NITRATE BMP GRANT PROGRAM-FLORIDA DEPARTMENT OF AGRICULTURE

Final Report - Years 1 to 3

Foliar Feeding of Urea as a Substitute for Ground Applied N in Citrus Production
DACS Project #3267

Principle Investigators - L. Gene Albrigo and James P. Syvertsen
University of Florida. Citrus Research and Education Center, Lake Alfred, FL 33850

Funding Year One of 3 years	Funding second of 3 years	Funding third of 3 years
DACS Grant $38.083.00	DACS Grant $12,652.50	DACS Grant $15,802.50
U of Fl Salaries $19.000.00	U of Fl Salaries $19,000.00	U of Fl Salaries $20,000.00
Total Funding $57.083.00	Total Funding $31,652.50	Total Funding $35,802.50

TOTALS FOR PROJECT

DACS Grant	$66,538.00
U of F Salaries	$58,000.00
Total Funding	$124,538.00

GENERAL CONCLUSIONS

1) Citrus trees can be established using foliar applied urea as the only added source of N.

Foliar urea for N appears to be as or more efficient than soil applied N for young tree growth. This may not hold true when the trees are bearing fruit and these studies should continue until yield response is determined..

Tree growth was similar between all treatments even though much less N was applied to the all-foliar N treatments. Trunk diameters were significantly larger for the foliar only treatment.

2) Leached NO_3 was detected during rainy periods in almost all of the ceramic suction cup samplers.

Consistent differences in NO_3 levels did not occur between treatments.

Most leached NO_3 was during the Summer when N was not applied to the soil.

Decomposing weed biomass may have contributed most of the N detected in leachate.

NO_3 levels were usually below 3 ppm, but spikes did occur that averaged up to 20 ppm for a given treatment. These spikes occurred across all treatments.

3) Economically, foliar application is not recommended because too many applications are required to apply a significant amount of N/tree due to the small leaf area per tree during the first two years. On the other hand some reduction in leached NO_3 is a benefit.

ACCOMPLISHMENTS YEAR ONE

The primary first year objective was to establish a well and irrigation system and get the 9.5 acre site planted in 2 cultivars with 2 rootstocks in randomized plots for comparison of foliar urea as a sole source of N compared to soil applied N as the N fertilizer source. A 50-50 treatment was included also. The following steps were completed:

1) A Consumptive Water-Use Permit was obtained from the St. Johns Water Management District (issued 5/14/96). Arrangements were made with Tampa Electric for 3-phase 480 Volt service which was installed to the well site before the well was completed. The well drilling was bid and the drilling begun 6 August and completed on September 23, 1996 with a submergible pump set, pumped out or tested at a yield of +400 gal/min for the 6 inch well. The well is 320 ft deep with the pump set at 63 feet. The irrigation system was designed and installation completed with underground mains, above ground tubing and microsprinklers.

2) The site was cleared of old trees and weeds. A program of frequent disking was initiated to eliminate sting nematodes. The effect of this program was to reduce sting nematode levels to near zero.

3) A ground penetrating radar profile was completed over the property on 90 feet centers traveling East and West to establish the characteristics of the underlying clay layer. The clay-sand layer appeared to be continuous for the entire block. A topography map with 1 foot contours above mean sea level was obtained and surface elevations compared to clay layer depths. This allowed construction of a contour map of the clay layer which was completed in September 1996. This allowed setting of suction cup samplers on the low elevation side of the clay layer in each plot. Parts for the suction cup water sampling tubes were purchased, samplers constructed and installed by mid-December, 1996. The two old 4 inch irrigation wells were cleared and capped with sampling ports in order to monitor NO_3 s at deeper levels. One well is 80 feet deep (to the limestone aquifer) and the other is more than 200 feet deep. The new well serves as a deep aquifer sampler also. Base-line water samples were taken for nitrate analysis before any fertilizer was applied. Porous cup sampling tubes were primed and sampled starting in January, 1997. These range in depth from 8ft 7in to 18ft 9in. The deepest sampler is in the lowest elevation of clay and nearly were a permanent water table exists.

