Going beyond liquid feed

Management practices that help to reduce nutrient leaching

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Northeast Greenhouse Conference
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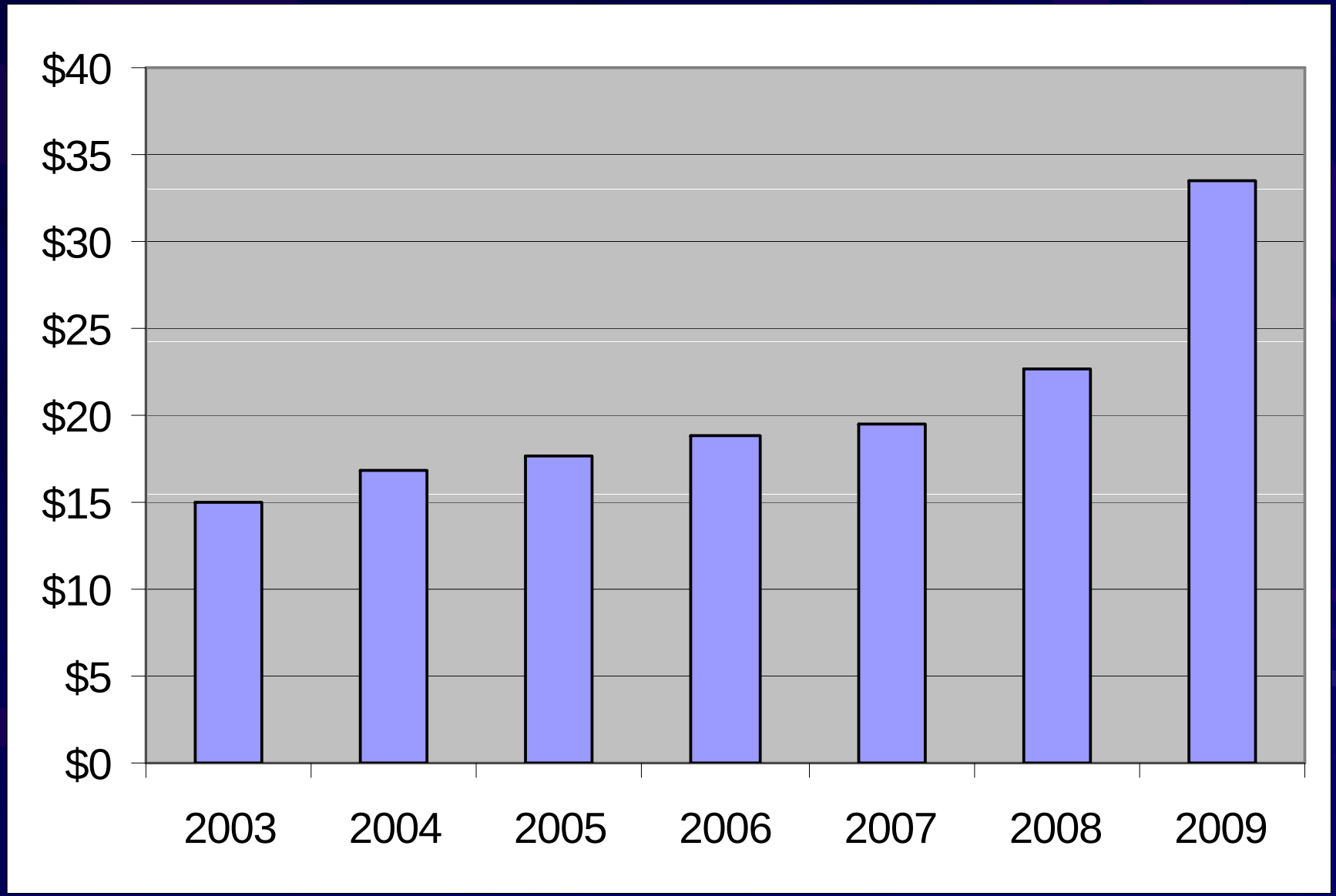
Skyrocketing Fertilizer Costs

25 lb bag of water soluble complete fertilizer



We are the GREEN industry!
and
good stewards
of the environment

Watershed

We should ALL be concerned!

Why Should You Care about Nutrient Leaching?

- **Efficient use** of water and fertilizer can:
  - grow a higher quality plant
  - save MONEY
- Consider **pesticides**
- Consider **groundwater and surface water protection**
- **Government Regulation!**
  - States with Ag production fertilizer use laws (to varying degrees) include:
    - Pennsylvania, West Virginia, Virginia, Maryland, Nebraska, Michigan, Arizona, Wisconsin, and Florida
  - Also some homeowner fertilizer use laws

Management practices that help to reduce leaching

- **Bridgen:**
  - How this research began
  - Mum studies: Advantages of using Controlled Release Fertilizers (CRF)
- **Mattson:**
  - Results of CRF work with poinsettias, bedding plants, and mums
  - Costs of CRF vs. CLF
- **Catlin:**
  - Practices to reduce leaching
  - Efficiency with irrigation

- **Our Mum Sponsors:**
  - Ball Chrysanthemum
  - GroLink Chrysanthemums
  - Syngenta (Yoder Brothers)
- **Scotts:** Osmocote fertilizers and funding
- **SunGro:** Sunshine Mix #8

Objective

To compare:

- Water Soluble Fertilizers (WSF)
- Controlled Release Fertilizers (CRF)
- Combination Program of CRF for 2, 4, & 6 weeks of WSF

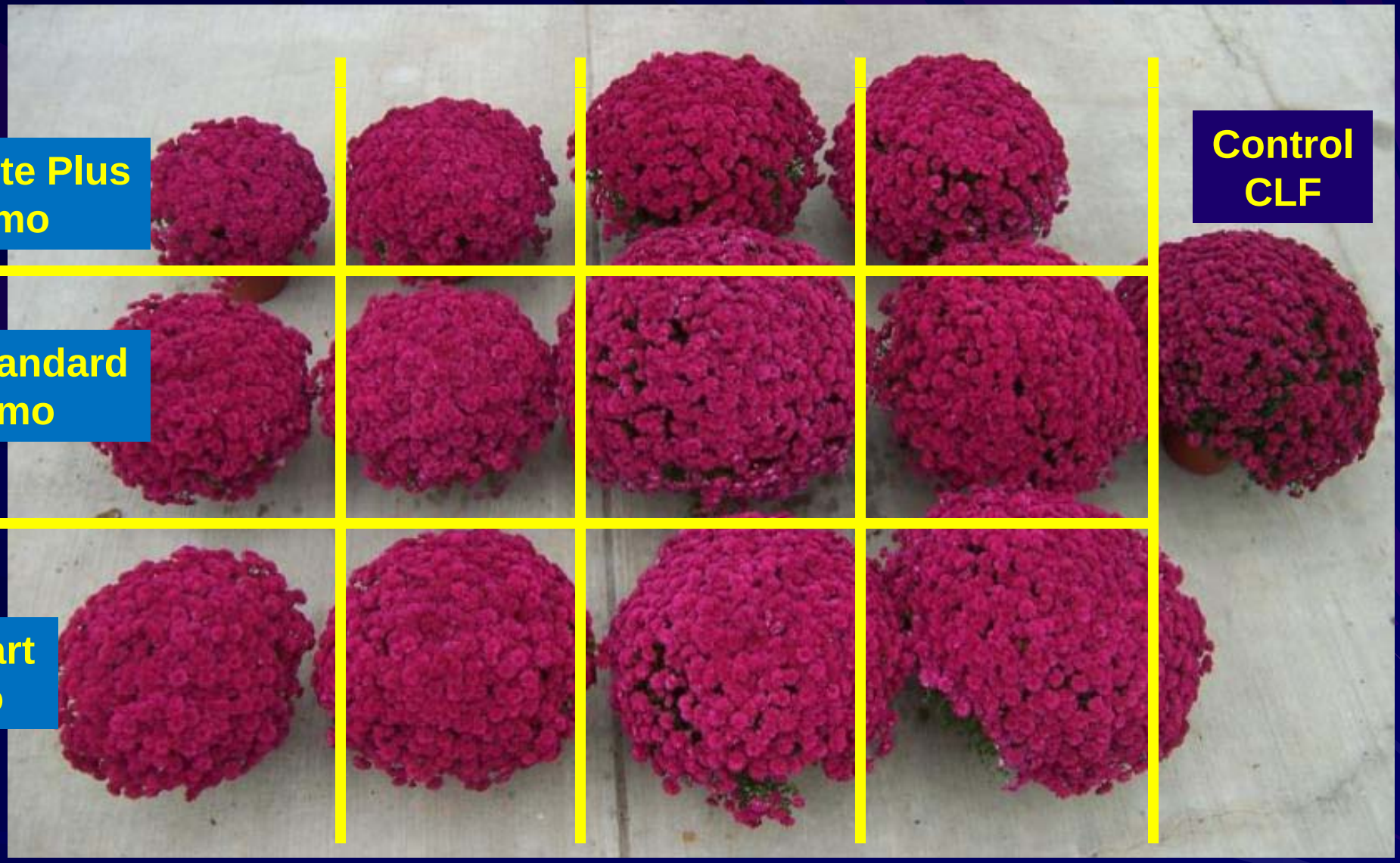
To quantify nutrient leaching and plant growth in response to fertilizer type

How We Grew Our Mums

- Planted: Week of June 22
  - 1 cutting per pot
- 9.5 inch plastic pan pots
- Sunshine #8 growing medium
- No pinch, No growth regulators
- Rooted cuttings direct stuck outside
- Drip irrigation

2007: Cultivar ‘Coparo’

HISTORY OF THIS RESEARCH



2008

What about growing with only a Controlled Release Fertilizer (CRF)? ie, NO liquid feed?

