Improving Pomegranate Fertigation and Nitrogen Use Efficiency with Drip Irrigation

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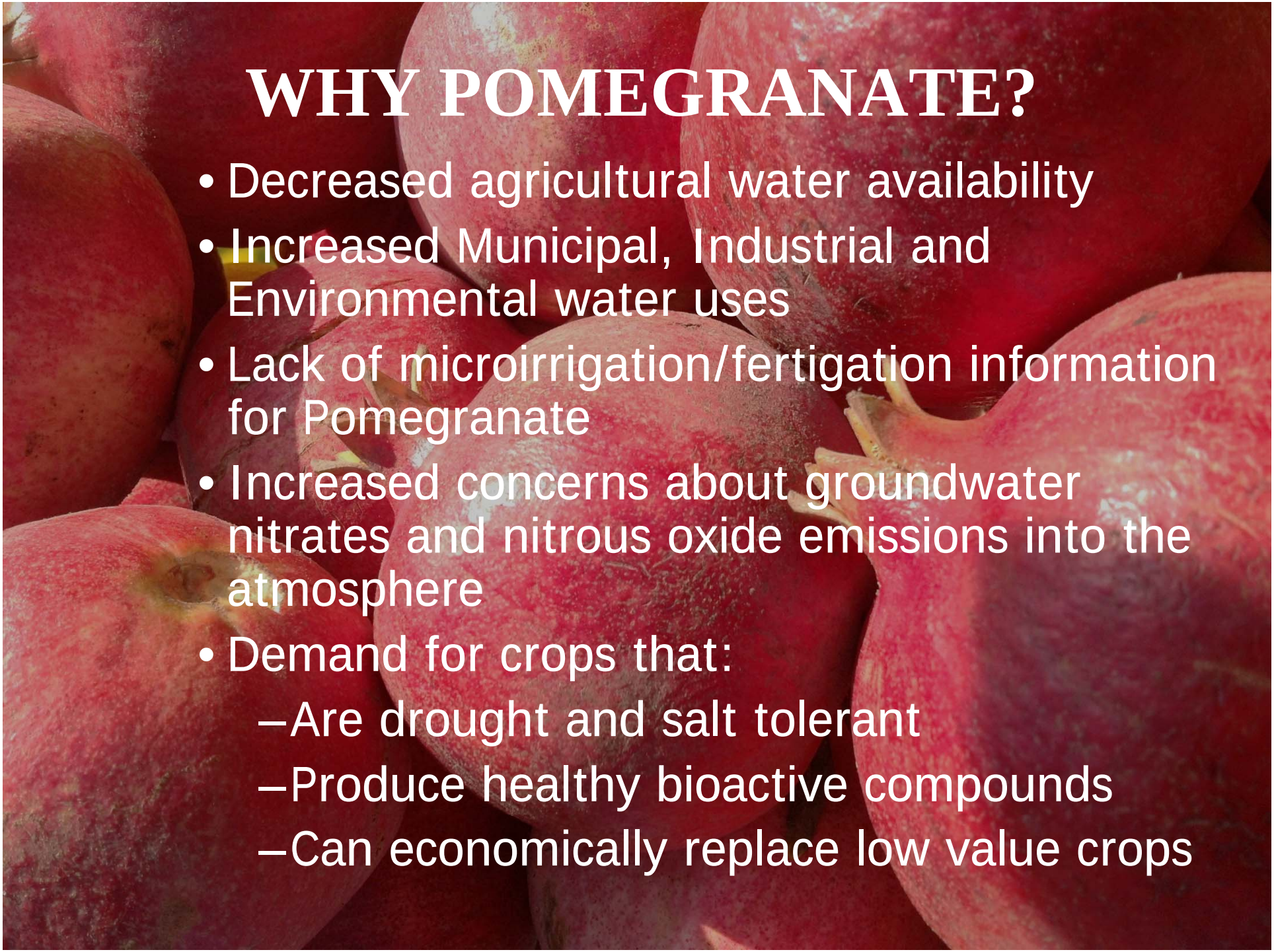


WHY POMEGRANATE?

- Decreased agricultural water availability
- Increased Municipal, Industrial and Environmental water uses
- Lack of microirrigation/fertigation information for Pomegranate
- Increased concerns about groundwater nitrates and nitrous oxide emissions into the atmosphere
- Demand for crops that:
  - Are drought and salt tolerant
  - Produce healthy bioactive compounds
  - Can economically replace low value crops

Objectives

Determine seasonal water and N requirements of DI and SDI young and maturing pomegranate

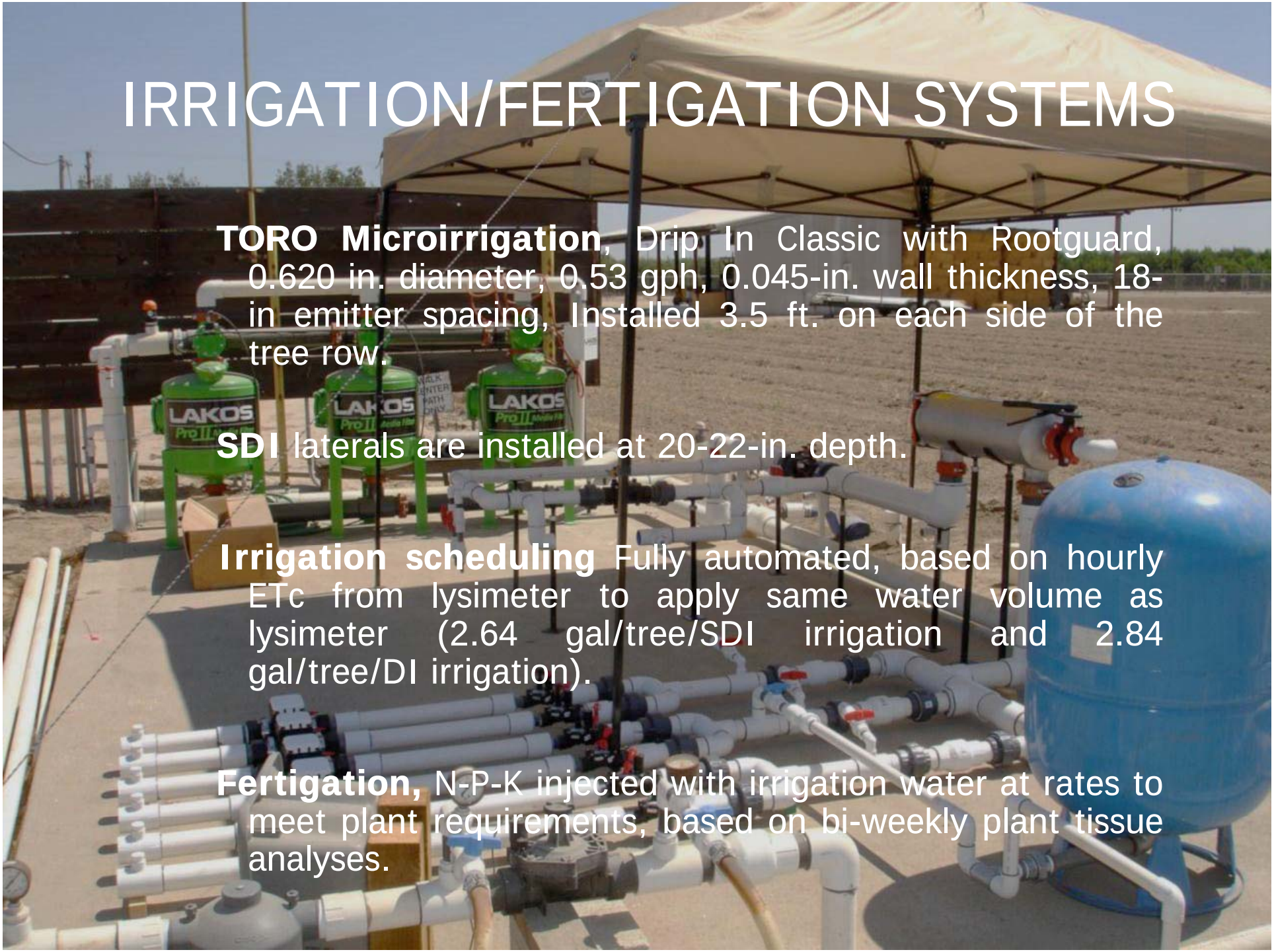
Determine effect of 3 N levels on maintaining adequate N level range in maturing pomegranate

Determine the effects of continuous N injection with DI and SDI on minimizing N leaching losses and nitrous oxide emissions

Develop grower-friendly N-fertigation management tools

Determine effect of N management on macro, micro nutrients and healthy bioactive compounds in fruit and juice

IRRIGATION/FERTIGATION SYSTEMS



TORO Microirrigation, Drip In Classic with Rootguard, 0.620 in. diameter, 0.53 gph, 0.045-in. wall thickness, 18-in emitter spacing, Installed 3.5 ft. on each side of the tree row.

SDI laterals are installed at 20-22-in. depth.

Irrigation scheduling Fully automated, based on hourly ETc from lysimeter to apply same water volume as lysimeter (2.64 gal/tree/SDI irrigation and 2.84 gal/tree/DI irrigation).

Fertigation, N-P-K injected with irrigation water at rates to meet plant requirements, based on bi-weekly plant tissue analyses.

