

# Development of Best Management Practices for Fertigation of Young Citrus Trees, 2003 Report<sup>1</sup>

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## **Abstract**

*'Newhall' navel oranges on 'Carrizo' rootstock were planted in Mar. 1997 at the Citrus Agricultural Center. The objectives of this experiment, conducted during 2000 - 2003, were to i) determine the effects of N rate and fertigation frequency for microsprinkler-irrigated navel oranges on tree N status, and crop yield and quality; and ii) develop Best Management Practices which promote optimum tree growth and production while minimizing nitrate leaching. The trees were equipped with a microsprinkler irrigation system. The experiment was a randomized complete block factorial with N rates of 0, 0.15, 0.30, and 0.45 lb N/tree/year, and fertigation frequencies of weekly, monthly, and three times per year. Each of the ten treatments was replicated five times. The trees were harvested in December or January of each growing season. Fruit were processed through an automatic fruit sizer, and fruit from each plot were further evaluated for fruit quality. Leaf N concentration and fruit yield of 4-6 year old trees were responsive to N rate, but not to fertigation frequency. Fruit quality and packout were not significantly affected by either N rate or fertigation frequency. Fruit yield was optimized at annual N rates of 0.25 lb/tree (four-year-old trees) to 0.35 lb/tree (six-year-old trees) during this experiment. We propose new tissue guidelines for guiding N fertilization of young microsprinkler-irrigated navel oranges.*

## **Introduction**

Presently there are more than 14,000 acres of citrus in Maricopa County under commercial production (Sherman and Oaks, 1999) of which about 2,500 acres are microsprinkler irrigated. As water costs increase many new plantings of citrus trees will be microsprinkler irrigated. The development of accurate fertilization guidelines for commercial citrus production is important to maximize profitability and minimize nitrate leaching to the ground water supply.

Nitrogen fertility has more influence on the growth, yield, and quality of citrus than any other single nutrient because it is the nutrient most often deficient in Arizona soils. Nitrogen fertilization is generally required in greater amounts by citrus than any other plant nutrient to maximize tree growth and development. Adequate supplies of N are necessary to optimize growth and development of newly planted citrus trees. Optimal growth requires optimal levels of N and irrigation, but an excess of either is nonproductive, costly, and may result in loss of N by leaching and/or runoff.

Current University of Arizona citrus fertilization guidelines are based on the best available research at the time, and were developed primarily for flood-irrigated production systems. The current Arizona recommendations are 0–0.5, 0.25–0.75 and 0.25–1.0 lbs/N/tree/year for the 1<sup>st</sup>, 2<sup>nd</sup>–3<sup>rd</sup> and 4<sup>th</sup>–5<sup>th</sup> years, respectively (Doerge et al., 1991). Nitrogen fertilizer recommendations in California are 0.25, 0.50, 0.75 and 1.0 lb/N/tree/year for the 2<sup>nd</sup>-5<sup>th</sup> years, respectively. In Florida,

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recommended rates are 0.15–0.30, 0.30–0.60, 0.45–0.90, 0.80–1.0 and 1.1–1.4 lb/N/tree/year for the 1<sup>st</sup>–5<sup>th</sup> years, respectively (Tucker et al., 1995). Recent research conducted at the University of Arizona suggests that these recommended rates can be decreased significantly for young microsprinkler-irrigated trees (Weinert et al., 2002). Further research is needed to refine N fertilizer recommendations for citrus in the 3<sup>rd</sup>–5<sup>th</sup> years as the trees begin producing fruit (Davies, 1997). Fertilizer requirements for citrus need to be reevaluated due to the recent changes in fertilizer formulation, application technology, irrigation practices (microsprinklers) and evidence of nitrate contamination. Microsprinkler irrigation with fertigation, when properly managed, has the potential to reduce leaching losses of nitrate and minimize the contamination of ground and surface waters.