Osmocote Plus 3-4 month

control high medium low

2008

Osmocote Plus 5-6 month

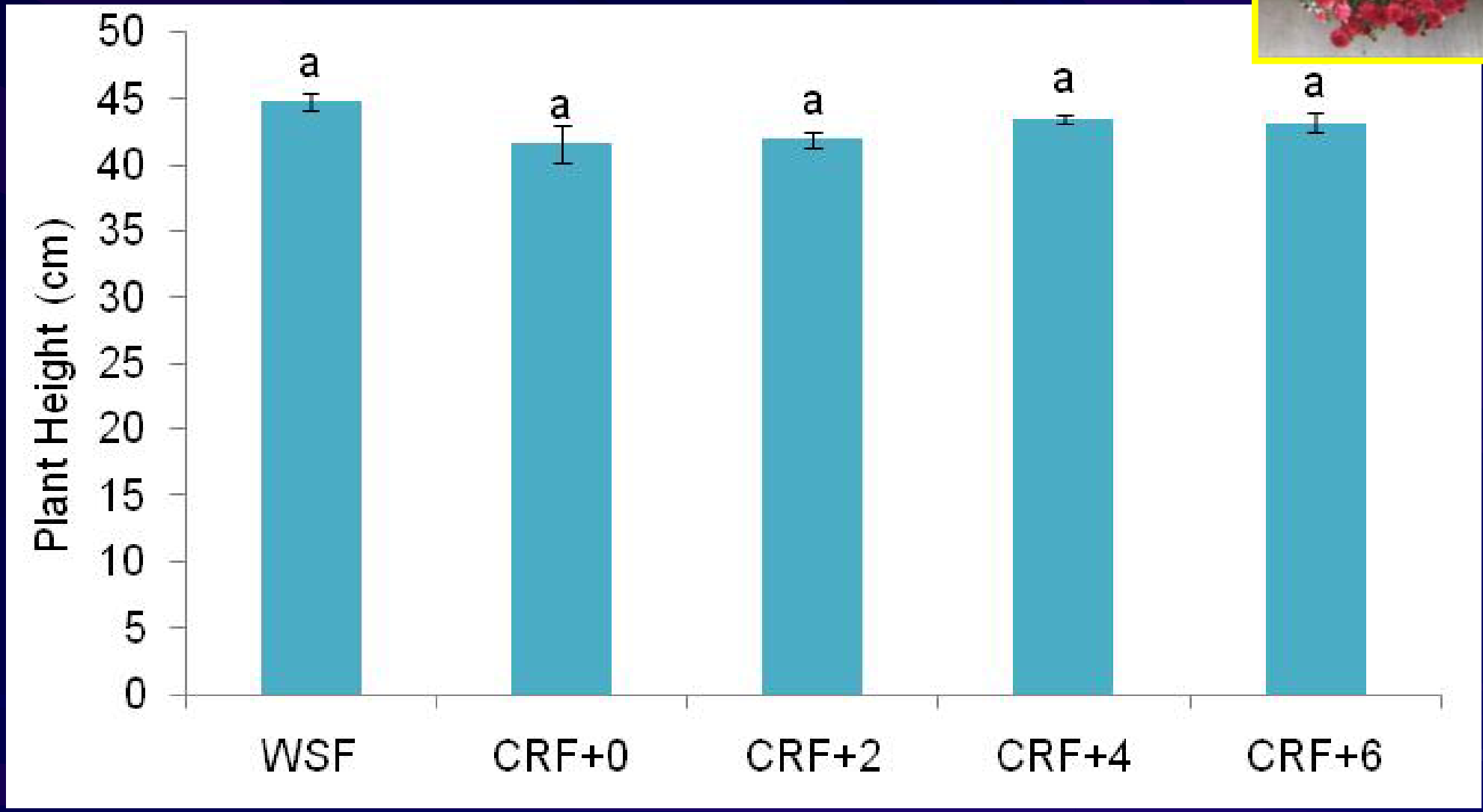
control high medium low

Osmocote Plus 8-9 month

control high medium low

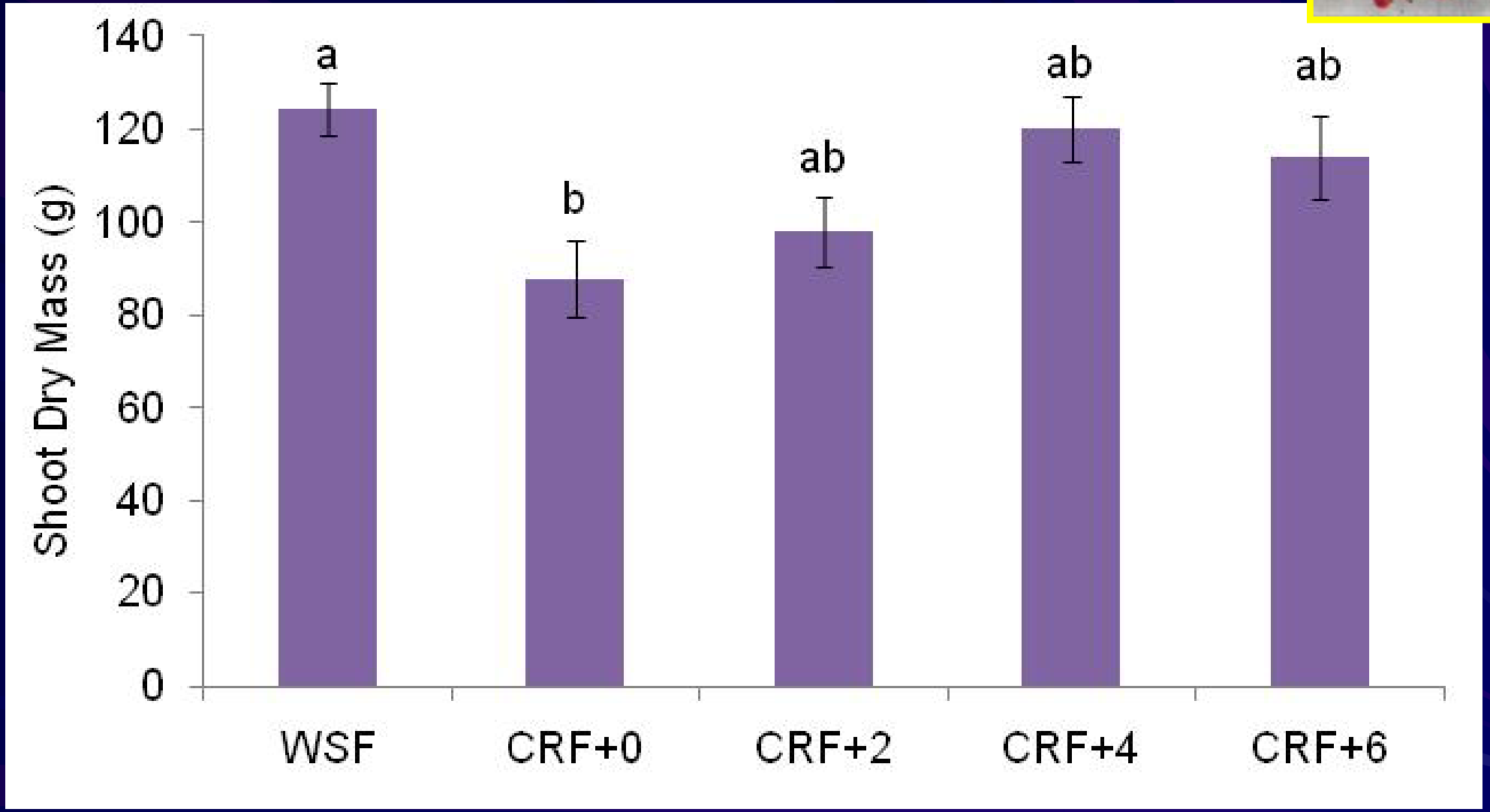
‘Terrano White’

2008 ‘Helen’ Plant Height



Anova *P*=0.08 Letters represent mean separation comparison using Tukey’s HSD, alpha=0.05

2008 ‘Helen’ Plant Dry Mass



Anova *P*=0.019 Letters represent mean separation comparison using Tukey’s HSD, alpha=0.05

Leachate Collecting Procedures

- 6 replications per treatment
- Leachate collected every 2 weeks
- Samples sent to be analyzed

2009 Treatments

Trt1-Control	Liquid Fertilizer	250 ppm constant liquid feed
Trt 2	16-9-12; 5-6 month; High Start	5 lbs/cu.yard
Trt 3	16-9-12; 5-6 month; High Start	9.3 lbs/cu.yard
Trt 4	15-9-12; 5-6 month	5.3 lbs/cu.yard
Trt 5	**15-9-12; 5-6 month**	**5.3 lbs/cu.yard + 4 wks**
Trt 6	15-9-12; 5-6 month	10 lbs/cu.yard
Trt 7	16-9-12 8-9 month; High Start	8.7 lbs/cu.yard
Trt 8	16-9-12 8-9 month; High Start	10 lbs/cu.yard
Trt 9	15-9-12; 8-9 month	8.7 lbs/cu.yard
Trt 10	**15-9-12; 8-9 month**	**8.7 cu.yard + 4 wks**
Trt 11	15-9-12; 8-9 month	10 lbs/cu.yard
Trt 12	15-9-12; 8-9 month	13.3 lbs/cu.yard

Observation 1: Trt 1 (CLF), Trt 5, and Trt 10 are same size and largest.

Trt 1 Control | Trt 2 | Trt 3 | Trt 4 | Trt 5 | Trt 6 | Trt 7 | Trt 8 | Trt 9 | Trt 10 | Trt 11 | Trt 12

***Remember Trt 5 and Trt 10 each had 4 weeks of CLF**

Treatment 1
Control
CLF

Treatment 5
15-9-12
5-6 months
+ 4 weeks CLF

Treatment 10
15-9-12
8-9 months
+ 4 weeks CLF

Treatment 1	Treatment 4	Treatment 5	Treatment 9	Treatment 10
Control	15-9-12	15-9-12	15-9-12	15-9-12
CLF	5-6 months	5-6 months	8-9 months	8-9 months
		+ 4 weeks CLF		+ 4 weeks CLF

Observation 2: Trt 1 (CLF) had the greatest delay in flowering Trt 5, and Trt 10 had a slight delay in flowering.

Trt 1 Control | Trt 2 | Trt 3 | Trt 4 | Trt 5 | Trt 6 | Trt 7 | Trt 8 | Trt 9 | Trt 10 | Trt 11 | Trt 12

Observation 2: Trt 1 (CLF) had the greatest delay in flowering Trt 5, and Trt 10 had a slight delay in flowering.

Trt 1 Control | Trt 2 | Trt 3 | Trt 4 | Trt 5 | Trt 6 | Trt 7 | Trt 8 | Trt 9 | Trt 10 | Trt 11 | Trt 12

Observation #3: Smallest plants were Trt 2, Trt 4, & Trt 9*

Trt 1 Control | Trt 2 | Trt 3 | Trt 4 | Trt 5 | Trt 6 | Trt 7 | Trt 8 | Trt 9 | Trt 10 | Trt 11 | Trt 12

*** Under 9# per cubic yard is least effective**

Observation #4: ALL plants would be commercially acceptable!

Trt 1 Control | Trt 2 | Trt 3 | Trt 4 | Trt 5 | Trt 6 | Trt 7 | Trt 8 | Trt 9 | Trt 10 | Trt 11 | Trt 12

WHAT HAVE WE LEARNED:

Mums can be grown with CRF only
- but use at least 9#/cu.yd of N.

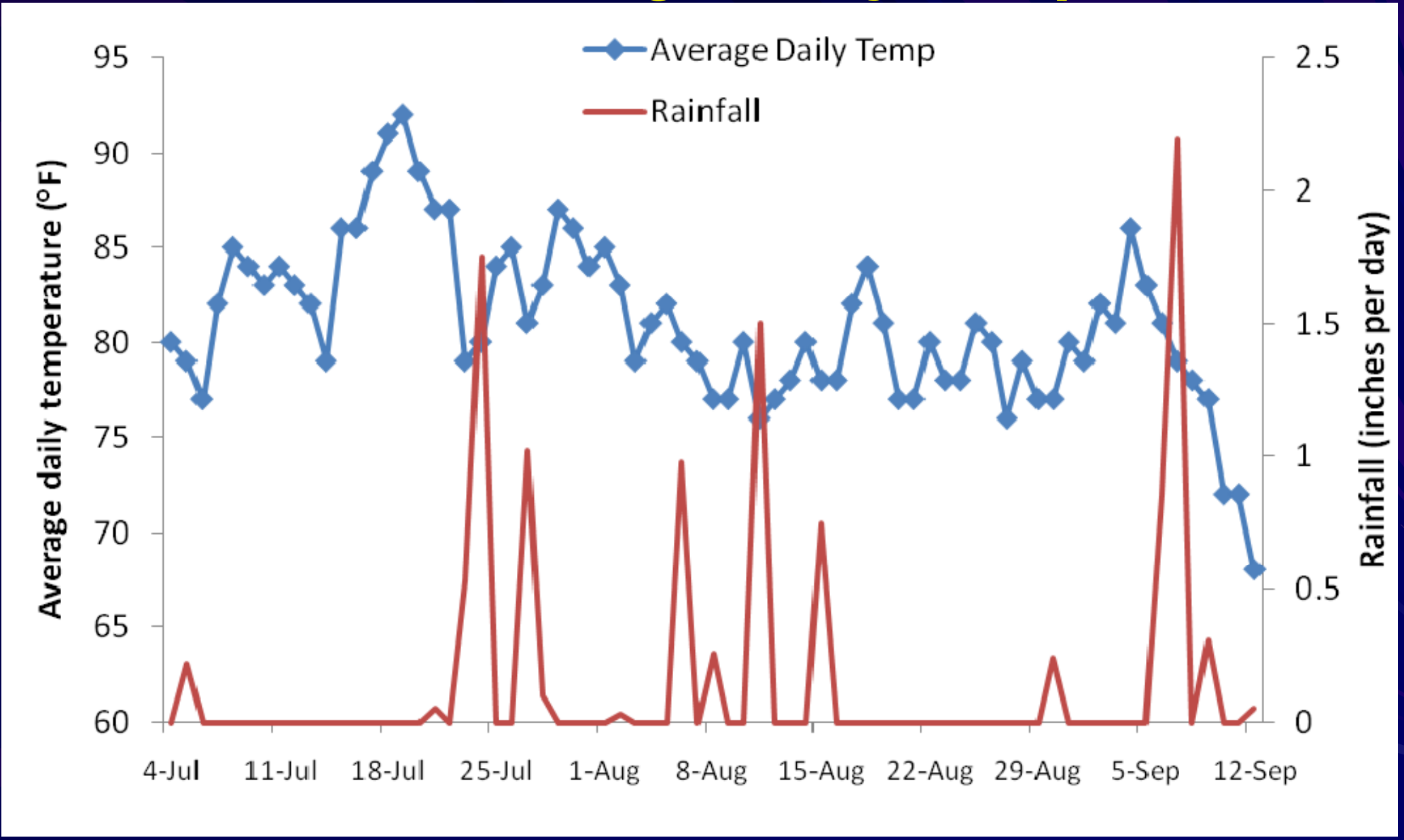
Nutrient leaching is much less if CRF are used.

Fertilization during the first 4-6 weeks is most important!

