SL-240

UF UNIVERSITY of FLORIDA
IFAS Extension

# Improving Citrus Nitrogen Uptake Efficiency: Understanding Citrus Nitrogen Requirements[1]

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This publication is one in a series of three looking at improved citrus nutrition by increasing the efficiency of fertilizer use. In these three publications, we address citrus nitrogen (N) requirements, seasonal water use, and how irrigation scheduling and fertilizer management are linked. The objectives of this document are:

1. To better match citrus tree N requirements at selected life stages with fertilization practices based on tree growth;
2. To explain the demands for fertilization by citrus trees recovering from leaf loss caused by storms, insects, or disease;
3. To relate citrus nutrient uptake efficiency (NUE) as a means to improve or maintain productivity while minimizing ground and surface water pollution.

This series of publications, dealing with citrus nutrition and irrigation management would be of interest to citrus producers, fertilizer dealers, Certified Crop Advisers, and other parties interested in citrus fertilization practices.

## Citrus Fruit Crop Requirement for Nitrogen

The citrus fruit crop requirement for N is equal to the amount of N contained in the harvested fruit crop (Figure 1). Mature fruit contain approximately 0.1 pound of N per 90 pound box of fruit. This N amount is removed from the grove with the fruit, and so is unavailable for recycling within the grove. Thus, this N must be added back into the grove on an annual basis to become part of the next citrus harvest. This N is added back to the grove by the application of inorganic fertilizers, which are often quite soluble after wetting. However, other sources such as compost or controlled release fertilizers may also supply the appropriate amount of N.

The bulk of the N within the grove, however, is really not in the harvested fruit, but in the actively growing trees. Blooms, fruit, woody tissues (both above and below ground), and leaves all contain N and other nutrients. As these materials fall to the ground, some (approximately 50%) of the N they contain is recycled within the grove. Therefore, citrus trees must take up N in excess of the crop requirement for young trees to increase in size.

1. This document is Fact Sheet SL-240, one of a series of the Soil and Water Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Publication date: April 2006. Please visit the EDIS Web site at **http://edis.ifas.ufl.edu**.
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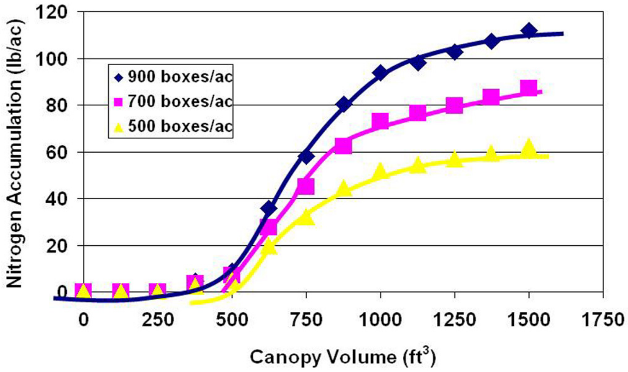


**Figure 1.** Relationship of tree size (canopy volume) to nitrogen accumulation and maximum harvestable citrus fruit yield.

## Citrus Biomass Accumulation

The increase in amount of plant parts (leaves, branches, roots, etc.) as citrus trees grow larger is called biomass accumulation. Since the concentration of N in these plant parts is within a relatively narrow range, the amount of N in a tree (N accumulation) is directly related to biomass accumulation as trees increase in size. A review of previous research found no clear trends in biomass and nitrogen accumulation with increase in tree age. This finding appears due to inconsistent tree spacings, soil characteristics, and cultural practices among the studies resulting in variations in tree size with age.

To determine the relationships of biomass and N accumulation with tree size, a comprehensive study has documented the accumulation of N (and other nutrients) at selected growth stages. Sampled plant parts included roots, taproot, shoots, trunk, main scaffold branches, twigs, and leaves. In short, all of the plant parts were sampled except the citrus fruit. The findings indicated that N accumulation was directly related to biomass accumulation and thus tree size. This relationship was consistent regardless of rootstock or scion, and is useful for defining strategies to accurately manage N fertilization for citrus.

The above-ground portions of the tree accumulate more biomass than below-ground portions, indicating that scaffold limbs, twigs, and leaves must be present to support the increasing tree size and related increasing fruit production (Figure 2). Nitrogen accumulation in growing trees is proportioned between the above ground and below ground plant parts and is a sum of the two for the entire tree (Figure 3). The rate of N accumulation with increase in canopy volume decreases at trees get larger. Young trees (tree canopy 0-250 $ft^3$) have a higher proportion of leaves compared to stems. Leaves contain a greater N concentration than do stems, thus, accumulation of N for young trees is at the rate of 0.1 pound of N per 50 $ft^3$ increase in canopy volume. Larger trees (canopy volume 1000-1500 $ft^3$) have a greater increase in woody tissue than leaves and accumulate N at a lower rate of 0.05 pound of N for the same 50 $ft^3$ increase in canopy volume. Moderate sized trees (canopy volume 250-1000 $ft^3$) accumulate N at an intermediate rate.

