Optimizing Cotton Fertility in Yield Limiting Environments

High Plains Agricultural Consultants Conference
Lubbock, TX
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TEXAS A&M AGRILIFE RESEARCH

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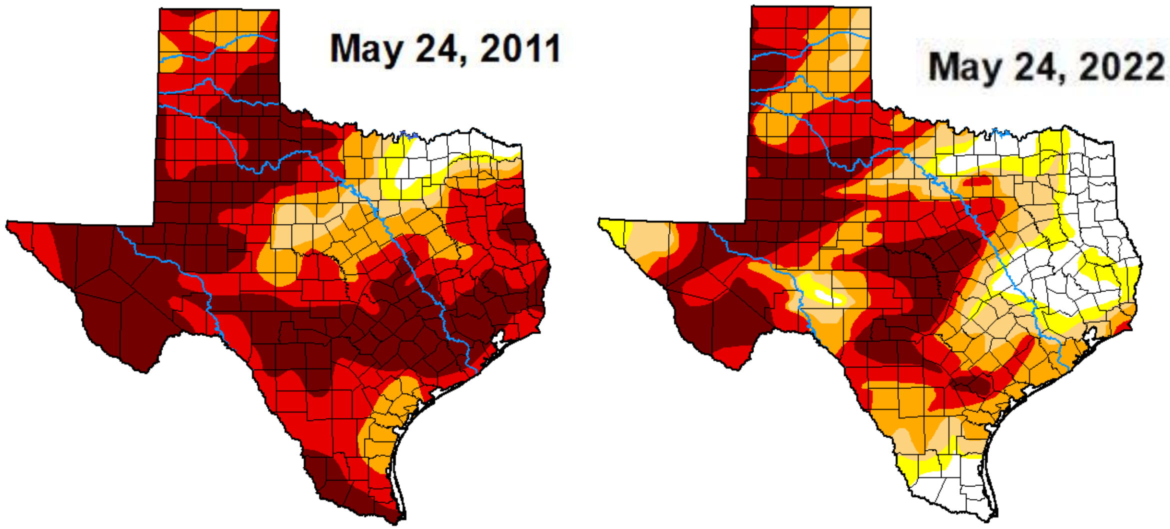
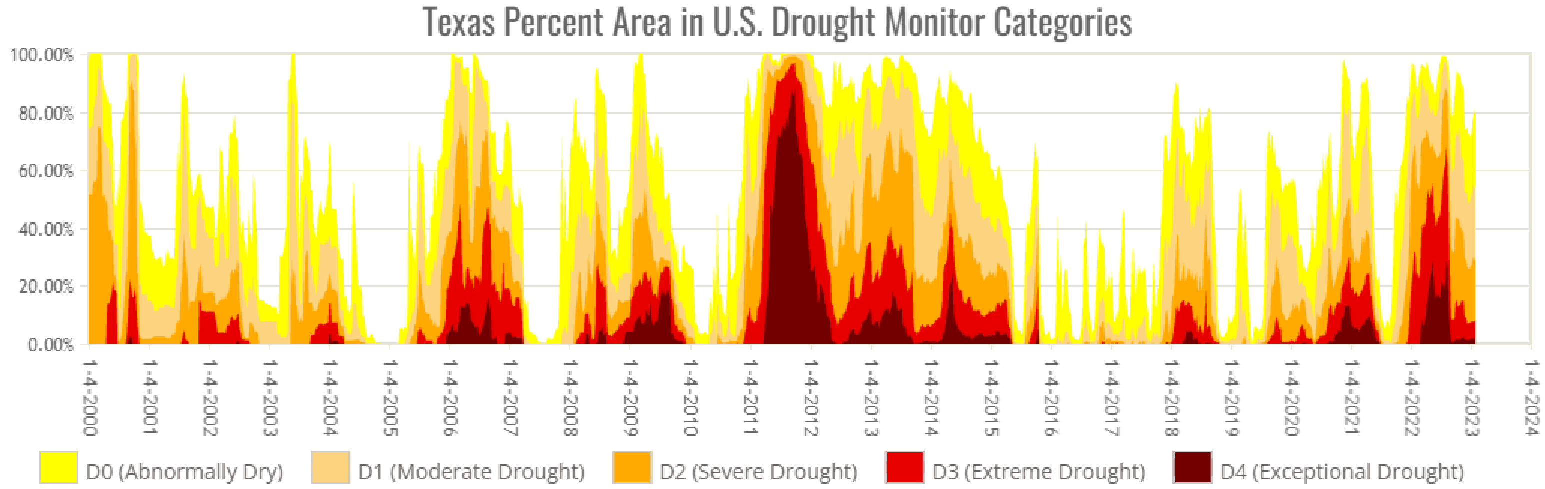
Farmer Concerns

