NITROGEN FERTIGATION OF YOUNG PRUNE TREES AND EFFECTS ON HORTICULTURAL PERFORMANCE

Steve Southwick, Bruce Lampinen, Ted DeJong, Ken Shackel,
Jim Yeager, and Al Bonin

Introduction:

Although there has been a great deal of research with regard to nitrogen fertility in fruit trees fewer experiments have been conducted with young trees. Generally, it is contended that young fruit trees should be handled in ways that foster the rapid filling of allotted space in the orchard planting. In many instances, to achieve those goals growers irrigate frequently and apply nitrogen fertilizers to enhance the vegetative growth on young trees. Young trees have limited root systems and as a result this frequent irrigation and fertilization insures that trees get off to a good start. However, because of these actions and young tree root distribution characteristics it is likely that significant amounts of water are wasted and nitrogen fertilizers are not efficiently utilized by the tree even though they may be applied to limited soil areas. We know there are many alternatives available to growers when trying to establish an orchard, but no concerted effort has been put forth to develop research based information that would help to make better nitrogen fertilization decisions when developing a prune orchard. It is our intent through these experiments to develop information that should help prune growers make better decisions with regard to nitrogen fertilization of young prune orchards and to demonstrate that techniques and technologies are available today to address some of the public concerns over excessive use of nitrogen in fruit production.

Objectives:

1. To determine if frequent application of nitrogen through fertigation during the growing season can lead to improved tree growth and productivity while minimizing the excessive use of nitrogen fertilizer.

2. To evaluate leaf analyses as an indicator of whether nitrogen should be applied to young trees and to measure the impact of that strategy on prune tree productivity.

3. To work toward the development of a nitrogen budget (N inputs and losses) approach for managing N fertilization of prune orchards.

4. To assess buried drip irrigation as a potentially high-efficiency alternative to above-ground drip irrigation.

Materials and methods:

Experimental

A 9 acre block of prune trees was planted in Winters, CA in February 1991. Trees were planted at distances of 17 feet between rows and 14 feet between trees. A drip irrigation system was installed and equipped to conduct fertigation experiments. Two, 1 gal/hour drip emitters were installed per tree. All treatments received similar amounts of water and fertilizer nutrients other than nitrogen. The nitrogen treatments in 1992 were as follows:

Treatments

1. No applied nitrogen (N) control.

2. Frequent N (Urea, UN 32) application at low rates at monthly intervals through the growing season (April, May, June, July, August, September) via fertigation.

   Rates:
   a. 1.0 lbs N/tree/year
   b. 0.5 lbs N/tree/year
   c. 0.25 lbs N/tree/year

3. N applied at a rate of 0.25 lbs N/tree/year via fertigation after leaf analyses in July indicates whether or not leaf N is below or above 2.3%. If above 2.3%, no N is applied. If deficient, N is applied in July, August, and September to equal 0.25 lbs N/tree/year.

4. Buried drip irrigation with continuous, low level nutrient injection (N, P), using an automated evaporation pan to estimate tree water requirements on an hourly basis.

Treatments were arranged in a randomized complete block design where 4 blocks of 24 rows per block were randomized so that 4 rows per block were assigned to each of 6 treatments. The 2 center rows of each treatment replication were used for measurement while the adjacent rows (one on either side) were used as guard trees.

Tree Growth and Nutrient Content Measurements

The 1991 season was utilized to initialize the experiment. No fertilizer was applied during the season so that experiments began in 1992 with less interference from residual fertility. At the time of planting, February 1991, 3 random trees were selected from the population and they were separated into roots, rootstock, trunk, and branches. They were dried, ground and ashed and dry weights and nitrogen contents of those parts were determined. Near the end of the growing season, mid October 1991, 3 randomly selected trees were also removed from the orchard. Again, trees were separated into roots, rootstock, trunk, branches and leaves and analyses were performed as above. Trunk measurements indicative of tree growth were made 7 February 1992 on all orchard trees. Trunk growth measurements were again made on 4 trees per replicate at the same locations where soil samples were taken 23 September 1992.

Soil Sampling

Soil samples were taken every foot from 1 to 5 foot depths in July 1991 throughout the orchard to identify high or low nitrate nitrogen areas. In April 9-15, 1992, soil samples were taken at random from each replicate. At each collection site, samples were taken at 0-1, 1-2, 2-3, 3-4, 4-5 feet deep from an area within 1 foot of an emitter. Additionally, in block 3, samples were taken at 5-6, 6-7, and 7-8 feet deep. These same locations will be utilized in future sampling. All sampling was done with an Oakdale tube. Samples were stored on ice in a chest before transport to an oven and dried at 70 C for approximately 1 week. Samples were analyzed for NO_3-N, NH_4-N and total N.

