This is a section from the

2023/2024
New Jersey Commercial
Tree Fruit Production Guide

The recommendations are **NOT** for home gardener use.

The **full guide** can be found on the Rutgers New Jersey Agricultural Experiment Station (NJAES) website at: *https://njaes.rutgers.edu/pubs/publication.php?pid=e002*. The guide is revised biennially.

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PESTICIDE USE DISCLAIMER

THE LABEL IS THE LAW

A pesticide applicator is legally bound by the labeling found on and with the pesticide container in their possession. Before using a pesticide, check and always follow the **labeling distributed with the product at the point of sale for legally enforceable rates and restrictions**.

In addition to the pesticide products listed in this Production Guide, other formulations or brands with the same active ingredient(s) may be commercially available.
ALWAYS CHECK THE LABELING ON THE PRODUCT CONTAINER ITSELF:
a) to ensure a pesticide is labeled for the same use,
b) to ensure the pesticide is labeled for the desired crop,
c) for differences in rates and percent active ingredient, and
d) additional restrictions.

Check the physical product label for the maximum amount of pesticide per application and the maximum number of applications per year.

IMPORTANT: DO NOT RELY ON ELECTRONIC LABELING (unless it is "web labeling" found directly on the product container)**.** *Online pesticide* labels may not be the same as the labeling distributed with the product. Some services include: Proagrica's CDMS *http://www.cdms.net/*; Agworld DBX powered by Greenbook *https://www.greenbook.net*; or Agrian *https://www.agrian.com/labelcenter/results.cfm.*

These electronic label services provide use disclaimers, and in some cases legally binding User Agreements assigning ALL liability to USER of service. For example, Agrian's webpages***** cite (in red): The *material and content contained in the Agrian Label Database is for general information only. Agrian Inc. does not provide any guarantee or assurance that the information obtained through this service is accurate, current, or correct, and is therefore not liable for any loss resulting, directly or indirectly, from reliance upon this service. This Label Database does not replace the official manufacturer issued label. Users of this database must read and follow the actual product label affixed to the container before use of the product. Use of the Label Database is subject to the Terms of Use and Privacy Policy* ***** [*date accessed: 12/23/2022*].

See a detailed regulatory discussion of this and other essential information on Pesticide Safety and the Pesticide Label in Chapter 1. Electronic labeling is discussed in section 1.3.1.

If you are having a medical emergency after using pesticides, always call 911 immediately.

POISON Help®
1-800-222-1222

In Case of an Accident

- Remove the person from exposure
- Get away from the treated or contaminated area immediately
- Remove contaminated clothing
- Wash with soap and clean water
- Call a physician and/or the National Poison Control Center (1-800-222-1222).
  Your call will be routed to your State Poison Control Center.
- Have the pesticide label with you!
- Be prepared to give the EPA registration number to the responding center/agency

3 Orchard Nutrition

3.1 Soil Management for New and Established Orchards

Soil Management for New Plantings

1) Selection of Soils

The best soils for growing fruit trees are medium textured, friable, well-drained soils that are deep with no hard pan. Sandy loam, loam, and silt loam soils are suitable for growing fruit trees. Loamy sandy soils should be avoided where adequate irrigation is not feasible. Soil organic matter levels should be around 2% for sandy loam soils and 3 to 4% for loam and silt loam soils.

Good subsoil aeration and drainage are essential for the growth and longevity of fruit trees. Soils that have high water tables or poor internal drainage, resulting from compacted soil layers, should not be used for orchards. On potential orchard sites, areas with poor drainage may be recognized by surface or subsoil water accumulation for several days following heavy rains or irrigation. However, a detailed inspection of the soil structure via a soil excavation is highly recommended. Several excavation pits should be dug down through the topsoil and subsoil to look for shale, clay layers, or hardpans caused by excessive soil compaction.

On rolling landscapes, side slopes provide desirable orchard sites. Fruit trees at the bottoms of slopes or lowlands are more susceptible to frost injury and these sites should be avoided.

2) Preparation of Soils Timeline

New orchards should be planned out at least two years in advance of planting.

Two Years Prior to Planting:
Select planting site.

1.5 Years Prior to Planting:
Take a soil test.

6 Months - 1 Year Prior to Planting: If soil test recommendations call for liming (the recommended soil pH for orchard sites is 6.5), the limestone should be broadcast. After broadcasting limestone, orchard soils should be sub-soiled to a depth of 2-3 feet in two directions prior to sod establishment and tree planting. Sub-soiling serves to break up hardpans and it helps to move limestone particles and nutrients down into the root zone. This practice is best done after a dry period when the soil hardpan is more susceptible to fracture.

1-2 Months Prior to Planting: Apply fertilizer according to soil test recommendations. The fertilizer should be broadcast and incorporated with tillage.

Planting: No fertilizer should be applied at the time of planting, especially near the bare roots. Tree nurseries may void tree warranties if any fertilizer is added to the planting hole.

For more details on liming and fertilization prior to and after planting, see sections 3.3, Leaf Tissue Analysis, and 3.4, Orchard Soil Fertiilty Management.

