

*Spectrum Analytic Inc.*

# FERTILIZING APPLES



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## Introduction

In all cases where a rate per acre is mentioned you should assume that this refers to the acreage of soil actually receiving fertilizer, not the outside dimension of the orchard. Make appropriate adjustments to applications.

Many factors, in addition to soil tests and fertilizer application rates affect the nutrition of apples and most other deciduous fruit tree species. Some varieties respond differently than others. Additional factors include rootstock, dwarfism, subsoil physical and chemical condition, and others. The intended use of the fruit is sometimes an additional factor in determining the proper fertilizer program. While soil testing is an indispensable tool in orchard management, **Annual leaf analysis (in addition to periodic topsoil and subsoil testing) is required to properly manage the crop nutrition.**

Remember that the photographs of deficiency symptoms in this paper can be confused with other symptoms such as a pathological symptom. In some cases these symptoms were created in a controlled environment and some of them may not appear the same in the field as they do in the controlled area. That is why the best way to diagnose and confirm nutrient deficiency is through the use of plant analysis.

# Soil pH and Lime

Orchard soils should have a soil pH of about 6.5 throughout the effective rooting soil profile. Since it is not feasible to incorporate lime into the soil profile of established orchards, **soils should be properly limed prior to planting.** After preplant liming, periodic lime topdress as recommended by soil tests will maintain the proper soil pH.

## Preplant Soil Preparation

Pre-plant adjustments to the both the topsoil (0-8") and the subsoil (8-16") will affect the orchards performance for years to come. Where soil and subsoil are naturally acid, it is recommended that they be slightly over-limed prior to planting. Adjust the topsoil to pH 6.5-7.0 and the sub-soil to pH 6.0-6.5, where the sub-soil is naturally acid. It is normally not economical to acidify large areas of high pH soils. Both the topsoil and subsoil should be sampled to determine the correct action needed. Follow soil test recommendations for both types of soil samples.

## Established Orchards

In established orchards you do not have the option of incorporating your lime. Others have looked at injection of lime around trees in various patterns and by various methods. There has been little or no success in positively affecting the tree performance. This seems to be due to the fact that all of the methods tried affected a very small percentage of the soil in the total rooting volume. Concentrating the soil amendment can work well with fertilizer, but does not work as well for lime. Where an established orchard soil requires lime, it is usually best to apply 1 to 2 tons per acre of a good agricultural limestone annually, re-sample the soil in both the 0 to 8 inch and the 8 to 16 inch depths annually until the soil pH is corrected (hopefully at both levels). The first surface application of lime will affect only the top 2 inches of soil; however a pH increase will gradually be seen at lower soil depths over time.

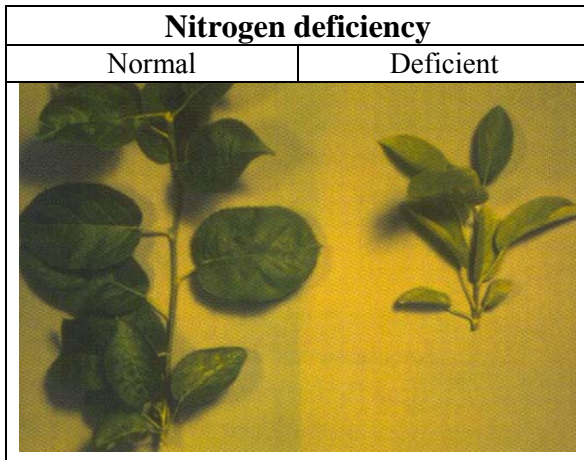
## Nutrient Requirement Data

In preparing this paper, many sources of data on apple nutrient requirements were looked at. There was significant disagreement in the data on how much of each nutrient was utilized and removed by apples. The cause of this disagreement appeared to be due to the differences in varieties, cultural practices, and location. A significant source of variability in uptake data exists between dwarf and standard tree varieties. **The data listed below represents typical range in values for each nutrient, assuming a good to high yield for the variety and production factors in effect.** These values can only be regarded as approximate. Individual situations may differ significantly from this data.

	Lbs./Acre					
	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Ca	Mg	S
<b>Removal</b>	30-50	30-60	75-120	8-13	5-8	10-16
<b>Total Uptake</b>	90-120	45-80	150-240	50-80	20-32	20-32

**As stated earlier, the grower should use routine leaf analysis and visual inspection to monitor an orchards nutrient status, and make appropriate changes to the nutrient program. This is the only way that the optimum crop performance and profits can be attained.**

# Nitrogen (N)



There is no single N program that is correct for all orchard situations. Insufficient N results in symptoms and problems similar to many crops. They include less vigor, light green to yellow-green leaves, less vegetative growth and low yields, as seen in the accompanying picture.

While low N can be a problem for most species of tree fruit, excessive N can be equally bad. Apple N programs vary according to many factors, some of which are listed in the following pages. Because of these many factors, **the grower must monitor tree growth, leaf nutrient levels, yield, and fruit quality in order to make annual adjustments to the nitrogen program.**

## Factors Affecting Nitrogen Program

**Bearing or Non-bearing Trees:** Young, non-bearing trees will often benefit more from higher N programs than older bearing trees. The goal with young trees is to produce wood and vegetative growth, while the goal with bearing trees is strong yields of high quality fruit.

**Nitrogen Requirements by Variety:** Apples can generally be divided into “low N” and “high N” requirement groups. Some of the varieties in these groups are as follows:

Low N Requirement Varieties (1.8% - 2.2%)					
Cortland	Empress	Britemac	Jerseymac	Jonathan	Jonagold
Jonamac	Macoun	McIntosh	Mutsu	Paulared	Summer Pippin
Spartan	Tydeman Red	Turley	Jerseyred	Gravenstein	Golden Delicious
Starr	Crispin	Ginger Gold			
Other early ripening, softer varieties and/or those typically intended for fresh market					

High N Requirement Varieties (2.2%-2.4%)					
Empire	Idared	Golden Delicious	Liberty	Melrose	Jonathan
R.I. Greening	Rome	Stayman	Red Delicious	Rome Beauty	York Imperial
Fuji	Honeycrisp	Granny Smith	Braeburn	Gala	
Other hard varieties or soft varieties if the fruit is intended for processing.					

**Note:** The reader may notice that Golden Delicious and Jonathan are listed in both N regimes. This is due to a conflict in the variety listings published by different states. It is generally agreed that apples of any variety grown for processing will benefit from higher N programs than those grown for fresh market.

**Growth Habit:** The N requirement of apples can be generally related to the amount of wood in the trees. In other words, larger trees generally require a higher N program than dwarf trees.

**Pruning Severity:** Heavily pruned trees generally require less N. This relates to the lower amount of wood and foliage present to utilize the N, and the higher “root to shoot” ratio after pruning.