- Environment
- Instability of availability
- Costs





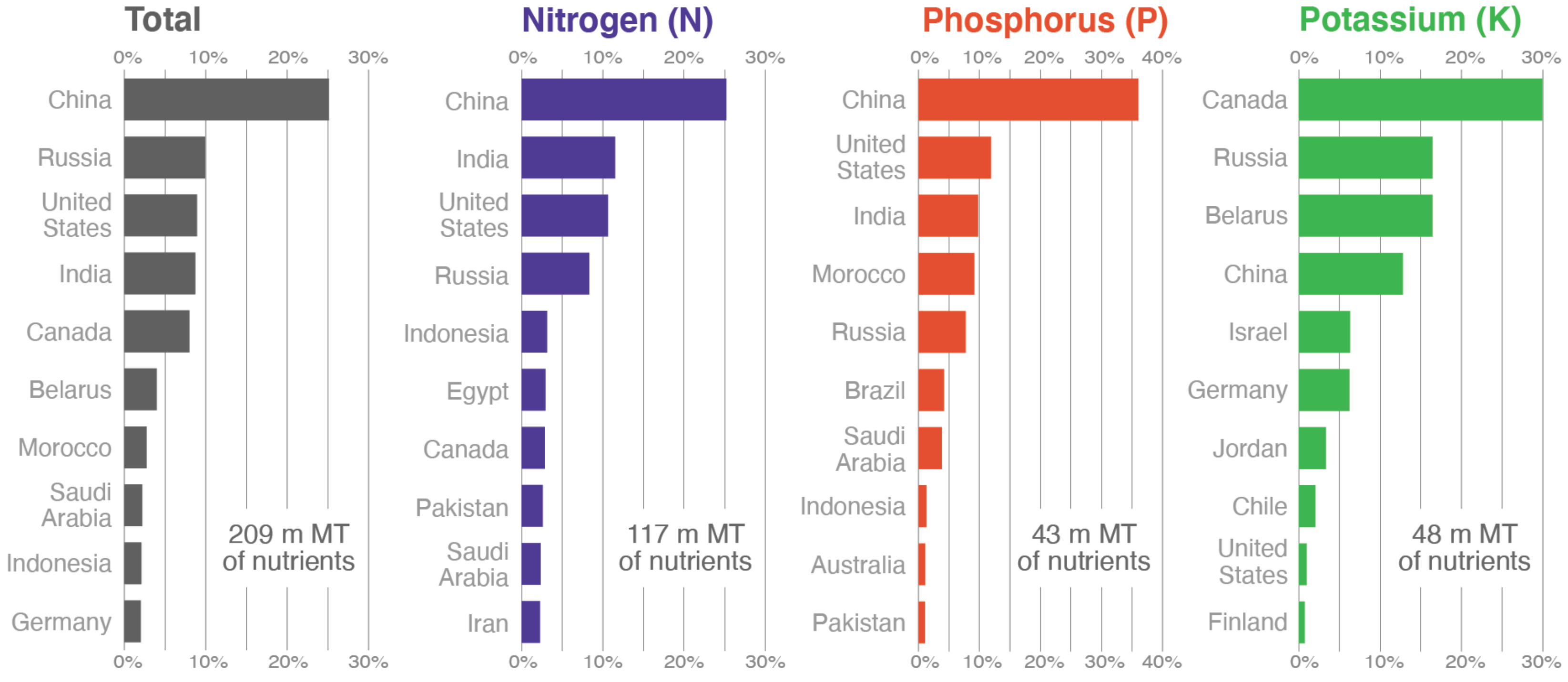
Farmer Concerns

Environment

Instability of availability

Costs

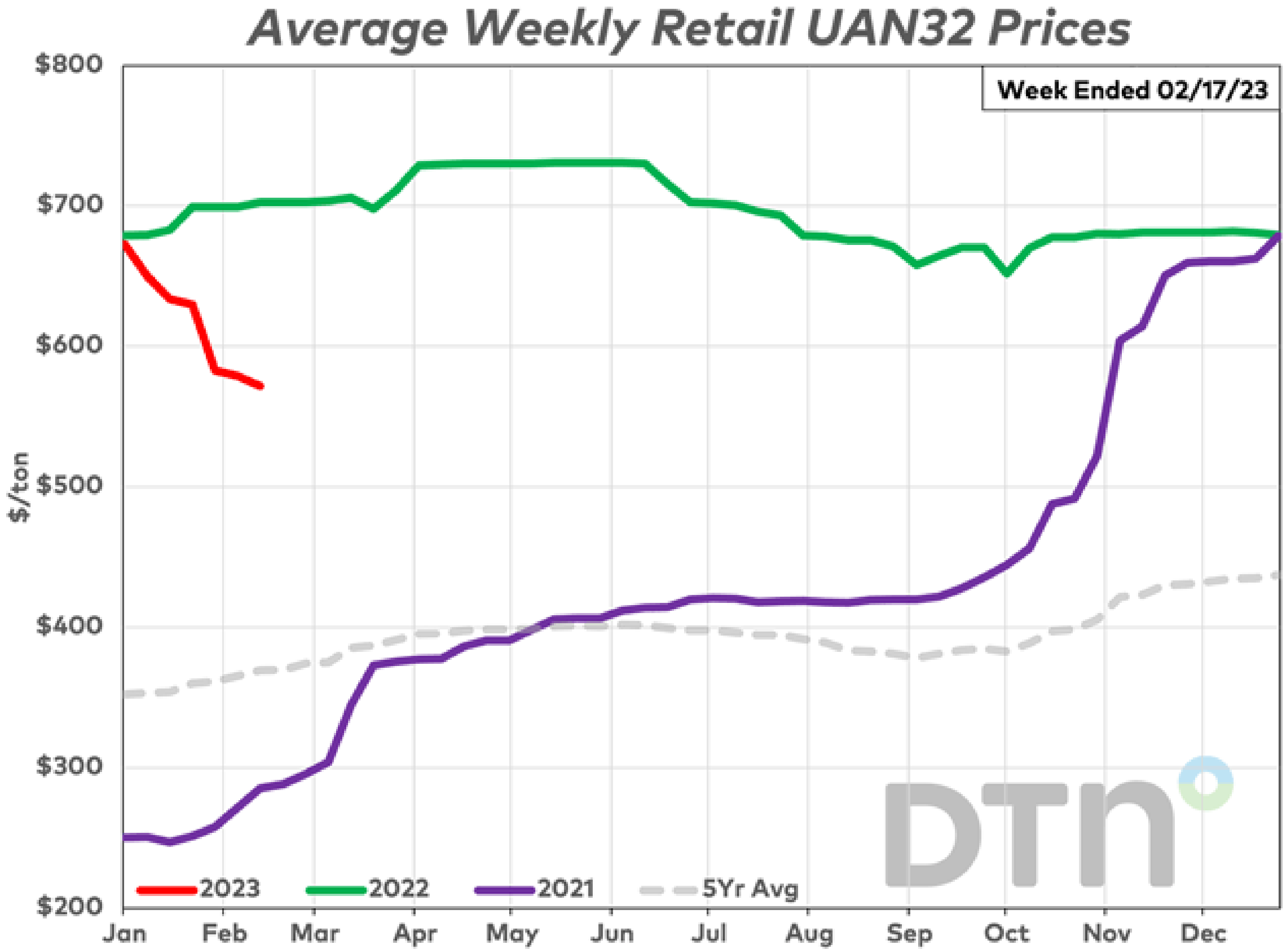
Chart 2. Major Global Fertilizer Suppliers



Source: IFASTAT, 2017-2019 average

Farmer Concerns

- Environment
- Instability of availability
- Costs
  UAN-32: $0.90/lb
  Urea: $0.75/lb N



Fertilizer Prices

Fertilizer	12/2/2022	02/21/2023
Urea	$795/ton	$686/ton ($0.75/lb N)
Anhydrous ammonia	$1,416/ton	$1,213/ton ($0.74/lb N)
UAN-32	$681/ton	$572/ton ($0.89/lb N)
MAP	$960/ton	$857/ton ($0.82/lb P_2O_5)
DAP	$926/ton	$838/ton ($0.91/lb P_2O_5)
10-34-0	$753/ton	$754/ton ($1.11/lb P_2O_5)
0-0-60	$831/ton	$692/ton ($0.58/lb K_2O)

Does Dryland Fertilizer Pay??

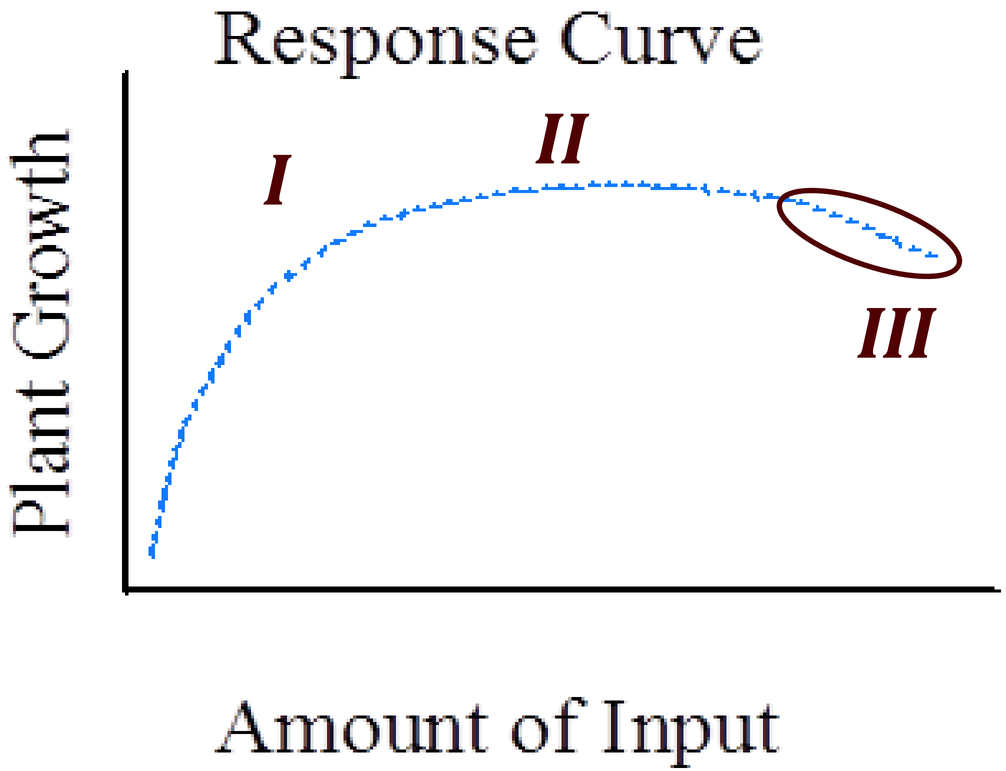
Does Dryland Fertilizer Pay?

- Rule for making input decisions is balancing Marginal Revenue (MR) and Marginal Cost (MC)

I. MR > MC : Profitable decision

II. MR = MC : Point of profit maximization

III. MR < MC: Losing profits



Economic Questions: Will Keeling (will.keeling@ag.tamu.edu)

Does Dryland Fertilizer Pay?

- Assume fertilizer rates are based on soil test
  - 40 lb N/A as UAN-32 ($0.99/lb N) and 30 lb P/A as 10-34-0 ($1.11/lb P)
- Applied as UAN-32 and 10-34-0
- Lint ($0.80/lb) and cottonseed ($250/ton)

100 lb lint yield increase

– MR = (100 lb x $0.80) + (0.071 x $250) = $97.75

– MC = ($0.99 x 40 lb N/A) + ($1.11 x 30 lb P/A) + $5/A (app. cost) = $77.93

– **MR ($97.75) > MC ($77.93): profitable decision**

– **Net Benefit of $19.82/A**

200 lb lint yield increase

– MR = (200 lb x $0.80) + (0.142 x $250) = $195.50

– MC = ($0.99 * 40 lb N/A) + ($1.11 x 30 lb P/A) + $5/A (app. cost) = $77.93

– **MR ($195.50) > MC ($77.93): profitable decision**

– **Net Benefit of $117.57/A**

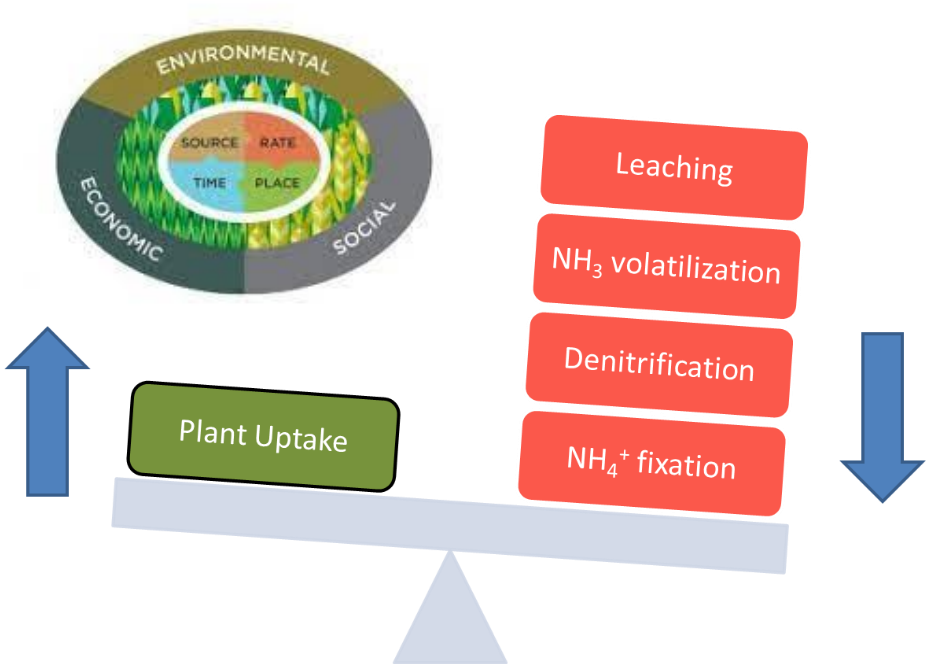
Economic Questions: Will Keeling (will.keeling@ag.tamu.edu)

