

Effects of Fluid Nitrogen Fertigation Frequency and Rate on Microsprinkler Irrigated Grapefruit

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Abstract

Microsprinkler irrigation offers excellent flexibility for site-specific management of water and nitrogen inputs for citrus orchards in the southwestern United States. Escalating water costs, declining water availability, and increasing regulation of nitrogen (N) fertilizer use are causing growers to adopt practices to improve water and N use efficiency. A three-year field experiment was initiated in the spring of 1996 on six-year-old pink grapefruit trees at the University of Arizona Citrus Agricultural Center. The objectives of this experiment are to i) evaluate the effects of fertigation frequency and fluid N application rate on the yield and fruit quality of microsprinkler irrigated grapefruit, and ii) develop best management guidelines for fluid N application frequency and rate for microsprinkler irrigated citrus. Treatments include a factorial combination of two N rates (recommended and 2 the recommended rate) and three fertigation frequencies (weekly, monthly, and tri-monthly). Minimal treatment effects were observed during the first season due to the influence of previous management practices. During the second season, fertilized trees yielded greater than the control trees. There was no significant difference between N rates, but fruit yield was generally higher with monthly or weekly fertigation. Leaf tissue samples collected during the second and third growing seasons showed increasing leaf N with increasing fertigation frequency at the high N rate.

Introduction

California and Arizona are two of the leading citrus-producing states in the United States. Grapefruit, lemons, oranges, and tangerines are harvested from about 290,000 acres each year in these states and have a total value of more than \$750 million. Much of the production in these two states is accomplished on arid and semiarid soils and represents 19% of grapefruit, 100% of lemon, 16% of orange, and 33% of tangerine production in the United States (Tippett, 1992; Sherman and Erwin, 1996).

Citrus production in the southwestern U.S. is highly dependent on inputs of irrigation water and N fertilizer to achieve optimum fruit yield and quality. Growers realize that these inputs must be carefully managed to ensure optimum profits and minimal environmental impacts.

Escalating water costs and declining water availability are causing growers to adopt production practices which allow them to significantly improve water and N use efficiency and decrease labor costs. One such practice is the conversion from surface flood irrigation systems to under-tree microsprinkler irrigation. In addition to allowing precise control of irrigation water applications, microsprinkler systems offer the ability to use high frequency fertigation with fluid N materials throughout the 9-month growing season. This greatly improves the potential for excellent N use efficiency due to decreased leaching losses. In addition, research in Florida has shown that high frequency fertigation with N decreased susceptibility to frost injury by 3.4°F using

the leaf disc electrolyte leakage test (Tignor et al., 1995).

The majority of new citrus plantings in Arizona and southern California are being equipped with microsprinkler capability except where water and land costs are unusually low. This translates to about 10,000 acres of new citrus plantings per year in the southwest, most of which are on microsprinkler systems. Some preliminary research on high frequency N fertigation has been done in Florida (Marler and Davies, 1989; Boman, 1996) but little research has been done in the west.

Additional research is needed in the desert southwest to evaluate the effects of fertigation frequency and fluid N application rate on the yield and fruit quality of microsprinkler irrigated citrus. Further, best management guidelines for optimum fluid N application frequency and rate are needed for microsprinkler irrigated citrus to augment existing BMPs for more conventional irrigation methods (Doerge et al., 1991). The movement away from flood irrigation and use of granular N fertilizers to microsprinkler irrigation using exclusively fluid N sources is seen as a major trend in western citrus production. This research addresses a critical and current and future need of the citrus industry. The results will facilitate the successful adoption of an efficient, high-yielding crop production system which is based on fluid nutrient sources.

The objectives of this experiment were to i) evaluate the effects of fertigation frequency and fluid N application rate on the yield and fruit quality of microsprinkler irrigated grapefruit, and ii) develop best management guidelines for fluid N application frequency and rate for microsprinkler irrigated grapefruit.

Materials and Methods

Site Characteristics. Field studies were conducted during the 1996 through 1998 growing seasons at the University of Arizona Citrus Agricultural Center in Waddell. The experiment is conducted on a Gilman loam soil, which has nearly the highest yield potential for grapefruit of any soil in central Arizona (Hartman, 1977). Chemical properties of the surface soil are pH 8.0, E_c 0.7 dS/m, extractable K 702 ppm, exchangeable sodium <1%, and $CaCO_3$ <1%. A uniform block of 8-year-old Redblush grapefruit trees on Sour Orange rootstock are used for this experiment. The trees have been managed for optimum commercial production and are just entering their prime fruit-bearing years.