Orchard Layout & Design

Irrigation Treatments

Subsurface-SDI

Surface Drip-DI

Nitrogen Treatments

N-1 50% N

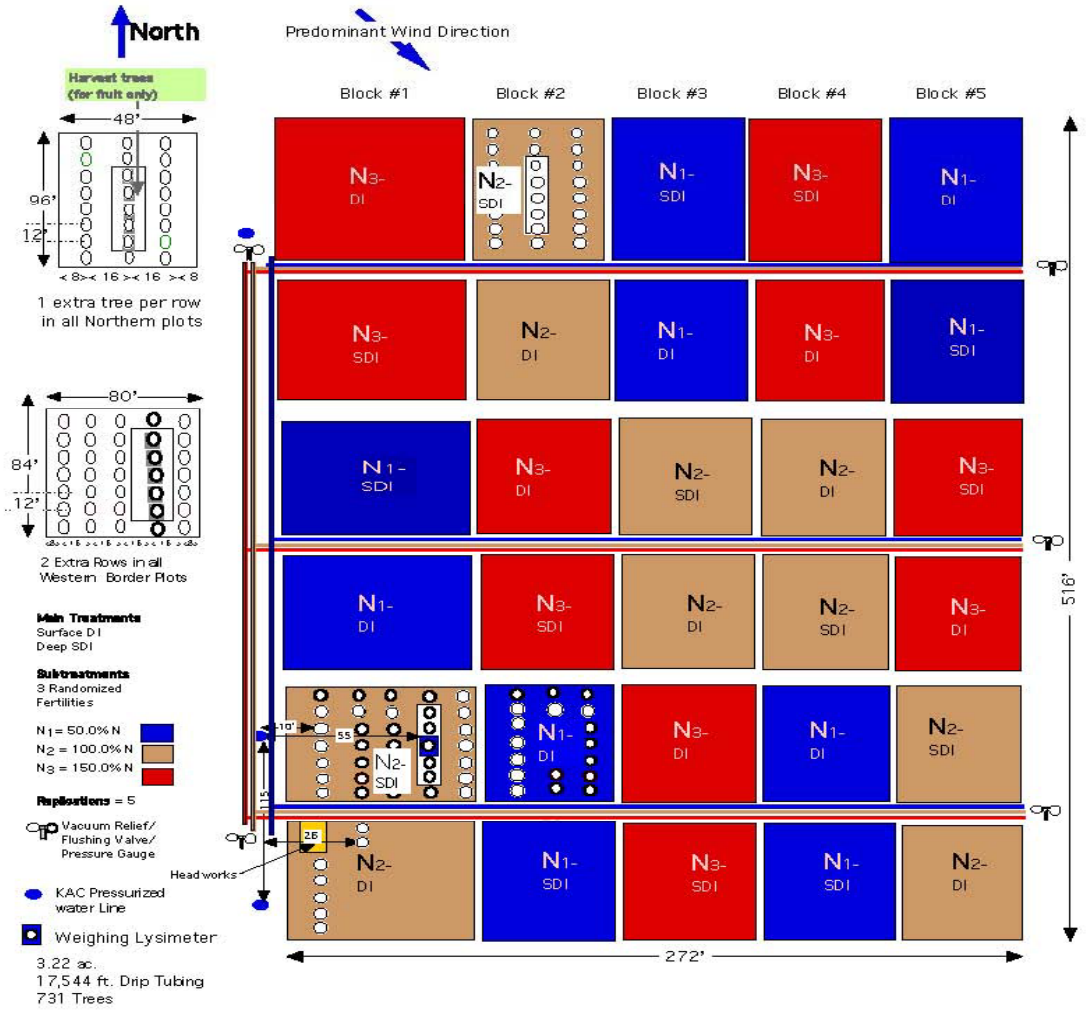
N-2 100% N

N-3 150% N

Five Replications

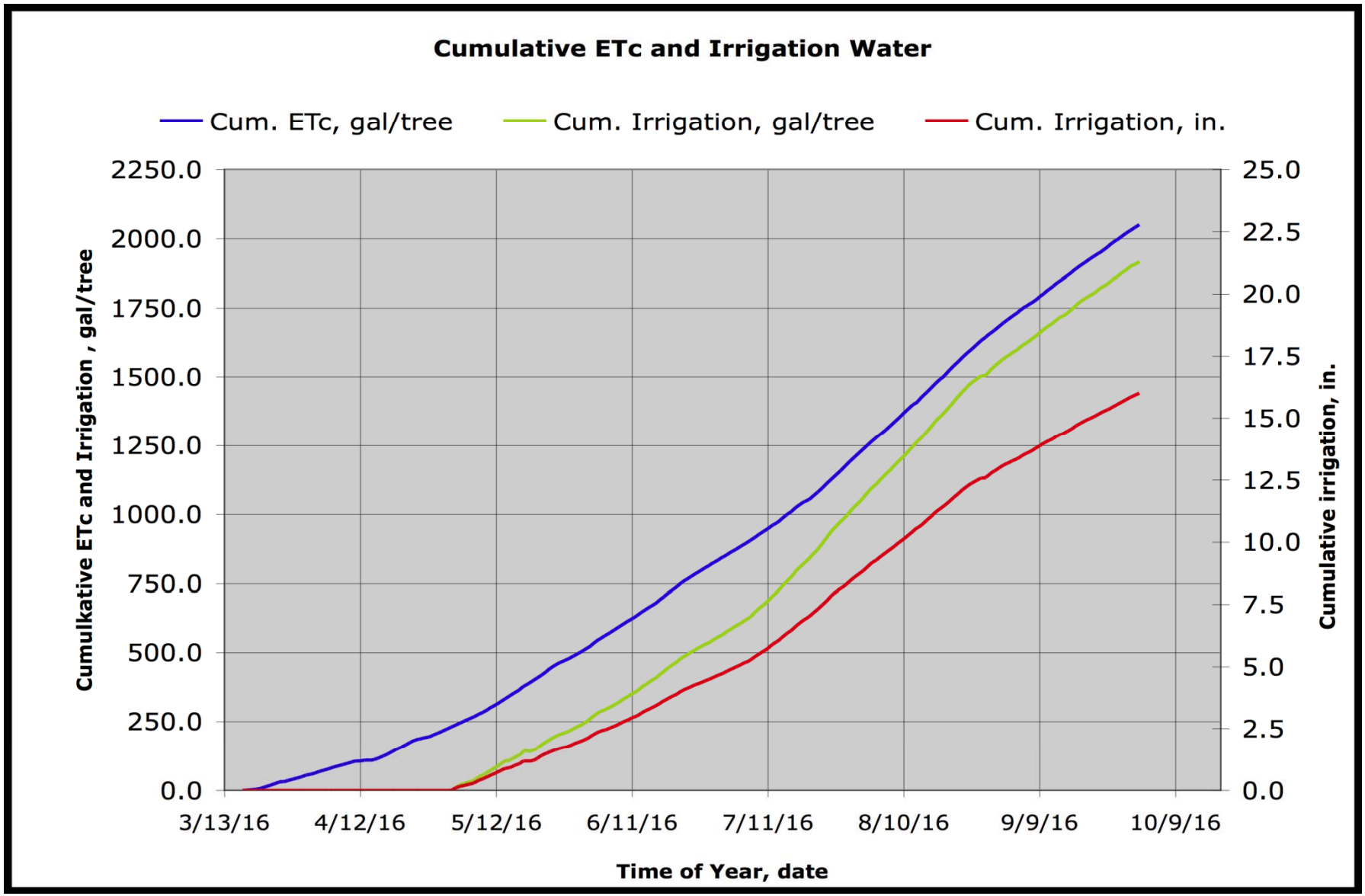
3.54 acres

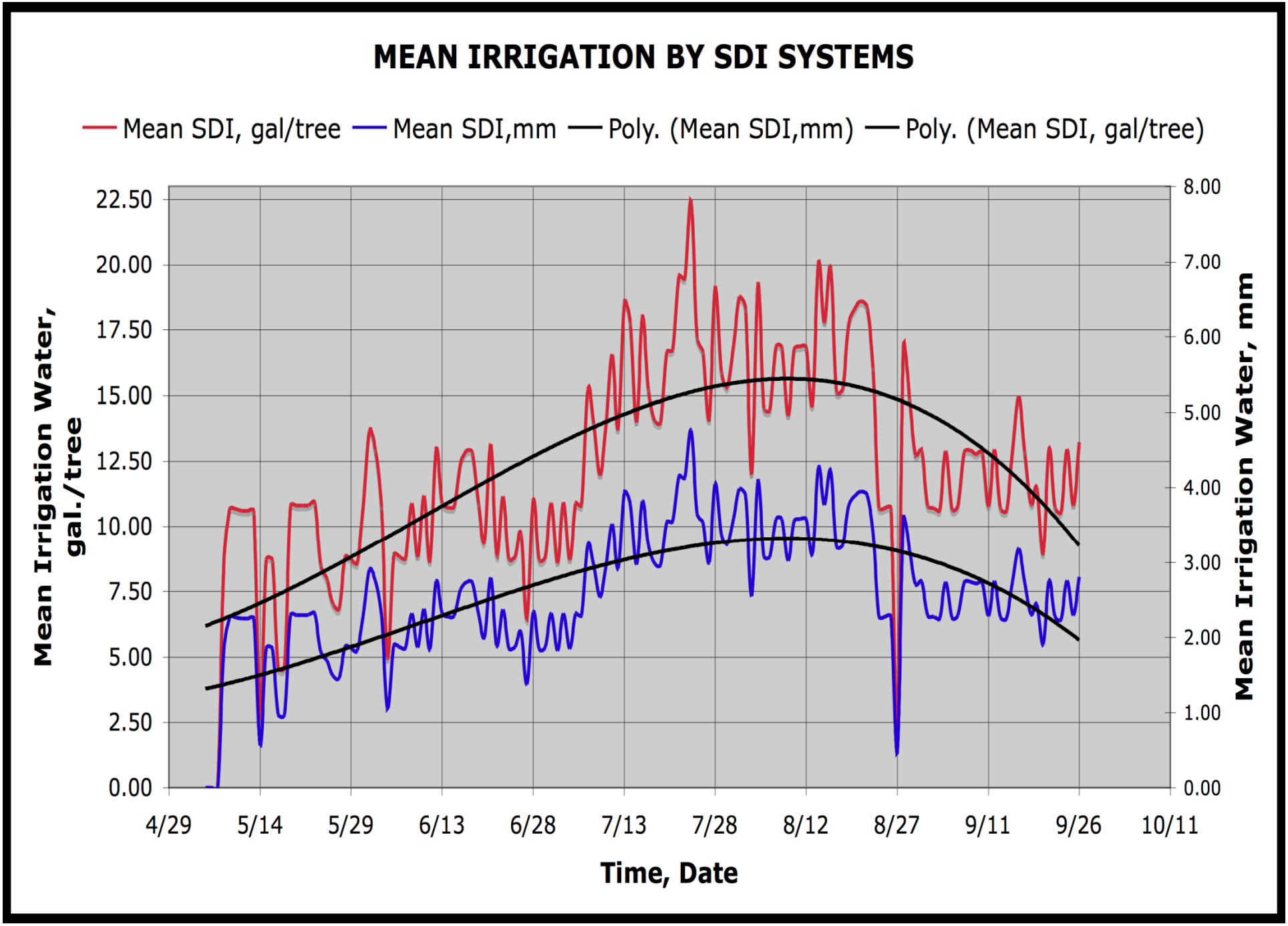
16 x 12 ft. tree spacing



Randomized Complete Block Design with subsamples

EVAPOTRANSPIRATION AND IRRIGATION APPLIED-- R. C. Phene




MEAN IRRIGATION BY SDI SYSTEMS
Mean SDI, gal/tree
Mean SDI,mm
