# Keeping Nutrients In Their Place: Irrigation Management to Enhance Nutrient Retention in Container Production

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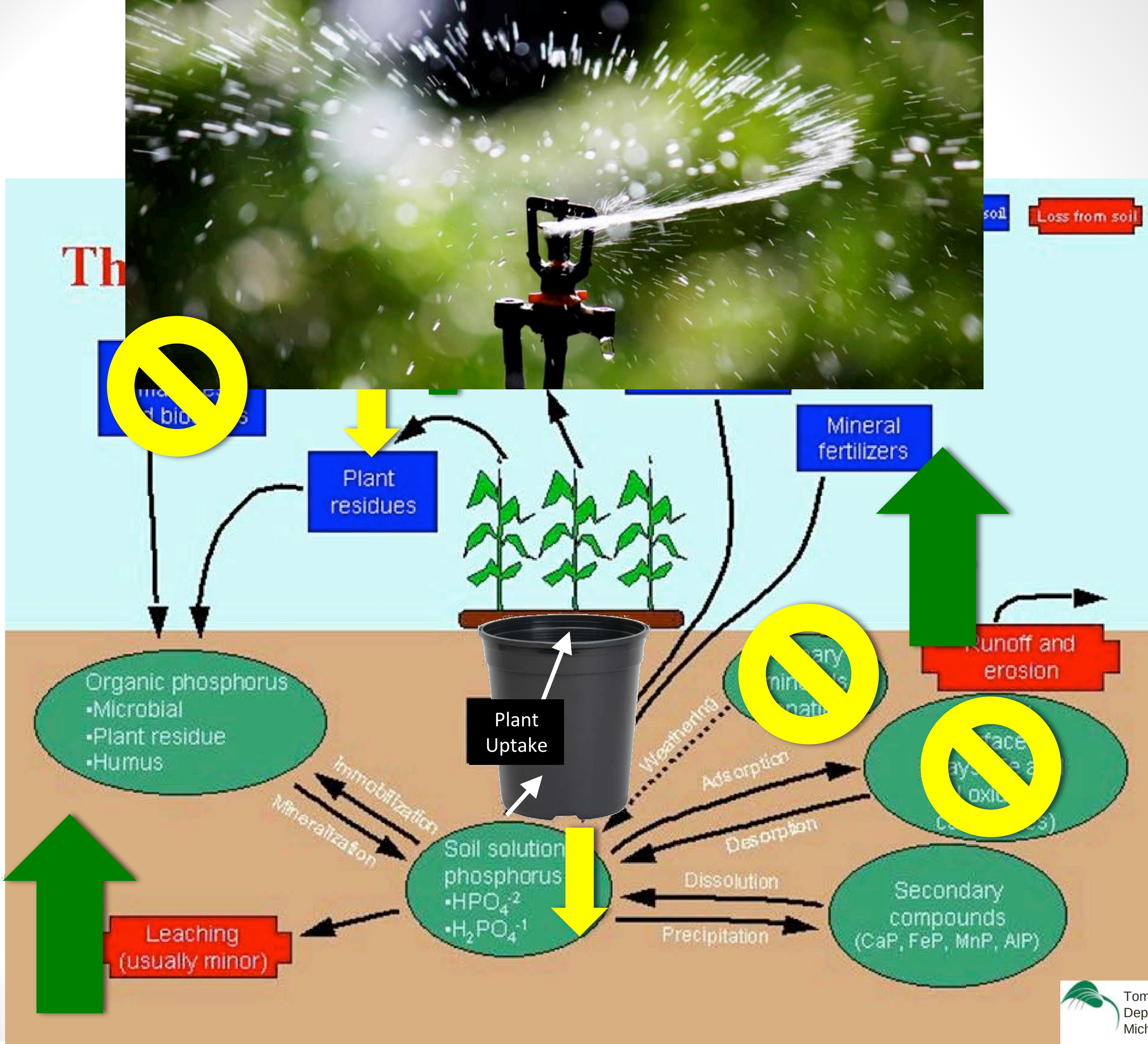


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# Important considerations

- Water quality
  - Soluble salts
  - Alkalinity
- Container substrate physical properties (water availability terminology)
- Determining irrigation application
  - System size, type and application rate (frequency of irrigation)
  - How much is too much
  - How much is enough
- Nutrients in effluent water
- Cost of water

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# Substrate Water Availability

- Container Capa ... er a container subs ... nage.
  - Typically 45 -
- Unavailable W ... e substrate and cannot be
  - Typically 25 -
- Available Wate ... xtracted by a plant.
  - = Container C
- Readily Availal ... can be easily extracte
  - Typically 25 -
- Permanent Wi ... cted all of the available water and is not able to regain turgor.

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# Container is the gas tank?


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Dollar DAYS
TULIP 10 STEM
WAS 8.00
SAVE 1.00
now
BUY
2
7.50
EACH
1 EA
flickr

CC =   45% SMC
UW = 25% SMC

AW = 20% water depletion
RAW = 11% water depletion (34% SMC)
But to avoid wilting replace at 6% depletion (39% SMC)

| Trade size | Container volume (gallon) | Volume AW in pot (gallon) | Irrigation to replace 6% RAW (GPA / Acre-Inch)* |
|---|---|---|---|
| #1 | 1.007 | 0.20 | 8,034 / 0.30 |
| #3 | 3 | 0.60 | 11,881 / 0.44 |
| #5 | 3.734 | 0.75 | 12,689 / 0.47 |
| #7 | 7.492 | 1.50 | 18,316 / 0.67 |
| #10 | 10.257 | 2.05 | 19,814 / 0.73 |
| #15 | 13.351 | 2.67 | 18,948 / 0.70 |

*Calculation based on overhead irrigation

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# Replace 6% RAW with Distribution Uniformity = 80%

| Trade size | Container volume (gallon) | 0% Leaching Fraction (GPA / Acre-inch)* | 10% Leaching Fraction (GPA / Acre-inch)* | 20% Leaching Fraction (GPA / Acre-inch)* |
|---|---|---|---|---|
| #1 | 1.007 | 10,042 / 0.35 | 11,047 / 0.41 | 12,051 / 0.44 |
| #3 | 3 | 14,851 / 0.55 | 16,336 / 0.60 | 17,821 / 0.66 |
| #5 | 3.734 | 15,861 / 0.58 | 17,446 / 0.64 | 19 033 / 0.70 |
| #7 | 7.492 | 22,896 / 0.84 | 25,186 / 0.93 | 27,475 / 1.01 |
| #10 | 10.257 | 24,767 / 0.91 | 27,244 / 1.00 | 29,721 / 1.09 |
| #15 | 13.351 | 23,685 / 0.87 | 26,054 / 0.96 | 28,422 / 1.05 |

*Calculation based on overhead irrigation

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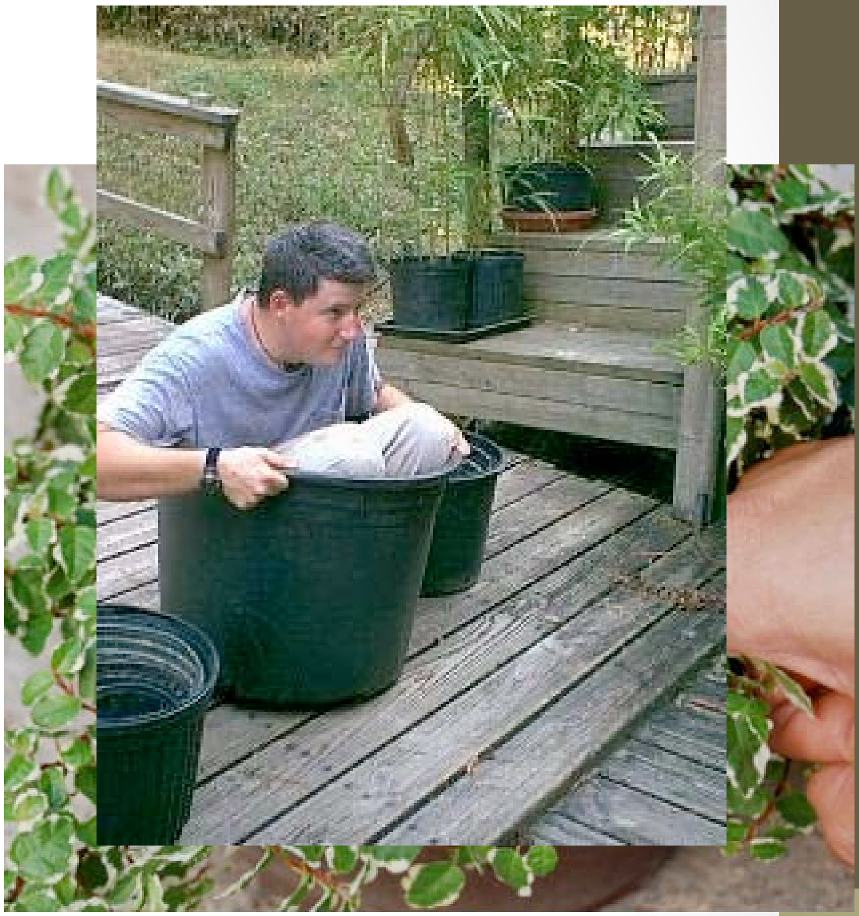
# How much is enough?

