# Nutrition

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Sustained, high-quality production of peaches demands a well-conceived nutrition program. Peaches are grown in a wide diversity of climatic and soil conditions. In some areas, peaches are grown on deep, sandy soil, while heavy clays predominate in other production areas. Accordingly, no blanket statement can be madein regard to orchard nutrition. General nutritional recommendations must be modified and refined to meet the needs of specific orchard blocks.

Results of an orchard nutrition monitoring project in the Ridge Area of South Carolina suggest that a *balance sheet* approach to nutrient management may be useful. The balance sheet approach involves treating nutrient supplies in the soil as a *bank deposit*. Fertilizer and lime application rates and dates are systematically recorded as *deposits*. Soil and leaf nutrient levels are carefully determined and recorded as the *balance* at the same time each year. Leaf nutrient levels are compared to established leaf nutrient sufficiency ranges (Table 1). Fruit yields, fruit size, and fruit quality are recorded for individual blocks of trees as *withdrawals* or *dividends*.

**Table 1.** Foliar sufficiency ranges for nutrients in peach leaves, Georgia.*

| Nutrient | Deficient Level | Sufficiency Range |
|---|---|---|
| N(%) | < 1.7 | 2.75-3.50 |
| P(%) | < 0.11 | .12-.50 |
| K(%) | < 0.75 | 1.50-2.50 |
| Ca(%) | < 1.0 | 1.25-2.50 |
| Mg(%) | < 0.20 | .25-.50 |
| Mn(ppm) | < 20 | 20-150 |
| Fe(ppm) | ----- | 60-400 |
| B(ppm) | < 20 | 20-45 |
| Cu(ppm) | < 3 | 5-20 |
| Zn(ppm) | < 12 | 15-50 |
| S(%) | < 0.01 | 12-40 |

*Plank, C. Owen. 1988. Plant Analysis Handbook for Georgia, Cooperative Extension Service, University of Georgia.

The balance sheet allows growers to develop a detailed history of orchard nutrition. Keys to consider follow:

(1) Establish a permanent identity, preferably a numbering system, for each orchard block of trees.
*(2)* Collect soil and leaf samples at approximately the same time each year.
(3) Use a record-keeping system that permits arraying several (10 or more) years of soil- and leaf-monitoring results on one page in easy-to-read columns. Examples of this system are presented in Tables 5, 6, and 7.

For example, by scanning columns for potassium levels in the soil (Table 5), foliage (Table 6), and fertilizer application records (Table 7), one can readily determine whether potassium deposits are roughly in balance with withdrawals. If the trend over several years shows upward or downward movement, or if potassium and calcium levels are getting out-of-balance, appropriate fertilizer adjustments can be made.

A nutrient balance-sheet approach provides a built-in auditing system. Proof of the system is in the fruit quantity and quality, and the health and vigor of the trees (Table 2). When nutrition problems are suspected, diagnosis and correction are greatly simplified when several years of systematicsoil, foliar, fertilizer, and crop records are available.

**Table 2.** Deficiency symptoms in peach (based on sand culture).

| Deficient Nutrient | Symptoms |
|---|---|
| Nitrogen | Tree growth stops as leaves first become pale, progressing to a reddish tint with spotting as leaves fall off. The older leaves fall first; much root decay with roots slender and extensive. |
| Phosphorus | Leaves dark green to purple; early defoliation; no other symptoms noted. |
| Potassium | Spindly shoots; necrotic spots on margins of crinkled leaves; chlorotic leaves; reduced root growth; fruit buds few. |
| Calcium | Twig dieback and reduced growth; older leaves normal but younger ones chlorotic with necrotic area in center; subsequent leaf drop occurs; poor root growth and dead root tips. |
| Magnesium | Leaves with interveinal chlorosis; older leaves have necrotic spots and abscise early; root system reduced; fruit buds reduced. |
| Manganese | Leaves become dull, yellowish-green; darker in the veinal area; more severe on young leaves; terminal growth stunted. |
| Iron | Leaves show interveinal chlorosis at first, eventually becoming totally chlorotic; necrosis is followed by defoliation, starting with the younger leaves. |
| Boron | Dark, water-soaked spots, exuding gum, about one inch back of the growing tips, all beyond it dying; lateral bud breaks caused “witches broom” appearance; some chlorosis, early defoliation from tips to base of shoot; small corky protrusions on bark; poor root system. |
| Copper | Dark green leaves, interveinal chlorosis; young leaves irregular, long, and narrow; severe wilting, defoliation, and terminal die-back when deficiency severe; some rosetting. |
| Zinc | On younger leaves, mottling at first, new leaves small, narrow and pointed with wavy margins, chlorosis, rosetting, defoliation; deposits of gummy materials on roots; fruit misshapen. |

