or stems of plants, but they can be easily encouraged to nest in cardboard tubes or wooden nesting blocks drilled with holes of the correct diameter.

In the Mid-Atlantic-region, *Osmia* are active only for about 6 to 8 weeks from about mid-April through mid-June. Males emerge about 1 week before pear trees bloom in the spring. Females emerge 2–3 days after males, or longer, depending upon weather conditions. Mating occurs immediately after females emerge.

Both male and female bees make floral visits. Females collect primarily pollen and carry it on the lower surface of their abdomens (unlike honey bees, which carry pollen on their legs). After their ovaries have developed fully, females begin provisioning cells and laying eggs within the nest "tube." They collect a large mass of pollen first and then nectar, which they regurgitate on the pollen ball. This sticky nectar acts as glue to hold the egg on the pollen ball. After the egg is laid, a mud wall is built and the next cell is provisioned and the next egg is laid. Females can make 1–2 cells a day under favorable conditions.

Newly laid eggs take approximately 3 days to hatch. The larvae consume the pollen over a 2–3 week period. They later pupate and develop into adults, but will remain within their cells throughout winter and emerge the following spring about 1 week before pear bloom.

Management of Osmia

Once they are initially obtained, *Osmia* species are relatively easy to manage. They will nest in cardboard tubes or wood blocks that have 5/16-inch diameter openings and are between 4 and 10 inches deep. Under favorable conditions, and with availability of abundant nest sites, populations tend to double or triple from year to year. Females tend to nest in the same area (instead of flying off to seek a new nesting site) when there are 3 to 5 times as many empty as full tubes. Both species of *Osmia* are susceptible to parasitic wasps if they are left in the field during June and July. It is best to remove the nesting tubes from the field once the adult bees are no longer active and store them in an unheated, parasite-proof shelter.

The Japanese hornfaced bee is less cold-tolerant and must be sheltered when temperatures get below 10°F. They do best in a humid, temperate climate, in USDA Plant Hardiness Zones 5–8. You may place hornfaced bees in a refrigerator for winter storage, but make sure humidity levels stay around 75 percent. Hornfaced bees require a cold period before they can emerge from their cells. It should be noted that experience has shown that *Osmia* obtained from the western U.S. may not adjust well to conditions in the Mid-Atlantic region.

While the Japanese hornfaced bee does not occur naturally in our area, the blue orchard mason bee (*Osmia lignaria*) and other solitary bees are common throughout the Mid-Atlantic region. It may be possible to encourage these bees to form aggregations in your orchard simply by providing nesting sites and restricting the use of pesticides during the short period that these bees are active.

To learn more about the management of solitary bees, where to obtain these bees and/or cardboard nesting tubes, please visit the MAAREC Web site at http://MAAREC.cas.psu.edu/, or contact your county extension office or the Penn State Department of Entomology at 814-865-1896.

Planting Depth

Apple rootstocks are usually propagated clonally in stool beds and have been selected because they root well. The roots are induced on aboveground parts of a stem. When apple trees are budded high on rootstocks and planted with a union at the ground, the belowground portion of the rootstock has the ability to form roots.

When the union is planted 2 or more inches aboveground, the exposed portion is unable to form normal roots and may form root initials or burr knots instead. Burr knots are areas of rootstocks where roots try to form but cannot because they are not in a medium conducive to root growth. Rootstocks with burr knots do not enlarge radially in a normal fashion because phloem and xylem cells do not develop all the way around the tree. Several species of tree borers may enter burr-knot areas. Thus, apple rootstocks should be planted with the union at ground level. When mechanical tree planters are used, trees may be set too high. However, trees can be set 1 or 2 inches deeper and manually adjusted to the proper depth. Research suggests that the height of the union also will influence the amount of dwarfing induced by a rootstock. The more of the rootstock shank that is exposed the greater the dwarfing. A general rule of thumb is that for every 4 inches of exposed rootstock shank below the graft union you can expect 10 percent more dwarfing.

Fertilizing Newly Planted Apple Trees

Newly planted apple trees require special attention where nitrogenous fertilizers are concerned. Lack of application, improper placement, or high rates can seriously damage young trees. Incorporating fertilizer into the hole at planting is not recommended because this practice can kill trees by burning young roots. Failure to apply nitrogen after planting can result in less-than-ideal growth. The rule of thumb when fertilizing new trees is to apply 0.02 pound of actual nitrogen per year in the orchard for the first 3 years. After this period, nitrogen application should be based on leaf analysis results and shoot growth. Any phosphorus or potassium as recommended by a soil test should have been applied to the field before planting and incorporated.