- Experience
  - Weather/evapotranspiration
  - Feel/weight
- Leaching Fraction
- Moisture sensors



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# Leaching Fraction (LF) =

(amt of water leached with plant / amt without plant) * 100

Courtesy Ted Bilderback, NCSU

# Determining Leaching Fraction

| Container | 1 | 2 | 3 | 4 | 5 | Avg |
|---|---|---|---|---|---|---|
| Plant Container (ml) | 250 | 225 | 160 | 275 | 210 | 224 |
| Empty Container (ml) | 775 | 770 | 740 | 870 | 760 | 783 |
| Leaching Fraction (%) | 32 | 30 | 21 | 31 | 28 | 29 |

Older recommendations are for LF ≤ 20 %, based on greenhouse studies

LF = 0 should be considered for nurseries (Eastern US). YOU MUST Monitor container EC if go to 0 LF

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# Leachate pH and EC

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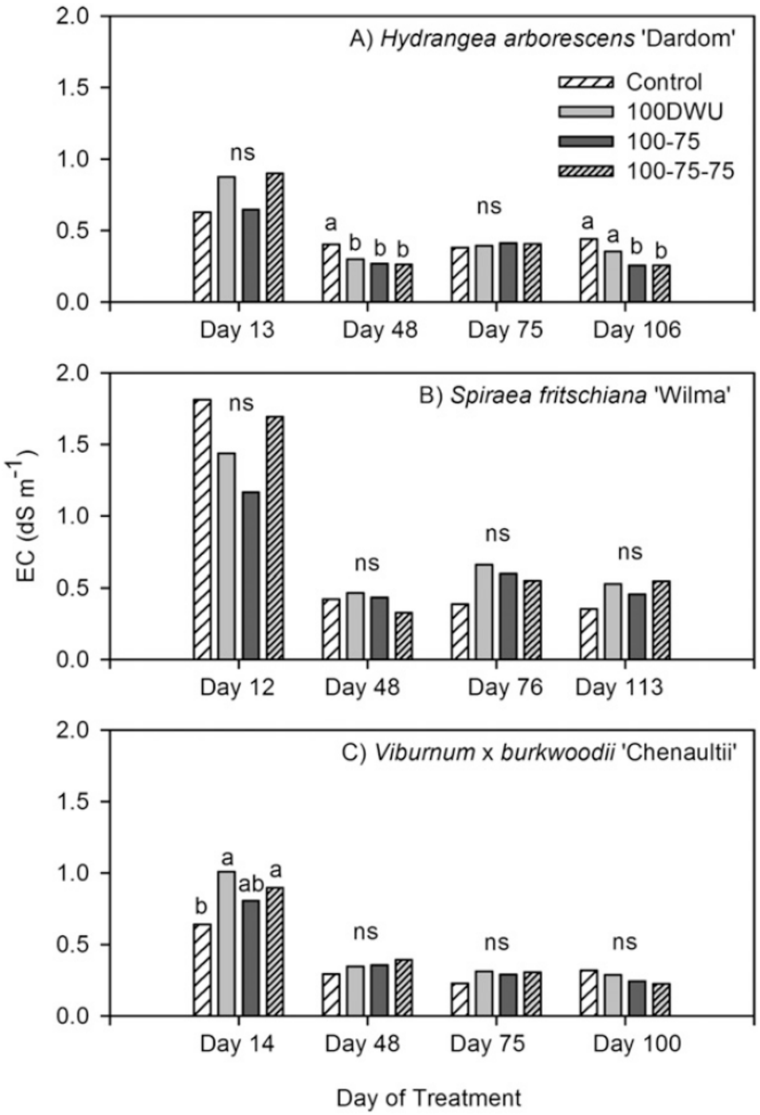
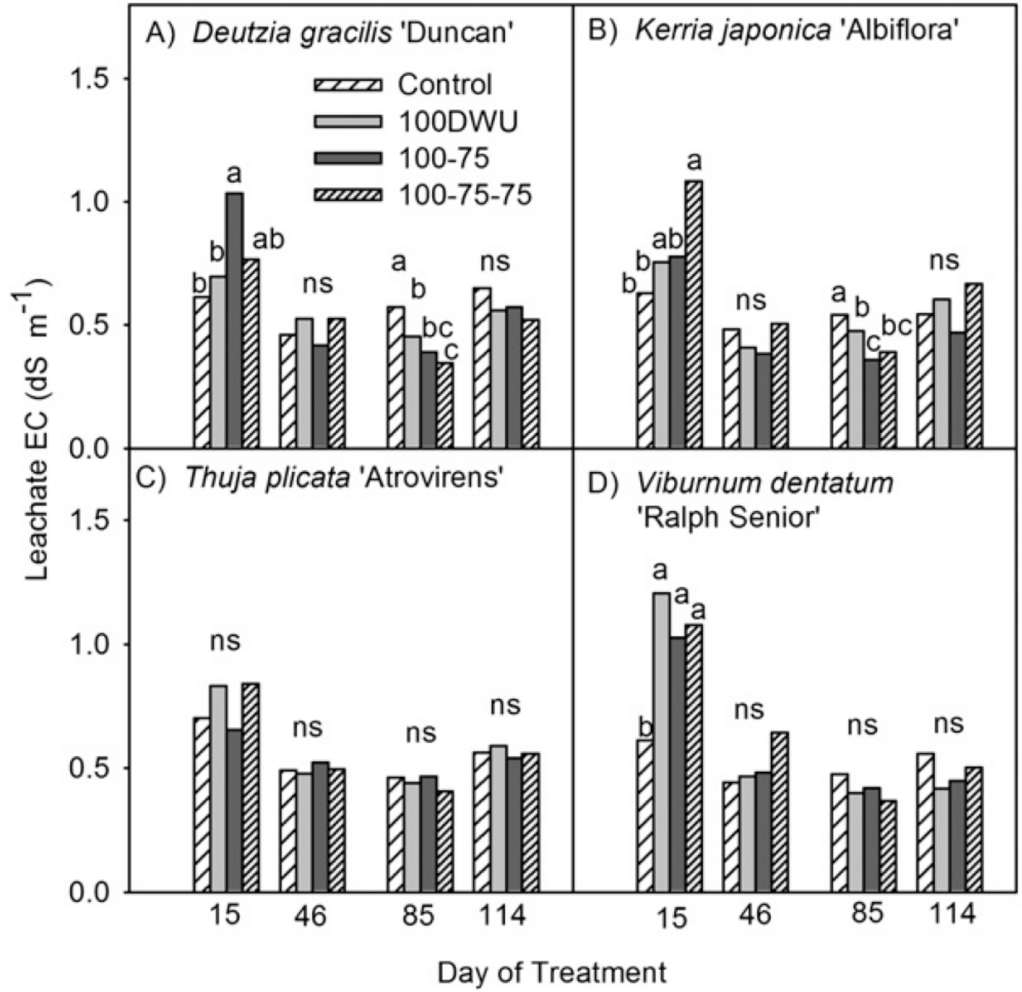
# Soluble Salts (EC)




