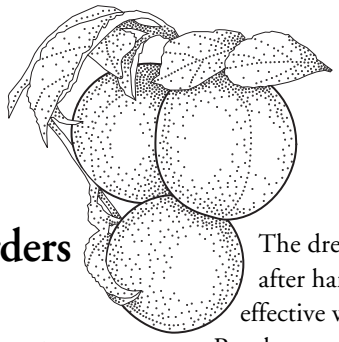
CHAPTER 7

General Orchard Management



Preventing Apple Disorders

Storage Scald on Apples

Storage scald is a physiological disorder of apples that results in a brown discoloration of the skin. It is usually a problem only when apples are held in long-term storage. The disorder usually does not extend below the skin, but the skin discoloration makes fruit unmarketable. Cultivars differ in susceptibility to scald. Susceptible cultivars include McIntosh, Cortland, Red Delicious, Stayman, Turley, and Rome Beauty. Other cultivars can occasionally develop scald.

Conditions that may result in increased scald include:

- Hot temperatures in the pre-harvest period;
- Overloading storage at harvest time, resulting in slow cooling; and
- Harvesting and storing fruit that is too immature.

Scald incidence can be minimized by considering the following:

- Pick fruit at optimum maturity for long-term storage;
- Get fruit cooled to storage temperature as quickly as possible; and
- Promote good color development on fruit by the optimum harvest time, e.g., avoid excessive vegetative growth, high nitrogen levels, and excessive pruning that results in heavy growth and shading.

Control: Diphenylamine (DPA) can be found in the U.S. as "No Scald DPA EC-283" 31% a.i. from Elf Atochem North America and "Shield DPA" 15% a.i. from Pace International LP. It can be applied only as a post-harvest drench. See product label for rates. The drench should be applied within 7 days after harvest (before storage) and is more effective when applied to warm, dry fruit.

Results are poor if fruit is cooler than 50°F. Scald is initiated during the first 30 to 40 days of storage for some cultivars, and after this time, treatment with DPA may have no beneficial effects. Do not mix calcium chloride or other chlorine products with DPA as they may react with the DPA. Drench fruit thoroughly by dipping the entire container or by overhead drenching of the containers long enough to cover fruit thoroughly, but not to exceed 30 seconds. Be sure the DPA solution is well drained out of containers, or fruit injury may result. Tilt bins if necessary. Do not use bins with liners. Wash and brush fruit either before treatment or after storage. Follow label instructions for rates for each cultivar. Some cultivars are more easily injured by DPA than others. Do not treat too much fruit with a batch of solution. The solution should be replaced with a fresh solution daily or more often if it becomes dirty, usually after dipping 30 bins (750 bushels) in 100 gal. of solution. Keep solution well agitated to avoid stratification. Test kits are available from the company from which the DPA was purchased for testing solution concentration. Test concentration of solution daily and adjust the chemical concentration in the treatment solution (Table 19). Do not rinse apples after treatment. Cool fruit as rapidly as possible after treatment.

Table 19. Recommended concentration for DPA solution.

DPA (ppm)[a]	Cultivar
1,000	Rome Beauty, Turley
1,111	Baldwin
1,000-1,500	McIntosh
1,500-2,000	Stayman
2,000	Cortland, Delicious, Idared, R.I. Greening, Fuji

a DPA is not recommended for Golden Delicious.

If apples are to be shipped to another country, a determination needs to be made if the country will permit the sale of treated fruit. The statement "Treated with Diphenylamine to retard spoilage" is required on the shipping container in the U.S. Fruit treated with DPA may not be used for livestock feed, as illegal residues may occur in meat or milk.

Disposal: DPA cannot be discharged into lakes, streams, or rivers since it is toxic to fish. Disposal should be in a manner recommended by the manufacturer. Common methods of disposal include spraying the diluted DPA on the orchard floor (not to exceed 1,200 gal./acre), disposal into a plastic-lined evaporation pond, or disposal through a commercial waste treatment company.

Internal Breakdown

Internal breakdown is characterized by a browning of the flesh of the fruit and eventual softening and disintegration of the fruit. It is increased substantially by delayed harvesting. Fruit should be harvested at the optimum stage of maturity. Late-harvested fruit should be marketed promptly to minimize breakdown problems. Cultural practices that increase nitrogen levels and decrease calcium levels can increase breakdown problems.

Controls: Harvest promptly at the optimum maturity and market in a timely fashion. Harvesting at pressure tests of 12 lb or more for Red Delicious will help. Calcium sprays or dips as discussed under "Cork Spot and Bitter Pit" also can be helpful.