**Population Density:** As a general rule, more trees per acre means more N required. However, where higher populations are coupled with strongly dwarfed varieties, and severe pruning (such as “hedgerow” planting), the grower may find that the N rate required for optimum leaf N levels may not differ significantly from lower populations.

**Other Nutrients:** The N status of apples is judged by both the absolute amount of N in leaf tissue, and by the relative amount of N present in relation to the other nutrients. In other words, a tree may have the proper amount N and another nutrient, but they can be “out of balance” with each other. In these situations it may be advisable to adjust fertilizer rates to adjust this nutrient balance. The N:K balance of apples may be the most important nutrient ratio. Low N trees such as McIntosh do better with an N:K ratio of about 1:1 to 1.25:1, while high N trees should have a ratio of about 1.25:1 to 1.5:1. Where leaf analysis shows both nutrients are within the proper range, but out of balance, the fertilizer rate of the nutrient that is out of balance on the low side should be increased.

## Visually Judging the N Status of Fruit Trees

The most desirable nitrogen management program provides a relatively high N status early in the season to encourage rapid leaf development, fruit set, and flower bud formation, but permits N to decline gradually as the season progresses. This tends to enhance favor, fruit color, and tree hardening. The following factors can be used to evaluate apple N status, but none will substitute for annual leaf analysis.

**Fruit Color:** In bearing-age trees, fruit color development is delayed when N levels are too high. If other factors are equal, the percentage of red color is reduced by about 5% for each 0.1% increase in leaf N. This relationship is particularly significant with less highly colored fruit varieties or strains. Yellowing of Golden Delicious fruit shows a similar reduction as leaf N increases.

**Fruit Size and Firmness:** These are usually inversely related, and both are influenced by N status. Size generally increases with higher N levels, if the crop load is not excessive, and this tends to result in less firm fruit flesh.

**Varietal Differences:** Differences in fruit coloring and/or flesh firmness are also a guide in evaluating N status. Soft varieties and apple crops intended for fresh market (eating apples) have a lower optimum N content than those that are bred to be harder, or are intended for processing.

**Biennial Fruit Production:** Some apple varieties have a tendency toward biennial bearing. Nitrogen stress will increase the biennial bearing tendency in many varieties, especially Golden Delicious and McIntosh. Reducing the N in these varieties to enhance color development may trigger the biennial bearing of these and other varieties.

**Vigor of Shoot Growth:** Nitrogen is also the major nutrient factor influencing the higher N uptake encourages the tree to produce longer annual terminal growth. This is desirable in new plantings, but not in established, bearing trees. **Sufficient vigor is also indicated by annual terminal growth of 8 - 12 inches for non-spur varieties, and 6 - 8 inches for spur varieties.**

**General N Relationships:** Leaf N tends to be higher in samples from trees that are carrying heavy crops. Off-year trees are generally lower in leaf N content. This condition reflects the inverse relationship between shoot growth and fruiting; trees bearing a lighter crop produce more shoots. Under such conditions, the concentration of N per unit of leaf dry weight is lower, although the total amount of N in leaves may be similar to that in a tree carrying a full crop. Leaf N is also reduced by drought and sod/weed competition.

**In general, a 10% increase or reduction in N application rates is usually reflected as a 0.1% change in Leaf N.**

<b>Indices for Judging N Status of Fruit Trees</b>			
<b>Index Point</b>	<b>Low N</b>	<b>Normal N</b>	<b>High N</b>
Terminal growth bearing trees non-bearing trees	avg. less than 4 in. avg. less than 10 in.	avg. 4 in. – 12 in. avg. 10 in. – 24 in.	avg. 12 in. – 20 in. avg. 24 in. – 40 in.
Leaf size	small, thin	medium to average	large, thick, often puckering at tip
Leaf color	uniform pale/yellow-green	normal green	very dark green
Fall leaf drop	early; leaves show red in veins	normal time; leaves green to light green	late; leaves remain dark green until severe frost
Bark color	light to reddish brown	gray to dark gray-brown	greenish gray to gray
Fruit set	poor; heavy June fruit drop	normal; 1-3 fruit/cluster	no effect or reduced fruit set
Fruit size	smaller avg./tree	normal	larger avg./tree
Fruit over-color	highly colored/earlier	normal	poor color up to and after normal picking period
Fruit under-color	yellow color earlier	normal	green to green-yellow for the variety. yellow at normal picking time
Fruit maturity	early	normal	5 - 10 days late

## Nitrogen Recommendations

In the absence of leaf analysis, or other locally specific data to determine the correct rate of N for apples, use the following guidelines.

### Soil Applied N:

**Preplant:** 40 lb. N/acre (80 Lb. N/Ac if non-legume cover crop plowed down) worked into the soil prior to planting. If a permanent sod is to be established, topdress an additional 40 lb. N/acre after the grass is established. This N application should be considered part of the first year's total annual N program for spring plantings, where additional N may be applied, as described below.

**Young, non-bearing trees:** Typical recommendations are for from 0.1 to 0.25 lb. N/tree. However the grower should adjust the N program to obtain an adequate leaf analysis and growth. It is desirable to obtain a growth rate of from 10 to 24 inches of terminal growth per year, and a sufficient N level in the late summer tissue analysis. Foliar N or fertigation can be used to adjust leaf N levels. Optimum growth of young trees is normally obtained with a leaf N level of 2.4 to 2.6%. The grower may need to increase the N rate by 0.2 to 0.4 lb./tree where weeds or sod are present under the trees.

**Bearing trees:** In the absence of leaf analysis to guide you, apply 40 lb. N/acre/yr. However, if the field has a history of strong N rates, the leaf analysis may indicate that little or no N is required for several years. Mature, standard size apple trees may require as much as 0.5-1.0 lb. N/tree. Dwarf apple trees typically require ½ as much. These N recommendations assume that the N was applied within the drip-line of each tree. Adjust the N program to obtain an annual terminal growth of 8 to 12 inches, good fruit color and quality, plus leaf N levels as follows...

**Soft Fruit Varieties and Fresh Market**

**1.8 - 2.2%**

**Hard Fruit Varieties and Processing**

**2.2 - 2.4%**

Generally a 10% change in N application results in a change of 0.1% change in the leaf N content. A supplementary guide for standard and semi-dwarf trees planted in hedge-rows is to apply 1/20 lb. N/tree/year of age, not to exceed 100 lb. N/acre unless need is confirmed by leaf analysis. Apply uniformly beneath the drip line of branches in early spring. Suggested applications should be reduced or eliminated the spring following severe pruning. Pruning decreases the N need of fruit trees, and heavily pruned trees need considerably less N than moderately pruned ones. Where a sod cover is

present, apply an additional 25 lb. N/acre for the sod crop. General soil nitrogen applications after July are not advisable. This may result in poor fruit over color and late growth that can increase the hazards of winter injury to wood and buds. To improve fruit quality and color (red varieties), nitrogen levels in trees should be low but not deficient as harvest nears.