Nutrient Leaching Summer 2008

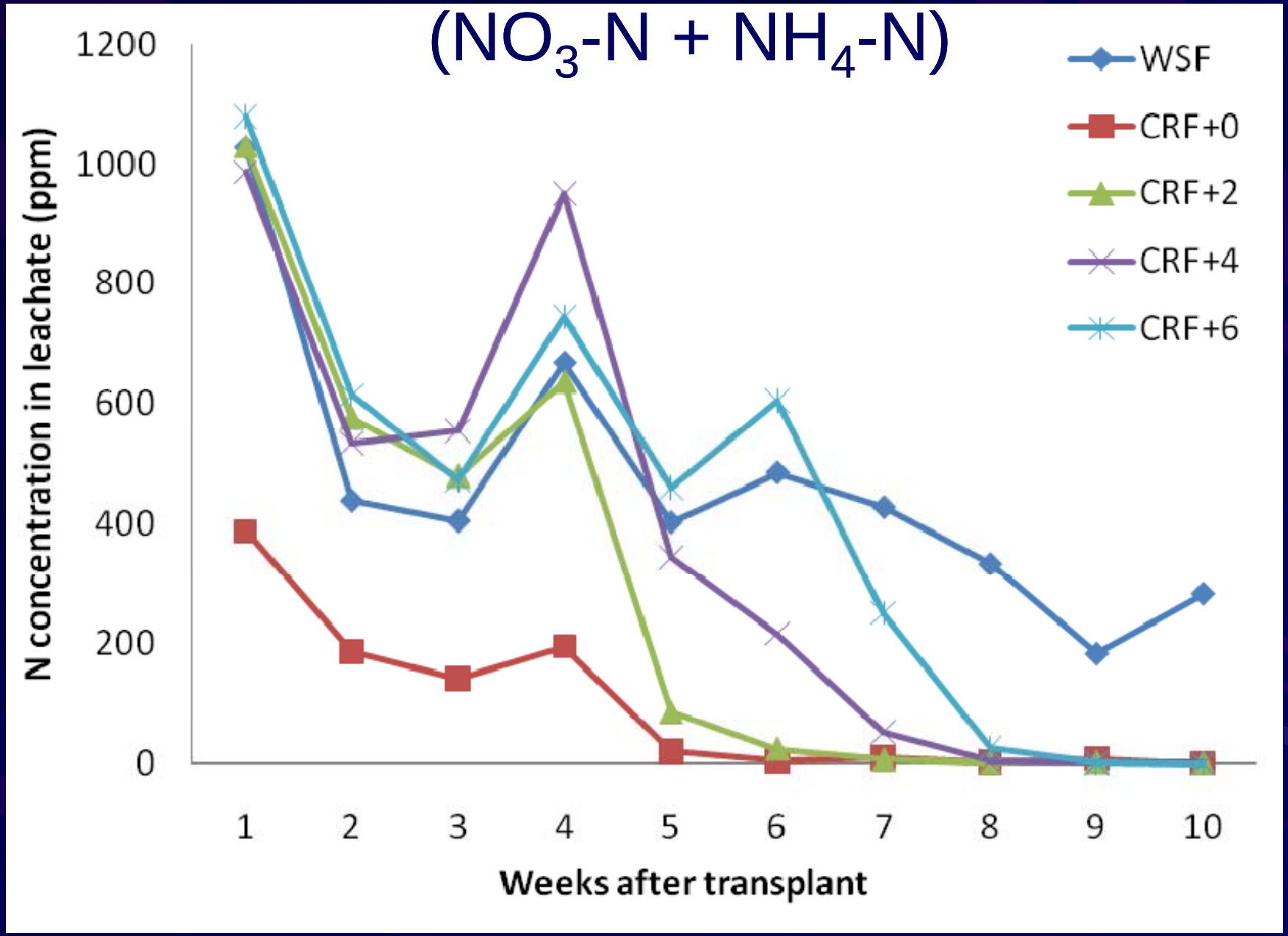
- Leachate collected weekly
- Total volume of water weighted
- Samples sent to a commercial lab (The Scotts Lab)

Rainfall and average daily temperature



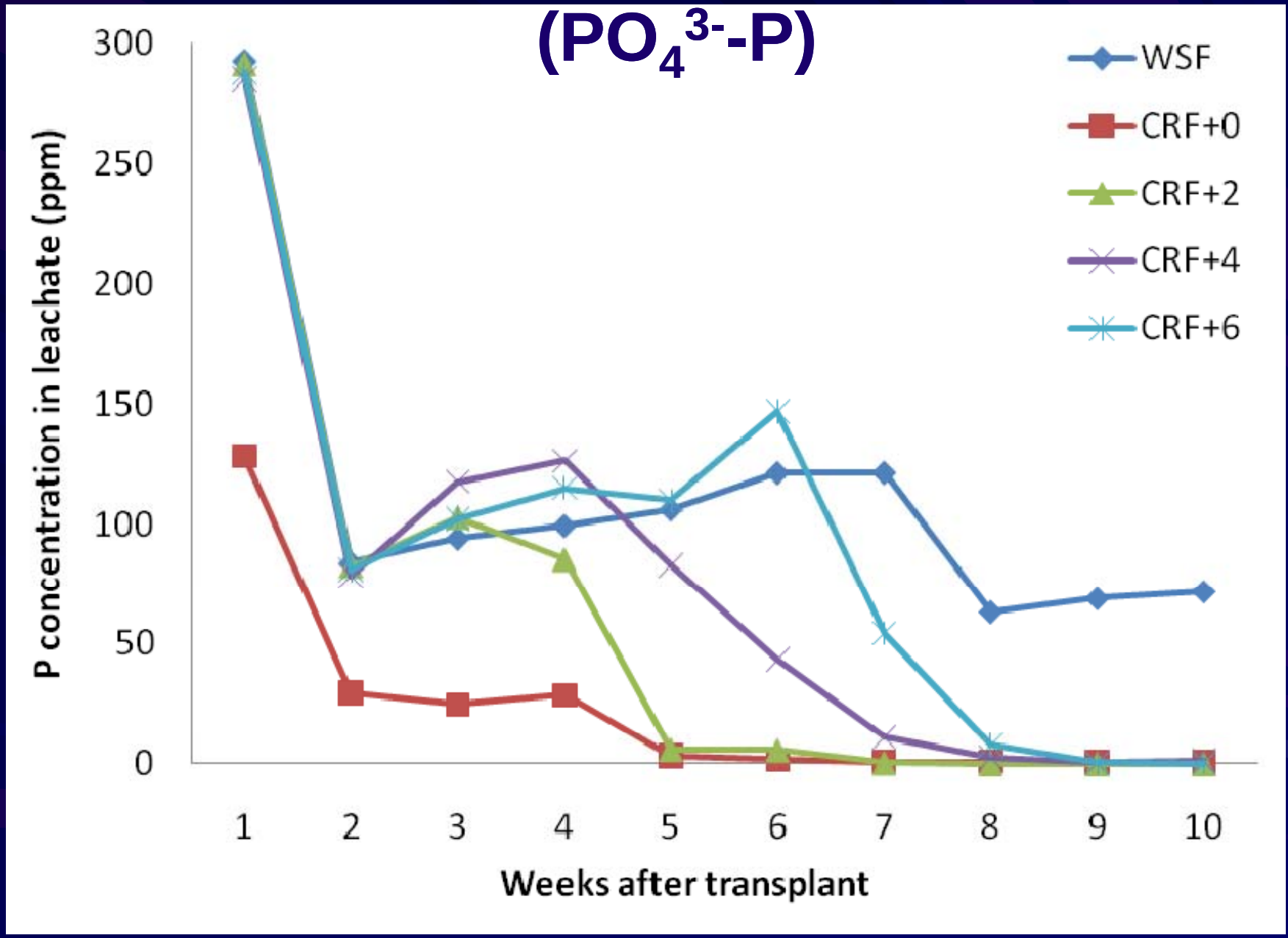
Total rainfall: 10.8 in (27.4 cm)
Average temp for 10 week period: 73 °F (23 °C)

Nitrogen concentration in leachate



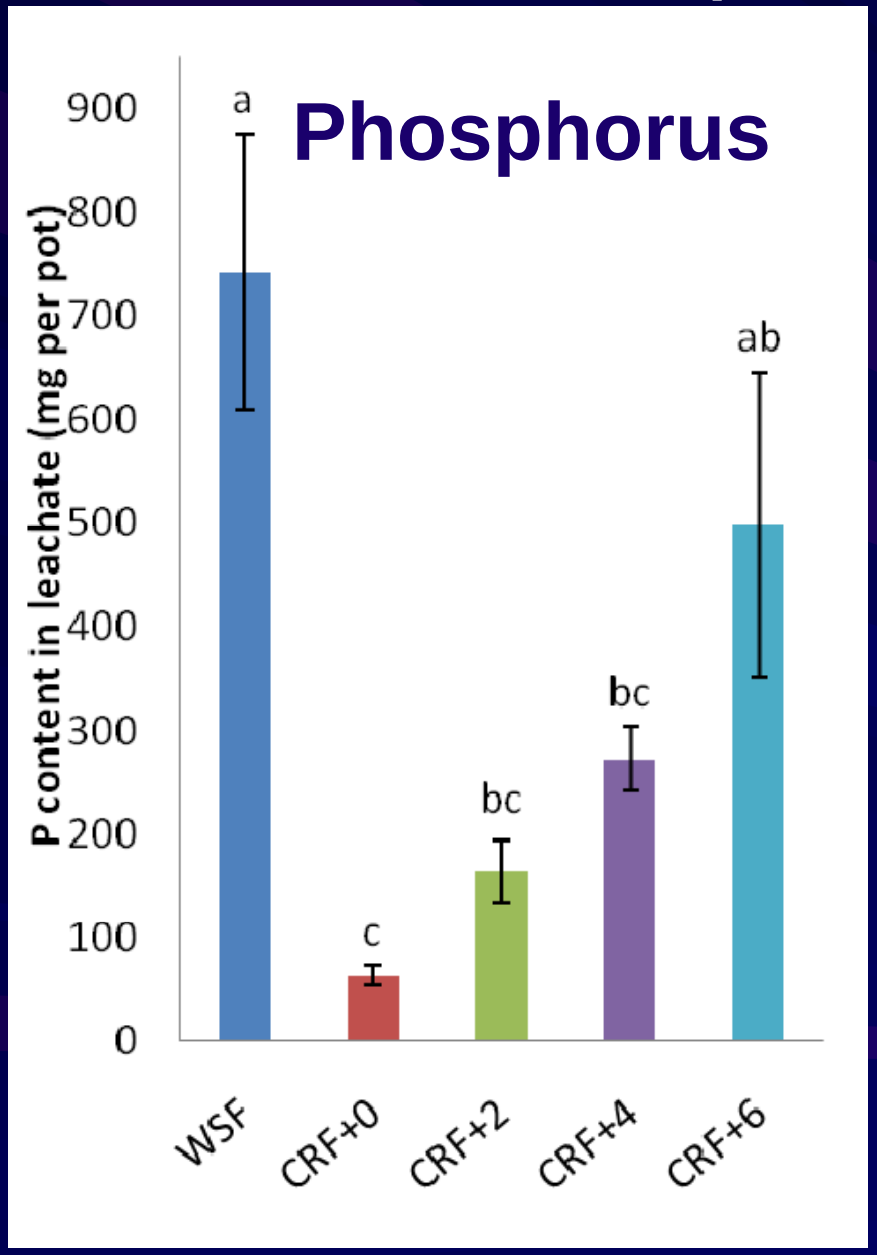
LSD	172	176	119	337	83	34	185	167	95	38

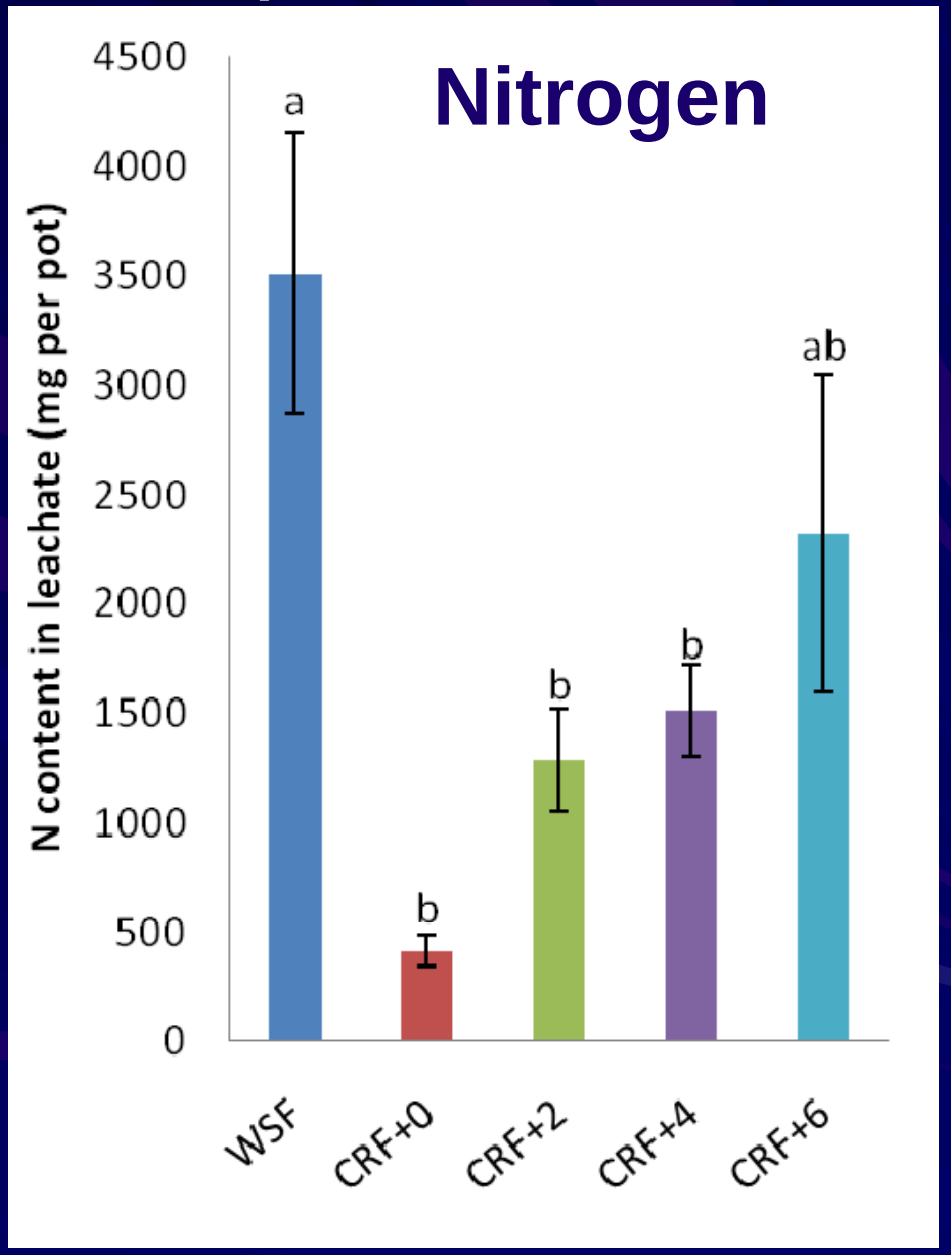
Phosphorus Concentration in Leachate (PO_4^{3-}-P)



LSD	76	23	28	33	19	24	60	19	25	7

Cumulative N and P content in leachate (weeks 4-10)





Letters represent mean separation comparison using Tukey's HSD, alpha=0.05

Results

- Within 2 weeks of stopping water soluble feed, leachate nutrient concentrations comparable to CRF only plants
- Leachate concentration reduced 5-8 fold in CRF+0 as compared to WSF
- CRF is a viable fertilization method

  growth←→leaching
- Cost?

