Keeping Water and Nutrients in the Citrus Tree Root Zone

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Topics

- Typical nutrient and water management practices.
- Nutrient budgets.
- N in groundwater and P in runoff.
- Opportunities to improve efficiency.
- Focus for future research.

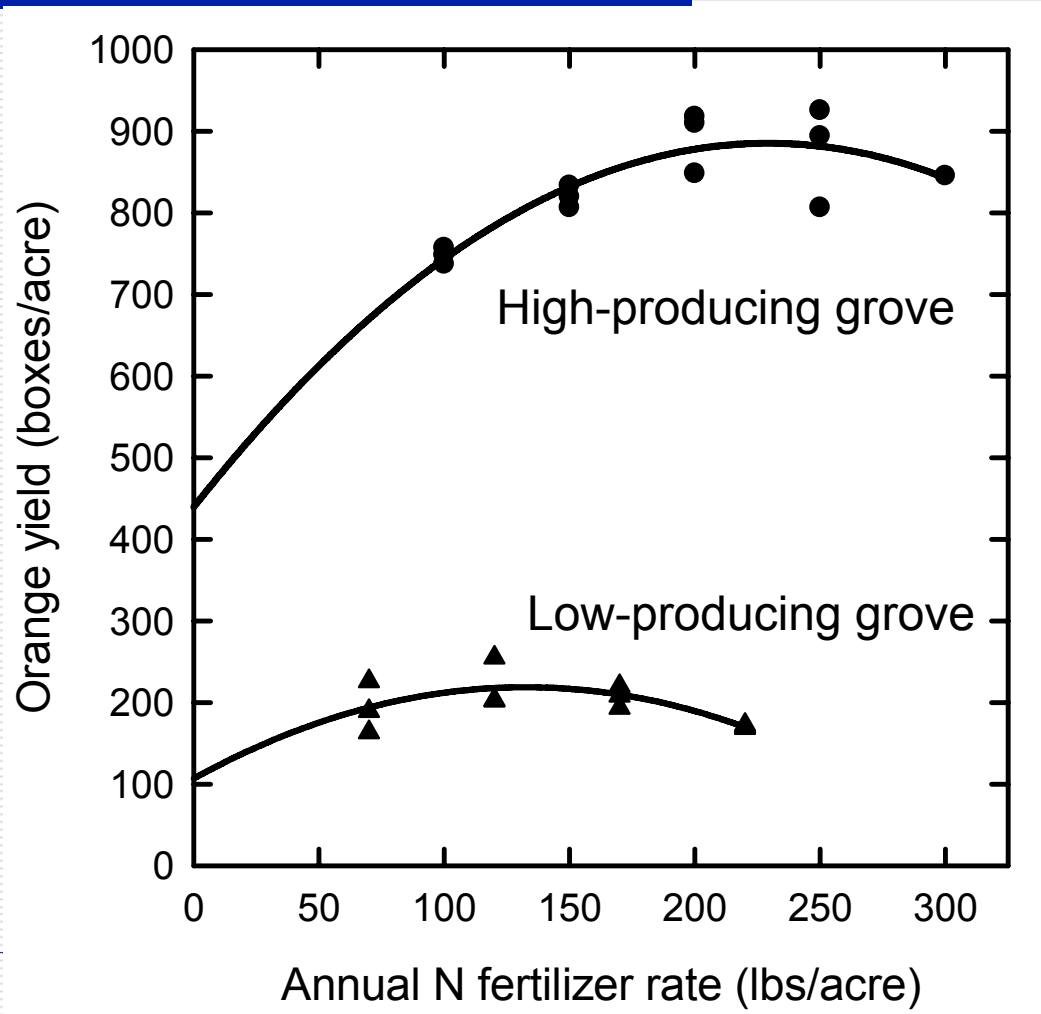
Typical N fertilizer management for citrus

- Fertilizer sources: Mostly water-soluble.
- N rates: 120 to 240 lbs/acre/year.
- Application frequency (dry): 2 to 4/year.
- Application frequency (fertigation): 10+/year.
- Placement: Over top of root zone.

