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Organic Apple Orchard Culture

Many aspects of apple production are similar for both organic and conventional systems. The basic considerations of orchard culture, including orchard establishment, variety and rootstock selection, pruning, tree nutrition, irrigation, orchard floor management, crop regulation and replanting, are well addressed in *Commercial Apple Production in California*, DANR publication 2456, referenced in the section “How to Use this Guide.” Information in this guide includes those additional considerations unique or particularly relevant to organic production.

Site Selection

The multiple climatic zones and micro climates within California can have a huge effect on fruit quality and pest pressures that could greatly enhance the profit potential of an organic apple orchard. Controlling codling moth and apple scab, two of the most prevalent pest problems are much easier in cool dry climates. These are some of the factors to consider when selecting a site -

- Land that has deep, well-drained soil with naturally high fertility, high organic matter content, excellent water quality, and plenty of available water offers an advantage to all growers, but especially the organic grower.
- Codling Moth will have more generations (up to four) in the warmest areas of California such as the Central Valley and southern California. The cooler coastal areas will have only two or sometimes three generations of moths and their larvae (worms). Where pressures for codling moth are very high, control of the first generation is extremely important. In low-pressure areas, the first generation is sometimes ignored.
- Isolating large blocks of trees away from other orchards and their pests is a very positive attribute since it will reduce or eliminate movement of moths or fungus spore

inoculum from entering the orchard. Orchards have an advantage if they are located at least ½ mile from other orchards of pear, apple, walnut, or back yard fruit trees.

- The pheromone confusion/mating disruption technique works much better on large solid blocks (> 10 acres) of trees because the edge effect is reduced.
- Flat land offers an advantage for pheromone confusion since the pheromone is heavier than air and will dissipate or flow down hill with the contour of the land. Flat ground is also easier to manage.
- Orchards located in areas with less spring rainfall will avoid attack by the apple scab fungus. Mild weather during bloom helps with fruit set, reduces fire blight disease, and moderates alternate bearing.
- The ability to grow a winter cover crop that provides lower cost nutrition and soil enhancement compared to applying organic fertilizers or compost is also important. Cold winter locations with snow or very hard freezes can limit winter cover crop production.
- When possible, avoid sites infected with problem weeds such as bermudagrass, field bindweed, or Johnsongrass, nematodes, Armillaria (oak root fungus) and Dematophthora, as these persistent problems are usually not adequately controlled by any available organic methods.

Land Preparation

Many potential problems can be reduced or eliminated by careful preparation of the orchard site prior to planting. It is a good time to improve drainage, incorporate organic matter, add nutrients, adjust soil acidity-alkalinity, and to control weeds. Old orchard sites or wooded areas should have as many roots as possible removed to limit holdover material for oak root fungus if present.

It is a good idea to plan at least one to two years in advance and plant a tall growing cover crop in the winter months such as bell beans to increase organic matter content. If

water is available, also grow a summer cover crop like Sudangrass to smother and weaken perennial weeds if present. Order nursery trees two years in advance if possible to get the best possible selection of varieties and to be able to plant trees with some side branches.

Soil solarization can benefit the growth of newly planted trees by reducing the incidence of most annual and some perennial weeds, nematodes, and harmful soil disease organisms such as Phytophthora root rot. Solarization entails tarping tilled and irrigated land for a month or more in mid summer with clear plastic. A detailed description of soil solarization requirements, timing, and methods can be found in *Soil Solarization: A Non-Pesticidal Method for Controlling Diseases, Nematodes, and Weeds* (DANR Publication # 21377).

At a minimum, the soil should be tested for mineral content (Phosphorous-P, Potassium-K, Calcium-Ca, Magnesium-Mg) and pH. Micro nutrient levels should also be determined if a problem is suspected. Other tests for both soil and water include tests for EC (electrical conductivity a measure of salt content), SAR (Sodium Absorption Ratio), Bicarbonate levels, Na and Cl levels, and Boron. These tests are done to avoid excess or deficiency situations and to provide a basis for corrective action prior to planting.