Leaf sampling

Fifty leaves per replication were randomly sampled from varying tree canopy positions 28 July 1992. Nutrient analyses were performed by DANR analytical lab at Davis.

Fertilizer

Nitrogen fertilizer was applied to the 3 frequent N fertigation treatments as UN32 (urea) by injection into the drip irrigation system on a weekly basis starting on 29 April 1992 and continued for 20 weeks (1/20th of the total treatment amount for each week). No other fertilizers were added to the other 3 treatments.

Irrigation Water

Irrigation water was applied on a weekly basis according to ET estimated from Davis and Zamora CIMIS data. From April to May, water was applied at 20% ET and then it increased through the year to adjust for the increasing canopy size of the young trees. Trunk water potential measurements were made periodically to verify that irrigation schedules were adequate to maintain the trees in a well-irrigated condition through the growing season.

Results and Discussion

Soil samples of 1991 indicated that there were no measured sites having unusually high or low levels of NO_3-N, NH_4-N or total N (data not shown). Tree trunk cross sectional areas were not different among treatments after the first season of growth (data not shown). Soil samples taken at various depths in 1992 indicated some N variability among the experimental treatments. Soil NO_3-N did not differ as a function of treatment when samples were collected at varying depths in April 1992 before treatment, but variability was found (Figure 1). Continued sampling at these same orchard locations over a period of time should help to delineate treatment effects on soil NO_3-N levels as a function of depth.

Nitrogen (N), potassium (K), zinc (Zn) and manganese (Mn) were compared among tree parts at planting and near the end of the first growing season. Bare root trees at February planting 1991 contained most N in roots (Table 1) on a N per cent dry weight basis, but overall the highest amount of N was found in the trunk. Leaves were harvested from trees in October, 1991 and the highest N concentrations were found in them. Leaves had the highest amounts of total N and trees had an average of about 10 to 11 g of total N (about 1/45th of a pound of N per tree). The increase in N per tree in one growing season was about 7 to 8 g N per tree. Similar analyses on the other elements were made and K, Zn and Mn (Table 2). The quantities of Zn and Mn accumulated in these trees was much lower than those for N and K.

The highest treatment level of urea-N applied (1 lb/tree per year) did not increase tree growth in 1992 (Table 3). Buried drip treated trees grew less than standard drip irrigated trees. The cause of growth reduction of buried drip treated trees is not clear, but we suspect those trees were under slightly more water stress early in the season as compared to other treatment trees. Data from tables 1-3 suggest that the amount of N in the irrigation water (<0.1 ppm), rainfall or derived through soil mineralization was satisfactory to meet the modest N needs of these young trees (grams of N per tree).

Leaf nutrient concentrations measured in July sampled leaves indicated that no other nutrient deficiencies were present (P, K, Mn, Mg, Zn, Cu, S, Ca, data not shown). Additional analyses over a period of years should help to determine if these nutrients are altered by increased amounts of applied N. Leaf N concentrations were higher in urea treated trees than in the <2,3% and buried drip treatment leaves (Figure 2). However, at the time of the September measurement, tree growth was not improved by 1.0 lb per tree urea-N.

In summary, our data suggest that increased N fertigation from urea-N sources did not improve the growth of these drip irrigated trees during the 2nd leaf. The total amount of N in trees after one growing season was 10 to 11 g. Most of the required N apparently was supplied by rainfall, irrigation water N, or from soil mineralized N and that amount supported the growth of these well irrigated trees.

Table 1. Dry weight and nitrogen content of French prune tree parts at planting and near the end of the first growing season.

Sample Date	Tree Part (n = 3)	Dry weight (g)	N (%)	Total N (g)
3/28/91+	Branches	32.2 C[z]	1.08 B	.35 D
	Trunk	125.3 A	0.79 C	.98 A
	Rootstock	49.9 B	1.07 B	.53 C
	Roots	39.6 BC	2.14 A	.84 B
10/17/91	Leaves	148.0 BC	2.77 A	4.32 A
	Branches	264.0 AB	0.91 C	2.02 B
	Trunk	280.7 A	0.55 C	1.41 B
	Rootstock	150.7 BC	0.79 C	1.10 B
	Roots	137.3 C	1.79 B	2.32 AB

+Three trees were sampled at March planting and October 1991.
[z]@ 5%, DMRT.