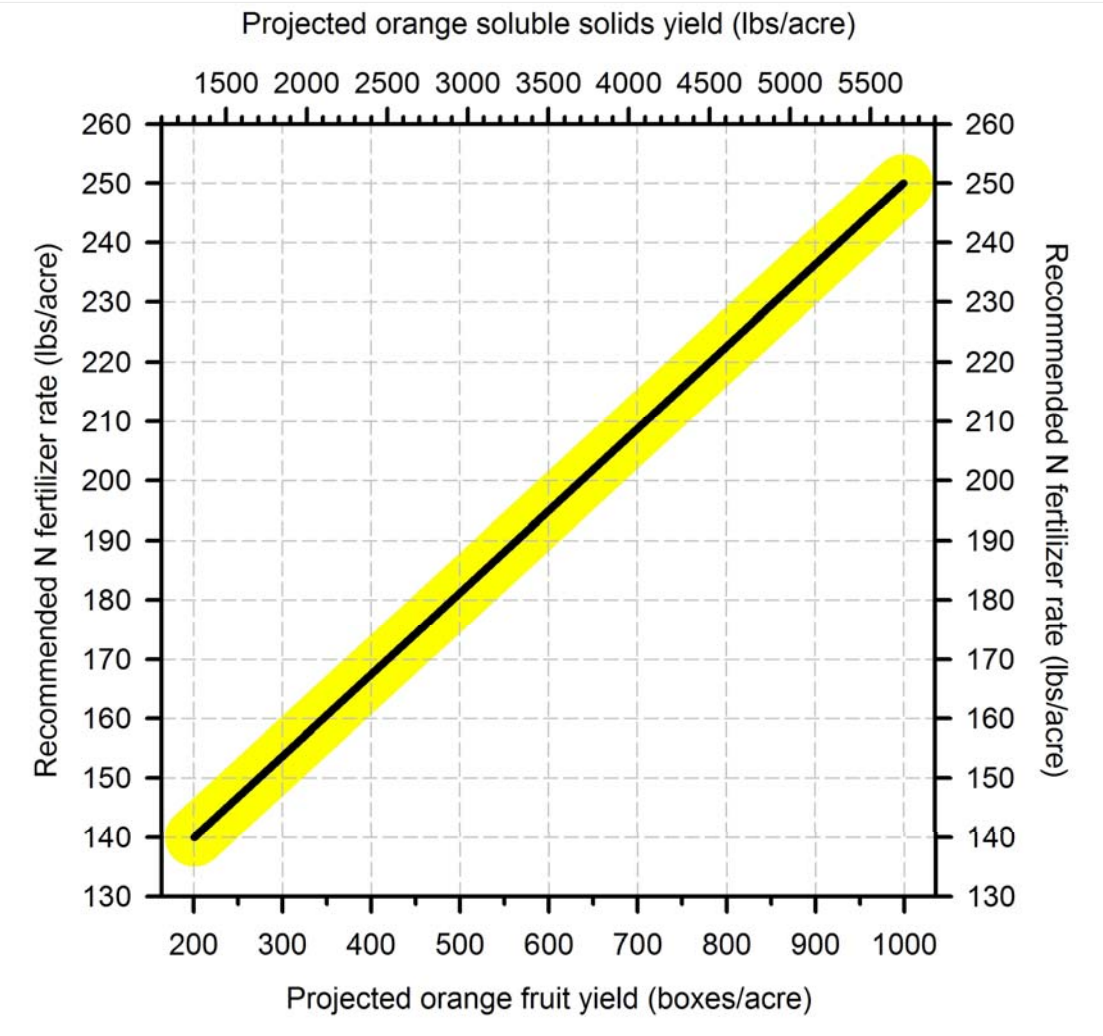
Other practices in use

- CRF incorporated into dry fertilizer blends.
- CRF used to fertilize young trees.
- Biosolids application.
- Foliar urea and/or phosphite application.
- Variable-rate fertilizer application.

