

Fertilizer Recommendations: Soil Test to Application

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Introduction

- ✓ Florida soils have poor water & nutrient retention and are prone to nutrient leaching and/or run-off
- ✓ Fertilizer recommendations provide general guidelines based on plant growth
- ✓ Improved nutrient plans including soil and tissue sampling matching nutrient supply to soil will improve growth and reduce the risk of potential N leaching on Florida sandy soils
- ✓ No Nutrient you Manage should be Limiting so that the right amount of each nutrient is available when needed

**Right
Source**

**Right
Rate**

**Right
Time**

**Right
Place**



Florida Watershed Restoration Act

- ✓ Authorizes FDACS to develop water quality and water quantity BMPs to address agricultural nonpoint sources to meet Total Maximum Daily Loads (TMDLS) and otherwise protect water quality.
- ✓ Implementation of FDACS BMPs, according to rule, provides “presumption of compliance” with state water quality standards for the pollutants addressed by the BMPs.



Ag Nonpoint Source Pollution

Nonpoint source pollution comes from diffuse sources. It is carried primarily by rainfall and irrigation water, which causes accumulated pollutants to either run off into surface waters or leach into ground water.

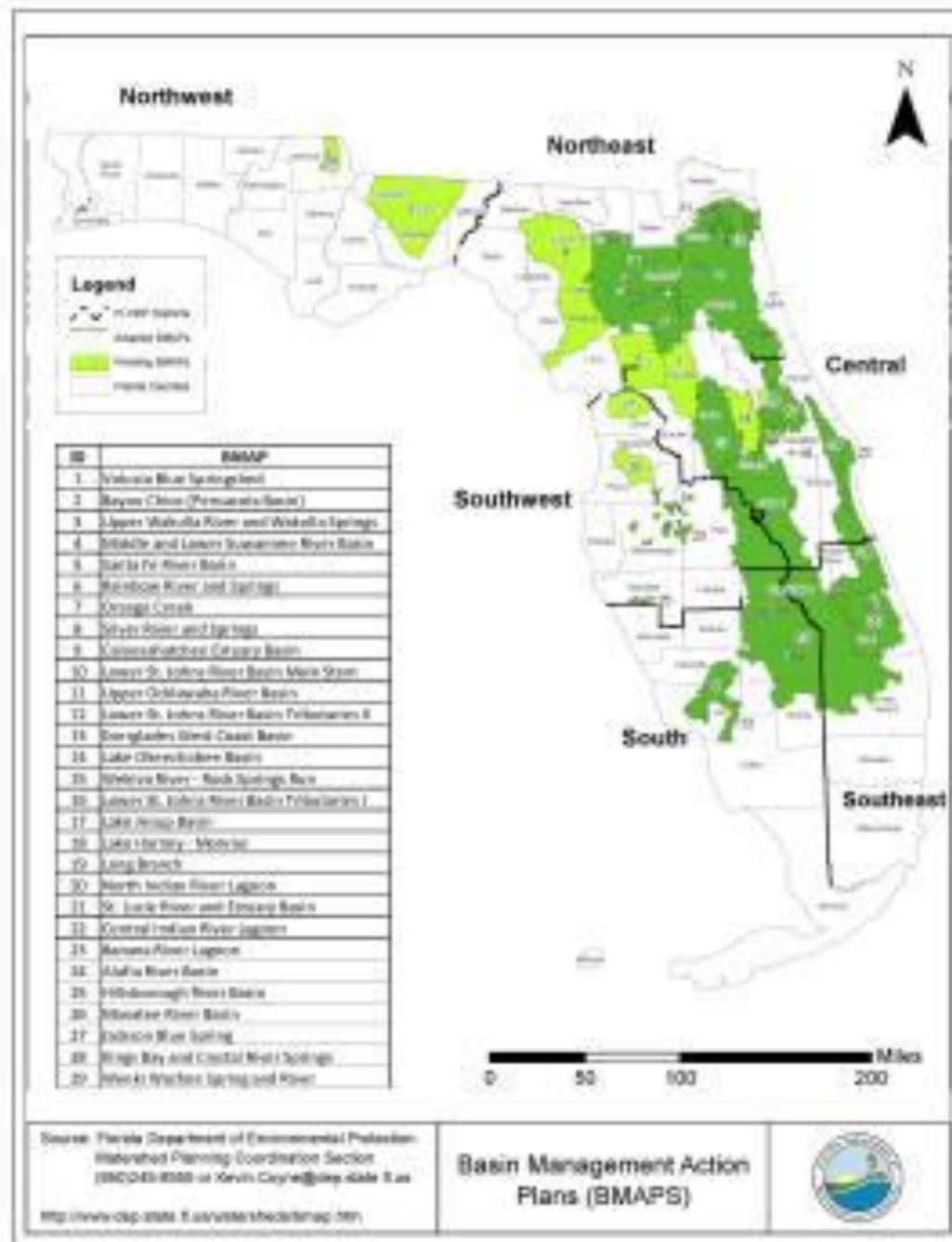


Basin Management Action Plans (BMAP)

- **Florida Department of Environmental Protection (FDEP) Establishes Basin Management Action Plans (BMAP)**
- **The "blueprint" for restoring impaired waters by reducing pollutant loadings to meet the allowable loadings established in a Total Maximum Daily Load (TMDL).**
- **Represents a comprehensive set of strategies-- permit limits on wastewater facilities, urban and agriculture**



Current BMAPs



Implementation of State-wide BMP Program

Programs

- ✓ 25 Basin Management Action Plan (BMAPs) areas
- ✓ BMAPs developed by FDEP
 - ✓ Total maximum daily loads (TMDL)
 - ✓ All water users not only agriculture
- ✓ BMP developed by FDACS-Office of Ag Water Policy

Consequences

- ✓ Less voluntary than in past
- ✓ Land owners required to sign notice of intent (NOI)
- ✓ Presumption of Compliance
- ✓ Implementation Assurance program under development
- ✓ Mandatory water quality samples may be required by FDEP



Best Management Practices (BMPs)

- ✓ Participation in FDACS BMP programs is agriculture's method of compliance
- ✓ BMPs are science based practices that will reduce environmental impact
- ✓ Practices include: nutrient management, irrigation scheduling, and water resource protection
- ✓ Financial assistance is offered by FDACS, water management districts and USDA -designed to implement the pollutant reductions established by the TMDL.



