

Development of Best Management Practices for Fertigation of Young Citrus Trees, 2002 Report¹

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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 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 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 in Jan. 2002. Fruit were processed through an automatic fruit sizer, and fruit from each plot were further evaluated for fruit quality. Leaf N concentration was responsive to N rate, but not to fertigation frequency. Leaf N in all fertilized plots was above tissue critical levels. Fruit yield in fertilized plots was higher than in unfertilized plots, but, in fertilized treatments, there was no significant effect of N rate or fertigation frequency on fruit yield or quality.

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

¹ The authors would like to thank the Arizona Citrus Research Council for ongoing financial support necessary to complete this study. This is the final report for Project 2001-02 "Development of Best Management Practices for Fertigation of Young Citrus Trees, 2001".

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 table spoon, 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 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 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) × 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 during January 2002. Fruit were processed through an automated fruit sizer, and ten fruit per plot were analyzed for fruit quality.

Results and Discussion

Trunk Diameter. Trunk diameter was measured in August 2001. Trunk diameter was unaffected by N rate or fertigation frequency, and in fact diameter of unfertilized trees was slightly greater than that of fertilized trees (Fig. 1).

Leaf Tissue N. Nitrogen concentration in leaves sampled in late August 2001 (Fig. 1) ranged from 24 mg/g (2.4%) in unfertilized controls, to 31.5 mg N/g (3.15%). Leaf N concentrations were higher than during 2000. Control trees had the lowest N concentration among the treatments, below the commonly accepted 2.5% N “critical concentration”. This is not surprising, because these trees have not been fertilized since planting, more than 4 years ago. This shows the relatively poor N status of these trees. Leaf N concentrations in fertilized trees were significantly affected by N rate, but not by fertigation frequency. Leaf N increased with N rate, but there was no consistent effect of fertigation frequency on leaf N. Leaf N in all fertilized trees was above the 2.5% N “critical concentration”.

Fruit Yield and Quality. Fruit yield was 30 -55 lb/tree, much higher than the first harvest in 2001 (Fig. 2). The yield in several of the fertilized treatments was above that of the controls. 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 (Figs. 2 and 3).

Conclusions

‘Newhall’ navel oranges, planted in Jan. 1997, were harvested for the second time in Feb. 2002. Unfertilized trees had lower leaf N and were deficient in N. Consequently, yield of unfertilized trees was lower than yield of several of the fertilized treatments. There were no significant yield differences among N rates from 0.15 to 0.45 lb N/tree and fertigation frequencies from weekly to three times per year. Similarly, differences in N rate and fertigation frequency did not significantly affect fruit quality. We hypothesize that subsequent harvests will result in greater differences between the various treatments. Continued experimentation will be needed to finalize best management practices.

Literature Cited

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Table 1. Fertigation frequency and N fertilizer application rate treatments for the 2001 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