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 100# 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

How does irrigation efficiency effect cost?

Scenario assumes 30% efficiency (i.e. 70% of water is lost)

Cost Comparison – 30% Water Efficiency

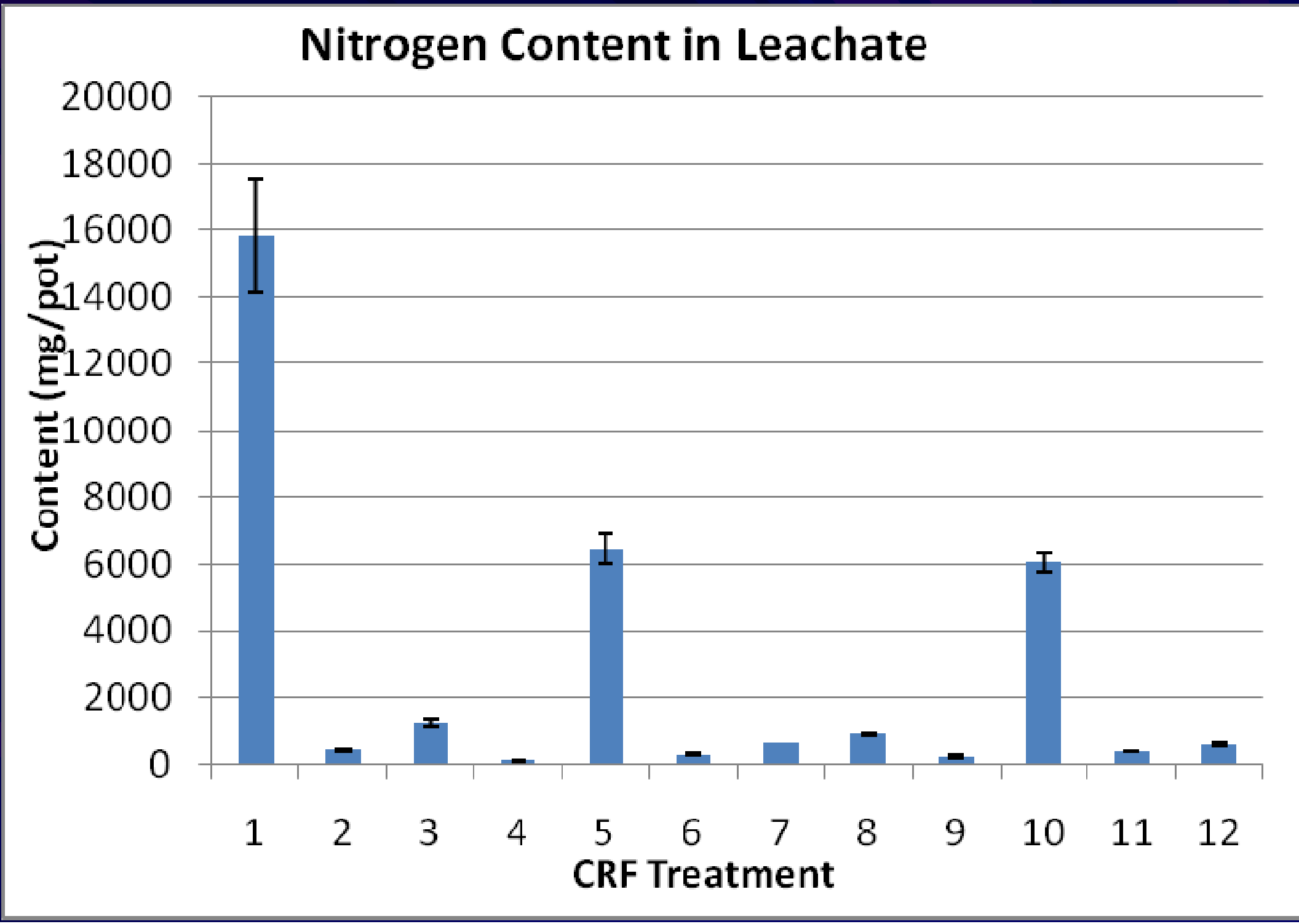
WSF = water soluble fertilizer

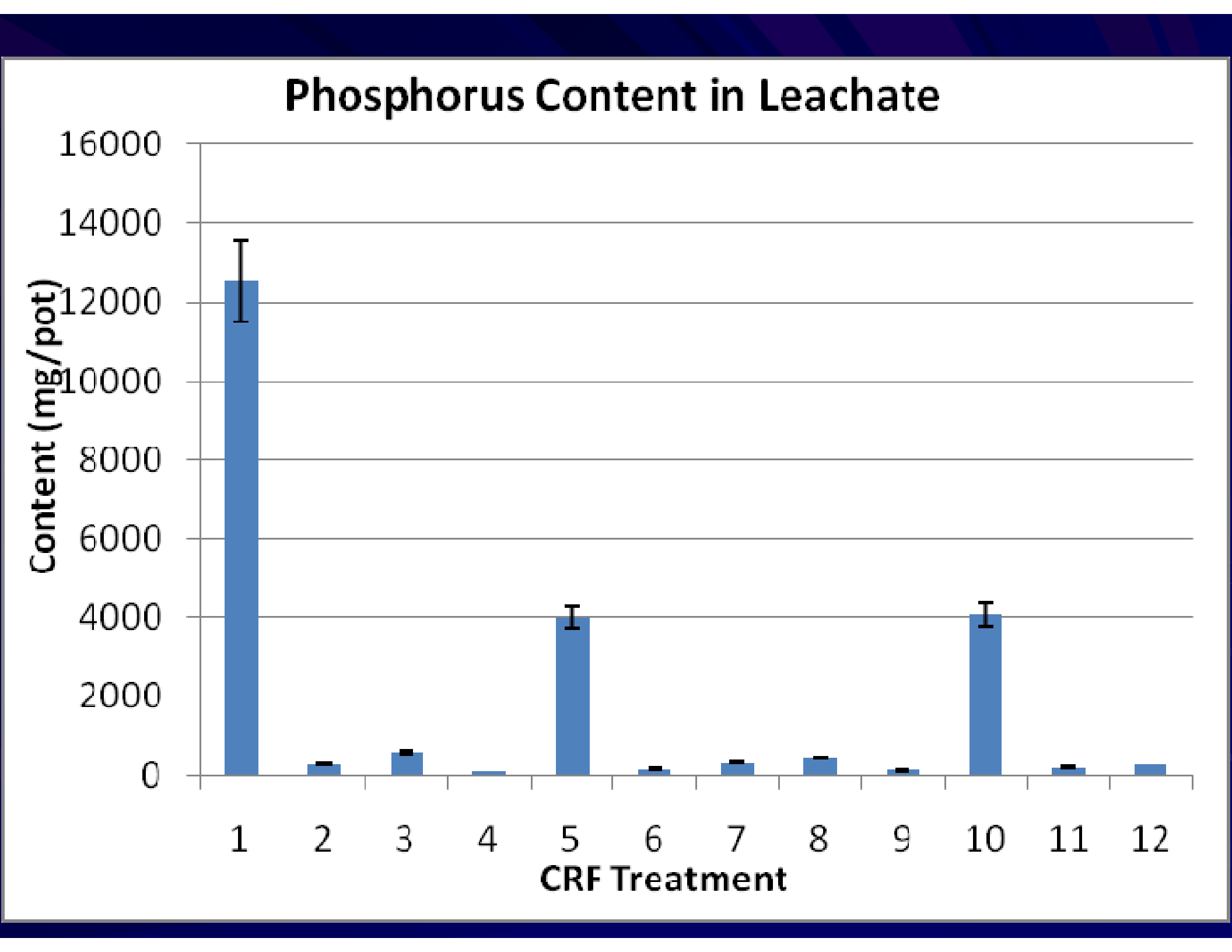
CRF = controlled release fertilizer

Treatments	Cost ($/pot)
WSF	0.29
CRF + 0 weeks WSF	0.15
CRF + 2 weeks WSF	0.17
CRF + 4 weeks WSF	0.23
CRF + 6 weeks WSF	0.29

Nutrient leaching and cost analysis

Summer 2009


Nitrogen Content in Leachate
Content (mg/pot)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1
2
3
4
5
6
7
8
9
10
11
12
CRF Treatment


Phosphorus Content in Leachate
16000
14000
12000
10000
8000
6000
4000
2000
0
Content (mg/pot)
1
2
3
4
5
6
7
8
9
10
11
12
CRF Treatment

Cost Comparison

Assumptions:

- 7 gallons of water used for 12 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 100# bag of Osmocote Plus

Cost Comparison

	$ per pot
Trt 1	0.10
Trt 2	0.06
Trt 3	0.13
Trt 4	0.07
Trt 5	0.11
Trt 6	0.14
Trt 7	0.11
Trt 8	0.13
Trt 9	0.12
Trt 10	0.15
Trt 11	0.14
Trt 12	0.18