Cork Spot and Bitter Pit

Cork spot and bitter pit are physiological disorders of apples generally caused by calcium and/or boron deficiency during the fruit development period or the storage period. Cork spot is characterized by greenish to brown sunken spots on the fruit or in the fruit flesh. Spots can occur in midseason. The spots themselves are brown, corky, dead tissue. Typically, spots are grouped on the distal part of the fruit close to the calyx. If spots are present throughout the flesh, boron deficiency is probable. If spots are limited to the outer flesh, calcium deficiency is suspected.

Severity of cork spot varies from year to year. Excessively wet or dry periods in the spring resulting in inadequate uptake of calcium or boron can increase severity of the problem. Cork spot is more severe on trees that are coming into bearing, that have light crops, or that were heavily pruned or excessively fertilized with nitrogen. Soils that are too low in pH or in available calcium are conducive to cork spot or bitter pit.

Controls for Cork Spot: Cultural practices which increase pH to 6.2 to 6.5 and increase available calcium and boron to optimum levels will minimize cork spot and bitter pit. Adequate boron nutrition will help reduce cork spot. Be careful with soil applications as too much can be harmful. Where foliar analysis shows boron is deficient, soluble boron sprays at petal fall will be helpful. Calcium sprays will help to increase fruit calcium levels and thus help to reduce both cork spot and bitter pit. Early-season sprays are helpful in cork spot treatment, and late-season sprays are helpful with bitter pit. Many growers now include calcium chloride in all cover sprays after checking compatibility with pesticides. Generally 25 to 40 lb/acre per season or 3.2 to 5 lb/acre in each cover spray for eight sprays is necessary.

Bitter pit usually appears close to or after harvest and frequently after storage. Bitter pit is characterized as small, brown, sunken spots, with corky tissue under the spot, which are located around the calyx portion of the fruit. Jonathan spot is very similar to, or a form of, bitter pit.

Controls for Bitter Pit: Calcium chloride sprays before harvest can reduce bitter pit substantially. In addition, as with cork spot, severity of bitter pit can be reduced by lowering nitrogen levels, reducing the severity of pruning through annual moderate pruning, and promoting smaller size fruit through heavier cropping. Fruit should be harvested at optimum maturity. Harvesting immature fruit will promote bitter pit.

A post-harvest dip or drench of calcium chloride can reduce bitter pit substantially. Michigan research has shown that a 4 percent dip or drench of calcium chloride containing 33 lb of actual calcium chloride

per 100 gal. of water will reduce the disorder or delay its development. The calcium chloride should be food-grade or technical-grade material. The treated fruit should be stored immediately. The calcium chloride must remain on the fruit. After storage, the fruit must be washed to remove the calcium chloride before marketing or processing. Apples with finish problems may be damaged by calcium chloride. Calcium chloride can be combined with DPA for scald control. Include a fungicide to minimize storage rots. Calcium chloride is corrosive to metal, so care should be exercised in providing good maintenance of equipment and containers.

Measles (Internal Bark Necrosis)

This is a physiological disorder characterized by raised bumps or pimples on 2- and 3-year-old branches. The area in the cambial region under the bumps has brown to black necrotic streaks and spots. In severe cases, growth is reduced, and young trees may die. The problem is largely limited to spur-type Red Delicious trees. Measles usually results from either boron deficiency or manganese toxicity.

Control: Soil and foliar analysis can help determine possible causes. Boron sprays or soil applications can be helpful if needed. Excess manganese can only be reduced by raising soil pH in the root zone. Soil pH should be in the range of 6.0 to 6.5. On young trees, a degree of success can be obtained by injecting hydrated lime into the soil around the trees. Fifty pounds of hydrated lime is suspended in 100 gal. of water, and 5 gal. of this suspension is injected into the soil around the tree. A much better technique is to correct the orchard soil pH before the trees are planted, with a soil analysis and liming as needed.

Tree Nutrition

A great deal of judgment is needed in managing the nutritional status of fruit trees, especially in applying nitrogen. Growth as well as production and fruit quality are useful indicators of nutritional status. The average length of terminal growth on bearing apple trees should be 6 to 10 inches; on peach trees, 12 to 20 inches. If the average does not fall within these ranges, both fertilizing and pruning practices should be modified.

Leaf Analysis

Leaf analysis also helps in managing fruit tree nutrition. Leaf analysis (foliar analysis) is a more reliable indicator of a tree's nutritional status than soil analysis. Leaf samples should be taken between July 15 and August 15. Correct sampling techniques are essential for reliable results. Normal blocks are sampled every 3 to 5 years.