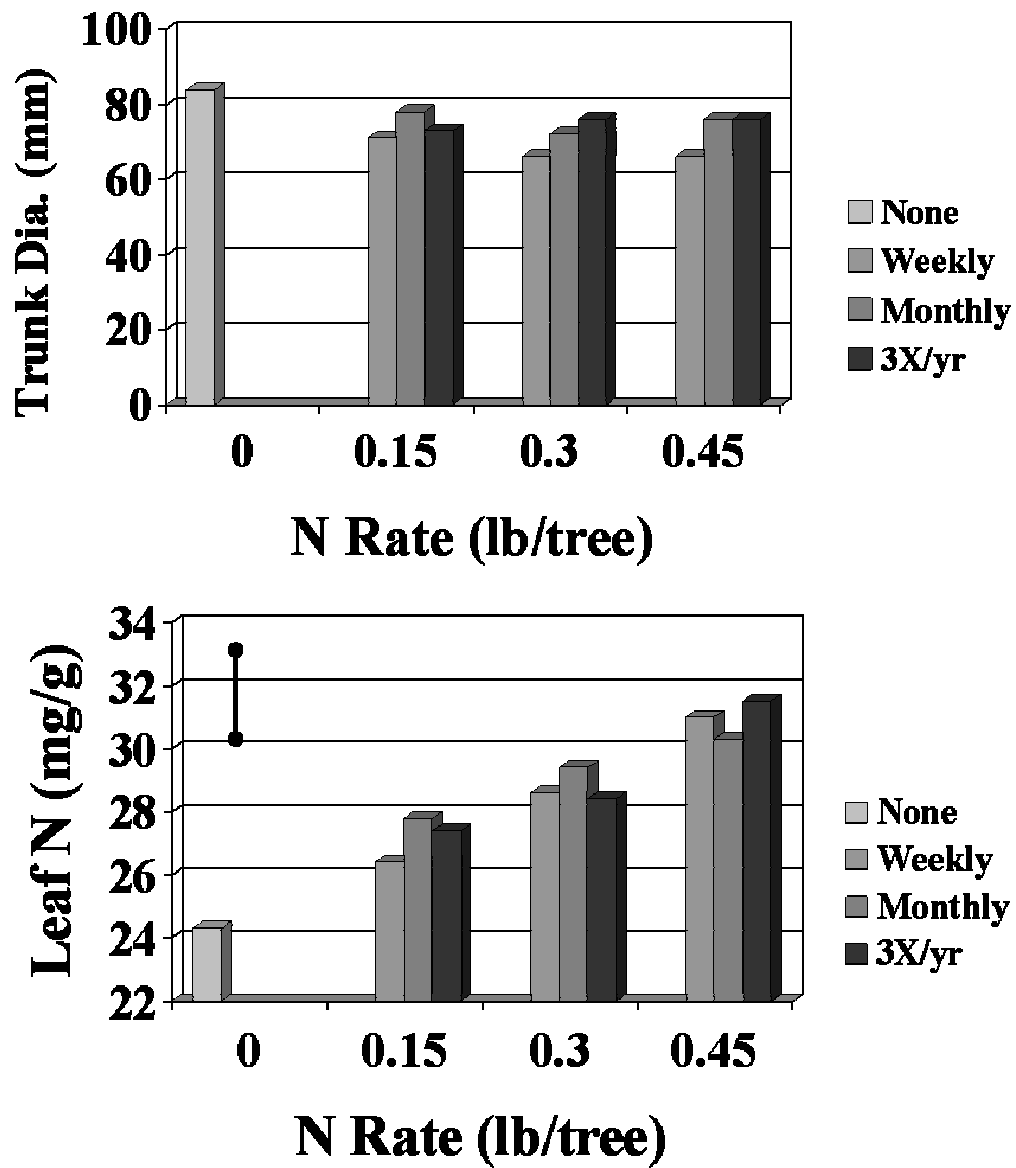


Figure 1. Trunk diameter and leaf N of 'Newhall' navel oranges in August 2001, Citrus Agricultural Center