Poly. (Mean SDI,mm)
Poly. (Mean SDI, gal/tree)
Mean Irrigation Water, gal./tree
Mean Irrigation Water, mm
22.50
20.00
17.50
15.00
12.50
10.00
7.50
5.00
2.50
0.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
4/29
5/14
5/29
6/13
6/28
7/13
7/28
8/12
8/27
9/11
9/26
10/11
Time, Date

FERTILIZER APPLIED (May 10-Sept. 26)

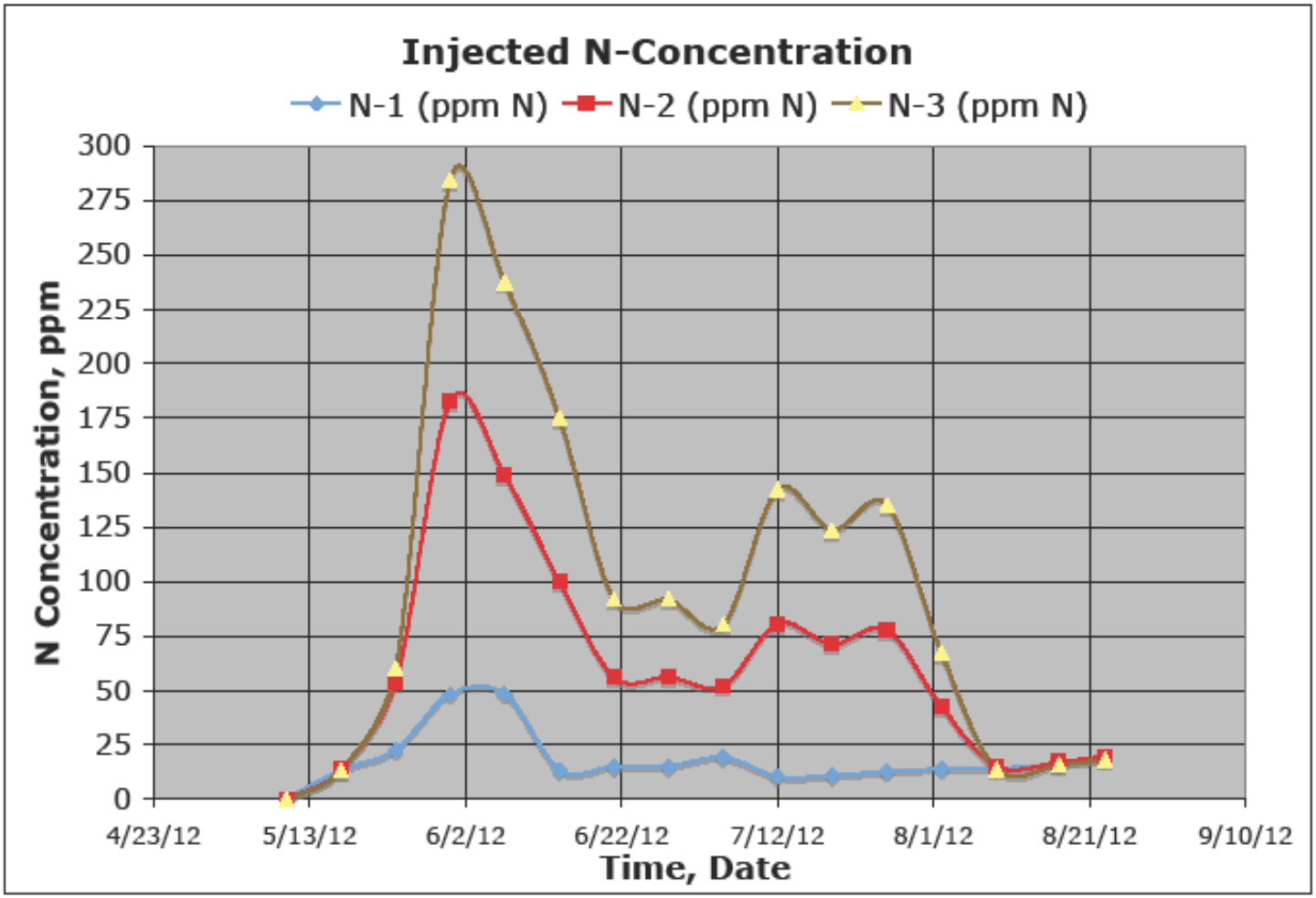
R. SCHONEMAN & C. J. PHENE

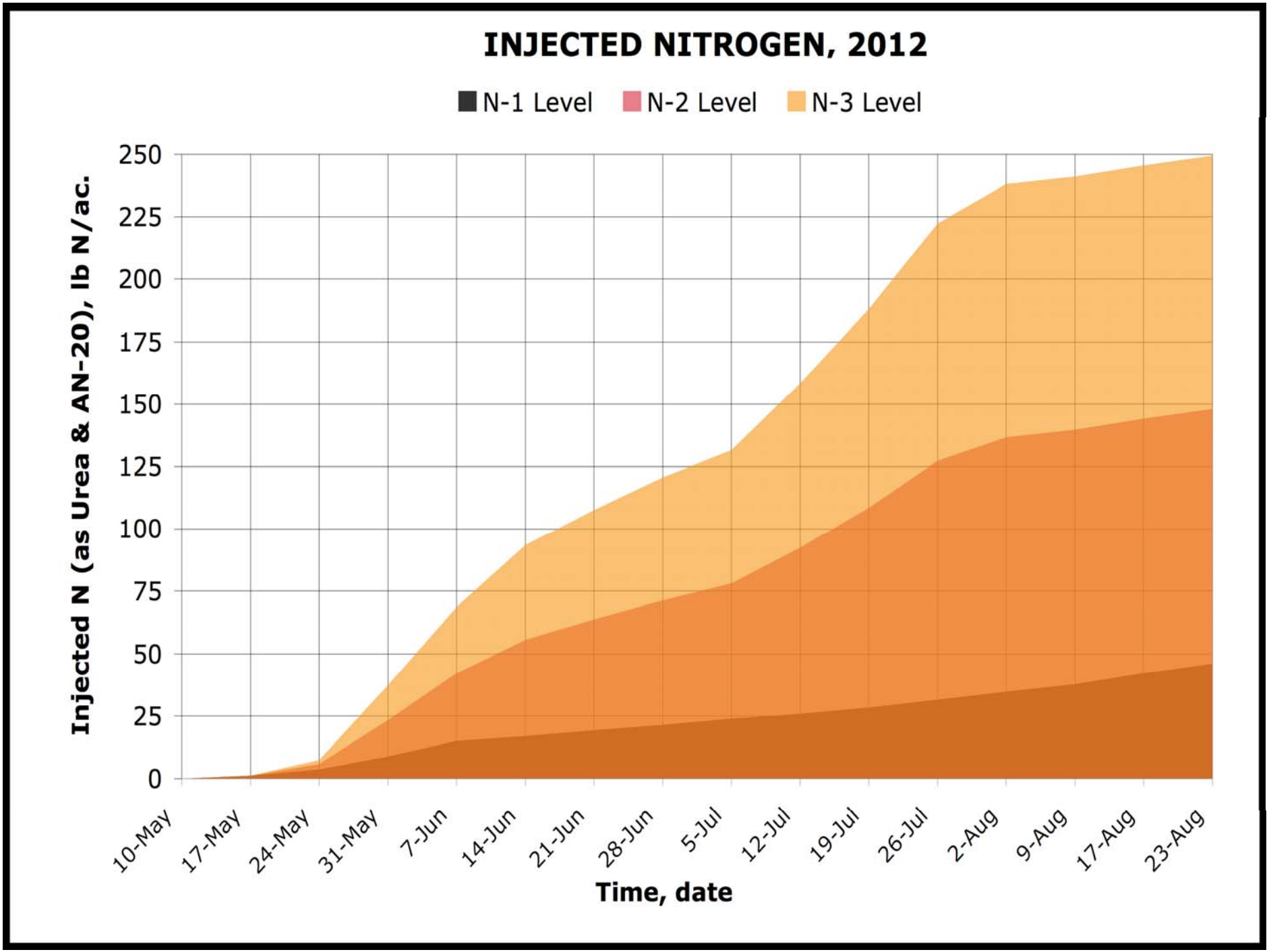
- N-pHURIC: 45.9 lb N/ac to maintain water pH between 6 and 6.5.