CRFs in Greenhouse Bedding Plants

Plant material: Calibrachoa, New Guinea Impatiens

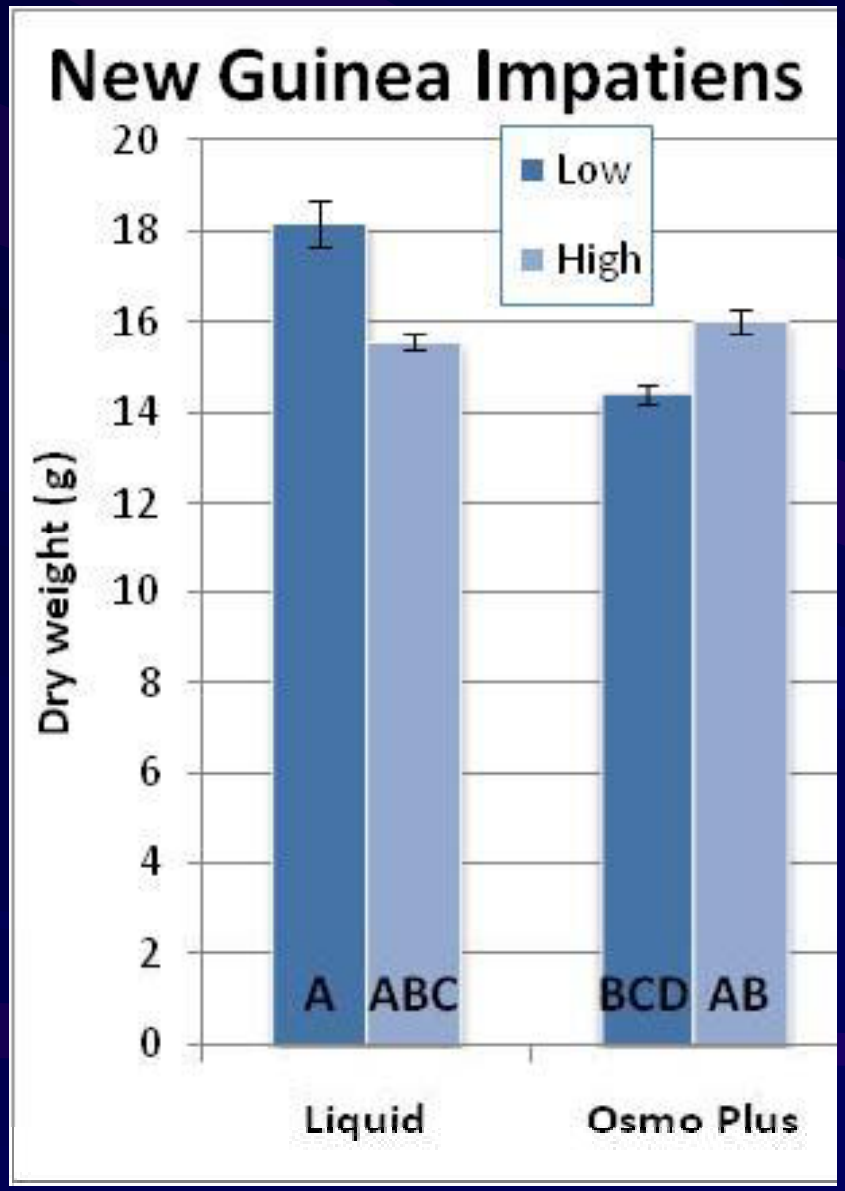
Fertilizers

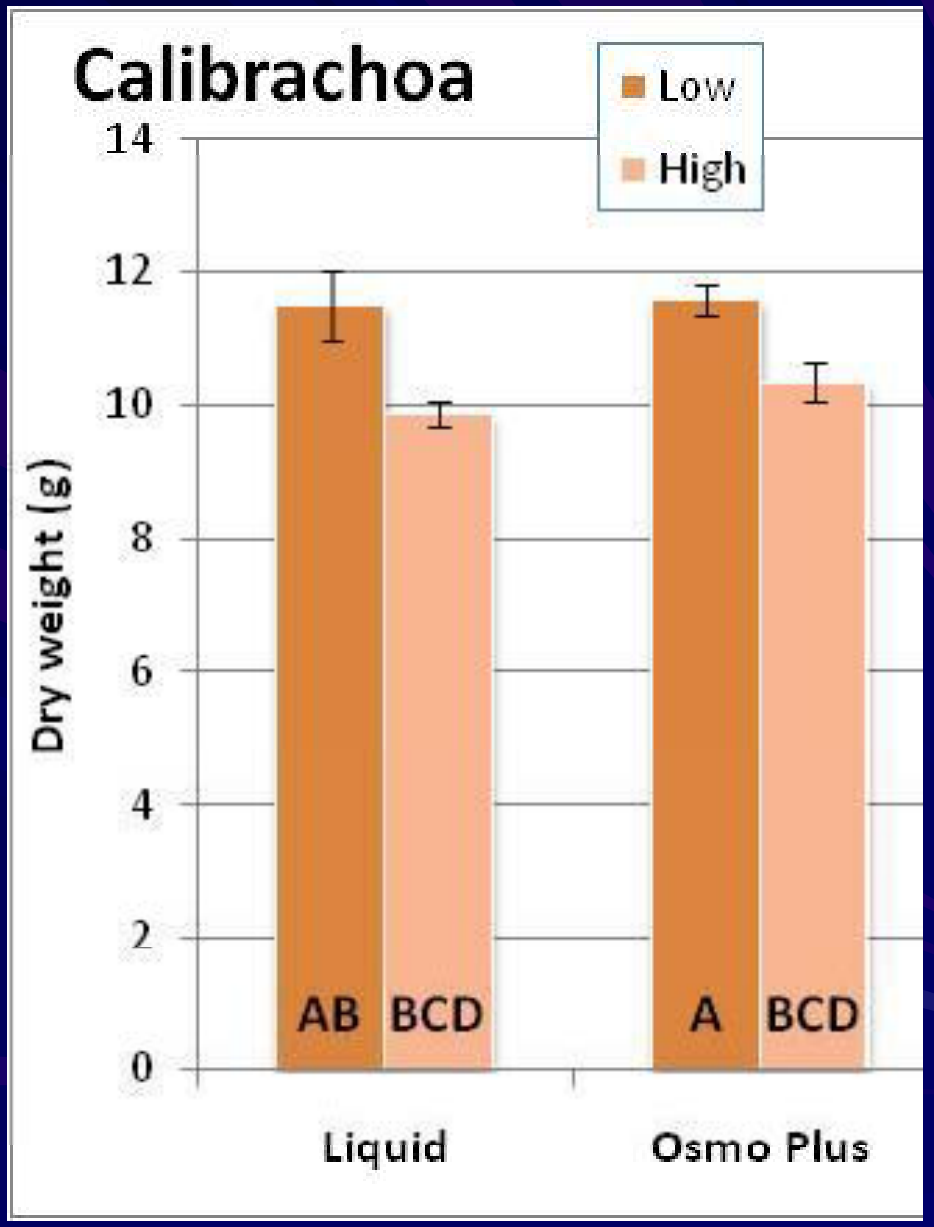
- 21-5-20 at 100 or 200 ppm Nitrogen
- Osmocote Plus ® 3-4 mo. at Low (3.3# / cu yd) and Medium rates (5.7# / cu yd)

6-inch pots, 6 week production period

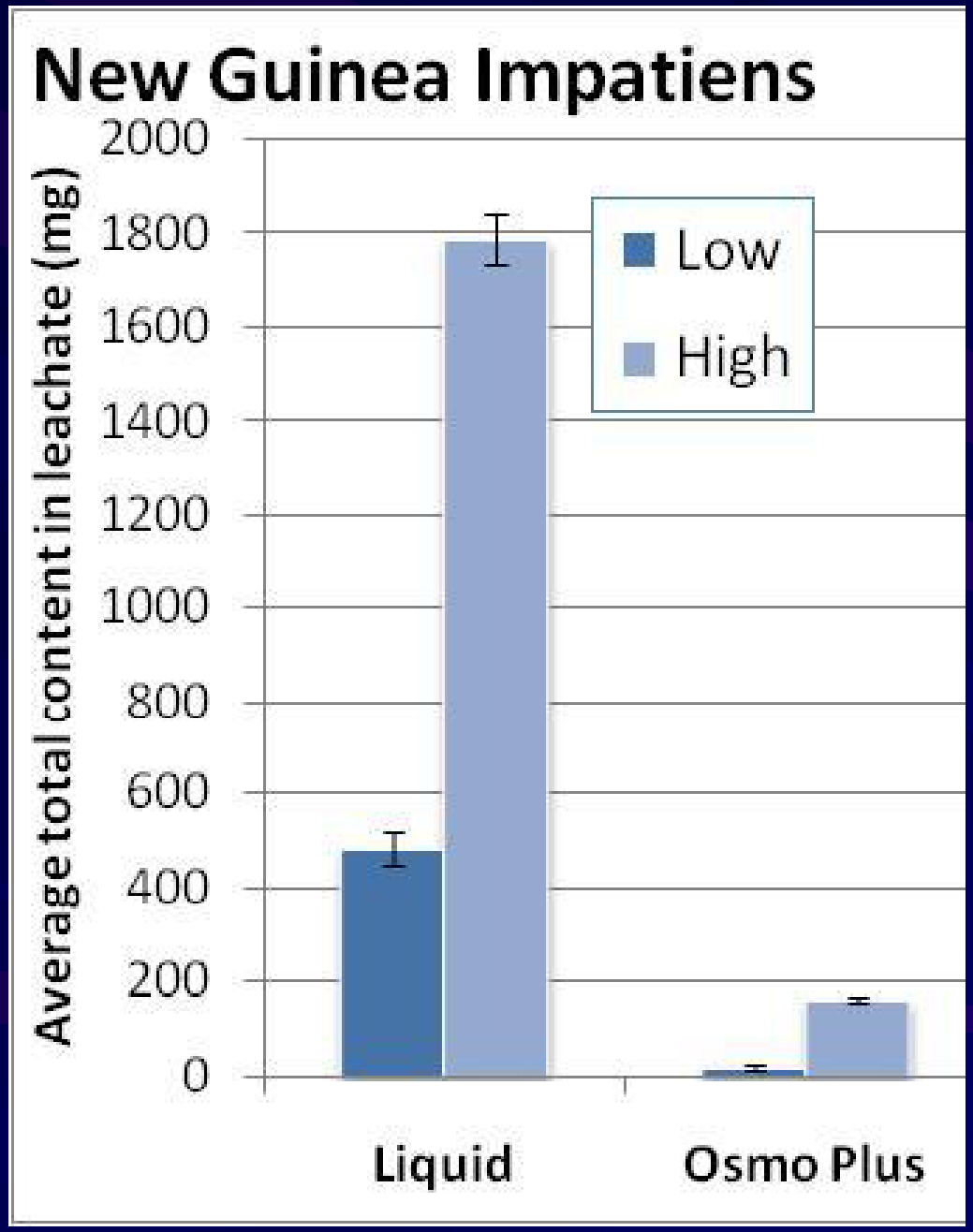
Drip irrigated

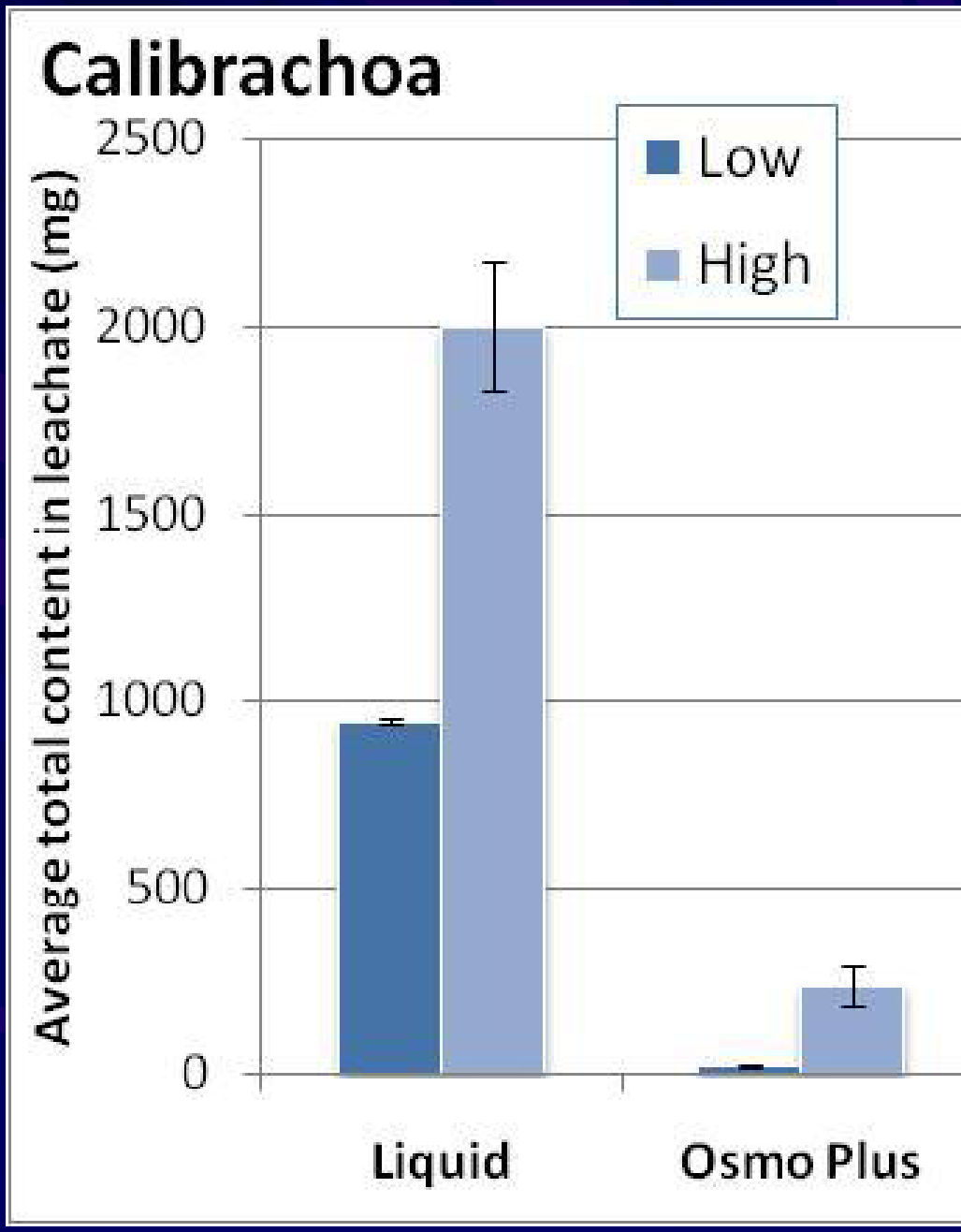
Plant Size


New Guinea Impatiens
Low
High
Dry weight (g)
20
18
16
14
12
10
8
6
4
2
0
A
ABC
BCD
AB
Liquid
Osmo Plus


Calibrachoa
Low
High
Dry weight (g)
14
12
10
8
6
4
2
0
AB
BCD
A
BCD
Liquid
Osmo Plus

Nitrogen Leaching





What did the plants look like?