Improving Nutrient Use Efficiency

BMP = Efficient use of Water and Nutrients

Efficient water and nutrient use will:

- ✓ Maintain adequate water and soil nutrient levels to maximize plant growth and health
- ✓ Increase growth
- ✓ Decrease production cost and resource depletion: facilitates sustainable production
- ✓ Reduce nutrient losses and environmental impacts



Statewide Participation

4.6 million acres enrolled in BMPs statewide

- ✓ **Cow/Calf 2.8 million acres**
- ✓ **Row Crops 1.04 million acres**
- ✓ **Citrus 578,812 acres**
- ✓ **Mixed Use 102,733 acres**
- ✓ **Dairies 56,710 acres**
- ✓ **Sod Farms 38,006 acres**
- ✓ **Nursery 30,539 acres**
- ✓ **Fruit/Nut 7,116 acres**
- ✓ **Equine 1,653 acres**



Emphasis for BMP Extension

- Increased emphasis on soil and tissue testing in nutrient recommendations
- Improved irrigation management scheduling
- Development of smart phone and tablet apps on irrigation and nutrient recommendations and fertilizer management calculations
- Development of improved nutrient documents to support FDACS BMP manuals

FDACS BMP Implementation Assurance (IA)

- **Written surveys to get producer feedback on BMP implementation –**
 - **Helps evaluate effectiveness of programs/identify producer needs**
- **Site visits conducted, to verify implementation**
 - **To review key BMPs, discuss questions, provide technical assistance**
 - **Implementation assurance is currently progressing through rule making**



BMP Record Keeping

- Record keeping, as specified in FDACS rules and BMP manuals are required.
- BMP records must be accurate, clear, and well-organized.

Fertilization/Nutrient Records (Retain all Lab Results)					
Date	Location	Acreage Covered	Type ¹	Formulation ²	Grade ³

Irrigation Maintenance							
Date	Location	Last Inspected	Motor Values ⁴	Withdraw Rate (GPM)	Pump Values ⁵	Current System Efficiency ⁶	Irrigation Lines Condition

Rainfall (In.)											
Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.

Well Records					
Location	Year Constructed	Constructed By	Last Modified	Modified By	Records Location



Agriculture's Role in Water Quality Protection

The Legislature provided for agricultural operations to implement BMPs as the preferred means to help meet TMDLs and otherwise protect water quality.

Agricultural operations within BMAP areas have two options*:

- ✓ Enroll in and implement FDACS BMPs

Or

- ✓ Follow an FDEP- or WMD-prescribed water quality monitoring plan at the producer's own expense (complicated and costly)

* Failure to do either could bring enforcement action by FDEP or the applicable WMD



**Estimated Costs of
Ground water Sampling
and Analysis Required
by FDEP if not
Implementing BMPs
in a BMAP**

Section	Action	Cost Range
Monitoring Plan Development	Initial Monitoring site selection report for– surface water and/or groundwater. PG or PE required	\$25,000 to \$45,000
Well Installation	Groundwater Monitoring Well installation 25 feet deep or less	\$1,500 per well
Well Installation	Groundwater Monitoring Well installation 70 feet deep or less	\$6,000 per well
Surface Water Monitoring Station	Installation/calibration of station	\$10,000 per station
Sampling Wells	Monitoring Well Sampling Dependent on depth of well	\$400 to \$600 per well
Sampling Wells	Groundwater analytical costs	\$400 to \$800 per sample
Sampling Report	Water quality monitoring report	\$1,500 to \$3,000



BMP considerations for nutrient and water management

■ Use of UF/IFAS recommendations:

Nitrogen rate & timing for the growth of young non-bearing trees depending on soil type, fertilizer source and placement, crop load, crop variety, and irrigation method (if applicable)

■ Use of soil analyses information for fertilizer application:

Growers can make informed decisions about crop fertilization requirements.



BMP considerations for water and nutrient management (2)

- ✓ **Use of tissue analyses for fertilizer application decisions:**
 - ✓ This helps in assessing nutrition status of crops for macronutrients (e.g. N and K) and micronutrients (e.g. Cu, Mn, Zn, Fe, B)
- ✓ **Training of fertilizer applicators:**
 - ✓ Adequate training of the field operators in the handling, loading and operating of fertilizer spreaders and accurate calibration of equipment.



BMP considerations for water and nutrient management (3)

- ✓ **Fertilizer placement near or over the root zone:**
 - ✓ Accurate placement of fertilizer facilitates uptake and reduces nutrient losses through runoff and leaching.
- ✓ **Avoiding fertilization during high water table or flooded conditions:**
 - ✓ Applying nutrients during wet conditions leads to leaching and lateral flow of nutrients, thus increasing costs of production and posing environmental concerns to surface and groundwater.



BMP considerations for water and nutrient management (4)

- ✓ **Split fertilizer applications:**
 - ✓ Split fertilizer applications >can reduce leaching losses particularly for N and K during excessive rainfall events.
- ✓ **Use of fertigation practices:**
 - ✓ Helps in precise control of nutrient placement in concert with irrigation for optimal water and nutrient uptake.