4) Five replications were established in Hamlin oranges and 4 replications in Flame grapefruit . Trees were planted from September 27th to October 4, 1996. This was about two and 1/2 months later than originally projected, but permitting and obtaining services was delayed by several suppliers. Each plot has 30 trees of each rootstock (5 rows times 6 trees/row). The center 3 rows x 5 trees (15) are record trees for each rootstock and extra trees were planted in some plots to sacrifice after two years for detailed measurements of canopy and root development.

5) Because of the delayed planting date, little tree growth was expected into the Winter so fertilizer treatments were not started until January, 1997. The soil-applied fertilizer rate was

chosen at 0.24 lbs N/tree, 40 % below the highest value in the recommended range for year old trees ((0.15-0.30 lbs N), Nutrition of Florida Citrus Trees, SP 169, Tucker *et al.*, University of Florida). The 0.24 lbs N/tree was applied in 6 applications of 0.04 lbs N/tree. Soil fertilizer was a 8-2-8 mix and the soil supplemental fertilizer to foliar N treatments was an 0-2-8 mix. The fertilizer treatments were started on January 16, 1997 and the schedule is shown in Table 1.. Urea N in 6 % solutions was applied every 3 weeks until spring growth ceases. The 50-50 plots received half the ground rate and every other foliar application. The goal is to maintain leaves at 2.6 to 2.8 % N.

6) Measurement of plant growth were started. Trunk diameter and tree height of record trees (15 per rootstock per plot, 810 total) were taken as a base-line. Extra trees in the total foliar and total soil N fertilizer treatments will be used for end of 2nd year growth for detailed measurements requiring sacrificed trees.

The treatment phase of the project was underway by the end of the first year with sufficient Fall and Winter time in the ground to expect good Spring growth. We were not able to collect any partial first year growth data in 1996 beeause of the later than anticipated planting. Detailed expenditures are presented below.

EXPENDITURES IN YEAR 1

Category	**Budgeted**	**Expended***
Land Clearing	$2,500	$ 2,261
Well Drilling (Inclusive of all irrigation 22,500)		12,625
Underground irrigation lines		2,210
and installation		1,725
Above ground irrigation lines		2,303
and installation		1,470
		20,333
Trees	5,220	3,024
Operating Expenses	3,400	2,087
Personnel Services	2,600	8,515
Travel	50	50
Overhead	1,813	1,813
Total	38,083	$38,083

Table 1. PLAN FOR FERTILIZER APPLICATIONS - FIRST GROWTH YEAR

Date	Type of Application
Jan.16, 1997	Foliar and Ground # 1
Feb. 14	Foliar # 2
Feb. 24	Ground # 2
March 7	Foliar # 3
March 28	Foliar # 4
April 9	Ground # 3
April 18	Foliar # 5
May 9	Foliar # 6
May 22	Ground # 4
May 30	Foliar # 7
Oetober 10	Foliar # 8
October 15	Ground # 5
October 31	Foliar # 9
Nov.14	Ground # 6
Nov. 21	Foliar # 10

Applied N per tree foliar was = 0.04 lbs N/tree, while the soil only treatment received 0.24 lhs N/tree.

ACCOMPLISHMENTS YEAR TWO

The first year of tree growth and nitrogen treatments was completed on trees planted in October of 1996. Six applications of NH_4NO_3 were applied to the soil fertilizer plots (total = 0.24 lbs/tree/year 1) and 8 foliar sprays of urea (total = about 0.04 lbs N per tree) were applied to the all foliar urea treatments. Some yellowing of leaves was evident in the foliar plots during the summer, but not by Fall. The leaf N values were nearly the same and in the acceptable to excess range (Table 2). The small leaf area on these young trees made it difficult to load an equal amount of N/tree compared to the ground treatment without many more applications or soaking the ground. If these low application rates of N affected tree growth, tree measurements at the end of year did not reveal the reduced growth. No difference in tree growth was deteeted between treatments, but tree growth was not as good as would have been expected in a commercial grove. See paragraph two for possible reasons. One of the foliar applications was made using spray grade urea that contained 1 % biuret. The product was not labeled for biuret content and the biuret level was determined after injury was observed. This injury was the typical marginal yellowing and leaf tip-burn. Overall the injury was not severe.