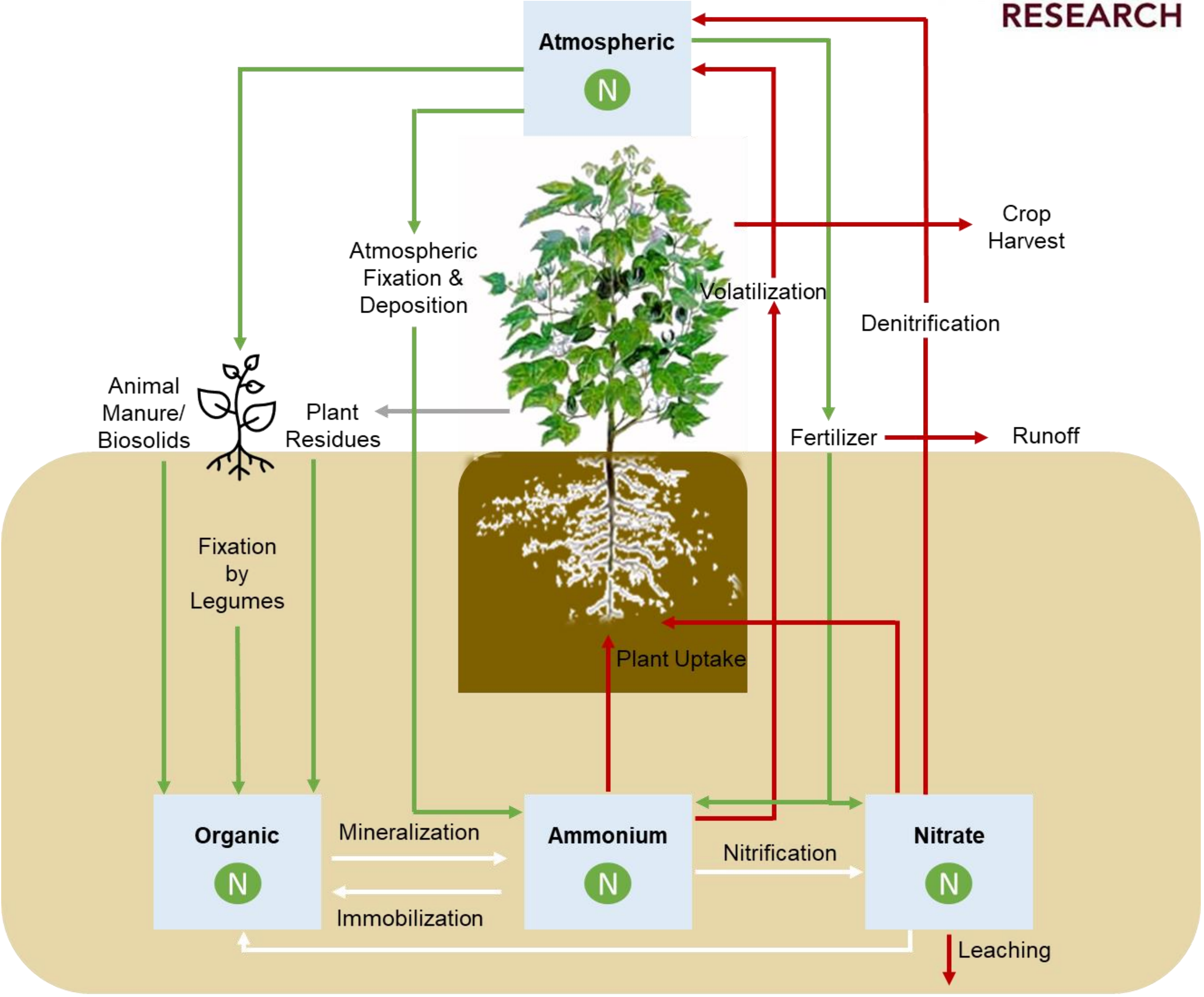
YES!

Nitrogen

-ammonium (NH_4^+) & nitrate (NO_3^-)-

Nitrogen is the greatest limiting nutrient





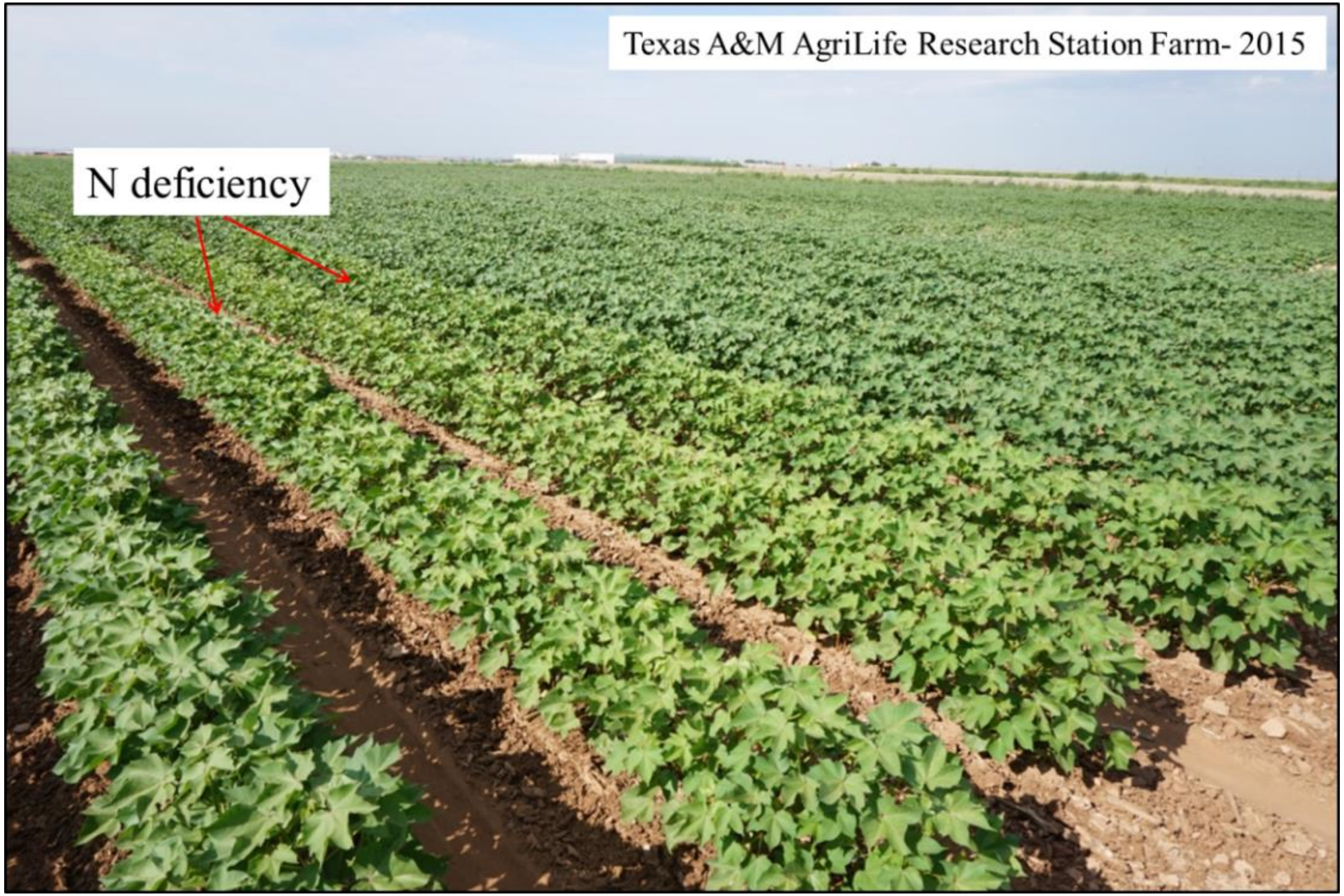
Nitrogen Rates *(based on yield goal)*

1st bale:

40 lb N/A/bale

2+ bales:

35-40 lb N/A/bale

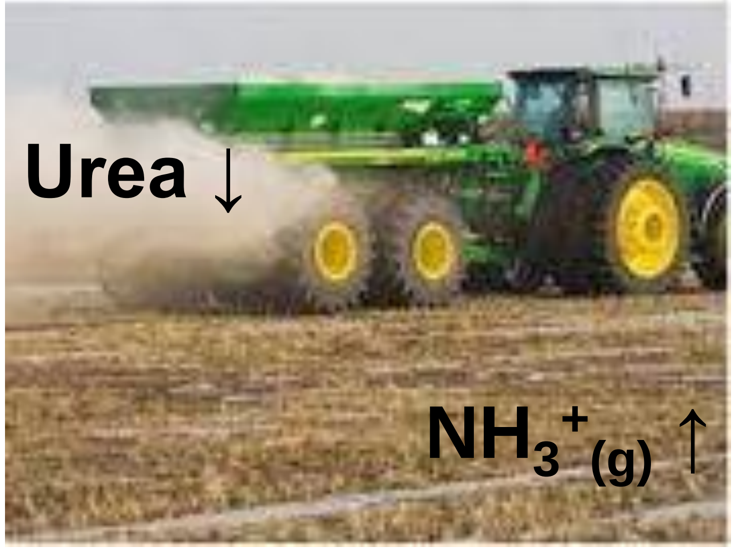


Ammonia Volatilization

$NH_4^+ \leftrightarrow NH_3 \uparrow + H^+$

The gaseous loss of ammonia (NH_3) that may occur when ammonium (NH_4^+) is surface applied to a **calcareous soil** or when urea [$(NH_2)_2CO$] is surface applied to **any soil**.