### **Foliar Applied N:**

Reasons for using foliar applications of nitrogen might include adjustment of the nitrogen status of flower buds to encourage improved fruit set and to supplement or replace a part of the nitrogen applied to the soil. A low nitrogen status of flower buds leads to a more rapid degeneration of the ovules, thus reducing the effective pollination period. This is of particular importance during long, cool bloom periods when pollen tube growth is retarded. In such situations, nitrogen sprays, either in the fall (between harvest and leaf drop) or prior to bloom in the spring, are often beneficial. Fruit set on trees low in nitrogen, i.e., with previous-year leaf sample levels below about 2.2 %, may be improved by using nitrogen sprays. Nitrogen sprays should also be considered in the year following a heavy crop. Such sprays are not likely to be beneficial if the previous-season leaf samples contained 2.4% or more nitrogen. Other situations in which nitrogen sprays may be useful include...

- Where maximum vegetative growth is desired.
- Where soil applications might result in excessive nitrogen being taken up by the trees at times detrimental to fruit color or quality or to maturation of the woody tissues.

Including N, especially urea, in foliar applications of other nutrients, often increases their uptake by the foliage. Urea is the most frequently used form of nitrogen for foliar application to apples and pears. Foliar sprays of urea are not recommended on stone fruits because they do not absorb and utilize urea efficiently. Because of danger of injury to foliage, **only those formulations of urea that contain less than 0.25 percent biuret should be used in foliar sprays.** The usual rates of application suggested are 3 pounds of urea (1.35 pound N) per 100 gallons (dilute rate equivalent) in pre-bloom sprays, and 5 pounds of urea (2.25 pounds N) per 100 gallons in petal fall or later sprays. Tank-mix concentrations of urea at rates greater than 10 pounds per 100 gallons may injure young foliage.

**Foliar applications of nitrogen applied later than 10-14 days after petal fall may delay fruit coloring and increase the risk of early winter cold injury to the trees.** Applications later than this should be avoided unless there are visual symptoms of nitrogen deficiency.

**Calcium nitrate has been used in foliar applications on apples and pears, but is not recommended on certain apple varieties such as Delicious, because it may induce the development a corkspot-like disorder in the fruit.**

# Phosphorus (P)

Figure 2: Phosphorus



The status of an orchard soils P supplying power can be difficult to determine, even with the best soil testing program. Fruit trees are deep rooted and can absorb P throughout a deeper soil profile than annual crops. Therefore they are using soil P that isn't identified by normal soil sampling. Apple trees also absorb P over a long portion of the year, and most soil test calibration assumes a somewhat shorter uptake period. Of course other soil factors such as pH, temperature, moisture, compaction, etc. (at all rooting depths) also affect P uptake. With all of these complications, it may seem futile to take a soil sample, however it remains a fact that a healthy tree will take up more P from a high testing soil than a low one, so periodic soil testing is still a recommended practice. These

complications with trees illustrate the need for annual leaf analysis, coupled with the ability to apply needed nutrients by foliar, or fertigation methods.

**Soil Applications:** Phosphorus is nearly immobile in most soils, except over many years, so surface applications of P to an established orchard are not as efficient in feeding a plant. Much of the surface applied P will not feed the current year's crop. It will instead go into the reservoir of soil P and be slowly released to the crop over succeeding years. However roots that are feeding near the soil surface will utilize any available P resulting from annual applications. All of this leads to the obvious conclusion that **when establishing a new orchard, it is very important to correct any soil nutrient deficiencies that may exist.** This may be the only practical opportunity that you have to increase the deeper soil fertility. Deep soil fertility is a great aid in times of tree stress.

Spectrum Analytic's phosphorus recommendations for apples are shown below. They are designed to build up a soil to the Good level and then maintain it at that level. Spectrum's soil P status (L, M, G, H, and VH) is regionalized plus it is dependent on the soil test level and the soil CEC, so no single table can define the status

<b>New Planting</b>	<b>P<sub>2</sub>O<sub>5</sub> (lb./a)</b>			
Soil Test Status	Low	Medium	Good	High
Recommendation	200	100	60	0

**COMMENTS:** When the soil test is poor, higher rates of incorporated P<sub>2</sub>O<sub>5</sub> may be beneficial in later years.

<b>Established Trees</b>	<b>P<sub>2</sub>O<sub>5</sub> (lb./a)</b>			
Soil Test Status	Low	Medium	Good	High
Recommendation	90	60	30	0

**Foliar Applications:** None recommended



# Potassium (K)



Potassium Deficient Apple

Adequate potassium contributes to improved fruit size, color and flavor. It is also a major factor in reducing winter injury, spring frost damage to buds and flowers, and generally reduced incidence of diseases. The benefits of adequate potassium can be lost however, if the leaf ratio of nitrogen to potassium (N divided by K) is too high. Low N trees such as McIntosh do better with an N:K ratio of about 1:1 to 1.25:1, while high N trees such as Red Delicious should have a ratio of about 1.25:1 to 1.5:1. Where leaf analysis shows N and K are sufficient, but the ratio is high, the annual  $K_2O$  should be increased to correct the leaf balance.

**Soil Applications:** Apples are very responsive to potassium, so a strong soil test, and sound fertility program are vital to top yields. Soil K status is a function of the test level and the soil CEC; therefore no single table can list the desired levels.



Effect of K Shortage on Apple Color  
Left Sufficient K Right Deficient K

New Planting	$K_2O$ (lb./a)			
	Soil Status	Low	Medium	Good
Recommendation	300	200	90	0

**Comments:** When the soil test is poor, higher rates of incorporated  $K_2O$  may be beneficial in later years.

Established Trees	$(K_2O$ lbs/ac)			
	Soil Status	Low	Medium	Good
Recommendation	150	120	90	0

According to Cornell University Bulletin 219, "Applying potassium fertilizers in narrow, 6-8 inch bands on both sides of the row approximately one-half the distance from the trunk to the outer-spread of the branches also has been effective"... "Applications after harvest but before the soil freezes have resulted in a more rapid plant response than similar applications the following spring. Fall is preferred when appreciable amounts of potassium must be applied." Experimental results from New York, reported in "Better Crops, Summer 1989, pg.12-13" indicates that the maximum benefit from K fertilization may frequently be limited by shortages of other elements. Their results indicated that leaf levels of Mg decreased to below acceptable levels in the presence of increased K treatments, even though Mg was applied as a component of the K treatments. Results also showed that as leaf Cu was increased (into the sufficient range used by Spectrum Analytic), apples showed an increased response to K.