Citrus response to N is strong



New UF-IFAS N fertilizer recommendation for oranges is yield-based



Typical P fertilizer management for citrus

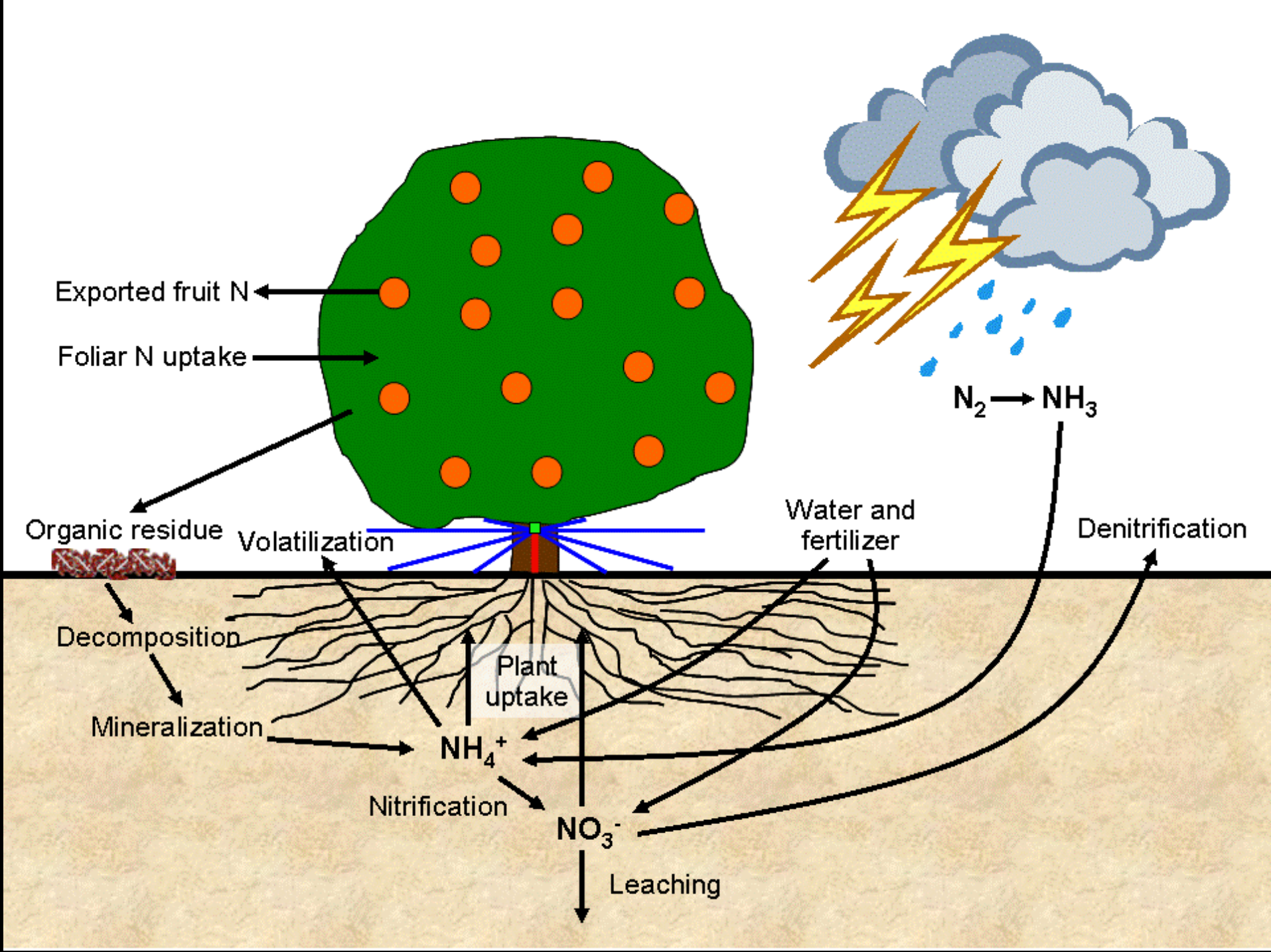
- Don’t apply any P in a mature grove.
- Apply a maintenance application every few years.
- Apply a low rate of P every year.
- Include some P in young-tree fertilizer.

