These mites are very small and can be seen only with the aid of a handglass or microscope. However, they cause green or brown lesions (injured areas) on the leaves and fruit, which may easily be recognized.

Control may be obtained by applications of liquid lime sulfur at the rate of 7 to 8 gallons per 100 gallons of water as a delayed dormant spray, and a second application of 2 gallons of liquid lime sulfur plus 4 pounds of wettable sulfur per 100 gallons applied at the cluster, or pink-bud stage.

These applications are also effective in control of apple scab.

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APPLE GROWING IN CALIFORNIA

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Section VII. Harvesting and handling

Harvesting at proper maturity and good handling methods influence eating and market quality

1. When to pick

Time of harvesting is determined by a number of factors—the variety, the season, the location of the orchard, and the purpose for which the fruit is intended.

Early apples to be marketed locally in limited quantities and solely for cooking may logically be harvested considerably in advance of their full size and color or the development of their characteristic flavor. There is a definite demand for a limited quantity of such fruit when all else is sacrificed for earliness. This demand for an inferior product is, however, soon filled; and to harvest the more important summer and fall varieties so as to fill an order by a certain date, with no regard for maturity, cannot be recommended. Premature harvesting, though undoubtedly advantageous to certain individuals, can only result in fruit of poor color and low quality. A few such shipments soon have a depressing effect upon the subsequent returns that the majority of growers are able to realize for the larger part of their crop. First shipments of California Gravensteins, the first boxed apple to arrive on the eastern markets and offered as a dessert apple, have frequently lacked their characteristic flavor and color. Bitter pit, a physiological trouble that develops much less on well-matured fruit, is also frequently so serious as to discount any advantages of extreme earliness.

Although premature harvesting sacrifices size, color, and quality, too late harvesting may mean excessive dropping and poorer keeping quality.

Considering the variety, the relative earliness or lateness of the season, and the purpose of the fruit, most commercial growers know from experience when their crop is ready. Their judgment is usually based on several considerations, among which the following are the most important:

Ease of removal. The ease with which the apple can be removed from the fruit spur. Dropping of sound apples is a natural sign of maturity, and most varieties when ready for picking can be broken from the spur easily.

Taste. Specimens should be cut and tasted. The flesh should be decidedly firm and sharply acid, but with practically no starchy taste. For best dessert quality. some indication of the characteristic flavor of the variety should be present—this is particularly true in the case of Golden Delicious.

Changes in color. With red apples, full color development is desirable. Color,

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however, may vary rather widely in different districts and in different seasons. If the weather be cloudy or foggy, the fruit may be well developed and yet show little color when ready to pick. Where weather conditions just before harvest time are ideal for coloring, the fruit will assume its natural color often considerably in advance of the proper time for picking. Particularly may this be true of the red bud sports. The red or overcolor is therefore not an accurate indication of ripeness. In varieties that are only partially colored a much more accurate index is the green or yellow undercolor of the skin. Whenever this color begins to change from a decided green to a slight yellowish green, the fruit may generally be considered in the proper condition.

This initial change from the original dark green to a lighter shade is also applicable to green varieties. With the Yellow Bellflower, color differences may readily be observed; but with the Yellow Newtown they can best be ascertained by comparison with the standard color chart used by the State Department of Agriculture.

Firmness of the flesh. Softening is an unmistakable sign of ripening. As the fruit pressure tester has shown, this softening starts before the normal time of harvest. Thus, accompanying increases in color of the fruit, there is normally a decrease in firmness. Both color and firmness can be measured rather definitely, and considered together they furnish a very good guide. Different varieties, however, vary in firmness just as in color; and firmness standards have been determined for only the more important varieties.

Soluble solids. As apples become more mature there is a gradual increase in the sugars and other soluble solids in the juice. These total solids are now quickly and easily determined by the use of a hand refractometer.

In addition to these picking indexes some growers believe that apples are ready for harvesting as soon as they attain a given size. Unless, however, size is considered with reference to other changes mentioned above, its value as a picking index is questionable.

County Agricultural Commissioners in apple-growing sections are equipped with refractometers, color guides, and pressure testers for determining the maturity of apples. They will, on appointment, test the fruit for growers.

For growers wishing to purchase their own equipment (which is very expensive) the refractometers may be purchased at optical supply houses; the pressure testers from one company only (D. Ballauf Mfg. Co., 619 H Street N.W., Washington, D.C.).

The darkening of the seed in apples is another rather unreliable criterion sometimes followed to determine proper maturity for harvesting. Although some varieties do have dark seed when ready to eat out of hand, others are sufficiently mature to harvest for shipment before the change occurs. In other instances, notably in Yellow Newtown, the seed may be dark considerably in advance of the proper time for harvest.

Days from full bloom. In considering the proper maturity for harvesting, pomologists on the U.S.D.A. have suggested using the number of days from the time the tree was in full bloom. The number of calendar days from full bloom to proper maturity have been suggested for the harvesting of the more important commercial varieties grown in some apple states, but limited work has been reported from California.

Suggestions made for harvesting the Yellow Newtown are 150 to 170 days from full bloom; for Delicious, 155 to 160 days; for Golden Delicious, 150 to 160 days.

Maturity standards. With a few exceptions, the Agricultural Code of Cali-

TABLE 4

Minimum Maturity Requirements of Color, Firmness, and Soluble Solids for Harvesting Gravenstein, Yellow Bellflower, Yellow Newtown, and Delicious Apples

Variety	Minimum color development*	Maximum pressure test†	Minimum soluble solids ‡
Gravenstein	2	17.0	10.5–11.5
Yellow Bellflower	2	17.0–18.0	10.5–11.0
Yellow Newtown	1½–2	22.0–23.0	10.5–11.0
Delicious	2	16 –18	10.5–11.0

* Figures refer to those used on State Dept. of Agr. color chart. 1—original dark green; 2—light green; 3—yellowish green.

† Figures refer to pressure in pounds necessary to force a 7/16-inch plunger point into the flesh of the peeled fruit to a like depth.

‡ Figures are in per cent, read on a hand refractometer.

fornia specifies (in part) that all apples offered for sale shall be properly matured, meaning that the apples ". . . at the time they were taken or fell from the tree, had reached that stage of development necessary to insure the proper completion of the ripening process . . ."

Just when that stage of development occurs has been approximated, at least, from studies of the major varieties made jointly by the Experiment Station (Division of Pomology), and the Bureau of Fruit and Vegetable Standardization of the California Department of Agriculture.

Using a combination of the factors outlined above, certain standards have been recommended for judging when apples are "properly matured." These standards are outlined in table 4 above, and may serve as a guide for the initial harvesting of the primary varieties grown in California.

The fruit should meet one or more of these minimum requirements. The Gravenstein variety now meets minimum legal maturity requirements on a soluble solids basis alone.

It should be borne in mind that the requirements in table 4 are *minimum* requirements. All apples should show some slight lightening of the original green ground color before harvesting—fruit that has attained only minimum color will rarely (if ever) ripen with more than fair quality.

Better size, greater yields, more red color and less bitter pit on Gravensteins, together with higher sugar content and better storage and dessert quality will be secured by allowing the fruit to attain greater maturity before picking.

Gravensteins and Yellow Bellflowers are more attractive and of much better quality when not harvested until yellowish green or light yellow.

Yellow Newtowns are best when not picked until light green to yellowish green (2 to 3) color, according to the locality in which the fruit is grown, or whether the strain is green or yellow.