Liquid Feed
ppm

Osmocote Plus
/ cu yd

Poinsettia Trial

- Liquid feed used from Transplant till 2 weeks after pinch
- Then treated with:

1. Constant liquid feed — 250 ppm N 20-10-20
2. Osmocote 3-4 month — 8# per cubic yard, top dressed
3. Osmocote 5-6 month — 8# per cubic yard, top dressed
4. Osmocote 8-9 month — 8# per cubic yard, top dressed

- “Prestige Red” and “Peterstar Red”

Peterstar Red

Liquid Feed
250 ppm N

Osmocote 8-9 month
8.4# / cu yd

What is an organic fertilizer?

A fertilizer that is derived from animal or vegetable matter, or from naturally occurring minerals

Examples:

- *manure*
- *blood meal*
- *worm castings*
- *seaweed*
- *hydrolyzed fish*
- *rock phosphate*
- *limestone*

Organic fertilizers are a “slow-release” fertilizer source

Conventional liquid fertilizers (ex: 20-10-20)

- Nutrients readily absorbed by plant roots
- Nutrients readily leach from potting mixes esp. Nitrate (N), and Phosphate (P)

Organic fertilizers

- Release nutrients slowly through decomposition and microbial action
- Therefore may leach less N and P

Comparing Fertilizer Products

Case Study

- How much does it cost to fertilize a crop with different product types?
- Can alternatives to liquid feed produce a high-quality crop?
- Do the alternatives leach less nitrogen and phosphorus?

Comparing the cost of 5 different fertilizer products

Conventional	Water Soluble	Peat-Lite Special ®	20-10-20
	Controlled Release	Osmocote Plus ®	15-9-12
Certified Organic	Hydrolyzed Fish +	Drammatic One ®	4-4-1
	Oilseed extract + $NaNO_3$	Daniels Pinnacle ®	3-1-1
Sustainable	Oilseed extract + inorganics	Daniels Professional ®	10-4-3

Comparison of 5 different fertilizer products

		Cost	Cost per lb Nitrogen
Conventional	Peat-Lite Special ®	$30 / 25# bag	$6.10
	Osmocote Plus ® 3-4 mo	$85 / 50# bag	$11.40
Certified Organic	Drammatic One ®	$114 / 5 gal	$68.00
	Daniels Pinnacle ®	$51 / 4.7 gal	$43.00
Sustainable	Daniels Professional ®	$34 / 5 gal	$8.10

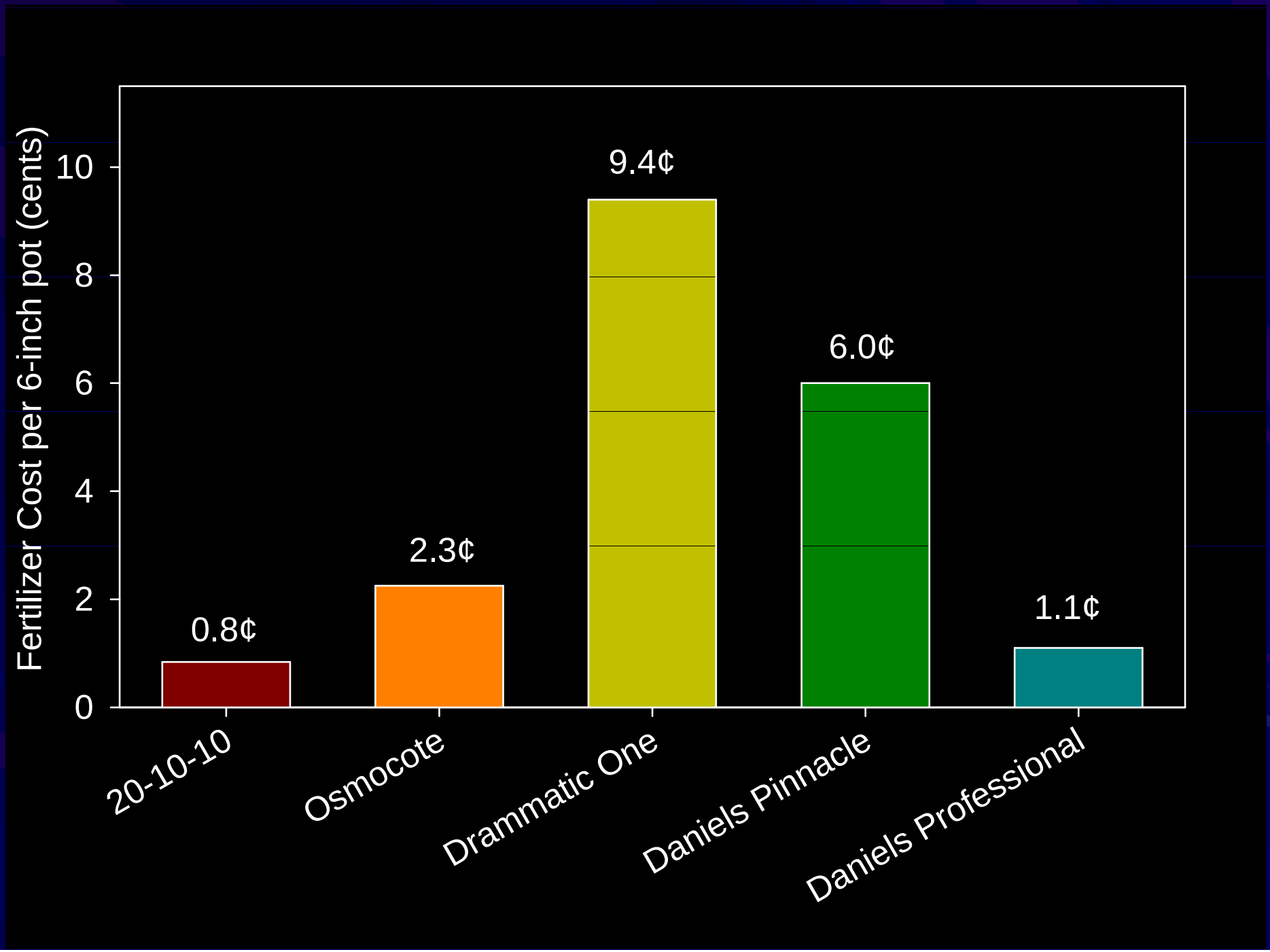
Estimated cost to produce a 6-inch crop?

Scenario Assumptions

- 6 week production period
- 1.1 gallons of water used per pot

- Crop of ‘medium feeders’ (ex: Petunia)
- Liquid products applied at 150 ppm Nitrogen
- Controlled release fertilizer added at medium rate (3.6 pounds per cubic yard)

¢ents to fertilize a 6-inch pot



Organic/Sustainable Fertilizer Trial

Plant Material

- French Marigold, Impatiens, Pepper, Petunia, Tomato, Torenia

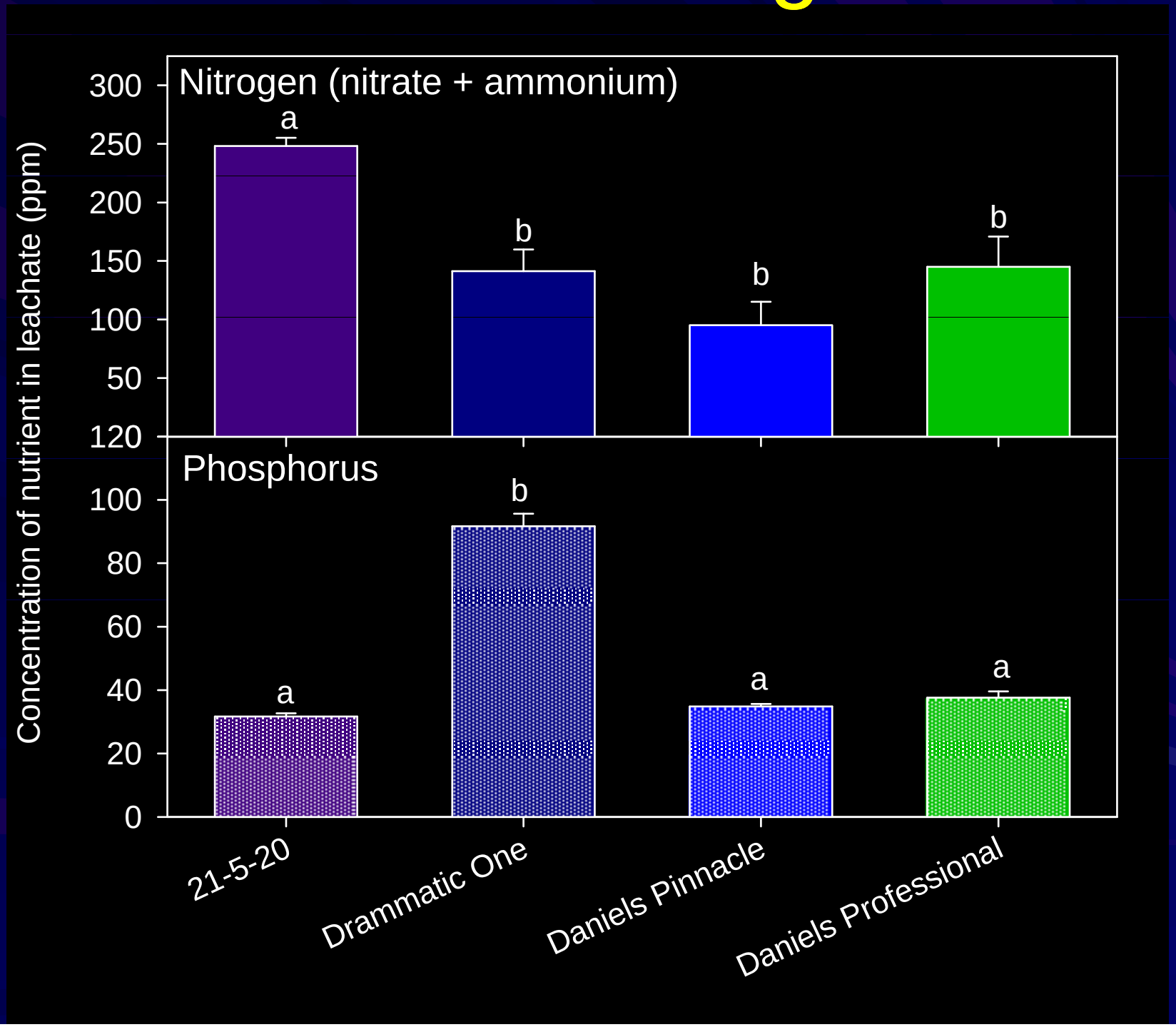
Fertilizers, applied at 150 ppm N

- 21-5-20 liquid feed
- Drammatic One ®
- Daniels Pinnacle ®
- Daniels Professional ®

Plugs/Liners transplanted in 4½-pots

Grown for 5 weeks

Was nutrient leaching reduced?

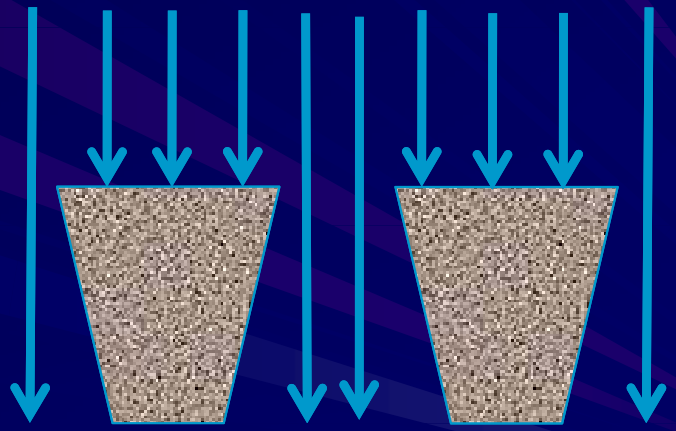


Ways to Reduce Leaching Volume, Nutrient Leaching, and Non-Target Application of Fertilizers

Nora Catlin

Switch to Drip Irrigation

- Overhead irrigation vs. micro-irrigation/drip irrigation/trickle irrigation (drip tubes, spaghetti tubes, etc.)
- Much of water or fertilizer solution applied by hose or sprinkler is wasted
- Affected by pot spacing, size, and canopy
- **When using overhead irrigation, as little as 25% can enter the containers**



Irrigating Overhead?
Hit your target.

- Collect effluent and leachate using trays or saucers to prevent loss from non-target watering

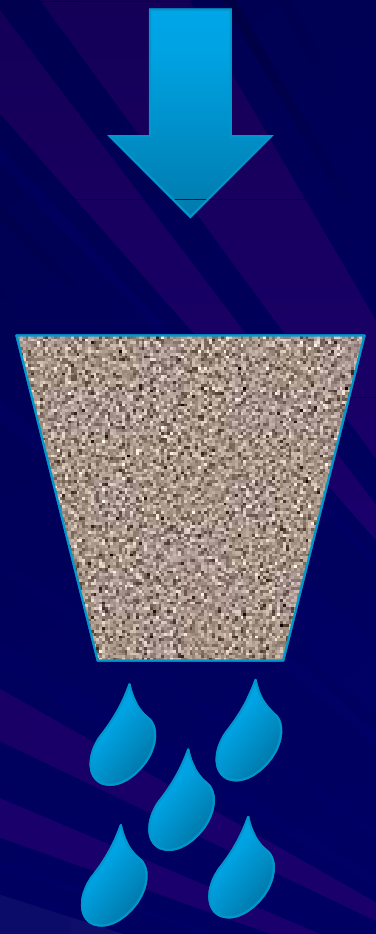
D. Cox, UMASS

Reduce the leaching fraction

- Leaching fraction (LF)– the volume the drains from the bottom of the pot.