4 R Crop Nutrient App

The app interface consists of four main screens:

- Home Screen:** Features a blue background with a plant illustration. The text "RIGHT Source Rate Time Place" is displayed vertically. A red "Start" button is at the bottom. The UF IFAS Extension logo is in the bottom right corner.
- Right Rate Screen:** Titled "Soil Test Results (lbs/acre)". It shows a table of soil test results with sliders for P, K, Mg, and Ca. The values are: P=120, K=56, Mg=49, Ca=205.
- Rate Source Screen:** Titled "Bean, snap". It shows a table of nutrient recommendations for Nitrogen, Phosphorus, Potassium, and Magnesium. The values are: Nitrogen (Index N/A, Recommendation 100), Phosphorus (Index High, Recommendation 0), Potassium (Index Medium, Recommendation 150), and Magnesium (Index High, Recommendation N/A).
- Right Time/Method Screen:** Titled "Right Rate / Time". It shows a table of fertilizer rates and application rates. The values are: Fertilizer Rate (Lbs/100L) 11478, Fertilizer Per Application (Lbs/100L) 1913, Fertilizer Rate (Lbs/Acre) 100, and Fertilizer Per Application (Lbs/Acre) 16.

Right Rate

Rate Source

Right Time/Method

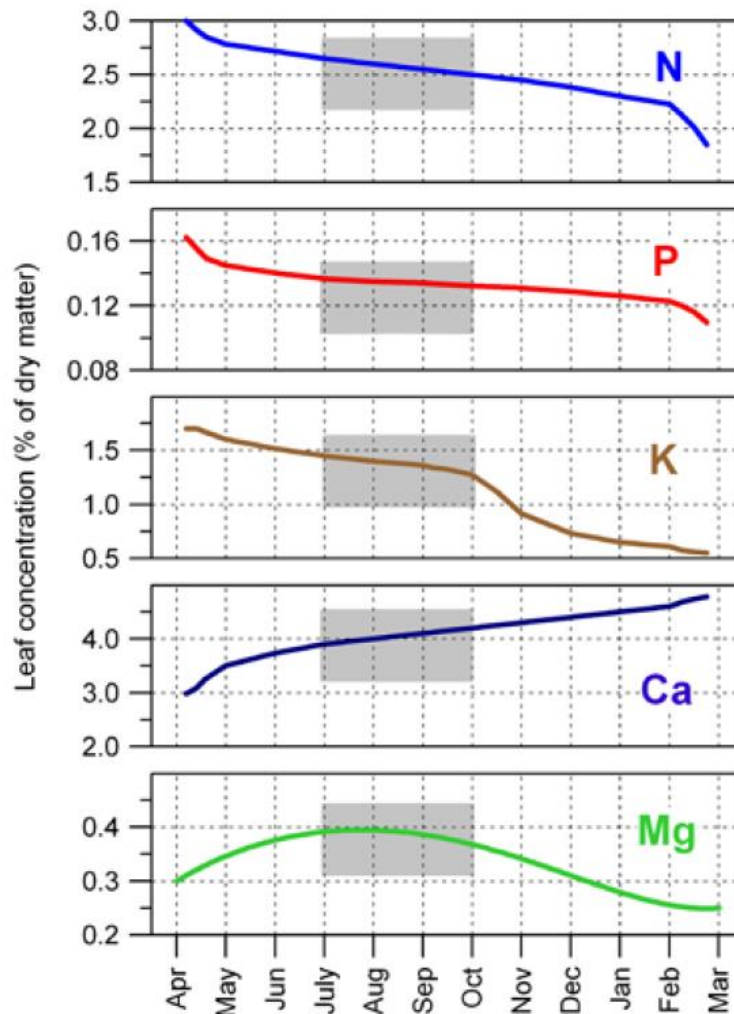


Leaf Nutrient Concentrations



Leaf Nutrient Concentrations

- Leaf nutrient concentrations continuously change.
- As leaves age from spring through fall, N, P, and K concentrations decrease, Ca increases, and Mg first increases and then decreases
- Leaf mineral concentrations are relatively stable from 4 to 6 months after emergence in the spring



Soil pH



Alkalinity

- ✓ Primarily determined by presence of bicarbonates (HCO_3^-), Carbonates (CO_3^{2-}), and hydroxides (OH^-) in water.
- ✓ A measure of the capacity of water to neutralize acids.
- ✓ Alkaline compounds in water remove H^+ ions and lower the acidity of water (increase pH).

