Top ten tips to save water and fertilizer

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Why reducing nutrient leaching?

High nutrient consumption

- Ex. greenhouse tomatoes (Sonneveld and Voogt, 2009):
  - 1,060 lbs. N / acre / yr
  - 253 lbs. P / acre /yr
- Greenhouse container ornamental producers in Maryland (Majsztrikvet al., 2018):
  - 177 lbs. N / acre / yr
  - 47 lbs. P / acre /yr

Variability in fertilizer practices

Maryland Greenhouses (Majsztrikvet al., 2018)

Plant type/container size	No. of MUs	Quartile value	No. of plan ts/ha	NPK application rate[z] (kg/ha/yr) N	P_2O_5	K_2O
Annuals/10–11 cm	13	Lower	790,734	57	18	57
		Middle	858,147	112	37	112
		Upper	994,101	173	73	176
Annuals/20–30 cm	9	Lower	107,639	87	22	87
		Middle	134,783	88	26	88
		Upper	153,484	88	26	88
Annuals flats (e.g., 606, 1204)	15	Lower	736,160	59	18	59
		Middle	1,490,492	74	38	74
		Upper	2,554,543	176	79	162
Hanging baskets/25 cm	13	Lower	79,073	90	36	105
		Middle	107,436	206	129	194
		Upper	147,531	579	258	579

1 kg / ha = 0.9 lbs / acre

Variability in fertilizer practices

Maryland Greenhouses (Majsztrikvet al., 2018)

Plant type/container size	No. of MUs	Quartile value	No. of plan ts/ha	NPK application rate[z] (kg/ha/yr) N	P_2O_5	K_2O
Chrysanthemums/4–8 L	7	Lower	62,456	135	202	135
		Middle	107,639	188	349	188
		Upper	175,046	484	535	484
Poinsettias/8–18 cm	11	Lower	90,942	121	39	125
		Middle	154,999	191	196	241
		Upper	275,755	674	288	674
Poinsettias/20–25 cm	12	Lower	26,910	112	35	112
		Middle	62,021	256	110	262
		Upper	84,491	406	229	498

1 kg / ha = 0.9 lbs / acre

Increasing fertilizer costs

Know your crops fertilizer needs

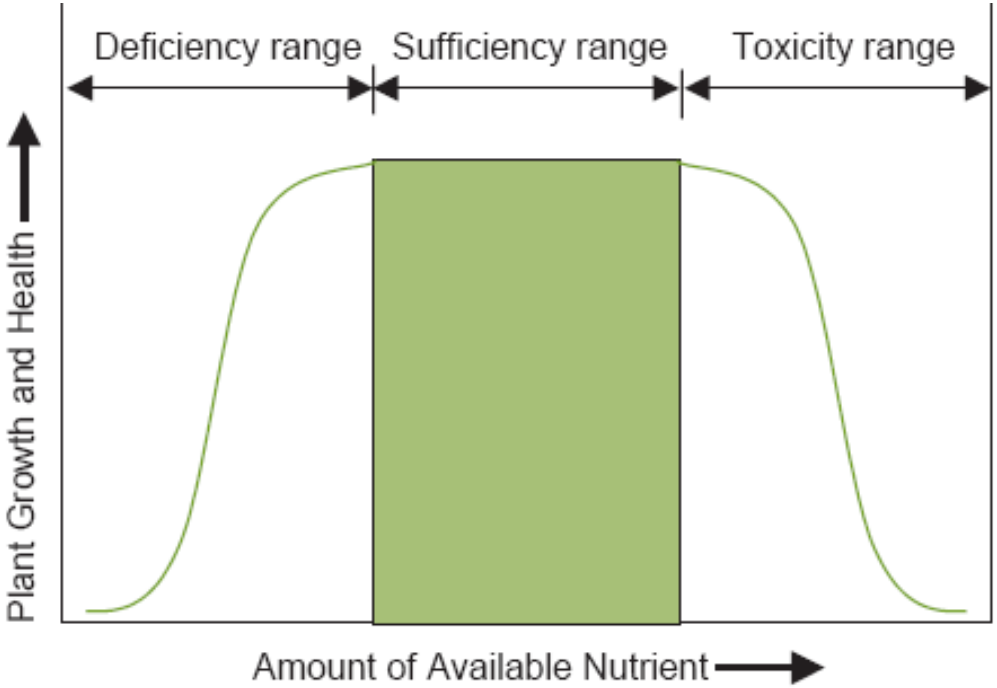


Figure 1. Relationship between plant growth and health and amount of nutrient available (Brady and Weil, 1999).

Fertilization impacts plant growth and quality

50 100 200 350 500

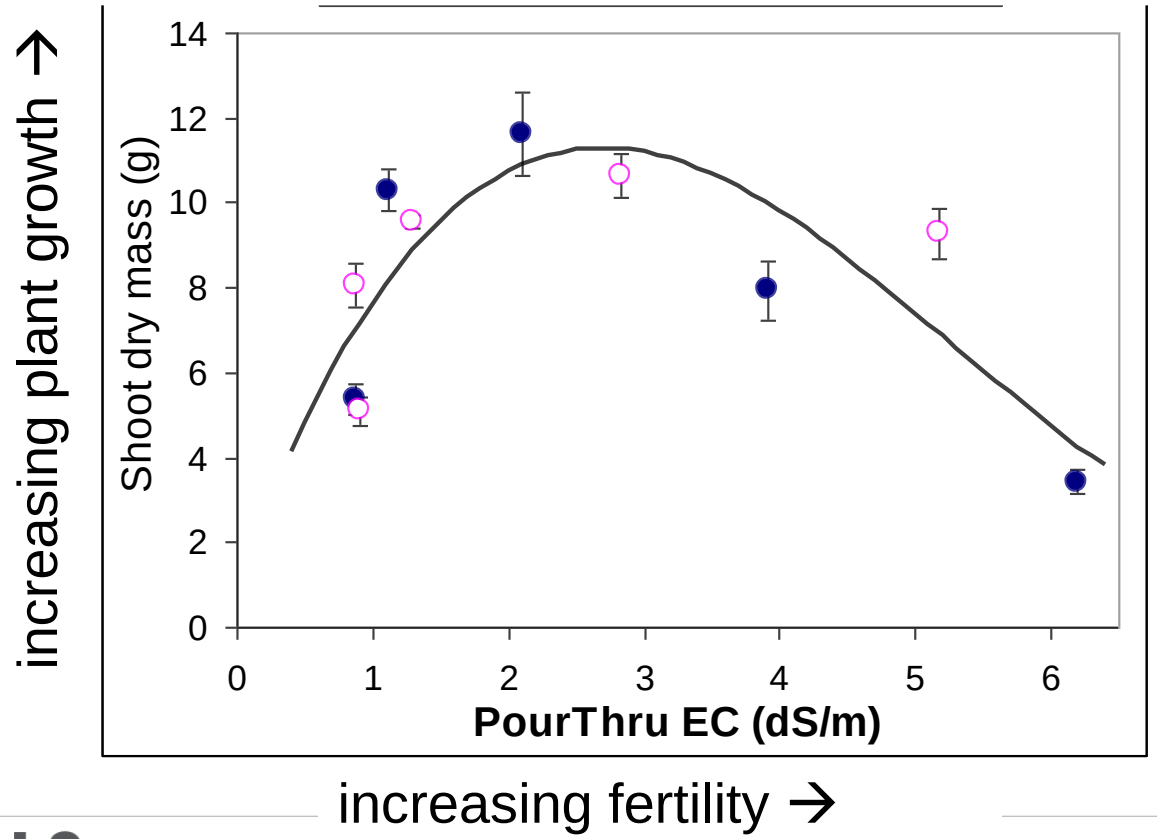
ppm Nitrogen

Impatiens ‘Super Elfin Mix’

