Fertilization Programs for Apple Orchards

Cooperative Extension Service
College of Agriculture and Home Economics
NEW MEXICO STATE UNIVERSITY

Guide H-319

Esteban A. Herrera, Extension Horticulturist

This publication is scheduled to be updated and reissued 6/06.

Many factors, including climate, soil, irrigation, varieties, pruning, insects, and tree nutrition influence the growth and production of fruit trees. Some of these factors can be controlled by growers; others cannot. Tree nutrition is probably the most important factor for a successful orchard operation, and it can be controlled through a proper fertilization program.

Sixteen mineral elements are essential for plant growth. Three (oxygen, hydrogen, and carbon) are obtained by the tree from water and air. The thirteen remaining elements are divided into two groups:

1. Major essential elements: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S).

2. Minor (trace) elements: iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), boron (B), molybdenum (Mo), and chloride (Cl).

Major elements are needed in much larger quantities than minor ones; all are found in the soil. However, it is not enough for these elements to be present in the soil—they must also be in a form available to trees so that trees can take them up and use them. Among other factors, soil pH (acidity or alkalinity) and balance between elements will affect the availability of nutrient elements in the soil.

Nitrogen, potassium, phosphorus, iron, and zinc appear to be the nutrients mainly needed in New Mexico apple orchards.

NITROGEN (N)

Nitrogen is the nutrient most used in fruit trees and is usually the first element to be considered in an orchard fertilization program, as shoot growth depends highly on nitrogen content. Nitrogen fertilizer rates for young trees are based on tree age and growth rate of shoots; fertilization of mature, heavy-bearing trees may be based in part on terminal growth. Nitrogen deficiencies can reduce fruiting and make fruit small and highly colored; leaves will be small and pale green, dropping early. Low or older leaves turn light green first; individual limbs may die and entire trees are stunted.

Excess nitrogen delays fruit maturity and negatively affects red color on apples. It also delays flowering and can promote late-season vegetative growth, increasing chances of freeze injury, especially in young trees. Excessive tree vigor resulting from too much N can be partially compensated for by late summer pruning. This has two main effects: it improves fruit color by improving light distribution and tends to limit root growth.

Recommendations for time of nitrogen application to apple orchards are often confusing and vary considerably among apple-growing regions in the country. However, a nitrogen fertilization program can be better understood if it is based on the root uptake period, nitrogen storage pattern in trees, and on time of the season or tree physiological stage.

The entire tree root system is capable of nutrient absorption; however, the absorption rate is greatest in new root growth (root tips), which usually are white in color. The period of greatest nutrient uptake coincides with the period of maximum root growth. Depending on the year, this would be from about March through October in New Mexico, but this period always will be shorter in northern New Mexico than in the southern area. Nitrate uptake increases with shoot elongation and remains high until leaf fall; it then decreases sharply from leaf fall to the initiation of root growth.

Annual nitrogen applications are necessary to maintain sufficient nitrogen reserves in the tree. About 80% of the annual nitrogen use is from tree reserves, while only 20% is from the immediate nitrogen application. The later nitrogen is applied during the growing season, the less it is used the year of application, and the greater its contribution the next year. Therefore, nitrogen applied late in the year is stored, mainly in the root system, for use the following year. Nitrogen used during bloom is drawn from nitrogen the tree has stored from the previous year's application. Shoot growth in late spring or early summer then becomes dependent on external nitrogen supply. In some cases, all stored nitrogen is exhausted by the end of June. In nitrogen-deficient orchards, nitrogen from fertilizers applied during the current season can be absorbed immediately.

Based on these findings, half the recommended nitrogen should be applied during the post-harvest period, to be stored and used early in the following season. The other half should be applied after bloom. (Coarse textured (sandy) soils are an exception to this recommendation because nitrogen fertilizer applied in the fall is subject to leaching.) Foliar application of nitrogen during the season also helps trees. Fall season applications will be absorbed by roots while trees have foliage, and whenever temperatures are above 45°.