Tissue testing, however, of tree leaves in an existing planting is a much more accurate measure of plant nutritional status than soil testing. For corrective procedures, sampling methodologies, and desired values for nutrients in soil and water, see - *Plant and Tissue Testing in California*, DANR Publication #1879 and *Water Quality Effects on Plants*, DANR Publication # 2995.

Large quantities of manure or compost (up to 20 tons/acre) are very beneficial to the growth response in young trees, and should be applied and incorporated into the soil before planting. These amendments provide a slow release of nitrogen and some of the phosphorous and potassium necessary for the first year or two of growth. Organic amendments should be incorporated into the soil by disking or other tillage equipment in order to prevent the nitrogen from volatilizing into the air.

Soils low in P or K should be corrected with heavy applications of these minerals from organically certifiable sources. P commonly comes from soft rock phosphate and K from mined potassium sulfate. (See “Tree Nutrition and Fertilization” later in this chapter).

Soil pH should be adjusted to between 5.5 and 7.5 through the addition of lime to raise pH or through the addition of soil sulfur to lower it. Lime requirements can be calculated by a diagnostic laboratory from soil samples and application rates depend on soil type and the original pH value. Types of organic matter typically associated with raising or lowering pH work very slowly (over a period of hundreds of years) which make their use for that purpose unreasonable.

Apple trees will grow and produce well in a wide range of calcium and magnesium containing soils. Calcium and Magnesium levels are sometimes adjusted to a 5 to 1 ratio in favor of calcium, but this can be expensive and comparable benefits are not always evident (see the discussion of bitter pit in the “Disease and Physiological Disorder” section for calcium recommendations)

Planting

Trees should be planted when dormant. Composts or amended soils should not be placed in the planting hole because they create such a good environment for root growth that the roots stay within the planting hole and grow in a circle. Apply 3”- 4” of compost or mulch to the soil surface just after planting if it is available.

Immediately after planting, paint the dormant trees with interior water based paint or commercial whitewash from the soil line to the top to protect them from sunburn and attack by wood boring insects.

Good irrigation, fertilization and weed control are vital for vigorous tree growth the first year. Weeds compete with the young tree for soil moisture and nutrients, and should be eliminated within 2-3 feet of the trunk by mulching, burning, or cultivation, especially for

the first three years of growth. Weeds allowed to compete with young trees can reduce growth by as much as 50%.

Rootstock Selection

Dwarfing or semi-dwarfing rootstocks are now commonly used for most new or replacement plantings of apples. These stocks produce smaller trees than standard/seedling rootstocks. They also come into bearing earlier and provide a quicker return on investment. The smaller trees can also improve fruit color; pest and disease control through better spray coverage, and eliminate or reduce the size of ladders for increased orchard safety, efficiency, and convenience. All the size-controlling rootstocks require regular irrigation and are not suitable for dry-farmed sites. For greater detail regarding the horticultural characteristics of apple rootstocks refer to *Commercial Apple Production in California*, DANR publication # 2456.

The proper choice of rootstock may allow the apple grower to avoid expected pest or disease problems. Resistance to woolly apple aphid, Phytophthora root rot, and fire blight are perhaps the most important rootstock characteristics to select for, as there are no suitable organic controls for these pests. The common rootstocks available in California and their important pest avoidance characteristics are described below –

Seedling or standard rootstock: This was the only stock used for many years in California apple orchards. It produces large, very vigorous, full-sized trees that do not come into bearing until the trees are 7-10 years old. Today, standard rootstock is used only in non-irrigated or low vigor sites or for spur type varieties. Its one advantage is a greater tolerance to “wet feet” and Phytophthora root rot compared to dwarfing stocks. It is very susceptible to woolly apple aphid and susceptible to fire blight.

M111: Semi-Dwarf rootstock usually produces a tree 80% the size of a tree on seedling. It tolerates varying soil conditions, and reportedly resists woolly apple aphid. It was typically planted in the Central Valley, as it is more resistant to the Phytophthora root rot species found there, but its excess vigor is a problem. It is also somewhat resistant to fire blight.