50	100	200	350	500 ppm N
0.9	1.2	2.1	3.9	6.2 dS/m

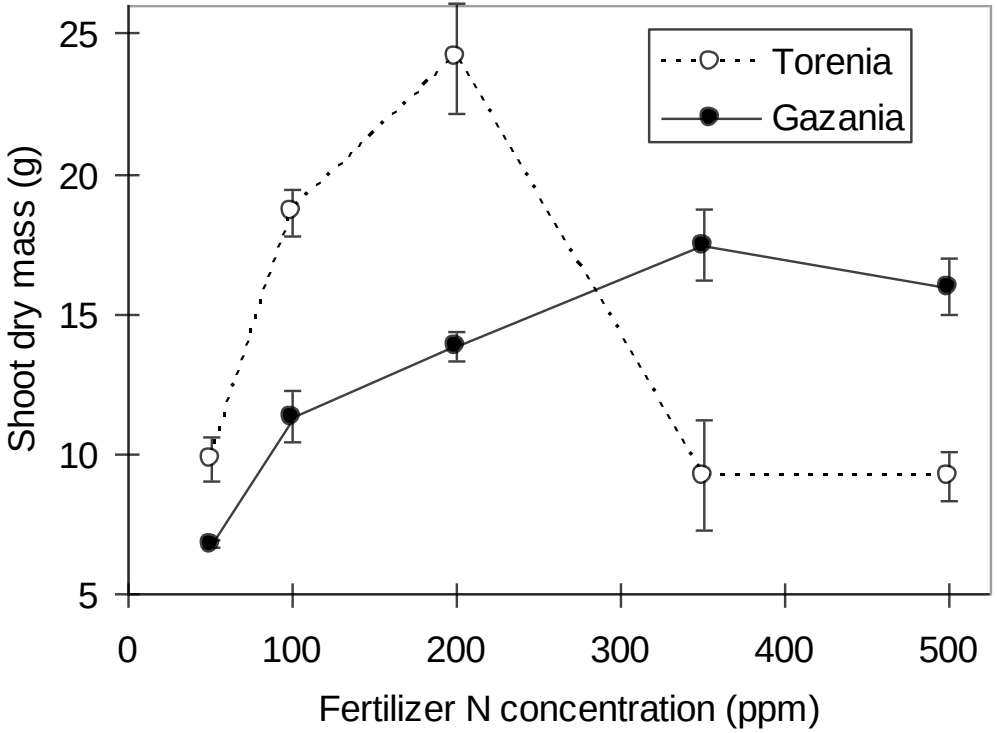
Subirrigation

Impatiens growth response to fertilizer



Type of Crop

Effect of fertilizer concentration on plant growth



Low fertility affects plant marketability

Low fertility

Normal fertility

A one-size fits all fertilizer solution is hard to find

Crops have:

- Different fertilizer requirements
  - Low, moderate, and heavy feeders
- Different pH requirements

Group crops by fertilizer requirements

Group	Light	Moderate	Heavy
Liquid fertilizer Rate	100 ppm N	150 ppm	200 ppm
Pour Thru EC (mS/cm)	1.0 – 2.6	1.5 – 3.5	2.6 – 4.6
Examples	Fibrous begonia Marigold New Guinea Impatiens Pansy Bedding plants in packs	Calibrachoa Dianthus Lantana Zonal geranium Petunias Snapdragon Many vegetative annuals	Garden mums Poinsettias Wave petunias (Hanging baskets with vegetative annuals)

What does it cost to fertilize 1 pot?

- Bag of 20-10-20 = $45.00
- At 250 ppm N this makes: 2,220 gallons of fertilizer water
- One 4½”-pot takes 1 cup water / day
  × 8 weeks → 224 fl oz. = 3.5 gallons

→$ 0.07 / pot

- 10,000 pots in one 30’ × 100’ greenhouse

→$700

What does it cost to fertilize 1 pot?

- Bag of 20-10-20 = $45.00
- At 150 ppm N this makes: 3937 gallons of fertilizer water
- One 4½”-pot takes 1 cup water / day
  × 8 weeks → 224 fl oz. = 3.5 gallons

→$ 0.04 / pot

- 10,000 pots in one 30’ × 100’ greenhouse

→$400 = SAVINGS of $300

Reduce leaching fraction / only leach when necessary

How often do you leach with clear water?

A) Never

B) 1+ times a week

C) Only when salts SEEM high

D) When EC measurements tell me salts are high

EC Guidelines

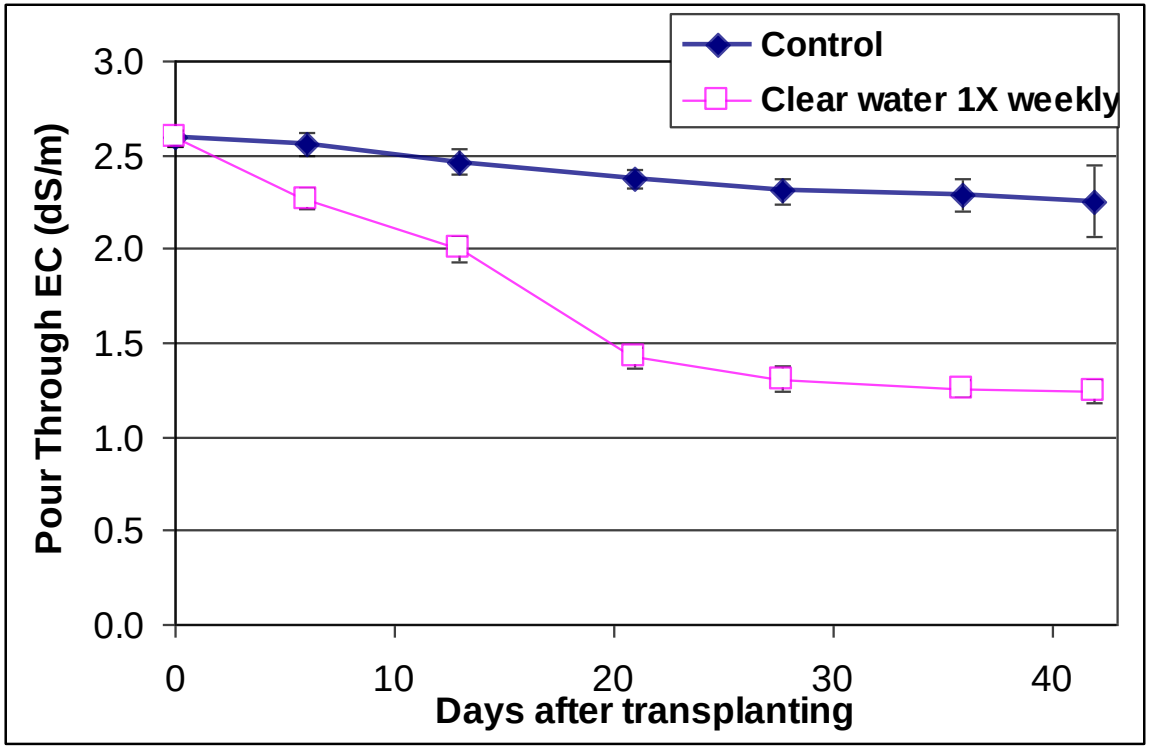
Table 3. EC interpretation values (mS/cm) for various extraction methods[1].				
1 : 5	1 : 2	SME	PourThru[2]	Indication
0 to 0.11	0 to 0.25	0 to 0.75	0 to 1.0	**Very Low.** Nutrient levels may not be sufficient to sustain rapid growth.
0.12 to 0.35	0.26 to 0.75	0.76 to 2.0	1.0 to 2.6	**Low.** Suitable for seedlings, bedding plants and salt sensitive plants.
0.36 to 0.65	0.76 to 1.25	2.0 to 3.5	2.6 to 4.6	**Normal.** Standard root zone range for most established plants. Upper range for salt sensitive plants.
0.66 to 0.89	1.26 to 1.75	3.5 to 5.0	4.6 to 6.5	**High.** Reduced vigor and growth may result, particularly during hot weather.
0.9 to 1.10	1.76 to 2.25	5.0 to 6.0	6.6 to 7.8	**Very High.** May result in salt injury due to reduced water uptake. Reduced growth rates likely. Symptoms include marginal leaf burn and wilting.
>1.1	>2.25	>6.0	>7.8	**Extreme.** Most crops will suffer salt injury at these levels. Immediate leaching required.

[1]Adapted from: On-site testing of growing media and irrigation water. 1996. British Columbia Ministry of Agriculture.
[2]Due to the variability of the PourThru technique results, growers should always compare their results to the SME method to establish acceptable ranges.