Follow the suggestions below for newly planted apple trees:

- Apply all fertilizer on undisturbed soil and keep the material 12 inches away from any disturbed soil (for trees planted by either auger or tree planter).
- If the nitrogen source is not critical, use whatever material is cheapest per unit of nitrogen. Table 1-10 lists the amounts of various nitrogen sources to be applied per tree to achieve the required 0.04 pound of actual nitrogen per year. If you use a source other than those listed, calculate the amount of material needed in the following fashion. First, multiply 0.02 by 1 (for a result in pounds per tree); or by 16 (for ounces per tree); or by 454 (for grams per tree). Divide the result by the decimal equivalent of the percentage of nitrogen in the material.

  Example: You have a material with a nitrogen content of 46 percent. You wish to find out how many ounces to apply per tree before the beginning of the second growing season.

  0.02 x 16 oz = 0.32 oz
  0.32 oz / 0.46 = 0.7 oz
  0.7 oz x 2 years = 1.4 oz per tree at the beginning of the second year

Table 1-9. Sources of nitrogen, nitrogen content, and application rates.

Nitrogen source	Nitrogen content	Actual amount of material to apply per tree
Urea	(46% N)	0.04 lb or 0.7 oz or 20 g
Ammonium nitrate	(33% N)	0.06 lb or 0.97oz or 28 g
Monammonium phosphate	(11% N)	0.18 lb or 2.9 oz or 83 g
Diammonium phosphate	(18% N)	0.11 lb or 1.8 oz or 50 g
Calcium nitrate	(15.5% N)	0.13lb or 2.1 oz or 59 g
Sodium nitrate	(16% N)	0.125 lb or 2.0 oz or 57 g
19-19-19	(19% N)	0.10 lb or 1.7 or 48 g
10-10-10	(10% N)	0.20 lb or 3.2 oz or 91 g
5-5-5	(5% N)	0.40 lb or 6.4oz or 182 g

Cork Spot and Bitter Pit Fruit Disorders

Cork spot and bitter pit in York Imperial, Delicious, and Golden Delicious apples, along with other calcium-deficiency physiological disorders, continue to cause apple producers economic losses. These disorders appear to be specifically related to low levels of calcium and sometimes high levels of nitrogen in the fruit flesh. Fruit flesh calcium content is influenced by many factors. Good horticultural management techniques that improve soil conditions, encourage uniform annual cropping, and encourage moderate tree vigor will decrease calcium-related fruit disorders.

Corking, characterized by spherical dead areas in the flesh, is an orchard disorder, while bitter pit is primarily a storage disorder and usually attacks the skin and adjacent cells. However, symptoms vary according to area, variety, and environmental conditions, making this distinction less than clearcut.

While corking is worse under conditions of low calcium, lack of calcium does not appear to be the sole cause. Corking is worse under conditions of excessive tree vigor or moisture stress and has been most severe on Delicious and York Imperial. Bitter pit is worse on Golden Delicious and is aggravated by early harvest.

During the past 20 years much research has been conducted on calcium nutrition of apples in South Africa, Australia, New Zealand, England, and the United States. From this research, as well as research conducted in Pennsylvania, a comprehensive program is recommended to reduce corking and bitter pit.

A program to control bitter pit and corking should involve almost all cultural practices conducted in apple production, since no one practice guarantees control of the disorder below the economic injury level. An effective program should be based on the consideration of all five factors explained below, since in any specific orchard block one factor could be primarily responsible for the problem. Growers are urged to use these recommendations when the cost of control practices is less than losses from the disorders.

The five points in the program are listed as a person should think of them in the life of an orchard and not in order of effectiveness. Calcium chloride sprays, though listed last, offer many advantages over other parts of the program mainly because they can be started in June the year of harvest, while some of the other practices take years to accomplish.

Soil conditions

Poor soil conditions can contribute to low-calcium fruit; factors to consider are explained in Table 1-11. Water stress caused by either excessive or deficient soil moisture can contribute to increases in corking and bitter pit. Tiling to remove excessive moisture and irrigation to supply supplemental water should be practiced as appropriate.