Limits nutrient availability in soils



Bicarbonates in Water

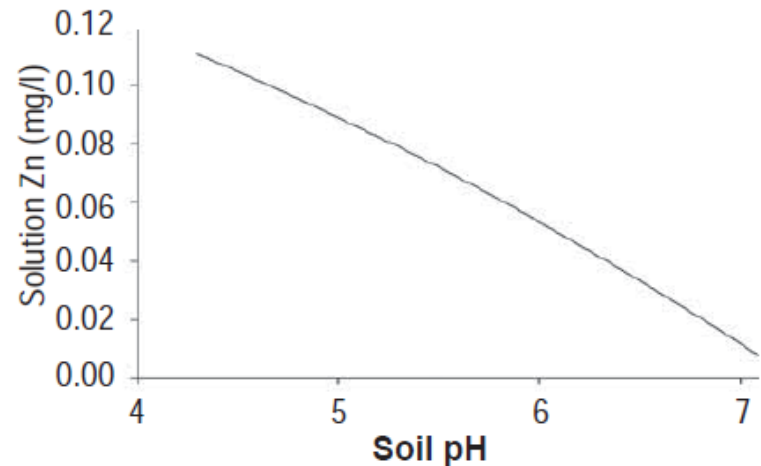
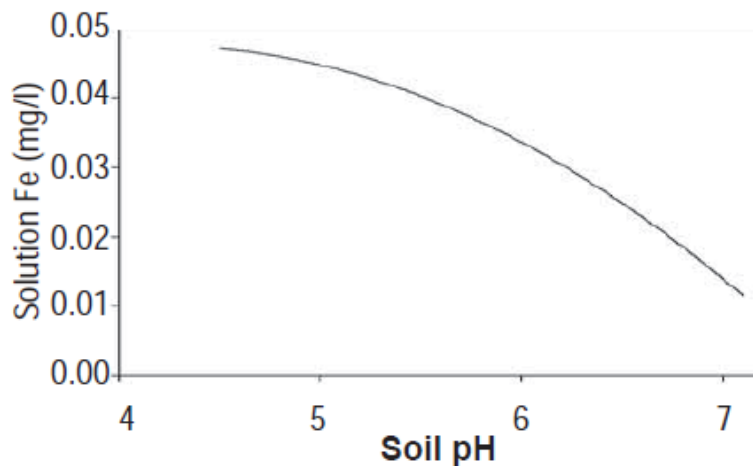
- ✓ Water above pH 7.5 is usually associated with high bicarbonates.
- ✓ Recommend levels of 100 ppm or less
- ✓ Forms bicarbonate salts with Ca, Mg, Na, and K.
- ✓ High Ca concentrations will react to form Calcium carbonate or lime.
- ✓ Higher calcium carbonate in soils increases pH making many nutrients less available.
- ✓ Particulates can drop out of water and plug emitters or microsprinklers.
- ✓ Soils with excess Ca forms CaCO_3 (lime).
- ✓ Treatments:
 - calcium or gypsum (calcium sulfate) to increase calcium availability to plants and soil,
 - elemental sulfur can be used to reduce soil pH,
 - applications of acidified water or acidic fertilizer



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IFAS

Plant Uptake

- ✓ Bicarbonate induced chlorosis is caused by transport of bicarbonate into the plant leading to reduced nutrient uptake.
- ✓ Lime-induced chlorosis effects many annual crops and perennial plants growing on calcareous soils.



Horneck, D. 2006. Acidifying Soil for Crop Production East of the Cascades. Oregon State

Water Treatment

- ✓ Standard treatment is to lower the water's pH by adding an acid. Lowering the pH to 6.5 neutralizes about half the bicarbonate in the water.
- ✓ Injection of acidified water instead of a dry material to a wide area will reduce bicarbonate accumulation in the irrigated area where irrigation may cause to accumulation.
- ✓ Most common acids to inject are sulfuric acid, phosphoric acid.



Acidification of the soil and water reduces pH, increase nutrient uptake

Water conditioning, **Faster, lower soil bicarbonate**

Injection of N-furic acid or sulfuric acid (40%) to adjust irrigation water to pH 6.5



Soil conditioning, **Slower , high soil bicarbonate**

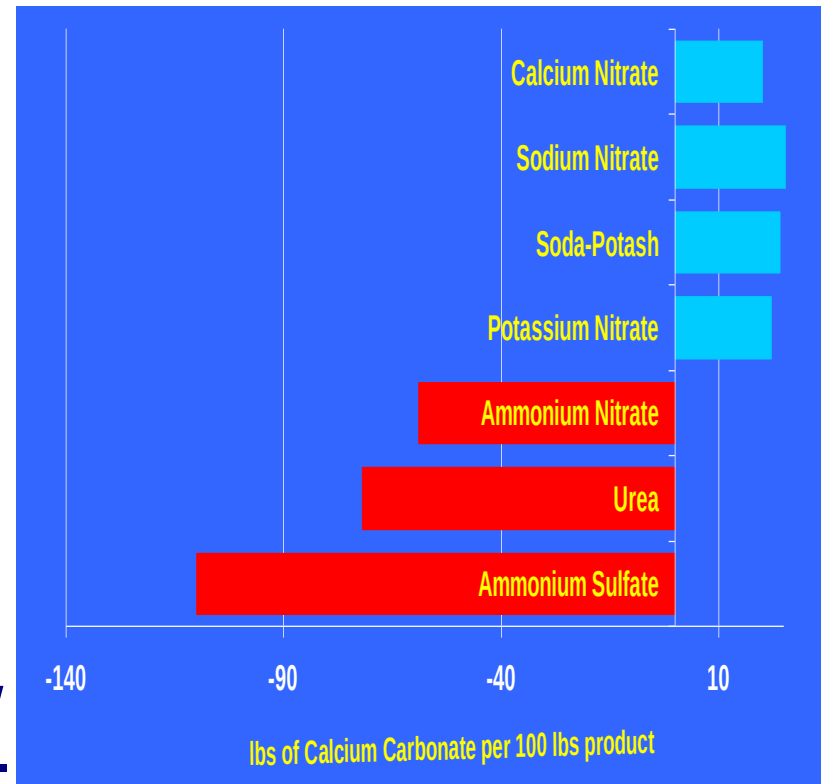
300 lbs/treated acre of Tiger 90 sulfur
lowered soil pH in 9 months
Valencia/Swingle - 10 yr old

<u>Sulfur</u>	<u>pH</u>	<u>Root density (mg/cm³)</u>
No	6.4	1.1
Yes	5.9*	1.4*

*Significant difference $P < 0.05$

Acidifying Fertilizers

- ✓ **Alternative Acidifying methods**
 - ✓ **Formulations with acidifying materials**
 - ✓ When ammonium is converted into nitrate in the soil $3H^+$ are released increasing soil pH
 - ✓ Ammonium thiosulfate is also acidifying because it supplies both ammonium and sulfur
 - ✓ Replace any filler with slow release forms of sulfur (e.g. Tiger 90)



Soil Testing and Nutrient Recommendations



Soil Analysis or Plant Tissue Analysis

- Soil Analysis typically used to determine application needs prior to planting
- Extractable vs. available
- Deficiencies, toxicities and imbalances
- Plant analysis typically used during the season to determine if proper amount of nutrient are available “potential uptake conditions”