When a suspected nutrient deficiency or excess exists, take samples as soon as visual symptoms appear. Take samples both from trees where the suspected nutrient problem exists and from "normal" trees of the same variety, but keep the samples separate. The closer the "affected" and "normal" trees are together in the orchard, the better the comparisons will be. Do not include dead or severely affected leaves in the sample.

To increase the reliability of leaf analysis results, take leaves from different trees but from the same areas on the trees. Pull leaves from all sides of the trees in a band 4 to 6 feet above ground. Collect leaves from the middle of the current season's shoot growth, or if there is little or no shoot growth, collect spur leaves. Do not include the oldest or youngest leaves on a shoot. For one sample, collect four to eight leaves per tree from 25 trees of the same cultivar and apparent condition.

Avoid selecting dusty or soil-covered leaves if possible. Under normal conditions, rainfall is frequent enough to keep leaves fairly clean. If necessary, brush or wipe with a damp cloth to remove dust. If leaves are covered with spray materials, wash quickly in a mild detergent solution and rinse quickly in water. Do not let samples remain in the wash or rinse water very long. Contact your state Extension specialist for information on how and where to send the sample.

Soil conditions and nutrients available will vary widely from state to state, especially as soil pH changes. Inexperienced growers are advised to consult state Extension horticulture specialists to develop a fertilizer program.

Nitrogen

The "rule of thumb" about nitrogen for apple trees is 1 oz of actual nitrogen (3 oz of 33 percent ammonium nitrate) per year of tree age up to 1 lb of actual nitrogen per tree. For peaches, the suggestion is 2 oz of actual nitrogen (6 oz of 33 percent ammonium nitrate) per year of tree age up to 1 lb of actual nitrogen per tree.

For example, the suggested amount for an 8-year-old apple tree is 8 oz of actual nitrogen or 24 oz (1 1/2 lb) of 33 percent ammonium nitrate; for an 8-year-old peach tree, 16 oz of actual nitrogen, or 3 lb (48 oz) of 33 percent ammonium nitrate.

The amount of nitrogen applied should be adjusted according to the vigor and performance of the tree, the variety, and the amount of pruning. Increase the amount of nitrogen for weak trees and reduce the amount for vigorous trees. When pruning is heavy, reduce the amount of nitrogen applied, or add no nitrogen for one season. Also, when low-temperature injury occurs, do not apply nitrogen fertilizers.

Excess nitrogen increases fruit size and cork spot, but it delays maturity and seriously reduces color, sugar content, flavor, shelf life, and storage life. Excess nitrogen also increases the amount of pruning required and delays the hardening-off of the trees in the fall, making them more susceptible to winter injury.

A ground application of nitrogen is preferred to foliar feeding. If supplemental nitrogen is needed on red apple varieties, urea or calcium nitrate may be added to pesticide sprays. Apply during the period from pink to 30 days after petal fall. Use up to 5 lb of urea or up to 3 lb of calcium nitrate per 100 gal. of water. Do not use foliar applications on yellow apple varieties or on peaches or other stone fruits.

Ground applications of fertilizer may be made in the late fall, or in the early spring 4 to 6 weeks before bloom. Fall application frequently is more convenient because of the crush of pruning and other spring work. Numerous studies indicate little if any difference in effectiveness between fall and spring applications. The roots of fruit trees are active in nutrient absorption whenever the ground is not frozen, even though the tops are dormant. Peach growers may wish to apply half of the nitrogen in the fall or early spring and the other half about petal fall if a normal crop is present.

Phosphorus

In the central states, very few leaf samples are low or deficient in phosphorus. Soils apparently supply adequate amounts of phosphorus for normal fruit tree growth without the addition of phosphorus fertilizer. If soil tests show low phosphate levels, the cover crop may need phosphate fertilization.

Potassium

About a third of the leaf samples from commercial peach orchards and about a fourth of the leaf samples from commercial apple orchards in some midwestern states have been low in potassium. Harvested fruit removes considerable quantities of potassium. Each 100 bu of apples or peaches contain about 10 lb of potassium oxide (K_2O). Prunings also remove sizable amounts of potassium. Therefore, periodic maintenance applications of potassium are advisable.

For peaches, a maintenance application of potassium should be made each crop year. On soils with low available potassium (below 200 lb per acre by soil test), apples should also receive an annual maintenance application. If the soil has more than 200 lb of potassium per acre, apples should receive maintenance amounts every other year. Check the nutrition conditions by leaf analyses.

