

Increasing Efficiency and Reducing Costs of Citrus Nutritional Programs¹

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To maintain a viable citrus industry, Florida growers must consistently produce large, high quality, economic fruit crops from year to year. Efficiently producing maximum yields of high quality fruit is difficult without an understanding of soils and nutrient requirements of bearing citrus trees. Most Florida citrus is grown on soils inherently low in fertility with low cation exchange capacity (CEC) and low water-holding capacity, thus they are unable to retain sufficient quantities of available plant nutrients against leaching by rainfall or excessive irrigation.

Nitrogen and Potassium

Nitrogen (N) and potassium (K) are the two most important nutrients applied as fertilizer in Florida citrus groves. Nitrogen influences vegetative growth, flowering, and fruit yield more than any other nutrient. Potassium plays a key nutritional role in determining yield, fruit size, and quality. Fertilizer application ratios of N to K are usually 1:1, but a ratio of 1:1.25 may be useful on high pH or calcareous soils if K is low in the tree.

Management practices that improve fertilizer efficiency include:

- checking leaf analysis results for nutritional deficiencies or excesses,
- basing N fertilizer rates on IFAS recommendations and expected production (Tables 1, 2, and 3),
- selecting fertilizer formulations appropriate for existing conditions,
- carefully placing fertilizer within the root zone,
- timing applications to avoid the rainy season,
- splitting applications, and
- irrigating to meet the needs of the tree while minimizing leaching.

Leaf Analysis

Leaf sampling and analysis is a useful management tool for making fertilization decisions. One indicator of successful fertilizer management is a citrus tree with leaf nutritional standards within

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optimum ranges (Table 4). Trends of leaf N and K results over several years provide the best criteria for adjusting rates within the recommended ranges. Soil analysis is useful to determine soil pH and extractable phosphorus, calcium, and magnesium. Current Florida soil test interpretations for a variety of crops including citrus are presented in Table 5.

Recommended Fertilizer Rates

Numerous N fertilizer rate and timing studies conducted by University of Florida and USDA-ARS scientists for many years on a wide range of soil types, tree ages, varieties, rootstocks, and cultural conditions have verified that N rates in excess of 200 to 240 lbs/acre are not justified except for unusually productive groves (e.g. > 700 boxes/acre for round oranges). Excessive rates of N can reduce yields and fruit size.

Grove Conditions

In a mature grove where there is little net increase in tree size, N used for leaf growth is largely recycled as leaves fall, decompose, and mineralize. Replacing N removed by fruit harvest becomes the main focus of fertilization, and nutrient requirements should vary as the crop load changes. Nutritional programs should also be adjusted when leaf or tree canopy loss occurs due to severe pruning or freezes, or if extensive root damage occurs following flooding, tropical storms, or hurricanes. In the case where leaves and fruit have been lost but the root system remains intact, fertilizer rates may need to be elevated to support the growth of replacement leaves and fruit. If roots and canopy both suffer damage, fertilizer rates should be reduced proportionally to the amount of canopy loss. With the reduction in rates, application frequency should be increased.

Inorganic and synthetic organic N fertilizers are high-analysis materials and are generally most economical for use in citrus groves. They are rapidly available unless formulated as a controlled-release product. The use of high analysis fertilizers almost eliminates the need for filler, so a substantial portion of the mixing, transportation, and application cost is reduced. Loss of N through ammonia volatilization on calcareous soils is a concern when ammoniacal-N is applied to the soil surface without being

incorporated by rainfall or irrigation. The use of controlled-release fertilizers for resets in established groves is a viable option.

Applying Fertilizer

Two-thirds of the fertilizer applications to citrus each year should occur between January and early June, timed so that nutrients are available during the flowering and fruit-setting period. The remaining one-third can be applied in September or October. Split fertilizer applications or fertigation combined with sound irrigation management increase fertilizer efficiency by consistently supplying nutrients and by reducing leaching if unexpected rain occurs. With these circumstances, less fertilizer is required. Fertilizer reduction can also be realized by targeted placement within the root zone, timing applications to avoid rainy periods.