## Higher Leaf K and Cu Levels Increased Yields of Empire Apples with at Least 3-inch Diameter and 65% Color

% Leaf K	Leaf Cu ppm		
	5.5	6.5	7.5
Yield, bushel/acre			
0.59	38	81	124
0.93	79	122	165
1.27	121	154	207
1986, $R^2 = .663$			

**Foliar Applications:** Foliar application of potassium to fruit trees has been beneficial in orchards on soils with inadequate supplies, but not in those containing adequate potassium. The source of potassium for use in foliar sprays must be chosen carefully. Potassium nitrate (46.5%  $K_2O$  equivalent) and potassium sulfate (27%  $K_2O$  equivalent) are most frequently used

for foliar application. Rates of 6-10 pounds of either material per 100 gallons of water, applied as a dilute spray, have been suggested when foliar symptoms of potassium deficiency are present. New York trials with various complete (N-P-K) materials formulated for foliar application indicate that these usually contain too much nitrogen and phosphorus and not enough potassium to meet crop needs. These trials indicate that the amount of potassium required to obtain a significant improvement in fruit size and/or color with apples is similar to that recommended for soil application; i.e., 60 pounds or more of  $K_2O$  per acre.

## Sulfur (S)

Sulfur is not often a concern with apples. The most likely exception would be on light colored or sandy soils. Plants take up only the sulfate ( $\text{SO}_4$ ) form of sulfur. Applications of this form will be immediately available. Elemental sulfur (S) requires bacterial conversion to the sulfate form to become available. This process can take an entire season. Where leaf symptoms or plant analysis confirms the need, soil applications of 30 lb. S/acre (as  $\text{SO}_4$ ) will correct most problems.

## Magnesium (Mg)

**Soil Applications:** Soil Mg status is a function of the test level and the soil CEC, which results in a complex relationship. Therefore no single table is listed. Recommendations vary according to whether lime is required and whether the soil K/Mg ratio exceeds 1.5 (K lb./acre: Mg lb./acre). If lime is recommended, and there is a need for corrective Mg applications, we recommend dolomitic lime, and assume that it will be applied. This may remove the need for additional Mg fertilizer. If additional Mg is needed, it is recommended in pounds of Mg/acre. Or, if Mg is already recommended due to a low soil Mg level, and the soil K/Mg ratio is greater than 1.5, the recommendation for Mg will be increased.

**Foliar Applications:** Foliar sprays of Epsom salts ( $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ) are an effective temporary means of supplying magnesium to many fruit crops. These sprays supply enough magnesium to prevent deficiency symptoms if used at the appropriate rate and time, but they should be considered as a supplement to, rather than a substitute for, adequate soil applications of magnesium. In mature orchards, three sprays applied at 10 to 14-day intervals beginning at petal fall may be adequate. The suggested rate of Epsom salts for these sprays is 15 pounds per 100 gallons of dilute spray equivalent (1.5 pounds Mg). Such sprays have been effective at tank-mix concentrations up to 15 X (see comments about foliar fertilization, pg. 13). Avoid the application of Epsom salts under slow-drying or high-temperature conditions when severe damage to the foliage may occur. **Magnesium chelates have low magnesium content and have not been sufficiently effective as foliar sprays**

# Calcium (Ca)

Apples leaf analysis frequently shows a need for higher Ca levels. Low Ca in the fruit cause several disorders, the major ones being bitter pit, cork spot, and senescent breakdown during storage. Apples are not efficient at obtaining calcium from the soil, and are not especially efficient at translocating Ca from the roots to the leaves and fruit. Also, during drought stress, water containing calcium may be translocated from the fruit back into the leaves, thus reducing the Ca content of the fruit. Because of this, foliar sprays, spraying the fruit directly, and apple dips are commonly used to increase the Ca content of the fruit. Soil applications to crops with identified low leaf or fruit Ca levels do not have a strong success record, however growers should take the necessary actions to correct soil Ca deficiencies, and add lime to acid soils, because this also affects other aspects of proper crop nutrition and growth. Foliar Ca applications, while effective, are not a substitute for keeping the soil properly limed. Acid soils make Ca, and other nutrient problems worse, so proper liming is essential. The normal leaf Ca range is from 1.0% - 2.0%, however values above 1.5% are generally required to minimize low Ca related fruit problems.

## Conditions That Affect Apple Ca Status:

- Apple tree roots are poor at absorbing Ca from the soil. The problem is magnified by any outside factors that can interfere with Ca availability, such as...
  - low soil Ca levels
  - low soil pH
  - high levels of competitive cations, such as K, Mg, and NH<sub>4</sub>
- Any Ca absorbed by the roots moves very slowly through the trees and into the fruit. It appears to take from 2 - 4 years to get Ca from the root tip to the fruit, depending on the size of the tree. The quickest responses come from applying Ca directly on the surface of the fruit.
- There is intense competition between vegetation and fruit for available Ca in a tree, and vegetation is by far the stronger competitor. Anything that stimulates vegetative growth will work against adequate fruit Ca levels. The apparent increase in Ca deficiencies in recent years is likely a result of grower's efforts to increase orchard productivity. Higher yields and earlier production from new trees requires higher fertility programs, resulting in more vigorous foliage growth and less Ca available for the fruit.
- **Tree Management:**
  - **Fertilization Practices**
    - Excess N will stimulate vegetative growth, thus increasing the demand for Ca by the foliage and reducing the availability of Ca to the fruit.
    - Excess K or Mg will compete with Ca, both in uptake by the trees, and in translocation into the fruit.
    - Boron deficiencies may reduce Ca movement in a tree.
- **Pruning Practices**
  - Excessive pruning will stimulate vegetative growth and thus promote Ca deficiency in fruit. However, summer pruning tends to be beneficial since it reduces vegetation while fruit are still on the tree, and the fruit may benefit immediately.
- **Growing Excessively Large Fruit**
  - For a given variety, fruit Ca will decrease as size increases. The fruit size problem is usually aggravated by excessive vegetation, since a light crop promotes vegetative growth. A strong cropping tree is much less likely to have Ca deficient fruit than a light-cropping one.
- **Encouraging Good Pollination**
  - Seed number affects fruit Ca. A high seed number encourages accumulation of Ca in the fruit. It appears that seeds help direct the flow of Ca into fruit. Even though fruit with high seed numbers tend to be larger, the positive effect of more seed on Ca exceeds the negative effect of larger size on fruit Ca. Therefore, fruit with more seeds are both larger and higher in fruit Ca. Improving pollination by using more bees, better location of pollinizers, or planting windbreaks should not only improve fruit cropping, but also improve fruit quality.
- **Soil Management**

- **Avoid Water Stress:** Roots require adequate soil moisture to absorb Ca, or any other element. Water stress may also directly lower fruit Ca, since leaves can draw water and Ca from the fruit when severely stressed.
- **Maintain Soil pH** at 6.2 - 6.5: Lime provides little Ca directly to the trees, however a correct soil pH establishes the maximum availability of all nutrients, including Ca.
- **Gypsum:** (see Soil Applications)