3) Sod Establishment

Permanent sod covers in orchard middles help prevent soil compaction, decrease surface water runoff, increase soil-water infiltration rates, minimize wind and water erosion, maintain or increase soil organic matter content, conserve plant nutrients, and make it easier to move sprayer and other equipment in the orchard during wet periods. It is very important to treat sod middles to eliminate broadleaf weeds, which not only compete with trees for the attention of bees during bloom, but may also harbor harmful insects that can serve as virus vectors in orchard settings.

Seed areas to a permanent sod cover at least 6 months in advance of planting trees. Fall is the best time to establish new sod, with August 15 through September 15 as the target seeding period. Hard and tall fescue cultivars are the preferred grass species. Nutrient recommendations for preparing soils for new tree plantings and maintaining orchard middles can be found in Table 3.5. The sod should be left in the row middles when planting new trees.

In the tree row, either plant through killed sod, or use tillage to make rows for planting trees. Killed sod in the new tree row has several benefits during the first season of tree establishment, *e.g.*, suppression of summer annual weed growth and better water infiltration and retention. Killed sod also adds organic matter to the soil.

For additional sod cover recommendations, see section 4.1, Weed Control Measures and Orchard Floor Management.

Soil Management for Established Plantings

Soil management in established fruit tree plantings can be divided into two distinctly different programs:

1) Soil Management for Tree-Row Middles

Maintain a permanent sod cover of tall or hard fescue (or a mixture of both) in tree-row middles of orchards. Tree-row middles should be kept adequately limed based on soil tests to maintain a soil pH near 6.5. The grass sod should be fertilized with about 20 to 50 lb N/A annually in the fall to maintain a dense permanent sod cover (Table 3.5), unless a broadcast fertilization program is being followed that covers the entire orchard area.

2) Soil Management under Drip Areas

Fruit trees take up most of their water and nutrients from soil in the drip area. Keep soil areas under trees as free of vegetation as possible to reduce competion for water and nutrients between weeds and trees. Adequate lime and fertilizer should be provided in the drip area based on the results of soil and plant analyses (Tables 3.1, 3.2, and 3.6). In established orchards where tillage is not possible, limestone should be surface applied, but the rate of pH adjustment will be much slower. Monitor soil pH changes and avoid unnecessary limestone additions. Surface limestone application rates should not exceed 3,000 pounds CCE per acre. Both limestone and fertilizer contribute to crop yield and quality and correct application rates are important factors for achieving profitable fruit crop production. Mulch or compost may be applied under trees to increase soil organic matter content and improve soil water holding capacity.

3.2 Soil Testing

Soil testing can be used to evaluate soil acidity and soil fertility conditions prior to and throughout the growing season. A soil test provides an index of soil nutrient availability that is correlated with plant responses. It is not a direct measurement of the total plant-available nutrient content of a soil even though the results are often reported in units of pounds per acre. Soil test results and interpretations are specific for the soils of a region and for the soil test methods employed.

Procedures for Soil Sampling

Soil samples should be taken and sent to the laboratory in the fall after the harvest season every 1-3 years per field. Growers who wait until the following spring may not get their soil test report back from the laboratory in time to make effective use of the results.

Take soil samples from under the tree dripline. Collect about 15 cores from each area by sampling the 0-6-inch depth. Label each soil sample by location and date.

For a detailed sampling protocol refer to the Rutgers Soil Testing Laboratory ‘How to Have Your Soil Tested’ at: *https://njaes.rutgers.edu/soil-testing-lab/how-to.php*.

Soil Test Interpretation

A soil fertility test evaluates the nutrient-supplying power of a soil. Test results are used to predict if, or how much, fertilizer is required for optimum plant growth. The interpretation of a soil report requires an understanding of soil test methods and units that are used to express soil nutrient levels, *i.e.*, pounds per acre, or parts per million (ppm). Most laboratories will include the extraction method, soil nutrient level units, and interpretive information on their soil test reports. If not, contacting the lab is advised.

Several soil test extraction methods are in use, but only a few are appropriate for soils in New Jersey. The Mehlich-3 soil test is used by the Rutgers Soil Testing Laboratory and is the most widely used method in the Eastern United States.

The conceptualized relationship between soil test nutrient levels and plant response is shown in Figure 3.1. Relative soil fertility levels for **macronutrients** (phosphorus, potassium, magnesium, and calcium) are classified into three main categories: **Below Optimum**, **Optimum** and **Above Optimum**. Below Optimum is divided into subcategories: **Very Low**, **Low**, and **Medium**. These soil fertility categories gauge the probability of a plant having a beneficial response to the addition of a given nutrient, assuming that other crop production factors (*e.g.*, weather) are not limiting. The soil test categories are the basis for phosphorus (P) and potassium (K) fertilizer applications. For liming recommendations, soil test categories for calcium and magnesium are used to select the most appropriate amount and type of limestone (calcite, or dolomite).

The Rutgers Soil Testing Laboratory also tests for the **micronutrients** Boron (B), Copper (Cu), Iron (Fe), Manganese (Mn), and Zinc (Zn). Soil test interpretations for micronutrients are described as either “Low”, “Adequate”, or “High”. Because micronutrient availability is strongly influenced by soil acidity, the soil pH must also be taken into account. Except for molybdenum, most micronutrients become less plant available as soil pH increases. A soil test level of “Low” indicates a micronutrient is very likely deficient. A soil test level of “Adequate” indicates the micronutrient is probably not deficient but additional data on leaf tissue nutrient concentrations and soil pH should be consulted to accurately assess soil micronutrient availability.