Recently, the University of Florida revised citrus fertilization guidelines for young citrus trees and reduced recommended fertilizer rates 50% for the first 3 years after planting (Tucker et al., 1995). However, these new recommendations were based on years of research and the development of a relevant local database. Previously, most fertilizer studies on young citrus trees were conducted to determine the optimum rate or application frequency needed for maximum tree growth with little consideration given to the effects on ground water quality. However, nitrate movement into ground water is of concern particularly in central Arizona. Groundwater studies indicate that many wells around citrus producing areas contain nitrate concentrations above the EPA's Maximum contaminant Level (MCL) of 45 ppm (Reffruschinni and Watson, 1994).

Fertigation may reduce leaching of nitrate and minimize the contamination of ground and surface waters. The increased use of fertigation has led to many questions concerning optimum fertilizer rate and frequency of application for liquid fertilizers. Nitrate is readily leached through the soil profile with excessive irrigation or heavy rainfall (monsoons). Research in Florida showed that fertigating a newly planted citrus tree 10 or 30 times per year resulted in very little change in soil nitrate concentrations at a depth of 18–30 inches. However, treatments applied 5 times/year fluctuated considerably and had higher nitrate concentrations at the 18–30 inch soil depth (Willis et al., 1990). In addition, newly planted citrus trees have 85% of their roots located between 3 and 12 inches within the soil profile (Marler and Davies, 1989). Due to the limited root zone, it may be important to increase fertigation frequency to reduce nitrate-nitrogen downward movement beyond the root zone. Willis et al. (1990) recommended that producers consider fertigating on a weekly or bi-weekly basis.

Concern over the introduction of fertilizer materials into ground water also requires greater attention to efficient fertilizer management practices. Therefore, in Arizona where soil and climatic conditions make soluble fertilizers prone to substantial leaching losses, the use of Best Management Practices is particularly important.

The objectives of this experiment were to i) determine the effects of N rate and fertigation frequency for microsprinkler-irrigated navel oranges on tree N status, and crop yield and quality; and ii) develop Best Management Practices which promote optimum tree growth and production while minimizing nitrate leaching.

## **Materials and Methods**

*Site Characteristics.* Field studies have been conducted since March 1997 at the University of Arizona Citrus Agricultural Center in Waddell. The experiment is conducted on a Gilman loam soil, which has a pH of 8.0,  $E_c$  of 0.7 dS/m, extractable K of 702 ppm, exchangeable sodium <1%, and  $CaCO_3$  <1%. 'Newhall' navel orange trees on 'Carrizo' citrange rootstock were planted in March 1997. This scion/rootstock combination was selected because navel oranges are the prominent citrus crop in Maricopa County and the rootstock is common for newly planted citrus trees.

*Cultural Practices.* The trees were equipped with a microsprinkler irrigation system and plumbed to separately deliver the 10 N fertigation frequency x rate treatments listed in Table 1. Treatments were arranged as a 3 (fertigation frequencies) × 3 (fertilizer rates) factorial experiment with 5 dual tree replicates per treatment. Treatments included 3 fertigation frequencies, from March to September, of: 3 times, monthly, and weekly. Included in the design was a control treatment which has received no N fertilizer since the experiment began.

Trees were irrigated using single 300 degree microsprinklers to deliver 10 gallons per hour. Irrigation was applied to maintain soil moisture above 1/3 soil moisture depletion, which is the optimum level for young citrus trees. Water and N were delivered through a microsprinkler irrigation system with all buried main lines and laterals and one 300° pattern microsprinkler per tree. Nitrogen was supplied as urea-ammonium nitrate solution (UAN-32) injected into the appropriate fertigation lines using Dosatron injectors.

*Crop Measurements.* Tree growth and development were monitored by leaf tissue analysis. Leaf tissues were collected in August and analyzed for total N, P, and K to determine nutrient status of the trees as affected by fertigation frequency and N rate. Trees were harvested during December or January of each growing season. Fruit were processed through an automated fruit sizer, and ten fruit per plot were analyzed for fruit quality. Fruit quality parameters measured included percent juice, peel thickness, brix, and titratable acidity.

## Results and Discussion

Results from the 1999-2002 seasons were presented in earlier submissions to the Citrus Report. Therefore, we will present results only from the 2002-2003 season, and summary results drawn from all seasons.