Source: NCSU http://www.pourthruinfo.com/

Leaching is an effective method to reduce salts

Example: Clear water application 1x / week



Leaching adds to fertilizer costs

- In the previous example
  - 150 ppm N not leached was normal fertility
  - Leached 1x week → low fertility
- Often not needed for short-term crops
- Should be done on substrate EC basis

Cost for 4½”-pot @ 150 ppm N = $0.04

With 20% leaching fraction → $0.05

50% leaching fraction @ 200 ppm N = $0.08

Know what your crop is really getting

Injector Calibration

- Fertigation / chemigation requires the injector to be working properly
  - Under application or over application can result
    - Ex: set at 1:100 but is delivering 1:130 – plants receive 30% less fertilizer than you planned
- Calibrate monthly
  - Check that it is within 5% (ex: 1:100 should be within 1:95 -1:105)

Injector not working leads to crop delays/losses

- Low overall fertility

Calibration EC method

- Uses an EC (electrical conductivity meter)
- Checks if EC from hose-end matches the value from the fertilizer label
- Also need to account for tap water EC

Fertilizer label and EC

- Fertilizer EC = Total EC - Tap water EC
- Example
  - Tap water EC = 0.5
  - Fertilizer EC (150 ppm N) = 0.96
  - Total EC = 1.46

Ounces of Peters EXCEL 21-5-20 Per Gallon of Concentrate						
Nitrogen	Injector Ratios*					E.C.**
ppm N	1:15	1:100	1:128	1:200	1:300	mmhos/cm
25	0.24	1.61	2.06	3.22	4.83	0.16
50	0.48	3.22	4.12	6.43	9.65	0.32
75	0.72	4.82	6.17	9.65	14.48	0.48
100	0.96	6.43	8.23	12.86	19.29	0.64
150	1.45	9.65	12.35	19.29	28.94	0.96
200	1.93	12.86	16.46	25.72	38.58	1.28
300	2.89	19.30	24.69	38.58	57.90	1.92
400	3.86	25.72	32.92	51.44	77.16	2.56

Troubleshooting

Calibration Volume Method

- Fill a container of known volume (A)
  - Ex: 5 gallon bucket
    - = 18,921 mL
    - = 220 ml
- Measure volume that injector line took up (B)
  - Put injector line in a small container with water
  - Cheap plastic graduated cylinders are ideal
  - Record volume
- Ratio is A / B

Injector calibration – volume method

- Ratio greater than expected
  - Ex: reads 1:120 but set at 1:100
  - Injector is dosing less than target
    - Low fertility or not enough product applied
- Rater lower than expected
  - Ex: reads 1:75 but set at 1:100
  - Injector is dosing more than expected
    - High fertility or too much product applied
- Aim for less than 5% difference
- Can make small adjustments with dialing in ratio or adjusting fertilizer calculations

Irrigate more efficiently

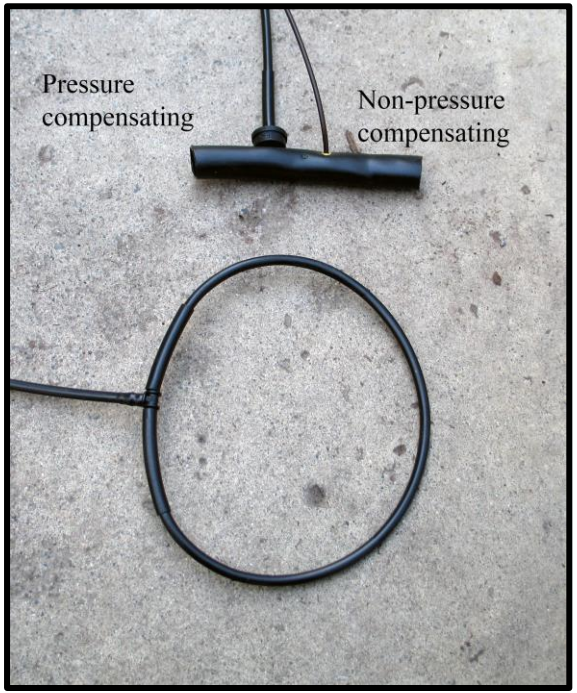
How much water is wasted?

Survey of 8 propagators (Fisher, 2008)

	Min	Avg	Max
Vol leached (gal / acre)	4,800	17,000	49,000
N applied (g/ft^2)	0.1	0.5	0.8
N leached (%)	14	22	45
N leached (lbs / acre)	3	10	16
cost N leached ($ / acre)	$15.54	$58.56	$97.00

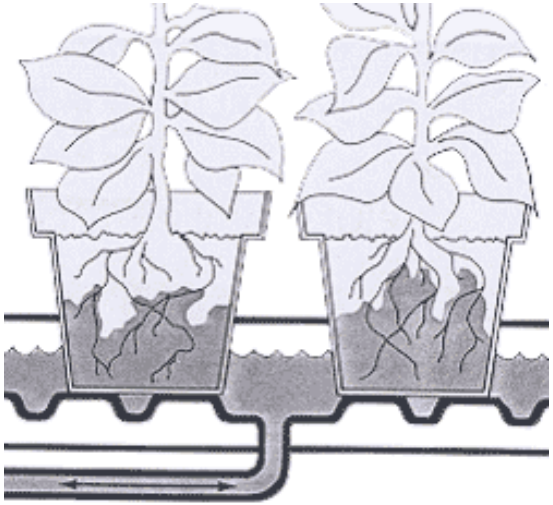
When to use drip irrigation?

- Watering labor becomes too much
- When overhead watering is inefficient
  - pots are spaced far apart
  - pots are hard to reach (hanging baskets)
- Longer term crops (i.e. poinsettia)
- Uniform drip system?
- Ability to turn off un-used lines



Subirrigation systems

- Watering from the bottom up
- Makes use of capillary action
- Allows for water capture and reuse



Ebb and Flow

Ebb and Flow Benches

Ebb and Flow – Common Problems

Troughs

Flooded floor

Heated floor required

Subirrigation: Advantages

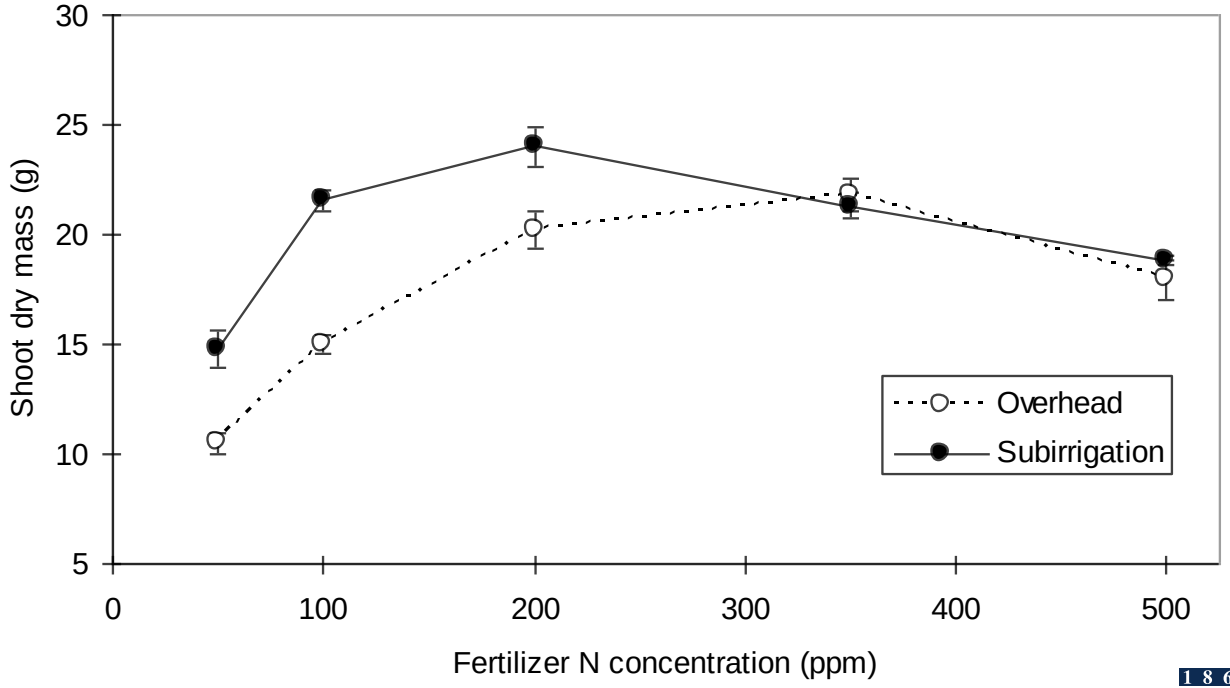
- Decreased labor for watering
- Increased uniformity of watering
- Less foliar disease
- Eliminates fertilizer and water leaching (environmental protection)
- Saves water and fertilizer expenses

Subirrigation: Disadvantages

- Cost of the system – payback time (3-10 years)
- Managing fertilizer and SALT levels
- Potential for spread of root-borne pathogens
  - Need for a filtration/disinfestation system

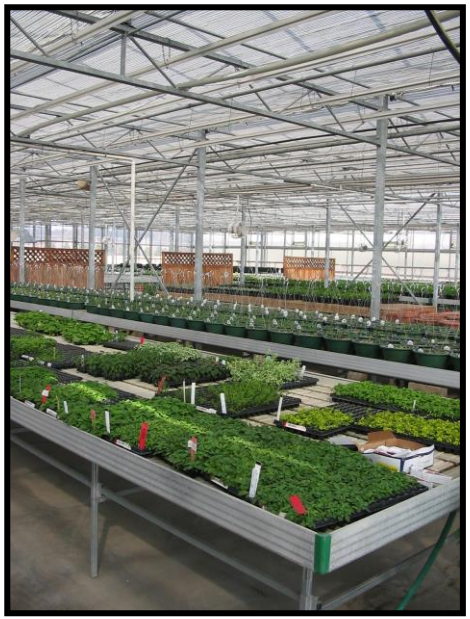
Sub-irrigation requires lower fertility

Snapdragon 'Rocket Light Pink'