A number of trees died this first year and required replacement. The following problems were involved in these tree losses: fire ant and termite damage, phytophthora foot and root rot after fire ant or termite damage, phytophthora root rot after ground fertilizer burn of the root system and lightening damage. About 3 % of the trees were replaced. In addition, citrus leaf miner, orange dogs, and grasshoppers have attacked the canopies of many trees. A number of pest control methods were applied to correct or minimize the above problems. Many of these factors probably contributed to the poor growth of trees in all plots.

All plots have porous cup sampling tubes positioned in the soil. Complete sealing of these sample tubes was difficult. A special glue was found that bonds ceramic to PVC pipe. Several samplers were dug up, rescaled and reset. In some plots, 6 foliar and 6 ground applied fertilizer plots, newly designed buried funnel collectors have been installed (Figure 1). This methodology is still to be evaluated, but in theory this approaeh to sample eollection would allow quantification of leachate volume per surface area as well as the nitrate content of the leachate for a known surface area of soil. It took nearly two months for these samplers to collect percolated water after their installation. The disturbed (lower density) soil layer above the funnels appeared to have caused the water to channel away from the funnels. The soil over the funnels should have remained undisturbed by digging at the side of the intended collection area and under-cutting to place the funnel.

Following recommendations of the review committee, monitoring wells were installed on the two slopes in the field to determine if any lateral flow was occurring across the clay layer surface. Although these wells have occasionally reeorded rises in water level, standing water over the clay has never exceeded 2 or 3 cm and not all of the wells on a slope have recorded free water from the same rain event. It appears that no significant lateral flow is occurring on the clay layer and therefore, the plots are not being cross-contaminated by lateral flow on the surface of the clay.

Leached water sample could be obtained after the rainy season started in June. The NO_3 levels were generally less than 5 ppm, mostly less than 3 ppm (Figure 2). On some occasions

however, the NO_3 levels were above 10 ppm in several plots. On these occasions, the high levels occurred in foliar urea as well as ground fertilizer plots. It appeared that these events occurred after a significant weed population was killed by herbiciding. The NO_3s may have been released by decomposing weed material. These events, if they occur again, need to be evaluated in more detail. Fertilized and unfertilized weed plots, with or without herbiciding, could be compared for NO_3 leaching over time. Dr. Syvertsen has proposed to look at this aspect in a new research proposal.

The previous Winter and early Spring were unusually wet. For much of that time little fertilizer was applied and weed growth was still accumulating. However in December of the first year of growth , ground fertilizer had been applied just before the heavy rains (Figure 2, 12th month). The ground water recovered NO_3 in the collected solution averaged at or above 10 ppm for all treatments at the peak.

Generally, NO_3 leaching was not severe in relation to fertilizer treatments. This data collection, however, has occurred during the low end of application rates on young trees. The application rate thisin the second year was raised to 0.45 lbs/N/tree/year or 78 lbs N/acre. This is still less than half of the expected mature tree rate. The fourth or fifth year of growth should represent a full rate on N application and full potential for leaching.

EXPENDITURES FOR YEAR TWO OF GRANT

Category	Budgeted	Expended
OCO	0	0
Operating Expenses	2,000	2,000
Personnel Services	10,000	10,000
In-State Travel	50	50
	Overhead	602.50
	Total to date	$12,652.50

Table 2. Leaf N values (% dry wt) for Summer leaves collected in November 1997 after 1 year of growth.

Treatment	Hamlin	Grapefruit
Soil N Only	2.93, plot range 2.86-3.09	2.70, plot range 2.36-2.86
Mixed Application	2.97, plot range 2.83-3.33	2.73, plot range 2.51-2.79
Foliar N Only	3.16, plot range 3.01-3.33	2.53, plot range 2.23-3.09