M106: Semi-Dwarf rootstock produces a tree about 65-75% the size of a tree on seedling, but without proper care will not reach its size potential. This rootstock is resistant to woolly apple aphid, somewhat resistant to fire blight, but has been susceptible to root rot caused by some Phytophthora species. It has been less susceptible to root rot in the coastal growing areas presumably due to the presence of different Phytophthora species.

M7a: Semi-Dwarf rootstock produces a tree about 60% the size of a seedling rooted tree. It performs well in irrigated replant situations, but tends to sucker. It is resistant to fire blight, but susceptible to woolly apple aphid.

M26: Semi-Dwarf to dwarfing rootstock produces a tree 30 to 50% the size of a tree on seedling. It has performed very poorly in most situations in California and is extremely susceptible to fire blight.

M9: Dwarfing rootstock produces a very small tree less than 30% the size of a seedling-rooted tree. It is poorly anchored with a brittle root system and must be trellised. It stunts if not adequately managed, but has become the most planted rootstock in the world commercially because of its excellent performance efficiency and precocity.

Mark: This rootstock is similar in size to M9, but it has been a very poor performer in California and other apple growing regions.

Virus-free forms of most of the semi-dwarfing and dwarfing rootstocks are available and are indicated by the preface EMLA in front of the rootstock number. These virus-free rootstocks tend to be longer lived and 10-15% more vigorous than the original, virus-infected releases of the same clones (those prefaced by an M or a MM). However, if the variety grafted onto the rootstock is not virus free, it will infect the rootstock and the expected benefits will be lost. Only use certified virus-free grafting wood with EMLA rootstocks.

Variety Selection

Choosing the right variety is one of the most important decisions for the commercial apple producer. The variety should be adapted to the climate of the district in which it is to be grown and it should enjoy good market demand. Apples grown in cooler climates develop better red color than those in warm climates; thus green varieties are better suited to warmer areas. In most districts, there are usually several satisfactory varieties of proven adaptability. Anticipated market demand and potential competition from other districts should govern additional plantings of these varieties.

For the organic producer, it is important to select varieties that are resistant to anticipated pests and diseases. In parts of the state with spring rainfall, apple scab resistance is very important. Most available apple scab resistant varieties have also been selected for resistance to powdery mildew, and some for fire blight, which could be important in all growing regions. Early-maturing varieties generally sustain less damage from codling moth. If the fruit can be removed from the tree prior to the next generation, sprays or additional applications of pheromones can be eliminated.

Cultivars also differ considerably in their susceptibility to various postharvest disorders. For example, Granny Smith and Red Delicious are very susceptible to storage scald, and Granny Smith, Red Delicious, and Golden Delicious apples are very susceptible to bitter pit.

There are many new varieties being introduced. Some of these are potentially adaptable to organic production in the state because of their excellent fruit characteristics and disease resistance. Since market prices vary so much by variety there is a trend to plant new varieties for early production to capture the high prices paid for new varieties. Growers will find it worthwhile to have small trial plantings of new varieties for evaluation of adaptability to local conditions. Unique varieties with flavor, harvested at the peak of maturity, have always been one of the potential advantages of small-scale apple growers in California. When combined with organic production, prices have been very good (see section on “Antique, New, & Novelty Varieties” later in this chapter).

Lowering pest control costs through the use of disease resistant varieties could also increase profits.

Most apple varieties require cross-pollination from another variety that blooms at the same time and produces viable pollen. In hedgerow plantings, pollenizers may be planted as solid rows alternating with the main variety or as single trees spread 50-100' apart in the main variety row. Fewer pollenizers are needed if planted in the tree row, as honeybees tend to move down rather than across the rows. Flowering crab apples are commonly used to avoid harvesting difficulties with in-row pollenizers, but many are very susceptible to fire blight.

Principal Varieties

According to a 1995 survey and 1999 estimates of California apple acreage, the top ten varieties grown in California, with over 1,000 bearing acres, listed in descending order are: Granny Smith, Fuji, Gala, Red Delicious, Golden Delicious, Yellow Newtown, Pink Lady, Rome Beauty, Sommerfeld, and Gravenstein. In the past 10 years, there was a doubling of Granny Smith acreage, as well as large plantings each year of Fuji and Gala in the San Joaquin Valley. In the last four years, Fuji acreage has decreased dramatically due to poor fruit color and susceptibility to fire blight. Acreage of Gala has remained flat, Granny Smith acreage is replacing Fuji, but has lowered, and acreage of Pink Lady and Sommerfeld have increased.