*Based on work of Weinberger and Calliman, reported in “Fruit Nutrition,” Horticultural Publications, 307-310, Norman F. Childers (ed.); and “Diagnostic Criteria for Plants and Soils,” Quality Printing Co., Homer D. Chapman (ed.).

Further refinement of the balance sheet approach is possible, especially for nitrogen, if the record includes rainfall and irrigation data for specific blocks, as well as annual growth data for mature, bearing trees. Records of nematode populations may explain poor tree performance even though nutrition appears adequate.

Area soil and foliar nutrient surveys enable growers to compare their nutrient balance sheets to the ranges and averages of their neighbors.

## Pre-Plant Considerations

The importance of proper site preparation cannot be over-emphasized. Peaches perform best on well-drained soils with a pH of 6.0 to 6.5. Monitoring by soil testing and adjusting proper soil pH to a depth of 16 inches through liming is the key to increasing tree survival and maximizing production. Lime does notreadily move down through undisturbed soil, so pre-plant soil preparation is the key to deriving the benefits of liming (Table 3). Phosphorous is similarly immobile through undisturbed soiland should be included in pre-plant preparation if soil tests indicate a need. Sites should be subsoiled in two directions (cross-checked) and lime and/or fertilizer should be turned in with deep plowing. Such pre-plant site preparation helps trees develop a large root system throughout the rooting zone. Refer to other sections for discussions of nematode control and methods of planting.

**Table 3.** Recommendations for pre-plant lime.*

| Soil pH | Recommendation, tons/A |
|---|---|
| | |

| Surface (0-6 in.) | Subsoil (0-6 in.) | Plowed Deep | Disked In |
|---|---|---|---|
| below 5.5 | below 5.5 | 3 | 1 |
| 1 5.5-6.0 | below 5.5 | 2 | 1 |
| 5.5-6.0 | 5.5-6.0 | 1 | 1 |
| 5.5-6.0 | 6.0 + | 0 | 1 |
| 6.0 + | below 5.5 | 2 | 0 |
| 6.0 + | 5.5-6.0 | 1 | 0 |
| 6.0 + | 6.0 + | 0 | 0 |
| 6.0 + but soil Ca less than 400 lbs/acre | | 0 | 1 |

*Myers, S. C., Gerard Krewer and Thomas Crocker, 1988. Fruits and Pecans. *In* C. Owen Plank (ed.), Soil test handbook for Georgia. Cooperative Extension Service, University of Georgia, Athens, Georgia.

## Fertilizing Young Trees

**First Year.** Fertilizer should never be incorporated in the planting hole at planting or applied to the soil surface around newly planted trees until a drenching rain has settled the soil. Newly planted trees should be fertilized three times during their first season in the orchard as follows:

(1) March – evenly broadcast one pound of 10-10-10 fertilizer over a circle five feet in diameter around each tree;
(2) Mid-May – evenly broadcast one pound of calcium nitrate or one-half pound ammonium nitrate over a circle six feet in diameter around each tree;
(3) Early to mid-July – repeat of application made in mid-May. Do not applyafter August 1, because late fertilizer application to vigorous trees increases susceptibility to cold damage.

**Second Year.** Second leaf peach trees should also be fertilized three times. Rates should be increased, and the area of application should also be increased to feed the larger root system. Banding of the fertilizer in the herbicide strip is recommended.