**Soil Applications:** Soil applied gypsum will typically provide a modest increase in the fruit Ca content. However, this is often not enough to correct significant Ca shortages. Tree response to soil applied gypsum is slow, since it may take from 2 to 4 years for soil applied Ca to reach the fruit. However, once the Ca has reached the upper parts of the tree, the effect can last for years. University of Massachusetts data indicates that a single application of 20 to 30 lb. of gypsum per tree, applied under the drip line is normally adequate, and the benefit should persist for at least 6 years. This rate of gypsum can severely reduce the exchangeable Mg and K, so annual leaf analysis is required to identify any needed adjustments to the fertilizer program, and monitor the results. Gypsum applications should be considered a *preventative* practice, or as support to a foliar program... not a corrective practice. Another option would be to annually apply about 10 lb. of gypsum per tree, in addition to an aggressive foliar Ca program. This approach could offer, over time, a small amount of improvement in Ca uptake from the soil, and not be as likely to cause problems with the uptake of K and Mg.

**Foliar Applications:** The two generic fertilizer products commonly used for foliar Ca applications are calcium nitrate ( $\text{Ca}(\text{NO}_3)_2$ ) (15% N, 19.4% Ca), and calcium chloride ( $\text{CaCl}_2$ ) (36% Ca). Apply calcium chloride (78%  $\text{CaCl}_2$ ) at a rate of 1.0-2.0 lbs/100 gal., dilute equivalent basis, in 3 or 4 sprays at 14 day intervals beginning 7 - 10 days after petal fall, followed by 2 sprays at 3.0 – 4.0 lbs/100 gal, 4 and 2 weeks before harvest. These rates provide 27 - 48 lb. of  $\text{CaCl}_2$  (7.5 - 13.4 lb. Ca) per acre for orchards that require 300 gal of dilute spray per acre for thorough coverage. Rates should be reduced according to tree-row-volume for smaller trees to minimize injury to foliage and fruit. Calcium nitrate applied at 2.0 – 4.0 lbs/100 gal, dilute equivalent basis, may be used in place of calcium chloride to control bitter pit, but is not suggested for Delicious and York Imperial. These and possibly other varieties develop a cork spot-like disorder when sprayed with calcium nitrate. Chelated forms of Ca have not been effective due to the low Ca content. Alternative proprietary calcium compounds are available for use as foliar sprays and/or dips. Effectiveness of these materials may be comparable to that of calcium chloride when used at rates providing equivalent rates of calcium. Likewise, the relative crop safety should be similar to that of calcium chloride when applied at equivalent rates. In some areas, calcium chloride is added to each of the summer pesticide applications. These sprays may cause foliage and/or fruit injury if applied when low temperatures and wet weather delay drying of the spray, and under high temperature (over 80°F) and/or high humidity conditions.

The best control of bitter pit that develops after harvest and senescent breakdown during storage has been obtained with post-harvest dipping or flooding of fruit with a solution containing 20 pounds of calcium chloride (7.2 pounds Ca) per 100 gallons of water.

## Boron (B)

Boron plays a significant role in pollination success and it plays a role in the trees ability to translocate Ca from the roots to other parts of the tree. It is highly mobile in the soil and supplied primarily by organic matter, so deficiencies are most likely to occur on light colored, coarse textured soils. Deficiencies can contribute to poor fruit set. Boron may be applied to the soil or the foliage with good effect, however **please note that Cornell Univ. recommends against pre-mixing Solubor™ and calcium chloride**. A complete boron program frequently includes both a soil application to meet the basic need of the crop, plus one or more foliar applications to supply additional boron at critical stages of crop development. Growers and their advisors should be aware that excessive B applications have the potential for direct toxicity to the crop. One sign that B uptake is excessive, is premature fruit maturity, and early fruit drop.

### Soil Application:

Soil Test Level	Boron rate
Low	3.0 lbs/ac
Medium	2.0 lbs/ac
High	1.0 lb/ac
Very High	0
If no soil test apply	2.0 lb/ac if leaf analysis B < 35 ppm

Many authorities recommend that soil applications be made months in advance of pollination in order to insure that an adequate amount of B is present in, and around the bud tissue at flowering.

**Foliar Application:** Foliar applications containing boron have been effective for preventing drought spot, checking and cracking of the fruit surface, and internal corking of the fruit, as well as shoot dieback from boron deficiency. Additionally, post-harvest and pre-bloom foliar boron sprays have been shown to increase fruit set. Foliar applications of boron are not effective in supplying adequate amounts of this element to the roots of fruit trees. Although boron sprays have been applied successfully using low-volume spraying equipment, this method increases risk of injury from over application, particularly near the sprayer manifold. Further, since boron applied as a foliar spray is not readily mobile within the tree it is essential to obtain thorough and uniform coverage.

Therefore, tank-mix concentrations of 1X to 3X should be used when possible, and should not exceed 6X-8X. Foliar applications of boron should be used to supplement soil applications but should not be applied unless the boron status of the trees is known. Because of the extreme sensitivity of apricots and peaches to excessive boron, foliar and soil applications to these crops must be made with the utmost caution. The following rates are in amounts per 100 gal water and applied at 300 gal/a rate.

**Pre-Bloom/Bloom:** Pre-bloom to bloom sprays are usually applied from the time that blossoms are exposed in the bud until and including full bloom, using rates of 0.5-1.0 pound of Solubor™ (the most common boron source for foliar application) per 100 gallons of dilute spray equivalent. These rates provide 0.3-0.6 pound of B per acre in orchards that require 300 gallons of dilute spray equivalent for thorough coverage. A pre-bloom application is recommended when the previous-season leaf sample boron level is less than 35 ppm. This application provides boron to the flower during the critical period of development of the ovules and anthers, improves pollen germination and pollen tube growth, and improves early season leaf and shoot growth. A pre-bloom spray of boron is also beneficial in overcoming the effects of winter injury to buds. Pre-bloom foliar applications of boron have little effect on boron content of leaf samples collected in mid-summer, but do increase calcium uptake in some cases.

**Post-Bloom:** Post-bloom sprays containing 1.0 pound of Solubor™ (0.2 pound B) per 100 gallons of dilute spray equivalent are frequently recommended at petal fall or in one or more cover sprays within the first month after petal fall. These sprays have a greater effect than pre-bloom applications in preventing cork formation or premature fruit ripening due to boron deficiency, and in increasing the leaf content of boron, but usually have little effect on calcium uptake. Boron sprays generally should not be used late in the season because of the possibility of stimulating abnormal ripening and breakdown of the fruit. Applications 7-10 days after petal fall and at approximately 30 days after petal fall may be required with crops such as apples and pears.