Potassium should be applied to the soil rather than the leaves, since the leaves do not absorb appreciable quantities of this nutrient. Either muriate of potash (0-0-60) or sulfate of potash (0-0-50) may be used. Potassium may also be applied in mixed fertilizers if the rates are adjusted to apply amounts equivalent to the rates suggested. A general suggestion for apples is 1 lb of muriate or sulfate of potash per tree for young trees, 2 lb per tree for dwarf or semi-dwarf trees in full production, and 4 lb per tree for large trees in full production. For broadcast applications, use 150 to 200 lb per acre.

For peaches, apply 1 lb of muriate or sulfate of potash per tree for young trees and 2 lb per tree for

trees in full production; or apply 150 to 200 lb per acre broadcast.

Since the levels of phosphorus and potassium vary among geographic locations, preplanting soil tests are strongly advised.

Boron

Boron is the minor element most likely to become low in central states apple orchards. So far, leaf analyses do not indicate a shortage of boron on peaches.

Boron is most conveniently applied to apple trees as a foliage spray. Boron is essential for pollen germination; therefore, the first application should be in the pink stage. Add 1 lb of Solubor per 100 gal. of water (2 lb per acre for low-volume sprays) to the pink spray, and again in the petal-fall spray. Do not exceed this amount. Excess boron can be toxic. Do not mix Solubor with calcium chloride.

Calcium

Low levels of calcium in the leaves and fruit of apple trees are associated with the physiological disorders bitter pit and Jonathan spot. Although low levels of calcium are not considered to be the primary cause of these disorders, their severity is frequently reduced by increasing the calcium levels of the leaves and fruit.

Spray applications of calcium chloride are suggested, especially for varieties subject to corking disorders. Starting with the first-cover spray, add calcium chloride at the rate of 2 lb per 100 gal. of dilute spray (4 lb per acre for low-volume spray) until late July. Then increase the calcium chloride rate to 3 lb per 100 gal. of dilute spray (6 lb per acre for low-volume spray) for the later cover sprays.

During prolonged dry weather, eliminate calcium chloride applications to prevent an excessive buildup on the foliage, which may cause leaf burn. If there has been no rain for two calcium chloride applications, wait until rain washes the calcium chloride off before reapplying. Increasing the calcium chloride application rate just before harvest helps to prolong the shelf life and storage life of the fruit.

Adding calcium chloride to the regular insecticide and fungicide sprays should have no effect on the action of these materials. Likewise, the addition of calcium chloride to the regular sprays should have no adverse effect on the fruit finish. The commercial grade of calcium chloride (94% to 97% $CaCl_2$) at the rates added to cover sprays does not greatly affect spray water pH. Added to alkaline tap water, it tends to make the water less alkaline.

Calcium chloride is corrosive to metal. After spraying with calcium chloride, rinse the sprayer thoroughly, and hose down the sprayer and the tractor.

Soil Reaction (pH)

Soil reaction (pH) affects fruit trees indirectly through its effects on the availability of several soil nutrients. In strongly acidic soils (pH below 5.0), the availability of phosphorus is reduced and the solubility of iron, aluminum, and manganese is increased so much that they may become toxic to plants. The pH of orchard soil should be kept in the 5.5 to 7.0 range through applications of agricultural lime.

Spray materials and fertilizers applied to fruit trees may cause the soil under the trees to become more acidic. In testing for pH, it is advisable to test samples taken under the trees separately from samples taken from the aisles. The soil under the trees may be more acidic and thus may require more lime than that in the aisles.

Young apple trees sometimes develop a condition called “measles” (internal bark necrosis) when the soil pH is 5.5 or below. Red Delicious trees are especially susceptible. Some growers have prevented or reduced the symptoms of measles by watering each tree with 5 gal. of a solution of 40 lb of hydrated lime in 100 gal. of water.

Pollination

Pollination of flowers on all midwestern-grown fruit plants is required for fruit production. Viable seeds are required for fruit development in all fruits. In apples, pears, and quince, multiple seeds are required for good fruit development. In most fruits, self-pollination will

result in the development of fruit. However, cross pollination is required for some cultivars of fruits.

In apples, pears, sweet cherries, and some plums, adequate numbers of pollenizer trees with compatible pollen must be provided throughout each orchard block to provide for pollination. Peaches and tart cherries do not require cross pollination.