Warsaw et al., 2009

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# Types of Moisture Sensors




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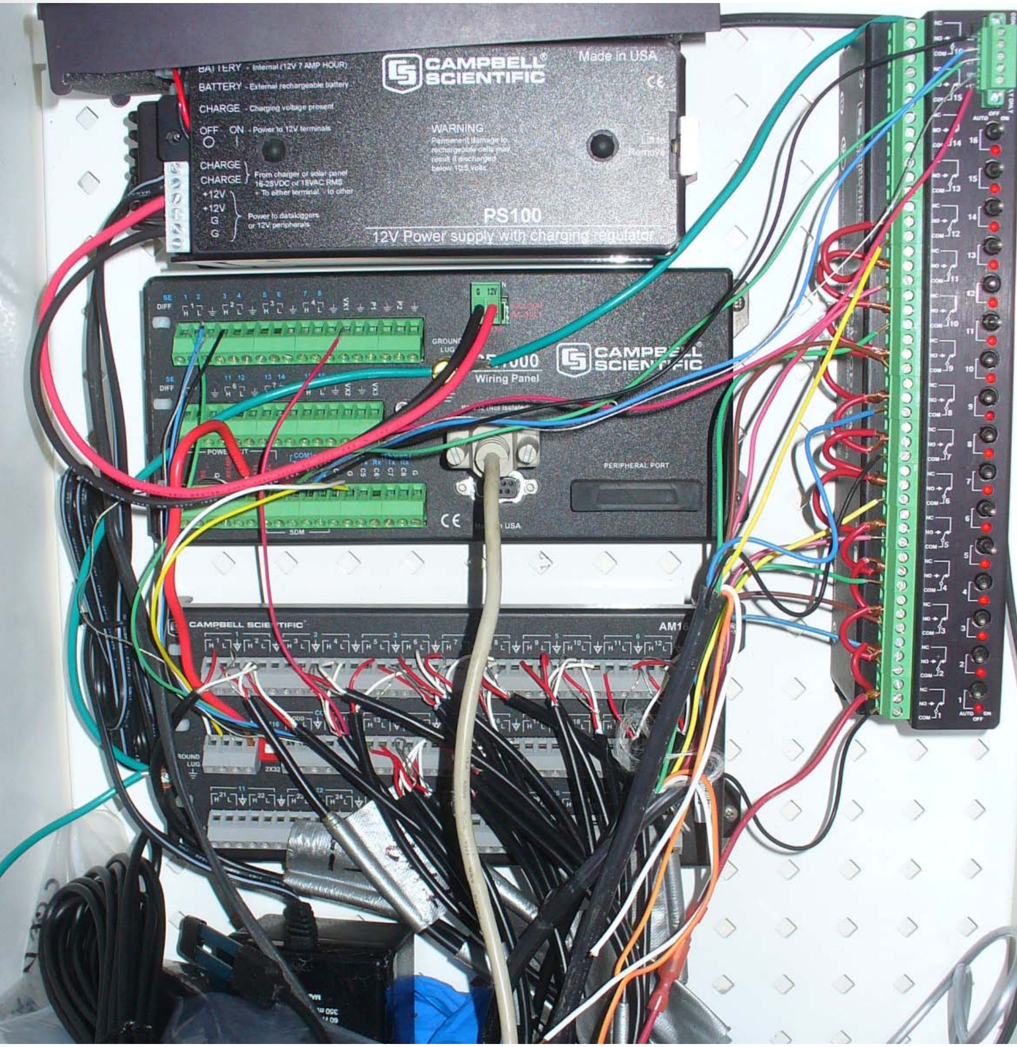
# 2010 - 2015





Substrate volumetric moisture content determined with Theta probes or Decagon 10HS sensors via a Campbell datalogger programmed to calculate DWU and apply irrigation by controlling solenoid valves. Irrigation applied based on the highest plant DWU.

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# Wireless sensor networks



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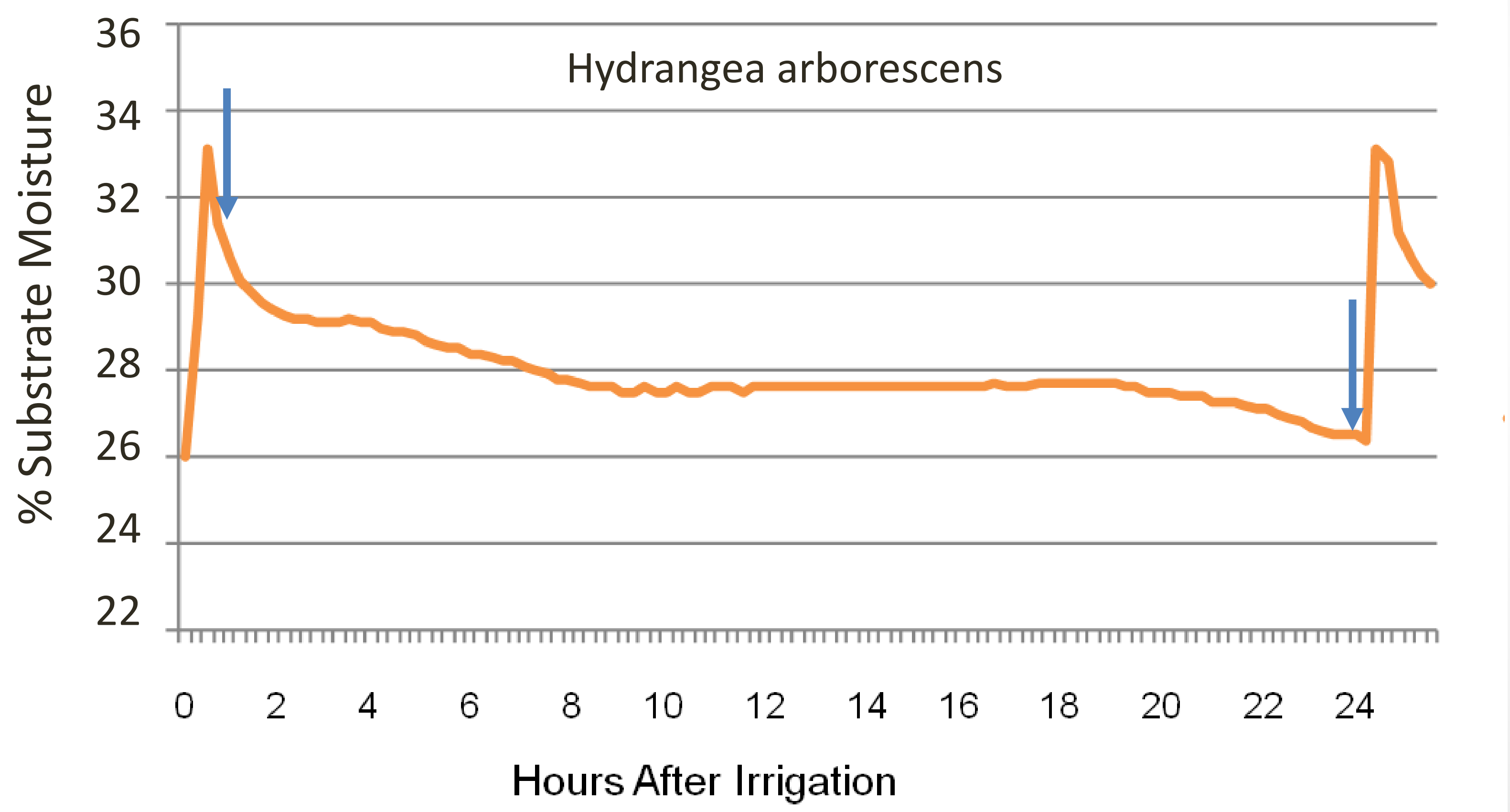
# Calculating Daily Water Use (DWU)





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# Overhead Irrigation Usual Treatments

- Control = ¾ acre-inch per day
- 100 DWU = 100% of plant daily water use replaced
- 100-75 DWU = alternating 100% DWU with 75% DWU daily
- 100-75-75 DWU = alternating 1 day at 100% DWU with 2 days of 75% DWU