**Post-Harvest:** Post-harvest boron sprays have been beneficial in improving fruit set of pears, prunes, and cherries in some cases. This response is independent of any increase in leaf boron content during the following season and is based on improved development of the reproductive organs within the flowers. Rates of 1.0-2.0 pounds of Solubor per 100 gallons of dilute spray equivalent are suggested for post-harvest applications while the foliage is still active. Some literature indicates that boron can be absorbed through the bark of the youngest twigs, and directly into the buds of apples, although the efficiency of this approach isn't known.

## Iron (Fe)

Iron deficiencies are primarily associated with high soil pH, and sometimes associated with over-watering, high water tables, poor drainage, or the use of irrigation water high in bicarbonates. If deficiencies occur, evaluate these possible causes and make appropriate changes as needed and feasible.

**Soil Application:** Soil applications of Fe are not recommended due to the extensive soil fixation of any applied Fe.

**Foliar Application:** Little information exists on the effectiveness of foliar Fe on apples or other tree fruit. Where recommendations for foliar Fe are made they are 1.0 lb. Fe per tree as Fe chelate (EDDHA) from Washington State University, or Michigan State University recommends applying Ferbam in early cover sprays according to the current MSU fruit spraying calendar). Michigan also suggests that chelated Fe may be applied.

## Zinc (Zn)

**Soil Application:** Most University data does not indicate strong responses to soil applied zinc. When soil tests indicate a need, Washington State University suggests applying 20 lb. Zn per acre, and Cornell University studies indicate effective results from 120 lb. Zn/acre applied preplant. While these rates would undoubtedly increase the uptake of Zn from the soil, growers should be able to get a significant response from much lower rates. Annual rates of from 3.0 - 10 lb. Zn/acre should be adequate for most situations, and the higher rates should increase the soil Zn level over time. However, at this time, it may be best to apply Zn foliar when need is indicated by soil tests, and more importantly when leaf analysis indicates the need.

**Foliar Application:** Foliar applications are effective for supplying zinc to established fruit trees. Various methods of applying zinc are available, the most common being late dormant sprays of zinc sulfate, summer applications of zinc chelates or other materials, and post-harvest applications of zinc-containing products. Zinc-containing fungicides have been partially effective in established orchards, but have not always met total requirements or completely corrected a zinc deficiency. One of the most critical periods that a zinc shortage may seriously impair tree performance is between bud break and fruit set. A zinc shortage at this time often results in poor growth of the leaves and new shoots as well as abnormal development of pollen tubes, ultimately resulting in poor fruit set. Later in the season, the effects of limited zinc are small fruit and/or poor color development. Zinc is not readily mobile within the tree and applications must be thorough and timely for optimal response

**Late-Dormant Sprays (full dormancy to “silver-tip” buds):** Zinc sulfate at 3.5 – 5.0 lb. Zn/100 gal water as a dilute (not over a 2X tank-mix concentration to obtain adequate coverage of buds and shoot surfaces). **CAUTION: Ohio State Univ. cautions that injury to the tree may occur if zinc is applied within 3 days preceding or following an application of oil, and the Univ. of California cautions that Zn and oil should not be applied within 30 days of each other. Also, freezing weather 2-4 days before or after dormant Zn sprays have resulted in the killing of spur systems in apples.** Spray alone or with fresh hydrated lime as a safener (2.0 lb./100gal. per Ohio State Univ.). These sprays should be dilute (not over a 2X tank-mix concentration) to obtain adequate coverage of the buds and shoot surfaces.

**Summer Applications:** Both inorganic forms such as ZnSO<sub>4</sub> and EDTA chelates are effective.

**Caution: NTA-zinc chelates have caused severe defoliation when applied foliar.** EDTA chelates have less likelihood of foliar burn and can be effective later into the summer. EDTA chelates should be applied at 10-14 day intervals, beginning 1-2 weeks after petal fall are effective. Use at rates recommended by the manufacturer. A pre-bloom application may also be needed to stimulate early bud, leaf, and shoot development if the Zn status of the orchard is marginal or deficient. Suggested rates of inorganic sources of Zn are similar to those listed under Post-harvest sprays

**Post-Harvest Sprays** have shown variable results. In some cases 3.0-6.0 lb. of 36% Zn sulfate (1.0-1.8 lb. Zn) plus 5.0 lb. urea (2.3 lb. N) per 100 gal water, applied as a dilute spray has been effective in mature apple orchards in some cases. Zinc containing fungicides are partially effective, but cannot meet total requirements, or correct a deficiency.



# Manganese (Mn)

## Soil Application

Most University fruit recommendations do not recommend soil applied Mn. Where soil conditions exist that limit Mn availability, broadcast soil applied Mn is normally rendered unavailable very quickly.

## Foliar Application

Manganese sulfate is the most commonly suggested Mn source. Recommended rates range from 1.0 – 5.0 lb. of manganese sulfate/100 gallons, applied as a dilute spray (300 - 400 gal./acre, depending on source of recommendation). The final application rate is typically 1.0 – 2.0 lb. Mn/acre. Cornell University, a primary source of information on many tree fruits, recommends applying foliar Mn at 0.5 - 1.0 lb. of Mn/100 gal. of water as a dilute spray (see section on foliar fertilization), applied 7 - 10 days after petal fall. Ohio State University recommends including 2.0 lb. of hydrated lime per 100 gallons of water. Recommended application timing listed by many Universities is “as needed”.

While several Universities suggest that manganese can be effectively supplied to fruit trees by soil application, our experience at Spectrum Analytic suggests that unless soil applied Mn is banded, it does not stay in an available form long enough for most plants to utilize it. It is suggested that one spray of manganese sulfate at a rate of 2.0 – 4.0 pounds (0.5-1.0 pound Mn) per 100 gallons, dilute equivalent applied 7-10 days after petal fall, is often adequate to prevent deficiency symptoms over the remainder of the season.

Manganese-containing fungicides have provided enough of this element to prevent the appearance of deficiency symptoms when used in several post-bloom sprays at rates normally applied for disease control.

Alternative manganese sources for foliar application, including chelated forms, should be used according to product label instructions. Some product labels caution that they should be used with a zinc material, i.e., the EDTA chelates, to minimize the potential of injury. It is advisable to test these materials on a limited scale before assuming that they are safe and effective for use in a particular situation.

# Copper (Cu)

Copper malnutrition of fruit trees is reported as becoming more prevalent in many areas of the country. Growers may find a need to apply Cu for only as many years as the trees indicate a need (see following comments).