Cultural Practices. The trees were equipped with a microsprinkler irrigation system and plumbed to separately deliver the 6 N fertigation frequency x rate treatments listed in Table 1. The experimental design is a randomized complete block factorial with three N fertigation frequencies and two fluid N rates. The N rates have been increased during each year of the study, because they are just entering their prime fruit-bearing years. There are 10 individual tree replications per treatment, and the trees are planted on a 22 ft. by 22 ft. spacing (90 trees/acre). Eight replicate unfertilized control plots are also included in the experiment.

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		
			1996	1997	1998
1	Tri-monthly	3	0.25	0.30	0.45
2	Monthly	9	0.25	0.30	0.45
3	Weekly	36	0.25	0.30	0.45
4	Tri-monthly	3	0.5	0.60	0.90
5	Monthly	9	0.5	0.60	0.90
6	Weekly	36	0.5	0.60	0.90

Water and N are delivered through a microsprinkler irrigation system with all buried main lines and laterals and two 300° pattern microsprinklers per tree. The microsprinklers are placed on both sides of the trunk so that the spray pattern covers the entire area within the drip line and water-trunk contact is avoided. 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.

The N rates selected represent marginal (0.45 lb N/tree) and conventional (0.90 lb N/tree) rates. A typical grapefruit crop of 20,000 lbs/acre will contain about 35 lbs. N in the fruit plus an additional 20-40 lbs. N/acre in the new shoot and leaf growth each year. Treatment 4, with 0.9 lbs. N/tree applied in three split applications per year represents a conventional practice used by many growers today. All trees are irrigated uniformly 2 to 3 times per week. Daily readings of tensiometers placed at 12, 18, and 24 inch depths are used to maintain soil moisture above about 1/3 available moisture depletion, which is the optimum level for bearing citrus trees. All other cultural practices are done in accordance with accepted commercial standards.

Crop and Soil Measurements. Tree N nutritional status is monitored by late summer leaf tissue analysis (Doerge et al., 1991) in each year. Each year, fruit yield and quality are measured. Yield is determined on all 60 individual trees. Standard quality parameters including fruit weight, peel thickness, juice weight, total soluble solids (TSS), titratable acidity (TA), and TSS/TA ratio are measured on 10 fruit collected randomly from 3 to 4 trees per treatment. Soil samples were taken in one foot increments to depths of 4 feet at the beginning of the study (March 96) and at the end of the 1996, 1997, and 1998 growing seasons. The soil samples were analyzed for 1M KCl-extractable NH_4 and NO_3 .

Results and Discussion

Fruit Yield and Quality. No significant effect of fertigation rate or frequency on yield, fruit number, and fruit size was observed during the 1996-97 growing season (Table 2). However, yield was generally higher in fertigated treatments compared to the unfertilized control. The treatments were initiated in March 1996, therefore it is possible that treatment effects were masked during the first season because of the effects of previous management.

During the 1996-97 season, there was no significant treatment effects on fruit weight or juice weight (Table 3). However, peel thickness decreased with both increasing N rate and increasing fertigation frequency. Thin peels are a desirable quality in fresh market citrus. Although there was no effect of N rate or fertigation frequency on TSS/TA ratio, the values for the fertilized treatments were higher than that for the unfertilized control. A high TSS to TA ratio is generally indicative of sweeter, more mature fruit.

During the 1997-98 season, yields were generally lower than during the first season (Table 4). This reasons for the lower yields are not known, but may reflect normal year-to-year variability. There were no significant differences in yield or fruit quality between treatments, but all treatments had significantly greater yield and fruit numbers than the controls. These results indicate that during the second season the effects of the current treatments were becoming more pronounced. In general, fruit quality during 1997-98 was not affected by treatment (Table 5). However, peel thickness was significantly lower at the high N rate.