(1) Late-February – apply 10-10-10 fertilizer at a 250 pounds per acre rate,concentrated in a six-foot wide row band (three feet wide on each side of the tree row);
(2) Mid-May – apply calcium nitrate at a 150 pounds per acre rate or ammonium nitrate at a 75 pounds per acre rate as described above;
(3) Early to mid-July – repeat application of mid-May, do not apply after August 1, because late application to vigorous trees may make them susceptible to cold damage.

## Fertilizing Bearing Trees

With diligent young tree management, trees entering their third leaf should be capable of producing sufficient fruit to justify harvest. Accordingly, a fertilization program for bearing trees should be implemented.

Application of five plant nutrients is routinely required to produce peaches in southeastern soils; specific practices may vary in other areas. Nitrogen is needed annually, while phosphorus and potassium should be applied based on soil test and foliar analysis results. The other two plant nutrients most often needed are calcium and magnesium.

Supplemental applications of other essential plant nutrients may or may not be required. Growers are strongly encouraged to monitor these nutrients through foliar analysis to determine if such applications are needed to maximize production and maintain tree health.

## Maintenance of Soil pH (Lime)

Maintenance of soil pH at 6.0 to 6.5 increases tree survival and yield. As lime moves down through the soil slowly, deep incorporation in bearing orchards is impractical. Growers should maintain soilpH by annual or periodical liming. This maintenance liming program should be based on soil tests. If more than two tons of limestone per acre is recommended, apply half the first year and the other half the following year. Avoid applying lime when fruit and/or foliage are on the tree. Late fall is the ideal time to lime. If soil tests indicate magnesium is not low and a faster reaction is desired, apply a fast-reacting lime source such as hydrated lime. Conversion rate for hydrated lime is in Table 4.

**Table 4.** Conversion rate for hydrated lime.*

| Lime Recommendation | Alternate Lime Source** |
|---|---|
| **Dolomitic Limestone Tons/A** | **Hydrated Lime* Tons/A** |
| 1 | 0.75 |
| 2 | 1.50 |

*Myers, S. C., Gerard Krewer and Thomas Crocker. 1988. Fruits and Pecans. *In* C. Owen Plank (ed.), Soil text handbook for Georgia. Cooperative Extension Service, University of Georgia, Athens, Georgia.
**Since hydrated lime is quite fine, apply using an Easy Flow or similar applicator.

## Nitrogen (N)

More than other elements, nitrogen controls growth and fruiting in plants. Nitrogen management requires balancing of nutritional goals. When the nitrogen level is optimum for fruiting, vegetative growth may be inadequate and vice versa. In 1980 Barker and Mills proposed an economic definition of optimum nitrogen. This system works well for all nutrients and relates to the balance sheet approach discussed at the beginning of this section.

Nitrogen interacts strongly with pruning and irrigation. For maximum fruit production, trees should be managed to produce maximum leaf area early in the season. This involves moderate pruning, establishing high nitrogen levels in the tree early in the season, early thinning, maintaining adequate soil moisture, and slowing vegetative growth just prior to harvest by depletion of nitrogen. In the Southeast, this can usually be accomplished with 45 to 90 pounds of nitrogen per acre annually, with at least half as the nitrate form.

Research shows that peach tree survival is greatly improved when the annual nitrogen fertilization of an orchard is split, with some nitrogen being applied in mid- to late August (post-harvest) and the remainder in late winter. Because the post-harvest nitrogen application is used to help maintain healthy foliage in the fall and improve winter hardiness of the tree, the late summer application should be considered food for next season’s crop. The annual quantity of nitrogen applied to an orchard should be figured as that applied before harvest of next season’s crop, not as the total applied during a calendar year. For example, if 15 pounds of nitrogen per acre are applied in late August to an orchard that has performed well with an annual nitrogen rate of 75 pounds per acre, then 60 pounds of N per acre (75 - 15 = 60) should be applied in late winter. A rule of thumb on the amount of nitrogen to apply in August is 15 pounds of nitrogen per acre on trees exhibiting healthy foliage and adequate (12” to 18”) terminal growth, and 30 pounds of nitrogen per acre on trees exhibiting an obvious need for nitrogen. Trees growing vigorously in August should not receive the post-harvest application of nitrogen.