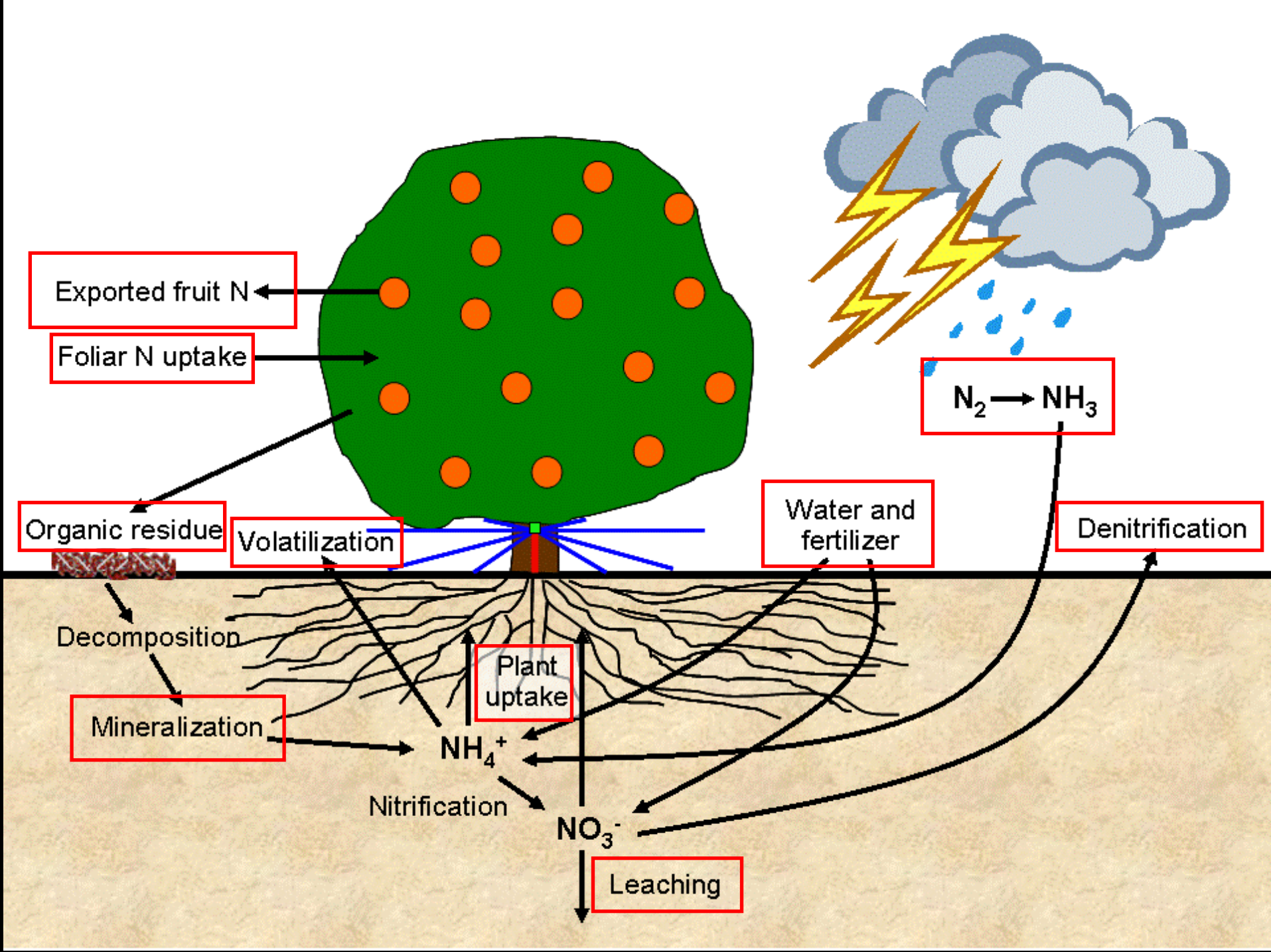
New UF-IFAS P fertilizer recommendation is based on leaf and soil test results.