The following variety descriptions provide cultural information about the California apple varieties grown organically. Most of the principal varieties grown in California have name recognition and specific reputations in the marketplace, but most of them lack resistance to common diseases.

Granny Smith - This green colored, late-maturing variety has medium to large, round to slightly conic fruit. It is susceptible to mildew, scab, bitter pit, fire blight, and water core (especially on young trees). May scald in storage. As one of the latest maturing varieties it is susceptible to codling moth damage through late October. In coastal growing districts it provides adequate annual bearing with only hand thinning.

Fuji - A late-maturing variety, Fuji has become very popular due to its excellent sweet eating quality, but Central Valley growers have not been able to get good color. It is very sensitive to fire blight, scab, water core, and sunburn damage. It is prone to biennial bearing, slow to come into production and difficult to thin. It is subject to core rots, and fruit harvested later in the season may exhibit internal browning in controlled atmosphere storage in some years. Its late maturity makes it more likely to be attacked by codling moth than earlier varieties.

Gala - This is an early-maturing, small, summer apple with excellent quality due to its firmness and keeping quality. It is susceptible to fire blight, scab, and European canker. Its earliness provides some advantage for avoiding codling moth damage.

Red Delicious - One of the most widely planted red varieties in the world, but losing favor because of poor flavor in the marketplace due to harvest of red sports that are picked prior to full maturity. It is primarily a fresh market apple that matures in late August to September and can be severely attacked by codling moth. It is susceptible to scab, mildew, and fire blight.

Golden Delicious - This is a widely planted yellow apple of excellent dessert quality. It, however, is usually harvested immature with little flavor, so its reputation is poor in the US. It is self-fruitful, sets a good crop almost every year, but is difficult to thin. Golden apples are late maturing and very susceptible to codling moth. This variety is susceptible to mildew, scab, bitter pit and russet, and somewhat susceptible to fire blight.

Yellow Newtown - Grown chiefly in the Watsonville district as a processing variety. It is late maturing, susceptible to stem-end russet, mildew, scab, bitter pit and internal browning in storage.

Pink LadyTM - This is a new commercial variety to California. Very late maturing and therefore susceptible to heavy codling moth pressure. It is extremely susceptible to fire blight and apple scab.

Rome Beauty - This red-green striped to solid red, mostly processing apple, is very susceptible to powdery mildew and scab and because of its late maturity is subject to heavy codling moth pressure. It also does not keep well in storage.

Sommerfeld – Appears indistinguishable from **Sensyu**, which is its real name. An early variety, mature just after Gala, but with better size, and sweetness similar to Fuji. This is not a variety developed from any disease-resistance breeding program, and exact disease susceptibility is unknown at this time.

Gravenstein - This early summer apple is primarily grown commercially in the Sebastopol area for processing and has good fresh market value because of earliness and name recognition. It matures in late July to mid-August and often avoids the second and third generations of codling moth. It is susceptible to bitter pit, scab, and mildew, does not store well, and bruises easily.

Other Varieties

Jonathan - A variety that matures in mid season with excellent quality for both fresh and processing use in coastal growing areas. In Sebastopol it is harvested prior to the third generation of codling moth. It is highly susceptible to mildew, scab, Jonathan spot, and fire blight.

Braeburn - A variety that is a natural spur type tree with very high quality fruit and late maturity. It is susceptible to water core, scab, mildew, bitter pit and fire blight.

Jonagold – This is a new variety with a mid-to-late-season maturity. Jonagold has excellent eating quality when mature. It is susceptible to scab, mildew, bitter pit, sunburn, and fire blight.

McIntosh - This variety has name recognition, but does poorly compared to the quality produced on the East Coast. It is susceptible to scab, mildew, and fire blight.