Table 2. Mineral content of French prune tree parts near the end of the first growing season.

Tree part (n = 3) 10/17/91	K (%)	Total K (g)	Zn (ppm)	Total Zn (mg)	Mn (ppm)	Total Mn (mg)
Leaves	2.33[z] A	3.66 A	22.00 A	3.33	130.00 A	18.72 A
Branches	0.52 B	1.20 B	10.33 AB	2.22	20.67 C	4.95 B
Trunk	0.31 B	0.86 B	7.67 B	2.26	13.33 D	3.42 B
Rootstock	0.34 B	0.66 B	16.00 AB	3.00	18.67 CD	2.78 B
Roots	0.48 B	0.51 B	16.33 AB	2.00 NS	37.00 B	5.15 B

[z]@ 5%, DMRT.

Table 3. Effect of nitrogen fertigation and buried drip irrigation on prune tree growth in 1992.

Treatment	TCSA (cm^2)
Control No N	21.0[z] AB
1 lb N/tree	22.1 A
Buried Drip 0.14 lb N/tree + 0.10 lb P/tree	18.6 B

[z]DMRT @ 5%.

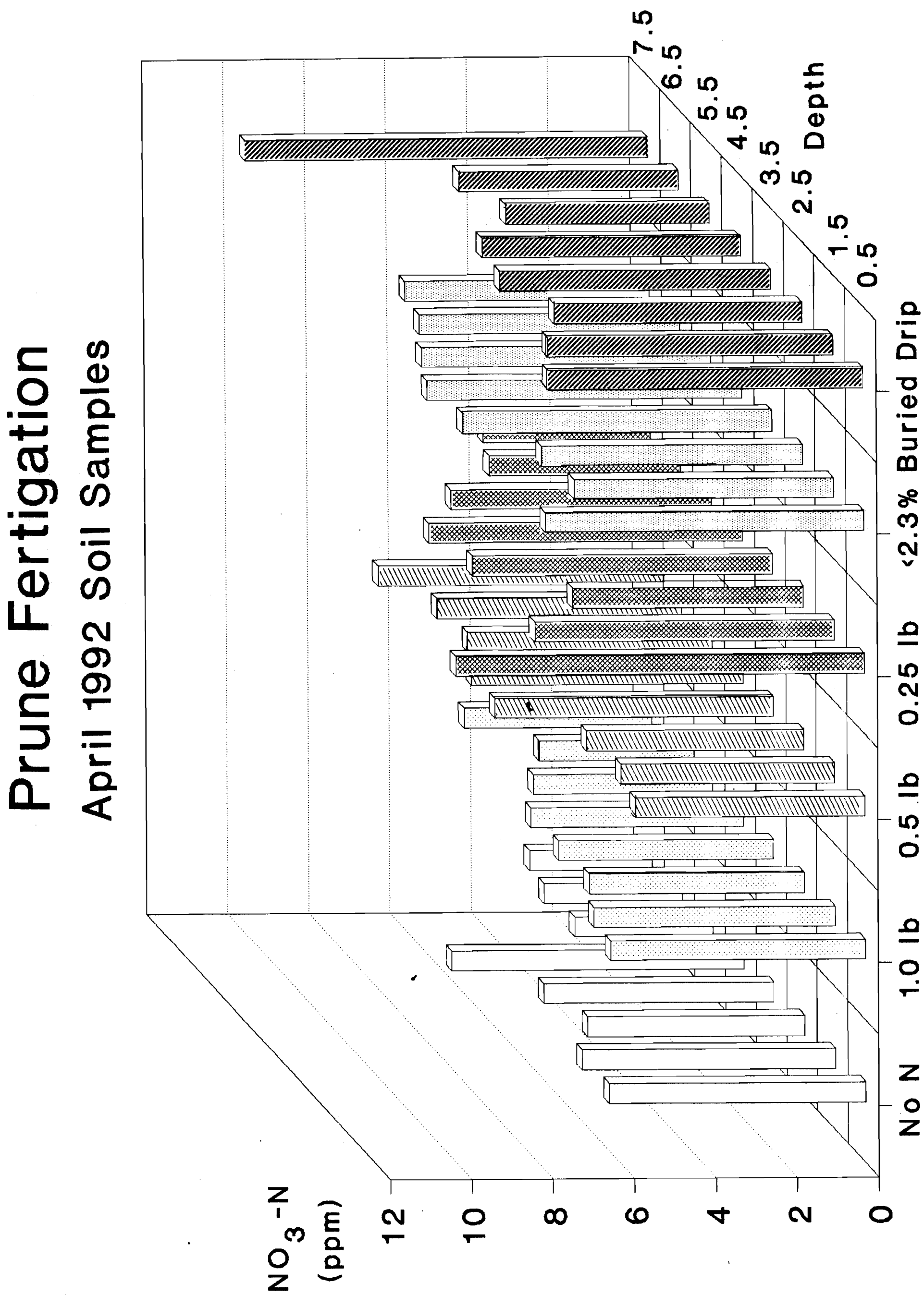
Prune Fertigation
April 1992 Soil Samples
NO_3-N (ppm)
12
10
8
6
4
2
0
No N
1.0 lb
0.5 lb
0.25 lb
‹2.3% Buried Drip
Treatments
Depth
0.5
1.5
2.5
3.5
4.5
5.5
6.5
7.5