Ideally, no tree should be farther than 100 feet from a pollenizer tree, and the nearer the pollenizer is to the main cultivar, the better the chances are of good pollination. Be careful that the cultivars used as pollenizers have viable pollen. Mutsu (Crispin), Sir Prize, Jonagold, Stayman, and a few others are triploids that do not have viable pollen, so they cannot be used as pollenizers.

In most blocks, double rows of pollenizer trees can be planted between rows of the main cultivar in a pattern such that the 100-foot requirement is satisfied. The double rows are suggested to improve management of the second or pollenizer cultivar. Because of the possibility of lack of overlap of bloom in some years, at least two pollenizer cultivars are suggested. Another pollination scheme is to plant a solid block of the main cultivar and interplant crabapple trees trained to a single slender spindle. Care must be taken to select crabapple cultivars that will bloom at or just ahead of the main cultivar. Extremely early-blooming cultivars such as Braeburn benefit from crabapple pollenizers. Most midwestern orchards grow enough fruiting cultivars that the cultivars can be interplanted to provide a satisfactory pollinating mix. Yet another configuration of pollenizers used is every third tree in every third row. This represents a minimum of supplied pollen, however, and it also creates management problems.

Bees

Pollination is accomplished primarily by insects such as bees and wasps. The domestic honeybee is the most important insect pollinator for the fruit industry. Bees pick up pollen in the process of visiting flowers of the fruit plants. This pollen is redistributed in the course of the bees' travels to hundreds of flowers on each flight. Recent work in Michigan indicates that pollen exchange among bees in the hive is an important method of achieving cross pollination of fruit crops.

In placing bees in an orchard for pollination, it is suggested that at least one strong hive be used per acre of fruit. Strong hives with plenty of worker bees are much better than weak hives or package bees that have not been established. The number of bees will depend on the weather during bloom and the amount of viable pollen available. Rainy, cold, windy weather will reduce bee activity and result in poor pollination. Tree canopies that are open and admit adequate light will be most conducive to good bee activity. Very low humidity during bloom can reduce the time that flower stigmas are receptive.

Hives need not be placed individually across the orchard, but may be placed in groups of four to six hives where they may be more conveniently handled. Choose sites that are well distributed through the orchard, but that are also sunny and protected from wind. Bring bees in at about 10 to 20 percent bloom and remove after good pollination has been achieved or before the petal-fall spray is applied. Remove all competing bloom on the orchard floor or in adjacent spaces by mowing or chemical weed control so that the bees are not distracted.

For most growers it is probably better to rent bees unless the orchardist is interested in beekeeping as a separate enterprise. Bees may usually be rented for a reasonable fee, and the contractor will bring the bees into the orchard and remove them promptly when notified that the petal-fall spray is to be applied. The fruit grower must notify the contractor and must not spray with insecticides during the time the bees are in the orchard. A written contract would be desirable.

Protecting Honeybee Colonies during Pollination

Mow orchard cover crops before placing hives in or near the orchard. This eliminates the availability of competing pollen and nectar plants and also reduces the risk of pesticide injury to bees.

After honeybees have moved into the orchard, no work should be done during honeybee activity which might interfere with pollination, such as overhead

irrigation, pesticide application, or cultivation when dust will be excessive. These activities not only disturb bees, but they also interfere with normal pollen gathering, germination, and fertilization.

Provide an uncontaminated water supply for the bees. Notify neighboring farmers around the orchard of the dates the bee colonies will be placed in the orchard and for how long. Applying pesticides to plants that bloom near orchards and are attractive to bees should be done with caution.

Chemical Fruit Thinning of Apples

Chemical fruit thinning of apples enables growers to overcome the alternate bearing habits of some cultivars and to improve the size and quality of the fruit in years of heavy set. The materials suggested are Accel (benzyladenine), NAA (naphthaleneacetic acid), Amid-Thin (naphthaleneacetamide), and Sevin (carbaryl). Suggested materials and dosages for the different varieties are given in your state's tree fruit spray guide.

Because of variability of chemical thinner response, it is recommended that growers use all thinners on a trial basis until they become experienced. If seed numbers are small, or trees are weak, or if the weather is cool and cloudy, use lower concentrations of thinner chemicals. Also, remember that young trees are generally easier to thin than mature trees. All thinner applications should be based on average fruit diameter. Average fruit diameter should be determined by measuring all growing fruitlets per cluster. Sample randomly selected clusters throughout the tree canopy and orchard. At least 100 fruitlets should be measured to calculate average diameter. Measure each cultivar separately. All hand-gun applications should be made to the point of runoff at a rate of chemical use that is one-third to one-half the rate recommended for an airblast application.