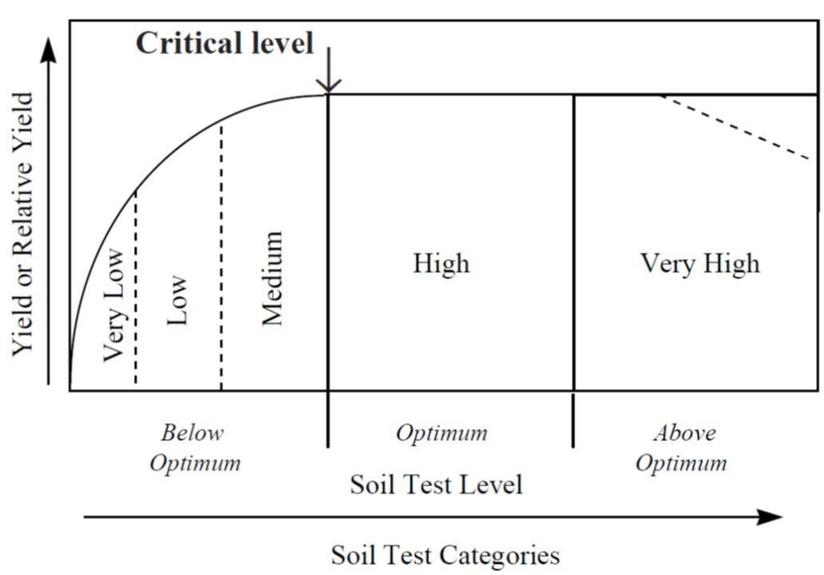
Figure 3.1 Soil Test Response Curve

This conceptual soil test response curve is divided into categories that correspond with **Below Optimum**, **Optimum**, and **Above Optimum** soil test values. The critical level is the soil test level below which a crop response to a nutrient application may be expected, and above which no crop response is expected.

Below Optimum (Very Low, Low, Medium)
The nutrient is considered deficient and will probably limit crop yield. There is a high-to-moderate probability that crops will benefit from additions of the nutrient.

Optimum (High)
The nutrient is considered adequate and addition of more of the nutrient will probably not benefit crop production. A maintenance application may be recommended to account for nutrient removal.

Above Optimum (Very High)
The nutrient is considered more than adequate and will not limit crop yield. There is a very low probability of a benefit from additions of the nutrient to crop production. At very high levels there is even a possibility of a negative impact on crops if nutrients are added. Thus, no application of the nutrient is recommended.



3.3 Leaf Tissue Analysis

Leaf tissue analysis is a widely used method to monitor fruit tree nutritional status in response to various cultural practices and to identify nutritional disorders. In New Jersey, the nutritional status of fruit trees can best be diagnosed from the analysis of leaf samples collected between July 15 and August 15. Leaf nutrient concentrations change throughout the growing season, so for correct interpretation, leaf collection must be performed during the same, aforementioned testing period every year. Nutrient status of leaves should be monitored by sampling leaf tissue every 1-3 years or more often, if necessary.

Procedures for Leaf Sampling

Leaf tissue sampling should be performed in the same year as soil is sampled for each field, every 1-3 years. Samples of 50-60 leaves should be taken 60-70 days after petal fall (July 15 through August 15). Leaves should be collected from trees of the same cultivar and age. Avoid mixing leaf samples from different rootstocks, or from trees under different management. Also, avoid leaf sampling after pesticide cover sprays which can leave residues that may affect the test results. The leaves should be normal looking leaves taken from the midpoint of the current season's shoot growth. The leaves should come from branches midway up the tree (about shoulder height) in the outer canopy. Use clean hands for leaf sampling and prevent any contamination (*e.g.*, with dust or soil).

Leaf Tissue Analysis Interpretation

Leaf tissue analysis measures the concentrations of macro and micronutrients in leaf tissue and provides an assessment of nutrient deficiency, sufficiency, or toxicity. Keeping records of leaf tissue analyses over several years is important; it enables growers to identify trends and nutrient deficiency or toxicity problems. The person interpretating leaf tissue analysis data should have:

1) a thorough knowledge of the optimal ranges for leaf nutrient concentrations in fruit tree leaf tissue (see Tables 3.1 and 3.2),
2) be able to recognize which nutrient(s) might be related to unwanted symptoms of deficiency or toxicity, and
3) be able to formulate fertilizer program adjustments to remediate tree nutritional problems.