The post-harvest application should be banded in the herbicide strip or injected through a drip irrigation system so that the trees get most of the nitrogen. Weak areas within blocks should receive additional supplemental nitrogen. For example, if 15 pounds of nitrogen per acre are applied to the entire orchard in August, hand application of one pound of calcium nitrate or one-half pound ammonium nitrate around weak trees is also suggested.

In the Southeast, the spring nitrogen application should be made in mid- to late winter, *at least six weeks before bloom* for early maturing varieties. Fertilize varieties in order of ripening, completing the fertilization of late maturing varieties four to six weeks before bloom. Some growers split the spring application of nitrogen on late maturing varieties; half four to six weeks before bloom and the other half immediately after the threat of frost is over and a crop is set. If growers choose to use this practice, nitrate nitrogen (calcium nitrate) is recommended for the post-bloom application.

Plants can take up nitrogen either as nitrate or ammonium. At low pH, excess ammonium nitrogen may be toxic, causing feeder root necrosis, dark, water-soaked areas in the leaves followed by collapsed, necrotic tissue. The marginal burning may resemble potassium deficiency, but is not corrected by addition of potassium. Cool, wet soils in the spring delay microbial conversion of ammonium to nitrate and may contribute to ammonium toxicity.

When ammonium nitrogen is applied to peaches, it should be in combination with nitrates. The presence of nitrates decreases ammonium toxicity. Increasing calcium and potassium levels in the soil enhances nitrate uptake. Ammonium ions inhibit nitrate uptake.

**Nitrogen Deficiency Symptoms.** Leaves yellowish-green at shoot tips to reddish-yellow at base; red, brown, and necrotic spots develop; leaves shed prematurely; twigs spindly, short, stiff with brownish-red to purplish-red bark.

**Excess Nitrogen Symptoms.** Delayed ripening, decreased red color of fruit, and terminal shoot growth greater than 24 inches in mature trees. Severe excess in young trees may produce sudden leaf drop and death of tree.

**Soil Testing.** Laboratories at landgrant universities in the Southeast do not routinely include nitrogen in soil test results. Nitrogen levels in soil are highly variable and in a constant state of change. Ammonium and organic forms of nitrogen are converted to nitrate by soil microorganisms. Soil nitrogen has not correlated well to nitrogen levels in plant tissues. Tissue analysis coupled with careful observation of fruit quality and vegetative growth is more effective for monitoring nitrogen in peach trees.

## Phosphorus (P)

In peach, reports of phosphorus deficiency are very rare. Most fertilizer experiments with peaches, other than in sand culture, show little or no response to phosphorus.

**Phosphorus Deficiency Symptoms.** Dark green leaves, turning to bronze and purple. Progresses to narrow leaves with downward turning margins shedding prematurely.

**Maintaining Phosphorus in Orchards.** Peaches remove relatively little phosphorus from the soil each year. Only about 12 pounds $P_2O_5$ per acre are removed by a heavy fruit crop. The developing trees have been estimated to retain about three pounds $P_2O_5$ per acre (not returned to the soil by leaves and pruning). Therefore, no more than about 15 to 20 lbs $P_2O_5$ per year should be required to maintain phosphorus, once adequate levels (moderate to high) are established in the soil. Addition of phosphorus on alternate years should be a practical approach for most southeastern orchards.

**Excessive Phosphorus**. Many southeastern peach orchard soils test high-plus for phosphorus. Continued addition of phosphorus to these soils may cause deficiencies in zinc, iron, or copper. Foliar copper levels are marginal or low in many orchards where high levels of phosphorus are present. Do not add phosphorus to soils where soil test results read moderate or higher.