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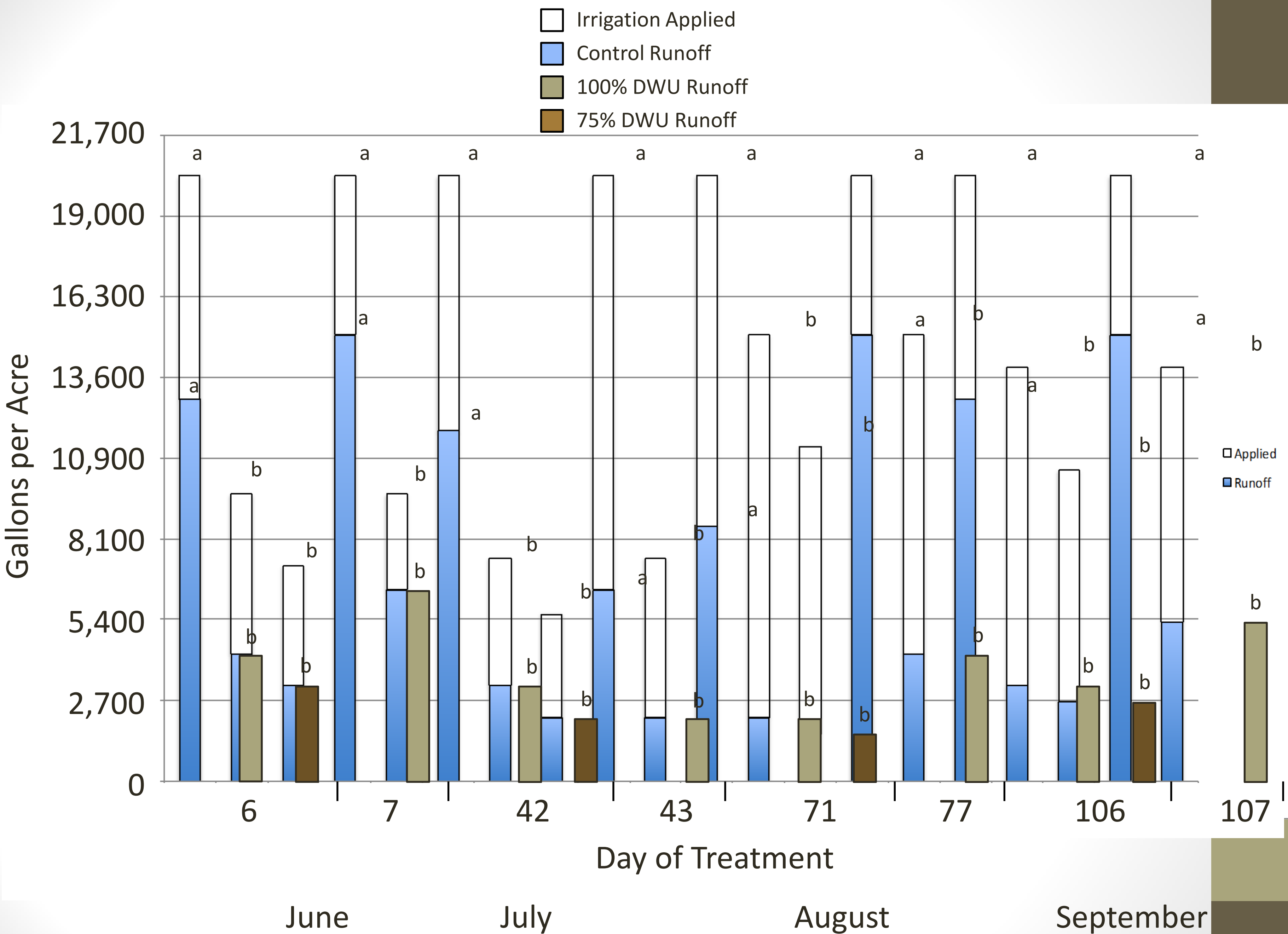


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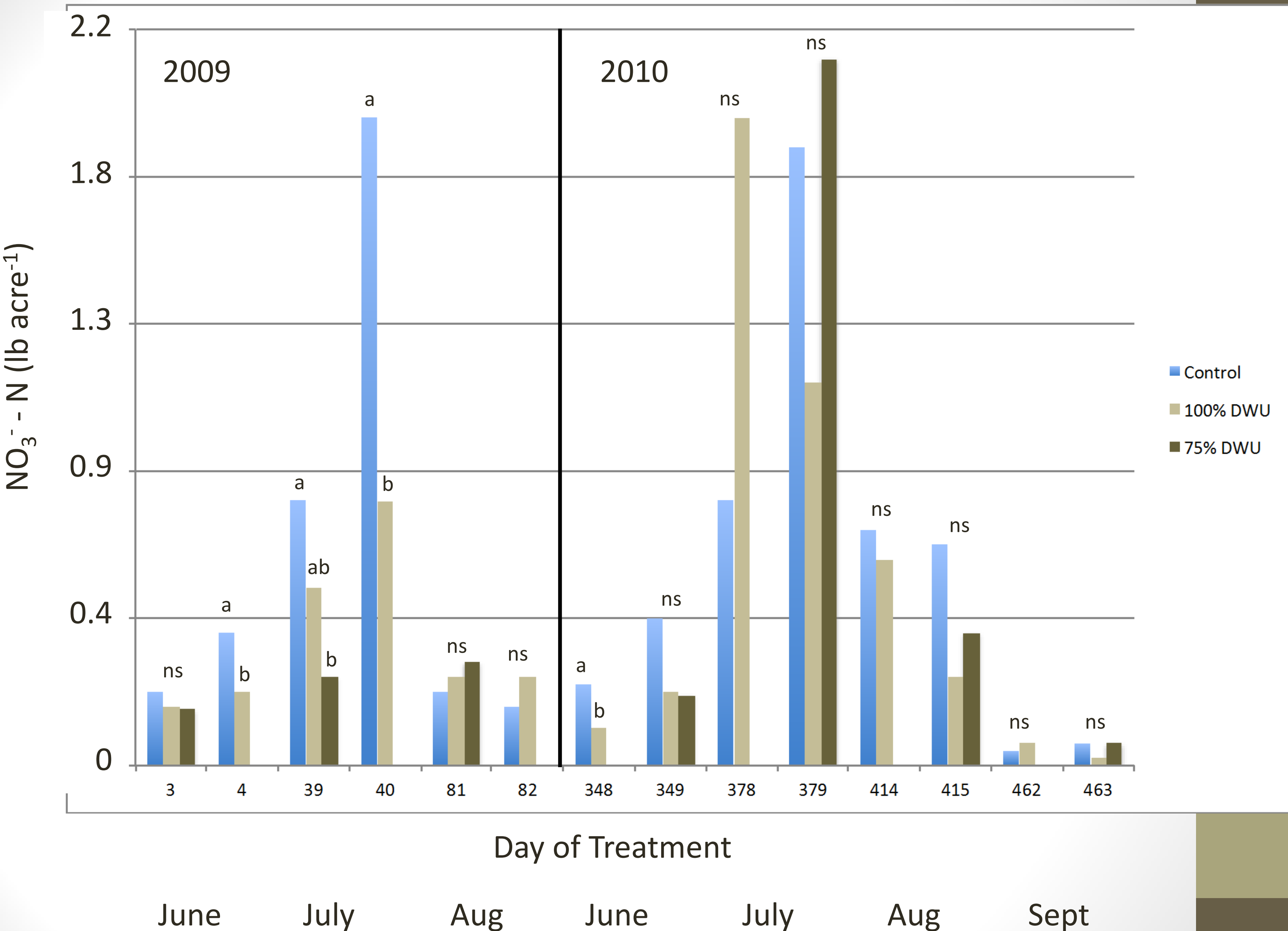
Warsaw et al., 2009 HortScience

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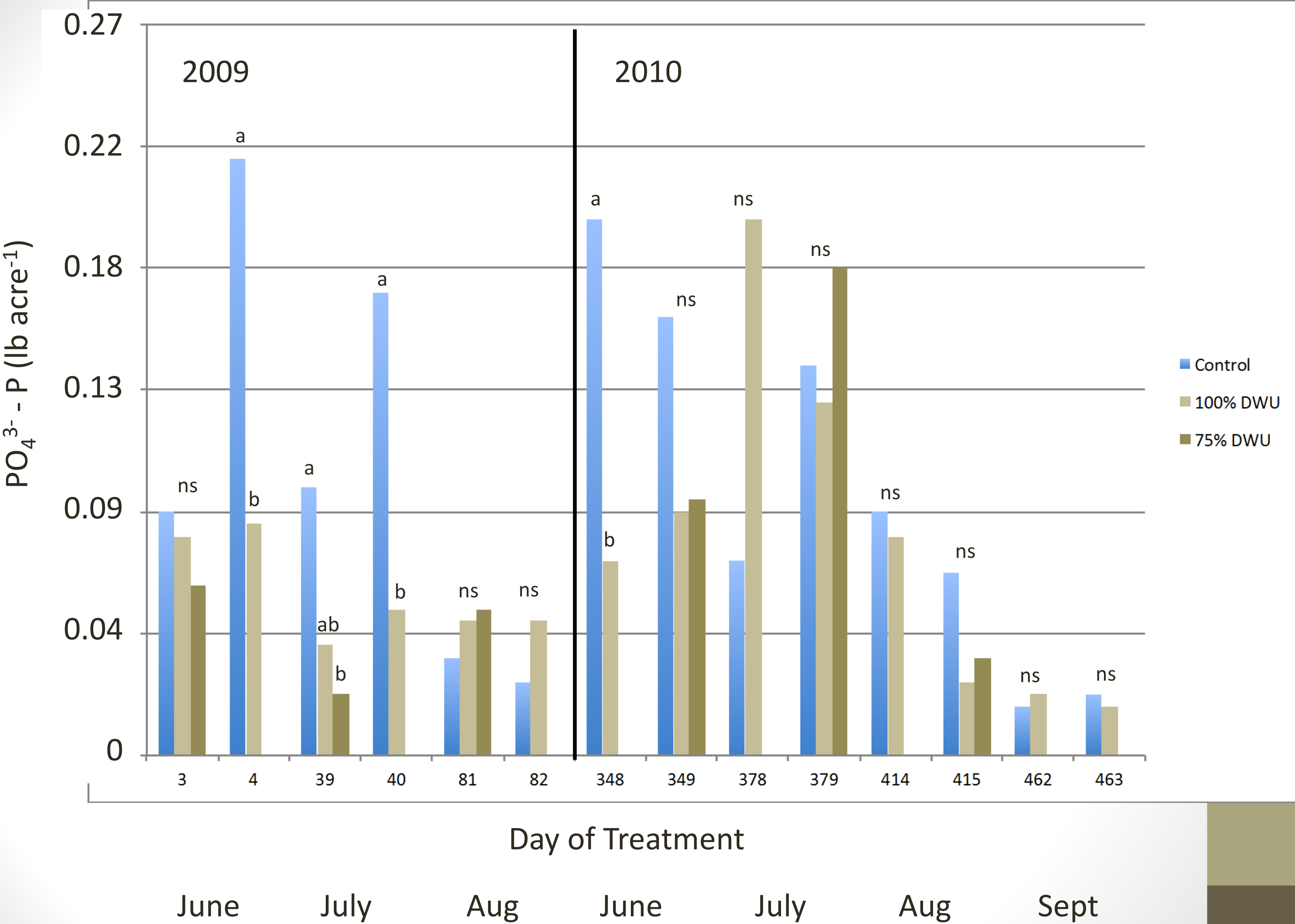