Loss may be *50 to 75%* of added N



Ammonia Volatilization

Environmental Factors ↑ Volatilization

- Soil pH – can happen at any pH but greater when pH > 7.0
- Water content of surface soil – moist surface required for hydrolysis

$$(NH_2)_2CO + 2\,H_2O \overset{\text{urease}}{\leftrightarrow} (NH_4)_2CO_3$$

- SOM↑ → Microbial activity↑ → Urease↑ → Urea hydrolysis ↑
- <0.25” rain can result in ↑ NH_3
- Wind↑ → Evap.↑ → ↑ NH_3
- Temp↑ → Urease, Evap.↑ → ↑ NH_3

Ways to ↓ Volatilization

- Incorporation to > 0.5” will ↓ loss by >50%
- Addition of 0.25” to 0.5” irrigation to move below surface prior to hydrolysis (urea is uncharged, water-soluble molecule)
- Use of sulfur-coated urea
- Use of urease inhibitors to temporarily reduce activity of urease enzyme (NBPT)
- Use urea phosphate or other acid forming fertilizers containing urea
- Addition of $CaCl_2$, KCl, etc with urea (more effective in alkaline soil)

Mineralization and Immobilization

Organic N ↔ Inorganic N
Equilibrium in soils
(Nitrogen cycling)

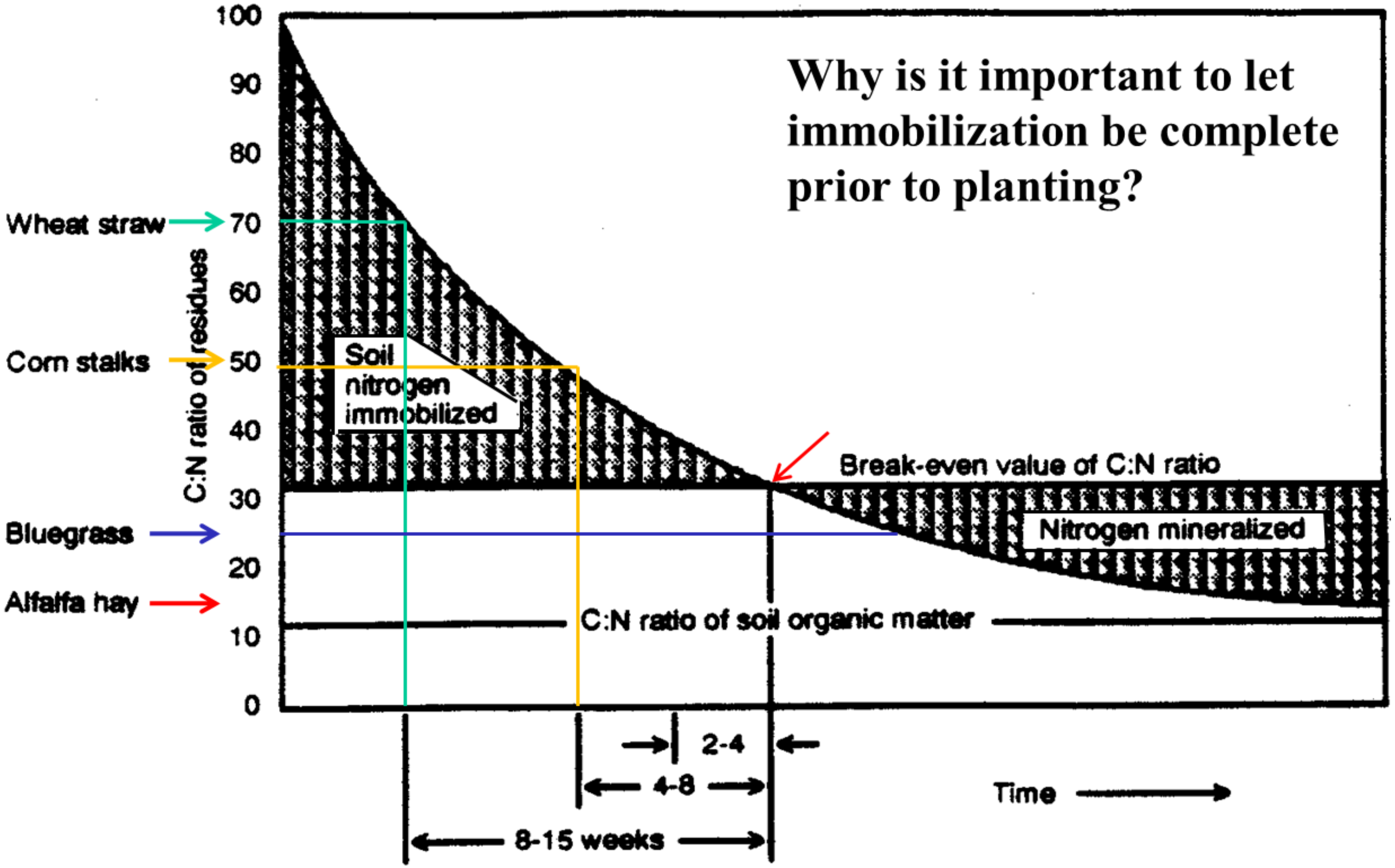
Mineralization – conversion of plant-unavailable organic N to plant-available inorganic N (NH_4^+); C:N < 30:1

Immobilization – conversion of plant-available inorganic N (NH_4^+, NO_3^-) to plant-unavailable organic N (**microbial tissues**); C:N > 30:1

Practical significance??

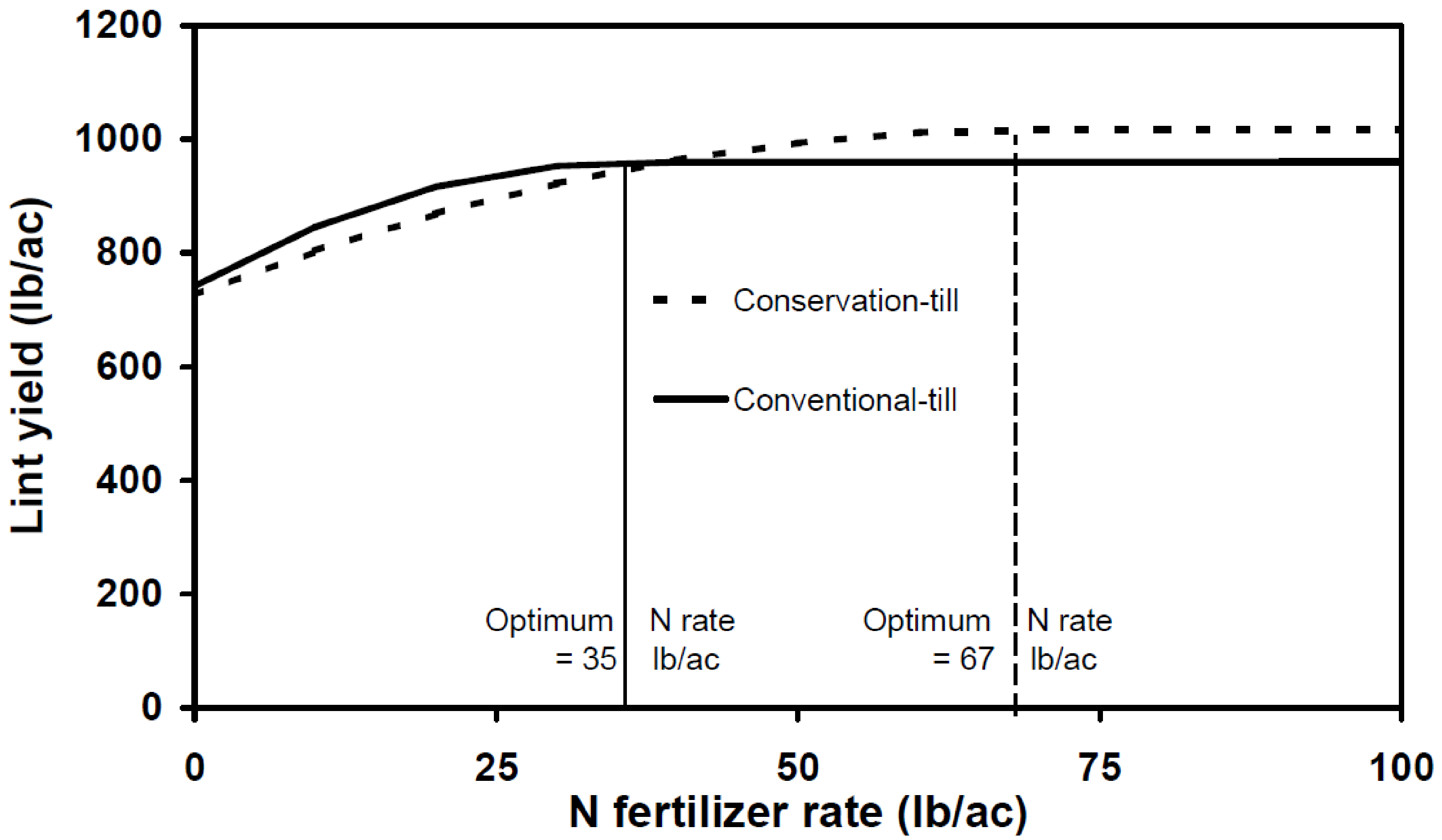
Determining Factor for Net N Mineralization or Immobilization

Time required for completion of N immobilization as affected by C:N ratio of crop residue



Soil Health and Nitrogen

AG-CARES, Lamesa, TX



Source: Nutrient Management of Conservation-Till Cotton in Terminated-Wheat

K.F. Bronson, J.W. Keeling, R.K. Boman, J.D. Booker, and H.A. Torbert, April 2004