When fertigating, nutrients are placed in the wetted area where feeder roots are extensive. The fertilizer can be applied frequently in smaller amounts so it is available when the tree needs it. Thus, application costs are lowered when compared with dry or foliar fertilizers. Efficiency and cost savings of fertigation are greatest for young trees. Fertigation is not a recommended production practice if the irrigation system is non-uniform or poorly designed. Remember that fertilizer and water are wasted when a calendar-based fertigation schedule applies nutrients to very wet soil. Water and nutrient uptake are drastically reduced under saturated soil conditions.

Nutrient uptake is enhanced by foliar feeding when a soil is calcareous or possesses any other condition that decreases a tree's ability to take up nutrients. Foliar applications of low-biuret urea (25 to 28 lbs N/acre) or phosphorous acid (2.6 quarts/acre of 26 to 28% P_2O_5 material) in late December or early January are known to increase flowering, fruit set, and fruit yield. Post-bloom foliar applications of potassium nitrate or mono-potassium phosphate (8 lbs/acre K_2O) in late April have been found to increase fruit size and yield.

Phosphorus

Phosphorus (P) applied to citrus groves during establishment and early growth stages does not leach significantly, but rather P accumulates in the soil where it becomes slowly available. Consequently, fertilizer applications containing P can be reduced or omitted in mature groves. Phosphorus does not leach readily when the soil pH is 6 or higher, and the fruit crop removes very little P. Therefore, regular P fertilizer applications are not necessary. Some soils used for new citrus plantings may be naturally low in P--for example the commonly known "sand-soaked" areas. In this situation, P fertilizer should be applied, but only until soil tests show it is no longer necessary.

Micronutrients

The use of most micronutrients is recommended only when deficiency symptoms persist. Copper should not be included in the fertilizer if copper fungicides are used or if a soil test shows sufficient copper is present (5 to 10 lbs/acre). Molybdenum deficiency occurs on soils that have become very acidic, and can serve as an indicator of potential problems with aluminum toxicity. A lime application will raise soil pH and usually corrects this problem. Iron deficiency can be corrected by applying an Fe chelate, for example Fe-EDTA where soil pH < 7 and Fe-EDDHA where soil pH > 7. Foliar spray applications of micronutrients (manganese, zinc, copper, boron, and molybdenum) are much more effective and economically practical than soil applications. These micronutrients should be included with post-bloom or summer foliar sprays after full leaf expansion of the new growth flush.

Soil pH

Targeted soil pH should be between 5.5 and 6.5. Soils high in copper should be maintained at the high end of the range. A distinct advantage of pH 6 compared with pH 5 has been demonstrated in several studies, and pH of 7 was no better than 6. Soil pH can be increased by application of either calcitic or dolomitic lime. Dolomite supplies both calcium and magnesium, so the choice of dolomite would be more advantageous if magnesium is also necessary. Liming

a soil that has a pH of 6 or greater is costly and unnecessary. In groves where soils have a favorable pH but a soil test or leaf analysis indicates low calcium, gypsum (calcium sulfate) can be applied as a source of calcium that will not affect soil pH. Applying dolomite as a source of magnesium is not a recommended practice if the soil pH is in the desired range. Under these conditions, soil application of magnesium sulfate or foliar application of magnesium nitrate are effective for correcting magnesium deficiency.

Key points summarized

- Increasing the efficiency of applied nutrients is a key to economic citrus production.
- Nitrogen and potassium fertilizers affect fruit production and quality more than any other applied nutrients.
- Management practices that improve fertilizer efficiency include:
 1. Using leaf and soil analysis to guide fertilization programs.
 2. Choosing realistic fertilizer rates based on established guidelines and expected production.
 3. Selecting fertilizer sources appropriate for grove conditions.
 4. Careful placement and timing of fertilizer applications.
 5. Managing irrigation to minimize leaching of soluble nutrients.
- Foliar feeding is appropriate when soil conditions prevent sufficient uptake of nutrients to meet tree demands.
- Phosphorus fertilizer should be applied judiciously because P can accumulate in the soil.
- Micronutrients should be applied only when deficiency symptoms persist.

- Keep soil pH in the range of 5.5 to 6.5. Do not overlime.

Table 1. Current UF/IFAS-recommended N fertilizer rates for citrus.