Nitrogen rates should be adjusted so young, nonbearing trees grow 24–36 in. per year. The recommended rate is 1/20 lb of pure nitrogen per year of age of tree. To calculate the amount of a given nitrogen fertilizer needed, use the following equation:

$$\frac{\text{Age of tree (years)} \times 5}{\text{\% of N fertilizer}} = \text{lb fertilizer / tree}$$

Example: Fertilizing 30-year-old trees with ammonium sulfate (AS) which has 21% N —

$$\frac{30 \times 5}{21} = 7.1 \text{ lb AS / tree}$$

Other formulas recommend 1/5 lb N (or 1 lb of ammonium sulfate) per inch of trunk diameter.

Nitrogen fertilization rates for mature, heavy-bearing trees fluctuate from 150 to 200 lb of nitrogen per acre, or 750–1,000 lb of ammonium sulfate per acre. Annual shoot (terminal) growth should be around 6-10 in. per year. If growth patterns are higher or lower, nitrogen rates should be adjusted accordingly. A general recommendation for apple trees is listed in table 1.

Table 1. Amount of N recommended for apple trees.

Age (years)	N per tree or per acre
1	None*
2	1/4 lb/tree if growth is poor
3–5	1/4–1/3 lb/tree
6–7	1/2 lb/tree
over 7	150–200 lb/acre

* When leaves have appeared and young trees are growing vigorously, broadcast monthly applications of N at the rate of 0.05 lb N per tree (0.25 lb ammonium sulfate).

Ammonium sulfate is the nitrogen formulation most recommended for orchards in New Mexico because it acidifies the soil somewhat. Although temporary, this action can make available some minor elements for use by apple trees.

Any formulation of nitrogen fertilizer is converted to ammonium, then to nitrate, before it is absorbed by the tree's root system. Nitrates are water soluble and can be easily leached out in irrigation water. Generally, tree utilization of surface broadcast nitrogen fertilizer is low; thus, good fertilization practices are needed to prevent nitrogen losses through leaching. The best way to apply nitrogen and other fertilizers is through drip irrigation, where nutrients are carried close to the root system and recommended rates can be evenly distributed throughout the season. Another good way to incorporate nitrogen into the soil is by injecting liquid fertilizers into the soil; several applications are needed during the year to take full advantage of this system. Surface broadcast application of nitrogen and other nutrients, with subsequent soil incorporation by discing, will always have some losses, first through volatilization, then through leaching. Splitting fertilization rates throughout the year may prevent most leaching losses, but may not be practical.

POTASSIUM (K)

Potassium deficiency is not common in New Mexico or in the southwestern states, mainly because the clay contained in soils releases enough potassium for tree use. In many cases, apple trees' perennial root system permits absorption of enough nutrients from soil that would be deficient for annual or seed crops. Apple trees growing in sandy soils, however, usually require potassium applications. Leaf analysis will help determine if potassium fertilizer applications are needed. Potassium sulfate (44% K) is preferred over potassium chloride (muriate of potash) to avoid chlorine toxicity that can occur in low-rainfall areas. Mild potassium deficiency is similar to nitrogen deficiency, causing yellowish-green leaves. A severe deficiency will cause foliage necrosis, especially with scorched leaf margins, similar to soil salt build-up symptoms. Apply 150–200 lb of potassium per acre every other year if a deficiency occurs.

Although no specific research has been conducted, it is believed potassium and phosphorus fertilizers can be soil-incorporated before planting at a rate of about 200 lb per acre. These nutrients will be spread throughout the soil and be available for root uptake for several years. Higher amounts are needed when a cover crop or sod is present.

PHOSPHORUS (P)

Fruit trees, including apples, have not responded to phosphorus fertilization, regardless of soil or leaf analysis results; therefore, no phosphorus fertilization has been recommended in the past. Furthermore, the high pH in New Mexico soils makes soil-applied phosphorus fertilizer immobile, and it will not move down the soil profile more than 1 in. per year. As with potassium, the extensive and perennial root system of apple trees tends to absorb enough soil phosphorus to fulfill tree requirements. Whenever phosphorus deficiencies occur, they appear on the shoots, petioles, and leaves. The shoot growth appears slender, petioles of the leaves are somewhat upright, the leaves may be smaller than normal, and they tend to be dark green with reddish or purplish tinting of the midrib and larger veins.