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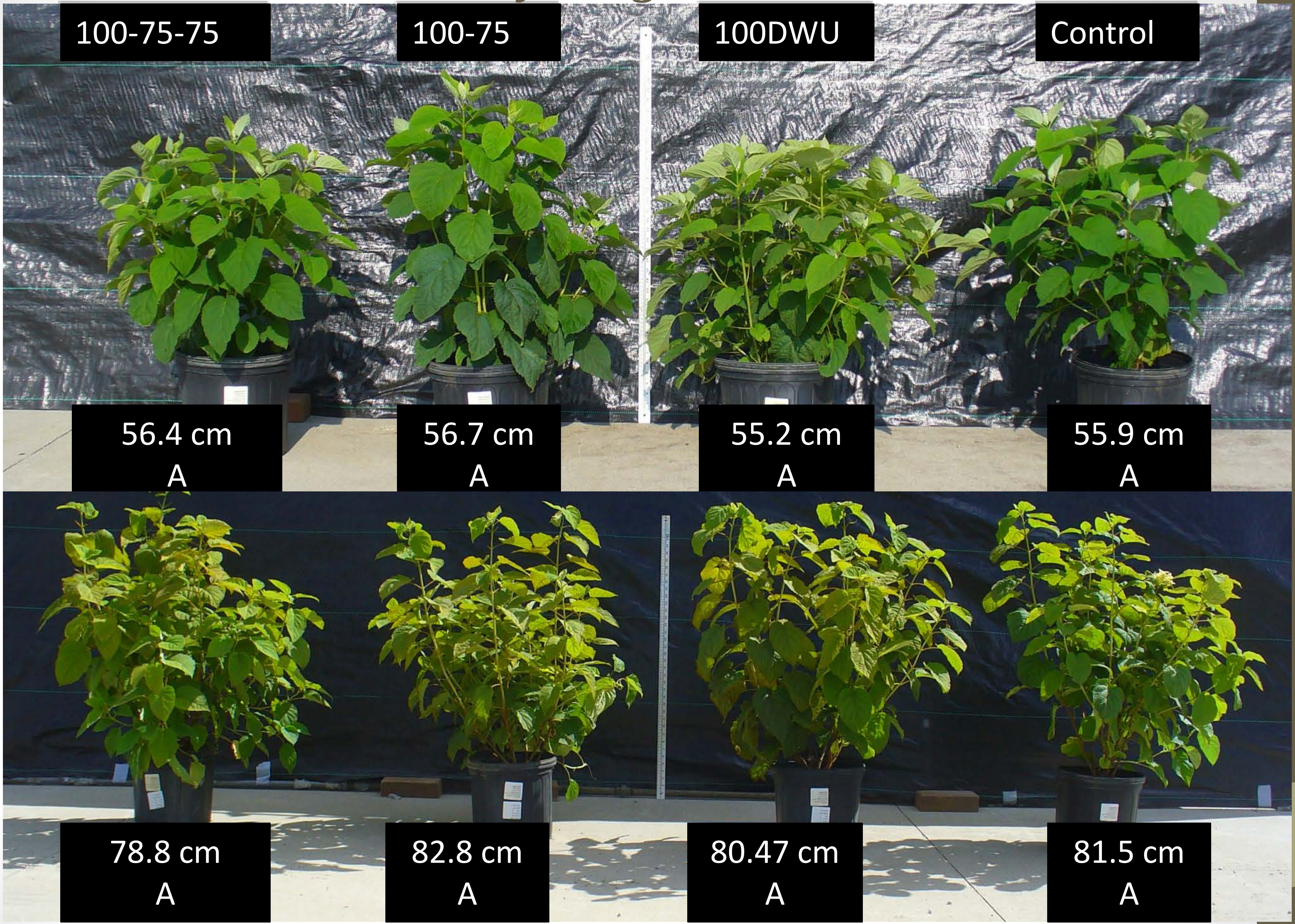
# Growth Index-*Hydrangea arborescens* 'Abetwo'




• Means in each group showing the same letters are not significantly different from each other ($p \leq 0.05$). Means separated by Tukey's Test.

*Kerria japonica* 'Albiflora'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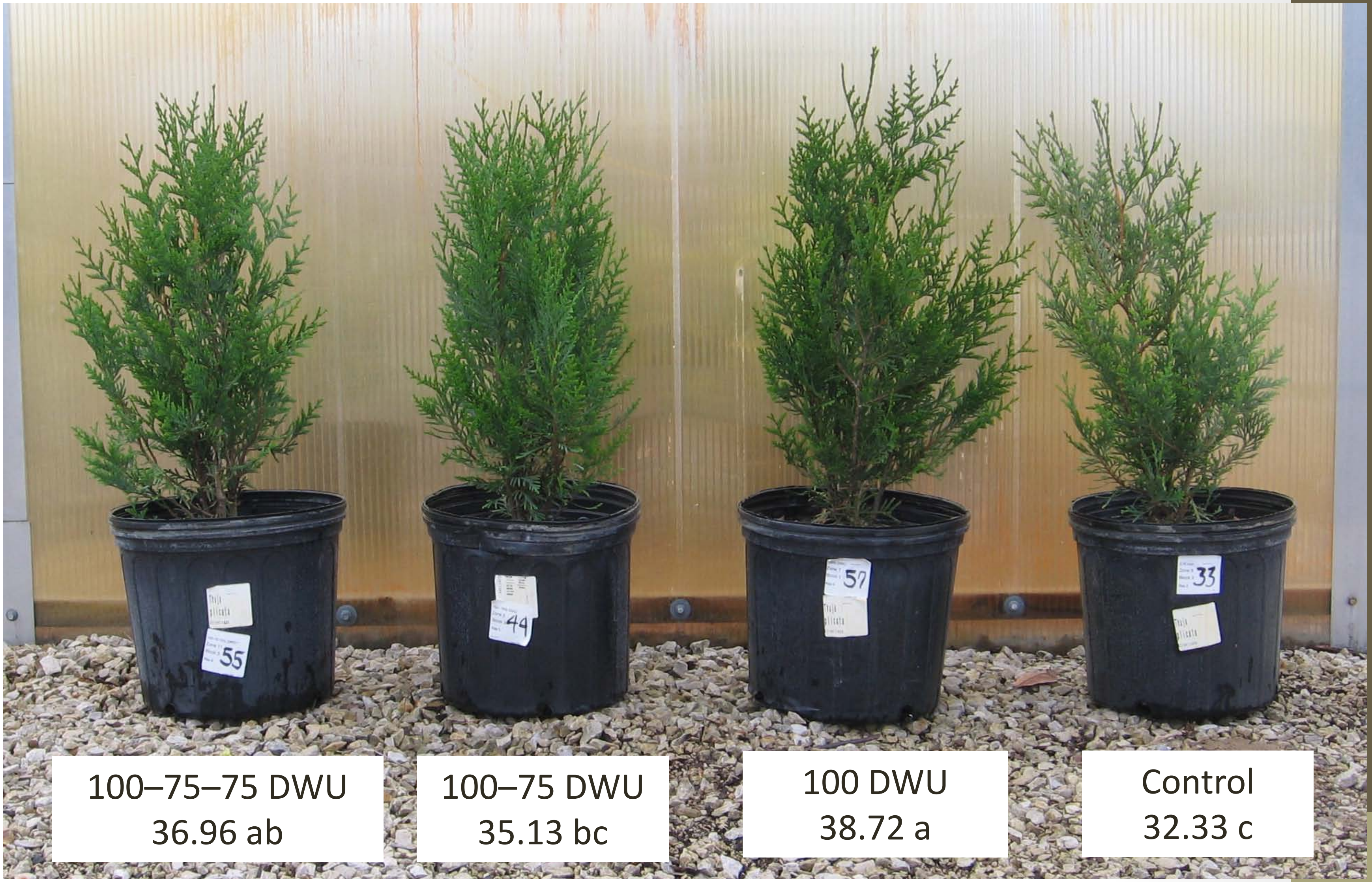
# *Thuja plicata* 'Atrovirens'