Table 3.1 Optimal Foliar Nutrient Ranges of Macronutrients for Different Fruit Trees

Nutrient (% Dry Matter)	Apple	Pear	Peach/Nectarine	Cherry
Nitrogen	1.0 - 2.0	1.60 - 2.40	2.50 - 3.40	2.30 - 3.30
Phosphorus	0.15 - 0.30	0.18 - 0.26	0.15 - 0.30	0.23 - 0.38
Potassium	1.2 - 2.0	0.20 - 2.0	2.10 - 3.0	1.0 - 1.90
Calcium	1.3 - 3.0	1.3 - 3.0	1.9 - 3.50	1.60 - 2.60
Magnesium	0.2 - 0.40	0.30 - 0.60	0.20 - 0.40	0.49 - 0.65
Sulfur	0.16 - 0.41	0.17 - 0.26	0.20 - 0.41	0.15 - 0.49

Table 3.2 Optimal Foliar Nutrient Ranges for Micronutrients for Different Fruit Trees

Nutrient (ppm, parts per million)	Apple	Pear	Peach/Nectarine	Cherry
Boron	35 - 50	35 - 80	25 - 50	39 - 80
Iron	40 - 100	50 - 400	51 - 200	50 - 250
Manganese	22 - 140	20 - 200	19 - 150	18 - 150
Copper	6 - 25	6 - 25	6 - 25	6 - 25
Zinc	20 - 200	20 - 200	20 - 200	20 - 200

3.4 Orchard Soil Fertility Management

3.4.1 Soil pH and Lime Applications

The frequency of lime applications varies with soil characteristics, cropping system, and fertilizer practice. Most orchard soils in the Mid-Atlantic region are naturally acidic and tend to become more acidic because of crop removal of calcium and magnesium, and from the use of ammonium or urea based fertilizers. Careful attention to liming prior to planting orchards is very important. Once the trees are established, it may be difficult to correct a soil acidity problem with surface applications. Limestone reacts slowly in soil, and the desired soil pH increase may require several months.

For an effective liming program, results of both the soil pH and the soil fertility test are needed to determine the amount and type of liming material to apply. The optimum soil pH for tree fruit production is slightly acidic with a target of pH 6.5. When soil pH in the orchard approaches pH 6.0, liming is necessary to adjust it towards a soil pH of 6.5 and to supply crops with calcium and magnesium. The fall and winter months are often the best and most convenient times for lime applications.

Selection of Liming Material

Selection of an appropriate liming material depends on the degree of soil pH correction required and the need to replenish soil Ca and Mg. Fine sized liming materials are recommended when rapid neutralization of soil acidity is desired. Medium and coarse sized liming materials are best suited for maintenance of soil pH once the desired soil pH range has been attained using fine sized liming material.

Soil fertility testing can be used to determine the right type of limestone and how much to apply. Soil test reports that include a “buffer pH” result (aka Lime Requirement Index by the Adams & Evans method at the Rutgers Soil Testing Laboratory) provide an estimate of the limestone application rate based on the soil’s pH buffering capacity. Soil test reports based on the Mehlich-3 method report percent saturation of the CEC (Cation Exchange Capacity) with the three major cation nutrients: calcium, magnesium, and potassium. Properly limed fertile soils with a pH near 6.5 will typically have about 68% of CEC exchange sites occupied with calcium, 12% with magnesium, and 3 to 5% with potassium. These soil test CEC saturation percentage levels are not requirements but they each serve as a useful target. When a soil test report shows that exchangeable calcium levels are below the 68% saturation level, calcite limestone (high calcium limestone) should be applied.

Calcite limestone is generally the preferred liming material for orchard soils, except for soils that test very low for available magnesium. In those cases, dolomite limestone (which supplies calcium and magnesium) may be used, however, excessive application of magnesium to orchard soils could result in reduced uptake of calcium. Magnesium limestone should never be used on soils that test medium or high in magnesium.

Occasionally, soil test results show that the soil pH is adequate (around pH 6.5) and liming is not recommended. However, if the same soil test shows low calcium levels but adequate magnesium levels, an application of supplemental calcium is recommended. Where extra calcium is needed, calcium sulfate (or gypsum 23% Ca) is an excellent source. Gypsum supplies plant available calcium and sulfur yet it does not appreciably change soil pH. Whether adding calcium through limestone or gypsum, appropriate application rates may be calculated based on data for targeted cation saturation levels as shown in Table 3.3.

A simple but less accurate guide to liming practice is based on soil test levels for calcium and magnesium without using data on soil pH. Soil test levels for major nutrients on the Rutgers Soil Test Report are expressed as Below Optimum, Optimum, or Above Optimum. Calcite limestone should be used except when magnesium soil test levels are rated as well Below Optimum. A more advanced and accurate guide to liming practice factors in the initial soil pH, the target soil pH, and the soil texture as listed in Table 3.4.

Calculating the Lime Application Rate

Because liming materials are not pure substances, application rates are based on the Calcium Carbonate Equivalent or CCE of the liming material. Thus, soil test recommendations for liming soils are given in pounds of calcium carbonate equivalent per acre (lb CCE/A). Pure calcium carbonate ($CaCO_3$) has a CCE of 100% and is the standard against which all liming materials are measured. In New Jersey, the CCE of liming materials varies between 40 and 179%, however, the more commonly available calcium carbonate-based limestone materials typically have CCE values between 80 and 100%. The CCE of a liming material must be given on the product label by law.

The amount of liming material needed to supply a given quantity of CCE can vary considerably and needs to be calculated. The following is an example of how to calculate the application rate of a given liming material:

1. Soil test recommendation is 2000 lb CCE/A.
2. CCE of the liming material is 80%.
3. Actual amount of liming material required: (2000 ÷ 80) x 100 = 2500 lb /A.