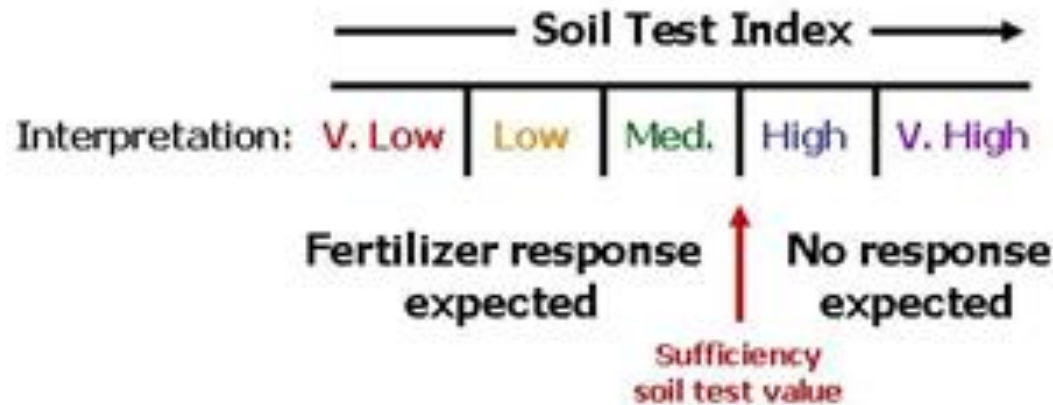
Soil Sampling Method

- Take sample cores to a 15 cm depth
- One sample per management unit
- Minimum of 20-30 cores per 15 hectares
- Composite samples by management unit
- Random patterns across field avoiding edges



Soil Test Results

- ✓ Soil test results are extractable nutrients
- ✓ An index of available nutrients
- ✓ Not a measure of plant-available nutrients
- ✓ Not be used to calculate available nutrients



The probability of response to added fertilizer decreases as Soil Test Index increases.



Soil Nutrients Recommendations Using Mehlich-3

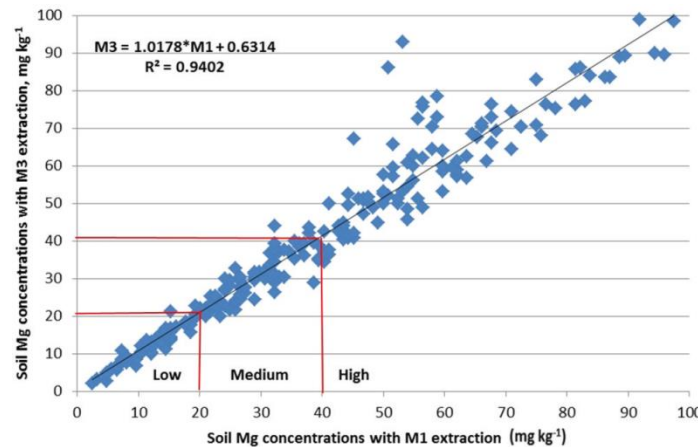
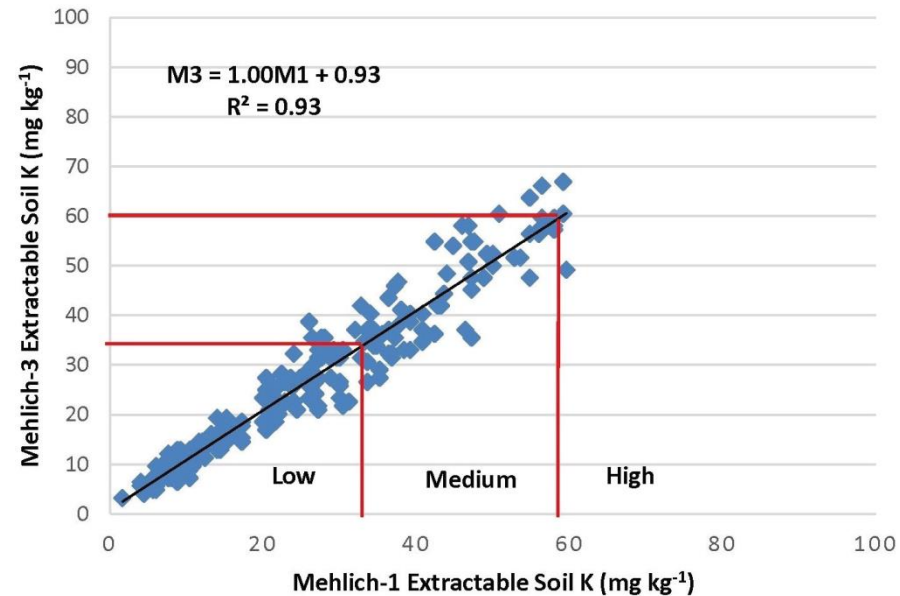
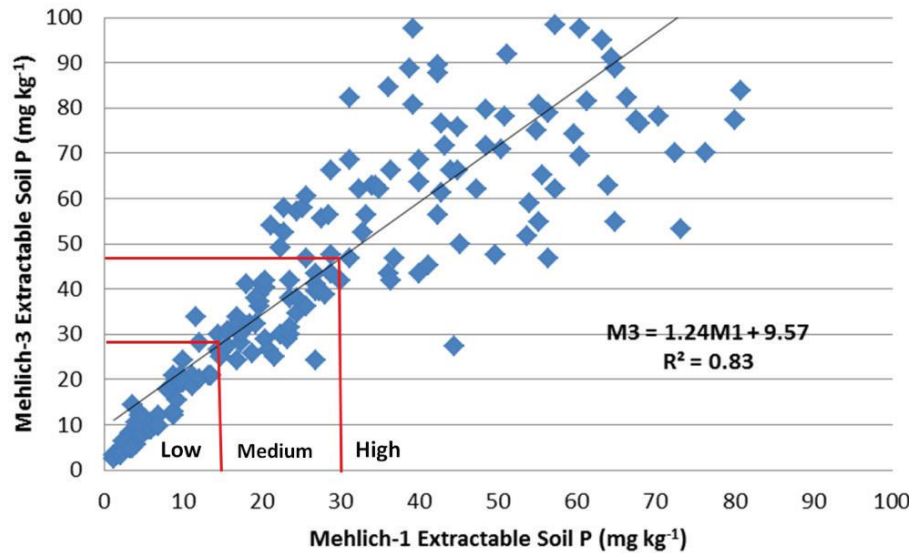
Table 1. Comparison of Mehlich-1 and Mehlich-3 soil extractants