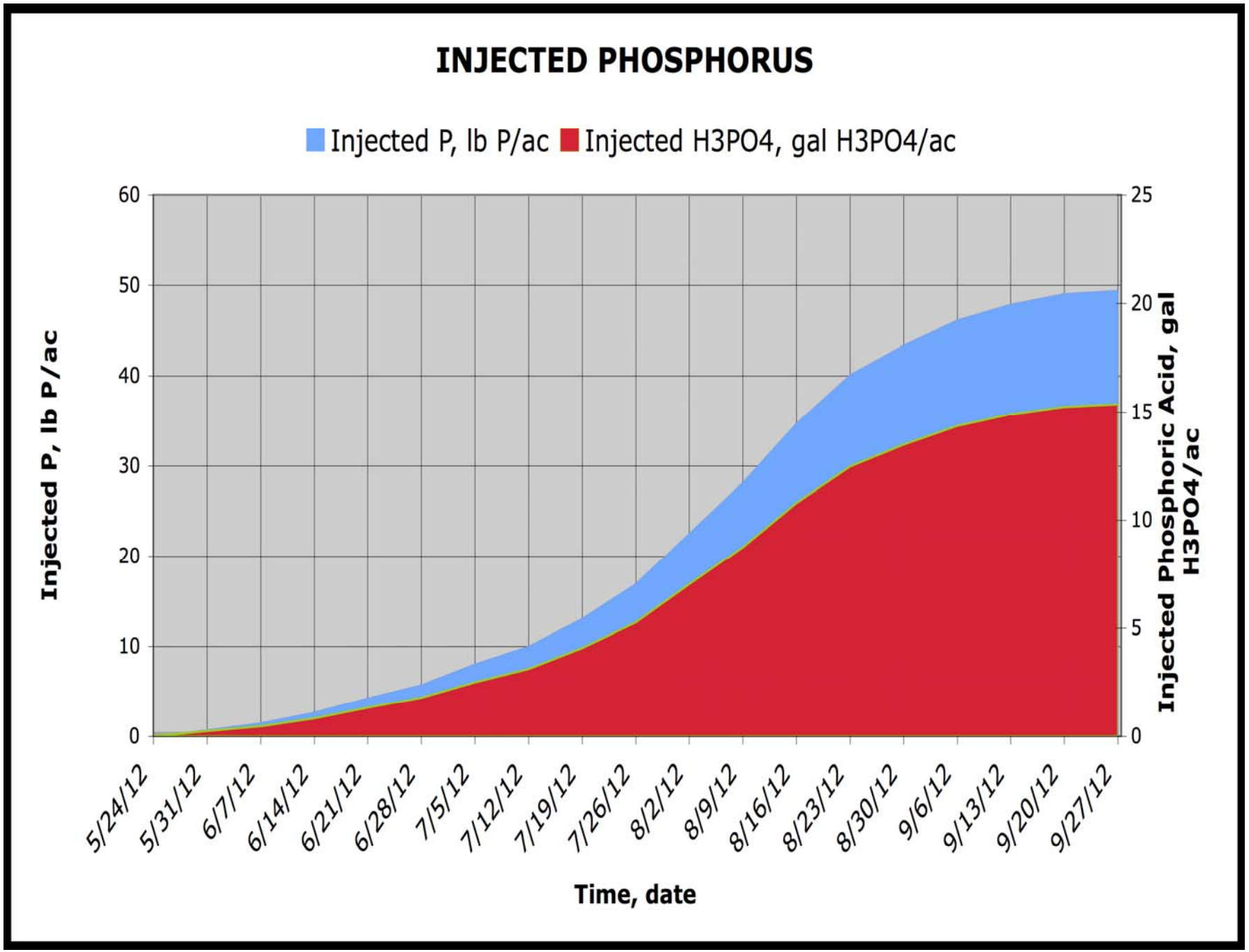
- --N1 treatment 45.9 lb N/ac as N-pHURIC.
- --N2 treatment 45.9 lb N/ac as N-pHURIC + 102 lb N/ac as AN-20.
- --N3 treatment 45.9 lb N/ac as N-pHURIC+ 203 lb N/ac as AN-20.

- Phosphoric Acid: 49.5 lb P/ac.

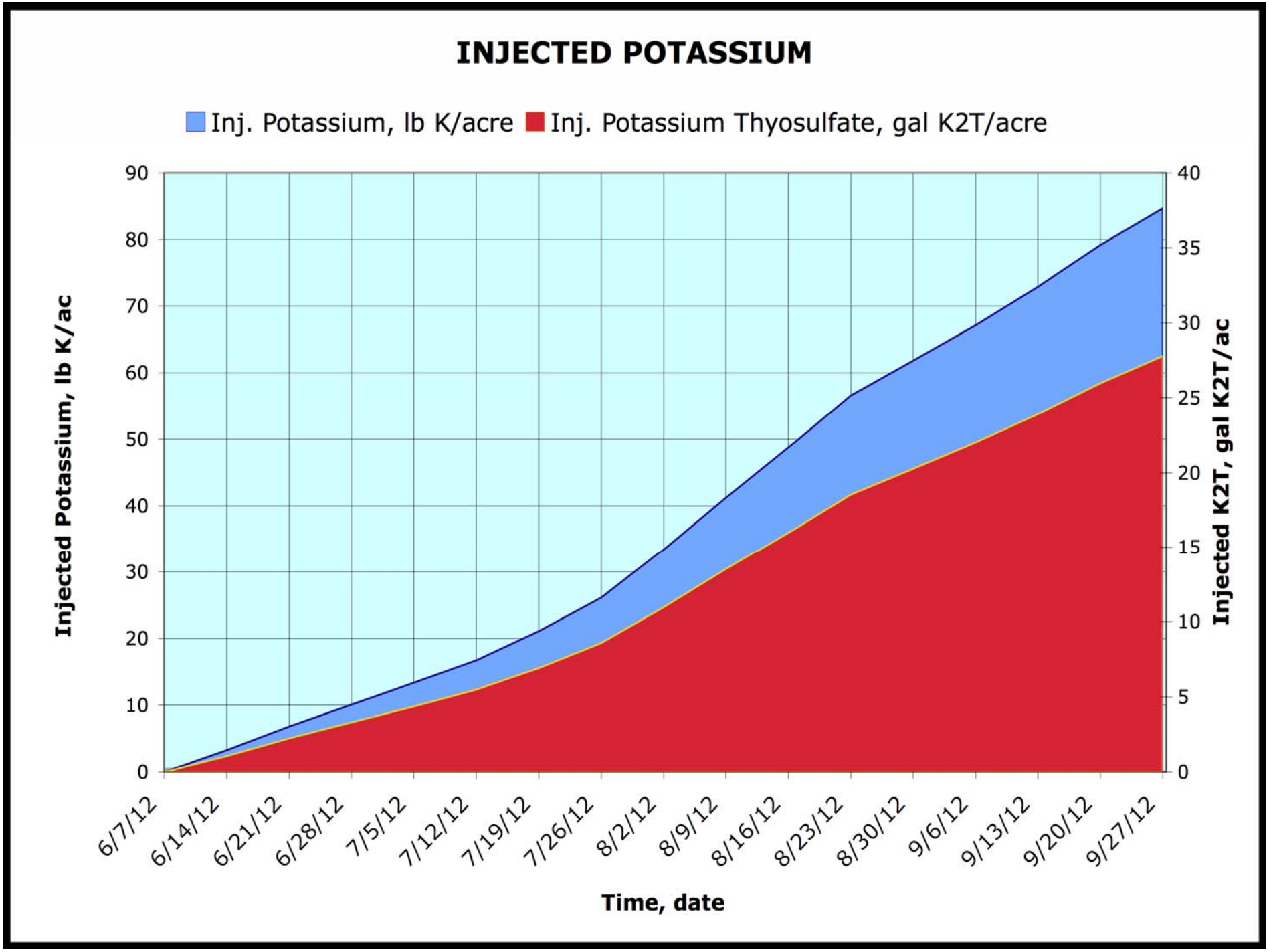
- Potassium Thyosulfate (K_2T) 84.7 lb K/ac.