Winesap - An old and still popular late variety, Winesap is best adapted to mountain districts in California. It matures in October and can be severely attacked by codling moth. Susceptible to scab, mildew, and fire blight.

Disease Resistant Varieties

There are several scab resistant varieties developed in breeding programs for the Eastern States where this disease is quite severe due to summer humidity and rain. Some have received limited testing here under California growing conditions. In growing districts with extended spring rains, organic growers should experiment with some of these varieties to see how they perform in their orchards.

Enterprise: A large fruited, late maturing, dense, crisp variety that has good keeping qualities. The color is dark red over a yellow green background. This is one of the best of the scab resistant varieties.

Florina: A promising scab resistant selection from France, this variety has large, round-oblong, purple-red colored fruit. It ripens late and has a mixed sweet tart flavor.

Freedom: Is a late season variety with large fruit and mild flavor; not completely immune to scab.

Goldrush: A scab immune selection with Golden Delicious parentage, this fruit is late maturing, large, firm textured and tart with an excellent flavor. It stores well.

Pristine: This moderate to large tart yellow apple is immune to scab and resistant to fire blight and mildew.

Jonafree: A mid season apple compares with Jonathan, with soft flesh and uneven coloring.

Liberty: One of the best quality apples of the disease resistant varieties, Liberty is very productive and requires heavy early thinning to achieve good size. It ripens in mid-season, has an attractive red color with some striping and a good sweet flavor.

Prima: Is an early season, uneven ripening, moderate quality variety.

Priscilla: Is a late season variety with small fruit, soft flesh, and mild flavor.

Red Free: Is early July maturing, heat sensitive, a small-fruited variety that is susceptible to water core, sunburn and russet.

Williams Pride: An early maturing, scab immune variety that is also resistant to fire blight and mildew. The fruit is medium to large with a round-oblique shape. It has an attractive red striped color on a green-yellow background

Early Maturing Varieties

Most early maturing varieties do not store well and are not disease resistant. Williams Pride is both early and disease resistant. Gala and Gravenstein are the only early varieties extensively planted in California. Some of these other varieties have acceptable horticultural and culinary qualities, but there is limited experience with them in California. Early varieties (ripening dates in parenthesis), which may be of interest to try include –

Anna (July 1)

Sunrise (August 1)

Vista Bell (July 1)

Williams Pride (August 1)

Jerseymac (July 10)

Ginger Gold (August 10)

Dorset Golden (July 10)

Sansa (August 10)

Paulared (July 15)

Jonamac (August 15)

Akane (August 1)

Summerred (August 15)

Mollygold (August 1)

Antique & Novelty Varieties

The antique and novelty varieties have name recognition in the marketplace and have been grown historically, but were generally replaced by other varieties because of color, alternate bearing, disease susceptibility, or other considerations. Many have promise as

specialty varieties with unique flavor. Varieties that were traditionally grown by smaller organic growers were produced with more attention to detail, especially harvest maturity, thereby providing better flavored fruit. Organic growers have often taken advantage of this difference in flavor due to maturity and small-scale handling. This has created an increased interest in non-traditional varieties, grown organically, with good flavor for niche markets.

Antique Varieties for Trial

Arkansas Black

Black Twig

Baldwin

Cox's Orange Pippin

Empire

E. Spitzenburg

Winter Banana

Northern Spy

Red Golden

Staymen Winesap

Sierra Beauty

Wagner

New or Novelty Varieties for Trial

Carousel

Honeycrisp

Pink Pearl

Arlet

Cameo

Gala Supreme

Golden Supreme

Pink Parfait

Senshu

Elstar

Hawaii

Fortune

Tree Nutrition and Fertilization

In general, any material applied to the soil or crop as a fertility or growth enhancement agent in organic apples must be derived from natural sources as defined by state (and federal) regulations. Included are amendments derived from animal sources (i.e., manures, and manure products, composts, fishmeals and emulsions, and blood and bone meals).