Delicious is prized for its high dessert quality and in addition to having a light green color, should be at least 50 per cent streaked before picking. Red strains of Delicious, which color early, should not be harvested ahead of the common Delicious. Optimum attractiveness or quality in Golden Delicious is not obtained until the fruit is near full color, and the flesh has begun to assume something of its characteristic flavor.

Fruit harvested for processing or for drying purposes should be fully mature, but not soft.

2. How to pick

Picking should be done in such a way that the fruit remains in good condition. Each specimen 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 from the fruit and tearing the skin in the cavity. Any such break affords a source of infection for various molds and rots.

Tender varieties, such as Winter Banana and the Stayman Winesap must be picked with special care or they will show the fingermarks of the picker—often within a few hours after removal from the tree.

To remove varieties that naturally grow in clusters, such as Gravensteins, both hands must be used. When only one or two apples are removed from the cluster, those remaining are likely to drop.

Pickers should be warned against filling the boxes so full that when they are stacked the fruit will be bruised.

Unless time is of utmost importance, pickers should be paid by the day, rather than by the box. Although fewer boxes will be harvested, the fruit will generally show much less bruising and the trees will be left in much better condition for the following year's crop.

3. Handling methods and practices

Actual procedures in the handling of apples differ considerably, depending upon the topography of the orchard, the quantity of apples to be handled, and when and how they are to be sold. Small growers with orchards on hillsides may use sleds to transport their fruit to the orchard packing house, or to a loading platform, from which they are reloaded on a truck for delivery to a central packing storage house or processing plant. Other growers use low wagons or trailers on which the boxes are either loaded directly or else onto pallets. In either instance the boxes must be handled individually in the orchard. Where, however, forty to sixty boxes are loaded on a pallet and handled as a unit, material savings are made in time, labor and expense in the packing house, storage or processing plant.

Avoid delay in handling. After apples are picked, it is advisable to get them under cover without delay. As discussed in the section on storage, rapid handling and cooling is of the greatest importance where it is desired to store the fruit for any considerable period of time. Occasionally the boxes of apples are stacked under a tree where they may remain for several days. Picked apples left in the orchard ripen faster than those remaining on the tree and, in addition, uncovered fruit in the top boxes is subject to sunburn.

Avoid rough handling. Each time a box of fruit is picked up and set down, or stacked, there is likelihood of damaging some of the apples. Although apples are not as perishable as the softer fruits, if the boxes are filled too full or are not handled in a careful manner, bruising will occur. At the time, this may appear to be insignificant but a little later the effects become evident. The first "law" of apple handling, therefore, is to handle the fruit carefully. Avoid having so many apples in any box that another cannot be stacked on top of it without injury to some of the specimens. Avoid dropping the boxes, even a few inches, as they are being stacked; when sorting, grading or washing, dump boxes slowly and carefully. Even after packing, careless handling, lidding and stacking can, and often do, result in injuries detrimental to the keeping quality and sales appeal of the fruit.

In order that the information in our publications may be more intelligible it is sometimes necessary to use trade names of products or equipment rather than complicated descriptive or chemical identifications. In so doing it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended nor is criticism implied of similar products which are not mentioned.

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APPLE GROWING IN CALIFORNIA

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Section VIII. Packing, storing, processing

Success depends on market returns. Methods used in postharvest operations may determine profit or loss

Postharvest operations, done either by the grower himself, by his cooperative packing and marketing organization, by a processor or by a grower-buyer-shipper who either purchases the fruit outright or handles it for a specified charge, consist of washing, grading, packing, and storing. Whether or not California apples pass through all of these operations, and also the order in which they may occur, varies to a large degree with the time and methods of selling.

The necessity of washing will depend upon the amount, if any, of spray residue present. In any instance most apples to be sold as fresh fruit are passed through a water bath to remove dust or dirt and to increase their attractiveness. Apples which are peeled for processing may or may not be washed depending upon their condition. Particular attention, however, is given to the condition of apples utilized for baby foods.

Whether or not apples are graded, sized, wrapped and packed depends upon the market to be supplied. Apples intended for eastern markets (Gravenstein) and for export (Yellow Newtown and Gravenstein) must be individually wrapped and packed, and in order to pack them properly and to conform to state grades, sizing and grading are necessary. California markets like fruit to be of relatively uniform size and grade, but unpacked. Fruit for processing, sold loose in field boxes, is either orchard run or consists of the smaller sizes and lower grade sorted out from the better fruit.

Although early apples and a certain amount of the later varieties are sold during the harvest season, the larger part of the California apple crop is stored for varying periods of time—from a few weeks to ten months or possibly longer.

Where apples are to be sold as fresh fruit on distant markets, washing, grading and packing have usually preceded storage. When the operations are carried out in this order, any spray residue or dirt is removed from the fruit before the skin becomes oily and makes its removal more difficult, the small size and lower grade fruit is sorted out and sent immediately to a processing plant, the packed boxes are more economical of storage space and market orders can be filled on instant demand.

Since, however, such a large proportion of California apples are now processed in one form or another, and because local fresh fruit markets prefer the apples unpacked, the above order of procedure

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is usually reversed. Fruit which is not to be used as harvested most often moves directly into storage in the field picking boxes. Washing and removal of the small and defective fruits are then delayed until the apples are to be sold or processed. The advantages of this method are that fruit can be stored and cooled more quickly after harvest than if it had to be washed and sorted previously, and that all specimens when exposed for sale are clean and free from any decay.

Further, it gives the grower or owner of the apples opportunity to condition them any time during the storage period and to sell them either to the fresh fruit trade or to the processor. Against these advantages are the disadvantages that storing all sizes and grades of apples requires more storage space (paid for by the number of boxes stored); that more loss will occur because of rots spreading from infected specimens; and that washing is somewhat more difficult after fruit has been stored for several months.

1. Removing spray residue

Some of the sprays used in controlling pests in apple orchards may leave a residue on the fruit, which, if present in sufficient quantities, would be considered dangerous to the health of the consumer.

Arsenate of lead sprays are particularly dangerous from this standpoint and for many years made the question of spray residue and its removal one of major importance. With most growers now using DDT or other organic sprays in place of

This is typical of pallet loading, using a fork truck for hoisting in a storage warehouse.

lead arsenate, the problem of residue is greatly reduced, but still worth consideration.

Tolerances. The Pure Food and Drug laws allow certain minimum tolerances for spray residues, but since this entire question is (at the time of this writing) undergoing study, only provisional tolerances for a few spray materials for the 1951 season can be given here.

	Grains per pound	Parts per million
Lead (expressed as metallic lead)	.050	7.1
DDT	.049	7.0
Fluorine (expressed as elemental fluorine)	.049	7.0
Arsenic (expressed as arsenic trioxide)	.025	3.6

Data from Bureau of Chemistry, Department of Agriculture.

The method of determining just how much spray residue is present on any given lot of fruit is a laboratory process, usually performed by a state chemist.

Lead arsenate residue in quantity is detectable by sight—it leaves a whitish color on the fruit. Any fruit showing such residue should be washed (see below).

Experiments with DDT with as many as 3 or 4 applications (when the last application was made at least 30 days before harvest) have not resulted in residues in excess of 5 parts per million—well within the provisional tolerance limits for the 1951 season.

The Division of Entomology at the Riverside Experiment Station reports that when parathion was used 30 days before harvest, residue of less than 0.1 parts per million was found to be present on the fruit.

It should be kept in mind, however, that variations from the general recommended spray program—both as to time and materials—could result in such amounts of spray residue as are now or in the future may be considered deleterious to health. For the latest information on residue tolerances and for greater details of washing practices, consult the local County Agricultural Commissioner or the local Farm Advisor.