Typical water management

- Microsprinkler or drip irrigation.
- Around 15” to 17” of water applied per year.
- Variety of irrigation scheduling methods:
  - Experience.
  - Calendar method.
  - Monitor soil water status.
  - Calculate a water budget.
- Drainage: Wide-open vs. controlled

The citrus N budget


Exported fruit N
Foliar N uptake
Organic residue
Volatilization
Water and fertilizer
Denitrification
$N_2 \rightarrow NH_3$
Decomposition
Plant uptake
Mineralization
NH_4^+
Nitrification
NO_3^-
Leaching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Quantity of nutrients removed by the fruit crop

Average total amounts of various nutrients in 100 boxes of orange fruits (1 box = 90 lbs).

N	P	K	Ca	Mg	S	Fe	B	Zn	Mn	Cu
---------- lbs nutrient/100 boxes of fruit ----------										
12.1	**1.7**	**14.5**	**4.4**	**1.2**	**1.0**	**0.04**	**0.02**	**0.03**	**0.02**	**0.01**

N cycling in a citrus grove

Biomass and N distribution in a mature orange tree.

Total tree dry wt. = 273 lbs **Total N in tree = 2.3 lbs (includes 4.8 box/tree mature fruit crop; 1 box = 90 lbs)**		
	% of total tree dry biomass	**% of total N in tree**
Leaves	10	28
Twigs and branches	40	24
Trunk	3	2
Roots	23	20
Fruit	24	26

N cycling in a citrus grove

- Soil organic matter varies between 0.5 and 1.5% in a typical citrus grove.
- N mineralization from OM ≈ 50 lbs/acre/yr.
- N mineralization via residue decomposition varies widely:
  - 35-75 lbs N/acre in a young grove
  - 110-135 lbs N/acre in an old grove.

N leaching losses:

How N source and rate affected estimated nitrate-N leaching below a mature citrus grove on the ridge.

N source	N rate	Estimated NO_3-N leached			
		1994	1995	1994	1995
	lbs/acre/year	----- lbs/acre NO_3-N -----		----- % of N applied -----	
Dry granular	100	9	11	9	11
	150	10	12	7	8
	200	13	12	7	6
	250	20	19	8	8
Fertigation	100	15	16	15	16
	150	16	22	11	15
	200	21	27	11	14
	250	26	31	10	12
Controlled-release	50	1	1	2	2
	100	1	3	1	3
	150	3	7	2	5

N use efficiency:

Recovery of labeled N fertilizer by 6-year old orange trees 280 days after it was applied. The applied N rate was equivalent to 15 lbs/acre.

Tree component	Nitrogen fertilizer source	
	Ammonium nitrate	**Urea**
	--------- % of N applied ---------	
Leaves	9	5
Twigs	5	3
Trunk	1	1
Roots (fibrous + woody + tap)	7	5
Fruit (9-month-old)	18	10
Total	**40**	**24**

N budgets:

N balance at the end of a 6-week period for a single application of soluble N fertilizer (LEACHM simulation).

N inputs		N outputs					
From N fertilizer application	From organic matter	Plant uptake	Leaching	Volatili-zation	To microbial biomass	Soil storage	% of N fertilizer that leached
---------- lbs/acre ----------							
25	13	18	13	9	2	- 4	36
50	13	29	13	13	2	6	21
75	13	35	25	17	2	9	29
100	13	46	27	26	2	12	24

Citrus N budget estimation and simulation by the LEACHM model for a 20+ year-old, very high-producing orange grove on deep sandy soil with optimum irrigation.

	N budget	Simulation
	---------- lbs N/acre/year ----------	
Input		
Fertilizer N applied	250	250
Mineralization	80	70
Atmospheric deposition	10	-----
Non-symbiotic N fixation	5	-----
Initial soil profile N	18	22
Total	363	342
Plant uptake		
Total N in fruits (1140 boxes/acre)	160	
Spring growth	30	LEACHM does not partition N by tree component
Fibrous roots	40	
Storage	25	
Total	255	251
Estimated losses/residual soil N		
Gaseous loss	38	21
Drainage (leaching) below the root zone	-----	**53**
Soil residual N	13	17
Total	51	91
Unaccounted N (likely to be leached)	**57**	

Nitrate-N in groundwater

Phosphorus in runoff

Nitrate-N concentrations in surficial groundwater beneath five Highlands county citrus groves 2 years prior and 5 years after implementing a nitrogen fertilizer BMP program that included optimum irrigation scheduling.

