

# Improving Fertilizer Use Efficiency for Horticultural Crops

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Tom Obreza and Jerry Sartain  
Soil and Water Science Dept.



# Topics

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- Water-soluble vs. controlled-release fertilizers.
  - Fertigation.
  - Foliar fertilization.
  - Costs of materials and application.
  - Irrigation effects.
  - Opportunities to improve efficiency.
  - Focus for future research.
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Water-soluble fertilizer

# “Standard” N and P fertilizers are...

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- ❑ ...water-soluble.
- ❑ ...plentiful.
- ❑ ...lowest cost materials.
- ❑ ...leachable.



# Typical water-soluble N and P fertilizers used in horticultural production

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## Nitrogen

- Ammonium sulfate
- Ammonium nitrate
- Urea
- Potassium nitrate
- Calcium nitrate

## Phosphorus

- Concentrated superphosphate
  - Mono-ammonium phosphate
  - Di-ammonium phosphate
  - Ammonium polyphosphate
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Controlled-release fertilizer

# High-volume use of controlled-release fertilizer is limited to...

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- ...turfgrass
- ...greenhouse
- ...nursery
- ...landscape



# Slow and controlled-release fertilizers used in horticultural production

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## Non-coated

- Nitroform ®
- Nutralene ®
- Nitamin ®
- IBDU

**(N sources only)**

## Coated

- Sulfur-coated urea
- Osmocote ®
- Polyon ®
- Nutricote ®
- Polymer/Sulfur-coated fertilizers




**(N, P, K + others)**

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# Nutrient release from CRF depends on temperature and moisture

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Water-soluble	Controlled-Release	
 <p data-bbox="211 968 605 1011">Ammonium nitrate</p>	<p data-bbox="814 544 1087 586">Non-coated</p>  <p data-bbox="750 968 1157 1011">Urea formaldehyde</p>	<p data-bbox="1410 544 1587 586">Coated</p>  <p data-bbox="1372 968 1626 1011">Osmocote®</p>
<p data-bbox="262 1072 559 1182">Dissolves all at once</p>	<p data-bbox="712 1072 1239 1182">Slowly decomposes to soluble N</p>	<p data-bbox="1338 1072 1702 1182">Nutrients “leak” through coating</p>

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# What do we know about CRF...

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- ...rates?
  - ...timing?
  - ...placement?
  - ...plant response?
  - ...leaching?
  - ...release rates as affected by temperature and moisture?
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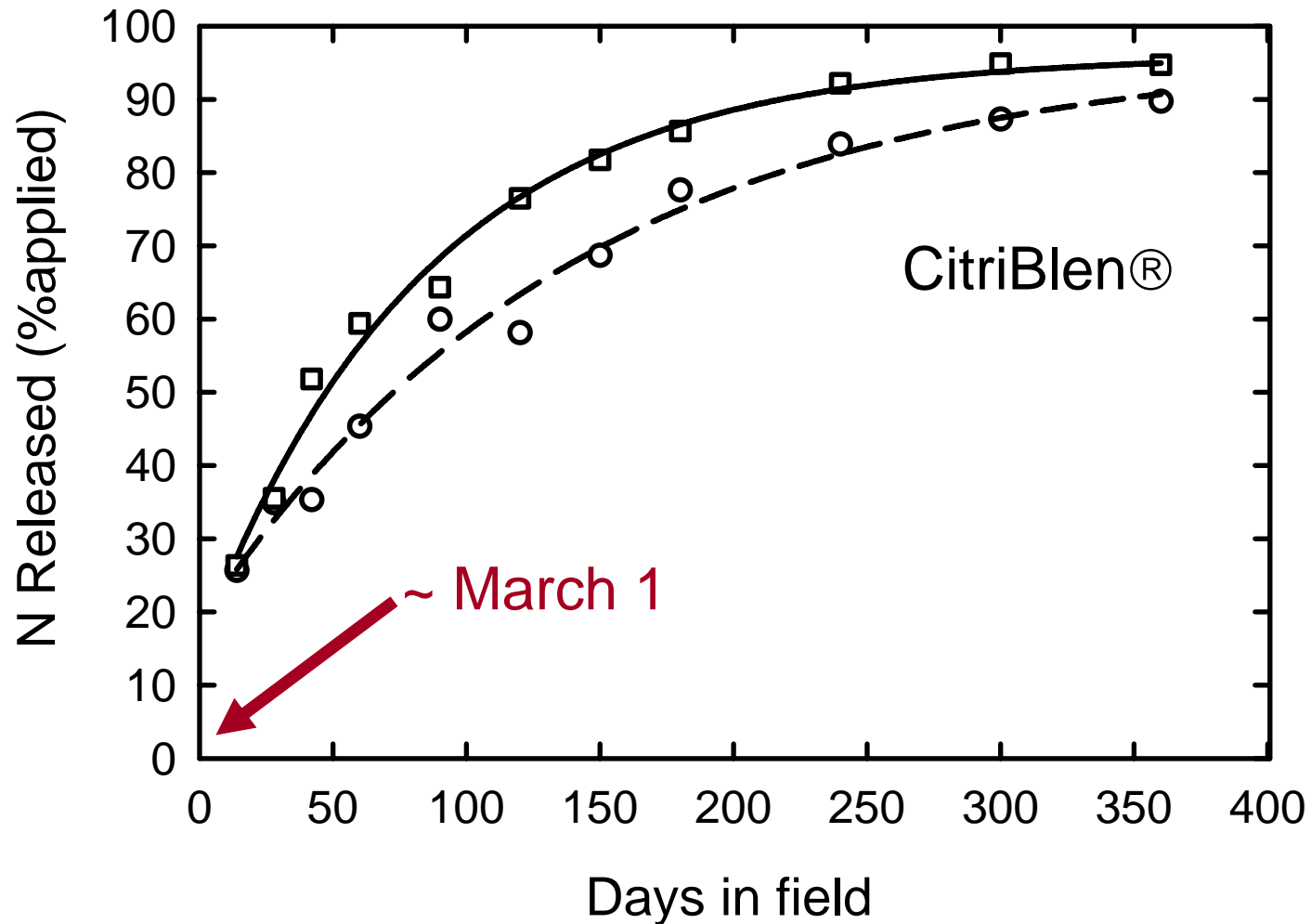
Producer asks:

“Can I apply a lower fertilizer rate when using CRF compared with my conventional WSF program and get the same response?”

# Did a lower **RATE** of CRF perform as well or better than a higher rate of WSF?

Crop/Response	No. of studies	Yes	No
Young citrus trees-growth and yield	5	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Mature citrus trees-yield and quality	3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
Turfgrass- growth	5		<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
Turfgrass- quality	5	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
Vegetables-yield and quality	3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>

# CRF application **TIMING**: Match initial portion of release curve with beginning of growing season

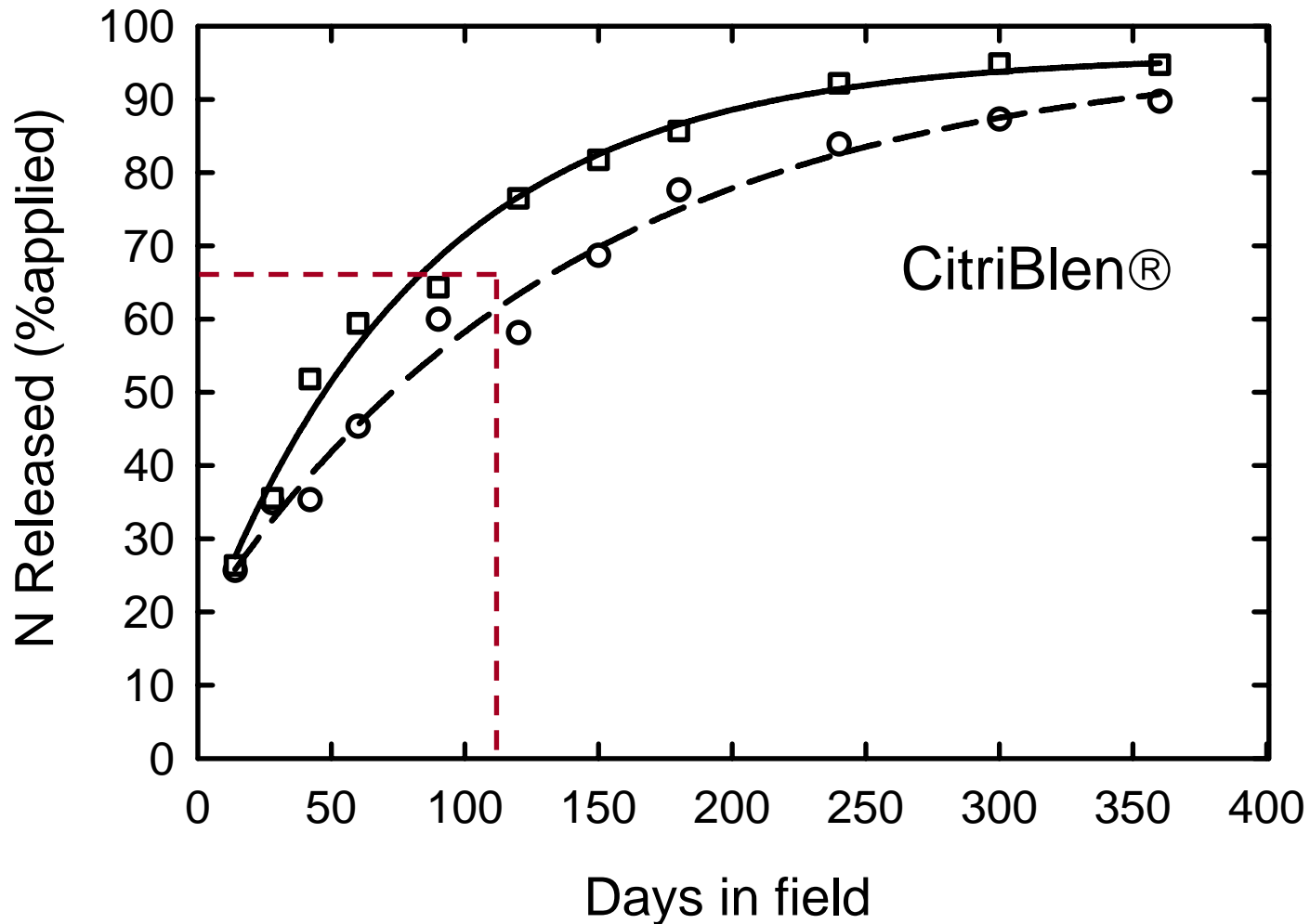


CRF **PLACEMENT** (surface vs. incorporated) doesn't matter as long as the fertilizer remains moist.

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- Sweet viburnum in greenhouse:
    - No plant growth difference with surface vs. incorporated Osmocote®.
    - N/P leaching losses were reduced 16/25% with surface application.
  - Field-grown citrus:
    - Surface application did not detrimentally affect performance of both coated and non-coated CRFs.
    - CRF always applied within irrigated zone.
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**PLANT RESPONSE** to CRF depends on how well the release curve matches plant need.



Nitrogen **LEACHING** from field-applied CRF is minimal because by design, CRFs release water-soluble nutrients to the soil at a slow rate.



Leaching of water-soluble and controlled-release N 125 days after applying 2 lbs N/1000 square ft to ryegrass.

<b>N source</b>		<b>Percentage of applied N that leached</b>
Water-soluble	Ammonium sulfate	12.8 a
Water-soluble	Urea-Ammonium nitrate	8.1 b
CRF	CoRon®	7.2 b
CRF	Nutralene®	2.9 c
CRF	Polyon®	2.8 c
CRF	Sulfur-coated urea	2.8 c
CRF	IBDU	1.1 d