Washing recommendations. The decision as to whether or not to wash, and what washing solution to use, is best based on the spray programs used by the individual growers. Where fruit from different growers whose spray programs also differ, are run together in a general or cooperative packing house certain lots of apples may have to be washed separately from others. Occasional lots of fruit may carry excessive residues of lead arsenate or lead arsenate combined with oil. Such fruit should be washed in a 1 per cent hydrochloric acid solution (3 gallons of commercial—32 per cent—hydrochloric acid to each 100 gallons of water). From 8 to 24 pounds of salt may be added to the solution to assist in removing arsenical residues. Heating the solution to 100° F or the use of certain detergents may be necessary with heavy residue deposits or where the fruit is stored for some time previous to washing.

Where the spray program has been such that residues are of no consequence (e.g., organic sprays applied at least 30 days before harvest) washing in water, simply to remove excess dirt, may be sufficient.

Washing equipment. The type of washing equipment used will be determined largely by the quantity of fruit to be washed. When this amount does not justify better equipment, the fruit may be placed in crates and merely hand-dipped in barrels or tanks. A somewhat easier method is to dip in a partitioned trough, one-half containing the acid or cleansing solution and the other the rinse water. In each compartment is hinged a covered slat tray with handles on one end. The fruit, placed on the tray in the cleaning solution, is raised and lowered in it several times. The top is then lifted, and the tray tilted sufficiently so that the fruit

passes into the rinse portion of the trough, where the same process is repeated.

Where larger quantities of fruit are involved and yet the expense of a commercial washer is too great, growers have devised various types of homemade washers operated either by hand or by an electric motor. The simplest of these are known as flotation washers because the fruit, forced along by means of revolving paddles, floats in the solution. In other instances the fruit is carried through the washer on a series of rollers. Cloths, pieces of soft rubber, or brushes hanging in the acid compartment turn the fruit as it passes under them and act as scrubbers. An inclined conveyor dipping into the cleaning solution at the end of the tank carries the fruit over into the rinse compartment, which is equipped with a similar conveyor to lift it out into boxes or on to the sorting belt.

These machines, which vary considerably in size and details of design, are simple and relatively inexpensive. Although they lack certain advantages of the better commercial washers, they should prove entirely satisfactory under California conditions. Drawings and specifications for building one type appear in United States Department of Agriculture Bulletin 1752.

Where the amount of fruit justifies the expense, the commercial flood-type washers are best adapted for rapid cleaning. In these machines, some of which have a daily capacity of 2,000 boxes or more, the acid solution and the rinse water are pumped over or sprayed with considerable force upon the fruit as it passes between revolving brushes or is turned by a special type of conveyor. The brush type of washer has proved especially efficient with residues that are difficult to remove.

The washing operation. Where apples are being washed in quantities the concentration of the solution is gradually lowered and should be tested at least every 2 hours.

The operation of testing the strength of the acid is simple. The equipment needed is two 10-cc measuring pipettes graduated to 0.1 cc; a standard solution of sodium bicarbonate (23.0 grams to 1,000 cc of water containing 25 milligrams of methyl orange indicator); and a small bottle or cup.

To make the test, fill one pipette from the acid tank, and allow the excess to flow out until even with the mark on the upper part of the stem. Then place the measured amount (exactly 10 cc) in the bottle or cup. Fill the second pipette with the sodium bicarbonate solution; and after allowing any excess above the mark to flow out, allow the solution to flow slowly into the container holding the acid, shaking it meanwhile. At the point where the color of the acid changes from red to yellow, note the number of cubic centimeters (cc) of sodium bicarbonate used. Divide this number by 10 to obtain the per cent strength of the acid. Thus if 7.5 cc of the sodium bicarbonate was required, the strength of the acid is 0.75 per cent.

Always use the same pipette each time for the acid and for the sodium bicarbonate solutions, and rinse out the former with some of the acid solution to be tested before taking sample.

To increase the concentration to any desired point, add one quart of acid per 100 gallons for each 0.09 per cent of acid desired. To increase a 0.75 per cent solution to a 1.00 per cent solution would require a 0.25 per cent increase or approximately 3 quarts of acid.

During the washing process, dirt, decay spores, and residue are removed from the fruit; this necessitates renewing the acid daily or after 1,000 to 1,200 boxes have been put through 100 gallons of solution. In commercial washers the acid is usually drained off after each day's run, and the tank rinsed out.

After the acid wash, the fruit should be rinsed thoroughly to prevent damage from the acid solution or soluble residues. A simple test to determine whether or not

all the acid has been removed is to taste the water in the calyx basin of the apples; if sour or tart rinsing is incomplete. For most efficient rinsing a continuous supply of fresh water should be added to the rinse tank as a spray on the fruit as it leaves the tank. Where only a limited supply of water is available, so that rinse water must be used continuously, it may be kept neutral by frequently adding small quantities of lime (approximately 2 pounds to each 50 gallons of water). In that case, however, the rinse water should be renewed as often as possible.

Drying of washed fruit is not considered essential, although, to facilitate packing, most commercial washers are provided with fans or other means of removing the excess moisture.

Improper handling or lack of attention to the washing process may result in such injuries as (1) acid burning, caused by leaving the fruit in the acid for an excessive period; (2) arsenical injury, caused by soluble forms of arsenic building up in the washing vat or remaining on the fruit after washing; and (3) heat injury, caused by permitting the temperature of the washing solution to get too high. Obviously the remedy is to remove the cause.

2. Packing

Many of the apples grown in the Pajaro Valley, and also in the smaller apple districts, are sold as loose apples. Loose apples destined for fresh fruit sale on the California markets are sorted and graded but not packed. "Place-packed" apples are sorted and graded, and as the name indicates, the individual specimens are arranged compactly in layers throughout the container. Fruit for interstate or export shipment must, as a rule, be both wrapped and packed, if it is to be delivered in good condition after rail or water shipment. Unless the individual apples are placed in separate layer compartments or surrounded by some packing material, wrapping is essential for a solid pack and the prevention of bruising.

Previously, a considerable amount of packing was done in individual orchards, in temporary packing sheds or outbuildings—the grower and his family doing much of the work. This type of packing has now been largely discontinued—most growers now either sell their fruit loose, place-packed, or haul it to a central packing-house for packing by experienced helpers. Packing is a slow operation for the amateur but an expert will wrap and pack 125 to 150 boxes in a 9-hour day. Besides handling the fruit expeditiously and economically, central packing-houses turn out a standardized pack; carload quantities of fruit can be sold under a single brand or trademark; and the buyer, who purchases largely according to specifications, can be assured of uniformity.

Grading and sizing. After removing any spray residue, the first step in packing is to sort out and discard the cull fruit and to grade and size that which is to be marketed. The former work is usually done by girls or women standing or seated at endless grader belts that carry the apples. These helpers should be able to see defects quickly and, as the fruit passes before them, to classify it according to the proper grade.

The provisions of the California Agricultural Code relating to apple standards state that all apples shall conform to one of the 3 standard grades: Extra Fancy, Fancy, C Grade, or to any combination of such grades. Copies of these regulations giving the detailed requirements for each grade may be obtained from the State Department of Finance, Division of Printing, Document Section, Sacramento, California. The grades given are those revised for 1950. Only minor changes are being considered for 1951.

To be first or Extra Fancy, the fruit must not only be free from injury but as nearly perfect in size, color, and shape as is possible in commercial quantities. The percentage going into this grade, even in the best years, will therefore be small.