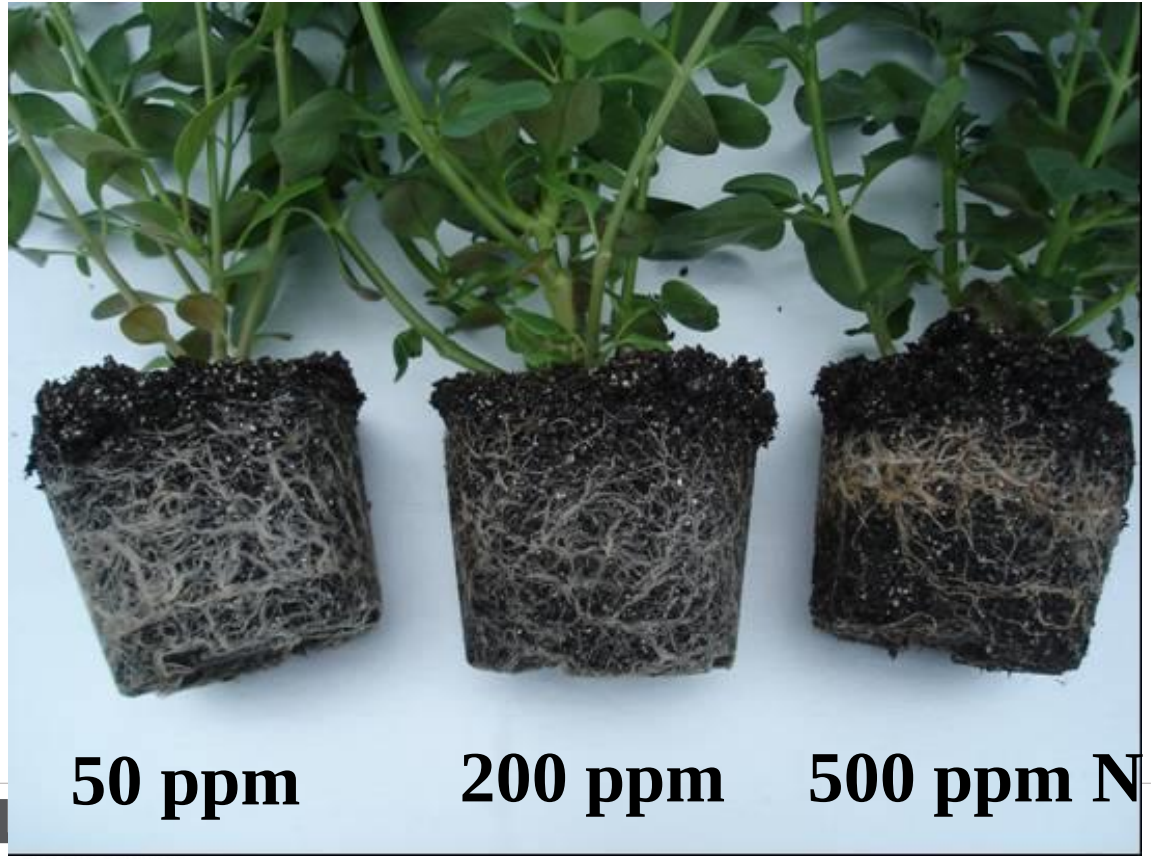
Sub-irrigation requires lower fertility

- Fertilization
  - Double Impatiens – 100 ppm
  - Begonia – 130 ppm
  - Poinsettia – 125-175 ppm
  - Zinnia – 105 ppm



Subirrigation causes salt buildup

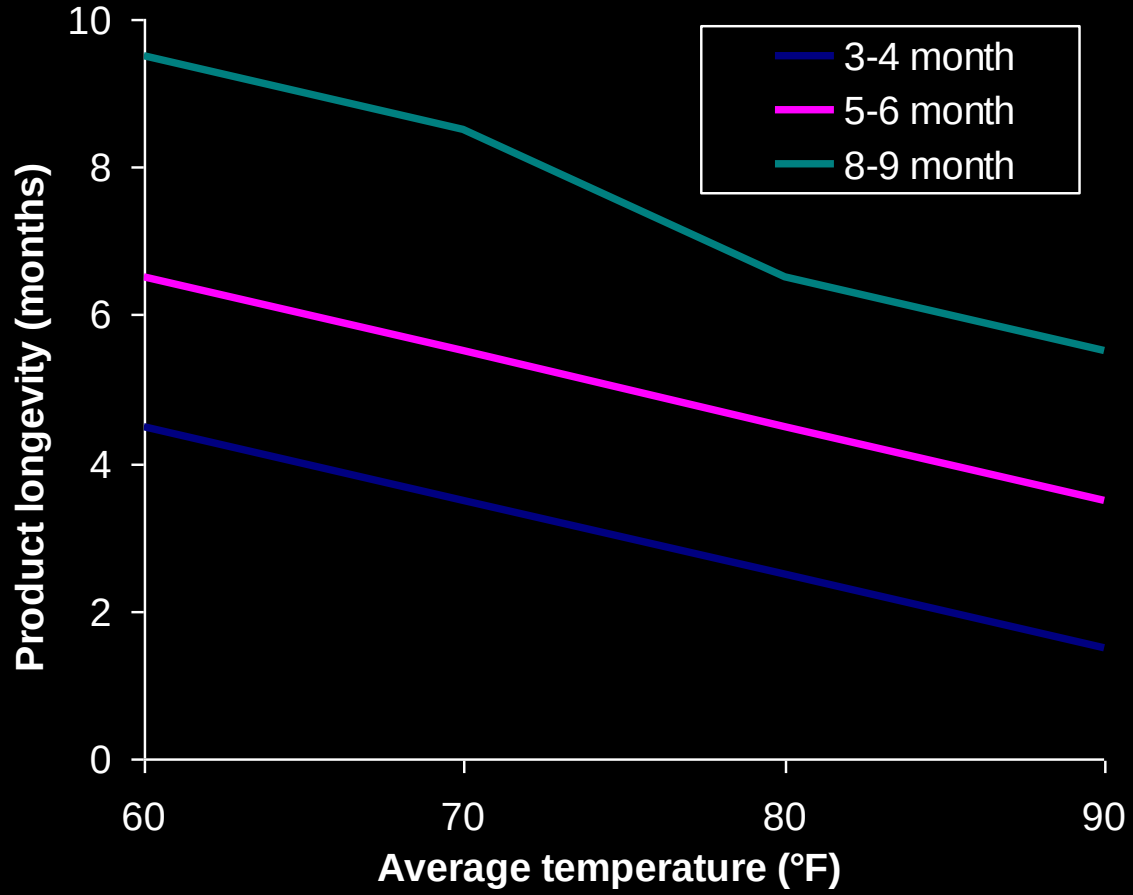
Snapdragon subirrigated with a complete fertilizer



Controlled Released Fertilizers

- Application
  - Top dressing
  - Incorporated
- Types
  - Urea-Formaldehyde
  - Sulfur-Coated
  - Polymer-Coated

Temperature controls rate of release



WSF
Only
250 ppm N

CRF
Only
10#/yd^3

Controlled release fertilizer (CRF) and water soluble fertilizer (WSF) on Garden Mums

Cultivar 'Helen'