- If 20% of the applied volume drains from the pot, the leaching fraction is 0.2

- Traditional recommendation: water plants until 10-15% of the volume drains from the bottom of the pot (0.1-0.15 LF)



- However, in practice the LF can be in excess of 0.1-0.15
  - Estimated that many growers achieve a 0.4-0.6 leaching fraction
- **1st step: make sure you leach only the appropriate amount and that you aren't leaching too much**

Is it time to rethink 10-15% leaching?

- Rethink the 0.1-0.15 LF recommendation and aim for 0
  - Consider wasted fertilizer
  - BUT watch salts carefully when LF reduced. Rule of thumb, cut fertilizer rate 25-50% if 0 LF (when using liquid feed)
  - Possible size reduction if grown too dry (less than 20-30% field capacity)

How can you reduce the leaching fraction?

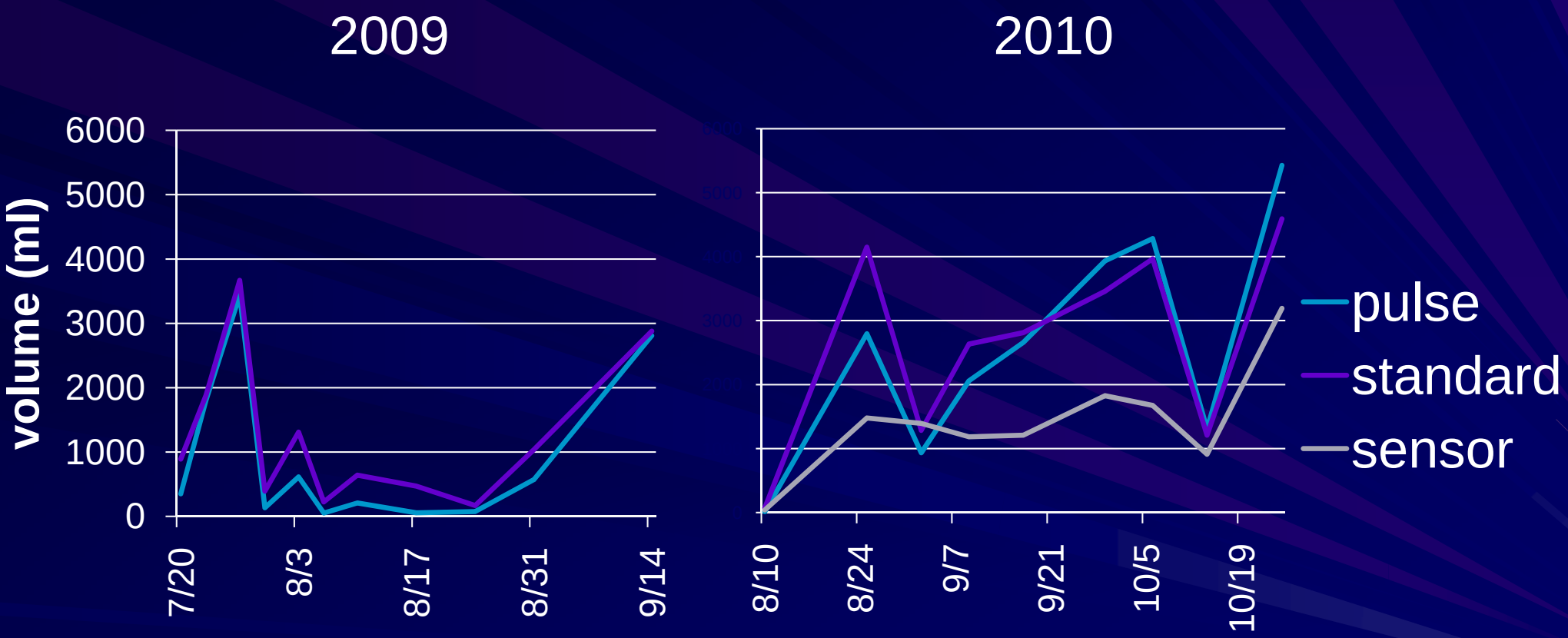
- Group plants with similar water needs
- Pressure compensated drippers
  - output is not affected by pressure changes, length of line or elevation difference – even distribution
- Timers or schedulers
- Spread irrigation throughout day—‘pulse’ or ‘cyclic’ irrigation
  - Irrigate more frequently, but for shorter amounts of time
- Use environmental sensors
  - Soil moisture sensors

Irrigation Timing Trial

- Tested irrigation timing strategies and different media on leaching from and plant quality of container-grown mums
  - Irrigation:
    - Standard: ~10 minutes each morning (250ppm N, 20-10-20)
    - Pulse: ~10 minutes total – 2 minutes, 5x/day, every 4 hours during daytime (250ppm N, 20-10-20)
    - 2010: Moisture Clik moisture sensors
    - All on drip stakes, ~0.25gal/hr

- Leachate volume collected, every 1-2 weeks (or more frequently if rain)
- Final plant size compared (dry weight)
- Leachate tested for quantity of nutrients present

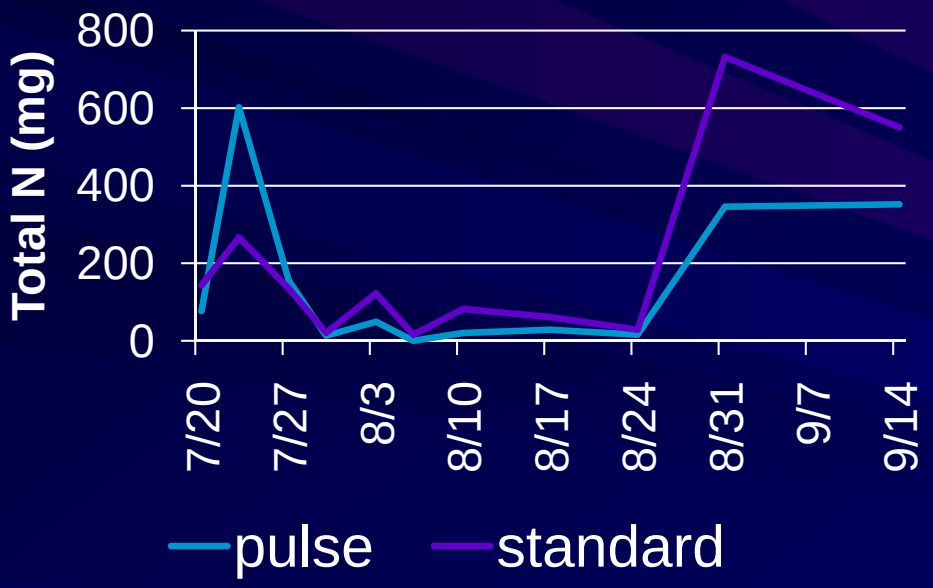
Volume of leachate from 9-inch mum containers subjected to different irrigation strategies

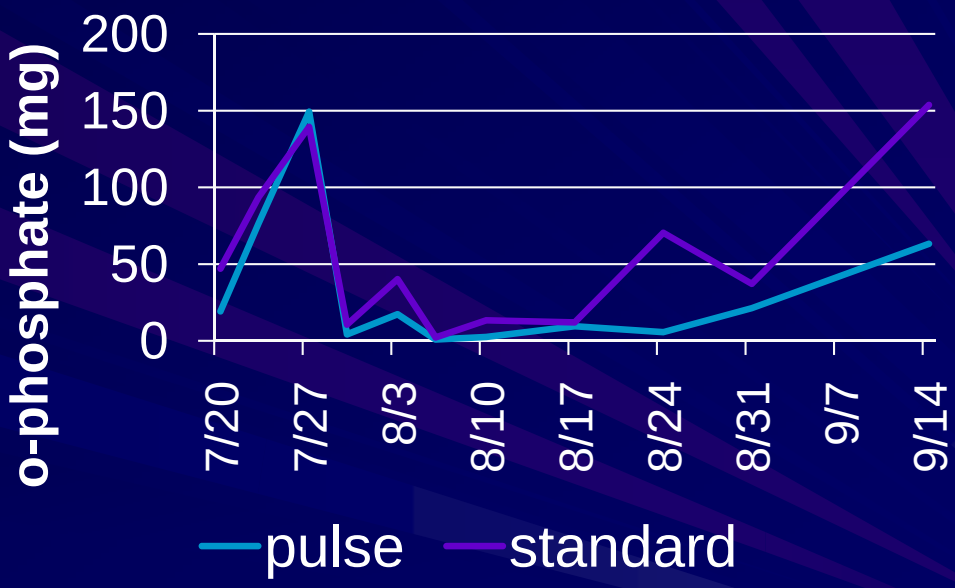


For most collection dates, standard irrigation resulted in significantly more leaching than the pulse irrigation

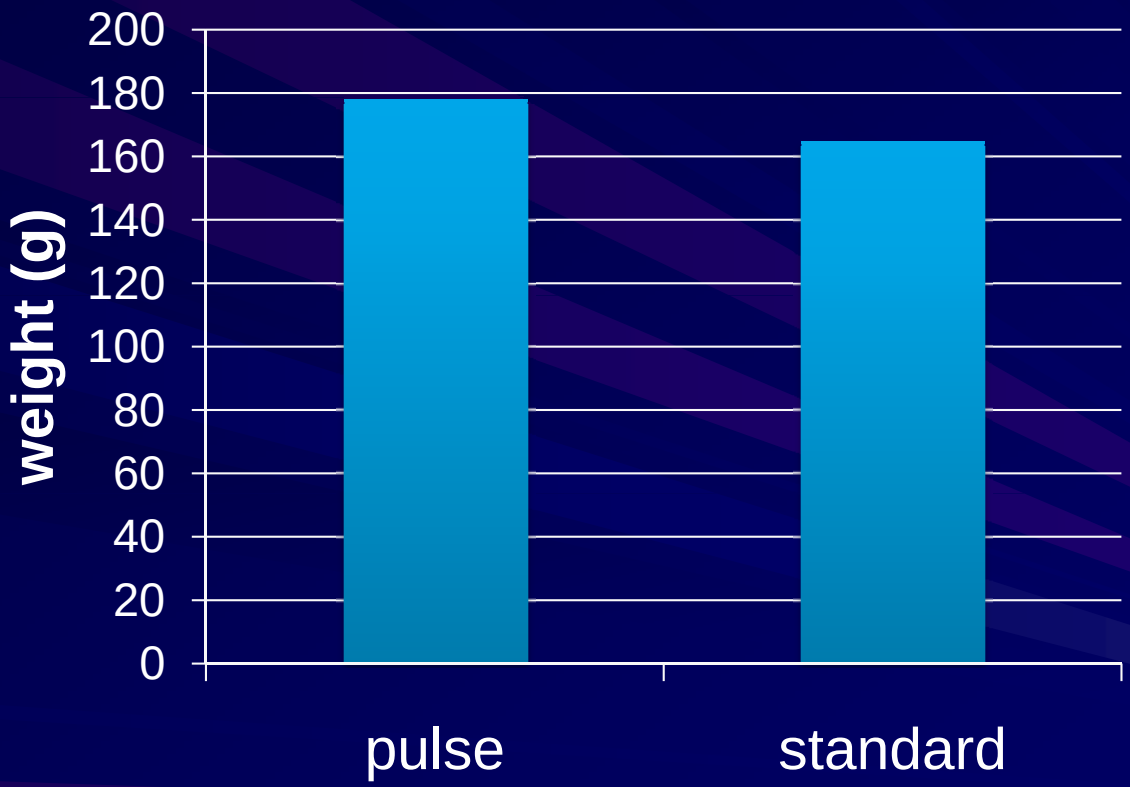
- Pulse irrigation reduces cumulative volume by ~20-25% (2009 and 2010) compared to standard irrigation
- Moisture Clik irrigation reduced cumulative volume by ~50% (2010) compared to standard irrigation

Total N and P leached from different irrigation treatments (2009)





Final dry weight - 2009



Some Estimates

- ~3500ml more volume and ~500mg more total N was collected per pot from the standard treatment than the pulse treatment over the 11 week trial
  - For 5000 pots: 17,500 L (~4500 gal) and 5.5 lb N leached

Other Ways To Reduce Nutrient Leaching

- Try using controlled-release fertilizers (CRF)
- CRF can greatly reduce nutrient leaching
  - Liquid feed can result in over 5X more nitrate leaching compared to CRF
- Is top-dressed better than incorporated?
  - Some research indicates that topdressed CRF or CRF buried a few inches in the media result in less nutrient leaching than topdressed