Soil Health and Nitrogen Management

AG-CARES, Lamesa, TX

Evaluate yield response to added N fertilizer at different times in conventional and conservation management

Managment systems

1. Continuous cotton (CC)
2. CC with rye cover (CCRC)
3. Wheat-fallow-cotton rotation

Nitrogen treatments

1. Farm Practice (120 lb N/A; 3-4 applications)
2. Preplant (+30 lb N/A; 150 lb N/A)
3. Emergence +3 wks (+30 lb N/A; 150 lb N/A)
4. PHS + 2 wks (+30 lb N/A; 150 lb N/A)

Cotton Yield

2018-2020 averages

Cropping System	Nitrogen fertilization strategies FP	PPN	PEN	PHSN	
	Lint yield (lint acre^{-1})				AVG
CC	723	787 (8.9%)	715 (-1.1%)	683 (-5.5%)	**727**
CCRC	806	938 (16.4%)	965 (19.6%)	857 (6.2%)	**891** (23.3%)
CWR	1,134	1,032 (-9.0%)	1,117 (-1.5%)	1,064 (-6.2%)	**1,087** (50.4%)
AVG	**888**	**919** (3.5%)	**932** (5.0%)	**868** (-2.2%)	

Fertilization strategies:

- FP = farmers practices (120 lb N A^{-1})
- PPN = FP + 30 lb N A^{-1} at preplant
- PEN = FP + 30 lb N A^{-1} at post emerg. + 2 wks
- PHSN = FP + 30 lb N A^{-1} at pinhead square + 2 wks

Cropping systems:

- CC = Continuous cotton, conventional tillage (>25 yrs)
- CCRC = Continuous cotton-Rye cover
- CWR = Cotton-Wheat rotation

Gross Margins

2018-2020 averages

Cropping System	Nitrogen fertilization strategies				
	FP	PPN	PEN	PHSN	
	Gross Margin ($ acre^{-1})				AVG
CC	434	489 (12.7%)	441 (1.6%)	420 (-3.3%)	**336**
CCRC	489	591 (20.7%)	608 (24.3%)	536 (9.5%)	**556** (65.5%)
CWR	609	575 (-5.6%)	610 (0.3%)	587 (-3.6%)	**595** (77.1%)
AVG	**511**	**552** (8.0%)	**553** (8.2%)	**514** (0.6%)	

Fertilization strategies:

- FP = farmers practices (120 lb N A^{-1})
- PPN = FP + 30 lb N A^{-1} at preplant
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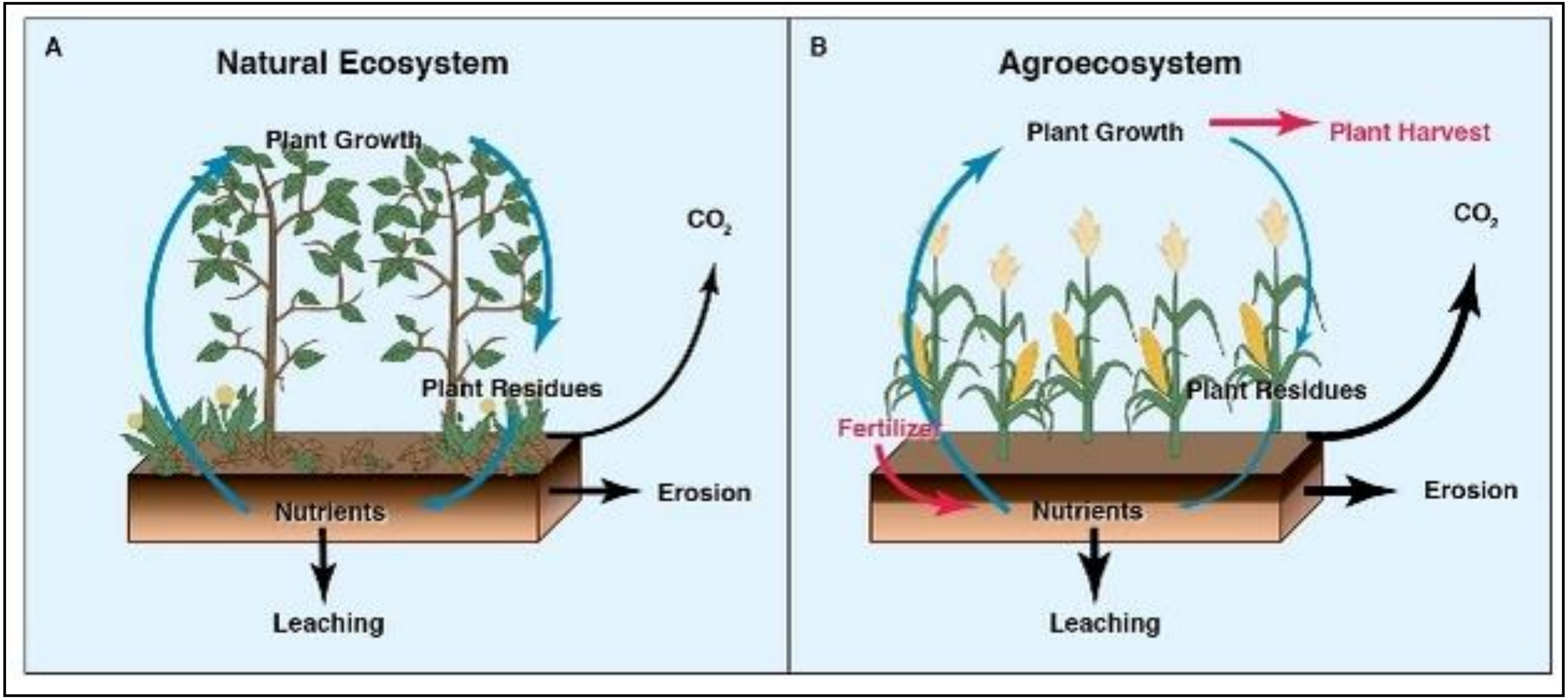
Phosphorus



Over time we have mined our soils……

Nutrient Requirements

Cotton Nutrient Requirements		
Element	Nutrient	Estimated amounts needed (units/bale)
Primary Nutrients		
N	Nitrogen	45 - 60 lb N/acre
P	Phosphorus	20 - 25 lb P_2O_5/acre
K	Potassium	40 - 45 lb K_2O/acre
Secondary Nutrients		
Ca	Calcium	13 lb/acre
Mg	Magnesium	10 - 14 lb/acre
S	Sulfur	10 - 14 lb/acre
Micronutrients		
B	Boron	0.25 lb/acre
Zn	Zinc	0.06 lb/acre
Mn	Manganese	0.1 lb/acre
Fe	Iron	0.07 lb/acre
Cu	Copper	0.15 lb/acre

Bronson, K. 2004. Nutrient management for Texas High Plains cotton production. Texas A&M University. http://www.lubbocktx.tamu.edu.

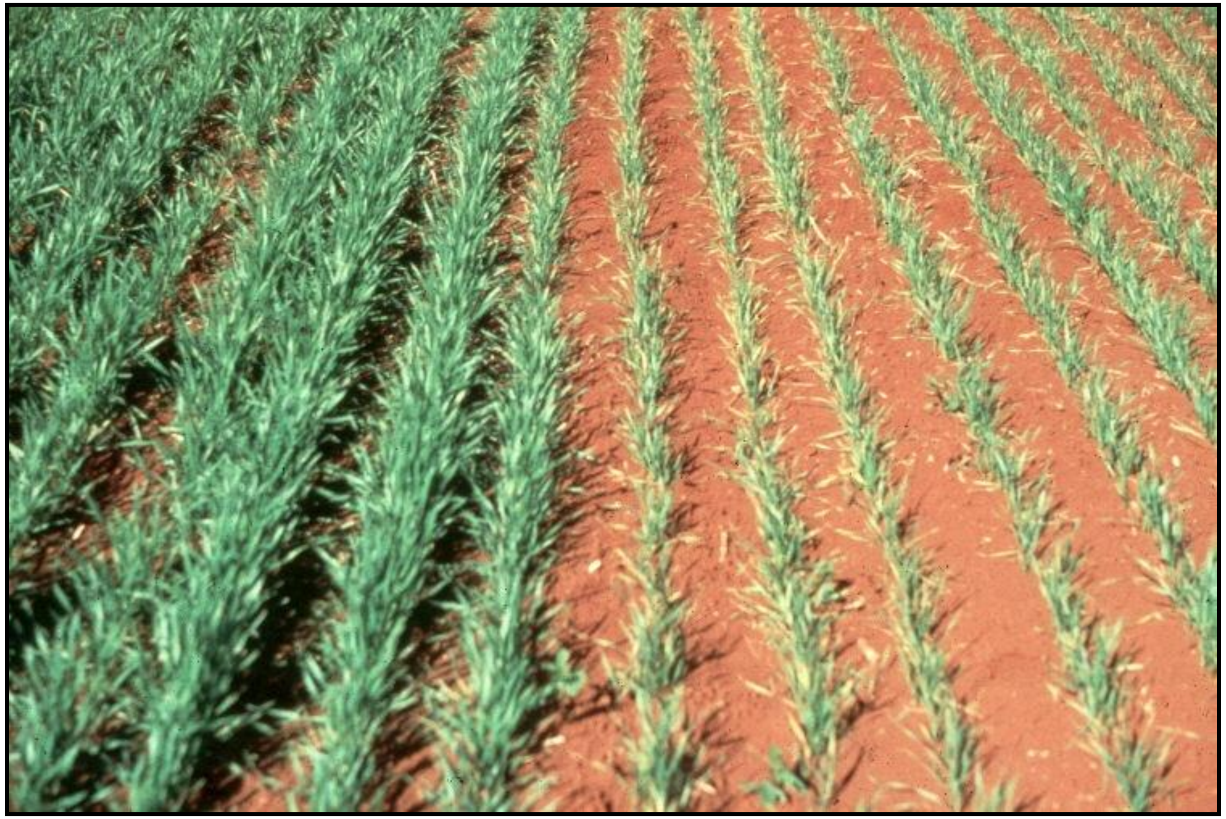
If the amount of nutrient removed by plant is greater than what is being added, <u>soil fertility declines</u>