Correcting low soil pH with agricultural limestone is recommended to reduce the availability of soil aluminum and manganese, thereby maximizing the size of the root system. The magnesium content of the lime should be regulated by the tree's requirement for magnesium and the total amount of lime needed. High-magnesium (dolomitic) lime should not be used for routine soil pH correction. High-magnesium lime should be used when a soil test indicates the need for lime and a leaf analysis indicates the need for a large amount of magnesium.

Balanced nutrition

Soil testing to check soil pH and leaf analysis to determine the plant's uptake of essential nutrients are necessary in managing an orchard fertilization program. Listed in Table 1-12 are the nutritional elements that need to be managed to produce high-calcium fruit, their modes of action, and grower actions. Avoid excessive levels of nitrogen, potassium, and magnesium and deficient levels of calcium, boron, and zinc, since these conditions may contribute to deficient fruit-calcium levels.

Although soil testing and leaf analysis are not practiced by all growers, they are universally recognized as the best methods on which to base a sensible nutritional program. These two tools will minimize wasted money on unnecessary fertilizer, prevent the application of nutrient elements already present in adequate

Table 1-10. Poor soil conditions that may result in low-calcium fruit disorders, their modes of action, and corrective measures.

MODES OF ACTION	CORRECTIVE MEASURES
Excessive soil moisture	
1. Water stress in trees owing to lack of air for roots.	1. Plant orchards on deep, well-drained soils with good water-holding capacity.
2. Restricted root system caused by poor root growth.	2. Install drainage tile.
Deficient soil moisture	
1. Water stress in trees caused by deficient soil moisture.	1. Plant orchards on deep, well-drained soils with good water-holding capacity.
2. Restricted root system owing to poor root growth.	2. Irrigate as needed to reduce water stress.
Low soil pH	
1. Restricted root growth caused by aluminum and manganese toxicity. 2. Deficient soil calcium. 3. Deficient soil magnesium.	Maintain soil pH between 6.0 and 6.5 with high lime. Regulate the quantity of magnesium applied analysis indicates magnesium is very low. Dolomitic lime should probably be thought of as a potent magnesium fertilizer and also as a liming agent.

or excessive amounts, and recommend application of only those fertilizer elements necessary to ensure a profit for the grower.

Calcium sulfate

The use of gypsum (calcium sulfate), also called landplaster, to correct poor soil structure is a reasonably old practice. Gypsum can improve soil structure by increasing the aggregation of several small soil particles into larger particles. This can result in faster rates of water infiltration. Gypsum also is used as a source of calcium for soil applications on some crops. Peanuts in the southeastern U.S. are routinely sidedressed with about 1,000 pounds of gypsum annually. The use of gypsum to improve the calcium status of apple trees and fruits has been investigated in only two North American sites.

In Massachusetts, a series of studies has been conducted on Delicious and Cortland apple trees. In general, it appears that it takes 2–3 years for results to appear in the fruit. The treatments raised leaf and fruit calcium levels (20 percent and 10 percent, respectively), depressed leaf and fruit magnesium levels (20 percent and 5 percent, respectively), but had no effect on leaf and fruit potassium levels. Little or no effect was seen on fruit firmness at harvest or after storage, but bitter pit (50 percent reduction) and senescent breakdown after storage were reduced. Although high rates were used in early studies, in later studies it appeared that annual rates of as low as 3 to 4 tons per treated acre per year were effective. In a Nova Scotia study, annual applications of 5 tons per treated acre, for 5 years, raised leaf and fruit calcium levels in years 2 through 7 of the study but lowered magnesium levels.

For growers who have persistent calcium problems and who feel adventurous, the following treatment regime is suggested on an experimental basis. Apply 3 tons per treated acre, banded under the trees. This likely will be between 1.5 and 2.0 tons per acre of orchard. Follow a strict soil and leaf analysis program on an every-other-year basis to avoid nutritional problems. Special attention should be paid to magnesium, as gypsum may depress magnesium uptake.

Gypsum comes in various grades based largely on its color, with white grades being more expensive. For this use, the only relevant characteristic is the percentage of calcium in the product. The use of gypsum will not reduce the grower's need for lime.