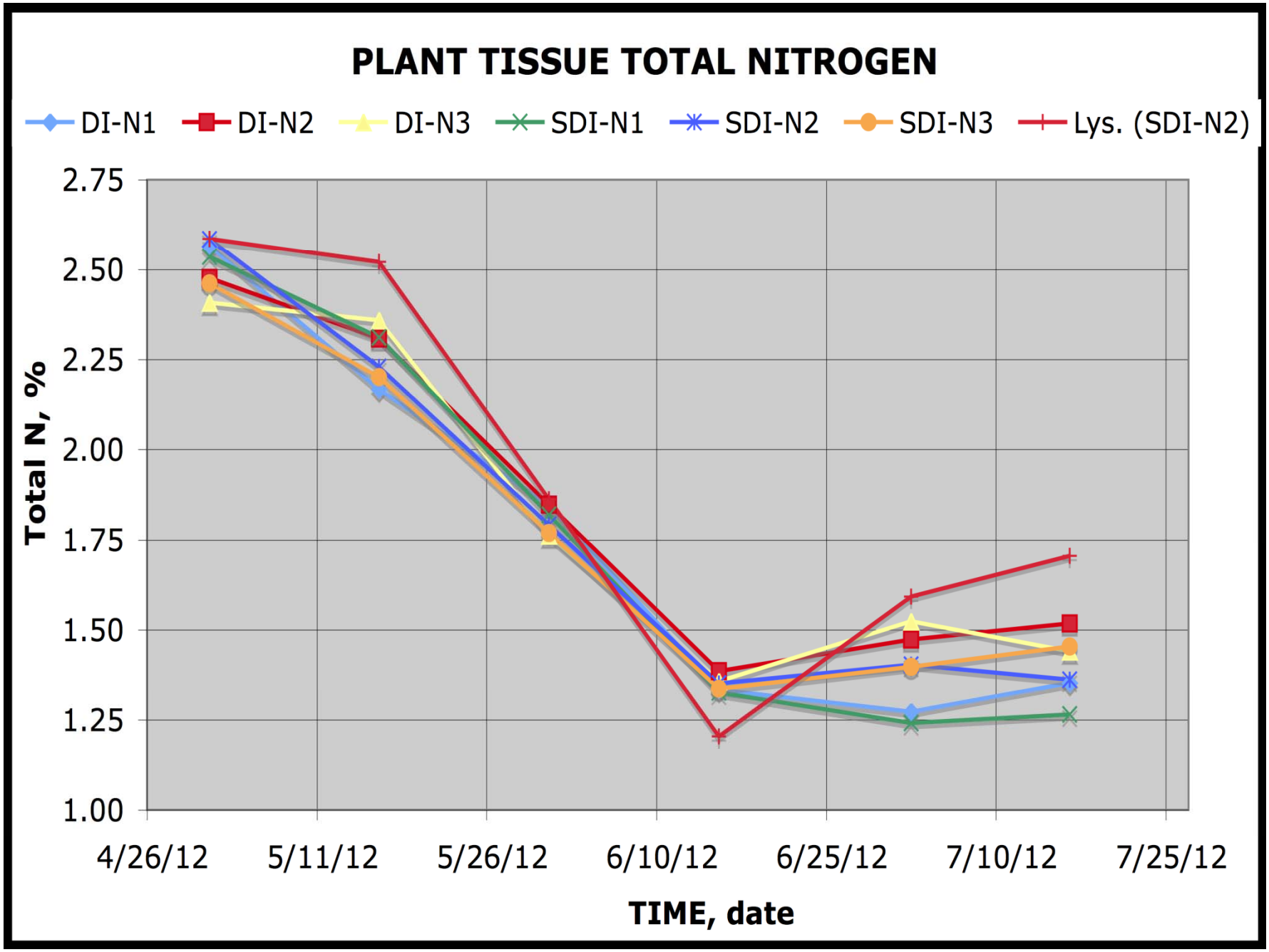

Injected N-Concentration
N-1 (ppm N)
N-2 (ppm N)
N-3 (ppm N)
N Concentration, ppm
300
275
250
225
200
175
150
125
100
75
50
25
0
4/23/12
5/13/12
6/2/12
6/22/12
7/12/12
8/1/12
8/21/12
9/10/12
Time, Date

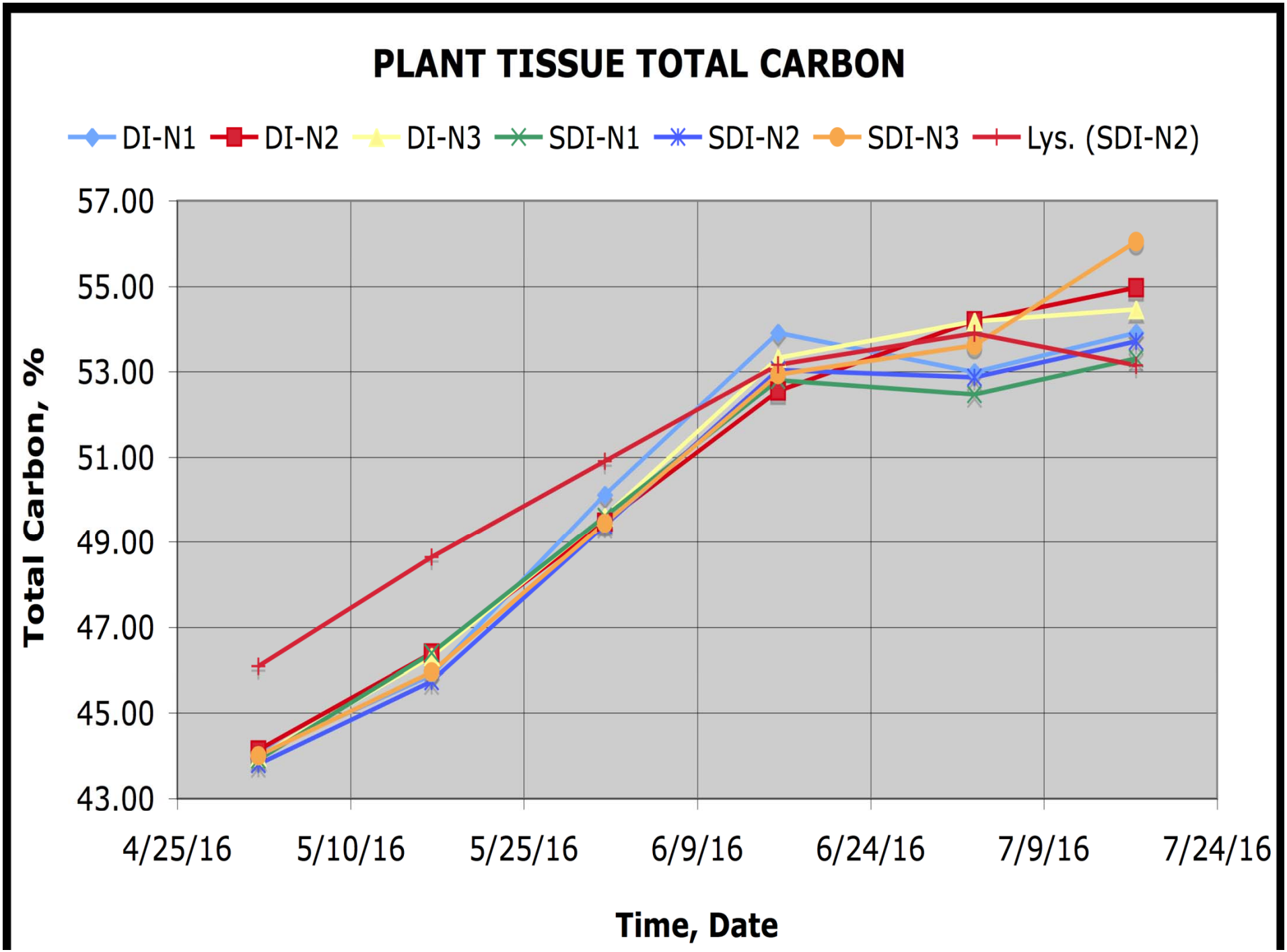

INJECTED NITROGEN, 2012
N-1 Level
N-2 Level
N-3 Level
Injected N (as Urea & AN-20), lb N/ac.
250
225
200
175
150
125
100
75
50
25
0
10-May
17-May
24-May
31-May
7-Jun
14-Jun
21-Jun
28-Jun
5-Jul
12-Jul
19-Jul
26-Jul
2-Aug
9-Aug
17-Aug
23-Aug
Time, date