Sources of phosphorus fertilizer for apple orchard use have always been superphosphate or the formulation 18-46-0 (N-P-K). Unfortunately, phosphorus fertilizer will not travel down the soil profile in basic (calcareous) soils. However, research in Washington state with monoammonium phosphate (MAP) fertilizer has shown excellent responses in apple orchards, especially in low-vigor trees. This fertilizer is highly soluble and travels down to the root system, making it available for uptake by the trees. Applying 200 lb of MAP about every 2 years will improve apple trees' growth and production.

IRON AND ZINC (FE, ZN)

For the most part, iron and zinc are found in sufficient amounts for tree needs in New Mexico soils; however, calcareous soils (pH > 7.5) render iron and zinc nutrients unavailable for tree uptake. Bright or pale yellow foliage (iron chlorosis) with a network of green veins identifies iron deficiency. Zinc deficiency is characterized by small leaves and short internodes, making all the foliage in a shoot clump together, appearing like a rosette or lion's tail. In acute deficiencies some necrotic (dead) spots between leaf veins also can be seen. Symptoms of iron chlorosis usually appear with flushes of new growth; zinc deficiency appears in the middle of the season. In some instances, twigs die back after the first year.

Foliar sprays are recommended to correct this problem. Chelated forms of iron and zinc have been successful. Although such sprays are expensive, they are less likely to cause leaf burning. Zinc and iron sulfate also work when combined with foliarly formulated urea (uran 42%). Sometimes it is necessary to include a water buffer in the solution, which neutralizes the water and helps the chemical be absorbed better by foliage. Usually two sprays are required to correct iron deficiency. Apply the first about 4 weeks after bloom and the second about 3 weeks later.

Zinc may be applied in the fall as a post-harvest application, but the most effective time for application is in the spring before buds open. Higher rates can be used at this stage than later in the season. Spray at or before green tip. Fall applications may be needed where deficiencies are difficult to correct; both applications, post-harvest and spring, may even be needed.

Chelated forms of zinc and iron must be used for soil applications. These formulations dissolve slowly in the soil and can be used by trees before being tied up by soil particles. In high-pH soils, iron and zinc sulfate are quickly transformed to unavailable forms and cannot be taken up by roots. Though chelated formulations of iron and zinc are more expensive than sulfates, they are more effective. Chelates usually help overcome zinc and iron deficiency problems for more than one season, but tree response is slower. Seques-trene 330 Fe has been the best chelated source for iron.

General Guidelines

Annual soil tests are recommended for apple orchards to monitor salt build-up and nutrient (N, P, K) accumulation throughout the soil profile. Minor elements need not be tested. Topsoil (1-1/2 ft) and subsoil (1 1/2–3 ft) should be tested separately. Leaf (tissue) analysis is recommended once or twice a year, if possible, to indicate nutrient uptake by the trees. Several years of tissue analysis will show the trend followed after a given fertilization program. For accurate results, sample 60–100 leaves from the current year's shoot growth in July. Collect leaves from shoulder height at the tree's periphery, using leaves from the middle of the current season's shoot. Sample the same orchard area and the same variety every year. Select only healthy leaves with no spray, insect, or disease damage; sample problem trees separately.

Incorporating manure into orchard soil can also add needed N, P, K. One ton of manure contains around 10 lb N, 5 lb P, and 10 lb K. Manure also increases the soil's organic matter content. Organic matter is a transitory part of the soil that is continually decomposing and must be replaced regularly. When organic matter is lacking, clay (heavy) soils become physically difficult to manage, as water intake and aeration is reduced because of soil compaction. Sandy soils without organic matter lack body and the capacity to hold water and nutrients.

Cover (green) crops can also be used to increase soil organic matter. Legumes (beans, clover) also incorporate some nitrogen into the soil. When a nonlegume cover crop is plowed under as a green manure crop, it is recommended that 30 lb N be applied for each ton of material to speed up decomposition.

Reprinted June 2001 **Las Cruces, NM**
5C