

Development of Best Management Practices for Fertigation of Young Citrus Trees

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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 were: i) to 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) to develop Best Management Practices which promote optimum tree growth and production while minimizing nitrate leaching. The trees are equipped with a microsprinkler irrigation system. The experiment is 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. Unfertilized control trees are also included in the experimental design. Each of the ten treatments is replicated five times. The trees were harvested for the first time in Feb. 2001. Fruit were processed through an automatic fruit sizer, and fruit from each plot were further evaluated for fruit quality. Although unfertilized control trees had lower leaf N content than fertilized trees, fruit yield and quality of controls was no lower than fertilized trees. Similarly, there were few statistically significant differences in fruit yield and quality between trees receiving different N rates and fertigation frequencies.

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. A large number of wells in the Phoenix area are already contaminated with NO₃ (Reffruschinni and Watson, 1994).

The level of N fertility has more influence on the growth, yield, and quality of citrus than any other single plant 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.

Currently, 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 1st, 2nd–3rd and 4th–5th years, respectively (Doerge et al., 1991). Nitrogen fertilizer recommendations in California are 1 tablespoon, 0.25, 0.50, 0.75 and 1.0 lb/N/tree/year for the 1st–5th years, respectively. In Florida, 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 1st–5th years, respectively (Tucker et al., 1995). Recent research conducted at the University of Arizona and

elsewhere suggests that these recommended rates can be decreased significantly for microsprinkler-irrigated young trees. Further research is needed to refine N fertilizer recommendations for citrus trees in the 3rd–5th 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: i) to 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) to 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 0.7 dS/m, extractable K 702 ppm, exchangeable sodium <1%, and $CaCO_3$ <1%. 'Newhall' navel orange trees on 'Carrizo' citrange rootstock were planted in January 1997. This scion/rootstock combination was selected because navel oranges are the prominent citrus crop in Maricopa County and the rootstock is currently the most 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) \times 3 (fertilizer rates) factorial experiment with 5 dual tree replicates per treatment. Treatments include 3 fertigation frequencies of 3 times per year, monthly and weekly fertigation. Included in the design is a control treatment, which has received no N fertilizer since the experiment began.

Trees are 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 are delivered through a microsprinkler irrigation system with all buried main lines and laterals and one 300° pattern microsprinkler per tree. The N is supplied as urea-ammonium nitrate solution (UAN-32) and is injected into the

appropriate fertigation lines using an in-line Dosatron injector.

Crop and Soil 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 for the first time during February 2001. Fruit were processed through an automated fruit sizer, and ten fruit per plot were analyzed for fruit quality.

Results and Discussion

Fruit Yield and Quality. There were few significant differences in fruit yield and quality between the treatments (Tables 2 and 3). In fact, yield and quality of unfertilized control trees were higher than in some of the treatments.

Leaf Tissue N. Nitrogen concentration in leaves sampled in late August 2000 (Fig. 1) ranged from 26 to 29 mg N/g. N concentrations were lower than in previous samplings conducted in 1998 and 1999, but remained fairly high. There were statistically significant differences in leaf N between N rates and fertigation frequencies. Control trees had the lowest N concentration among the treatments. This shows the relatively poor N status of these trees. However, as shown in Tables 2 and 3, this poor N status did not diminish fruit yield and quality.

Conclusions

Fruit was harvested for the first time in Feb. 2001 from navel oranges planted in Mar. 1997. Although unfertilized control trees had lower leaf N content than fertilized trees, fruit yield and quality of controls was no lower than fertilized trees. Similarly, there were few statistically significant differences in fruit yield and quality between trees receiving different N rates and fertigation frequencies. These trees have been receiving the same N rate and fertigation frequency treatments since 1997. We assume that subsequent harvests will result in greater differences between the various treatments. Continued experimentation will be needed to develop best management practices.

Literature Cited

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Table 1. Fertigation frequency and N fertilizer application rate treatments for the 1996-98 growing seasons.

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	0.00

Table 2. Fertilizer rate and frequency effect on yield of 'Newhall' navel orange trees harvested Feb. 2001.

N Rate (lb N/tree)	N Fertigation Frequency	Marketable Yield (g)	% Choice Fruit
0.15	Weekly	15600	5.0
0.15	Monthly	12000	3.1
0.15	3X/year	11100	5.4
0.30	Weekly	13700	3.3
0.30	Monthly	9400	4.7
0.30	3X/year	12500	1.7
0.45	Weekly	15100	6.0
0.45	Monthly	14800	5.4
0.45	3X/year	15600	2.0
0	None	14650	4.4

Table 3. Fertilizer rate and frequency effect on fruit quality parameters of 'Newhall' navel oranges harvested Feb. 2001.

N Rate (lb/tree)	N Fertigation Frequency	Avg. Fruit Wt. (g/fruit)	Avg. Juice Wt. (g/fruit)	Avg. Rind thickness mm	Brix %
0.15	Weekly	263	87	7.8	13.6
0.15	Monthly	299	85	8.4	12.8
0.15	3X/year	254	89	7.9	14.2
0.30	Weekly	245	80	7.9	13.7
0.30	Monthly	241	85	7.9	12.8
0.30	3X/year	286	79	7.8	13.6
0.45	Weekly	250	76	7.7	12.6
0.45	Monthly	286	89	7.5	13.0
0.45	3X/year	290	82	8.3	13.5
0	None	268	86	7.6	13.0

Figure 1. Leaf N in navel oranges sampled in August 2000.