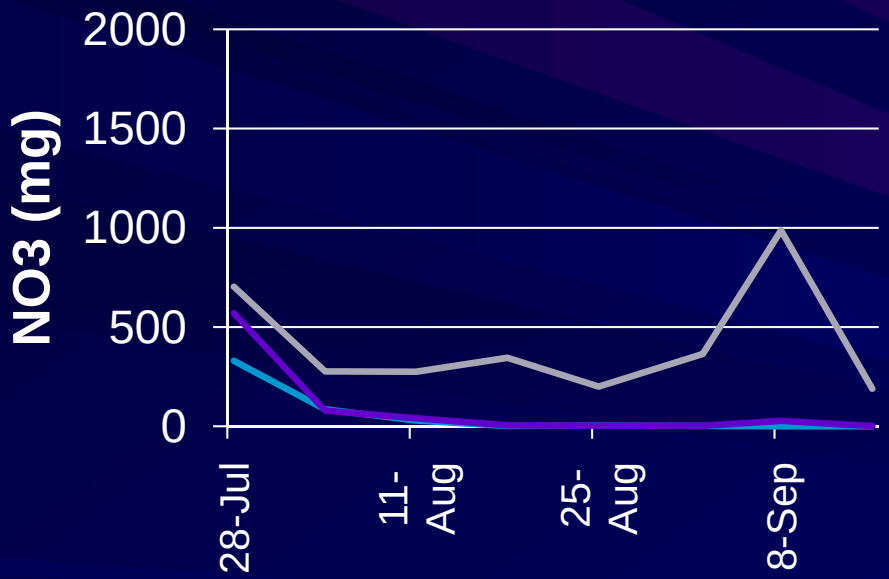
Fertilizer Type and Placement Trial

- Trials in 2008 and 2009 studying the effect of media type and fertilizer type and placement on leaching from and plant quality of mums
  - Fertilizer:
    - Liquid feed, ~250ppm N
    - CRF, Osmocote Plus (15-9-12), top-dressed
    - CRF, Osmocote Plus (15-9-12), incorporated

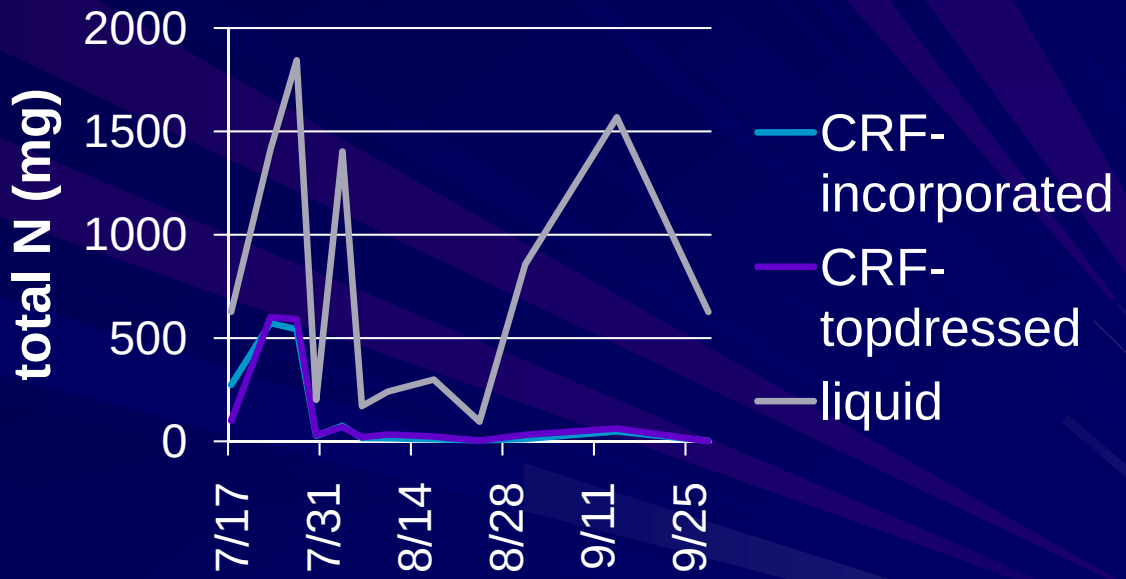
- Leachate collected at least weekly
- Lab analysis to determine nitrate N in leachate in 2008 and 2009, ammonium N and phosphorous analyzed in 2009.
- Final plant size compared (dry weight)

Average NO3 and Total N leached from different fertilizer treatments

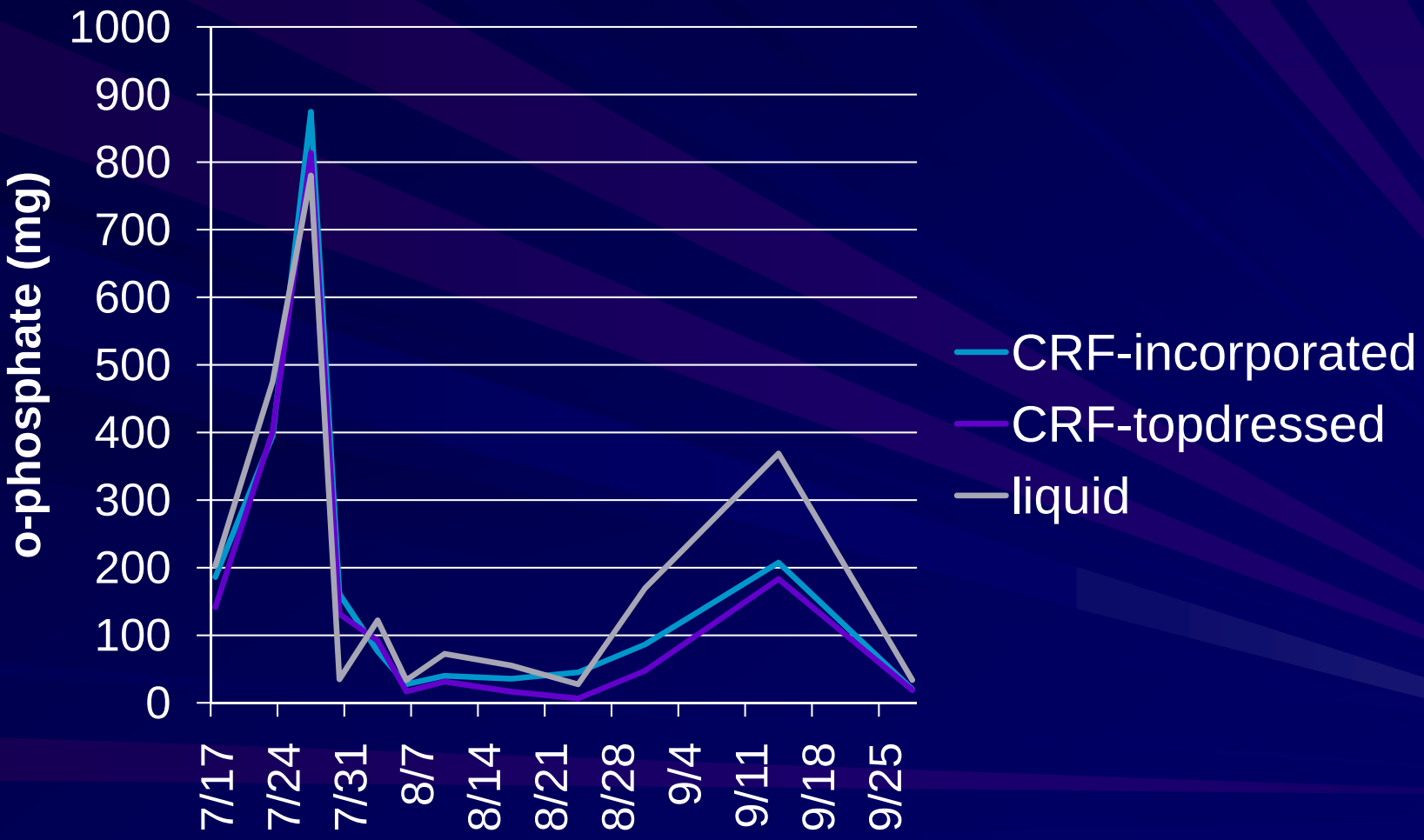
2008



2009

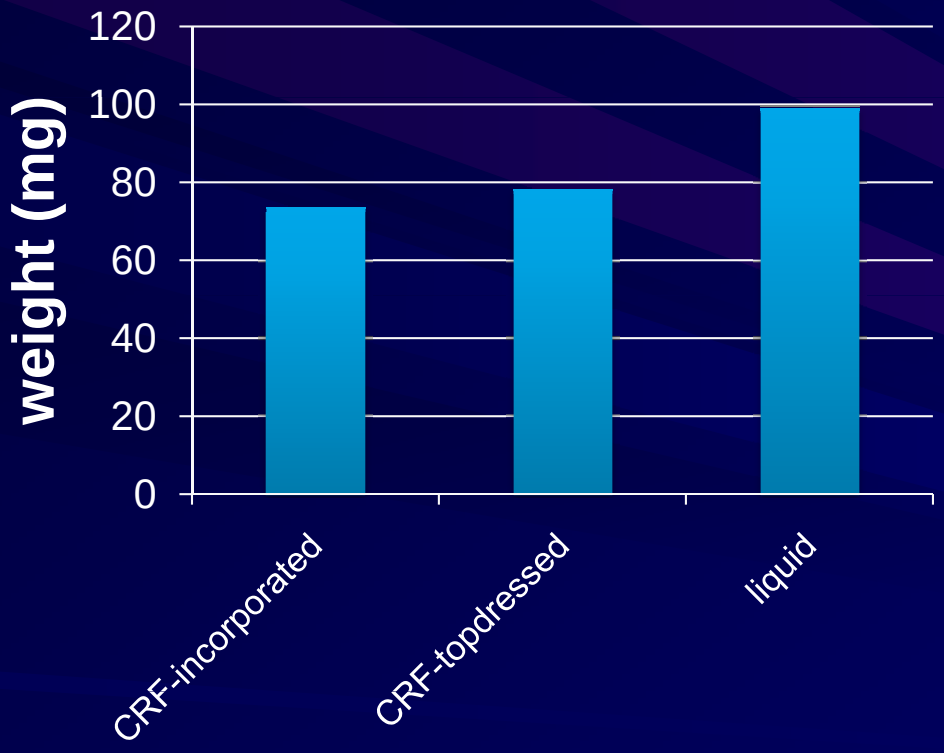


Average phosphate leached from different fertilizer treatments - 2009

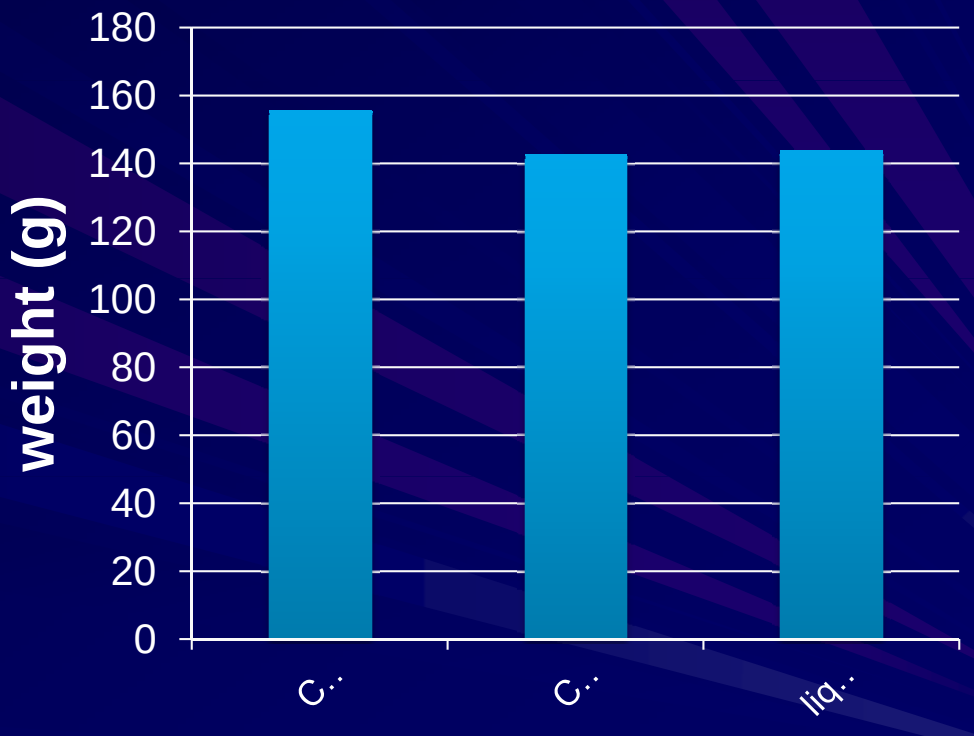


Final dry weight

2008



2009



Other practices to reduce nutrient leaching

- Make sure your fertilizer injector is calibrated and maintained
  - A fertilizer injector that is over-applying by just 50 ppm N can increase fertilizer costs by 20%
- If using CRF, pay attention to application and dose
  - For example, a heaping spoon vs. a level spoon can over apply by up to 50%

Thank you!

Slides to be posted at:

www.greenhouse.cornell.edu