Leaf Tissue N. The fertigation treatments did not affect leaf tissue N during the first growing season (Table 6). This was not unexpected, and reflects the influence of past management. Nitrogen concentrations in samples collected during August 1997 and 1998 show the effect of the treatments more clearly. In general, fertigation treatments resulted in leaf N contents higher than the untreated controls. In the high N treatments, more frequent fertigation resulted in higher leaf N contents. In all cases, the leaf N was below the published critical level of 2.2% N (Doerge et al., 1991; Tucker et al., 1995). However, previous research in central Arizona suggested that 1.9 - 2.0 % N may be a more appropriate critical range for grapefruit grown in Arizona (Hilgeman and Dunlap, 1972). This study should yield further information that will allow evaluation of this critical level.

Soil Analyses. Soil NH_4 -N and NO_3 -N were analyzed to 4 feet in each plot at the end of the 1997 and 1998 seasons. Concentrations at the 3-4' depth were <12 mg/kg. Concentrations were higher in the December 1997 samples, because they were collected <1 month after fertigation ended in November. In neither season were there significant differences in residual N between treatments.

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Table 2 Fertilizer rate and frequency effect on yield of Redblush grapefruit trees harvested on Jan. 23, 1997.

N Rate	N Fertigation Frequency	Fruit wt.	Fruit number	Average fruit size
lb/tree		lb/acre	number/tree	g
0.25	Tri-monthly	15,100	192	396
0.25	Monthly	15,000	191	396
0.25	Weekly	14,400	191	379
0.50	Tri-monthly	14,300	202	401
0.50	Monthly	16,100	188	401
0.50	Weekly	14,300	185	390
0	None	13,800	185	376

Table 3. Fertilizer rate and frequency effect on fruit quality parameters of fruit harvested on Jan. 23, 1997.

N Rate	N Fertigation Frequency	Fruit wt.	Juice wt.	Peel thickness	T.S.S.^H	T.A.^I	Ratio TSS/TA
lb/tree		g	g	mm	%	%	
0.25	Tri-monthly	345	142	10.1	10.7	1.67	6.4
0.25	Monthly	375	163	9.7	10.7	1.65	6.5
0.25	Weekly	356	155	9.4	10.9	1.65	6.6
0.50	Tri-monthly	362	153	9.8	10.5	1.63	6.4
0.50	Monthly	376	158	9.5	10.4	1.62	6.4
0.50	Weekly	385	165	9.0	10.8	1.69	6.4
0	None	362	156	9.8	10.7	1.72	6.2

^H T.S.S. = total soluble solids.

^I T.A. = titratable acidity

Table 4. Fertilizer rate and frequency effect on fruit yield of Redblush grapefruit harvested on Mar. 4, 1998.

N Rate (g)	N Fertigation Frequency	Fruit Weight	Fruit Number	Fruit Size
lb/tree		lb/acre	no./tree	g
0	Control	5500	47.4	585
0.3	Tri-monthly	8800	82.1	542
0.3	Monthly	10100	92.1	554
0.3	Weekly	10600	100.8	529
0.6	Tri-monthly	9000	86.1	526
0.6	Monthly	11900	119.9	495
0.6	Weekly	10600	105.9	505

Table 5. Fertilizer rate and frequency effect on fruit quality of Redblush grapefruit harvested on Mar. 4, 1998.

N Rate	N Fertigation Frequency	Fertigations per Season	Fruit Weight^z	Juice Weight^z	Peel Thickness^z	TSS^y	TA^x	Ratio (TSS/TA)
lb/tree			(g)	(g)	(mm)	(%)	(%)	
0	Control		521	180	12.9	11.2	1.53	7.3
0.3	Tri-monthly	3	534	183	12.3	11.1	1.48	7.5
0.3	Monthly	9	585	205	14.2	10.6	1.42	7.5
0.3	Weekly	36	502	184	11.7	10.4	1.43	7.3
0.6	Tri-monthly	3	490	177	12.1	10.8	1.5	7.2
0.6	Monthly	9	453	170	11.1	11.2	1.52	7.4
0.6	Weekly	36	517	189	12.2	10.7	1.44	7.4

H average of 10 fruit per tree and 4 replicates
 I Total soluble solids
 ' Titratable acidity

Table 6. Fertilizer rate and frequency effects on leaf tissue N concentrations in Redblush grapefruit trees.