WSF Only 250 ppm N

CRF Only 10#/yd^3

2 wks WSF

4 wks WSF

6 wks WSF

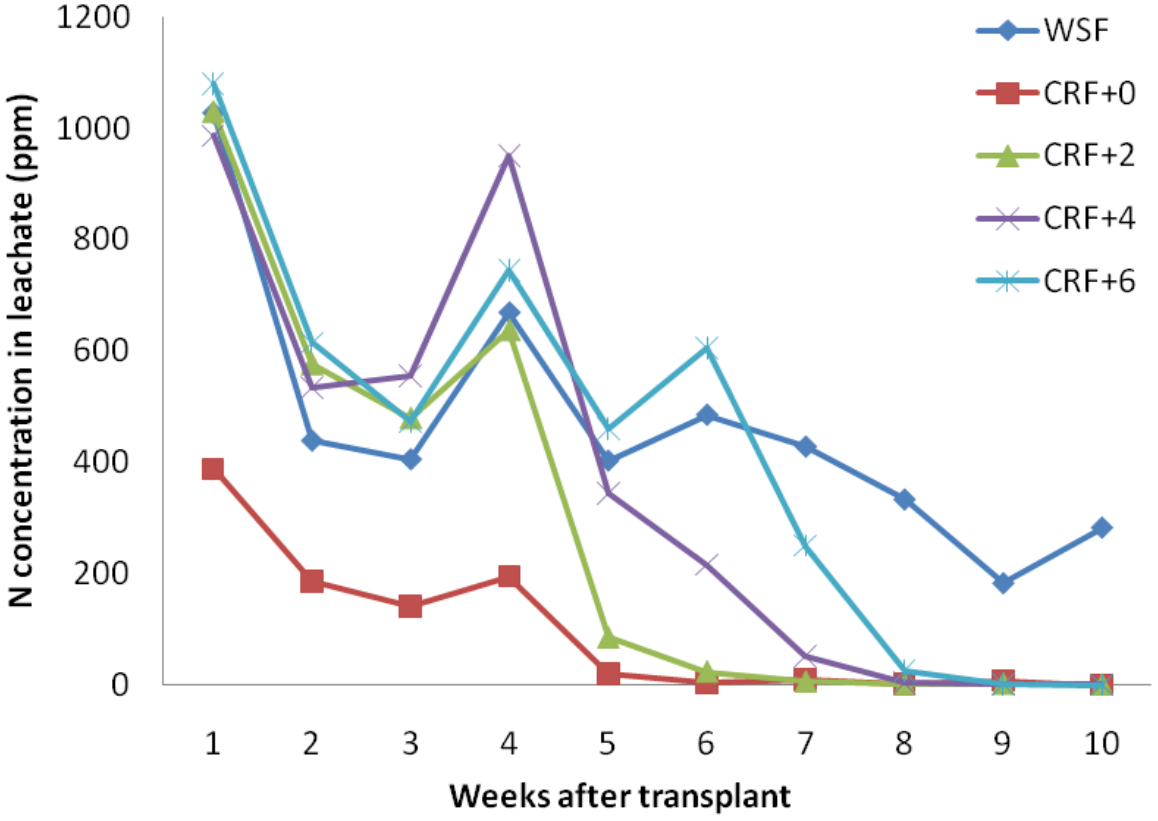
CRF 10#/yd^3 + WSF

Osmocote Plus 8-9 Month

Source: Mark Bridgen

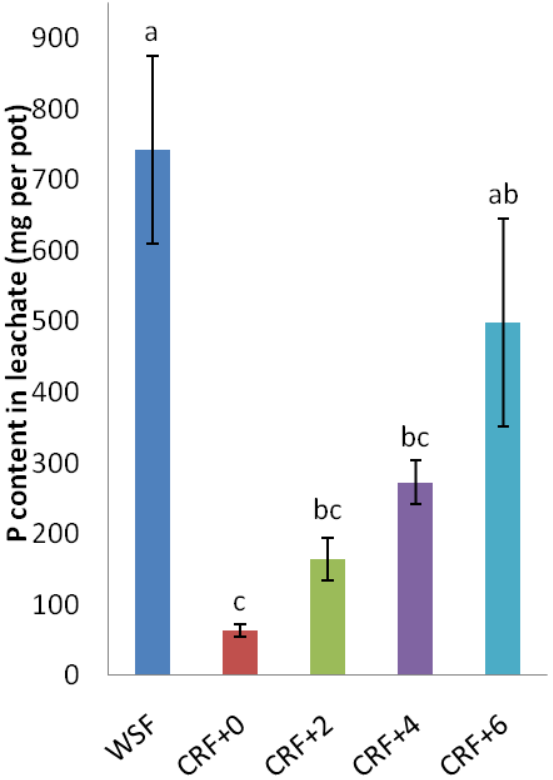
Nutrients in leachate

Nutrients in leachate

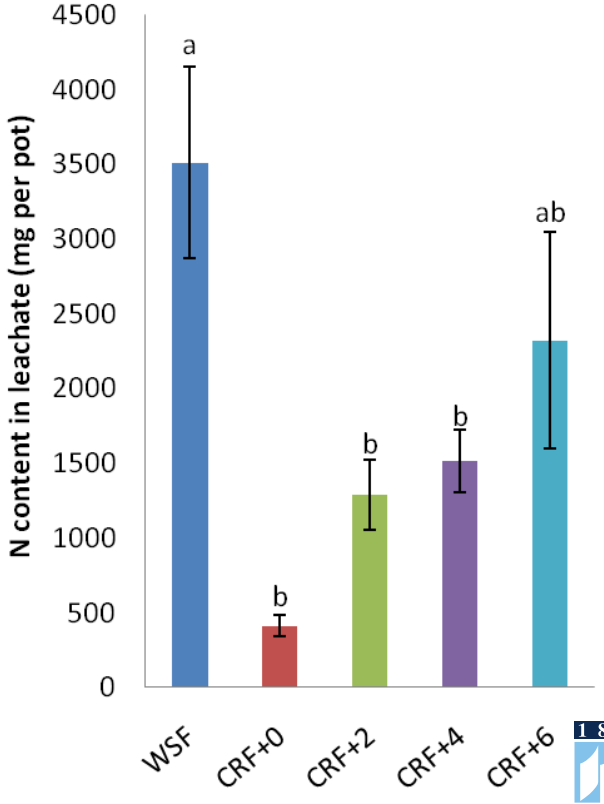


Total P and N Leaching

Phosphorus



Nitrogen



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Cost Comparison

Assumptions:

- 6 gallons of water used for 10 weeks
  - 10 mins drip/day, 0.5 gallons / hour
- $34 for 25# bag of 20-10-20
  - @250 ppm N → 2,370 gallons of water
- $100 for 50# bag of Osmocote Plus

Cost Comparison

WSF = water soluble fertilizer

CRF = controlled release fertilizer

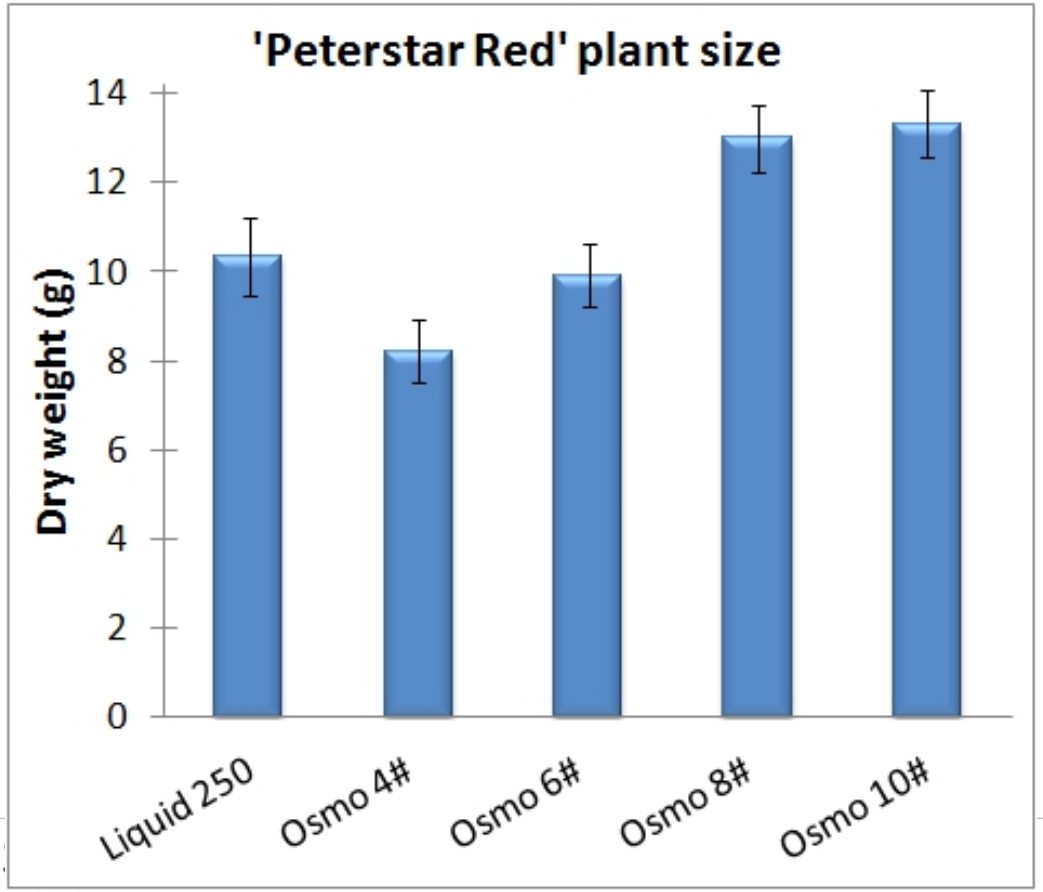
Treatments	Cost ($/pot)
• WSF	0.08
• CRF + 0 weeks WSF	0.15
• CRF + 2 weeks WSF	0.13
• CRF + 4 weeks WSF	0.15
• CRF + 6 weeks WSF	0.17