Pre-BMP (1993 – 1994)		Post-BMP (1995 – 1999)	
Grove N fertilizer management	**N concentration in groundwater, 1993 (ppm NO_3-N)**	**Grove N fertilizer management**	**N concentration in groundwater, 1999 (ppm NO_3-N)**
Grove A (flatwoods)			
Soluble N fertilizer; 125 lbs N/acre/year in 2 dry applications.	1.5	**Soluble N fertilizer; 125 lbs N/acre/year; 2 dry applications.**	0.5
Grove B (ridge)			
Soluble N fertilizer; 190 lbs N/acre/year in 3 dry applications.	30.0	**Soluble N fertilizer; 130 lbs N/acre/year in three urea sprays + 18 fertigations.**	7.5
Grove C (ridge)			
Soluble N fertilizer; 180 lbs N/acre/year in 2–3 dry applications	7.5	**Soluble N fertilizer; 154 lbs N/acre/year in 18 fertigations.**	2.5
Grove D (ridge)			
Soluble N fertilizer; 180 lbs N/acre/year in 3 dry applications.	11.0	**50:50 mix of soluble and slow-release N; 165 lbs N/acre/year; 3 dry applications.**	8.5
Grove E (ridge)			
Soluble N fertilizer; 180 lbs N/acre/year in 3 dry applications.	12.0	**Soluble N fertilizer; 160 lbs N/acre/year; 18 fertigations.**	9.0

Total P (TP), total dissolved P (TDP), and ortho P (OP) loads in runoff water from seven Indian River area citrus groves during a 2-year period.

Grove	P fertilizer application	Soil analysis method		P load in runoff water, 2001+2002		
		Water-P	Mehlich 1-P	TP	TDP	OP
	lbs/acre/year	ppm		lbs/acre		
1	33	4	38	1.2	0.8	0.2
2	34	5	34	0.7	0.5	0.2
3	34	3	15	3.4	1.6	1.3
4	34	2	13	4.1	2.5	1.3
5	33	8	60	7.4	6.4	5.4
6	21	1	9	2.7	1.8	0.8
7	14	7	57	4.5	3.4	2.4

Opportunities to improve water and nutrient use efficiency for citrus

- Best management practices.
- High-tech soil moisture monitoring devices.
- Irrigation scheduling considering daily ET.
- Precision nutrient application.
- “Open hydroponics” system??

Focus for future research efforts

- Controlled-release fertilizers.
- Precision nutrient application.
- Variable rate irrigation.
- Automated irrigation scheduling.
- “Open hydroponics.”

Summary of current BMP research areas for citrus, level of knowledge, and gaps.

BMP research area	Level of knowledge*	Gaps
Nutrient management plan	4	
Tissue/soil analysis	4	Confirm initial soil test P calibration.
Fertilizer application method (conv.)	5	
Variable rate application	3	Field performance under a wide variety of conditions.
Fertilizer sources	4	Horticultural performance of controlled-release fertilizers.
Fertilizer rates	5	
Fertilization timing	5	
Erosion control	5	
Irrigation method	3	Variable rate irrigation.
Irrigation scheduling	4	Automated irrigation.
Amendments to improve soil properties	2	Effect of long-term organic matter addition.
Open hydroponics	1	Performance in sandy Florida soils.

*Rating scale: 0 = None; 1 = Very low; 2 = Low; 3 = Medium; 4 = High; 5 = Very high.

Strategic areas of future research involving citrus for improving the quality of Florida waters, their respective approaches and estimated chances of success.

Approach used to improve water quality.	**Possible areas of research.**	**Estimated relative chance of success.**	**Why?**
Precision nutrient application.	Sensor-based fertilizer application.	Very good.	Technology exists but needs refinement and testing.
Controlled-release fertilizer.	Verify release curves for new materials.	Very good.	A sound method is being established.
Irrigation scheduling.	Link soil moisture sensors or ET to irrigation systems.	Fair to good.	Reliability of technology.
Open hydroponics.	Investigate its use in Florida.	Unknown.	System is only in the initial testing stage in Florida.