Accel

Accel (benzyladenine) is a relatively new thinner that was introduced in 1994. Accel thins over a wide window, probably bloom to 30 days after full bloom, and is reported to promote cell division. It is labeled post-bloom (10 mm fruit size). It is a gentle, mild thinner and is dose-dependent. It can be applied to all cultivars; however, further testing is being done on some cultivars, and the latest label should be checked for the list of cultivars and rates. At the present time, Accel is not recommended to be used with NAA or NAD on the same tree within the same year. The combined use, in the same year, of Accel and NAA or NAD on Red Delicious has resulted in more pygmy fruit.

NAA

On Lodi, Early Gold, and Transparent, a combination of NAA and Sevin applied at petal fall usually gives better results than either material alone. On Golden Delicious, some growers have had good results with the combination of NAA and Sevin applied at the normal time for applying NAA on Golden Delicious.

On Starkrimson and other spur-type Red Delicious strains, NAA has occasionally caused problems with pygmy fruit. Instead of dropping off, these seedless pygmy fruit remain on the tree until harvest, growing to about one-fourth normal size. Where pygmy fruit presents a problem, Sevin should be used for thinning. Do not apply high NAA concentrators late in the thinning season.

When NAA is the only thinning agent applied, its absorption and effectiveness are greatly increased by use of an activator. The concentration of NAA can roughly be cut in half if Tween 20, Amway wetting agent, or Regulaid is used. These activators help to counteract the variable effects of weather conditions on the absorption and effectiveness of Amid-Thin and Sevin.

Because of variable growing conditions, NAA sprays are best timed according to fruit size rather than days after full bloom. NAA is most effective on fall and winter varieties when most of the fruits are 8 to 10 millimeters in diameter, the king blossom fruit is 10 to 13 millimeters, and the smallest fruits are less than 8 millimeters.

NAD

NAD is similar to NAA, but milder. Its use should be limited to petal fall as later use can result in pygmy

fruit. It is recommended for use on cultivars that ripen before McIntosh and works best when applied under slow drying conditions. Frequently, follow-up thinning is required.

Sevin

XLR Plus is the preferred formulation of Sevin for thinning. Sevin, an insecticide, is toxic to bees, and they should be removed from the orchard before use. Sevin is dose-dependent up to a point; however, it seldom over-thins. It can be used from petal fall to about 21 days after bloom. It is frequently combined with Accel or NAA for heavy thinning late in the thinning window. The limit is about 25 millimeters fruit size. Over-thinning has been reported with these combinations, so local experience is the best way to determine rates.

Important reminders about chemical thinning: NAA generally gives best results under fast drying conditions, and when the temperature is between 70° and 75°F. Amid-Thin gives the best results under slow drying conditions and is often applied in the evening. Accel is most effective when air temperature is 70° to 75°F.

Thorough spraying and uniform coverage are necessary for satisfactory results. However, if you want to reduce the degree of thinning or are afraid of over-thinning, reduce the concentration but not the gallonage applied per tree.

Lower limbs are easier to thin than upper ones. Reduce the spray application on the lower limbs by shutting off one or more nozzles; some spray applied to the tree tops will fall on lower limbs.

Concentrate sprays of chemical thinners have been satisfactory. Care should be exercised that calibration is correct so that the right amount of material is applied to all parts of the tree and row. Be careful to avoid double applications to row ends, etc. Miscalculation of the sprayer manifold is magnified in concentrate application. Concentrating more than 4x has resulted in variable results and should be avoided.

Applying chemical thinning sprays after frost or freezing temperatures is risky. Foliage exposed to such conditions absorbs chemicals much more readily, and over-thinning may result. If you must spray under such conditions, reduce the concentration 25 to 30 percent.

Chemical thinners are generally more effective under the following conditions:

- low-vigor trees,
- light pruning,
- heavy bloom,
- poor pollination,
- high humidity before spraying,
- slow drying of spray,
- poor air drainage, and
- cloudy, cool weather preceding or following the bloom period.

You should keep records of the conditions prevailing when you make applications and should leave several trees unsprayed to evaluate critically the results of thinning applications. This way you will be able to work out the concentrations best suited for your orchard conditions.

According to Schwallier, "The weather during and just after the thinning application is the most important factor to consider in predicting the thinning response."

Summary: Apply thinning sprays separately from other sprays. When possible, use dilute concentrations with full coverage of the tree parts to be thinned. Low-volume application involves more risk. Growers having only low-volume spraying equipment should use the highest volume possible with these machines.