## Potassium (K)

The balance of nitrogen and potassium has a strong influence on red color development in fruit. Desirable skin and flesh color has been associated with relatively low nitrogen and high potassium levels in peach leaves. Both trees and fruit buds are more resistant to cold injury when adequate potassium levels are maintained. Foliar potassium levels below 1.0% may reduce fruit size. Potassium competes with magnesium and calcium for uptake in peach trees. Excessive levels of one may cause deficiencies of the others. Potassium leaches readily and may accumulate in the subsoil of some soils. In heavier soils, downward movement is minimal with movement restricted to the upper few inches.

**Potassium Deficiency Symptoms.** Peach trees can tolerate a wide range of potassium levels without obvious influence on total fruit production or tree growth. Potassium-deficient peach trees develop light green to pale yellow leaves rolling inward in a bean-pod shape. Severe deficiency eventually leads to necrosis of tips and margins, followed by upward curling of leaves and crinkled midribs. Fruit bud development is reduced.

**Maintaining Potassium.** An addition of 60 to 80 pounds of $K_2O_5$ per acre per year should maintain potassium in most orchards once adequate levels are established. Up to 300 pounds of $K_2O_5$ per acre may be applied to correct deficiencies. Occasional subsoil sampling for potassium should supplement topsoil and leaf testing for a complete potassium analysis. The source of potassium in commercial fertilizer usually should be based on economics. Potassium chloride (muriate) should be avoided where large, corrective quantities are added.

## Calcium (Ca)

Calcium is the dominant base in the soil-exchange complex, accounting for 60 to 85 percent of the total cation exchange capacity. Calcium promotes favorable soil structure for root growth and development. Most southeastern soils are acidic. In acid soils, Ca and Mg are replaced by hydrogen ions. Under low pH conditions, the solubility of metals such as manganese and aluminum may increase to toxic levels, which is a major reason for maintaining soil pH near 6.5 for peaches. Sodium competes with calcium in the soil complex. Excess sodium slows conversion of nitrite to nitrate at high pH, and toxic levels of nitrite may result. Also, toxic amounts of sodium may be absorbed by peach trees at high pH. Peach growers should select fertilizers that are low in sodium.

**Correction of Calcium Deficiency.** Calcium deficiency is usually corrected with lime if soil pH is low. If soil pH is adequate and leaf calcium is still low, gypsum or calcium nitrate may be used. Where sulfur is a major component of the peach spray program and acid-forming fertilizers are used, about 1,000 pounds of lime per acre per year will be required to maintain soil pH near 6.5. If foliar levels of magnesium are low, use dolomitic lime; if magnesium levels are sufficient, use calcitic lime.

Care should be taken to maintain soil pH below 7.0 to avoid deficiencies in iron and zinc.

## Magnesium (Mg)

**Magnesium Deficiency Symptoms.** Leaves near terminals show slight chlorosis and progress to water-soaked blotches on older leaves of current season’s growth. Blotches change to gray or pale green, then fawn to brown, followed by leaf drop. Young trees may not survive winter in cases of severe deficiency. Fruit buds are reduced.

**Factors Affecting Magnesium Levels.** Magnesium deficiency is not uncommon in peaches grown in sandy soils with high rainfall. High total salts will displace magnesium from topsoil to lower depths. High N levels in tissue are associated with higher Mg levels. Calcium and potassium compete with magnesium for uptake by the tree.

**Correcting Magnesium Deficiency.** Soil: Dolomitic lime (long-term) as indicated by soil pH. Magnesium sulfate: 100 pounds/acre for mature trees.

## Zinc (Zn)

Zinc deficiency is not uncommon in peaches on lighter soils of the Southeast. However, heavy liming (high pH), excessive phosphorus, and high rates of nitrogen contribute to zinc deficiency. Symptoms sometimes appear in the spring and disappear with increasing soil and air temperatures. Heavy root-knot nematode pressure can induce spring rosetting resembling zinc deficiency.