The requirements for Fancy grade apples are in some respects the same as for Extra Fancy. The essential difference is that there are no color requirements and that the law permits slight defects (but not appreciable damage) resulting from limb rubs, spray burn, sun scald, russeting, drought spot, hail marks, frost injury, internal browning, or various diseases and insect pests. Fancy grade apples comprise the larger percentage of those shipped and are the basis upon which most California apples are judged. Growers and packers should therefore strive, especially in unfavorable or small-crop years, to grade carefully and not "crowd" the pack by including fruit that belongs in the C Grade.

The C Grade includes apples lacking in normal color and shape or showing appreciable (but not serious) damage from the defects mentioned above. All apples of these three grades must, when well packed, be uniform in size.

Where apples are to be marketed as a combination of the above 3 grades, all specimens in the box must meet the requirements of the lowest grade; at least 25 per cent must meet the requirements of the highest grade; and at least 25 per cent must meet the requirements of the next highest grade. Where only 2 grades are combined, all specimens must meet the requirements of the lowest grade and at least 50 per cent must meet the requirements of the higher grade. The above grades of apples (or any combination of them) apply whether the fruit is place packed or loose in the container.

All specimens must be of sufficient size that they will not pass through a ring 2¼ inches in diameter. The exceptions to this are apples that are "well packed" (i.e., in compact, diagonal arrangement—usually but not necessarily wrapped), and C Grade apples loose in containers, or sold in bulk, and not in combination with another grade.

All apples must be hand picked, except C Grade fruit loose in containers, or in bulk.

Commercial apple packs may cover a range of 10 or more sizes, the size in each case being indicated by the number of apples packed in the box. Each size packed varies in its diameter measurements as much as 1/16 to 1/8 inch. In central packing houses and in others equipped with mechanical fruit sizers, the apples are automatically sized to approximately 1/8 inch variation as they drop into the various bins. The packer may further segregate the specimens in each bin into two sizes. Actual dimensions vary slightly with varieties, but average diameters for the different packs are shown in table 1.

To distinguish the different sizes is the most difficult phase of packing. For the amateur, who may have to do his sizing by hand, a measuring board of light wood or heavy cardboard in which a series of holes of different sizes are cut will prove helpful in first separating and fixing in mind the different sizes. Continued practice for a few days in picking out the various sizes will soon enable one to recognize them.

Containers. The California Agricultural Code specifies the different containers in which apples may be sold.

Wrapped apples. Where the apples are wrapped the following containers with inside measurements as given are listed as standard:

Wooden apple box—10½ inches deep; 11½ inches wide; 18 inches long.

Half wooden apple box—5¼ inches deep; 11½ inches wide; 18 inches long.

Fiberboard apple box—11⅜ inches deep; 11½ inches wide; 18 inches long.

Half fiberboard box—5 11/16 inches deep; 11½ inches wide; 18 inches long.

Wrapped apples may also be packed in containers smaller than the half box, provided such container is conspicuously marked IRREGULAR CONTAINER in letters one-half inch in height.

Unwrapped apples may be packed in the 4 standard containers listed above for wrapped apples, or in any of the

TABLE 1. Diameter Measurements and Number per Box of Commercial Sizes of Wrapped and Packed Apples

Diameter in inches	Number per box	Diameter in inches	Number per box
3 3/8	80	2 6/8	138–150
3 2/8	88	2 5/8	163–175
3 1/8	96	2 4/8	175–188
3	113–125	2 3/8	200–216
2 7/8	125–138		

standard apple lugs having measurements as follows:

A. Depth, 7½ inches; width, 13½ inches; length, 21¼ inches.

B. Depth, 7¾ inches; width, 14 inches; length, 22⅝ inches.

C. Depth, 6½ inches; width, 13½ inches; length, 20⅝ inches.

Unwrapped apples may also be put in other sized containers, and do not need to be marked as irregular, provided the container is open and the apples are not arranged compactly in layers.

Special packs, in addition to those mentioned, include those in which individual specimens, unwrapped, are placed in compartments of box fillers, or in cups molded in papier mache layer separators. There are also special gift packages of different sizes, and the newer consumer packages—transparent or net bags holding 5 to 10 pounds of fruit.

Packing arrangements. Styles of packs in California standard apple containers are usually spoken of as the "two-one" pack, the "two-two" pack, the "three-two" pack, and the "three-three" pack, which refer to the number of apples in rows across the box (see drawing). These differences in arrangement, with variations in the number of apples lengthwise in the box, and the number of layers, accommodate all the different sizes.

The two-one pack shown in the drawing, which contains only 3 layers in the box, is rarely used. It is designed to care for only the largest apples—those so large that when one is placed in each corner of the box, the space remaining between them will be approximately one-half large enough to take a third apple.

Where this space is sufficiently large to permit the three apples but not four

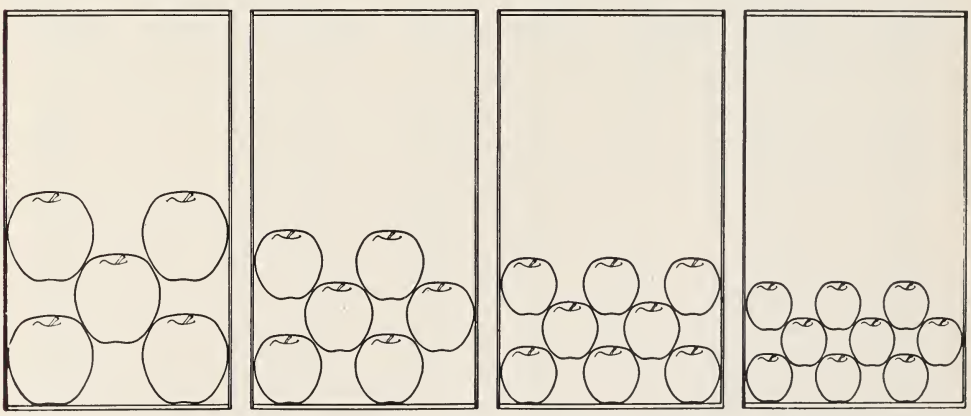

Diagram of standard apple packs. Left to right: the two-one; two-two; two-three; and three-three packs. The numbers refer to the number of apples in each row across the box.

in a straight row crosswise of the box, then the two-two arrangement should be employed. This style of pack is four layers in depth and will accommodate sizes which are from 48 to 96 to a box. The first layer of this pack is started as shown in the figures given above. The individual fruits in the second and third layer fit in the pockets formed by the apples beneath.

The three-two arrangement, five layers in depth, finds greater use than any other pack because it cares for all the medium and some of the medium to small-sized fruit—usually sizes 100 to 175. This pack should be used with apples where four in line would fill the box crosswise or where, as shown in the drawing, the fourth and fifth apples placed in the box cannot slip more than halfway into the spaces formed by the first three placed next to the end. In constructing the pack, the bottom layer is completed by repeating the same arrangement as shown. In the second layer the individual fruits are again placed so as to fit into the pockets formed by the apples beneath. The layer will be started with two apples instead of three. Layers 1, 3, and 5 and layers 2 and 4 will be identical, respectively.

For apples smaller than 175–188, or at least for those measuring less than 2¼–2⅜ inches in diameter, so that five apples would form a straight line crosswise of the box, the three-three pack is generally used. The arrangement for starting is shown. It is continued in similar fashion to the three-two pack except that three apples are used each time across the box. This pack contains six layers, the fruits being placed in the same general manner as already described.

Table 2 shows the general range of sizes and the arrangement of the more common packs.