CRF	Nitroform®	0.4 e

Estimated N leached below a central Florida ridge citrus grove root zone.

<b>N rate</b>	<b>Dry soluble fertilizer</b>	<b>Fertigation</b>	<b>CRF</b>
lbs/acre	-----	lbs N/acre/year	-----
50	---	---	0.8
100	11.1	16.3	2.9
150	11.8	21.5	7.1
200	12.2	27.1	---
250	19.0	31.3	---

Container-grown foliage plant size and relative amount of N and P leached 6 months after fertilizer application to pine bark-peat-sand media.

Fertilization method	Spathiphyllum plant size	Percentage of total N applied that leached as $\text{NO}_3^-$	Percentage of total P applied that leached as $\text{PO}_4^{3-}$
	dry weight (g)	%	%
Liquid WSF	30 a	48 b	28 a
Dry granular WSF	28 a	54 a	23 b
Lightly-coated CRF	31 a	29 d	12 d
Heavily-coated CRF	33 a	35 c	18 c

Fertigation

# Fertigation:

What do we know about...

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- ...nutrient use-efficiency?
  - ...application frequency?
  - ...plant response?
  - ...leaching potential?
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# Fertigation improved **N USE EFFICIENCY** in bell pepper production.

Yield at four pre-plant/fertigation N fertilizer combinations.

Fert. application method		Total fancy pepper yield	Total marketable pepper yield
Percent N applied pre-plant	Percent N applied by fertigation		
		----- tons/acre -----	
0	100	4.2	9.1
<b>30</b>	<b>70</b>	<b>4.4</b>	<b>9.5</b>
70	30	3.8	8.3
<b>100</b>	<b>0</b>	<b>2.9</b>	<b>6.6</b>
P-value		0.0531	0.0006

With good water management, fertigation  
**APPLICATION FREQUENCY** doesn't matter much.

6-year-old orange trees growing in lysimeters.

Year	Fertigation treatment	Fertigations per year	Relative amount of applied N that leached	N uptake efficiency <sup>z</sup>
			%	%
1999	Every irrigation	76	51	30
	Weekly	36	58	27
	Monthly	11	56	24
2000	Every irrigation	81	46	42
	Weekly	38	62	28
	Monthly	14	53	35

<sup>z</sup> Amount of N taken up by the citrus trees divided by the amount of N applied.