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# Growth Index-Hydrangea paniculata ‘Limelight’


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# *Viburnum dentatum* Autumn Jazz


100–75–75 DWU
13.69 a

100–75 DWU
13.13 a

100 DWU
13.43 a

Control
9.72 a

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| | Foliar Nutrient Content | | | |
|---|---|---|---|---|
| | Control[z] | 100DWU | 100-75 | 100-75-75 |
| | *Hydrangea paniculata* 'Limelight' | | | |
| Day 63 | | | | |
| N (%) | 2.87 A[y] | 2.88 A | 2.99 A | 2.96 A |
| P (%) | 0.24 A | 0.29 A | 0.30 A | 0.29 A |
| K (%) | 1.65 A | 2.23 A | 2.07 A | 2.07 A |
| Day 90 | | | | |
| N (%) | 2.24 A | 2.35 A | 2.38 A | 2.31 A |
| | *Itea virginica* 'Morton' | | | |
| Day 63 | | | | |
| N (%) | 2.50 A | 2.69 A | 2.46 A | 2.65 A |
| P (%) | 0.22 A | 0.22 A | 0.22 A | 0.24 A |
| K (%) | 0.65 A | 0.55 A | 0.58 A | 0.66 A |
| Day 90 | | | | |
| N (%) | 2.37 A | 2.74 A | 2.59 A | 2.55 A |
| K (%) | 0.48 A | 0.53 A | 0.54 A | 0.55 A |
| | *Physocarpus opulifolius* 'Seward' | | | |
| Day 63 | | | | |
| N (%) | 3.19 A | 3.19 A | 3.19 A | 3.33 A |
| Day 90 | | | | |
| N (%) | 2.15 A | 2.20 A | 2.28 A | 2.28 A |
| | *Spiraea media* 'Darsnorm' | | | |
| Day 63 | | | | |
| N (%) | 2.27 A | 2.38 A | 2.23 A | 2.42 A |
| P (%) | 0.63 A | 0.67 A | 0.66 A | 0.66 A |
| K (%) | 1.26 A | 1.63 A | 1.66 A | 1.64 A |
| Day 90 | | | | |
| N (%) | 2.50 A | 2.70 A | 2.63 A | 2.74 A |

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# Overhead Irrigation and Runoff

Application Rates: N = 123 lb/ac, P = 15 lb/ac (35 lb $P_2O_5$)

Amount recovered based on 100% land use with #3 containers spaced 1.5 ft on-center over 4 months.

| Treatment | Irrigation Applied gal/acre | Runoff volume gal/acre (% Applied, % of Control Applied) | Nitrate recovered lb/acre (% Applied) | Phosphate recovered lb/acre (% Applied) |
|---|---|---|---|---|
| Control | 2.4 million | 1.04 million (43%) | 12 (10%) | 3.1 (21%) |
| 100% DWU | 1.6 million | 0.48 million (31%, 20%) | 7.2 (6%) | 1.7 (11%) |
| 100-75% DWU | 1.4 million | 0.29 million (21%, 12%) | 5.9 (5%) | 1.2 (8%) |
| 100-75-75% DWU | 1.3 million | 0.37 million (29%, 15%) | 5.7 (5%) | 1.2 (8%) |

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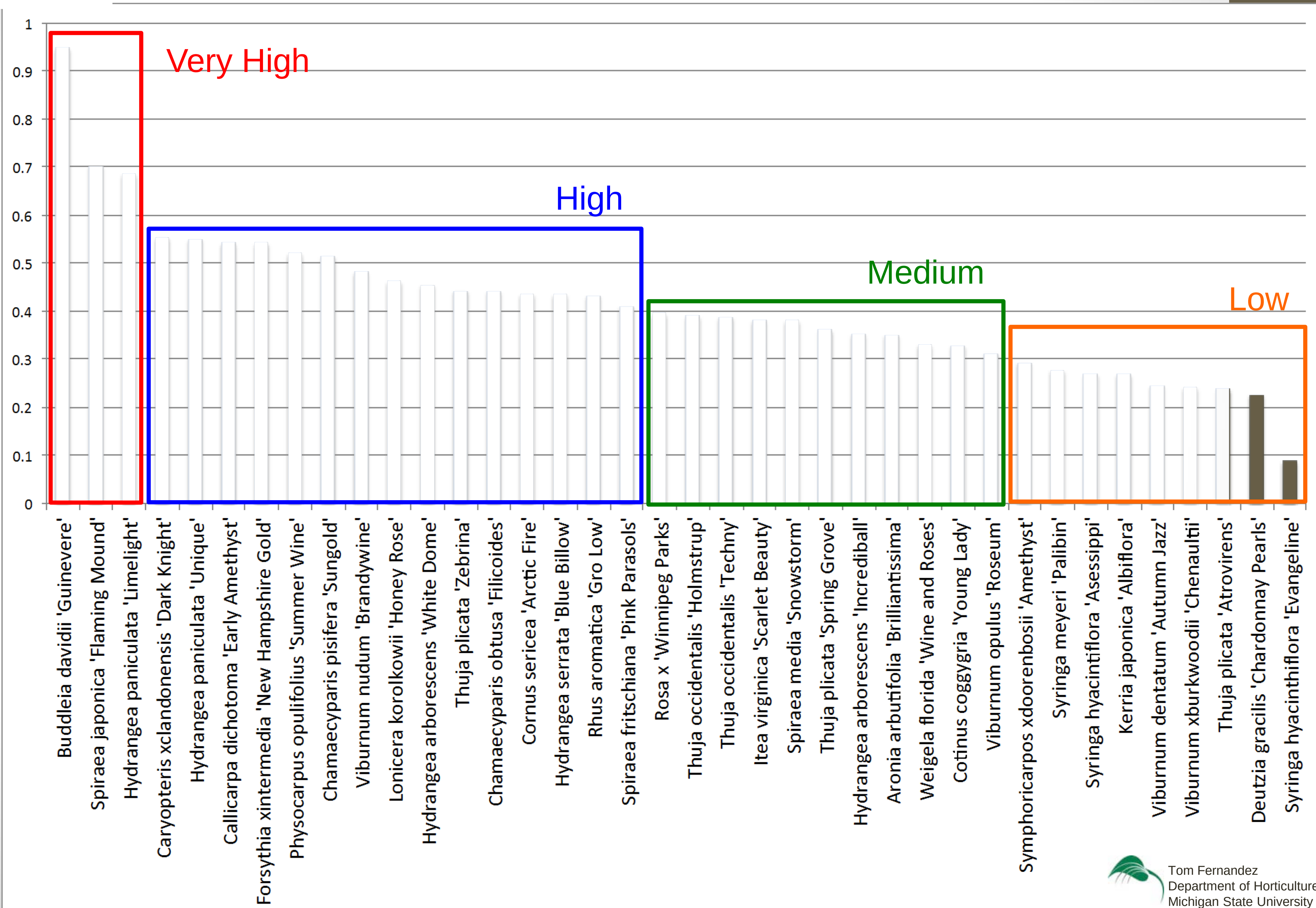
# Plant Grouping by Average Daily Water Use, #3 Pots