Table 3.3 Target Cation Exchange Values for Calcium, Magnesium, and Potassium

CEC (meq.L)	Calcium 68%	Magnesium 12%	Potassium 5%
2	544	58	78
4	1088	115	156
6	1632	173	234
8	2176	230	312
10	2720	288	390
12	3264	346	468
14	3808	403	546
16	4352	461	624
18	4876	518	702
20	5440	576	780

Table 3.4 Recommended Pounds of Calcium Carbonate Equivalent per Acre (lb CCE/A) for a Target Soil pH of 6.5

	Soil Texture			
Initial Soil pH	Loamy Sand	Sandy Loam	Loam	Silt Loam
4.1-4.4	4500	5400	9800	11600
4.5-4.8	3600	4500	8100	9800
4.9-5.2	2700	3600	6300	8100
5.3-5.7	1800	2700	4500	6300
5.8-6.0	900	1800	2700	4500
6.1-6.4	500	900	1800	3600
Above 6.5	0	0	0	0

Estimating the Lime Application Rate based on Soil Texture and PH

The application rate of limestone needed to raise soil pH is much greater on fine textured soils than it is on coarse textured soils. For example, a sandy loam soil with a starting soil pH of 6.0 may need an application of 1800 pounds of limestone per acre to raise the soil pH to 6.5. Whereas a silt loam soil may need 4500 pounds of limestone per acre to raise soil pH from 6.0 to 6.5. An alternative approach to determining the application rate of limestone is to base the estimated limestone application rate on soil pH and soil texture (Table 3.4). However, when a soil test includes a “buffer pH” (aka Lime Requirement Index), the soil test report will provide an estimate of the limestone application rate based on the soil's pH buffering capacity. The soil texture classification (*i.e.*, loamy sand, sandy loam, loam, or silt loam) may be considered a fixed property of a soil because it is not readily changed. Once soil texture is known and soil pH is measured, a soil’s lime requirement can be estimated. The Rutgers Cooperative Extension fact sheet FS902 “Liming New Jersey Soils for Fruit Crops” has tables showing how much limestone is needed (*https://njaes.rutgers.edu/pubs/publication.php?pid=FS902*). Be careful to avoid over-applying lime because an excessively high soil pH may induce nutrient deficiencies.

Lime Placement

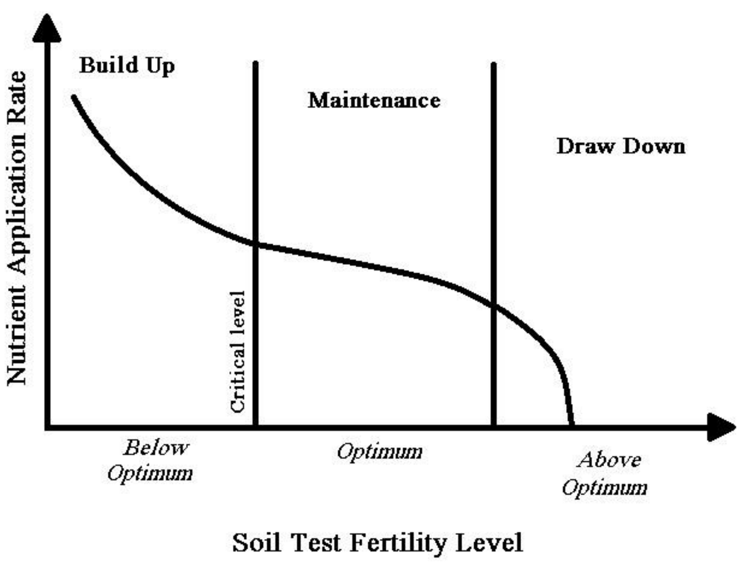
Lime applications are most effective at neutralizing acidity when they are spread uniformly and thoroughly mixed with the soil by plowing, disking, and harrowing. When fields are to be plowed and the limestone recommendation exceeds 3,000 pounds per acre, it is best to use split applications. Plow under half the needed amount and apply the other half after plowing and then disk in as deeply as possible. Liming rate recommendations are generally based on an assumed plow depth of 8 inches. In the case of 10-inch plow depth, multiply the usual application rate by 1.2 to adjust to the deeper treatment layer.

3.4.2 Soil Nutrient Applications and Timing

When the soil test fertility level is in the Below Optimum category, the nutrient recommendation for a particular crop is designed to achieve the crop's maximum yield and to build the soil fertility level into the optimum range over time. If the soil fertility level is already in the optimum range, the nutrient recommendation is designed to replace the amount of nutrient removed by the crop to maintain optimum soil fertility. No nutrient application is recommended when the soil test category is above optimum. This allows "draw-down" of the nutrient level to the optimum range. This concept is illustrated in Figure 3.2.

Fertilizer applications are generally more effective if they are applied in split doses. Apply half the nitrogen or mixed fertilizers on sandy loam or loamy sand soils 1 month before bloom and then the remainder after bloom, approximately two months later. Nitrogen or mixed fertilizers may be applied earlier on loam and silt loam soils.