The packing operation. As indicated in the drawing on page 7, the apples are always placed in the box on their side with the stem always pointing away from the packer. The spaces between the apples must be kept equal, and the alignment watched. Good spacing and alignment are easily obtained where the specimens are uniformly sized and are not permitted to turn sideways after being placed in the box. Where the fruit is of variable size, however, to make up a satisfactory pack is almost impossible.

Packing continues by placing the apples in the box in regular order until the first layer is completed and the fruit is held firmly in place by the pack. Proper

TABLE 2. Apple Packs

Arrangement crosswise	Number of fruits in rows lengthwise	Number of layers in depth	Number of fruits in box	Arrangement crosswise	Number of fruits in rows lengthwise	Number of layers in depth	Number of fruits in box
2–1	4 × 4	3	36	3–2	5 × 5	5	125
2–2	3 × 3	4	48	3–2	6 × 5	5	138
2–2	4 × 3	4	56	3–2	6 × 6	5	150
2–2	4 × 4	4	64	3–2	7 × 6	5	163
2–2	5 × 4	4	72	3–2	7 × 7	5	175*
2–2	5 × 5	4	80	3–2	8 × 7	5	188
2–2	6 × 5	4	88*	3–3	5 × 5	6	180
3–2	4 × 3	5	88†	3–3	6 × 5	6	198
2–2	6 × 6	4	96	3–3	6 × 6	6	216
3–2	4 × 4	5	100	3–3	7 × 6	6	234
3–2	5 × 4	5	113	3–3	7 × 7	6	252

* For flat apples. † For long apples.

compactness, spacing, and alignment of the first layer is of prime importance, for it governs the arrangement in subsequent layers and the total number of apples that must comprise the pack. The second and subsequent layers are constructed like the first by placing the apples in the pockets formed for them by the specimens beneath. Never allow an apple to be forced out of these pockets; the result will be a "broken" and irregular pack.

To make sure that individual specimens will not become loose and get bruised during shipment or storage, wrapped apples in standard wooden boxes are packed with a central bulge of about 1½ inches. The bulge, after lidding, should be about equally divided between the top and bottom of the package. This extra height of the apples in the center of the box may be secured either by pulling the center specimens in each layer slightly closer together than those at the ends, which makes the pockets smaller and increases the height of subsequent layers; or by packing the apples near the center of each layer in the box so that their longest crosswise diameter is perpendicular to the bottom of the box. Conversely the specimens in the first and last two rows at the ends should be turned with their shortest diameter in this direction. The ends of the completed pack should not extend more than ¼ to ⅜ inch above the ends of the box. This fruit is, of course, forced down into the pockets beneath when the box is lidded.

Difficulty is frequently experienced in getting the pack to finish at the proper height; packers must learn just how tight to pull the apples in each layer in order to build a perfect pack. The looser the pack the higher it may be built without bruising the apples when the box is lidded. Also the larger the apples in any given style of pack, the more loosely they should be placed in the box. Apples of sizes 100 and 175 are both packed in five layers according to the three-two arrangement, but in order to secure the proper height the smaller apples must be drawn closer together as packed.

Standard fiberboard boxes are approximately an inch deeper than standard wooden boxes, and are packed even with the top of the box. They usually contain only four layers of unwrapped fruit.

Wrapping the individual fruits aids in packing by holding the specimens in place, reducing bruises, preventing the spread of decay, and reducing transpiration losses.

Fruit wraps are now made mostly from light weight paper that is tough, but usually transparent. They usually carry the brand name or trademark under which the fruit is sold.

Oil-treated wraps are used largely where the fruit is to be stored. They help to prevent scald on most susceptible varieties (see page 14).

Most apple wraps are either 9 × 9 inches, or 10 × 10 inches, but can be secured in various sizes to accommodate different sized apples. They come in 50-pound bundles. It takes about one-half pound of paper to pack a box of average sized apples—10 × 10-inch wraps run approximately 300 to 325 sheets to the pound.

Methods of wrapping vary slightly with different packers, who, as they gain skill, have devised special systems of their own. Once learned, wrapping is a simple operation, but the ability to gain speed and to wrap neatly and smoothly can be acquired only through practice.

Boxed apples (of the better grades, at least) are lined with paper, or some form of cardboard. Corrugated pads are also used top and bottom to prevent bruising of the fruit.

3. Storage

Storage plays a most important part in the orderly marketing and utilization of apples. With suitable cold storage facilities the better keeping varieties may be held and marketed throughout a good part of the year. The consumer thus has

fresh apples over a long period and the grower usually profits by better prices than when all his crop must be sold during the few weeks of harvest. Processors are likewise benefited by being able to extend their season of operation over a longer period. Cold storage facilities formerly were confined to large commercial or cooperative houses in large producing and consumption centers. More recently, however, with the introduction of small refrigerating units, privately owned grower storages located in the orchard have been built.

Anyone interested in the construction of small, refrigerated storage units is referred to the local Farm Advisor for a copy of Extension Service Multilith leaflet, *Home Cold Storage Rooms for Your Apples and Pears*, by S. M. Henderson and F. W. Allen.

In the Watsonville area where Yellow Newtown is grown most extensively, storage facilities are available for over two million boxes. Delicious (now produced in increasing volume) and Yellow Bellflower (new decreasing in production) are stored to a considerable extent. Rome Beauty, Jonathan, Spitzenberg, Stayman Winesap, Golden Delicious, Rhode Island Greening, and other fall and winter varieties are also suitable for storage, but because of their more limited production, and often in districts where cold storage is not available, the quantities stored are limited.

The Gravenstein, a summer variety in California, has usually been marketed as harvested. Gravenstein growers, however, have felt that early picking and a concentrated marketing period of only a few weeks have been responsible for many of the low prices received. As a result of recent storage investigations with Gravenstein, it seems likely that storage for limited periods may be highly advantageous.

Storage conditions necessary for maintaining apples in good condition are: a low uniform temperature; a high relative humidity; good circulation of air kept free of noxious odors or gases. The most efficient type of storage for long holding, therefore, is one in which the rooms are refrigerated by circulation of cold air. The air is chilled to the desired temperature by passing it over ammonia or brine coils; through a brine spray in a bunker room; or by a combination of these systems.

One of the newer modifications of the brine spray and coil systems is the unit cooler placed in each storage room. In these units air is drawn in over cold coils and discharged into different parts of the room.

Good air circulation in all parts of the room is desirable both for cooling large blocks of warm fruit quickly, and for maintaining uniform temperatures.

In coastal districts where the temperature is moderate and the humidity relatively high, or in the foothill areas where the nights are decidedly cool before harvest, nonrefrigerated, air-cooled storage may be used to hold fruit for several months. But the results in no way compare with those obtained from refrigeration.

Houses designed for air cooling usually have air inlets below an open false floor and in the roof. At nights and at other times when the outside temperature is below that inside, the vents are opened and the cold air is drawn in. During the day when the outside temperature is likely to be higher than that inside, all ventilators are closed. Thus, by watching the inside and outside temperatures and by operating the ventilators, a certain degree of cooling is obtained.

Handling. Fruit moving into or out of storage may be handled and stacked either a box at a time, or by the newer method of pallet handling. This latter method consists of stacking boxes (40 or more), 5 or 6 high on a pallet, or skid, and handling these as a unit with a power-driven lift truck.

In the storage room, the pallets are

stacked one on the other, 3 or 4 high, as shown in the photo, page 2.