	Mehlich-1	Mehlich-3
Valid pH Range	pH < 6.5	Most normal soil pH ranges
Extraction of P	Limited in soils with high Fe and Al accumulations	Fluoride facilitates dissociation of phosphates from Fe and Al oxides
Extraction of Micronutrients	Dilute acid mixture, only some micronutrients extracted	EDTA (chelate) extracts micronutrients
Exchangeable Cations	Poor extractant for high CEC soils	Ammonium nitrate extracts exchangeable cations

- Changed from Mehlich 1 to Mehlich 3 in 2014
- Most Florida soils have increased in pH
- Mehlich 3 best extractant to provide fertilizer recommendations



Comparing Soil Test Results for Mehlich 1 and Mehlich 3



Current Mehlich 3 Soil Test Interpretation

	Mehlich-3, mg kg ⁻¹		
Nutrient	LOW	MEDIUM	HIGH
P	≤25	26–45	>45
K	≤35	36–60	>60
Mg	≤20	21–40	>40

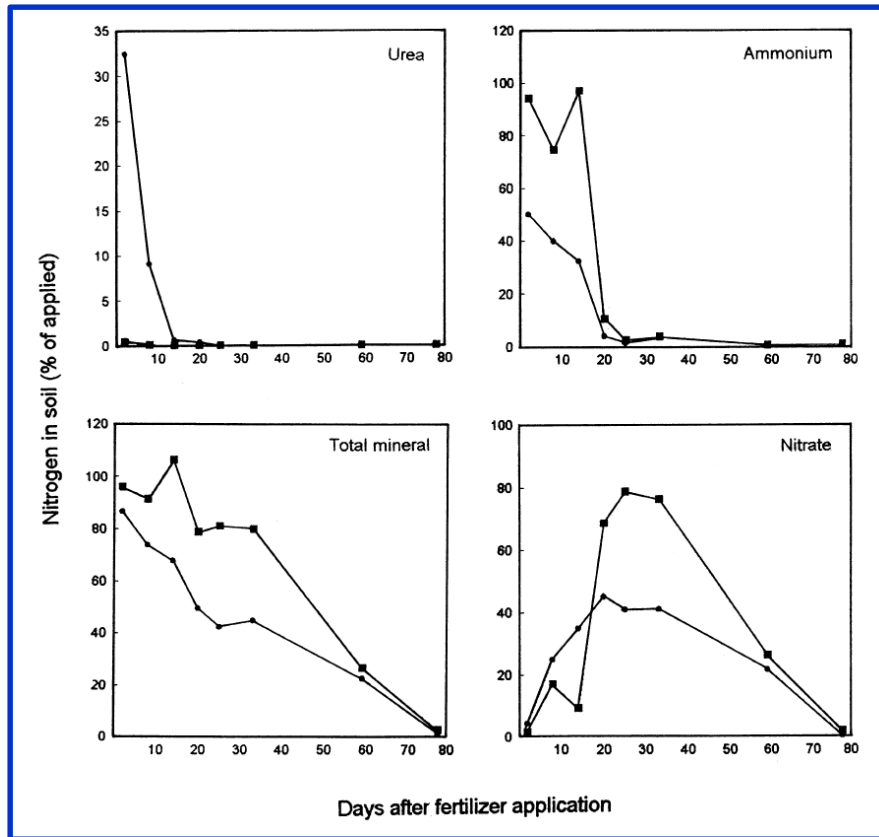


Availability

- P increasingly available with increased pH
- P increasingly not available above pH 7.0 in high Ca soils
- P most available in the pH range of 5.5 to 6.5
- P soil tests suggest that P can accumulate and remain available for years



Placement Determines N Form



Source: Prasertsak et al. 2002. Effect of fertilizer placement on N loss from sugarcane in Tropical Queensland