Figure 3.2 Nutrient Application Rates in Relation to Soil Test Category



Macronutrients

Nitrogen (N)

Soil tests do not directly measure soil nitrogen availability, however, test results for organic matter content can provide an indication of the nitrogen supplying capacity of a soil. An estimated 15 to 20 lb/A of nitrogen is released and available for uptake by trees annually from each percent soil organic matter content. Thus, depending on organic matter content, a soil may supply a significant part of the tree's nitrogen requirement. When the soil organic matter content is high for a given soil texture, the N fertilizer rates listed in Table 3.6 may be reduced by 10 to 20%.

Unlike soil analysis, leaf tissue analysis does provide information on the nitrogen status of trees, see Table 3.1. When combined with information on soil organic matter content and tree vigor, growers can reliably assess the nitrogen status of the trees.

Heavily pruned trees need considerably less nitrogen than moderately pruned trees.

Similar to the general fertilizer recommendation above, about half of the season's total fertilizer nitrogen application should be applied in late March before bloom. Apply the remainder of the recommended nitrogen application in May, after bloom. If fruit load has been reduced due to late freezes, reduce the nitrogen fertilizer application accordingly. For example if frost killed 50% of the desired fruit load, cut back about 50% on the intended N application rate.

Nitrogen deficiency appears as slow leaf growth and yellowing (especially of older leaves). In contrast, excessive nitrogen can cause excessive shoot growth and increased susceptibility to diseases, *e.g.*, fire blight. Excessive nitrogen can also result in lower fruit quality.

Phosphorus (P)

Many New Jersey soils are well supplied with phosphorus. Soil testing is an effective way of identifying the occasional orchard site where phosphorus is a limiting nutrient. Phosphorus fertilizer is most beneficial before new orchard establishment and for seeding of grass alleys. On established orchards where soil tests and leaf tissue analyses indicate phosphorus levels are high, eliminate phosphorus fertilizer applications. Symptoms of phosphorus deficiency are exhibited as a darker than normal leaf color.

Potassium (K)

Potassium deficiency occurs most frequently in sandy soils. Soil testing is an effective way to assess soil potassium availability. Fertile soils should have between 3 to 5% saturation of the CEC with potassium. It is important to balance the need for potassium against the needs for calcium and magnesium as these nutrients compete for plant uptake. Excess K application tends to suppress the uptake of calcium and magnesium. Symptoms of K deficiency appear first on older leaves as yellowing or necrosis around the leaf edge. Potassium draws water into plant cells and for this reason potassium fertility is also very important to fruit size.

Calcium (Ca)

Soils properly limed to pH 6.5 are generally well supplied with this nutrient. Calcium uptake into the growing fruit is very important for fruit quality. Fertile soils at pH 6.5 should have an exchangeable Ca saturation close to 68%. In pome fruits, Calcium sprays are commonly applied during the growing season to improve fruit quality and reduce the incidence of bitter pit in apple and cork spot in pear.

Magnesium (Mg)

Soils properly limed to pH 6.5 are generally well supplied with this nutrient. Fertile soils at pH 6.5 should have an exchangeable Mg saturation close to 12%. Growers should strive for a balance between K, Ca, and Mg availability in the soil. Selection of the appropriate liming material, calcite limestone versus dolomite limestone, as guided by soil testing, is key to achieving that balance. Magnesium deficiency is not common on fruit trees in New Jersey. A deficiency of Mg is exhibited as yellowing between the veins on older leaves.

Sulfur (S)

Soil testing and leaf tissue analysis reports for sulfur from across New Jersey suggest that sulfur deficiency is becoming more common. Sulfur is needed by crops in about the same amount as phosphorus. Use of commercial fertilizers such as ammonium sulfate, potassium sulfate, or gypsum will aid in preventing sulfur deficiency. Compost is also a good source of sulfur. Typical symptoms of sulfur deficiency are yellow or pale green leaves and slow growth. These symptoms are sometimes mistaken for nitrogen deficiency. Unlike nitrogen deficiency, sulfur deficiency is exhibited most clearly on younger leaves. Sulfur deficiency can also cause reduced flowering and increased susceptibility to plant diseases.

Micronutrients

Boron (B)

Boron fertility should be guided by both soil testing and leaf tissue analysis. Sandy soils with low levels of organic matter are most vulnerable to boron deficiency because it is lost from the soil by leaching. Multiple applications of boron sprays at low rates are the preferred method of application. The best times for boron sprays are after harvest or in spring just before flowering. When boron is sprayed before flowering it can enhance fertilization of flowers and fruit set. Boron application rates must be carefully calculated to avoid over-application which can be toxic.

Boron is particularly important for apple production. In general, broadcast 1 to 2 pounds of actual boron (B) per acre of mature apple trees that have been diagnosed to be boron deficient. If using fertilizer borate (14.9% B) apply 6.7 lb/A of this product to supply 1 lb/A of boron. Or if using Solubor fertilizer (20.5% B) apply 4.9 lb/A of this product to supply 1 lb/A of boron. Boron deficiency symptoms are exhibited as death of growing points, failed flower development, and poor fruit set. Other symptoms may include misshapen fruit, internal cork, cracking, fruit drop, discolored fruit, and reduced yield.