Plant-derived products include kelp meal and sprays, cottonseed meal, mulches, and covercrop biomass. Mineral nutrient sources (lime sulfur, copper, gypsum, limestone, elemental sulfur, Bordeaux (copper hydroxide), dolomite, rock phosphate, oystershell lime, calcium chloride, etc.) must be mined or otherwise naturally occurring; they cannot be synthetically manufactured. Manufactured micronutrients (zinc sulfate, iron

compounds) may only be used if a specific deficiency for that nutrient has been diagnosed. As with any applied materials or questionable practice, it is the grower's responsibility to consult state (and federal) lists of allowed products, then check with their certifier for additional compliance standards, if necessary.

Specific recommendations for fertilization of organically grown apple trees cannot be made because of variations in soil, moisture, and temperature within and among districts in California. However, multi-year studies in California indicate that it is not difficult to provide adequate nutrients to apple trees under organic management.

Annual average nutrient removal by apple fruit in a 20-ton crop is 29, 4, and 56 pounds per acre of N, P, and K respectively. Typically, a legume (bell bean/vetch) cover crop plus two or more tons per acre of chicken manure-based compost are incorporated in the spring annually. This is enough to provide the entire tree and crop needs for the season including micronutrients. Supplemental applications of kelp, fishmeal, or compost tea that are foliar-applied have never demonstrated any particular or significant benefit to apple trees.

Nitrogen (N) is usually the only element that needs to be added to the orchard on a regular basis because it is used in large quantities and most other nutrients are available naturally from the soil. Generally, mature apple trees need between 50-100 pounds of actual nitrogen per acre every year. Common ways for organic growers to add nitrogen to the orchard are through applications of manures, composts, dried blood meal, feather meal, and with leguminous cover crops. Nitrogen fixing cover crops tilled into the soil have been demonstrated to produce between 50-150 lbs. of nitrogen in one season (see "Cover Crops" in the Orchard Floor Management section).

Because nitrogen containing materials and cover crops break down into amino acids and subsequently into mineral nitrogen (NO_3 & NH_4) for plant uptake more slowly than conventional fertilizers, applications should be planned in advance. The low concentration and form of nitrogen in organic materials may require several months for microorganisms to convert it to the mineral form available to plants. Consequently

available nitrogen is more likely to come from an application made the previous year that had been stored in the soil. Yearly applications, therefore, should be made to maintain adequate levels over time.

In high rainfall areas, fall and winter applications of organic nitrogen containing fertilizers should be avoided to limit significant N loss from denitrification and leaching, leading to environmental contamination. Denitrification is the volatilization of nitrogen back into the air under low oxygen (saturated soil) conditions. Under these circumstances, early spring applications provide the greatest nitrogen use efficiency.

If necessary, composts or dried concentrated forms of organic fertilizers such as feather meal, blood meal, fish waste, etc. can be applied around the root zone to boost growth, especially in young trees. These forms of nitrogen will still take several weeks in warm weather or several months in cool weather to provoke a response from the trees.

Importing large quantities of materials from off-site can be expensive due to processing and hauling costs. Finished composts should be evaluated for major nutrients on a dry weight basis in order to calculate appropriate application rates for the orchard system. In general, application rates in organic apples have ranged from one to five tons per acre in fall or spring applications, depending upon the nutrient values of the compost or fertilizer meals. One ton (2,000 lbs.) of compost, for example, with a nitrogen analysis of 2%, will supply 40 lbs. of actual nitrogen per acre.

Uncomposted manures are restricted for use in California organic production, both by state regulations and certification agencies, due to N leaching potential during the winter and due to potential contamination of fruit with E coli bacteria.

The best way to monitor nitrogen, as well as other nutrient levels of apple trees, is by leaf analysis taken each July. At that time of year, the spur leaf nitrogen content should be at least 2 percent but not more than 2.4 percent

Phosphorus (P) deficiency is very rare in any California apple orchards because of naturally occurring high levels of phosphorous in most soils. Rock phosphate or bone meal are both organically acceptable forms of phosphorous and most composts contain some available phosphorous. Little or no reaction will occur in plant growth or performance if phosphorous is added to soils unless leaf analysis strongly indicates a deficiency. Phosphorous, however, is often applied to improve the growth of leguminous cover crops.