Horticultural **PLANT RESPONSE** to fertigation is as good or better than the response observed with well-managed dry soluble fertilization.

In both cases, irrigation (and sometimes drainage) water management is critical for success.



**LEACHING POTENTIAL** following fertigation can be minimized if the crop is not over-irrigated.

Fertigation prevents a large mass of nutrients from being leached in a single day (as could occur when heavy rain follows a dry fertilizer application), but leaching can still occur in smaller increments if irrigation management is poor.

## Why was there more leaching with fertigation compared with dry soluble fertilizer application?

Estimated N leached below a ridge citrus grove root zone.

<b>N rate</b>	<b>Dry soluble fertilizer</b>	<b>Fertigation</b>	<b>CRF</b>
lbs/acre	-----	lbs N/acre/year	-----
50	---	---	0.8
100	11.1	16.3	2.9
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200	12.2	27.1	---
250	19.0	31.3	---

Study authors: This occurred “purely because of unexpected prolonged irrigation or unexpected high rainfall following certain fertigation events in both years.”

# Foliar fertilization

# Can FOLIAR FERTILIZER APPLICATION improve nutrient use efficiency?

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## □ Citrus: Possibly

- Foliar uptake of urea can be 50% efficient; it has enhanced flowering and yield.
- Phosphite is recognized as a P source; it has increased flowering, fruiting, and lbs solids.

## □ Vegetables: No

- Leaves cannot absorb enough N/P to correct a deficiency.
  - Leaf burn is likely.
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Fertilization cost

The cost of fertilizer is skyrocketing.

Fertilizer	Location	Price	
		March 3, 2008	1 year ago
Urea	US Gulf	39¢ / lb N	37¢ / lb N
UAN solution	US Gulf	48¢ / lb N	36¢ / lb N
Amm. nitrate	US Gulf	53¢ / lb N	36¢ / lb N
Amm. sulfate	Southeast	69¢ / lb N	40¢ / lb N
Di-ammonium phosphate	Central FL	\$770 / ton	\$340 / ton
Mono-ammonium phosphate	Central FL	\$785 / ton	\$340 / ton

# How does the relative **COST OF FERTILIZER MATERIALS AND APPLICATION METHODS** affect fertilizer selection by producers?

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*Citrus:* Costs to fertilize orange trees for 6 years compared with yield and gross return.

Fertilizer	6-yr fert cost (\$/tree)	Cumulative lbs sol/tree	Gross return (\$/tree)
Average of six coated products	\$ 17	26.4 a	\$ 27
Water-soluble	\$ 5	24.2 b	\$ 25

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# How does the relative **COST OF FERTILIZER MATERIALS AND APPLICATION METHODS** affect fertilizer selection by producers?

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## *Vegetables*

- ❑ Potato study: Cost of a water-soluble N fertilization program – \$38 to \$63 per acre.
  - ❑ Extra cost to use a CRF program cost – \$8 to \$79 more than the most expensive soluble N cost.
  - ❑ Extra cost could be offset by reduced application rate and/or providing cost-share to use CRF.
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# Irrigation effects

# How **IRRIGATION** affects efficiency: Conventional practices vs. BMPs at a commercial nursery

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## Spathiphyllum (Peace lily) production

### Conventional

- ❑ Overhead irrigation with up to 300 ppm N solution.

### BMP

- ❑ Overhead irrigation with plain water.
- ❑ Fertilization with coated CRFs.



# Conventional vs. BMP results

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- Similar plant growth.
  - Less salt in containers with CRF.
  - After 2½ years.....
    - Conventional production: Groundwater NO<sub>3</sub>-N peaked at 11 ppm.
    - BMP production: Groundwater NO<sub>3</sub>-N was below 2 ppm.
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Wrap it up

# BMPs:

## Opportunities to improve efficiency

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- ❑ Educate and train workers.
  - ❑ Develop a nutrient management plan.
  - ❑ Use appropriate application equipment.
  - ❑ Properly calibrate and maintain application equipment.
  - ❑ Apply fertilizers to target sites.
  - ❑ Avoid high risk fertilizer applications.
  - ❑ Split fertilizer applications.
  - ❑ Try to wet only the root zone when irrigating.
  - ❑ Add organic matter to the soil whenever possible.
  - ❑ Use appropriate fertilizer sources and formulations.
  - ❑ Use precision nutrient application where appropriate.
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# Focus for future research efforts

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1. Develop short-term laboratory procedure to verify the nutrient release period claimed on CRF labels.
  2. Evaluate plant response and nutrient leaching characteristics of CRF materials.
  3. Economic study of CRF use including material cost, plant response, and environmental benefits.
  4. Improve irrigation scheduling techniques.
  5. Continue to develop precision nutrient application.
  6. Variable rate irrigation.
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