Moderate tree vigor

Since the vegetative portions of a tree have relatively high concentrations of calcium and are seldom deficient in it, excessive tree vigor can use calcium that otherwise might be available for the fruit. Table 1-13 contains a list of factors that need to be considered to promote moderate vegetative vigor in apple trees. Excessive pruning and nitrogen fertilization, coupled with overcrowding of trees, are often interrelated and can result in overly vigorous trees. Excessive tree vigor can also result from an inadequate fruit load. Growth regulators should be used to obtain a uniform fruit load in order to promote uniform, moderate tree vigor.

Moderate fruit density

High levels of corking and bitter pit may be found on trees with a light crop. When trees bear a light crop of apples, the fruits are normally very large and low in calcium. They are prone to low-calcium physiological disorders. Apples on trees with an excessively large crop usually have little corking and bitter pit but seldom reach optimum size to maximize profitability. Table 1-14 contains a list of factors that need to be managed to produce annual crops of moderately sized fruit. Some factors to be managed for uniformity of cropping are frost protection, pollen source, bee population, and pollinating weather.

A prerequisite for achieving moderate annual fruit density is the annual production of high-vigor fruit buds. An essential ingredient in this program is the effective use of growth regulators to thin excessive crops and to encourage the production of high-vigor flower buds for the following year's crop. Many registered growth regulators are available for this purpose, including NAA, NAAm, Ethrel, and Sevin. See other sections of this guide for current recommendations in the proper use of these products.

Calcium sprays

Sprays of calcium chloride have been successful in reducing or commercially controlling corking and bitter pit, but seldom have these sprays completely eliminated the problem. Extensive research has been conducted around the world to define the products, rates, and timings that will minimize the incidence of low-calcium physiological disorders in apples. The major portion of the research has been conducted on Golden Delicious and York Imperials. However, recommendations developed from research in Pennsylvania have effectively controlled corking and bitter pitting in nearly all varieties.

The effective use of calcium chloride tree sprays may be the most cost-effective, quickest cultural practice for reducing low-calcium physiological disorders in apples. We recommend applying 15 to 50 pounds of calcium chloride per acre per season in six to eight cover sprays. Calcium in the form of calcium chloride is recommended because of its proven effectiveness and lower cost.

Other products that supply calcium are available. Many are recommended at rates that supply lower amounts. These products may be beneficial when only small amounts of calcium are needed to correct the deficiency. To evaluate other materials effectively, growers should compare the cost per pound of actual calcium and the amount of formulation needed to achieve an equivalent rate to the 15 to 50 pounds of calcium chloride per acre per season needed to control problems. See "Determining the amount of elemental calcium in a commercially formulated product." Growers experiencing severe bitter pit on summer cultivars, especially Summer Rambo, may need to apply special calcium sprays in addition to cover sprays.

15–20 pounds per acre per year: This is the lowest rate that should be used. It will give some control of bitter pitting and corking, will cause no leaf burning, and will probably not enhance storage life of the fruit.

20–30 pounds per acre per year: This rate should give good control of preharvest physiological disorders and probably should be the standard rate where these disorders are chronic problems. It will not cause any significant leaf injury and will probably not enhance the storage life of the fruit.

Table 1-11. Nutritional imbalances that may interfere with production of high-calcium apples, their modes of action, and corrective measures.

MODES OF ACTION	CORRECTIVE MEASURES
Excessive nitrogen (N)	
1. The flesh of fruit from high N trees is more likely to have corking (direct effect)	Regulate the N status of trees with the aid of leaf analysis and field observations.
2. High N trees normally are overly vigorous (indirect effect).	Keep other nutrients in balance so the desired vigor level can be attained with minimal N levels.
Excessive potassium (K)	
1. Some calcium deficiency disorders appear to be related to high levels of K as well as low calcium 2. Direct cation competition between K and calcium in soil and at the root surface.	1. Regulate the K status of trees with the aid of leaf analysis. 2. Do not apply K unless it's definitely needed.
Excessive magnesium (Mg)	
1. Some calcium deficiency disorders appear to be related to high levels of Mg as well as low calcium 2. Direct cation competition between Mg and calcium in soil and at the root surface.	1. Regulate the Mg status of trees with the aid of leaf analysis. 2. Do not apply Mg unless it's definitely needed. 3. Do not correct low soil pH with high magnesium (dolomitic) lime.
Deficient calcium (Ca)	
Many physiological disorders of apples are directly related to low fruit flesh Ca levels although low Ca may not be the direct cause.	1. Maintain a soil pH of 6.0 to 6.5 with high-calcium lime. 2. Use high-magnesium (dolomitic) lime only in cases with a proven need for large quantities of magnesium. 3. Apply Ca sprays. 4. Use all other parts of the program to increase fruit Ca levels
Deficient boron (B)	
1. B deficiency can directly cause fruit flesh deformities.	1. Regulate the B status of trees with the aid of leaf analysis. Maintain 35 to 60 ppm of leaf B.
2. Some B deficiencies appear to increase corking.	2. Make ground applications of borax or tree sprays of boron when needed.
3. Some B deficiencies appear to interfere with normal translocation of calcium.	