Poinsettia Trial

1. Constant liquid feed — 250 ppm N 21-5-20
2. Osmocote 5-6 month — 4# per cubic yard, top dressed
3. Osmocote 5-6 month — 6# per cubic yard, top dressed
4. Osmocote 5-6 month — 8# per cubic yard, top dressed
5. Osmocote 5-6 month — 10# per cubic yard, top dressed

- ‘Prestige Red’ (Dark Leafed)
- ‘Peterstar Red’ (Light Leafed)

Poinsettia Trial – Plant Growth



Peterstar Red

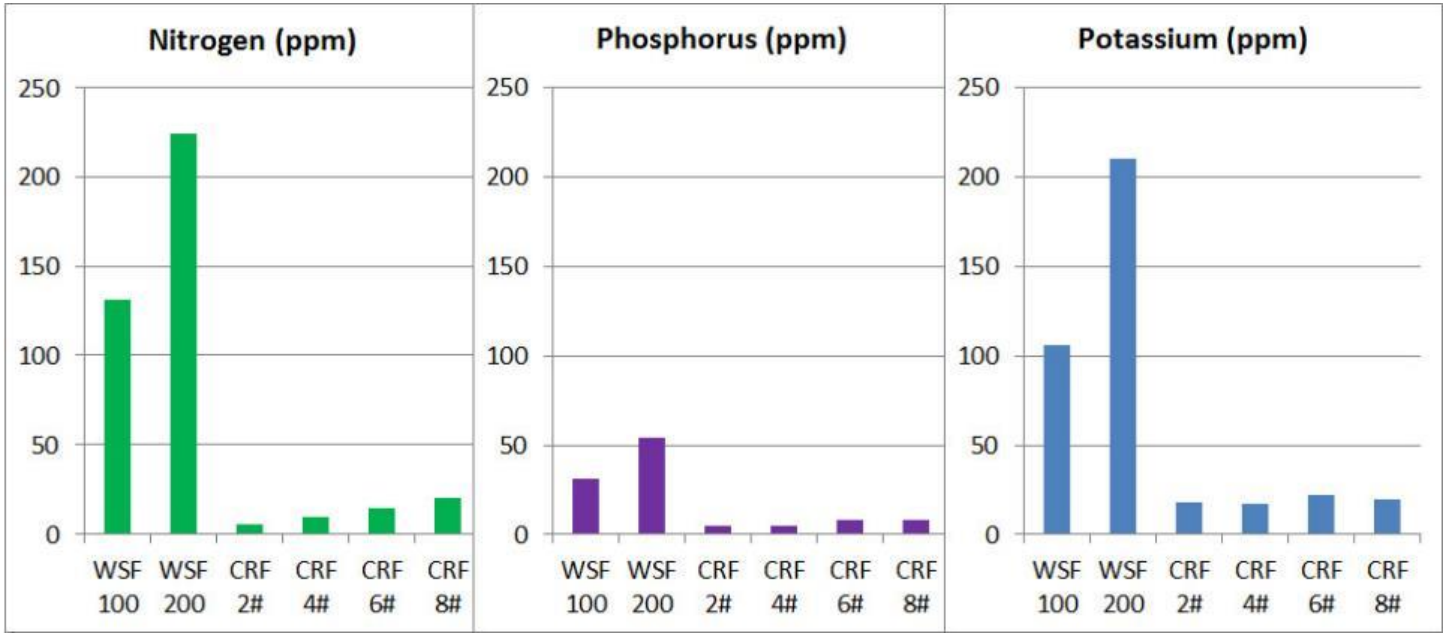
Liquid Osmocote 4# Osmocote 10#

Root Index – Peterstar Red

Liquid 250	2.9 C
Osmocote 4#	3.8 AB
Osmocote 6#	4.1 A
Osmocote 8#	4.6 A
Osmocote 10#	4.1 A

5	Large/White root system - roots growing all the way out to the edge of the container
4	Large root system, may not be completely white, may not grow completely to edge of container
3	Moderate root system, does not fill out the container, somewhat discolored
2	Poor root system, a bit of root growth out of the plug ball, quite discolored
1	Very poor root growth / small and dark brown color, plant pulls away from soil easily

CRF reduced nutrient leaching even when high label rate used



Concerns with Controlled Release

- PourThru values will be lower than liquid feed
- Will I run out of fertilizer?
  - Maybe, if temperature is warmer than 70 F
  - Can you prove to yourself that there is still fertility?
- Salt burn – not likely unless…
  - Excessively warm conditions without leaching
  - Overwintering and warm
  - Holding substrate with incorporated CRF too long

→DO remember to leach occasionally

If worried about rapid nutrient dump – move up to a longer release product (3-4mo. --> 5-6 mo.)

When to Use Controlled Release

- Conduct trials first!
- When injectors not available
- Target crops that irrigation method does not get water to efficiently
  - spaced out crops with overhead watering
  - hanging baskets
  - Garden mums with sprinkler irrigation
- Combinations CRF + water soluble program
  - 1 liquid feed rate
  - Add CRF for heavy feeders
- Insurance that your plants are getting fed

Fertilizer Insurance – Injector wasn't working

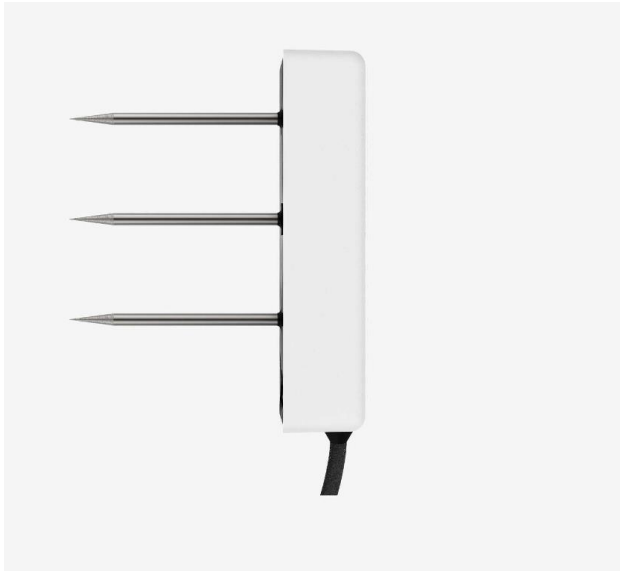
Clear water	Organic at 150 ppm	Osmocote
	NOT!	Med. Rate

Precision irrigation management

Soil Moisture Sensors

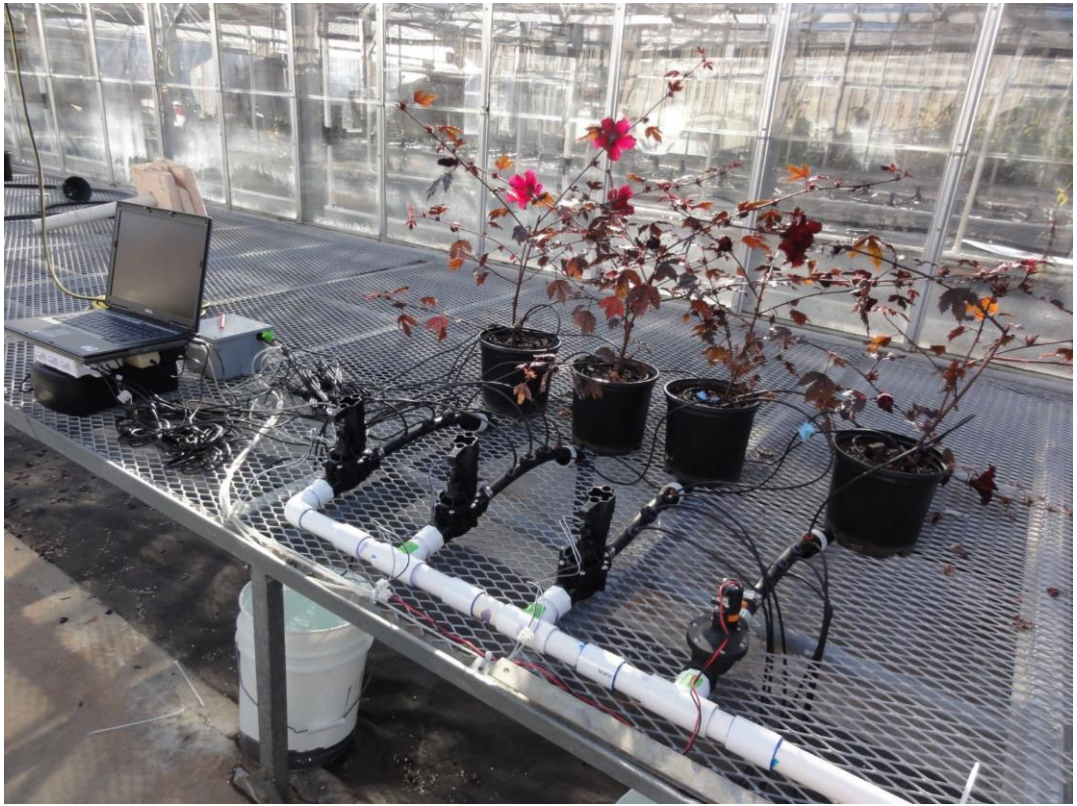
- Measure:
  - Volumetric water content
  - Substrate temperature
  - Electrical Conductivity