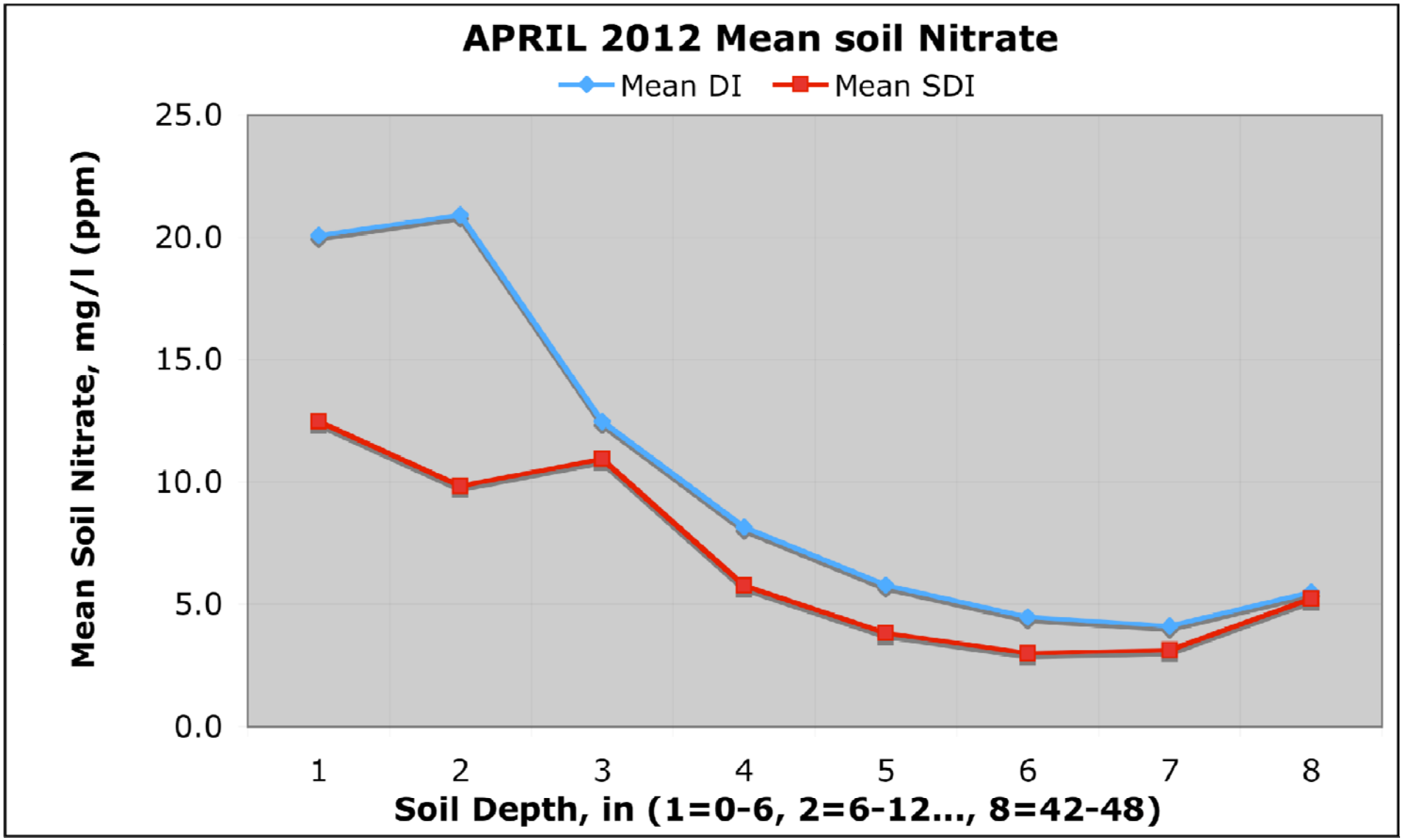

INJECTED PHOSPHORUS
Injected P, lb P/ac
Injected H3PO4, gal H3PO4/ac
Injected P, lb P/ac
Injected Phosphoric Acid, gal H3PO4/ac
0
10
20
30
40
50
60
0
5
10
15
20
25
5/24/12
5/31/12
6/7/12
6/14/12
6/21/12
6/28/12
7/5/12
7/12/12
7/19/12
7/26/12
8/2/12
8/9/12
8/16/12
8/23/12
8/30/12
9/6/12
9/13/12
9/20/12
9/27/12
Time, date

INJECTED POTASSIUM




PLANT TISSUE TOTAL NITROGEN
DI-N1
DI-N2
DI-N3
SDI-N1
SDI-N2
SDI-N3
Lys. (SDI-N2)
Total N, %
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
4/26/12
5/11/12
5/26/12
6/10/12
6/25/12
7/10/12
7/25/12
TIME, date


PLANT TISSUE TOTAL CARBON
DI-N1
DI-N2
DI-N3
SDI-N1
SDI-N2
SDI-N3
Lys. (SDI-N2)
57.00
55.00
53.00
51.00
49.00
47.00
45.00
43.00
Total Carbon, %
4/25/16
5/10/16
5/25/16
6/9/16
6/24/16
7/9/16
7/24/16
Time, Date


APRIL 2012 Mean soil Nitrate
Mean DI
Mean SDI
Mean Soil Nitrate, mg/l (ppm)
25.0
20.0
15.0
10.0
5.0
0.0
1
2
3
4
5
6
7
8
Soil Depth, in (1=0-6, 2=6-12..., 8=42-48)

LEAF TISSUE AND SOIL RESPONSES TO HIGH FREQUENCY N-FERTIGATION—Dr. R. TIRADO-CORBALA

- Bi-Weekly **Leaf Tissue** Total N from 5/1 to 7/16
- MEAN HIGH—5/1/12—2.52 %
- MEAN LOW—6/15/12—1.33 %
- MEAN INCREASED—7/16/12—1.44% (N-fertig.)

- April 2012--**Soil NO_3-N** (0-48 in. depth)
- DI—20.1 ppm (0-6 in.)→5.5 ppm (42-48 in.)
- SDI—10.3 ppm (0-6 in.)→5.2 p-pm (42-48 in.)
- Similar soil sampling was done in August and will be repeated in November 2012

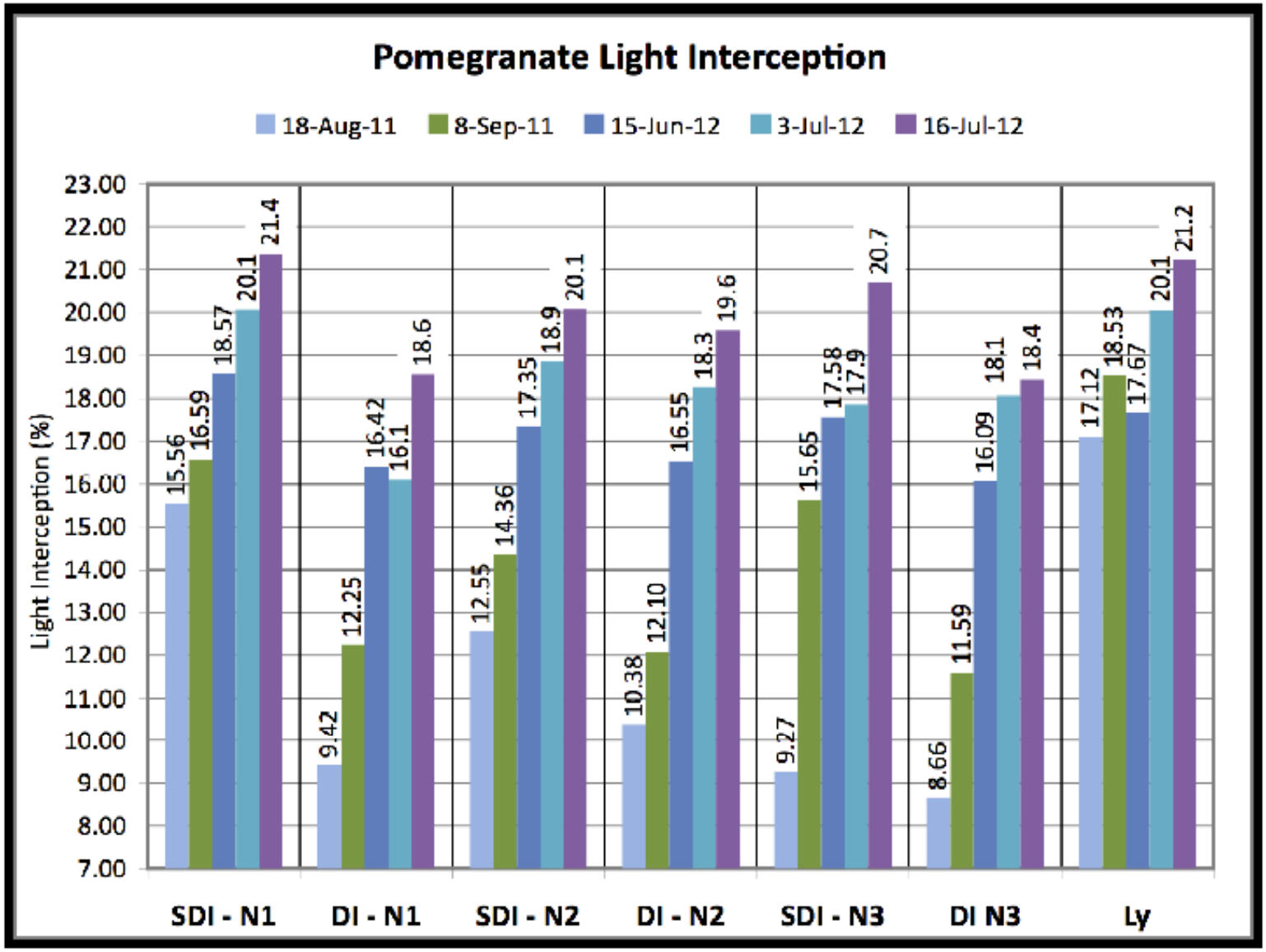
CANOPY COVER MEASUREMENTS WITH MULTISPECTRAL TETRACAM CAMERA--Dr. D. Wang & Staff