Table 1-12. Causes of excessive vegetative growth that may compete for available calcium, their modes of action, and corrective measures.

MODE OF ACTION	CORRECTIVE MEASURES
Excessive pruning	
Severe pruning can overinvigorate an apple tree.	1. Reduce tree vigor so that moderate pruning can be used to maintain tree size. 2. Maintain an annual, moderate pruning program.
Excessive nitrogen (N)	
Excessive N fertilization often results in overly vigorous trees.	Maintain a nutritionally healthy tree so that a minimum level of N can be used to maintain moderate tree vigor.
Inadequate spacing	
Planting trees too close together can result in a vicious cycle of excessive	Integrate variety, rootstock, soil type, and your management intentions into pruning followed by excessive vigor.
Low fruit load	
Trees bearing a light crop normally divert growth into excessive vegetation.	Maintain a system of annual cropping to avoid excessive tree vigor.

Table 1-13. Factors that may result in a small crop of large fruit, their modes of action, and corrective measures.

MODE OF ACTION	CORRECTIVE MEASURES
Poor fruit bud formation	
Production of annual crops must integrate the production of a fruit crop and good numbers of fruit buds each year	1. Maintain moderate tree vigor and tree health to encourage production of a bud crop each and every year. 2. Use growth regulators to encourage fruit bud formation 3. Thin excessive fruits to encourage annual production
Insufficient desirable pollen	
Without adequate pollen for cross-pollination, a crop cannot be produced.	1. Plant two desirable pollen-source varieties for the main varieties in all blocks. Can be crabapples. 2. Add bouquets at full bloom 3. Plant additional pollinizers in mature orchards. 4. Graft additional pollinizers onto trees of the main variety. 5. Use pollen inserts in beehives.
Poor weather conditions	
Cross-pollination by insects is most easily accomplished in warm sunny weather.	
Not enough bees	
Cross-pollination by insects is considered essential for fruit set. Additional bees should normally be placed in an orchard if other factors are not optimal.	Under normal conditions, use one hive for each acre.
Frost damage	
1. Eliminating or reducing the crop severely upsets any management system for annual production 2. Crop reduction results in stimulation of vegetative growth and excessive fruit size.	1. Select frost-free sites for orchards. 2. Use techniques such as wind machines or overhead irrigation to reduce frost damage

30–40 pounds per acre per year: This rate should give excellent control of corking and bitter pitting and should be the intermediate rate for Pennsylvania. It may somewhat enhance the storage potential of apples and should result in almost no leaf injury.

40–50 pounds per acre per year: This is probably the highest rate that should be used in Pennsylvania and should give outstanding control of corking and bitter pit. This rate may result in some slight burning on the edges of the leaves, but it usually does not appear until mid-September or October. This rate may enhance the storage life of the fruit.

Applying calcium chloride sprays

Time of application: Include in all cover sprays. Do not premix calcium chloride with Solubor in a small volume of water before adding to the tank, when both materials are to be applied together.

Gallons per acre: No restrictions; sprays with as little as 20 gallons per acre have been effective.

Compatibility: At the rates recommended, calcium chloride and/or Solubor may be mixed with spray oil (Superior 70 Sec.), with WP formulations, or with EC formulations of the more common fruit pesticides. Compatibility of materials other than calcium chloride is uncertain, and growers should either check the label for information or conduct a compatibility test in a small jar.

Leaf injury: Some leaf injury may occur from calcium chloride sprays following wet, cool springs or hot, dry summers. When injury is noticed, reduce calcium chloride to one-half the rate in the next spray or delete calcium chloride from the cover sprays until one-half inch of rain has fallen.