Fruit Maturity Analysis

Starting 3 weeks before the anticipated harvest, select at random two fruit per sample tree, record the cultivar, then determine the following indices of maturity: skin color (striped or solid), seed color, soluble solids, fruit pressure, and starch-iodine test. Taste, dark brown seeds, skin color, and pressure tests in the 16 to 19 lb range indicate fruit ripeness.

Starch-iodine Testing: As fruit mature, starch is converted to soluble sugars. Iodine turns starch black; therefore, an iodine solution can be used to determine the amount of starch remaining in the fruit. A solution of 10 grams of potassium iodide and 2.5 grams of

iodine in 1 liter of water should be used. During mixing and use of this solution, make sure the area is well ventilated—iodine fumes are toxic. This solution should be stored in a plastic or glass container as it is corrosive to metals. Providing the container is well stoppered, the solution will keep for long periods of time. Fruit should be cut in half through the equator and the cut surface dipped or sprayed with the iodine solution from a plastic spray bottle. The starch patterns will develop in approximately 1 minute. As fruit mature, starch clears from the core first, followed by the cortex. These patterns will be slightly different for each variety. The following photograph shows a generalized pattern that can be adapted for a given variety (Figure 8). Compare the starch iodine index of the fruit with those in Figure 8. The starch index at which fruit should be harvested depends on the intended length of storage. As a guide, fruit destined for storage should be harvested at a starch-iodine index of 4 to 5, whereas fruit for immediate sale should be harvested at an index of 6 to 7. As with any indicator of fruit maturity, the starch-iodine index should be used in combination with other maturity tests.

Pressure-testing Fruit: Pressure testing is one means to determine fruit maturity. A suitable sample will consist of 10 fruit selected at random from a number of trees within a block and from various locations within the trees. Two measurements should be taken on each fruit—one on the blush side and the other on the opposite side, at the midpoint of each side, after removing a 1/2- to 3/4-inch diameter disc of peel.

Use a 7/16-inch (large) plunger. Hold the fruit firmly in the left hand, while holding the fruit pressure-tester between the thumb and forefinger in the palm of the right hand. Set the indicator hand to zero and then place the plunger against the fruit, and press with increasing strength until the plunger tip penetrates into the pulp up to the notch.

Slow penetration of the plunger is essential. Sharp movements and sudden pressure application may impair your measurements. In order to avoid mistakes and to assure slow penetration of the plunger, hold the apple firmly and keep your arm rigid. You may want to hold the apple on a table for this.

Soluble-solids Testing: The soluble solids level in the fruit refers primarily to the fruit sugar level. The equipment needed includes a refractometer, paper towels or toilet paper, and a squeeze bottle of water. Clean the prism and cover it with water; then look through the instrument and adjust the refractometer to read 0 for the water if necessary. Clean and dry the prism, and squeeze a few drops of apple juice on the prism from the bottom portion of an apple not used in the starch-iodine test. Read and record the soluble solids (SS). Note the correction for the present temperature. Rinse and dry the prism between each reading. Usually the instrument will need calibration only once a day. It should be checked with water at the start of each site. Record one SS per apple pressure tested. Ripe Delicious apples usually have soluble solids of greater than 10 percent.

Seed Color: Seed color is recorded from the apples that are sampled above. Record seed color as white, light brown, dark brown, or black. Seeds from mature fruit will be dark brown to black.

Getting Good Fruit Finish

Obtaining good fruit finish on apples is a perennial problem in the Midwest because of our variable weather patterns. A roughness of the skin, commonly called russet, is most likely to occur on Golden Delicious but sometimes affects other cultivars. Although russet does not affect the flesh, it detracts from the appearance of the fruit, thus reducing its value.