Year in Grove	Oranges	Grapefruit	Tangerines	Murcotts	Other
----- lbs N/tree/year -----					
1	0.15 - 0.30	same	same	same	same
2	0.30 - 0.60	same	same	same	same
3	0.45 - 0.90	same	same	same	same
----- lbs N/acre/year -----					
4+	120 - 200	120 - 160	120-250	120-300	120-200
	120 - 200 ^A	120 - 210 ^A			

^A Nitrogen Best Management Practices range as specified by the Florida Dept. of Agriculture and Consumer Services.

Table 2. Average amounts of various nutrients contained within 100 boxes of Hamlin oranges.^A

Nutrient	lbs of nutrient per 100 boxes (90 lbs/box) of fruit
N	12.5
P	1.4
K	17.6
Ca	4.5
Mg	1.9
S	1.1
Fe	0.024
B	0.020
Zn	0.020
Mn	0.011
Cu	0.006

^A A. K. Alva, unpublished data.

Table 3. Average amounts of various nutrients contained within 100 boxes of four citrus varieties.^A

Nutrient	Hamlin	Parson Brown	Valencia	Sunburst
----- lbs of nutrient per 100 boxes ^B of fruit -----				
N	10.6	11.2	13.3	13.5
P	1.5	1.5	2.0	1.8
K	13.5	13.2	14.3	13.9
Ca	4.0	4.9	4.3	3.3
Mg	1.1	1.2	1.2	1.0
Fe	0.02	0.03	0.07	0.04
Mn	0.02	0.02	0.02	0.02
Zn	0.03	0.03	0.03	0.04
Cu	0.005	0.006	0.007	0.007

Table 3. Average amounts of various nutrients contained within 100 boxes of four citrus varieties.^A

^A S. Paramasivam, A. K. Alva, K. H. Hostler, G. W. Easterwood, and J. S. Southwell. 2000. Fruit nutrient accumulation of four orange varieties during fruit development. J. Plant Nutrition 23:313-327.
^B 1 box = 90 lbs of oranges.

Table 4. Standard table for assessing nutritional status and adjusting fertilizer programs for citrus: *Leaf analysis standard for assessing current nutrient status of citrus trees based on concentration of mineral elements in 4- to 6-month-old-spring-cycle leaves from non-fruiting terminals.*

Element	Deficient less than	Low	Satisfactory	High	Excess more than
Nitrogen (N) (%)	2.2	2.2-2.4	2.5-2.8	2.9-3.2	3.3
Phosphorus (P) (%)	0.09	0.09-0.11	0.12-0.17	0.18-0.29	0.30
Potassium (K) (%)	0.7	0.7-1.1	1.2-1.7	1.8-2.3	2.4
Calcium (Ca) (%)	1.5	1.5-2.9	3.0-5.0	5.1-6.9	7.0
Magnesium (Mg) (%)	0.20	0.20-0.29	0.30-0.50	0.51-0.70	0.80
Sulfur (S) (%)	0.14	0.14-0.19	0.20-0.40	0.41-0.60	0.60
Chlorine (Cl) (%)	-----	-----	<0.5	0.5-0.7	0.7
Sodium (Na) (%)	-----	-----	<0.2	0.2-0.5	0.5
Iron (Fe) (ppm)	35	35-59	60-120	121-200	250
Boron (B) (ppm)	20	20-35	36-100	101-200	250
Manganese (Mn) (ppm)	18	18-24	25-100	101-300	500
Zinc (Zn) (ppm)	18	18-24	25-100	101-300	300
Copper (Cu) (ppm)	4	4-5	6-16	17-20	20
Molybdenum (Mo) (ppm)	0.06	0.06-0.09	0.1-1.0	2-50	50

Table 5. Current Mehlich 1 (double-acid) soil test interpretation for Florida citrus on mineral soils.

Element	Very Low	Low	Medium	High	Very High
----- mg/kg -----					
Phosphorus (P)	< 10	10 - 15	16 - 30	31 - 60	> 60
Potassium (K)	< 20	20 - 35	36 - 60	61 - 125	> 125
Magnesium (Mg)		< 16	16 - 30	> 30	
Calcium (Ca)			150 - 250		
mg/kg = parts per million (ppm) = (lbs/acre) ÷ 2.					