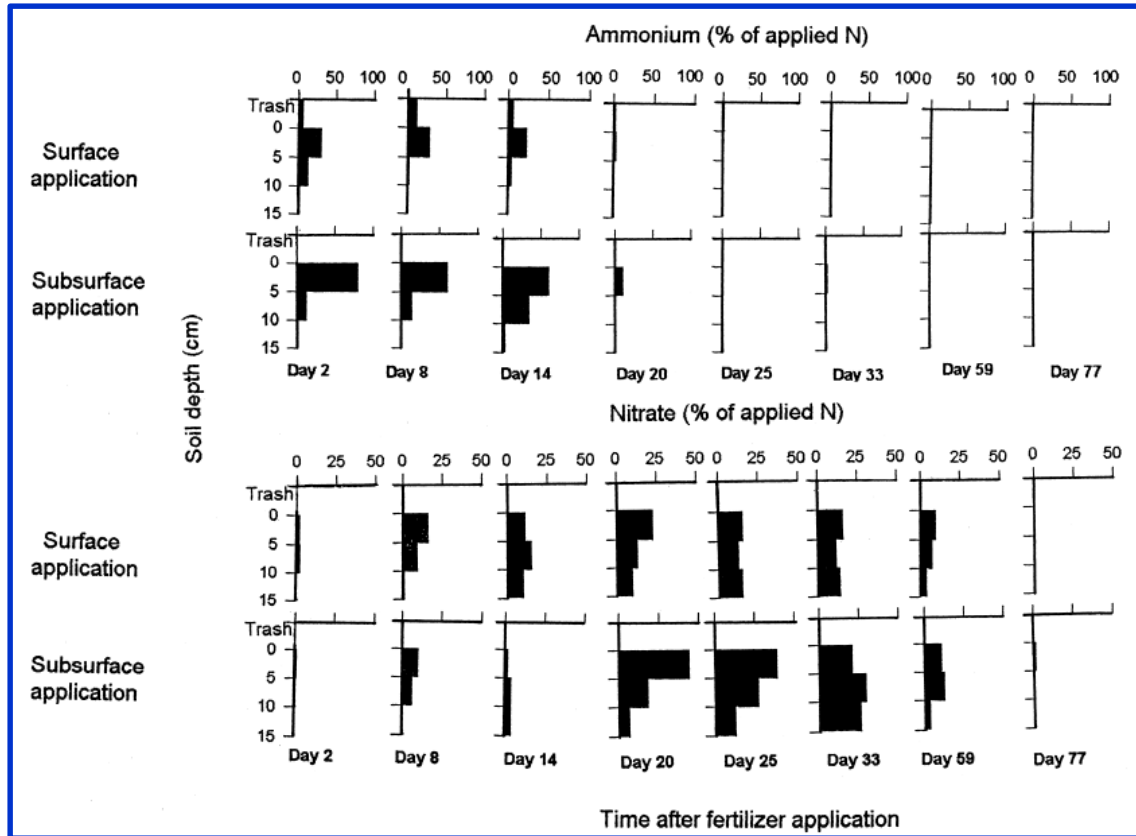
Queensland Australia
Clay soil
Fertilizer placement
impacts the amount
of N loss

Fertilizer source impacts
the type of N available
to the plant

Fertilizer source has
a direct impact on the
duration that an N type
is available

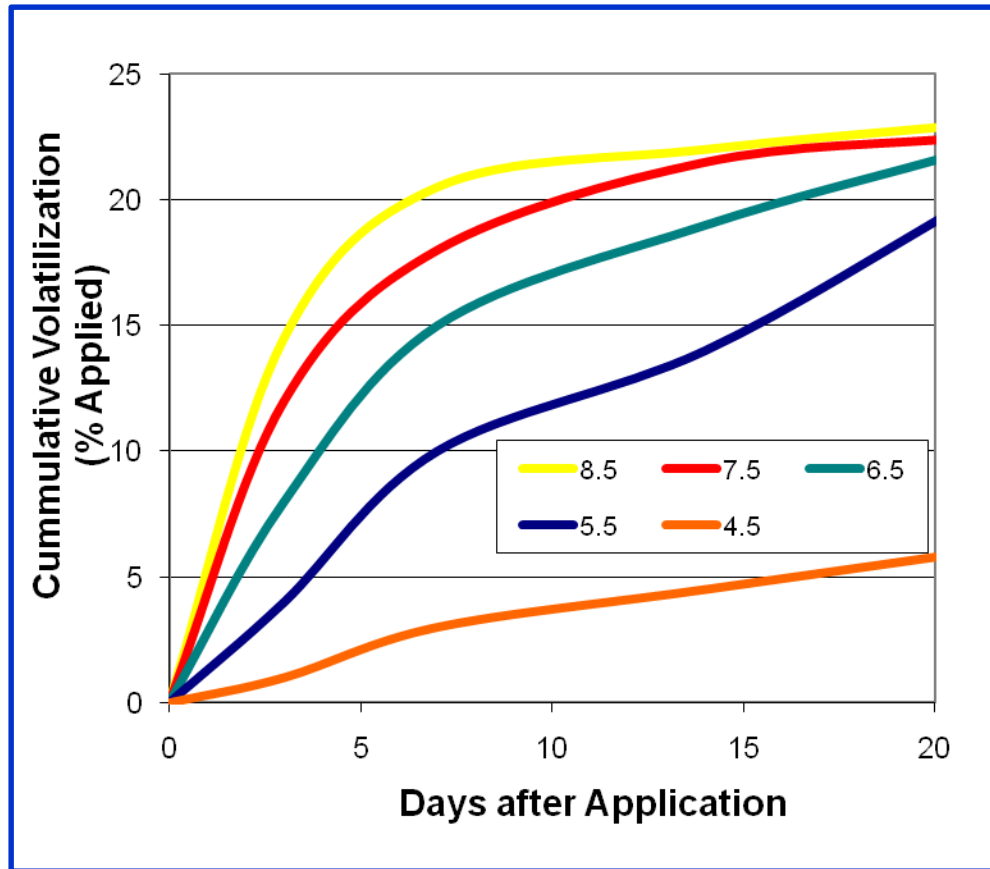


Nitrogen Transformation



- Ammonium applied to the surface decreases quickly by volatilization
- Conversion of Ammonium to nitrate begins less than 8 days, complete in 20 days

Effect of Soil pH



- **Cumulative volatilization with time is dependent on soil pH**
- **minimum volatilization below pH 5**



Source: Z.L. He et al. 1999. Ammonia Volatilization from Different Fertilizer Sources and Effects of Temperature and Soil pH. Soil Science 164:750-758.