The pallet system of handling reduces the labor required for box handling, and is now generally used in the larger, newer types of storage houses built at ground level and having large rooms, high ceilings, and wide doors. It is not adapted to handling in small rooms, with low ceilings, small doors, or where there are many supporting pillars.

Individual handling of boxes, one at a time, is still necessary for the small operator and for some of the large ones where the design of their storage rooms (for the reasons listed above) is not suitable for pallet handling. The extra cost of labor in individual handling is partly offset by the fact that less space is required to store the same number of boxes than is required for pallets. Labor and expense of high stacking may also be reduced by the use of portable electric endless belt elevators.

Where pallets are not used the stacks of fruit should be raised 4 to 6 inches from the floor by placing the bottom box of each stack on properly spaced timbers. Individual stacks in large blocks of fruit should be separated, and the stacks held firmly by dunnage strips (strips of wood nailed across the box ends).

Prompt storage is important. After being harvested, apples should be placed under storage temperatures with the least delay possible. Although the damage is not apparent at the time, allowing fruit to stand for several days may shorten its storage life by a month.

Delay between harvesting and the time of reducing the temperature of the fruit is a most important cause of mealiness. The Delicious variety is particularly susceptible to mealiness unless stored promptly.

Any rough handling resulting in bruises or skin punctures will also be reflected later in storage.

Care. If apples are to be stored successfully—maintaining their original appearance and crispness of flesh—careful attention should be given to the regulation of the temperature and humidity of the storage room.

Temperature. In general, apples will keep about 25 per cent longer, with less scald and decay, at 30° F than at 32° F. Thus for long holding of most varieties, temperatures of 30 to 31° F are recommended. Apples freeze at about 28.5° F, hence, where a 30° temperature is desired, the storage operator must be able to control the temperature within narrow limits. Two or three tested thermometers should be placed in different parts of the storage room (the warmest and the coldest locations) and the temperatures checked preferably several times daily.

Exceptions. While temperatures of 30 to 32° F are the most practical means of retarding ripening, many of the Yellow Newtown apples grown in the Pajaro Valley are subject to low-temperature injury known as internal browning when they are stored below 40° F. But since storing them at 40° F materially reduces their storage life, a compromise temperature of 36 to 37° F is generally adopted. Other fall and winter varieties, which are to be stored for short periods only, may be held at 35 to 36° F.

Humidity. Although low temperature is effective in holding ripening changes to a minimum, apples held for a considerable period may show a certain sponginess and may lack crispness. This is usually due to loss of moisture from the fruit through transpiration, and may be prevented by maintaining a relatively high humidity in the air surrounding the fruit.

Stored apples will remain more firm and crisp if held in an atmosphere which is 90 to 95 per cent saturated. At air temperatures of 45 to 60° F this higher humidity may render the fruit somewhat more susceptible to attack by various rots, but if all damaged specimens are sorted out before storage and the fruit is held in clean boxes in a room with good

air circulation, decay should not be serious.

Vapor removal. Apples in cold storage are much less likely to develop scald (see page 14) when the atmosphere surrounding them is kept free from the toxic vapors which they give off. It is usually impractical to ventilate cold storage rooms so the most feasible method of eliminating these vapors is to absorb them from the air.

One way of doing this has been with the use of oiled wraps around the apples. The oil in the wraps is absorbent. This method has, however, given only indifferent results with the Pajaro Valley Newtowns. In general, storing the fruit loose, in a good circulation of air which at least carries the volatiles away from the surface of the apples has given the best results.

A recent method which has given good scald control in some instances is that of filtering the air in the storage room through activated carbon. The full possibilities of this procedure are currently being studied.

Unventilated rooms in which large quantities of fruit are stored may have an atmosphere containing several per cent of carbon dioxide. Carbon dioxide itself in concentrations found in storage rooms is not harmful—in fact its action in reducing respiration may be beneficial in maintaining fruit firmness and (in green varieties) original color.

Tests conducted with Yellow Newtowns have shown that this variety when held at 40° F (where internal browning does not develop) in atmospheres containing around 5 per cent carbon dioxide, colored or softened no more than comparable lots held in air at 32° F. But because this so-called "gas" or "modified atmosphere" storage requires practically airtight storage rooms, filled at one time and kept closed for the entire storage period, it has at this date been adopted only to a limited extent in New York state for the McIntosh variety.

Storage periods. The normal storage periods for apples most commonly stored in California are as follows:

Yellow Newtowns have a variable storage period, depending somewhat on their susceptibility to internal browning. Some fruit should not be stored longer than 2 or 3 months; that from other orchards may be held until May or later.

Yellow Bellflowers may be kept until November or December, or even later, though such a practice is usually unprofitable.

Jonathan, White Pearmain, Tompkins King, Spitzenberg, Delicious, and ***Golden Delicious*** have a normal storage life of from 3 to 4 months.

Rome Beauty may be stored for from 4 to 5 months.

Winesap has a storage life of from 6 to 7 months.

Gravensteins are now being stored for 2 or 3 months in order to extend their processing season. For more detailed information on the storage of this variety, see Exp. Sta. Bul. 716, *Gravenstein Apple Storage Tests,* by Frank W. Allen.

In some instances the fruit may be held somewhat longer than the times given above, but quantities of apples held for commercial use should never become full eating ripe before being removed from storage. Late in the season the fruit out of storage will ripen very rapidly at the higher outside temperatures and may become overripe or develop scald or other trouble before it can be sold or used.

4. Storage and market diseases

The life of apples in storage may be terminated by the general internal breakdown of old age, by some physiological disease or by fungus rot. A few of these troubles are as follows:

Internal breakdown is associated with a general overripe condition and marks the end of the storage life of fruit not otherwise affected.

Apples lose their firmness and juiciness; the flesh becomes dry and mealy—

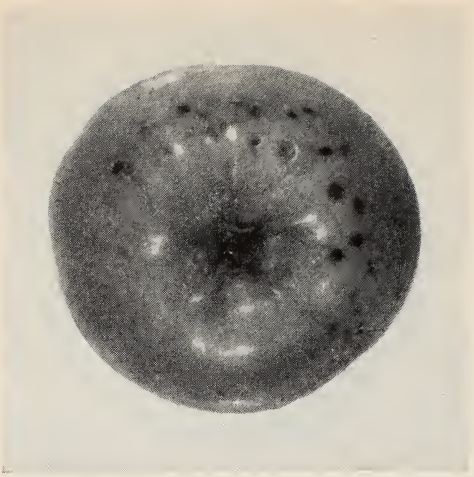

Photo of typical bitter pit in a Gravenstein apple. Gravensteins are particularly susceptible to this disorder.

in severe cases soft and brown. The disease, which is sometimes mistaken for freezing injury, most often occurs on large-sized, overmature fruits. Late harvesting, delay in storage, and high temperatures all favor its early development.

The amount and seriousness of the trouble vary from year to year and are influenced by growing conditions. It appears sooner and is more serious in fruit held in air-cooled storage houses than in cold-storage fruit.

Bitter pit is regarded by Carne and associates (1929) as embracing a group of nonparasitic disorders including tree pit, storage pit, crinkle pit and others. The normal type of storage pitting, which differs from tree pitting only in time of appearance, is recognized as being the original bitter pit, and is most prevalent in California apples.

The Gravenstein variety is particularly susceptible to pitting in storage. Even during a 10- to 12-day transit period to eastern markets, early-picked fruit showing no signs of the disease when packed, may arrive showing severe pitting.

The trouble also frequently appears in less severity in storage on Yellow Bellflower, Yellow Newtown, Winter Banana, Delicious, Stayman Winesap, and some other varieties.