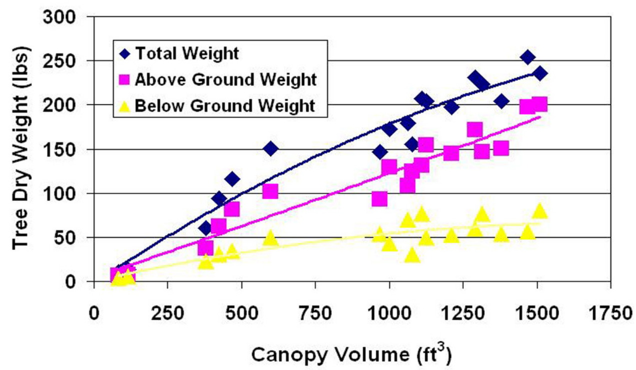


**Figure 2.** As tree size (canopy volume) increases, biomass (tree dry weight) is accumulated in both below ground and above ground plant parts similar to nitrogen accumulation. The above ground portions (trunk, scaffold branches, twigs, and leaves) accumulate more dry weight for a given tree size than below ground plant portions (taproot, lateral roots, and fibrous roots).

Knowledge of tree biomass accumulation based on citrus tree size, allows one to estimate the total annual N requirement, because it is directly related to the sum of the amount of N removed in the harvested citrus fruit and the N accumulation with tree growth. This sum must then be multiplied by an efficiency factor, the so-called nutrient uptake efficiency (NUE), for the selected fertilization source in concert with irrigation management to derive an appropriate N fertilization rate (discussed below). Examples of these calculations are given at the end of this publication.

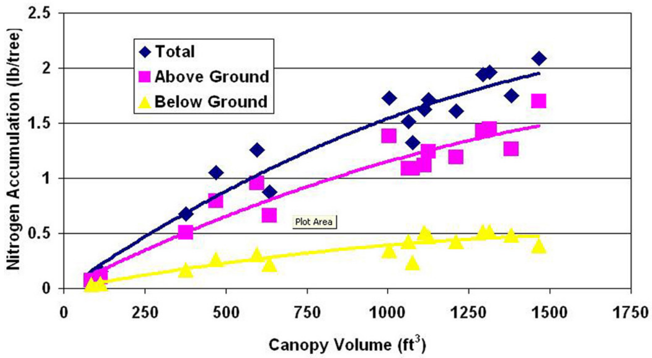


**Figure 3.** As tree size (canopy volume) increases, nitrogen is accumulated in both below ground and above ground plant parts. The above ground portions (trunk, scaffold branches, twigs, and leaves) accumulate more nitrogen for a given tree size than below ground plant portions (taproot, lateral roots, and fibrous roots).

## Fertilization for Rapid Tree Recovery from Storm, Pest, or Disease Damage

In addition to aiding fertilizer management decisions as tree size increases, knowledge of biomass and N accumulation can be useful to manage tree recovery after damage from storms or other defoliation causes. Leaves lost to storm, pest, or disease damage must be replaced rapidly to maintain fruit crop production. Nitrogen for new leaf growth is moved by the tree from woody tissue to the newly forming leaves. In turn, this N must be replaced from fertilizer or organic soil amendment sources to satisfy the crop nutrient requirements of the depleted woody tissue. To replace a 10% loss of leaves, a tree with a canopy size of 1,000 cubic feet requires approximately 15 pounds of N per acre (Figure 4). Similar sized trees that have lost 50 to 75% of their leaves, as happened to trees damaged by Hurricane Wilma, would require between 60 to 90 pounds of N per acre in the biomass to replace that N required to produce a full canopy of leaves. The amount of N application to replace these amounts of N will be discussed in the Improving Nutrient Uptake Efficiency section below.

If leaf loss is severe, leaves may not be replaced in one season, and may result in citrus yield reduction. A recent study determined that 25% leaf loss for two consecutive years had little effect on orange tree growth or yield. However, 50% leaf loss resulted in smaller leaves and fruit of both Hamlin

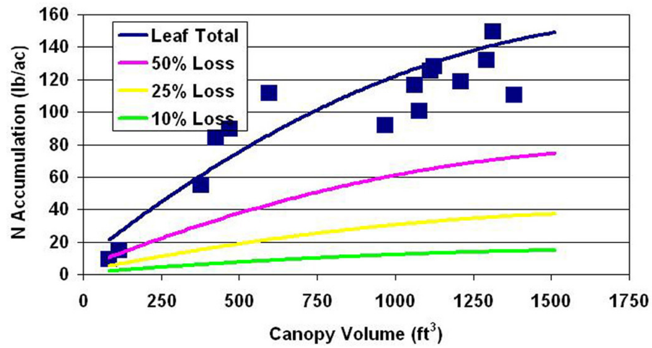


**Figure 4.** Relationship of tree size (canopy volume) to nitrogen accumulation and leaf loss due to storms or other damage.

and Valencia orange. Although yield of Hamlin oranges was not affected by 50% leaf loss, Valencia yield was significantly reduced in the second year. While yield loss is never a good thing, production managers can plan for this eventuality and implement additional fertilization practice changes. In cases where repeated defoliation has occurred, tree reserves will be lowered, decreasing the ability of the tree to recover. Again, grove managers can alter fertilization schedules to take advantage of this new information concerning N crop nutrient requirements based upon biomass measurements and the relationship to tree size.

