Importance of nutrients for citrus trees

Let's talk about phosphorus (P).

By Mongi Zekri and Tom Obreza

Intensifying production is essential to meet the challenge of future food demands. However, this intensification must be done while minimizing environmental impacts. The "4Rs Nutrient Stewardship" framework (right fertilizer source, right rate, right time and right place) is therefore very important.

PHOSPHORUS FUNCTIONS

Phosphorus is present in all living tissue. It is particularly concentrated in younger plant parts, in flowers, and in seeds. Phosphorus is needed for photosynthesis, synthesis and breakdown of carbohydrates, and the transfer of energy within the plant. The nutrient helps plants store and use energy from photosynthesis to form seeds, develop roots, speed maturity and resist stress. Phosphorus is involved in nutrient uptake and translocation. It is a major part of the cytoplasm and the nucleus of cells, where it is involved in the organization of cells and the transfer of heredity characteristics. Phosphorus is also important for cell division and enlargement. Thus, plant growth is reduced when the supply of P is too low.

Excess P can affect fruit quality by

- Reducing acid concentration, which increases the TSS/acid ratio.
- Increasing number of green fruit.
- Reducing peel thickness.
- Increasing expression of wind scar.

Phosphorus is listed on the fertilizer label as P_2O_5, where it is referred to as "available phosphoric acid." Phosphorus does not readily leach unless the soil is extremely sandy or low in organic matter. A citrus crop removes only around 2 lbs. of P per 100 boxes of fruit. Most mature Florida citrus groves contain sufficient residual P that accumulates from previous fertilizer applications, so regular P fertilizer application is usually not necessary.

Some soils used for new citrus plantings are naturally low in P. These soils are commonly found in "sand-soaked" areas. In this situation, P fertilizer should be applied until a soil test P rating of medium to high is

Effects of P on citrus fruit quality

Variable	P
Juice Quality	
Juice Content	0
Soluble Solids (SS)	0
Acid (A)	–
SS/A Ratio	+
Juice Color	0
Solids/Box	0
Solids/Acre	+
External Fruit Quality	
Size	0
Weight	0
Green Fruit	+
Peel Thickness	–

Increase (+), Decrease (-), No change (0) achieved. Phosphorus fertilizer should be applied each year in newly planted groves on previously non-fertilized soil until the groves begin to bear fruit. As the trees approach maturity, P applications may be reduced or omitted. Diagnostic information from leaf and soil testing can help determine if P fertilization is necessary.

PHOSPHORUS DEFICIENCY

Phosphorus deficiency is not common in Florida citrus groves. If it were to occur, it would be more difficult to diagnose than nitrogen (N) deficiency or other nutrient element deficiencies. Growth is reduced when P supply is too low. Phosphorus is highly mobile in plants, so when it is deficient, it may move from old leaves to young leaves and other actively growing areas where energy is needed to form seeds and fruit.

Since P moves from older to younger tissue, deficiency symptoms appear first on older leaves, which lose their deep green color. Leaves are small and narrow, with a lusterless purplish or bronze discoloration. Some leaves may later develop necrotic areas, and young leaves will show reduced growth rate. Leaves shed prematurely, and fruit can drop before normal harvesting time.

P deficiency symptoms are not strongly expressed on citrus foliage. Trees will exhibit limited flower development with reduced fruit set and fruit yield. The fruit will be rough in texture with a coarse, thick rind and a hollow core (see photo, page 14). The fruit will have high acidity in proportion to total soluble solids. Thus, fruit maturity will be delayed. Usually, roots are stunted and poorly branched.

The cause of P deficiency is a lack of available P in the soil. Phosphorus deficiency may occur due to leaching and erosion where soils are sandy and the climate is humid. Phosphorus may also react with clay, iron (Fe), aluminum (Al) or calcium (Ca) in the soil and become less available and less mobile.

In strongly acidic soils such as those found in Brazil, P can become quickly unavailable through fixation or immobilization by Fe and Al. Phosphorus availability can also be reduced in calcareous soils through fixation by Ca. When P fertilizer is added to a calcareous soil, it undergoes a series of chemical reactions with Ca. These reactions decrease P solubility through a process called P fixation. Consequently, long-term P availability to plants is controlled by the application rate of soluble P and the dissolution of fixed P. Applied P is available to replenish the soil solution for only a relatively short time before it converts to less soluble P forms.

Phosphorus deficiency can be corrected by applying P fertilizer to the soil or foliage after confirmation of P deficiency by leaf and soil analysis.

Common solid sources of P applied to citrus groves include:

- Ordinary superphosphate
- Concentrated superphosphate
- Monoammonium phosphate (MAP)
- Diammonium phosphate (DAP)

The P source in both ordinary ("single" or "normal") and concentrated ("triple") superphosphate is mono-calcium phosphate, $Ca(H_2PO4)_2$. The major difference between these two fertilizers is that ordinary superphosphate contains gypsum (calcium sulfate) and concentrated superphosphate does not. If the fertilizer program calls for dry material, the use of superphosphates may have the following advantages: relatively inexpensive, appropriate for application to soil of any pH (especially alkaline soil), and supplies sulfur to plants.