Both tree and storage pitting is characterized by small, sunken spots, usually concentrated near the blossom end of the apple (see photo). At first these may appear as water-soaked, bruiselike spots on the surface. As the trouble advances they become depressed into definite pits which take on a dark green, brown, or black appearance. Beneath the skin, dead brown, dry, spongy lesions appear in the flesh, usually at or near the surface, but sometimes extending through to the core line.

As the susceptibility to storage pitting decreases with maturity, early-picked apples should be avoided. Well-matured and well-striped Gravensteins are much less likely to develop pitting than those picked early in the season or without red color.

Cold storage temperatures retard, but do not prevent pitting.

Internal browning is another physiological disease apparently due to certain abnormal nutritional conditions in the tree that affect the fruit. It has little economic importance outside the Pajaro Valley, but in that section it is the most important trouble affecting the Yellow Newtown. Except in advanced stages the trouble is not apparent from any abnormal external appearance of the skin, and the fruit must be cut to determine its presence. A softening at the basal end of the apple around the stem, however, is an indication of severe browning.

Browning is first noticeable usually in December or January; then, when the apple is cut in cross section, one-third the distance between stem and blossom end, more or less elongated and slightly discolored areas radiate outward from the central portion. At first the discoloration is only slight, and the areas are adjacent to the primary vascular bundles. As browning becomes more severe, they spread rapidly to the secondary bundles, and finally the condition may become more or less general (see photo). When

Internal browning of Yellow Newtown apples. At left, severe browning; at right, a normal apple.

the trouble reaches its worst stage the thick-walled cells of the epidermis turn brown and the fruit appears as though affected with scald. In some instances browning may be confined largely to the core region, this sometimes being designated as "core browning" to distinguish it from the more usual form.

The conditions which produce browning in the Pajaro Valley are closely associated with a relatively low growing temperature and a high humidity, characteristic of that section. The browning is generally worse on the valley floor where these conditions are coupled with a fertile, heavy type of soil.

Fruit grown in the hill sections is less susceptible and frequently shows no browning.

In addition to growing temperatures, other factors as yet not understood apparently play a part in internal browning of the fruit. Individual orchards and even individual trees in the same orchard produce fruit that shows wide differences in its tendency toward browning.

In general, browning seems to be more prevalent in large fruits than in small, and in apples from trees producing light crops, and from those of abnormal vigor. Investigations conducted by the author also indicate that the severity of browning increases with the maturity of the fruit at picking time.

Storage temperature, however, is probably the most important factor influencing browning. Fruit from orchards known to produce susceptible apples will develop much less trouble at the recommended storage temperature of 36° F than at 32° F. Browning increases rather rapidly after the fruit is removed from storage.

Scald is one of the most serious and widespread of storage diseases. It occurs in all apple sections and on most varie-

Apple scald in a fruit of the Yellow Newtown variety.

ties. Arkansas (Mammoth Black Twig), Grimes Golden, Rome Beauty, Rhode Island Greening, Wagener, Stayman Winesap, Winesap, and Yellow Newtown are all highly susceptible.

Scald is primarily a skin disease which in mild cases appears as superficial browning. On red varieties it is confined primarily to the greener side of the fruit. In severe cases the entire surface may become discolored and separate from the pulp. Occasionally in later stages the flesh may become brown to a depth of ¼ inch or more.

The immediate cause of scald is the accumulation within the apple tissues of certain gases or vapors (other than carbon dioxide) given off by the apples themselves as a result of respiration. To prevent, or at least to reduce, scald, recommended treatment is to remove these gases from around the fruit by providing sufficient air circulation or else to absorb them, in the case of wrapped fruit, by means of oiled fruit wraps.

Good results have been obtained experimentally by drawing the air in the storage room through activated carbon. Oiled fruit wraps have proved helpful in some cases.

Unwrapped fruit shows less tendency to scald than wrapped fruit, but where large quantities are tightly stacked, cooled slowly, and held at a minimum temperature of 36° F (as is recommended for California Yellow Newtowns) conditions favor scald development.

Any scald which develops in storage is likely to become serious within a few days after the apples are removed to a higher temperature.

Immature fruit and poorly colored red varieties are particularly subject to scald. This susceptibility is intensified by delays between the time of harvesting and of placing in storage and cooling.

Soft scald differs from that described above in that the affected areas are depressed and well defined. The browning of the skin and flesh is characterized by a sharp demarcation between the diseased and healthy tissue. The spots vary in size from ¼ inch or less in diameter to rather large areas covering a considerable portion of the surface. The flesh beneath such areas is usually soft, spongy, and moist, but may become dry and collapsed. The disease occurs less frequently than ordinary scald and is rarely serious on well-matured fruit that is stored at 30 to 32° F the same day it is picked. Where there is a delay in getting the fruit under low temperature, holding at 36° F has been recommended. Ripening is approximately twice as rapid at this temperature as at 30–32°, but the susceptibility to soft scald is lessened.

The oiled wrappers used for ordinary scald are not effective in controlling soft scald. However, subjecting the fruit to an atmosphere of 25 per cent carbon dioxide for 24 hours before storing at 30–32° F has prevented development of soft scald.

Rome Beauty and Jonathan varieties are most susceptible, and Golden Delicious may sometimes be affected.

Jonathan spot is another skin disease often prevalent on storage apples in many apple sections but confined largely to the Jonathan variety. The spots are at first brown or blackish, very slightly sunken, roughly circular, and from 1/16 to ⅛ inch in diameter. Later they may increase in size or coalesce. In the early stages the spotting is confined to the color-bearing cells of the skin; but after the skin is killed, underlying tissues may become affected. Spotting is most severe on highly colored specimens. The cause of the disease is unknown. Immediate storage, however, reduces its severity.

Water core is an orchard trouble that develops in fruit ripening on the tree. It is recognized by hard, glassy, water-soaked areas, usually near the core or main vascular bundles. In severe cases, however, most of the flesh may be affected, and the symptoms may be visible at the surface. Although found in many

regions, water core is most severe in those of intense heat and sunlight. It is associated with mature or overripe fruit and is common in Yellow Transparent, Early Harvest, Jonathan, Delicious, Stayman Winesap, Winter Banana, Arkansas, Winesap, and Yellow Newtown. Partial control may be obtained by avoiding excessive exposure of the fruit to sunlight and by picking it before it becomes overmature. Where present in only a mild form, the trouble may disappear in storage, but such fruit is later more susceptible to internal breakdown.

Fungus rots. Numerous fungus rots may shorten the life of apples in storage, but the most common and destructive is the blue mold rot *Penicillium expansum.* This attacks the fruit through the lenticels, breaks in the skin, and soon produces soft, watery, light-brown spots of variable sizes. These enlarge rapidly and produce small patches of whitish spores, which soon become more numerous and change to the characteristic bluish-green color, whence the name blue mold. Blue mold occurs primarily in storage, and its development is hastened by a combination of high temperature and high humidity. Handling of the fruit in clean boxes and avoidance of skin breaks will do much to prevent rot losses.

Freezing injury. Cold-storage warehousemen watch their storage temperatures so closely that freezing injury rarely occurs. Before apples are injured from this cause the temperature must drop to 28.5 F or below and remain there for several hours. Moreover, even though the flesh may contain some ice crystals the fruit may subsequently fail to show freezing injury. Water-soaked bruises are not a sure sign of freezing. Usually the best indications are the discoloration of the fibrovascular bundles and the threadlike fibers extending throughout the flesh. This coloration may easily be observed in the cross section of frozen apples provided freezing has not been so severe as to result in complete discoloration. In extreme cases all the flesh may become either dry and mealy or brown and water-soaked in appearance.