Phosphorus Nutrition

Reasons to build soil test P

- Increase root growth for efficient uptake of other nutrients
- Capitalize on “good weather” years and minimize risk associated with “bad weather” years
- Increase yield potential of all crops in system
- Improve grower profit potential

Wheat



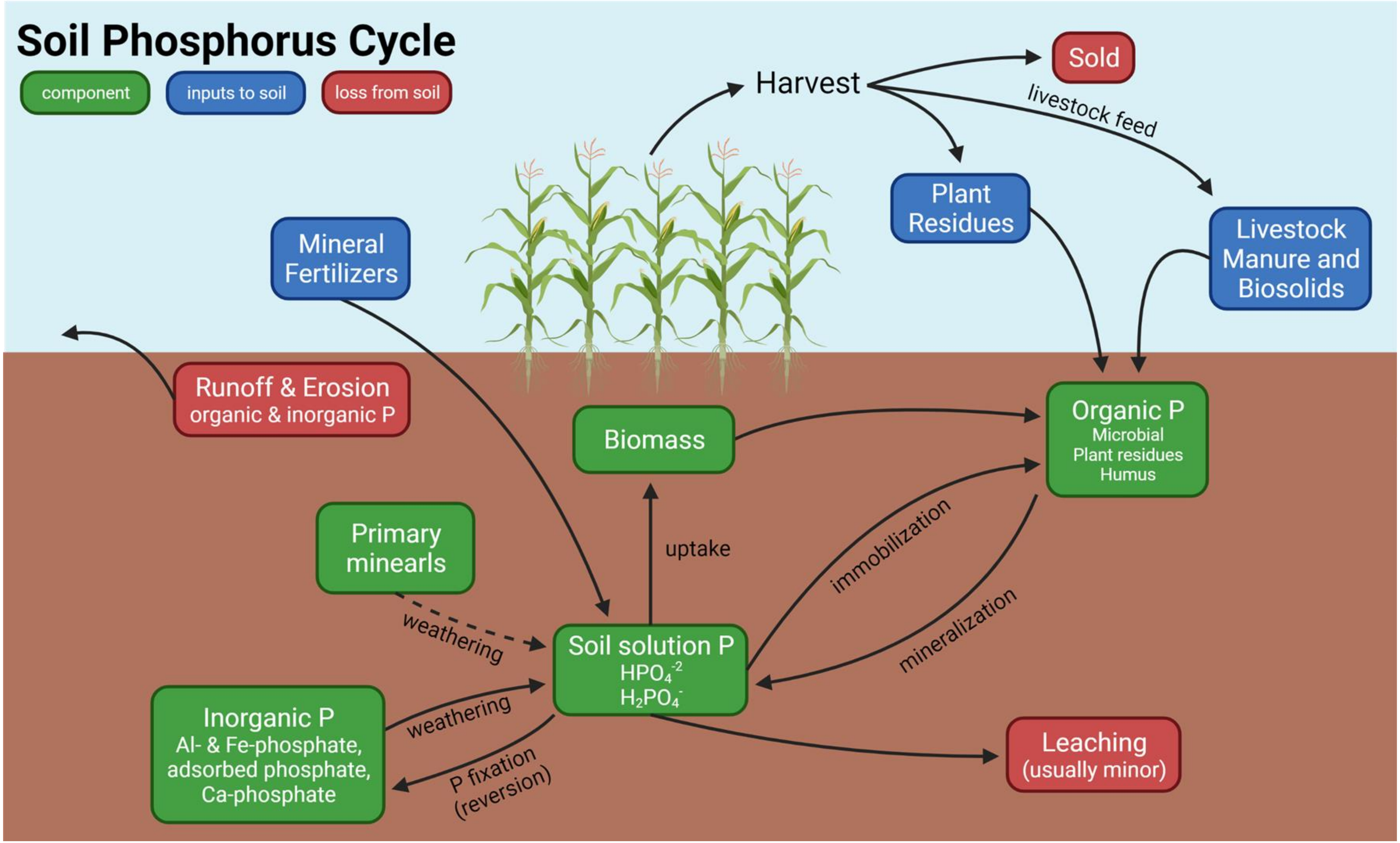
Phosphorus added **No phosphorus**

Phosphorus Nutrition

Soil P levels should be maintained in *medium (30-50 ppm P)* to *high (50-80 ppm P)* range to assure consistent production

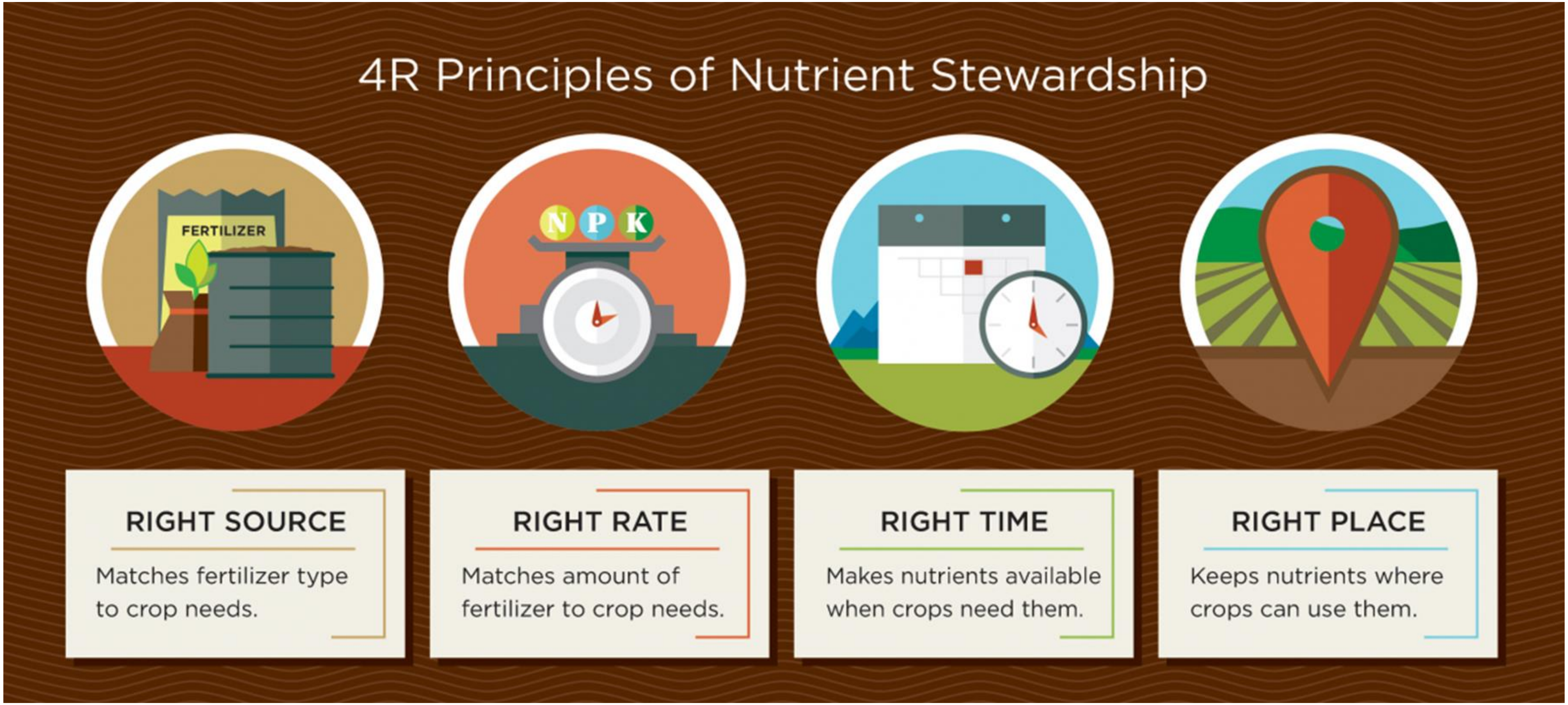
Very low (0-15 ppm) to *low (15-30 ppm)*

- Broadcast (build up) plus banding, fertigation, or as starter fertilizer (this season)
  – NOT to be done every year!