## Soil Application

Most Universities either do not recognize any Cu shortage in their state, or do not list a recommendation for soil applied Cu in their published information. However, agronomists have long recognized that applications of from 5.0 - 10 lb. of soil applied Cu per acre will build up the test level of most soils. While this may not guarantee adequate Cu uptake by apples, or other fruit trees, it works for many other crops. When using soil applications of Cu fertilizers, the grower should monitor the build up of soil Cu with annual soil tests. This is because there is the possibility of building soil Cu level to the point of toxicity, from continued application past the point of crop need. The first effect of excessive soil Cu levels is likely to be damage to the feeder roots, similar to some herbicide damage.

## Foliar Application

**CAUTION: Use extreme care because these materials can cause severe injury to young leaves, and russetting of fruit.** Current recommendations from Cornell are to apply only when deficiency symptoms, or leaf analysis confirm need. Apply at label rate. Apply between the green-tip and ¼ inch green stage, if the previous year's leaf analysis indicated a need. When spraying inorganic Cu, such as CuSO<sub>4</sub>, it is important that the pH of the spray solution be "basic" (above pH 7.0). The chances of foliar injury increase significantly as the pH of the spray solution decreases. In severe cases, a post-harvest spray of a copper-containing fungicide in addition the green-tip spray has been more effective than either spray alone. Current, (6/91), Cornell research looks promising for late season Cu applications to correct deficiencies. Copper chelates should be applied according to manufactures recommendations. In general, when leaf samples indicate a need for copper in any of the tree fruit crops, Cornell Univ. suggests that copper-containing fungicides be used at times and rates recommended for disease control on that crop. Examples of such uses include the control of fire blight in apples and pears, black knot in plums and prunes, leaf spot in cherries, and leaf curl in peaches.

Research at the Washington State University-Tree Fruit Research and Extension Center, Wenatchee, has not found this to be the case with apples. Their conclusions with foliar applications of Kocide (Cu hydroxide; Griffin Corp., Valdosta, GA), copper sulfate (Tech Spray Copper at 1 pt./100 gal./application, equivalent to 0.065 lb. Cu/100 gal.), and copper oxysulfate (Tech-Flo Copocal at 2 qt./100gal./application, equivalent to 0.26 lb. Cu/100 gal.) are, "the use of Cu sprays at late dormant through half-inch green timing will not influence fruit typiness or increase leaf Cu concentrations of Delicious apple, and are therefore not useful for nutritional purposes... certain Cu products have useful pesticidal properties when applied during this phenological period... Multiple midsummer Cu sprays (4 sprays, applied every 2 weeks, beginning in early May) are effective at increasing leaf Cu concentrations and presumably whole tree Cu status."

Cornell research in applying low rates of some copper materials during the later part of the growing season is encouraging, but there is insufficient evidence to recommend this practice (as of the 6/91 publication date of Cornell Publication 219, Orchard Nutrition Management).

# Comments about Foliar Fertilization

The following information on foliar fertilization is taken from the Cornell Cooperative Extension Bulletin 219

“Foliar application of nutrients provides an opportunity for supplying essential elements directly to the foliage, flowers, or fruit at times when rapid response may be required. Cold weather during bloom or cold soils in the spring often limits the availability of nutrients while increasing the plant requirements during this critical period. Likewise, the amounts of certain elements required for the rapid development of foliage and shoot growth during the grand period of growth often exceeds the rate at which they can be supplied by normal root absorption and transport processes. In still other cases, foliar application may offer the best means of supplying a particular element, either because it cannot be effectively supplied through the soil, or to precisely control the time and rate that the element is available to the plant. Foliar application of nutrients should, however, be considered as a method for supplementing soil-applied fertilization programs, not as a substitute for them.

Foliar application of nutrients involves the possibility of either damage to the crop or ineffectiveness from inappropriate rates, methods, or timing. The two major points governing this are: 1) the proper rate to apply in the individual orchard situation, and 2) the manner and time appropriate for the specific situation.

Differences in tree sizes and densities of planting make the tree-row-volume technique of determining the amount of material to be applied most suitable for adjusting rates to various orchard situations. Cornell recommendations are based on the application of 0.7 gallon of dilute spray equivalent per 1,000 cubic feet of tree-row-volume of well-pruned trees. Determining the dilute spray requirement in this manner provides the basis for calculating the appropriate rate of material per acre.

After the appropriate rates of materials have been determined, how the sprayer is set up to apply them must be considered. The volume of water used to apply different materials to the intended target should be determined by the type of material and/or the purpose for which it is being applied. Nutritional sprays should be applied in sufficient volumes of water to ensure adequate uptake by the foliage during the initial wetting period. Thus, relatively high volumes of water are required for optimal results. Most studies have shown that concentrating tank mixes of nutritional sprays by a factor of 6 or 8X increases both the difficulty of obtaining thorough distribution and the risk of injury to the crop. **It is therefore recommended that nutritional sprays be applied as dilute or near dilute-not over 3X concentrate-sprays (mixing at 3 times the dilute rate per 100 gallons of spray and applying this mixture at one-third of the gallonage required for a dilute spray).**

Weather conditions at the time nutritional sprays are applied should be closely monitored. Slow drying conditions or high temperatures, i.e., relative humidity approaching 80% and/or temperature approaching 80°F, favor increased absorption of the applied materials, but also increase the potential for injuring the foliage or fruit.

## Special Considerations in the Foliar Application of Nutrients

To minimize the number of sprays applied in the orchard it is frequently desirable to combine various nutrient materials, or to add them in tank mixes with pesticides. Several precautions must be observed, however.

Fixed-copper fungicides used as a source of copper at the late-dormant to one-fourth inch green stage of development, according to crop, are compatible with superior spray oils that might be applied at that time.

Generally, urea, Solubor™, EDTA-zinc chelates, and Epsom salts are compatible. Urea, Solubor™, and EDTA-zinc chelate have been used together safely in pre-bloom sprays on apples and pears. A tank-mix combination of urea plus Epsom salts has sometimes injured young apple foliage; if both are required we suggest they be applied as separate sprays.

Solubor™ and presumably other forms of boron should not be tank-mixed with any pesticide contained in water-soluble plastic packages because it inhibits the dissolution of the plastic. Solubor™ should not be tank-mixed with oil.

Epsom salts may increase the pH of the tank mix, and if used with pH sensitive pesticides such as organophosphates, or miticides, or some fungicides, pH of the tank mix should be tested and adjusted by adding a suitable buffering agent.

Although Epsom salts, Solubor™ and EDTA-zinc chelate are compatible for use in post-bloom sprays, many orchardists prefer not to add all three to one tank mix. A petal fall spray may then contain Epsom salts alone or with Solubor the first cover spray (7-10 days after petal fall) a combination of Epsom salts plus Solubor™ the second cover spray (10-14 days

later) a combination of Epsom salts plus EDTA-zinc chelate; and the third cover spray ( 14 days later) a combination of Solubor™ plus EDTA-zinc chelate.