Soil Characteristics and P

Soil affects on P fixation

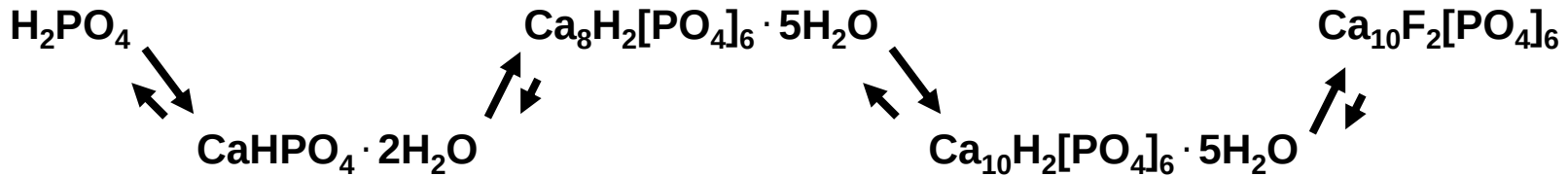
- Clay soils “fix” P in clay layers
- Organic matter “fixes” P on exchange sites
- Sand holds very little P
- P precipitates out as Ca compounds in calcareous soils

Phosphorus fertilizer affects:

- Fruit yield
- Juice quality
- vegetative growth
- much less dramatically than N or K



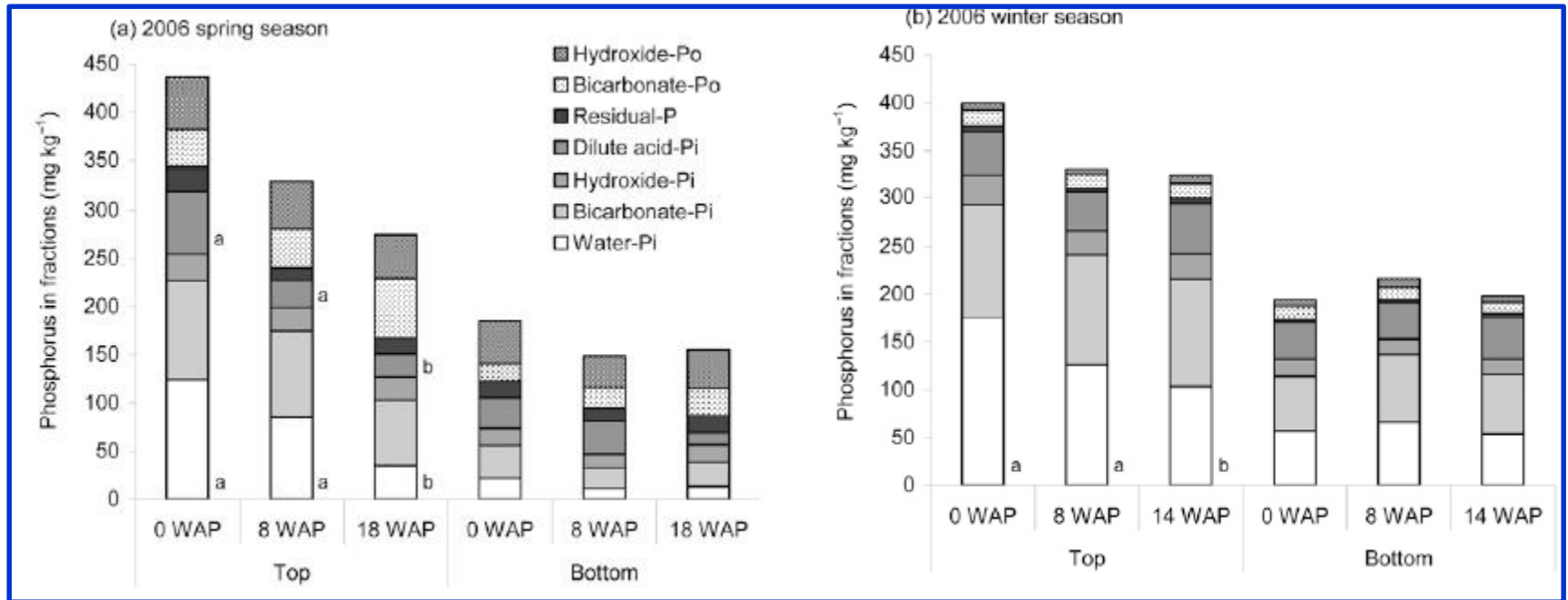
Soil Phosphorus



- Reduced Availability (pH = 7.0 to 8.3)
- “Fixed” by soil calcium
- Available to plant for short period of time
- Accumulates over time in-soluble forms
- Soil test measures “extractable” P and not “total” P
- “Extractable” P may contain P not available to the plant



P Availability Over Time



- Available P mostly water and some bicarbonate extractable
- Increasingly less soluble (less available) with increase as you move up Bar
- Indication of reduced concentration of dilute acid and water extractable P with time



The 5th R, Right Irrigation

- Water is the carrier for nearly all pollutants. Managing irrigation inputs and drainage to keep moisture and fertilizer primarily in the root zone will reduce nutrient-related impacts. Irrigating in excess of the soil's water-holding capacity or excessive drainage will lead to increased runoff or leaching, and may lead to higher production costs or lower marketable yields.



BMP considerations for water and nutrient management (5)

- ✓ **Soil moisture based irrigation scheduling:**
 - ✓ Use of TDR, tensiometers and other soil moisture measurement devices. This can reduce nutrient leaching beyond the root zone.
- ✓ **ET-based irrigation scheduling:**
 - ✓ Use of weather data to decide when and how much to irrigate. FAWN and other weather data help in using the soil water budget for irrigation.



Smart Phone Apps

My Florida Farm Weather

- ✓ Display similar to website
- ✓ Interactive temperature recording
- ✓ **SmartIrrigation**
- ✓ Supported by Multi-state NIFA proposals
- ✓ Released –



- ✓ citrus, Turf, strawberry, cotton, vegetable, avocado, peanut

- ✓ Under Development –
 - ✓ Blueberry



Take home messages

- **Good nutrient and water management improve biomass accumulation, canopy development, and yield.**
- **N accumulation greater than current recommendations.**
- **BMPs critical for reducing nutrient loads, irrigation water volumes and production costs.**
- **Ground water sampling may be required by FDEP within BMAPs if not enrolled in BMP program**



Thank You!

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