- Monitor with:
  - Argus, Priva
  - Meter loggers



Teros 12, Meter Group

Low-cost alternative for Monitoring: Arduino



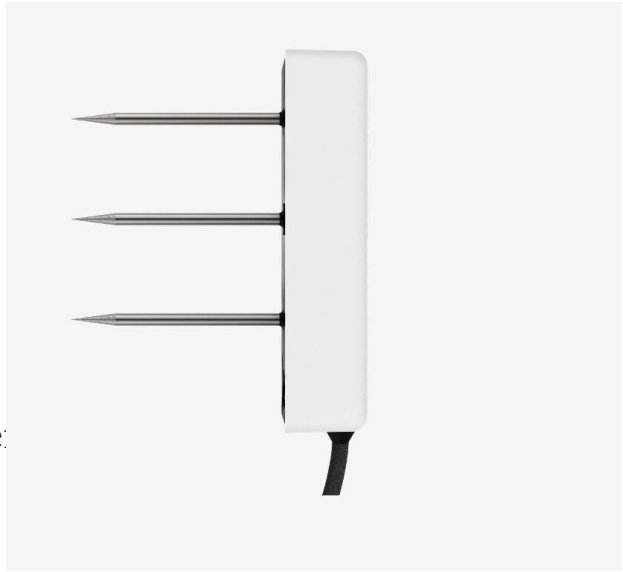
http://hortphys.uga.edu/irrigationcontrol.html

Precision irrigation management

Soil Moisture Sensors

- Installation considerations:
  - Insert the whole sensor
  - Place it where you want to measure

- Calibration:
  - Water content changes with substrate
  - Calibrate or become familiar with the measure



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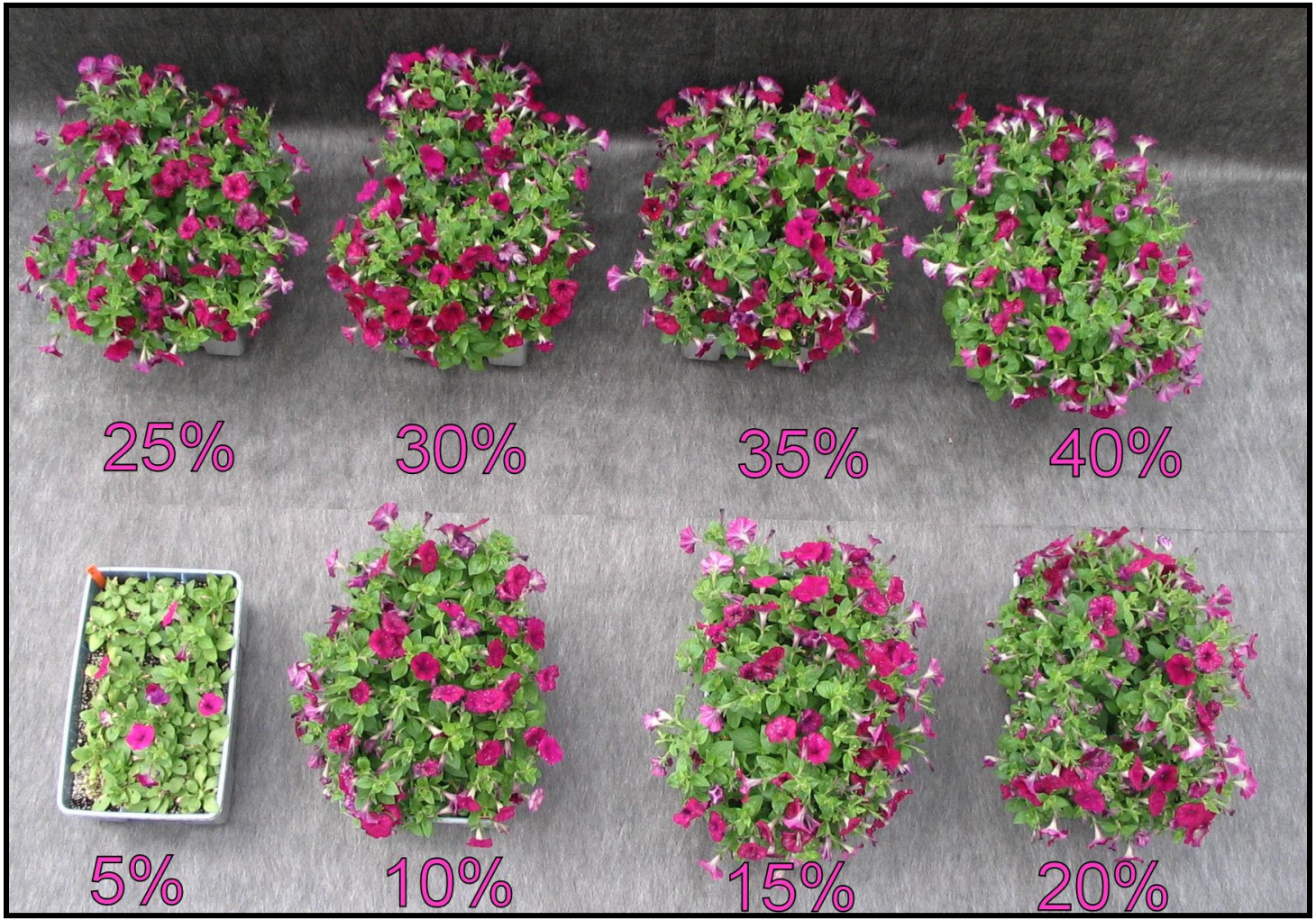
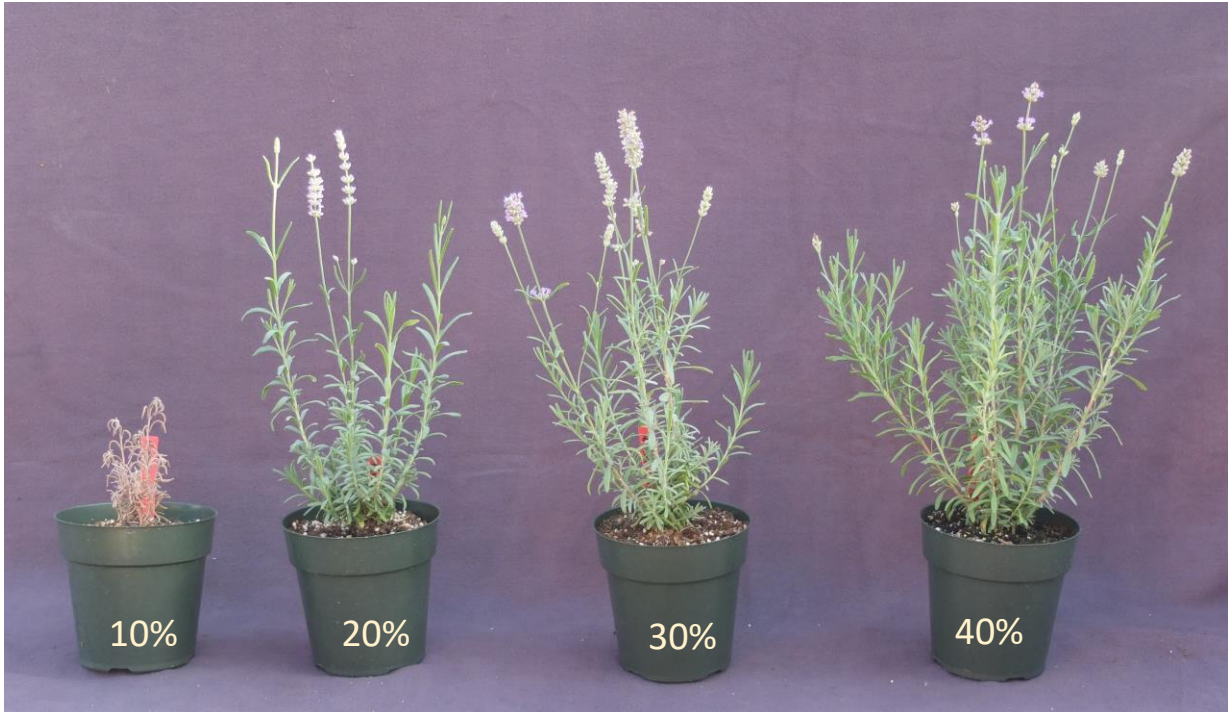