Such specimens as these may closely resemble those in the advanced stages of internal breakdown. Unless the fruit is known to have been subjected to freezing temperatures, the trouble is difficult to identify with certainty. Apples that have been only slightly frozen may be thawed out with little aftereffect other than a shortened storage life. Frozen apples, however, should not be handled, for any bruising they sustain may result in soft, watery areas, frequently extending deep into the fruit.

Rose (1944) indicates that a temperature of about 40° F has been found most satisfactory for thawing apples.

5. Processing

Burlingame, in Exp. Sta. Cir. 395, *California Apples: Situation and Outlook 1949*, shows a larger percentage of California apples are processed than in most other states or in the nation as a whole. Until the loss of foreign markets during and following World War II drying was the most important form of processing, and numerous growers operated their own driers. In the past five years the quantity of apples dried has decreased while other forms of processing, such as canning, freezing and crushing, have become of more importance.

With this change in the methods and the general advancement in technique, processing in general has become a specialized field. For this reason this publication includes only a brief general discussion of different processing methods and the kind of fruit desired. Technical details of interest to processing operators may be obtained from the University of California Division of Food Technology, to whom the writer is indebted for some of the information presented in this section.

Drying apples. Apples of almost any variety and size may be used for dry-

ing, but an attractive product can only be secured from suitable, mature fruit.

Very small apples are expensive to prepare. They also produce a low grade product and may better be utilized for other purposes.

Regular shape is preferred because they minimize labor and loss in peeling and trimming.

Yellow or green varieties are preferred to red because traces of skin left on the fruit are less noticeable. The color of the flesh may be either white or yellowish—trade preference on this point is divided.

The more important varieties are:

The Yellow Newtown gives the largest yield per ton of fresh fruit, slices well without undue breaking, dries with a uniform color, and holds its color well in storage.

Rhode Island Greening also gives a large yield and produces large slices drying a golden yellow. Because of its large core, however, core remains are more apt to appear in the finished product.

The Gravenstein is popular largely because its early ripening permits the producer to take advantage of early markets and a long drying season. It dries a cream yellow, but if the fruit is overripe, it tends to discolor badly in storage unless well sulfured. The yield per ton of fresh fruit is about 80 per cent of the yield secured from Yellow Newtown or Rhode Island Greening.

Yellow Bellflower, a soft apple, when mature bruises badly in handling. During preparation the slices break, and it is difficult to get a large percentage of rings with power machines. This variety is better adapted, therefore, and more popular for the production of quarters than slices. The yield per ton is less than from Yellow Newtown or Rhode Island Greening but is better than that from Gravenstein. The color is light, but because of bruising of the green fruit it may not be uniform.

Preparing the fruit. Peeling and coring may be done by machines, either hand or power operated. Within a given range, these machines may be set to adjust themselves automatically to fruits of different sizes.

After peeling and coring, the fruit passes along the inspection belt where any skin left on the surface, any worm holes, decayed spots, bruises and other blemishes are removed. Treating whole fruits lightly in a dilute sulfite solution immediately after peeling and coring prevents browning of the core.

Cutting into slices, quarters, sixths, eighths or into small cubes is usually done by machine after peeling and trimming.

Sulfuring may be done either before or after cutting. Sulfuring after cutting permits greater uniformity.

The fruit may be exposed to the sulfur fumes in an ordinary sulfur house where sulfur is burned in pans, pots, or pits, or in the kiln before drying. (See Exp. Sta. Cir. 382, *Sulfur House Operation*, by H. J. Phaff and E. M. Mrak.)

The quantity of sulfur used per gross tone of fruit ranges from 1½ to 5 pounds. The time of sulfuring varies from 20 minutes to 1½ hours. The texture of apples does not break down from exposure to fumes, as with apricots and peaches.

Evaporating is usually done in either a kiln evaporator or a tunnel dehydrator.

The kiln evaporators equipped with an exhaust fan are the most common type of evaporator in use. Fruit is spread on the slat floor to a depth of 6 to 18 inches or more. Air, initially heated to 175° F and later only to 100° F, from the furnace beneath is drawn up through the fruit and out ventilators at the top of the kiln.

Tunnel dehydrators are constructed so that the fruit passes through on shallow trays. Dry air, with a relative humidity of 18 to 20 per cent at the hot end, is heated to 160–165° F and passes over the fruit at the rate of 600 to 800 feet per minute. The usual time required for drying with this type of equipment is less than in the ordinary evaporator.

Moisture content. Fruit is usually considered sufficiently dry when a hand-

ful of slices pressed firmly together has an elastic, springy feel, and separates at once when pressure is released.

Grading and packing. Individual growers doing their own drying usually deliver their apples in sacks or other bulk containers to those operating commercial evaporators; to marketing associations; or to others equipped for grading and packing.

Apples for the bakery trade. Preliminary steps in handling apples for bakery trade are similar to those employed in drying. The peeled and cored apples are usually cut into sixths or eighths and then allowed to stand for several minutes in a sulfite solution or weak sulfurous acid to prevent browning. The treated fruit is then packed into 50 pound boxes or into 5-gallon cans to which some sugar is added. The sugared fruit, and some of that packed in boxes unsugared, is then frozen and held in a sharp freezer until ready for use. Recently, however, with processing plants operating throughout the year the apples are held in 32–36° F storage in their fresh state and then processed and delivered to the trade unfrozen as needed. Both rail and truck shipments in carload lots supply numerous California markets as well as some in Arizona and Nevada.

For the above method of processing the Yellow Newtown variety is used more than any other. For a short time in the late summer, however, when Yellow Newtowns from the previous season are no longer available, some Gravensteins and Winter Bananas are used.

Sauce. Demand for California apple sauce, for adult consumption and for baby food, has increased rapidly and large quantities of apples are now used for sauce purposes. By blending, most varieties of apples may be used. The Gravenstein, however, because of its flavor and texture is particularly desired. Extra cold storage facilities in the Sebastopol area now permit a longer processing season for this variety than formerly. After washing, peeling, and coring, the fruit moves directly to the cooker without being cut into segments. Aside from the necessity of removing spotted or defective areas in some individual fruits little trimming may be required. Small areas of peel left on the fruit are screened out in the cooking process. Special attention is given by the processors to maintaining uniform quality in the finished product, and laboratory testing for sugar-acid relationship, texture, color, etc. of the sauce are made frequently.

Crushing is employed for that proportion of the apple crop (10–15 per cent) destined to be used for fresh apple juice, frozen concentrates, cider, vinegar, and brandy. Crushing furnishes an outlet for small apples, perhaps unmarketable otherwise, and in part, at least, fruit of lower quality than could be used for canning or drying. High quality apple juice and cider, however, cannot be made from unsound apples.

Most varieties are used for crushing purposes, although processors may prefer certain sorts to give a characteristic flavor to the product. Some growers may still produce their own cider, but unless it can be marketed as made or is to be utilized as vinegar, the apples are usually sold to those who specialize in processing. The average grower does not have the equipment or the technical knowledge for handling, clarifying, sterilizing, blending and otherwise processing of juices.

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J. Earl Coke, Director, California Agricultural Extension Service.

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and this is what it looks like . . .

THE PHOTO above is taken from a circular on irrigated pastures in California. It shows a good lay-out of fences and gates for rotation grazing.

The drawing below is from a circular on selective weed killers and shows one reason why some weed killers are selective.

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