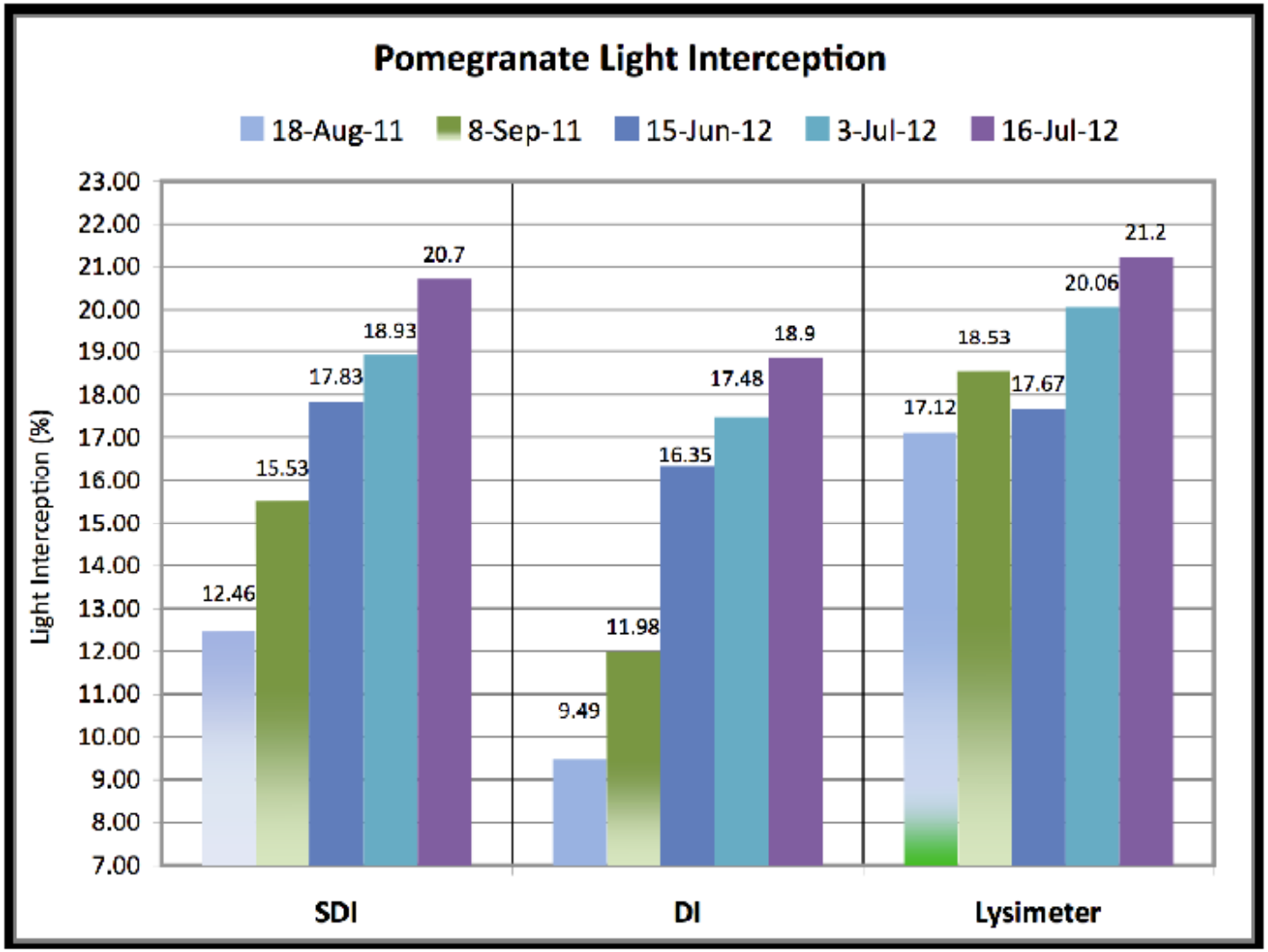
Pomegranate canopy cover was measured with a multispectral **Tetracam** camera on June 13 and July 17, 2012.

Measurements show a respective **10%** and **14%** increase in mean canopy cover for the SDI System over the DI System.

Canopy cover measurement of the lysimeter tree was 21% greater than the DI mean.

Additional measurements are planned for the rest of the season and will be correlated with ETc from the lysimeter and the light bar measurements to generate Kc's.


Pomegranate Light Interception
18-Aug-11
8-Sep-11
15-Jun-12
3-Jul-12
16-Jul-12
Light Interception (%)
23.00
22.00
21.00
20.00
19.00
18.00
17.00
16.00
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
7.00
15.56
16.59
18.57
20.1
21.4
9.42
12.25
16.42
16.1
18.6
12.55
14.36
17.35
18.9
20.1
10.38
12.10
16.55
18.3
19.6
9.27
15.65
17.58
17.9
20.7
8.66
11.59
16.09
18.1
18.4
17.12
18.53
17.67
20.1
21.2
SDI - N1
DI - N1
SDI - N2
DI - N2
SDI - N3
DI N3
Ly


Pomegranate Light Interception
18-Aug-11
8-Sep-11
15-Jun-12
3-Jul-12
16-Jul-12
Light Interception (%)
23.00
22.00
21.00
20.00
19.00
18.00
17.00
16.00
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
7.00
12.46
15.53
17.83
18.93
20.7
9.49
11.98
16.35
17.48
18.9
17.12
18.53
17.67
20.06
21.2
SDI
DI
Lysimeter

CANOPY LIGHT INTERCEPTION MEASURED WITH LIGHT BAR-- R. C. Phene

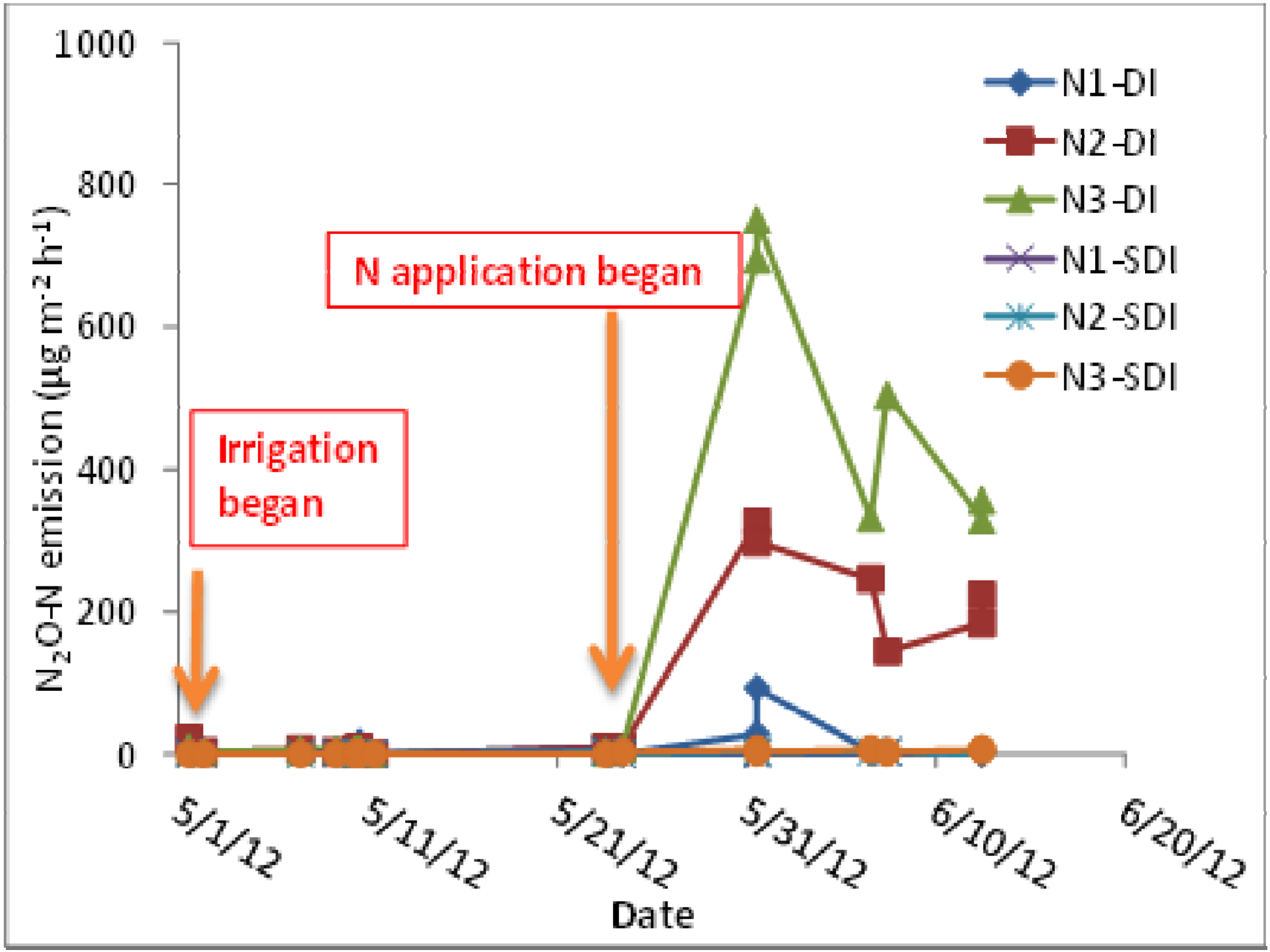
- The pomegranate canopy light interception was measured with a light bar in August 18 and September 11, 2011 and on June 15, July 3, and July 16, 2012.
- In the SDI treatment, the LI increased by 66% from **12.5%** in 2011 to **20.7%** in 2012.
- In the DI treament, the LI increased by 99% from **9.5%** in 2011 to **18.9%** in 2012.
- Overall, **SDI Increased by 10% over DI.**
- In 2012 light interception will continue to be measured every two weeks and will be related to ETc from the lysimeter and to the Tetracam measurements to generate canopy-related crop coefficients (Kc).

PRELIMINARY SOIL NITROUS OXIDE EMISSIONS IN DI AND SDI IRRIGATED POMEGRANATE

Dr. S. GAO & A. HENDRATNA

- Preliminary soil nitrous oxide (N_2O) emissions in the DI and SDI systems were measured using the static chamber method.
- On 5/31/2012, N_2O emission rates were affected by N application rates in the DI (surface drip irrigation) but not in the SDI (subsurface drip irrigation) for all N application rates ranging from 50 (N1), 175 (N2), and 275 ppm N (N3).
- Subsequent measurements indicated similar responses implying that SDI may help prevent N_2O emissions even at high N injection rates.

This portion of the project was funded by USDA-ARS and future research will be dependent on additional funding.