N Rate	N Fertigation Frequency	August 1996	August 1997	August 1998
lb/tree		%	%	%
0.25	Tri-monthly	2.0	1.9	1.9
0.25	Monthly	1.9	1.8	1.8
0.25	Weekly	1.9	1.9	1.9
0.50	Tri-monthly	1.9	1.8	1.8
0.50	Monthly	2.0	2.0	2.0
0.50	Weekly	2.0	2.1	2.1
0	None	2.0	1.8	1.8

Figure 1. Soil NH₄-N plus NO₃-N in samples collected in February, 1997.

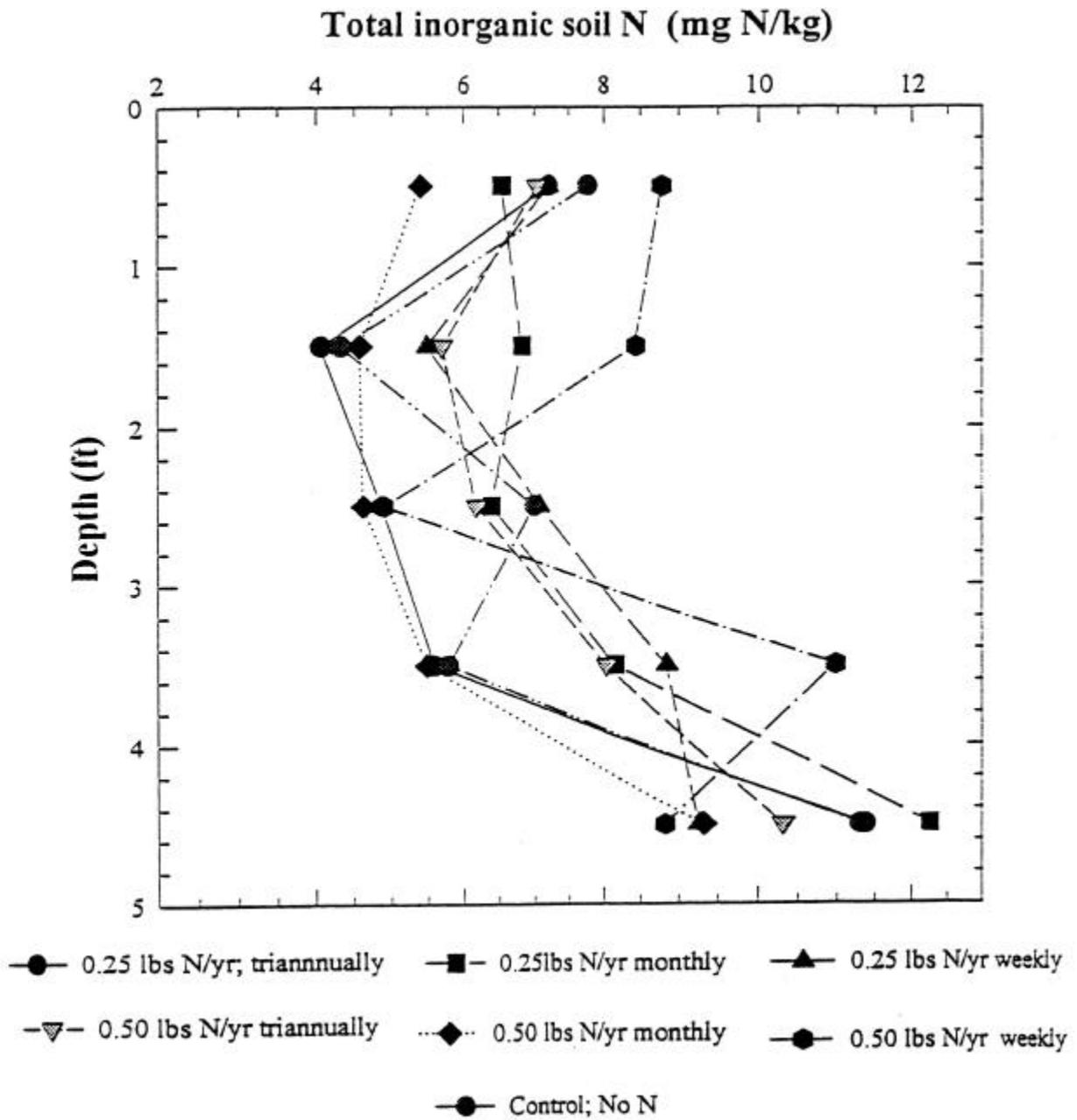


Figure 2. Soil NH₄-N plus NO₃-N in samples collected in December, 1997.