Table 3. SCHEDULE OF FERTILIZER APPLICATIONS - 2ND GROWTH YEAR

Date	Type of Application
Feb. 4, 1998	Ground and Mixed # 1
Feb. 9	Foliar # 1
March 2	Foliar and Mixed # 2
March 23`	Foliar # 3
April 1	Ground # 2
April 8	Foliar # 4
April 29	Foliar and Mixed # 5
May 13	Ground and Mixed # 3
May 20	Foliar # 6
June 12	Foliar and Mixed # 7
July 3	Foliar # 8
July 28	Foliar and Mixed # 9
August 14	Foliar and Mixed # 10
Sept. 1	Foliar and Mixed # 11
Sept. 15	Ground and Mixed # 4
Sept 28	Foliar and Mixed #12
Oct. 22	Foliar and Mixed # 13
Nov. 3	Ground and Mixed # 5
Nov. 16	Foliar and Mixed #14
Nov.30	Foliar and Mixed # 15

The applied N per treatment for the 2nd year of growth was as follows: foliar = 0.125 lbs N/tree/ year and soil only = 0.45 lbs N/tree/year and mixed was 0.32 lbs N/tree/year.

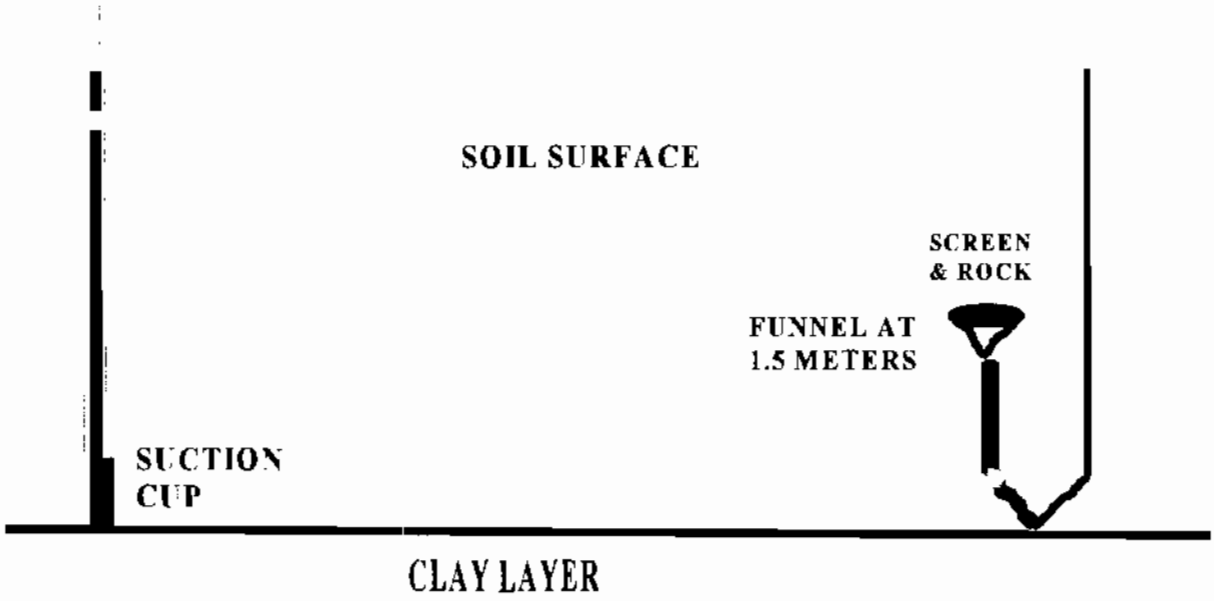
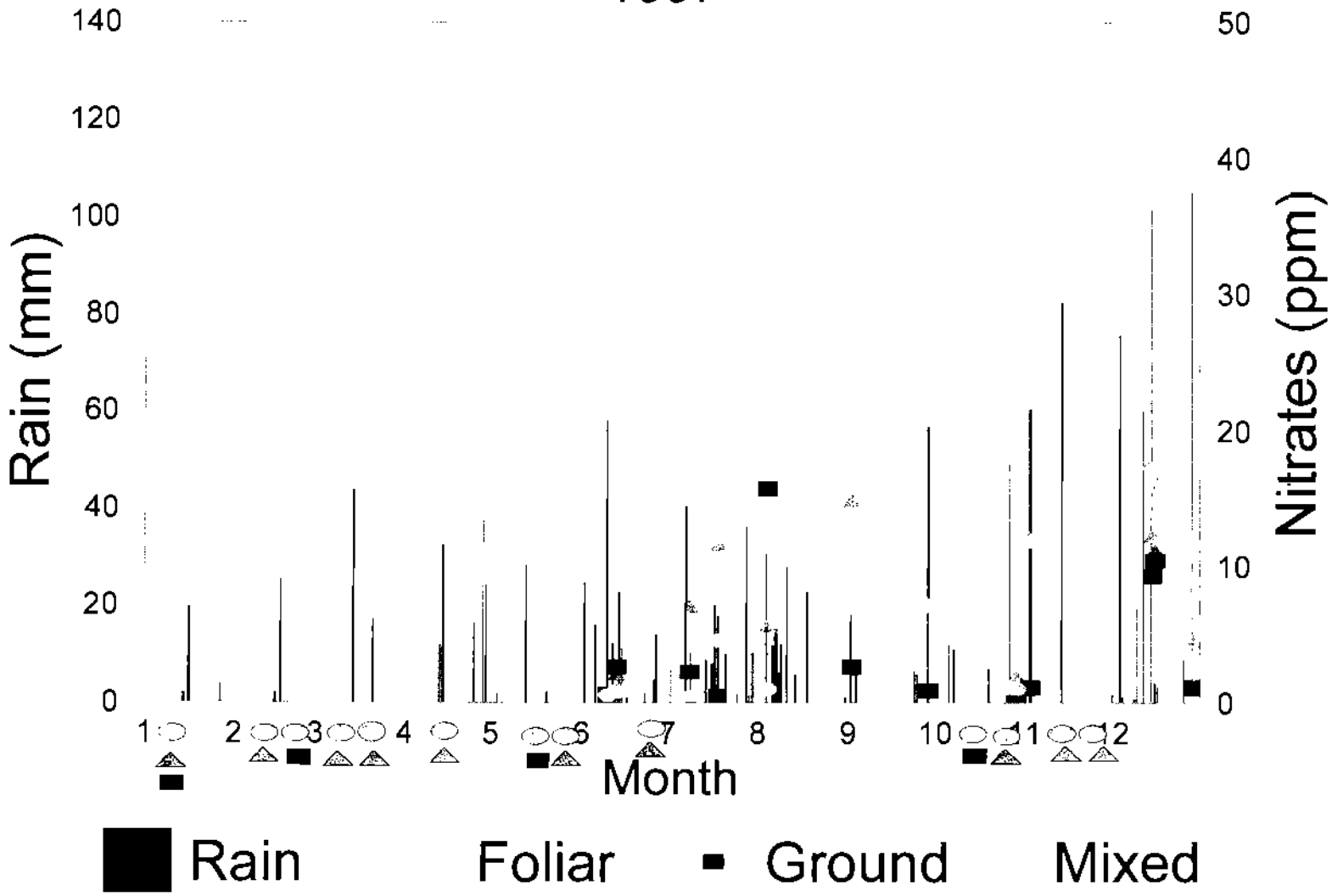