Equipment: Calcium chloride can corrode some types of spray equipment. Few problems have occurred if sprayers and tractors are rinsed after use. The newer sprayers made of stainless steel, fiberglass, or various plastics that are rust resistant are desirable.

Special considerations: If early maturing cultivars continue to exhibit bitter pitting and storage breakdown after the standard rate of calcium chloride has been used, a higher rate should be used. Only calcium that hits the skin of the fruit can increase fruit quality. Therefore, in the standard program, 8 pounds of calcium per acre per year may be applied to Delicious, Rome Beauty, and Golden Delicious, but early maturing cultivars such as Summer Rambo may be receiving only 4 pounds of calcium per acre per year prior to harvest.

In summary, many factors influence fruit calcium concentration, and since it is difficult to raise fruit calcium level, growers should use all methods possible to gain the upper hand against corking, bitter pitting, and other low-calcium-related disorders. Cultural practices involve soil and nutritional factors as well as tree vigor and fruit density.

Determining the amount of elemental calcium in a commercially formulated product

1. Look for, or determine, the percentage of elemental calcium in the product. This should be listed somewhere on the label.
2. For a liquid formulation multiply the percentage by the weight of the material per gallon. For a solid multiply the percentage by the weight of material you will add to the tank. Result equals the pounds of calcium per gallon or pound of formulated product.
3. Determine the rate of formulated material you intend to apply per acre per application. For a specific calcium product this is usually listed on the label.
4. Multiply the amount of material per acre by the number of applications to be made during the season. Result equals the amount of total product per acre per season.
5. Multiply the amount of total product per acre per season (from Step 4) by the pounds of calcium per gallon or pound of formulated product (from Step 2). Result equals the total amount of elemental calcium per acre per season.
6. Compare the result from Step 5 with our recommendation of 4 to 14 pounds of elemental calcium per acre per season.
7. Compare the season-long cost of materials. Multiply the amount of material used per season times the cost of the material.

Example 1. Product A sells for $6.50 per gallon and is a liquid listed as containing 15% elemental calcium. The weight per gallon is 12 pounds. The label recommends 2 to 4 quarts per acre per application with eight applications suggested per season. You decide to apply 2 quarts per acre per application.

Step 1: Product contains 15% elemental calcium.

Step 2: 12 lb x 0.15 = 1.8 lb of elemental calcium per gal.

Step 3: You choose to apply 2 quarts (or 0.5 gal) per acre per application.

Step 4: 0.5 gal per acre per application x 8 applications per season = 4 gal of material per acre per season.

Step 5: 4 gal x 1.8 = 7.2 lb of elemental calcium per acre per season.

Step 6: Our recommendation is 4.0 to 14.0 lb of elemental calcium per acre per season.

Step 7: 4.0 gal x $6.50 per gal = $26.00.

Example 2. Product B sells for $1.50 per pound and is a solid powder containing 30 percent elemental calcium. The label recommends 3 to 4 pounds per acre per application with eight applications suggested per season.

Step 1: Product contains 30% elemental calcium.

Step 2: 1 lb x 0.30 = 0.30 lb of elemental calcium per lb of material.

Step 3: You choose to apply 3.0 lb of material per acre per application.

Step 4: 3 lb per acre per application x 8 applications per season = 24 lb of material per acre per season.

Step 5: 24 lb x 0.30 = 7.2 lb of elemental calcium per acre per season.

Step 6: Our recommendation is 4.0 to 14.0 lb of elemental calcium per acre per season.

Step 7: 24 lb x $1.50 per lb = $36.00.

Comparing costs

You wish to compare the cost per pound of elemental calcium in two products. From Products A and B above, we can determine which is cheaper.

1. Determine the pounds of elemental calcium per gallon or pound of formulated product for each product you are considering. (Same as in Step 2 above).
2. Determine the cost per pound of elemental calcium in each product.
3. Compare the two materials' cost.

   Example: From Products A and B above, determine which is cheaper per pound of elemental calcium.

   Step 1:
   Product A = 12 lb x 0.15 = 1.8 lb of elemental calcium
   Product B = 1 lb x 0.30 = 0.30 lb of elemental calcium

   Step 2:
   Product A = $6.50 per gallon ÷ 1.8 lb calcium per gal of material = $3.61 per lb
   Product B = $1.50 per lb ÷ 0.30 lb calcium per lb of material = $5.00 per lb

   Step 3:
   Product A costs $3.61 per lb of elemental calcium
   Product B costs $5.00 per lb of elemental calcium

Determining the amount of product needed to apply 14 pounds of elemental calcium

You are comparing two products to determine what rate you need to apply to achieve 14 pounds of elemental calcium per acre per season. Again use the same two materials outlined above and assume that you will be making eight applications during the season.