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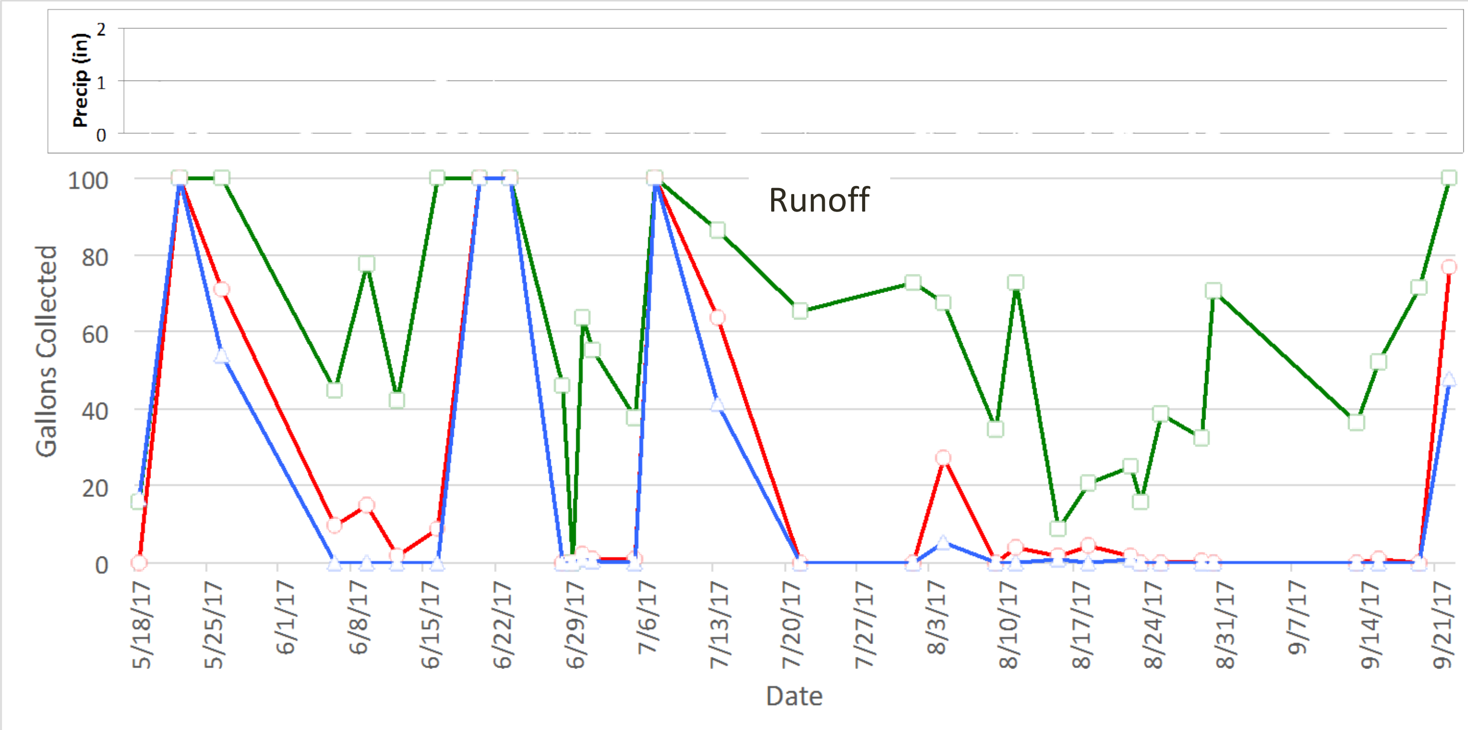