Figure 1. Ceramic cup suetion sampler and gravity feed funnel collector for rain leachate nitrate determinations.

Figure 2. Rainfall and concentrations of leached nitrates during the first year of field growth by treatment average. The time of fertilizer applications is shown below the months on the x-axis.


Block 22 Rain and Nitrates
1997
Rain (mm)
Nitrates (ppm)
140
120
100
80
60
40
20
0
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
Month
Rain
Foliar
Ground
Mixed

ACCOMPLISHMENTS IN YEAR THREE

In the third and final year of this first phase projeet. treatments were continued and water samples collected after significant rain events. The NO_3 concentration data, associated rain events and fertilization dates are presented in Figure 3. The Soil N only and to a less extent the Mixed application treatments had several events following rains were leached NO_3 exceeded 10 ppm. Unfortunately, total leached nitrates cannot be easily calculated from the ceramic cup samplers and insufficient funnel traps were installed to rely on them for both NO_3 and leached volume values.

Tree trunk calipers were measured at the end of the second season of growth and were significantly larger for the foliar than the mixed than the soil only treatments (Table 4).

Table 4. Trunk diameters at the end of 2 years of tree growth in the field.

TREATMENT	AVERAGE DIAMETER - MM*
SOIL N ONLY	29.9 A
MIXED APPLICATION	31.1 B
FOLIAR N ONLY	32.5 C

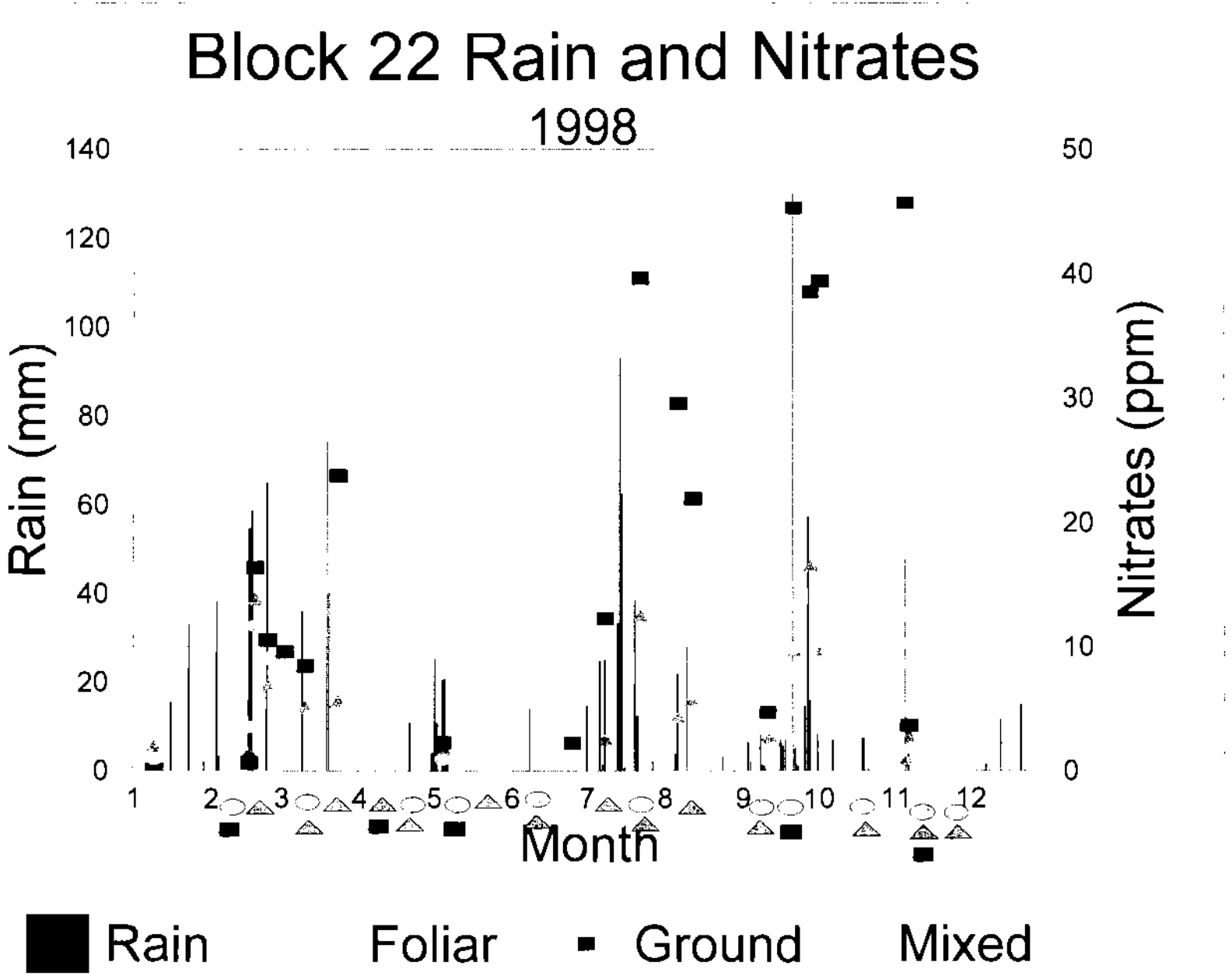
* Grapefruit trunk diameters were about 6 mm larger than the Hamlin trees.