25%
30%
35%
40%
5%
10%
15%
20%

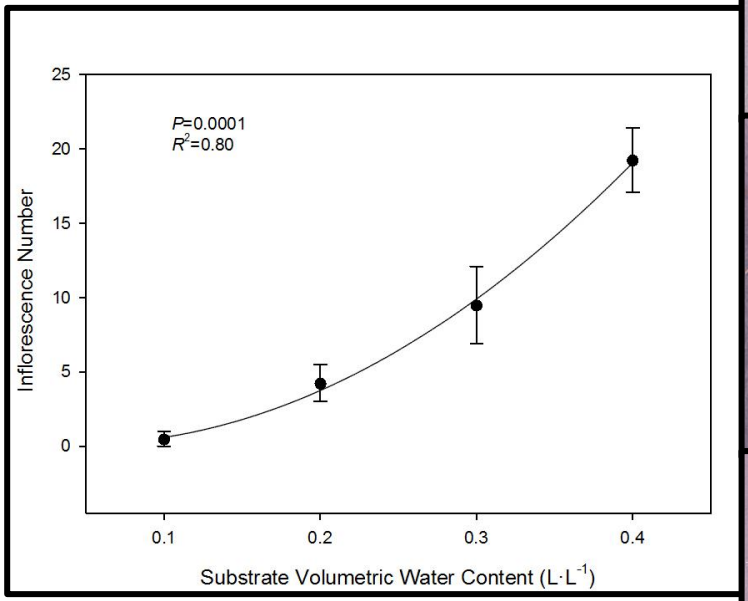
‘Hidcote’ English Lavender



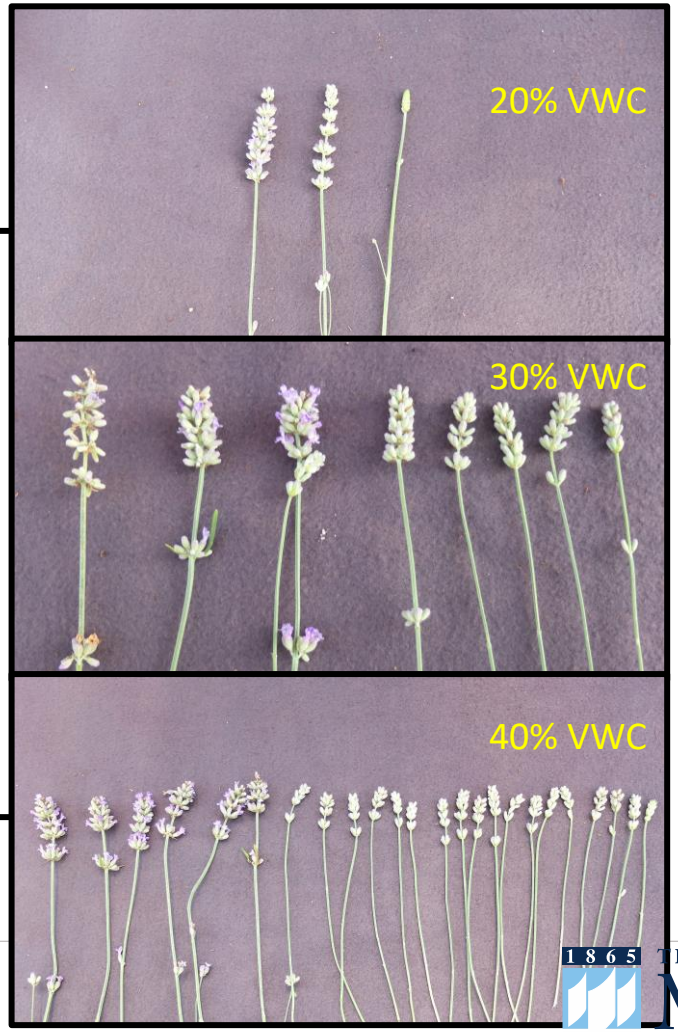
Less Water

More Water

English Lavender ‘Hidcote’



Inflorescence Number



‘Munstead’ English Lavender

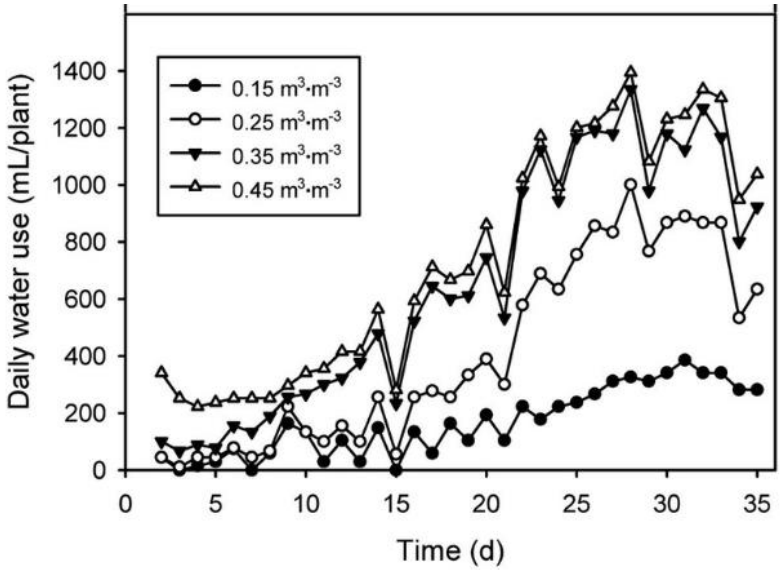
Less Water

More Water

Water use varies with plant species

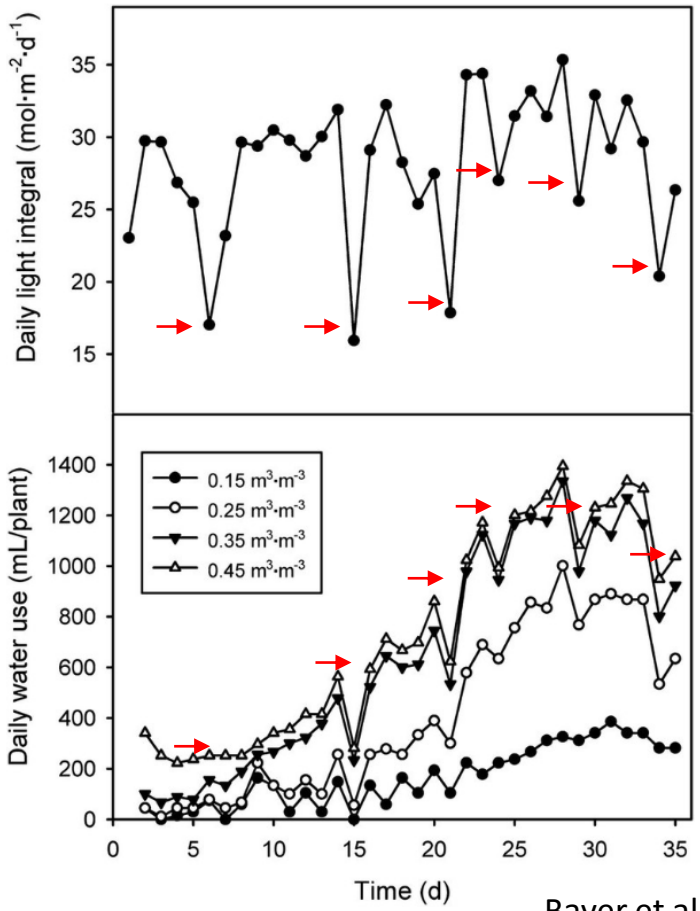
Less Water (10-20%)	Intermediate Water (20%-30%)	Most Water (30% or more)
Vinca	English lavender	Veronica 'Sunny Border Blue'
Columbine	Petunia	Hibiscus acetosella 'Panama Red'
Dianthus	Heuchera	Rosemary
Gaura	Coreopsis	Basil

Plant age and water use



Bayer et al., 2013

Light and water use



Bayer et al., 2013

Questions?

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