Calcium chloride generally contains lime as a contaminant and adding it to a tank mix will raise the pH of the solution. As indicated for Epsom salts, pH of the tank-mix solution should be tested and adjusted if pH-sensitive pesticides are included. Combining calcium chloride with Epsom salts may present a problem under some conditions when they react to form a calcium sulfate precipitate.

Unless the compatibility of a particular nutrient source with a pesticide is known it is more judicious to apply them separately. Physical compatibility of materials can be easily determined by mixing the appropriate rates of them in a jar of water. This test does not provide information about possible chemical incompatibilities, however. Check product labels and with industry representatives before mixing to be sure that various tank mixes are appropriate.”

## Fertigation

According to Orchard Nutrition Management, Cornell Univ. Bulletin 219, “Application of fertilizers through irrigation systems is referred to as fertigation. Although fairly common in arid areas, experience with fertigation under humid conditions is limited. The most feasible use of this technique in orchards of the Northeast is for adding various soluble fertilizer materials through trickle or drip irrigation systems. The efficiency of fertilizer uptake and use with this method is enhanced because applied materials move rapidly to the root system with the water. As suggested here, the use of this approach presumes that additions of lime, phosphate, and other nutrients have been completed as specified in preplant soil preparation.

Trials conducted in New York during the past five years indicate that nitrogen, potassium, magnesium, boron, and zinc can be effectively supplied through fertigation. In these trials, **the total amounts of fertilizer materials to be supplied were applied in 10 weekly applications** (emphasis by Spectrum Analytic).

The fertilizer materials should first be dissolved in water before injecting them into the irrigation lines. The system should be run long enough to fill the lines with water before injecting the fertilizer solution, and completely flushed after the injection has been completed to avoid plugging by dissolved salts or other contaminants.

Ammonium nitrate is a suitable source of nitrogen for trickle irrigation systems. Monoammonium phosphate or other forms of phosphates should not be used with magnesium sulfate (Epsom salts) because the reaction between these materials will form insoluble magnesium phosphate that will plug the emitters.

Rates of 0.5-0.75 ounce of ammonium nitrate per tree in each of 10 weekly applications have been used to provide 0.1-0.15 pound of actual nitrogen per tree over the season. These rates may be satisfactory for young nonbearing trees, but must be closely followed through leaf analysis and adjusted as necessary to achieve the desired nitrogen levels in leaves.

Application of potassium through trickle irrigation systems also offers an efficient means of meeting crop requirements. Trials to date indicate that muriate of potash (0-0-60) is a suitable source. Rates of muriate of potash in the range of 100-120 pounds (60-70 pounds  $K_2O$ ) per acre of orchard per season, using 10-12 pounds per acre per application, appear to be appropriate but should be adjusted as indicated by leaf analysis.

Epsom salts or magnesium sulfate solution can be used to provide magnesium in fertigation. Weekly applications of 35-40 pounds or more of Epsom salts (3.5-4.0 pounds Mg) per acre of orchard may be required. As indicated under nitrogen sources, **no phosphate materials should be applied at the same time that magnesium sulfate is being injected into the irrigation system** (emphasis by Spectrum Analytic).

Solubor is a suitable source of boron for fertigation, but rates of application must be closely monitored. A rate of 0.5-1.0 pound of Solubor™ per acre of orchard (0.1-0.2 pound of actual B per application) has been used successfully with young apple trees growing on a silt-loam soil. This rate may provide more boron than is required for coarse-textured soils because of the increased efficiency of uptake with this method. We suggest that these rates be reduced by one-half, or that the boron be added only in alternate applications with such soils. As with nitrogen and potassium, leaf analysis is critical to monitor boron levels in the trees and to make appropriate rate or timing adjustments.

Application of liquid chelated zinc through trickle irrigation systems will effectively supply this element. Research trials suggest 8-10 weekly applications of EDTA-zinc (6 %zinc) at rates sufficient to provide 10-15 pounds or more of zinc per acre per season may be necessary.

Application of a suitable copper material such as EDTA-copper chelate through trickle irrigation systems probably offers another alternative for supplying copper, but information on rates is insufficient to provide a recommendation at this time. Rates of application using this method should be carefully monitored by leaf analysis to avoid a copper toxicity problem.”

# Soil and Plant Sampling

## Commercial Fruit Tree Plantings

The use of routine leaf (and apple fruit) analysis is critical, for optimum tree crop production. The optimum time for orchard leaf samples, in most of the country is from late July through mid September. Apple fruit samples should be taken 2 times each season. The first sample is taken soon after the fruit reaches 1.5 inches in diameter, and the last is taken about 2 - 3 weeks before the expected harvest date. In all cases, each block of trees should also have the soil monitored with routine soil analysis.

This procedure uses "indicator trees", that are typical of that block of trees, to monitor the nutrient status and determine the fertility treatments for the entire block. Ideally, leaf samples should be collected between 60 and 70 days after petal fall. If possible, avoid taking samples too long before, or after this time period, since it makes interpretation less accurate. However, it is normally better to take a less-than-perfect sample, than none at all.

1. Divide the field into blocks of trees of the same species, age, and general soil condition. Identify the sampled trees with a number/letter code that identifies the group for future reference and re-sampling. Permanently mark the sampled trees so you can sample the same trees each season (paint, plastic marker, etc.). A colored weatherproof tag that can be written on in permanent ink which contains the sample identification for the block may be best. Use this code to identify both the soil and the plant sample. These trees will become a permanent indicator for the entire block that they represent.
2. Select 5 trees in each block that are the most typical trees in the block (growth, yield, quality, etc.). A composite soil, leaf, and fruit sample should be taken from these 5 trees in each block.
3. For each "indicator" tree in a block, take 3 - 4, 8 inch deep soil cores, evenly spaced around the perimeter, and just inside of the "drip line" of each tree (15 - 20 cores total). Mix these cores well in a plastic bucket and take a sub-sample (about 1 pint, which fills the soil bag to the line indicated on the bag) of this soil to send with the leaf sample.
4. Collect at least 10 leaves per tree (at least 50 total), of mature size, from approximately the middle area of the terminal shoots. Leaves should be collected from about shoulder height, evenly spaced around the entire perimeter of each tree.
5. With apple fruit sampling, you need to send at least 10 apples from each block of trees. The first apple fruit sampling will require up to 15 apples if they are the minimum size of 1 - 2 inches in diameter.
6. Record this identification and all other information such as sample data, treatments, and other data in a log so you can evaluate the progress of the crop. In most cases, a map of the orchard showing the location of the blocks and indicator trees is recommended.

**Note:** If certain trees exhibit probable nutrient problems that you want to identify, sample them individually as described above. Remember to take the total required leaves and soil cores from that tree. In this case, it would be helpful to take an additional set of leaves and soils from a normal tree to compare with.

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