Potassium (K) deficiency is fairly common in California. Organic growers can correct the requirement for K with a heavy application of mined potassium sulfate if the nutrient is limiting in the soil. Potassium becomes strongly absorbed by clay particles in the soil, so potassium fertilizers must be placed close to tree roots in order to get a response in the trees. Generally, 750 to 2,000 pounds of potassium sulfate per acre are trenched into the soil at a depth of about 6 inches at the drip line of the trees or applied to the surface in the fall. The higher rate is used on heavier clay soils and the lower rate is used on sandy or lighter textured soils. In drip irrigated orchards applications can be made directly under emitters at about 20% of the trenched rates

The minor element, micronutrient, deficiencies such as zinc, boron, calcium, manganese, copper, and magnesium are not very common. It is usually necessary to combine visual observation of symptoms, characteristic of specific deficiencies, with a tissue analysis in order to properly diagnose these micronutrient deficiencies.

When micronutrient deficiencies occur, they are normally treated with foliar mineral sprays. Foliar sprays containing a wide range of nutrients derived from organic sources such as compost tea, fish emulsion, and sea kelp can be used to correct deficiencies. Their concentration of any one micronutrient is very low, however and generally requires numerous applications in order to be effective. When applied on a regular basis they will usually turn leaves a deeper green color and have demonstrated effects on growth, yield, return bloom, and fruit size when a specific deficiency has been identified and corrected.

In most cases, when a deficiency has been identified through laboratory leaf analysis, current organic laws allow non-organic forms of micronutrients to be used to correct the deficiency. Generally one application is all that is needed. For more details and critical nutrient levels see the section on Tree Nutrition and Fertilization in *Commercial Apple Production in California*, DANR publication 2456. If micronutrient deficiencies occur or are suspected, consult the local University of California Farm Advisor for help in evaluating the problem and advice on organically acceptable materials.

Fruit Thinning

With good bloom, it takes about 10% of the blossoms to set apples for a full crop. Under adverse weather conditions or if bloom is sparse, growers ensure an adequate set by planting pollenizer trees within the main variety to provide pollen through synchronized bloom and by bringing in hives of honey bees (2 hives/acre) to make sure pollen is transferred between blossoms. Erring on the side of setting too many apples and then thinning excess fruit with hand thinning is preferable to not setting enough apples.

Alternate bearing, the term used to describe a heavy crop one year and a light crop the next year, is really caused by alternate bloom. In years with heavy bloom, many small fruit are set. During the 30 - 45 day period between full bloom and small fruit stage, the tree is also producing flower initials in the spurs for next year. The large crop of tiny fruit on the tree produces hormones that send a chemical message to the developing spurs and flower buds not to initiate flowers the following year. Consequently, next year's bloom is light, fewer fruit have an opportunity to set and crops are normally lighter as well.

Hand thinning is usually done when the fruit reaches ½-inch to 1-inch diameter size. The fruit is easier to remove and space when it is larger than this, but the most effective way to prevent alternate bearing and increase final fruit size is to thin the tiny fruits within the same period that flowers are being initiated for next year, that is, within the 30 - 45 day period after full bloom.

The advantage of early thinning is that the fruit removal occurs during or prior to blossom initiation for the following year and therefore has a positive influence on return bloom. It also thins the fruit very early, which provides the maximum benefit for fruit size on the remaining fruit. Estimates of hand thinning costs for an acre of mature trees can range from \$500 to \$1,500 per acre. The cost is higher for large trees because ladders must be used.

Hand thinning is done by removing the small fruit and leaving one to two fruits per spur (spaced 7 to 8 inches apart), depending on the total set of the crop, variety and growing conditions. Save the largest fruit because size differences that exist during thinning will still exist at harvest. Thin for size as well as proper spacing. To achieve the greatest fruit size, leave two large fruits together and thin smaller ones rather than leave a large one and a small one. It has been observed, however, that thinning to one fruit per cluster so that fruit are not touching can reduce codling moth damage because spray coverage is better, larvae often enter where the fruit are touching, and sometimes move from one fruit to the next if touching.