Soil Phosphorus Cycle
component
inputs to soil
loss from soil
Harvest
Sold
livestock feed
Plant Residues
Livestock Manure and Biosolids
Mineral Fertilizers
Runoff & Erosion
organic & inorganic P
Biomass
Organic P
Microbial
Plant residues
Humus
uptake
immobilization
mineralization
Primary minearls
weathering
Soil solution P
HPO_4^{-2}
$H_2PO_4^-$
Inorganic P
Al- & Fe-phosphate,
adsorbed phosphate,
Ca-phosphate
weathering
P fixation (reversion)
Leaching
(usually minor)

Phosphorus Nutrition



Phosphorus Source

Things to keep in mind when selecting P fertilizer

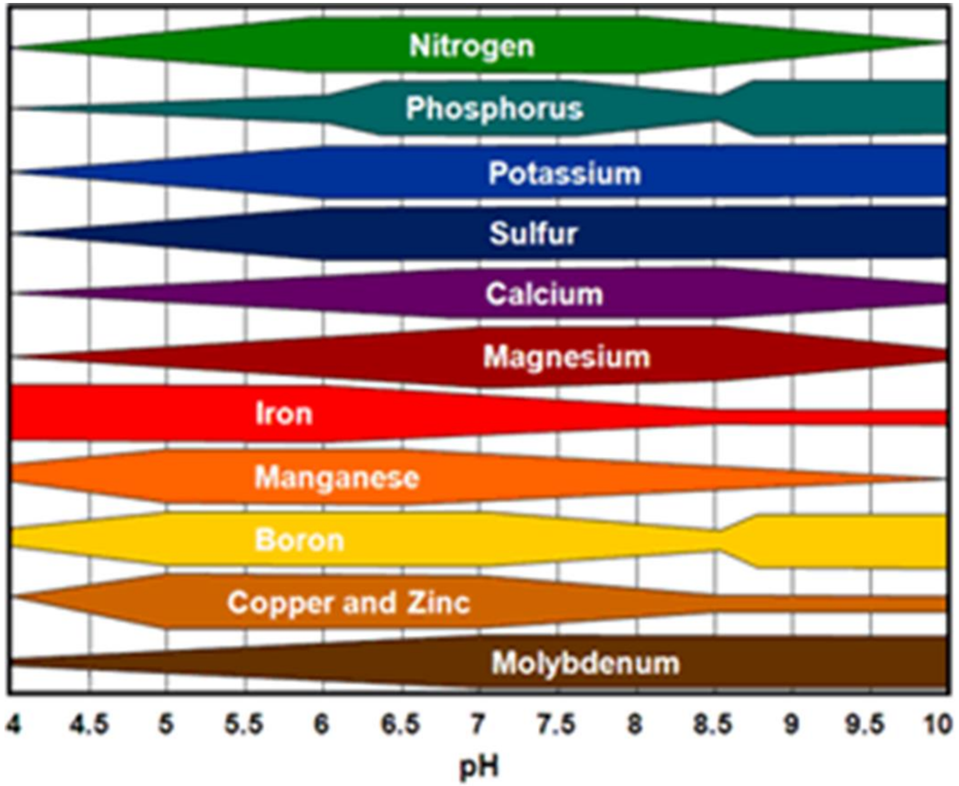
- Most P fertilizer sources perform similarly when equal P rates are applied using comparable application methods

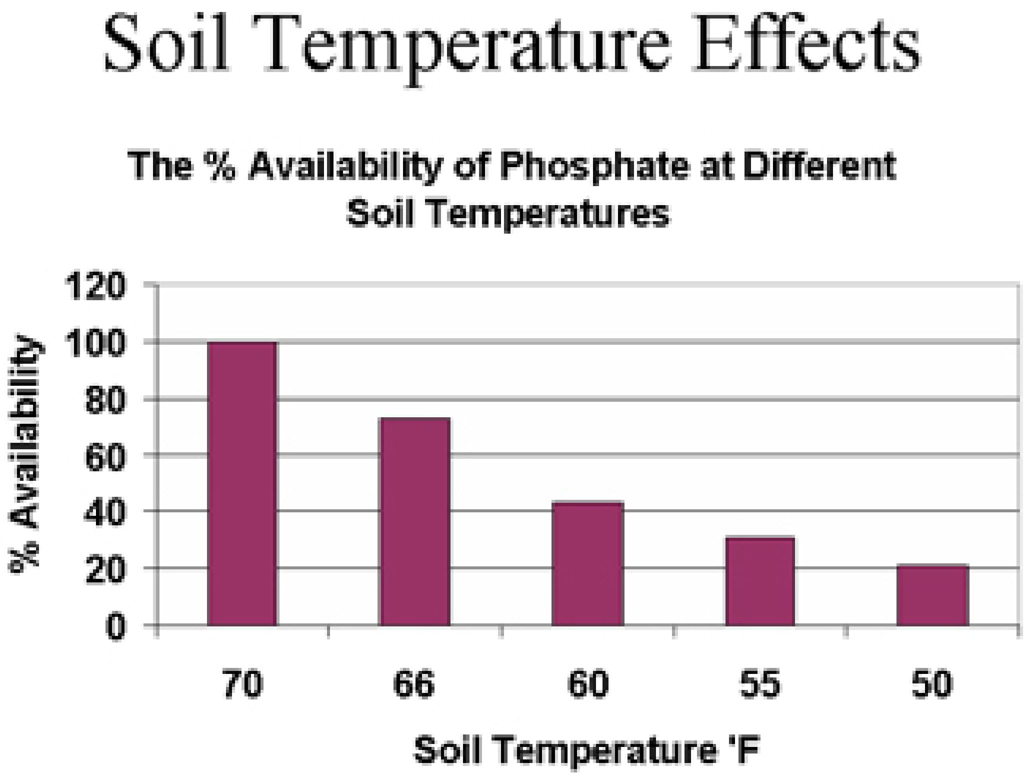
- When applying dry, in-furrow, consider MAP in alkaline and/or calcareous soil (rather than DAP)

- Best source is generally determined by product availability, preference, dealer service, and price

Phosphorus Timing

- Add phosphorus in the fall if your soil pH is between 6.5 and 7.5
- If the soil pH is at any other level, apply phosphorus closer to planting date
- Starter fertilizer applications (N and P) are designed to increase P uptake in cool soils (2”x2”); pop-up fertilizers should be used at low rates



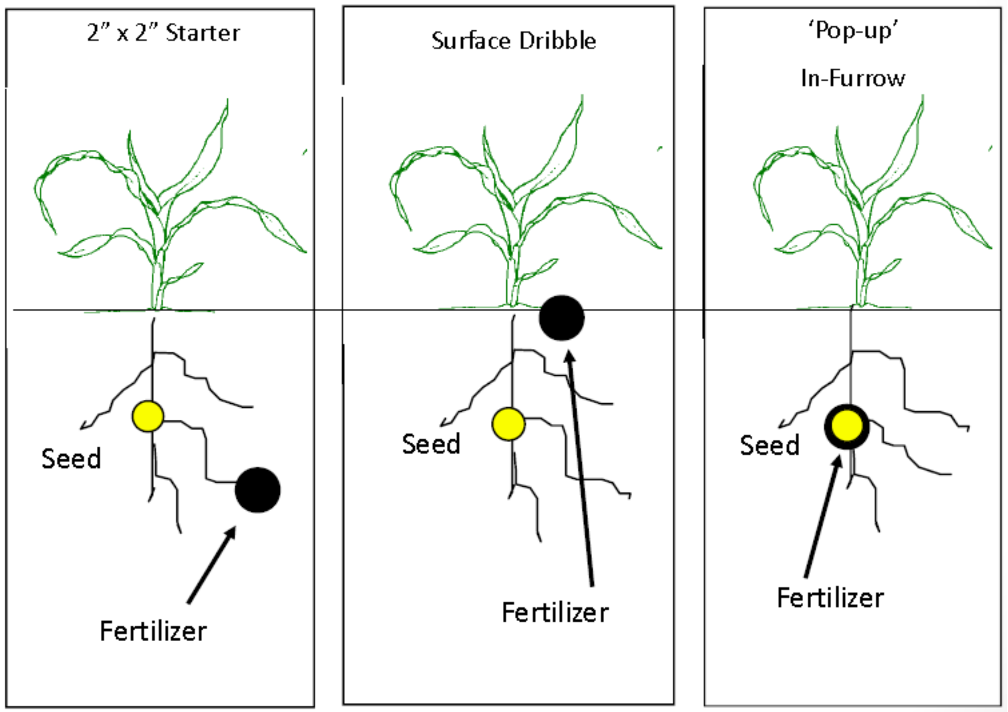


Source: The Pennsylvania State University

Phosphorus Placement

Starter

- Positives:
  - Positions P near germinating seedling
  - Reduce fixation and increase early uptake, especially in cool soil temps
  - More efficient – mechanical (at planting) and P use
- Negatives:
  - Potential for salt or ammonia injury to roots or seed in the band
  - DAP in-furrow has greater chance for seedling ammonia damage