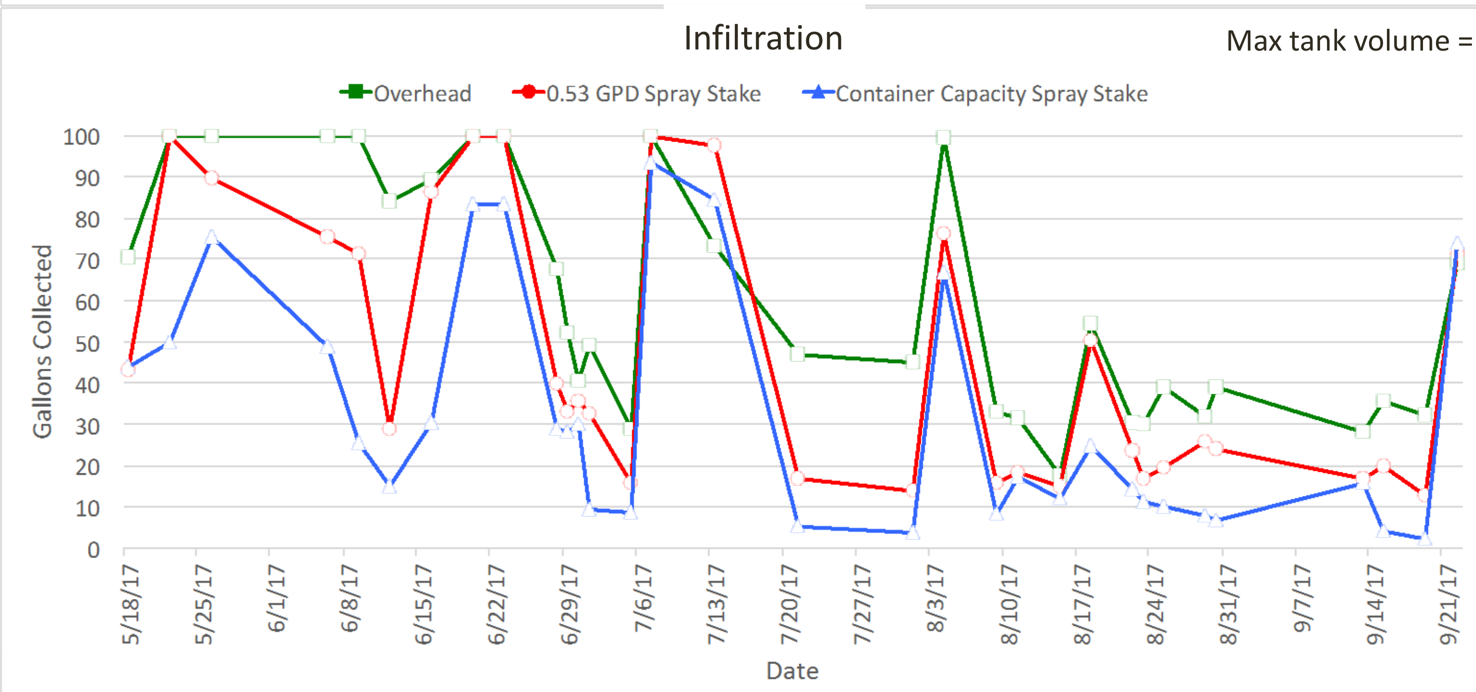


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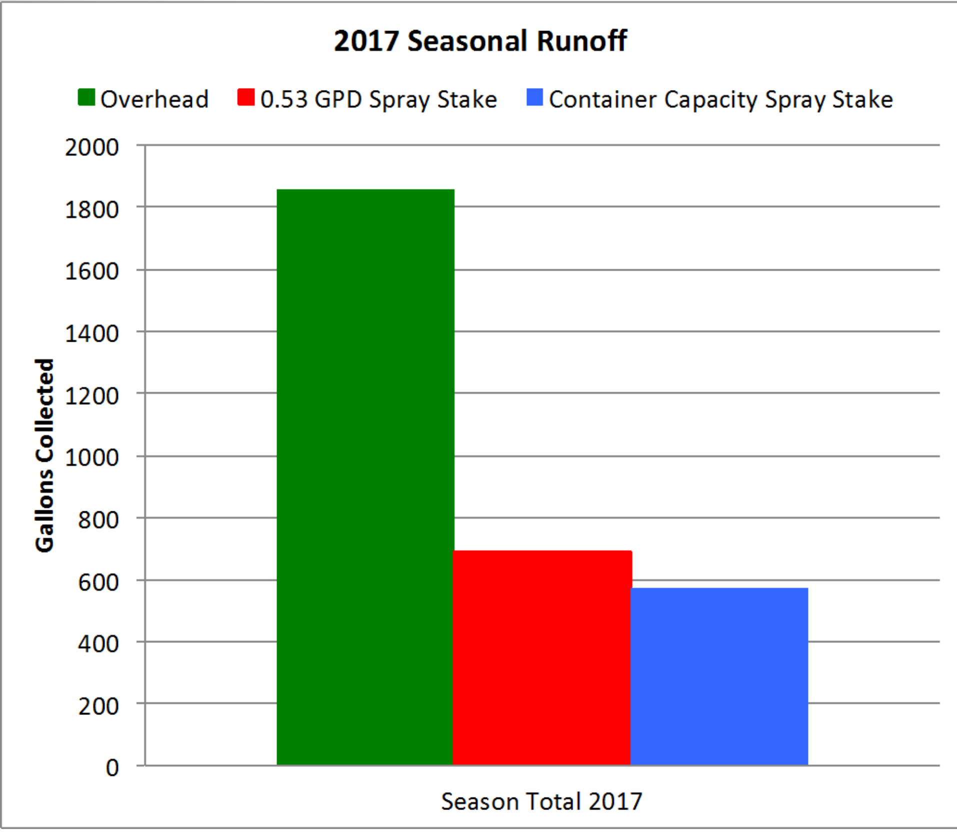
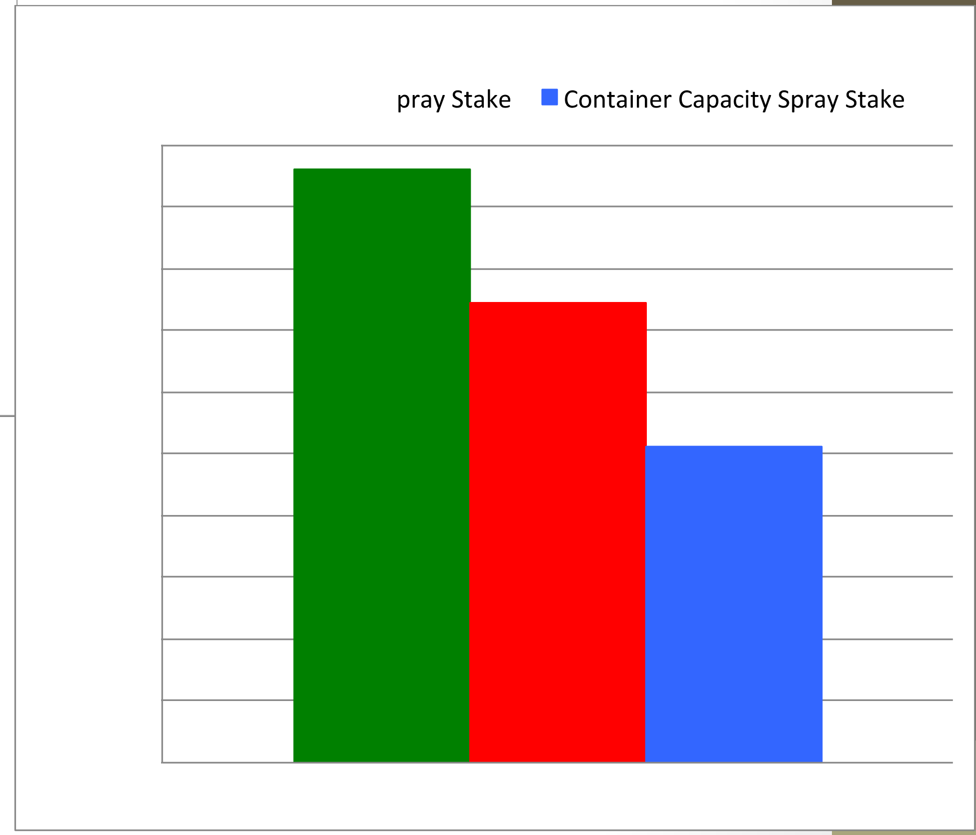
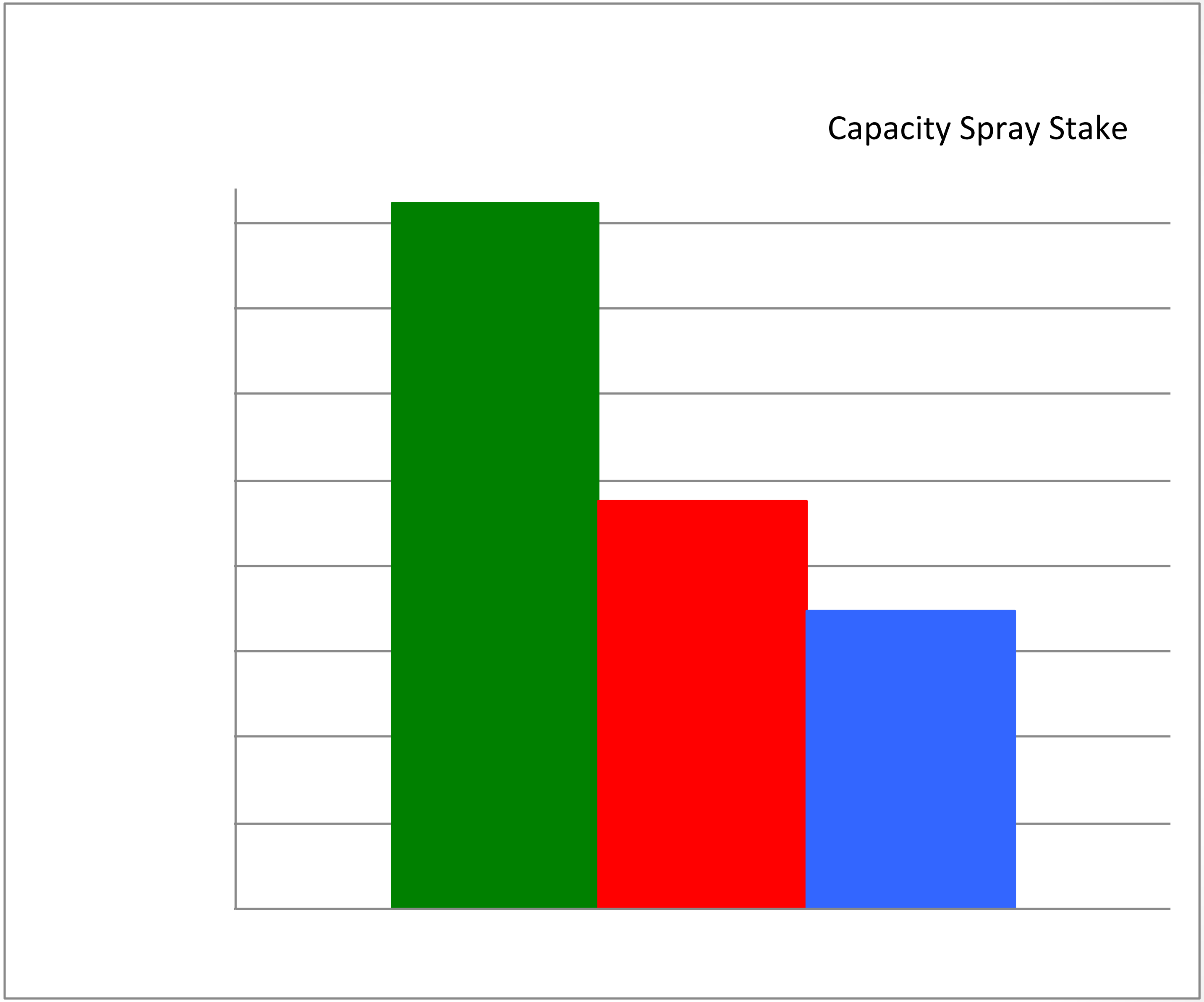



Sum of ± biweekly measurements

Sum of ± biweekly measurements



# Cost of Water at the Michigan State Research Nursery

- For 160 irrigation events per year = $0.032 cost per 3 gallon plant
- Reduce water use by 30% = $0.022 cost per plant
- Reduce water use by 70% = $0.009 cost per plant
- Reduce fertilizer leaching by 6% = save $0.005 per plant
- Saving **$0.015-$0.023** per plant, Whoopee!!
- Additional revenue of **$158-$242** per acre
- Water is cheap!

…..at least east of the Mississippi

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# McCorkle Nursery, GA

- Gardenia crop: 20,000 sq ft area with 23,400 plants (50,965 plants per acre)
- Gardenia was a “problem” crop for them
- Reduced production time from 11-22 to 8-11 months
- Improved survival from 10% loss to zero loss

Van Iersel, Chappell, Ruter, Lichtenberg, Majsztrik, U’s of GA and MD

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# Economic Impact

| Costs | |
|---|---|
| Control node | $675 |
| Sensors (4 @ $90) | $360 |
| Rain gauge | $300 |
| Base station, computer & software | $1,000 |
| Installation | $1,500 |
| **Total Cost** | **$3,835** |
| **Savings/Profit** | |
| Fewer plant losses | $13,000 ($6.50 per plant) |
| Time/interest (avg 6 months shorter production cycle @ 8%) | $500 |
| Less fertilizer, pesticides, maintenance, labor | $7,700 |
| **Total Savings/Profit** | **$21,200 ($0.90 per plant)** |
| **Net** | **$17,365** |

Van Iersel, Lea-Cox,Chappell, Ruter, Lichtenberg, Majsztrik, Belayneh; U's of GA and MD

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# Cost of Water

- Cheap! But not the consequences of over-irrigation
- For 160 irrigation events per year = **$0.032** cost per plant
- Save **$0.005** to **0.018** per plant!
- Less shrinkage, shorter production cycle, less fertilizer applied, less fertilizer lost, less labor, less pesticides used = up to **$0.90** more revenue per plant (remember this example is with a "problem" crop)
- Less off-site movement of water and contaminants

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# If scheduling done properly

- Use water more efficiently
- Retains fertilizer where it's needed
- Reduces certain problems with low quality water (alkalinity)
- Reduces plant losses
- Improves plant growth/quality
- Shortens production cycle (greatest cost benefit)
- Reduces runoff volume
- Reduces nutrient loss in runoff

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# Funding partners

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