Fig. 1

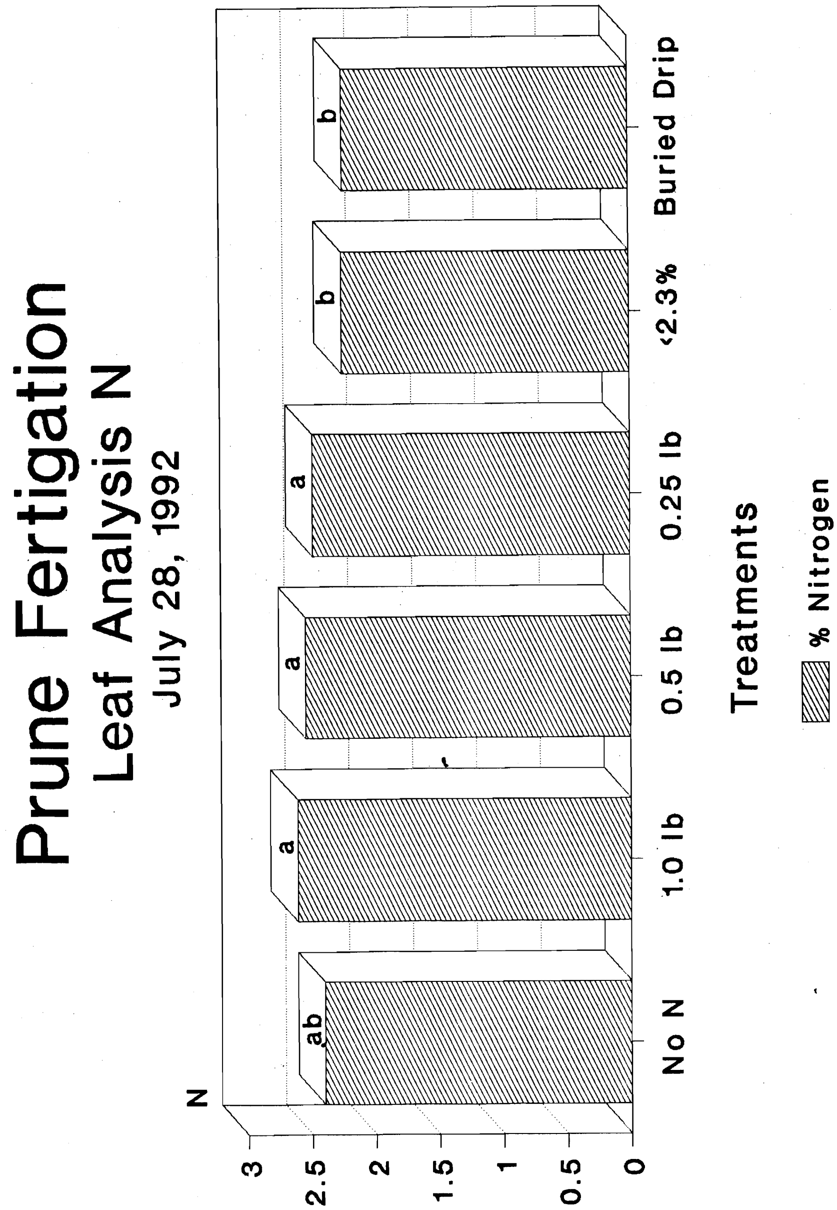
Prune Fertigation
Leaf Analysis N
July 28, 1992
N
3
2.5
2
1.5
1
0.5
0
ab
a
a
a
b
b
No N
1.0 lb
0.5 lb
0.25 lb
<2.3%
Buried Drip
Treatments
% Nitrogen

Fig. 2