**Zinc Deficiency Symptoms**. Leaves are chlorotic, mottled, narrow, and crinkled. Symptoms progress to shortened twigs with rosettes of leaves near terminals followed by defoliation and reduced fruiting. Deficiency symptoms sometimes appear in peach trees showing foliar zinc levels within the sufficiency range. Visual symptoms and poor fruiting suggest the need for foliar analysis to determine if symptoms are related to zinc deficiency.

**Correction of Zinc Deficiency**. The most effective treatments for zinc deficiency are sprays of chelated zinc formulations that are compatible with most insecticides and fungicides. Where no visual zinc deficiency symptoms are present, but soil pH readings are 6.5 or higher and soil phosphorus levels are high, one or two zinc sprays should be made. These sprays may include chelated liquid formulations, neutral zinc in the routine spray program, or a late fall application of zinc sulfate. The use of neutral zinc by most growers in their spray program to control bacterial spot is probably an effective maintenance treatment of southeastern peach orchards.

## Boron (B)

**Boron Deficiency Symptoms.** Leaves are reduced in size with interveinal necrosis; dieback of twigs and branches; sometimes confused with cold injury when spring growth begins.

**Correction of Deficiency.**
Soil: Apply 10 to 15 pounds fertilizer borate or Borax per acre every three years.
Foliar: Apply Solubor, one pound/100 gallons on well-developed leaves.

## Iron (Fe)

**Iron Deficiency Symptoms.** Leaves show interveinal chlorosis with sharp distinction between green veins and yellow tissue between veins; can be confused with simazine herbicide toxicity.

**Contributing Factors to Iron Deficiency.** Factors include high pH (above 7.0), excess soil moisture, high concentration of heavy metals in acid soils (Zn and Cu), extremely high or low soil temperature, nematodes, and poor drainage (oxygen deficiency). Excess phosphate in the soil may be the most common cause of iron deficiency in the Southeast.

## Copper (Cu)

**Copper Deficiency Symptoms.** Unusually dark green foliage, advancing to yellowish-green with malformed leaves at tips; progressing to long, narrow leaves, irregular margins with terminal dieback, and rosette formation due to multiple bud break near terminals.

**Correcting Copper Deficiency.** High levels of nitrogen and phosphorus induce copper deficiency. There is no reliable method to assay soil for available copper. Excess copper can induce iron deficiency, usually at low pH in sandy soils. Land suffering from "reclamation sickness" had a copper content of less than 2.5 ppm as determined by *Aspergillus niger* test. This was corrected by addition of 30 pounds copper sulfate per ton to mixed fertilizer per year. Copper deficiency is most commonly seen on leached sandy soils under heavy nitrogen fertilization.

Soil: Apply 50 to 100 pounds/A copper sulfate pentahydrate ($CuSO_4 - 5H_2O$) to soils followed by 50 pounds/A until 200 pounds have been applied or foliar analysis shows sufficiency.

Foliar: Apply Bordeaux mixture (5 to 10 pounds copper sulfate in 100 gallons water plus a like amount of lime).

## Manganese (Mn)

**Manganese Deficiency Symptoms.** Leaves become dull, yellowish-green; darker in the veinal area; more severe on young leaves; terminal growth stunted.

**Correction of Deficiency.** Foliar: Apply two to four pounds/100 gal manganese sulfate, late dormant or early summer foliage.

## Chlorine (Cl)

Chlorine is an essential element for plant growth. However, very little research has been reported on chlorine as a peach nutrient. Peaches are extremely susceptible to high levels of chlorine. Thus, where large amounts of potassium are needed to correct low levels of potassium, potassium chloride (muriate of potash) should not be used.

## Arsenic Toxicity (As)

Arsenic levels in peach leaves:

Normal – 1.0 ppm
High to Injurious – 5 to 20 ppm

**Symptoms.** Brown to red discoloration along leaf margins in mid-summer, followed by similar interveinal discoloration throughout the leaf. Tissues die and drop out, leaving a shothole appearance. Older leaves show symptoms; first terminal leaves often remain normal. Tree growth stunted. Reduced fruiting.