Chlorine (Cl)

Chlorine is typically present in soils and plants as the negative ion chloride. Chloride is often accompanied by sodium (Na) in which case it is present as salt. Although chlorine is classified as a micronutrient, it can be taken up in amounts comparable to levels of macronutrients. Excessive uptake of chlorine along with sodium is an indication of salt toxicity. In moderate amounts, chlorine aids in plant water uptake and disease resistance. It also plays a role in photosynthesis. Chloride is a constituent of many commercial fertilizers and manures and supply is seldom a limiting factor in crop production.

Copper (Cu)

Soil testing and leaf tissue analysis are effective ways to evaluate copper levels. Copper deficiency is not common in New Jersey orchards. Copper containing pesticide sprays can leave behind residues on leaf samples which can distort interpretation of plant tissue analysis. If copper leaf analysis levels are high, first consider possible contamination from spray products. If copper leaf analysis and soil test levels are low, a single application of copper fertilizer will correct a copper deficiency for many years.

Iron (Fe)

Soil testing and leaf tissue analysis are not definitive ways to evaluate iron status. However, measuring soil pH is a useful diagnostic tool to explain why iron may be deficient. Iron deficiency in orchards is not common in New Jersey. Deficiency symptoms are exhibited on leaves as loss of chlorophyll or yellowing between green veins. When deficiency occurs, it is probably a result of applying too much limestone resulting in an excessively high soil pH.

Manganese (Mn)

Soil testing and soil pH measurement are both effective ways to evaluate manganese availability. Manganese deficiencies are common on crops grown on the sandy coastal plain soils of New Jersey. Applying too much limestone, resulting in an excessively high soil pH, can lead to manganese deficiency, especially on sandy soils. On loamy soils and in the northern region of New Jersey, manganese deficiency is not common. Foliar applications of manganese are a more effective treatment than soil applications of manganese fertilizer. Manganese sulfate or chelated manganese products are effective fertilizers. Manzate, a widely used pesticide in orchards contains manganese. Spraying Manzate will likely provide more than enough manganese to prevent deficiencies. Spray residues from the use of Manzate may confound any interpretation of plant tissue analysis for manganese. Deficiency symptoms for manganese are much like those described for iron, loss of chlorophyll, or yellowing between green veins.

Molybdenum (Mo)

Deficiency of molybdenum is not common in orchards. Availability of molybdenum increases as soil pH increases. Molybdenum is needed for biological nitrogen fixation and for metabolism of nitrate in plants.

Zinc (Zn)

Zinc deficiency is widespread in fruit trees. On average, New Jersey coastal plain soils have lower levels of plant available zinc than the finer textured soils of Northern New Jersey. Soil pH has a marked influence on zinc availability. As soil pH increases, zinc availability decreases, thus excessive application of limestone may induce zinc deficiencies. Very high soil test levels of phosphorus are also antagonistic to zinc nutrition and may increase the incidence of zinc deficiency. The ratio of phosphorus to zinc in leaf tissue has been suggested as a way to evaluate the relative zinc status. To make this calculation, it is necessary to convert phosphorus from percent to ppm by multiplying by 10,000. A phosphorus to zinc ratio greater than 150 indicates zinc deficiency, a ratio in the range of 100 to 150 indicates that Zn is low, and a ratio less than 100 indicates that the Zn nutrition level is adequate. Zinc deficiencies are more common during cool, wet, spring weather, because low soil temperatures decrease zinc availability and cloudy weather reduces the ability of plants to take up zinc.

Leaf tissue analysis is a useful way to evaluate zinc nutritional status of trees, but the presence of zinc residues from previous zinc foliar fertilizations or from zinc containing fungicides (such as Ziram or Mancozeb) can make the results difficult or impossible to interpret. There are many zinc fertilizers, but only zinc sulfate, which contains 35.5% to 36% Zn, and zinc chelates are recommended for use on tree crops. Foliar applications of zinc sulfate should only be made during dormancy or postharvest. Zinc sprays should not be used during the growing season unless deficiency symptoms are severe.

Zinc is essential to several plant enzyme systems and is involved in the synthesis of the growth hormone indoleacetic acid, which regulates stem elongation. A critical period for zinc nutrition is between budbreak and fruit set. Zinc deficiency symptoms include stunted growth, shortened internodes (rosetting), leaves that are smaller and narrower than normal (little leaf), light green areas between the veins of new leaves (chlorosis), and small or poor fruit color development.