1. Divide the number of pounds of elemental calcium desired per season by the number of applications. Result is the pounds of elemental calcium needed per acre per application.
2. Divide the amount of elemental calcium per gallon or pound of material by the pounds of elemental calcium needed per acre per application. Result is the gallons or pounds of formulated material needed per acre per spray.

   Example:

   Step 1: 14.0 lb of elemental calcium per acre per season ÷ 8 applications per season = 1.75 lb

   Step 2:
   Product A = 1.75 ÷ 1.8 lb elemental calcium per gal = 0.97 gal per application
   Product B = 1.75 ÷ 0.3 lb elemental calcium per lb = 5.83 lb per application

   Warning: The maximum labeled rate per application for Product B is 4 pounds per acre per application. Therefore, you are exceeding recommended labeled rates by using Product B to achieve a 14-pound recommended rate.

In summary, to effectively evaluate materials other than calcium chloride, you need to compare the cost per pound of actual calcium with the amount of the formulation needed to achieve the 4 to 14 pounds of actual calcium per acre per season needed to control problems.

GROWTH REGULATORS IN APPLE AND PEAR PRODUCTION

Plant growth regulators (PGRs) are chemicals used to modify tree growth and structure, remove excess fruit, or alter fruit maturity. In order to be effective, PGRs must be applied with adequate coverage, and then be absorbed by the plant and translocated to the site of activity in sufficient concentration to give the desired response. Consequently, numerous factors affect PGR performance. Weather conditions before, during, and after application will impact their effectiveness. The environmental conditions before the application can alter leaf characteristics and affect the amount of chemical that will enter the plant. The environmental conditions (temperature and humidity) during the application and the details of the application itself (gallons of water applied, coverage, and surfactants) also can affect the amount of chemical that will enter the plant. The environmental conditions after the application can influence the responsiveness of the tree to the chemical that has entered the plant. Thus, the process of actually modifying plant growth processes is very complicated, and much research must be conducted to develop effective programs.

The amount of water in which PGRs are applied can also alter performance. In general, the more water in which PGRs are applied, the more uniform will be the response. We recommend that you determine the dilute spray gallonage requirement for your orchard blocks based on tree row volume (see the section on calculating tree row volume in Part III of this guide under "Orchard Spraying"). Although many pest control sprays are applied at 50 gallons per acre, we recommend a minimum of 100 gallons per acre for PGR application in most instances.

Increasing Branching

A growth regulator composed of cytokinins and gibberellic acid (BA+GA) such as Promalin, Perlan, or Typy can be used to stimulate additional branches to grow on young trees. Foliar applications should be made when new shoot growth is approximately 1 to 3 inches long, approximately 2 to 4 weeks after bloom. Apply 125 to 500 ppm (0.25 to 1.0 pt/5 gal) of spray mixture. Thoroughly soak the area of the tree where branching is desired. A buffering agent (e.g., buffer X) or nonionic wetting agent (e.g., Tween 20 or Triton X-100) should be added to the tank at a rate of 0.2 to 0.3 percent (1 to 2 oz/5 gal) before adding BA+GA. The final spray solution should have a pH no greater than 8.

Thoroughly wet the foliage and bark of trees to be treated. Five to 10 gallons of spray mixture applied with a pressurized hand sprayer will treat 200 to 300 nonbearing trees 1 to 4 years old.

BA+GA may also be mixed with latex paint and applied directly to buds. Apply in the spring when terminal buds begin to swell, but before shoots emerge. DO NOT apply after buds break. Applications made after buds have broken may cause injury to tender shoot tips and fail to promote shoot growth from that point. The application rate is 5,000 to 7,500 ppm (0.2 to 0.33 pt/pt of latex paint). Add a buffering agent or a nonionic wetting agent to the latex paint at a rate of 0.5 to 1.0 percent (0.1 to 0.15 oz/pt of paint) before adding BA+GA. The wetting agent improves the dispersion of BA+GA in the latex paint; it also improves wetting and absorption through the waxy layer of the bark.