Although MAP and DAP are two products that sound nearly the same, their reactions in the soil differ vastly. High acidity will form around a dissolving MAP granule, but high alkalinity will form around a dissolving DAP granule. Therefore, do not apply DAP to an alkaline soil because P will become unavailable due to tie-up by Ca, and N will be lost to the atmosphere by volatilization.

P nutrient sources used to manufacture true solutions include:

- Ammonium polyphosphate
- Phosphoric acid

Ammonium polyphosphate may be applied to the soil with a boom or injection wheel, but it should not be injected into a micro-irrigation system. Ammonium polyphosphate is not an acidic material, but has a slightly acidic reaction in the soil. Phosphoric acid is usually added to liquid fertilizers for application to soil or injected into irrigation water. If phosphoric acid is injected into a micro-irrigation system that is connected to a high-calcium water source, the emitters may clog due to precipitation of calcium phosphate.

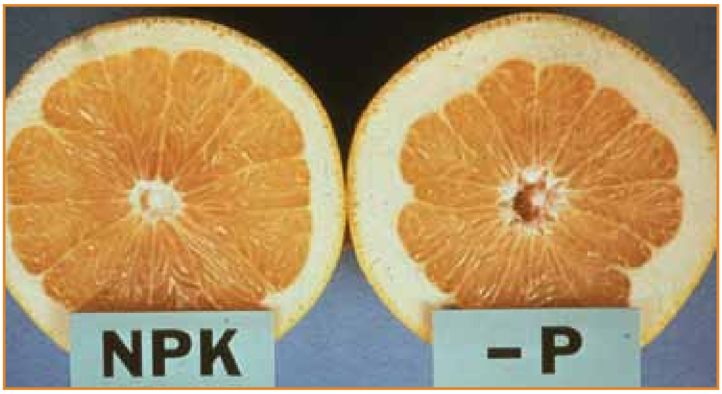
P nutrient sources applied in foliar sprays include:

- Potassium phosphite
- Ammonium phosphite
- Phosphorous acid

Phosphorus fertilizers are generally supplied to plants as salts of phosphoric acid (H_3PO_4). When phosphoric acid is neutralized by potassium hydroxide (KOH), it forms potassium phosphate (KH_2PO_4). However, if phosphorous

Interpretation of soil analysis data for P (ppm) using the Mehlich 1 (double acid) extractant				
Very Low	Low	Medium	High	Very High
<10	10 – 15	16 – 30	31 – 60	>60

Guidelines for interpretation of orange tree leaf P (%) analysis based on 4- to 6-month-old spring flush leaves from non-fruiting twigs				
Deficient	Low	Optimum	High	Excessive
<0.09	0.09 – 0.11	0.12 – 0.16	0.17 – 0.30	>0.30



Thick rind and a hollow core – a symptom of P deficiency

Recommendations for P fertilization of bearing citrus trees based on leaf tissue and soil tests (leaf and soil samples taken in July or August of each year)[1]

If leaf tissue P is...	..and soil test P is...	...the recommendation for P fertilization is:
Excessive High	Very High High Medium Low Very Low	Do not apply P fertilizer to the soil for 12 months following leaf and soil sampling, then sample again and re-evaluate.
Optimum	Very High High Medium	
Optimum	Low Very Low	Apply 8 lbs. P_2O_5/acre to the soil for every 100 boxes/acre of fruit produced during the current year. Sample leaves and soil again in 12 months and re-evaluate.
Low	Low Very Low	Apply 12 lbs. P_2O_5/acre to the soil for every 100 boxes/acre of fruit produced during the current year. Sample leaves and soil again in 12 months and re-evaluate.
Deficient	Low Very Low	Apply 16 lbs. P_2O_5/acre to the soil for every 100 boxes/acre of fruit produced during the current year. Sample leaves and soil again in 12 months and re-evaluate.

[1] These recommendations do not pertain to foliar-applied P.

acid (H_3PO_3) is neutralized with KOH, it forms potassium phosphite (KH_2PO_3), also known as phosphite or phosphonate. While the phosphate form of P is not easily absorbed by citrus leaves, the phosphite form is readily absorbed. Phosphite has been shown to accelerate foliar uptake of potassium, calcium, magnesium and most micronutrients. Because phosphite has one less oxygen molecule than phosphate, a higher degree of solubility and mobility within the plant is achieved. This unique characteristic permits phosphites to be rapidly absorbed by plant foliage and/or roots where it can play a nutritive role in the crop, including citrus trees.

The optimum range of P in citrus leaves is 0.12-0.16 percent. Phosphorus is deficient if leaf P is less than 0.09 percent. Appropriate P management is important not only for higher crop yield, but also for environmental protection. Slowing soil erosion can significantly decrease particulate and dissolved forms of P loss. Before deciding to apply P fertilizer to citrus, test the soil and leaves for P, and apply the results to the fertilization table (at left).

Growers should be aware that the soil mineral fraction reacts quickly to remove dissolved P from solution. In order to maximize the availability of soil P, soil pH should be monitored and maintained in the range of 6.0 to 6.5. To achieve optimum plant nutrition, an appropriate nutrient balance is necessary. Balanced use of plant nutrients corrects nutrient deficiencies and toxicities, improves soil fertility, increases nutrient and water use efficiency, enhances crop yields and fruit quality, develops tree tolerance to pests, diseases and other stresses, and improves environmental quality.

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