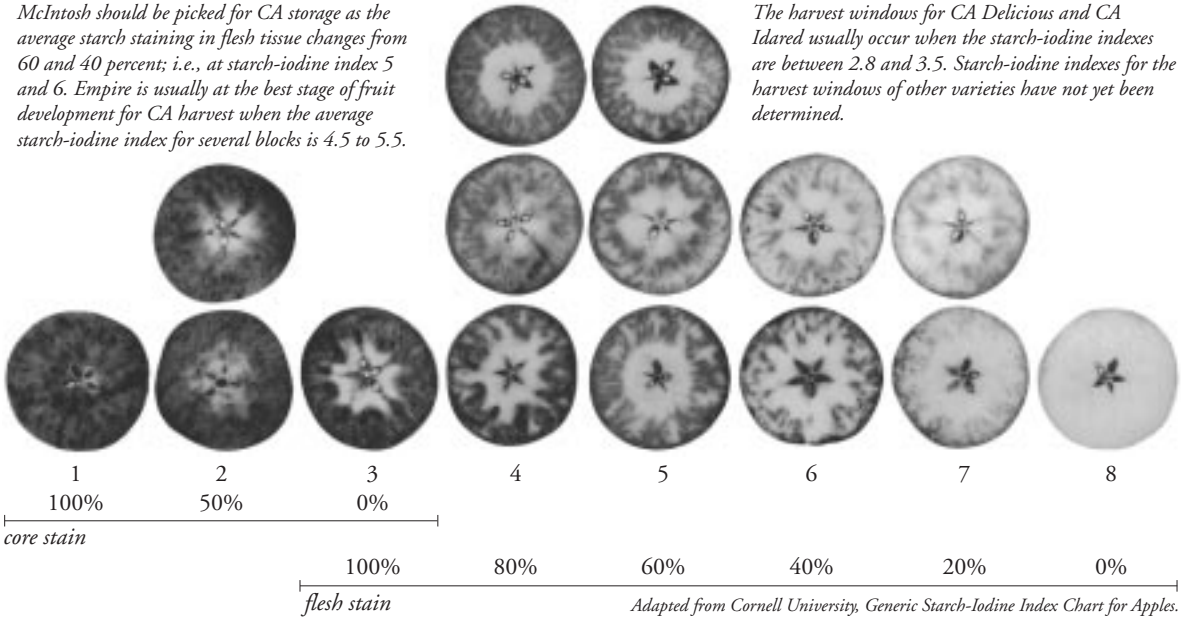
Table 20. Anticipated days from bloom to harvest for a number of cultivars.

Cultivars	Days from Bloom to Harvest
Yellow Transparent	70-90
Lodi, Pristine	75-95
Mollies Delicious, RedFree	120-125
McIntosh, Cortland, Gala	125-145
Jonathan, Liberty, Grimes Golden, Empire, Red Delicious, Jonafree, Golden Delicious, Jonathan	140-145
Mutsu	145-170
York Imperial	155-175
Rome, Winesap, Stayman	160-175
Granny Smith, Fuji, Braeburn, Goldrush, Enterprise	180-210

Figure 8. Starch-iodine indexes for Red Delicious apples.

McIntosh should be picked for CA storage as the average starch staining in flesh tissue changes from 60 and 40 percent; i.e., at starch-iodine index 5 and 6. Empire is usually at the best stage of fruit development for CA harvest when the average starch-iodine index for several blocks is 4.5 to 5.5.

The harvest windows for CA Delicious and CA Idared usually occur when the starch-iodine indexes are between 2.8 and 3.5. Starch-iodine indexes for the harvest windows of other varieties have not yet been determined.



Adapted from Cornell University, Generic Starch-Iodine Index Chart for Apples.

Weather conditions alone can cause russet, but most russet results from a combination of weather conditions and spray programs. Certain chemicals are more likely to cause russet than other chemicals when applied during certain weather conditions.

The most critical period for russet development is between the pink-bud stage and the third cover spray. But the period from the fourth cover spray until harvest is also important.

Some Precautions for Getting Good Finish:

- Do not apply the bloom, calyx, or first two cover sprays within 24 hours before a predicted freeze, during a freeze, or within 24 hours after a freeze. Almost any chemical will damage fruit if used during these weather conditions. Cyprex is especially dangerous in freezing or near-freezing weather. To be completely safe, do not spray when temperatures are below 45°F, particularly in the lower elevations of the orchard.
- Do not use any copper materials (Bordeaux mixture, insoluble coppers) except during the dormant and delayed dormant periods.
- Do not apply cover sprays in the heat of the day. Never spray when the temperature is above 90°F. During the late spring and summer, spraying at night, in the early morning, or after 4:00 p.m. is suggested.
- Do not use sulfur in any form when the temperature is 85°F or above.

The suggestions given apply to all varieties but are most pertinent for Golden Delicious. Two additional precautions should be taken for this cultivar:

- Select fungicides that are least likely to cause injury. Captan, Polyram, mancozeb, Nova, and Rubigan are the best suggestions.
- The organophosphates are likely to cause injury in the petal-fall spray. Most orchards that are well cared for and in which other varieties are sprayed with an insecticide in the early petal-fall and first-cover periods probably could use fungicides only in these two sprays on the Golden Delicious and would have less cull fruit. Make sure the aphids are controlled before the pink-bud stage.

If disease, insects, or mites should become critical during any period when spraying might cause russet, then you will have to decide which is the lesser of the evils.