*Leaf Tissue N.* Nitrogen concentration in leaves sampled in late August 2002 (Fig. 1) ranged from 26 mg/g (2.6%) in unfertilized controls, to 34 mg N/g (3.4%). Control trees had the lowest N concentration among the treatments, but were still above the commonly accepted 2.5% N “critical concentration”. Leaf N concentrations in fertilized trees were significantly affected by N rate, but not by fertigation frequency. Leaf N in all fertilized trees was above 2.5% N.

*Fruit Yield and Quality.* Fruit yield was 25 - 55 lb/tree (Fig. 2), much higher than the first harvest in 2001, and about the same as the harvest in Jan. 2002. The yield in all of the fertilized treatments was above that of the controls, and several of these differences were statistically significant. Among the fertilized treatments, there were no significant differences due to N rate or fertigation frequency. Neither N rate nor fertigation frequency showed consistent or significant effects on fruit quality, including Brix, fruit weight, or percent choice fruit (Fig. 3, Table 2).

*Yield Response to N Rate.* Across all four years of this experiment, there were no significant effects of fertigation frequency on fruit yield or quality. Therefore, fruit yield was evaluated as a function of N rate (Figs. 4 and 5). Fruit yields were maximized at N rates of 0.25 lb N/tree/yr for four and five-year old trees, and at 0.35 lb N/tree/yr for six-year-old trees. These yield-maximizing N rates are among the lowest currently recommended for flood-irrigated citrus in Arizona (Doerge et al., 1991). Therefore, recommended N rates for young microsprinkler-irrigated citrus are lower than those for flood-irrigated citrus.

## Conclusions

We recommend new N fertilization guidelines for young microsprinkler-irrigated citrus, based upon tree age and leaf N concentration (Table 3). Annual leaf sampling is important for assessing the nutritional status of the trees, and N rates should be adjusted accordingly. We further propose that a leaf N critical concentration of 2.8% is more appropriate for these young trees than the more commonly-used value of 2.5%.

There was no significant response of fruit yield or quality to variations in fertigation frequency from weekly to three times per year during the four years of this experiment. Therefore, fertigation frequency appears to not be a critical management variable. However, data from earlier years of this experiment suggested that nitrate leaching was greater with fertigation only three times per year compared to monthly or weekly fertigation. Therefore, we suggest that fertigation be applied approximately monthly during the growing season.

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Table 1. Fertigation frequency and N fertilizer application rate treatments for the 2002 growing season.

Treatment	N Fertigation Frequency	Fertigation Events per Season	Cumulative N Rate lb/tree
1	Weekly	27	0.15
2	Monthly	7	0.15
3	3X/year	3	0.15
4	Weekly	27	0.30
5	Monthly	7	0.30
6	3X/year	3	0.30
7	Weekly	27	0.45
8	Monthly	7	0.45
9	3X/year	3	0.45
10	None	0	0

Table 2. Fruit quality data for the December 2002 harvest.

Treatment	Rind Thickness	Juice	Brix	pH	TSS/TA
	mm	%	%		
1	8.1	42	13.0	4.1	25.1
2	8.3	35	12.2	4.1	23.6
3	7.7	40	13.0	4.2	26.4
4	7.5	41	11.9	4.2	27.1
5	7.9	40	12.2	4.4	26.5
6	8.3	41	12.8	4.2	25.6
7	7.4	40	12.3	4.2	22.6
8	8.0	38	12.9	4.3	27.4
9	7.6	41	13.2	4.3	26.6
10	7.4	39	12.8	4.2	26.3

Table 3 Proposed N fertilizer guidelines for microsprinkler-irrigated navel oranges.

Years After Planting	N rate to apply (lb N/tree/year)	
	Leaf N <2.8%	Leaf N >2.8%
0	0	0
1	0.2	0
2	0.2-0.3	0.2
3	0.2-0.3	0.2
4	0.3-0.4	0.2-0.3
5	0.3-0.4	0.2-0.3