1000
800
600
400
200
0
N2O-N emission (µg m-2 h-1)
N application began
Irrigation began
N1-DI
N2-DI
N3-DI
N1-SDI
N2-SDI
N3-SDI
5/1/12
5/11/12
5/21/12
5/31/12
6/10/12
6/20/12
Date

EFFECTS OF POOR QUALITY WATER ON NUTRITIONAL CONTENTS OF POMEGRANATE

Dr. G. S. Banuelos and Staff

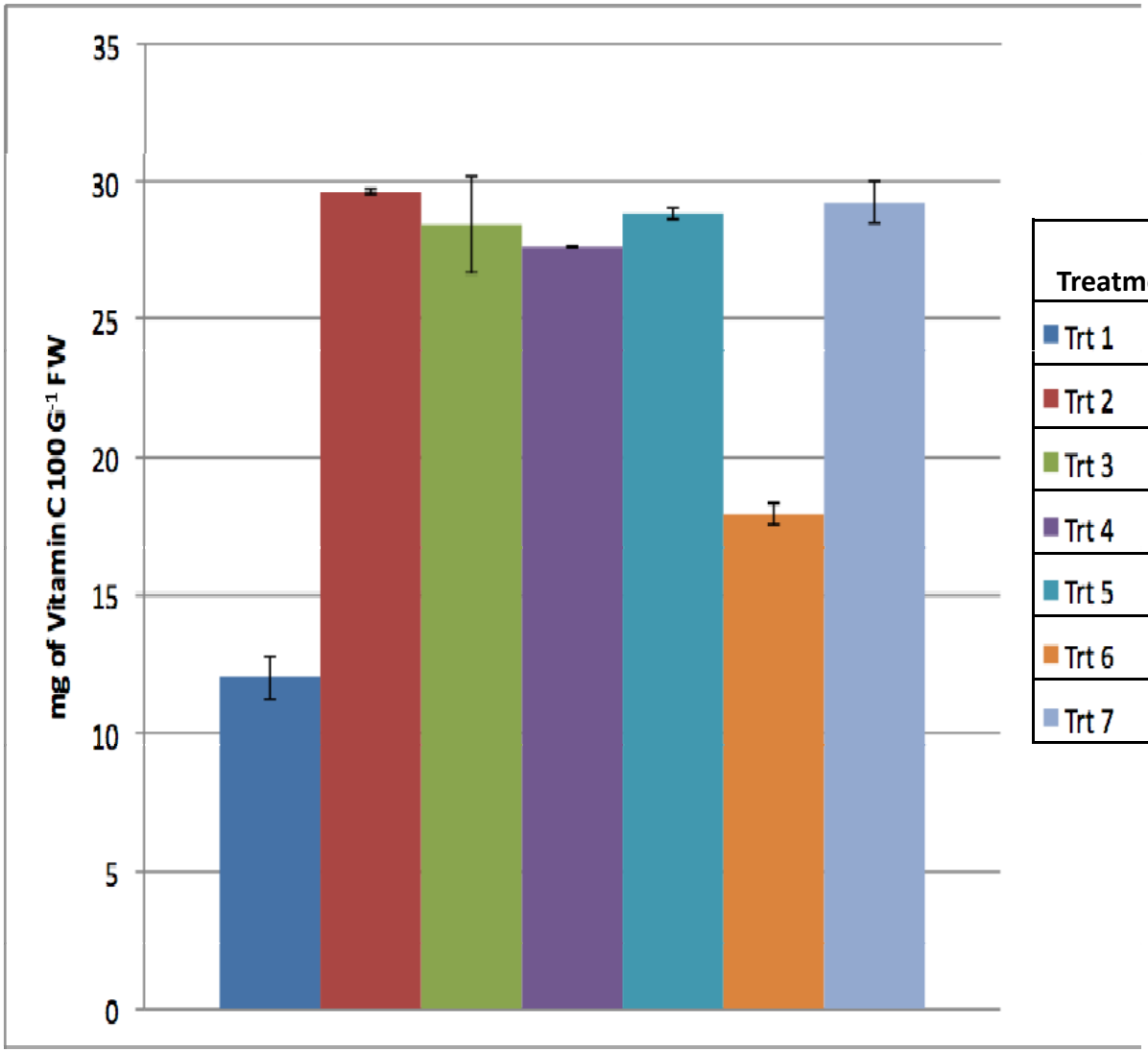
- One-year old pomegranate trees were irrigated with saline waters ranging from 1 to 6 dS/m, 4 ppm B, and 0.25 ppm Se.

- Ca, Mg, K, P, S and Se concentrations increased in fruit, especially Se in leaf tissue (not shown).

- Vitamin C levels increased in pomegranate fruits from trees irrigated with low quality waters.

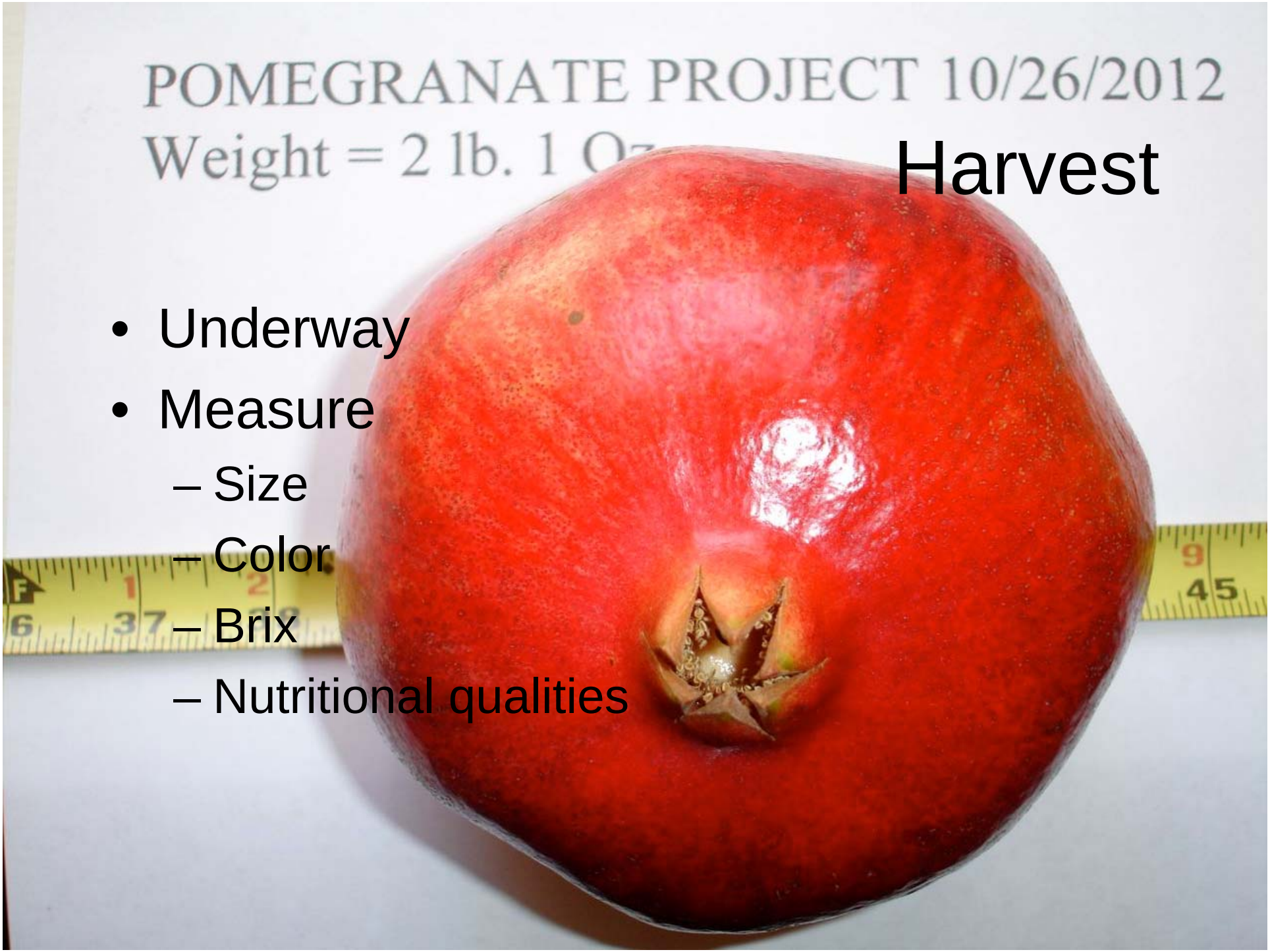
- Vitamin C and total phenolic levels, as affected by N treatments, will be carried out in 2012 on fruits from the SDI- & DI-fertigated orchard.

Effects of Water Quality on Vitamin C Level of Pomegranate



Treatments	
Trt 1	Control
Trt 2	< 1 dS/m + 0.250 ppm Selenate
Trt 3	< 1 dS/m + 0.250 ppm Selenate + 4 ppm B
Trt 4	3 dS/m + 0.250 ppm Selenate
Trt 5	3 dS/m + 0.250 ppm Selenate + 4 ppm B
Trt 6	6 dS/m + 0.250 ppm Selenate
Trt 7	6 dS/m + 0.250 ppm Selenate + 4 ppm B


Weeds in DI vs NO weed in SDI
September 26, 2012



Harvest

- Underway
- Measure
  - Size
  - Color
  - Brix
  - Nutritional qualities


10 28 2012


N2 SDI
Rep. 4
10 28 2012


10 28 2012

CONCLUSIONS

- Preliminary results have demonstrated that the high frequency SDI System has the potential to provide:
- More efficient WUE than DI
- More efficient NUE than DI
- Larger tree than DI
- Less weeds than DI
- Lower potential for NO_3-N leaching
- No N_2O gaseous emission compared to DI*
- Low quality waters improved vitamin C and phenolic compounds of pomegranate
- Improved orchard access for maintenance equipment

** Future N_2O emission research will depend on additional and/or external funding*

ACKNOWLEDGEMENTS

CDFA/FREP – partial funding (3 years)
Paramount Farming – trees
Lakos – Media filter set
Toro Micro Irrig – Rootguard drip tubing
Verdegaal Brothers--Fertilizers
Dorot – Solenoid & Manual valves
SDI+-- Consulting Time & equipment


QUESTIONS?