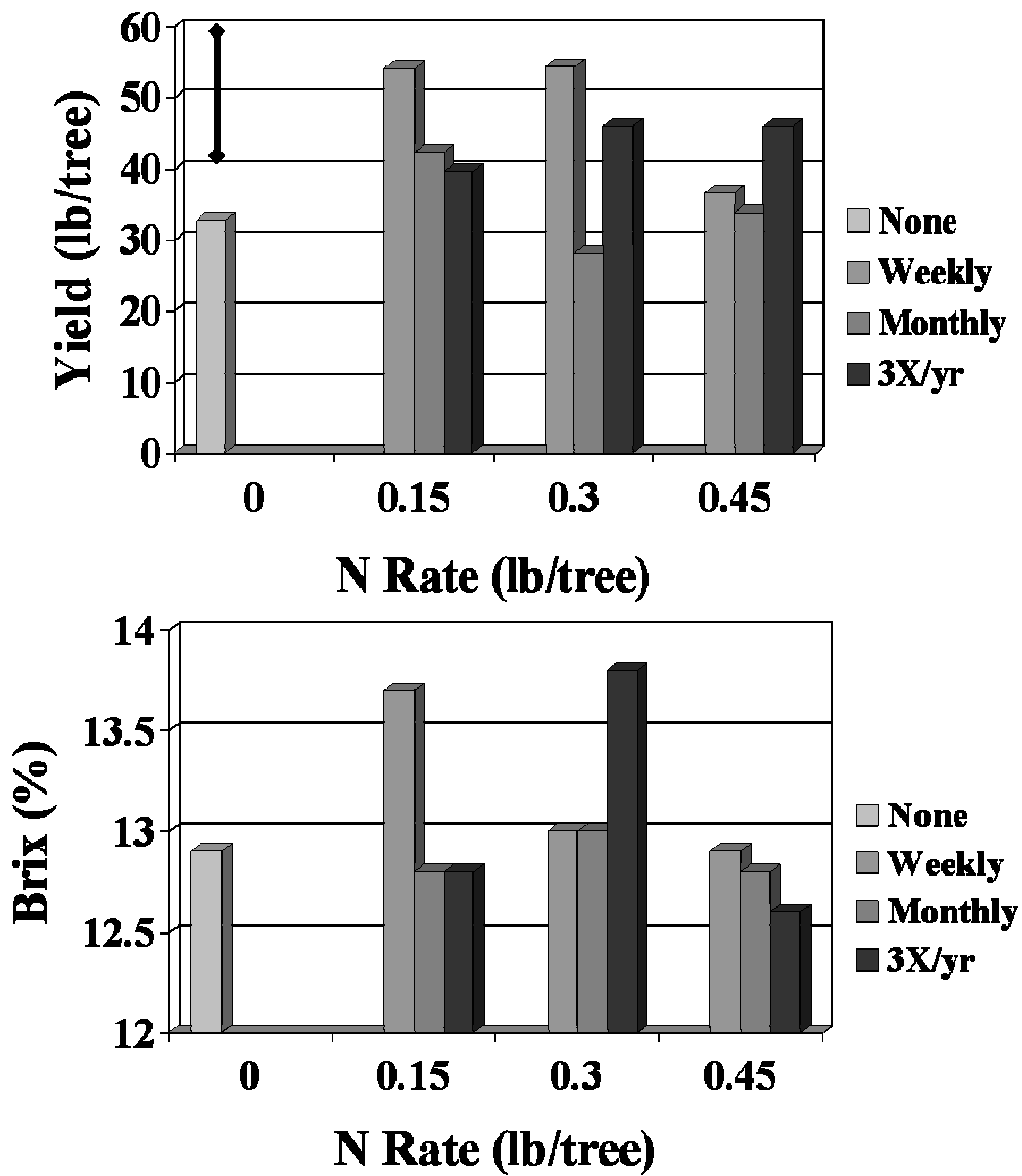


Figure 2. Yield and % Brix of 'Newhall' navel oranges harvested Jan. 2002, Citrus Agricultural Center

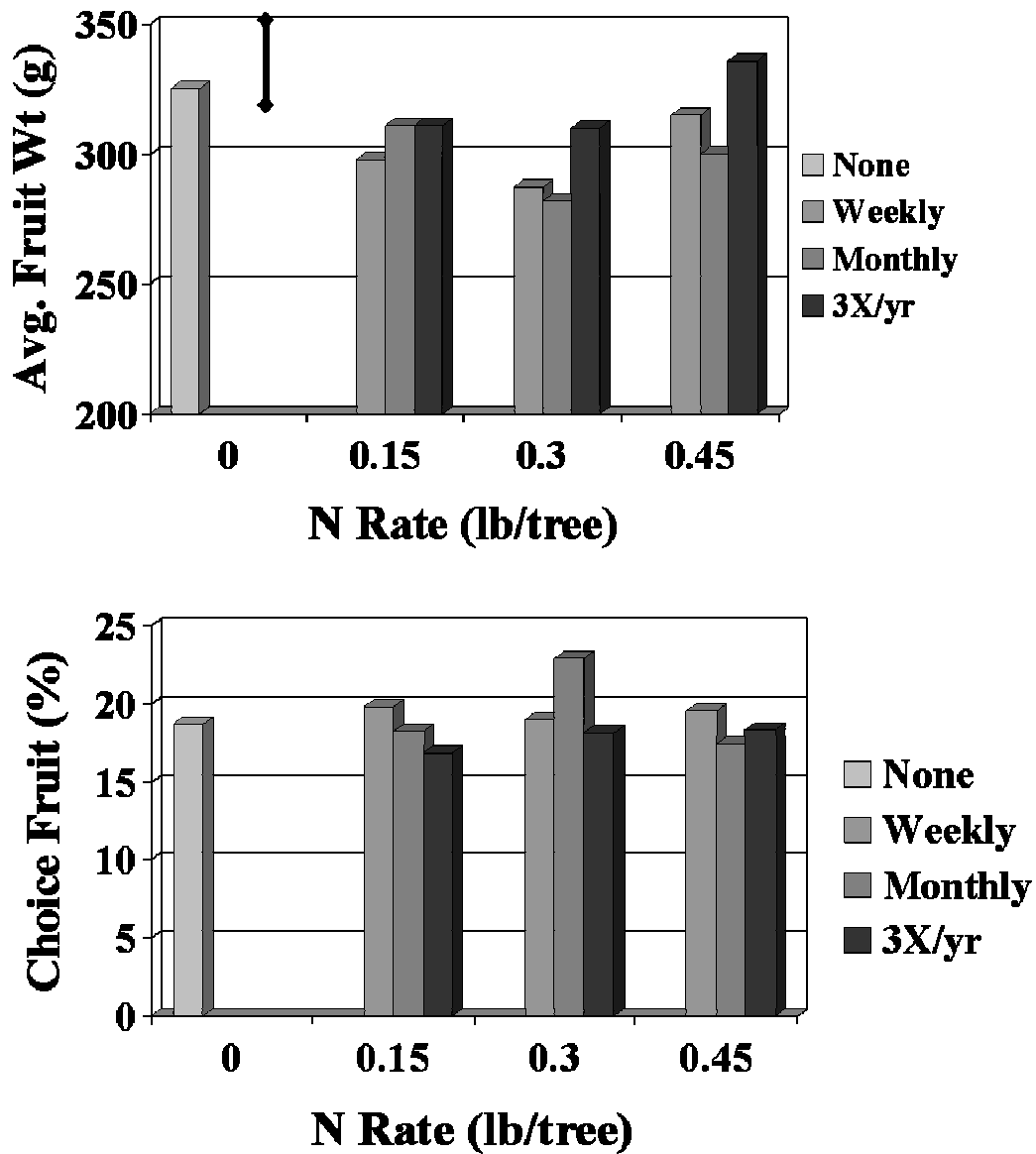


Figure 3. Fruit weight and % choice fruit of 'Newhall' navel oranges harvested Jan. 2002, Citrus Agricultural Center