At least three trees per plot and rootstock were sacrificed at the end of the second year's growth. Dry weights are still being determined, but a summary of leaf (areas and dry weights) are presented in Table 5. No significant treatment differenees occurred although foliar trees are larger.

Table 5. Leaf areas and dry weights per tree at the end of two years of field growth by treatment.

TREATMENT	HAMLIN LEAF AREA	GRAPEFRUIT LEAF AREA	HAMLIN DRY WEIGHT	GRAPEFRUIT DRY WEIGHT
SOIL N ONLY	4050 cm^2	5275 cm^2	345 gm	534 gm
FOLIAR N ONLY	4760	5833	426	882

Figure 3. The rainfall and leached nitrates concentrations during the second year of field growth by treatment average. The time of fertilizer applications are shown below the x-axis.


Block 22 Rain and Nitrates
1998
Rain (mm)
Nitrates (ppm)
Month
0
20
40
60
80
100
120
140
0
10
20
30
40
50
1
2
3
4
5
6
7
8
9
10
11
12
Rain
Foliar
Ground
Mixed

The fertilizer application sehedule for the 3rd year of tree growth, 4th year of study are shown in Table 6.

Generally after the first two seasons of growth, trees in the all-foliar N plots were similar in size even though much less N was applied compared to the all-soil N treatment. These initial results suggest that foliar applied N is at least as efficient for citrus tree growth as soil applied N. Elevation of leaf N by foliar urea in other studies supports this conclusion also.

However, economically, it would not be feasible to make 10 to 14 spray per year to apply foliar N as urea during early tree growth. Leached NO_3 values being larger for the soil only N fertilizer do suggest some benefit from using foliar applications. The fertilizer schedules planned for the third year of growth as shown in Table 6 would reach almost ½ pound of N per tree or nearly 80 lbs of N/acre/year. The following year would be in excess of 150 lbs N/acre/year for the all-soil N treatment. Tree canopies are getting large enough that over .08 lbs of N as urea can be applied per tree per application. Five sprays will deliver over .4 lbs of N/tree/year next year .

Weed decomposition still appears to be the probably source of NO_3 spikes in leached water during the first year of tree growth. Some work on this has been proposed for additional studies. Timing of herbicide applications to minimize available N from decomposing weeds may reduce leached N.

EXPENDITURES IN YEAR 3 OF GRANT

Category	Budgeted		Expended
OCO	0		0
Operating Expenses	2,500		2,500
Personnel Services	12,500		12,500
In-State Travel	50		50
		Overhead	752.5
		Total to date	$15802.50

Table 6. PROPOSED FERTILIZER SCHEDULES FOR 3RD YEAR OF GROWTH

Blk 22 Spray Scheldule for 1999

App #	Date	Amount Urea (lbs)	lbs N/tree/year	Water	BLOCKS	Completion
1	27-Jan	51	0.45	150	Mix and Foliar	
2	17-Feb	38	0.45	100	Foliar	
3	10-Mar	51	0.45	150	Mix and Foliar	
4	31-Mar	38	0.45	100	Foliar	
5	21-Apr	51	0.45	150	Mix and Foliar	
6	12-May	38	0.45	100	Foliar	
7	2-Jun	64	0.5	150	Mix and Foliar	
8	23-Jun	43	0.5	100	Foliar	
9	14-Jul	64	0.5	150	Mix and Foliar	
10	4-Aug	43	0.5	100	Foliar	
11	25-Aug	70.5	0.55	150	Mix and Foliar	
12	15-Sep	47	0.55	100	Foliar	
13	6-Oct	70.5	0.55	150	Mix and Foliar	
14	27-Oct	47	0.55	100	Foliar	
15	17-Nov	76.5	0.6	150	Mix and Foliar	
16	8-Dec	51	0.6	100	Foliar	

1	3-Feb	1.5 lbs/tree	0.6		Ground	
		1.25	0.6		Mix	
2	24-Mar	1.5 lbs/tree	0.6		Ground	
3	19-May	1.5 lbs/tree	0.6		Ground	
		1.25	0.6		Mix	
4	8-Sep	1.5 lbs/tree	0.6		Ground	
5	10-Nov	1.5 lbs/tree	0.6		Ground	
		1.25	0.6		Mix	