## Improving Nutrient Uptake Efficiency

Although understanding that N accumulation is important when selecting fertilization rates, the efficiency with which N is taken up into the citrus plant must be incorporated into the fertilizer management plan. Nutrient uptake efficiency can be optimized by linking the nutrient application rate and timing to crop tissue concentration. This approach can work equally well for regular production or for improving growth of damaged trees (see Linking Citrus Irrigation Management to Citrus Fertilizer Practices, future EDIS publication for additional information on this subject).

In a well-managed grove where irrigation is correctly timed to avoid excessive leaching, and where fertilizer applications are timed appropriately to take advantage of citrus biomass needs, NUE should be within 40 to 60%. This percentage is the amount of applied N taken up by the citrus tree. The remainder of the fertilizer is either lost to conversions in the N cycle, taken up by microorganisms or other plants in the grove (ground cover, weeds, etc.), or lost due to leaching or runoff. Therefore, the example given above requiring 60 to 90 pounds of N to replace a 50 to 75% leaf loss, would require 120 to 180 pounds of N to replace these leaves. Movement of any nutrients, especially N, from the grove reduces NUE (to as low as 40%), is potentially a detriment to Florida's environment, and wastes fertilizer resources that are not used within the grove.

To calculate the amount of N needed, the total annual N requirement (from biomass accumulation and fruit crop) must be estimated and then divided by the NUE (Figure 5).

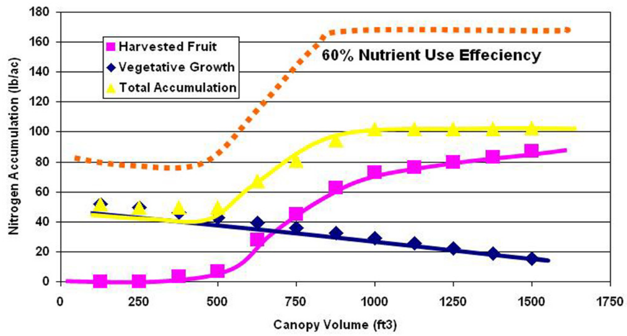


**Figure 5.** As tree size (canopy volume) increases, the total nitrogen accumulation reaches a plateau with much of the additional nitrogen accumulating in the harvested fruit. Total annual fertilizer requirement, assuming a 60% nutrient use efficiency for nitrogen, is shown as a function of tree size.

## Examples

**Example 1.** Assume trees average 750 ft$^3$ in canopy volume (12 ft tall and 9 ft in diameter), 200 trees per acre and produce 300 boxes of fruit per acre. Assume a canopy increase of 100 ft$^3$ and a 50% N uptake efficiency.

| | |
|---|---|
| Fruit N accumulation | 30 lbs of N per acre |
| Biomass N accumulation | 0.15 lb of N per tree |
| X 200 trees per acre | 30 lbs per acre |
| Total Fruit and Biomass N requirement | 60 lbs per acre |
| 50% maximum efficiency = 60 lbs/0.5 = 120 lbs per acre N requirement | |

**Example 2.** Assume trees average 1500 ft$^3$ in canopy volume (16 ft tall and 11 ft in diameter), 200 trees per acre and produce 700 boxes of fruit per acre. Assume a 50% N uptake efficiency.

| | |
|---|---|
| Fruit N accumulation | 70 lbs of N per acre |
| Biomass N accumulation (Figure 2) | 0.10 lb of N per tree |
| X 200 trees per acre | 20 lbs per acre |
| Total Fruit and Biomass N requirement | 90 lbs per acre |
| 50% maximum efficiency = 90 lbs/0.5 = 180 lbs per acre N requirement | |

## Conclusions

Recent research has documented the relationship between tree size and amount of leaves, branches, and roots of a citrus tree. Therefore, the need for N for both the tree growth and the harvested fruit can be estimated with increasing tree size. Using this new information about growth and tree development can be beneficial for N fertilization management. Also, this information must be considered when recovering from catastrophic leaf loss from storms, pests, and diseases. However, both fertilization rate and timing must be accompanied by efficient water management to avoid decreasing the nutrient use efficiency, which is at best between 50 and 60%. An integrated management approach must include knowledge of crop growth, fertilization efficiency, and matching irrigation management decisions. In addition to keeping fertilization and irrigation costs low, these actions ensure sustainable citrus production in Florida, and avoid environmental pollution associated with nutrient leaching from the grove.

## For More Information Regarding Citrus Biomass and N Accumulation

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