Table 3.5 Nutrient Recommendations for Preparing Soils for New Tree Plantings and Maintaining Orchard Middles for Apple, Peach, and Other Tree Fruit Production

Crop	Recommended Plant Nutrients Based on Soil Tests								
	Nitrogen (N) Pounds per Acre	Soil Phosphorus Level				Soil Potassium Level			
		Low	Medium	High	Very High	Low	Medium	High	Very High
		Pounds P_2O_5 per Acre				Pounds K_2O per Acre			
Cover crops at seeding time									
Legume-grass mixtures	20-30	100	50	25	0	100	50	25	0
Grasses only	25-50	100	50	25	0	100	50	25	0
Topdressing sod crops									
Legume-grass mixtures	0	100	50	25	0	100	50	25	0
Grasses only	20-50	75	50	25	0	75	50	25	0

Table 3.6 Nutrient Recommendations for Tree Fruit Production[1,2,3]

Crop	Recommended Plant Nutrients Based on Soil Tests						
	Nitrogen (N) Pounds per Year	Soil Phosphorus Level			Soil Potassium Level		
		Low	Medium	High	Low	Medium	High
		Pounds P_2O_5 per Year of Tree Age			Pounds K_2O per Year of Tree Age		
Apples							
Nonbearing trees	0.1 - 0.2	0.2	0.1	0	0.2	0.1	0
Bearing trees	0.05 - 0.1	0.1	0.05	0	0.1	0.05	0
Pears							
Nonbearing trees	0.05 - 0.1	0.2	0.1	0	0.2	0.1	0
Bearing trees	0.025 - 0.05	0.1	0.05	0	0.1	0.05	0
Peaches, Nectarines, Cherries and Plums							
Nonbearing trees	0.1 - 0.2	0.2	0.1	0	0.2	0.1	0
Bearing trees	0.05 - 0.1	0.1	0.05	0	0.1	0.05	0

[1]Recommendations in this table were developed for spreading the total fertilizer requirement in the drip area under trees. When fertilizer is broadcast over more area than is occupied by the drip area of trees, increase fertilizer rate so that the approximate rates recommended in this table will be applied under the drip area of trees. For example, if the drip area of trees occupies 50 percent of the land area, then multiply rates recommended in the table by the number of trees per acre and then double this rate to determine the rate per acre for broadcast application.

[2]For dwarf trees, reduce application rates in the table by half for nitrogen, phosphorus, and potassium.

[3]Mature, standard-size apple trees require 0.5 to 1.5 pounds of nitrogen (N) per year per tree. Dwarf apple trees require 0.25 to 0.75 pound of nitrogen (N) per year per tree. Pear trees should receive less nitrogen than apple trees because of fire blight problems. Mature peach, nectarine, cherry, and plum trees require 0.5 to 1 pound of nitrogen (N) per year per tree. Nitrogen needs of tree fruits depend on variety, rootstock, tree vigor, soil type and fertility level, and pruning and weed control practices.

3.4.3 Long Term Sustainable Soil Nutrient Management

A major objective of nutrient management is to bring the soil fertility levels into the optimum range and to sustain that fertility level in the long term. Once the soil fertility has been built up to the optimum level, the nutrient application rate should be only large enough to maintain the optimum level. This can be accomplished by applying nutrients at a rate that closely matches the rate of nutrient removal in the harvested crop. For example, on average, a 500-bushel per acre yield of apples would remove 10 lb P_2O_5 and 45 lb K_2O, and a 600-bushel per acre yield of peaches would remove 35 lb P_2O_5 and 20 lb K_2O.

Keeping records of soil test results enables growers to track changes over time and to adjust recommendations as needed, to maintain soil fertility in the optimum range. Meaningful records require a consistent approach to soil testing in terms of sample collection, sampling depth, and laboratory submission. Soil test levels can vary somewhat from sample to sample, and having records helps to spot unusual soil test values that should be rechecked.

If soil fertility levels are observed to fall below optimum, under-fertilization is indicated. The nutrient recommendation should be adjusted so that the nutrient application rate is large enough to meet the needs of the current crop and gradually rebuilds the nutrient supply to the optimum level. If soil fertility levels are observed to climb well above optimum, over-fertilization occurs by the application of additional nutrients. Good crop yields can be obtained without adding the nutrient. Over time, nutrient removal by crops should allow the soil fertility level to fall back into the optimum range.

3.5 Adapting Soil Fertility Recommendations to Organic Farming

Synthetic nitrogen fertilizers are prohibited materials in the organic growing system. Organic farmers may use compost or manures to build and maintain soil fertility. When using raw manure, the organic standards require a minimum of 120 days between time of application and crop harvest. These natural fertilizers will also supply, besides nitrogen, useful amounts of all essential nutrients, but they should be analyzed at a lab to determine nutrient content. If more phosphorus is needed than can be supplied by compost or manures, organic farmers can apply rock phosphate. If potassium is needed, there are several commercial potassium fertilizers, such as langbeinite or potassium sulfate, which may sometimes be used with certain restrictions in organic farming. If nitrogen is needed, naturally derived Chilian nitrate may be used in limited amounts as a supplemental nitrogen fertilizer. Legumes might be planted in the sod alley ways as a supplemental nitrogen source, however, such practice might complicate orchard pest management.

Since naturally occurring limestones are approved for use in organic farming, the practice of liming and soil pH management is much the same as in conventional farming. Industrial processed liming materials, such as burnt lime and hydrated lime, are not approved for use in organic farming.

When micronutrient deficiencies occur, they can be corrected as necessary for organic crop production using many of the same fertilizer materials and application practices as used in conventional agriculture. In organic farming, however, micronutrient fertilizer products cannot be routinely applied without prior soil or plant diagnostics to confirm a specific nutrient deficiency.

Always check with the organic certifier to be sure a certain product or material is approved for use in organic farming. Also, be prepared to provide documentation and farm records about any applied materials to one's organic certification program.