## Additional Notes

Nutritional deficiency symptoms may sometimes resemble symptoms of herbicide toxicity and of certain virus diseases. Excellent color photographs of certain nutritional, herbicide, and virus symptoms are available in USDA Agricultural Handbook No. 437, "Virus Diseases and Noninfectious Disorders of Stone Fruits in North America," U. S. Government Printing Office, Washington, D.C. 20402. Where two or more elements are deficient or excessive, symptoms become less defined. Diagnosis of specific problems requires experience, laboratory support, and careful record keeping.

## References

**Atkinson, D. 1980.** The distribution and effectiveness of the roots of tree crops. Horticulture Reviews (2): 424-490.
**Ballinger, W. E., H. K. Bell, and N. F. Childers. 1966.** Peach Nutrition, pp. 355-356. *In* Norman F. Childers (ed.), Horticultural Publications, New Brunswick, N.J.,
**Barker, A. V. and H. A. Mills. 1980.** Ammonium and nitrate nutrition of horticultural crops. Horticultural Reviews (2): 395-423.
**Batjer, L. R. and N. R. Benson. 1958.** Effect of metal chelates in overcoming arsenic toxicity to peach trees. Proc. Amer. Soc. Hort. Sci. 72: 74-78.
**Cain, J. C. and R. J. Mehlenbacker. 1956.** Effects of N and pruning on trunk growth in peaches. Proc. Amer. Soc. Hort. Sci. 67: 139-143.
**Chapman, H. D., Ed. 1973.** Diagnostic criteria for plants and soils. Quality Printing Co. 793 pp.
**Childers, N. F., Ed. 1966.** Nutrition of fruit crops, pp. 276-488. Horticultural Publications, New Brunswick, N.J.
**Koo, R. C. J. 1968.** Potassium nutrition of tree crops. The role of potassium in agriculture, pp. 469-483. *In* Kilmer, V. J., S. E. Younts, and N. C. Brady (eds.). Am. Soc. Agronomy, Madison, WI.
**Shear, C. B. and M. Faust. 1980.** Nutritional ranges in deciduous tree fruits and nuts. Horticultural Reviews (2): 142-163.
**Wilson, C. L., W. E. Loomis, and T. A. Steeves. 1971.** Botany, pp. 229-230. Holt, Rinehart and Winston.

**Table 5.** Illustration of soil test results arrayed for balance sheet interpretation.

*Block Number* _______________

| | Sample Dates | | | | |
|---|---|---|---|---|---|
| | | | | | |
| *pH* | | | | | |
| *P* | | | | | |
| *K* | | | | | |
| *Ca* | | | | | |
| *Mg* | | | | | |

**Table 6.** Illustration of leaf nutrient test results arrayed for balance sheet interpretation.

*Block Number* _______________

| Element | Sufficiency Ranges | Sample Dates | | | |
|---|---|---|---|---|---|
| | | | | | |
| N(%) | 2.75-3.50 | | | | |
| P(%) | .12-.50 | | | | |
| K(%) | 1.50-2.50 | | | | |
| | | | | | |
| Ca(%) | 1.25-2.50 | | | | |
| Mg(%) | .20-.50 | | | | |
| Mn(ppm) | 20-150 | | | | |
| | | | | | |
| Fe(ppm) | 60-400 | | | | |
| Al(ppm) | <400 | | | | |
| B(ppm) | 20-100 | | | | |
| Cu(ppm) | 5-20 | | | | |
| Zn(ppm) | 15-50 | | | | |

**Table 7.** Sample form for recording fertilizer application.

*Block Number*_______________

*Season (August 1- July 31)*

| Appl. Date | Anal. | Lbs/A | | Appl. Date | Anal. | Lbs/A | | Appl. Date | Anal. | Lbs/A |
|---|---|---|---|---|---|---|---|---|---|---|
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| Appl. Date | Anal. | Lbs/A | | Appl. Date | Anal. | Lbs/A | | Appl. Date | Anal. | Lbs/A |
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| Appl. Date | Anal. | Lbs/A | | Appl. Date | Anal. | Lbs/A | | Appl. Date | Anal. | Lbs/A |
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