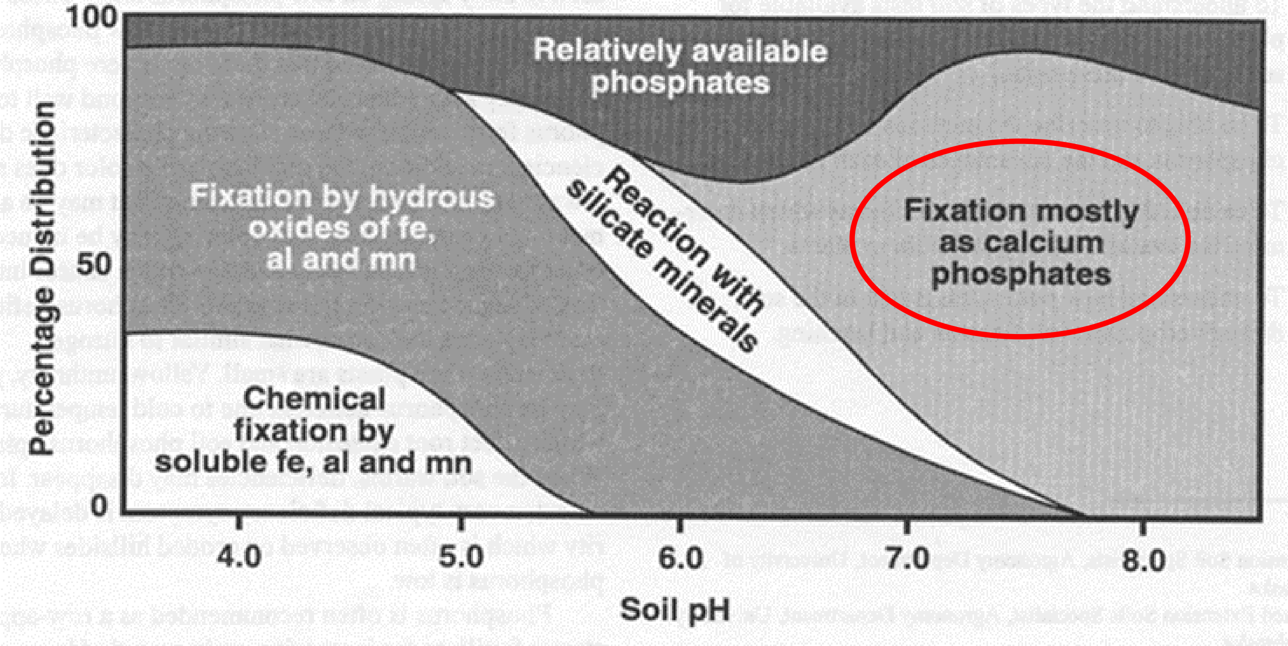
<u>Recommendation</u>

10-34-0:
< 10-15 gal/A in 2”x2”
< 3 - 4 gal/A in-furrow
(12 – 16 lb P_2O_5/A)

11-37-0: <1.5 gal/A in-furrow

Phosphorus Placement

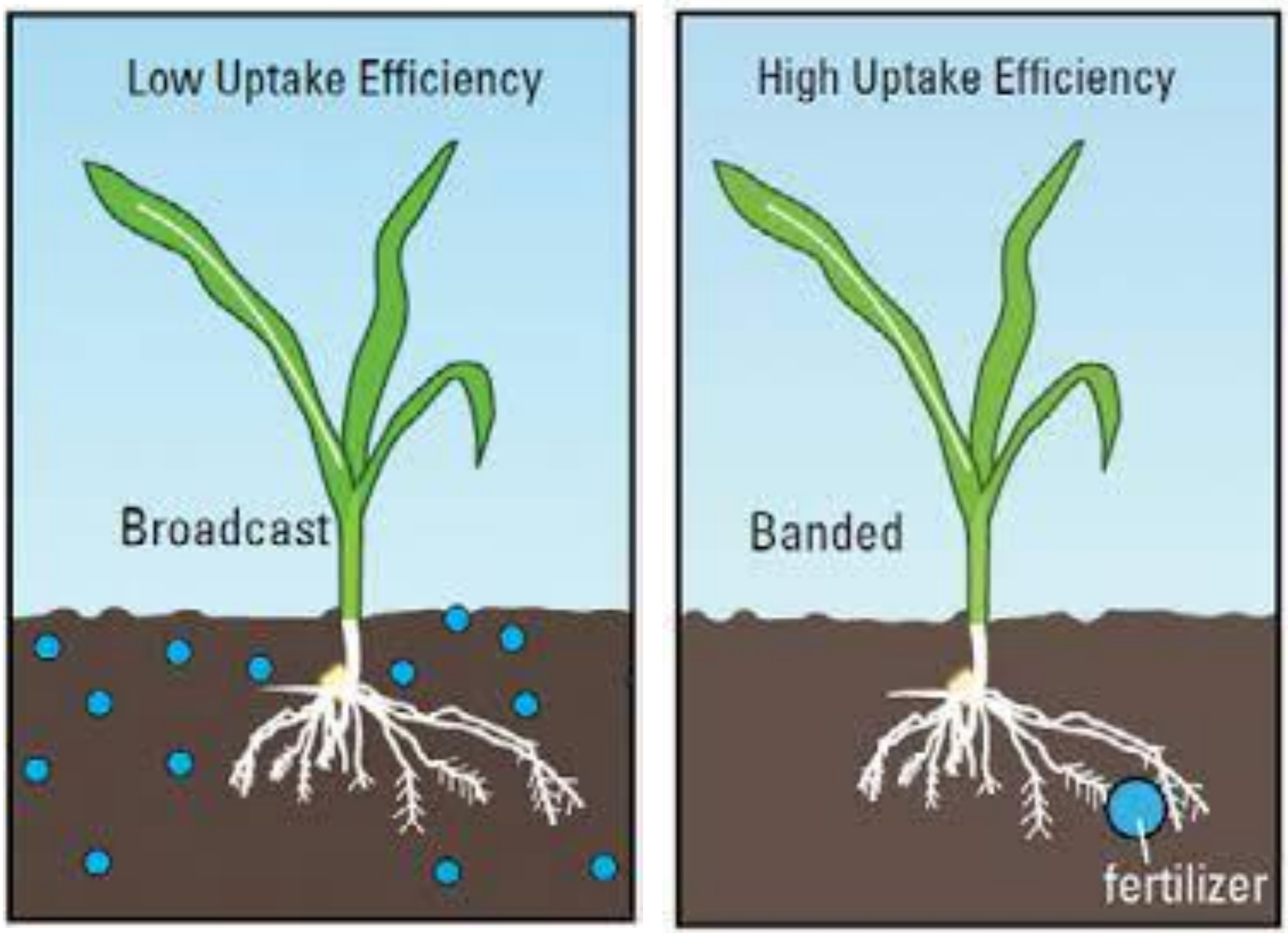
- Phosphorus added to soil quickly becomes fixed in less available forms
- Banding (pre-plant or starter) and fertigation is more efficient than broadcasting pre-plant
  - Calcium carbonates binding or “fixing” most of the phosphorus (as calcium phosphate) when broadcasted – incorporation does not help



Phosphorus Placement

Broadcast versus Band

Rates can be reduced when applied in a band compared to broadcast – exposed to less soil



Fertigation Frequency (SDI)

- Develop N and P fertigation strategies using SDI that optimize cotton lint yield and fertilizer return on investment.

- More specifically, we will determine the number of fertilizer applications that results in the greatest nutrient uptake and yield when using SDI.

Applic Freq: 1		Applic Freq: 3		Applic Freq: 9	
2021	2022	2021	2022	2021	2022
9-May	7-Jun	9-May	7-Jun	9-May	7-Jun
				28-May	17-Jun
			24-Jun	18-Jun	24-Jun
				8-July	1-July
		20-July	8-July	20-July	8-July
				2-Aug	18-July
		11-Aug		11-Aug	29-July
				20-Aug	12-Aug
				30-Aug	26-Aug

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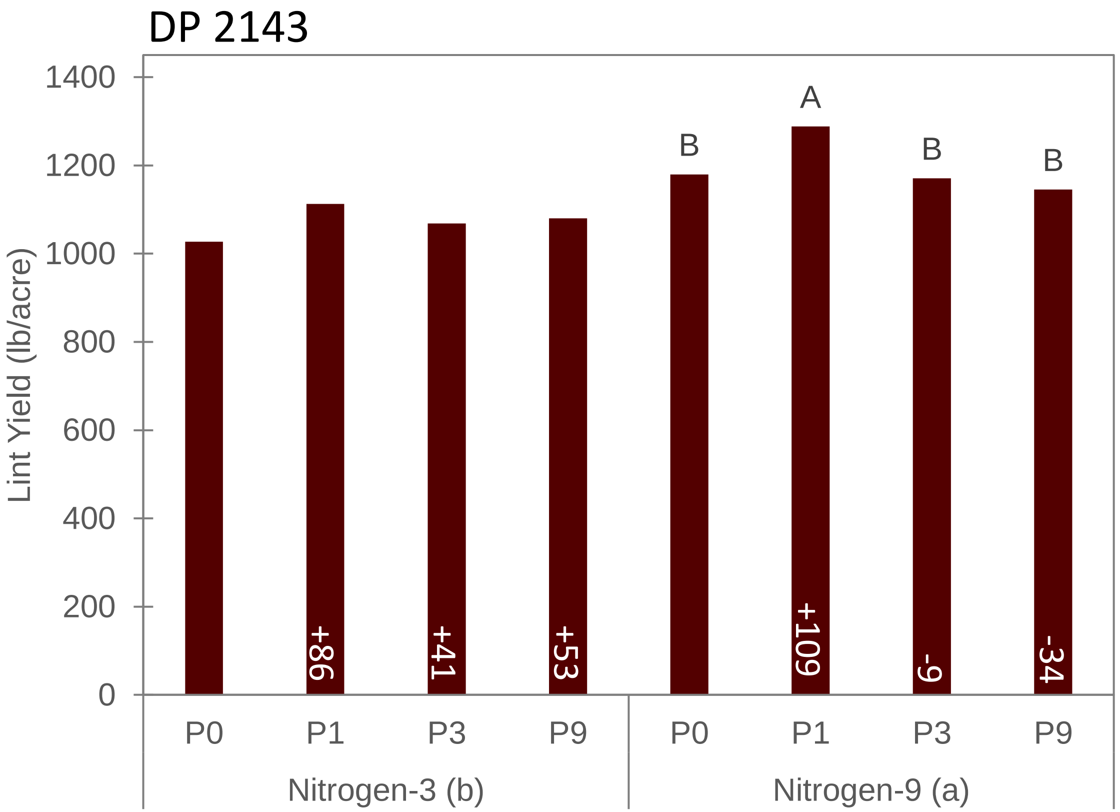
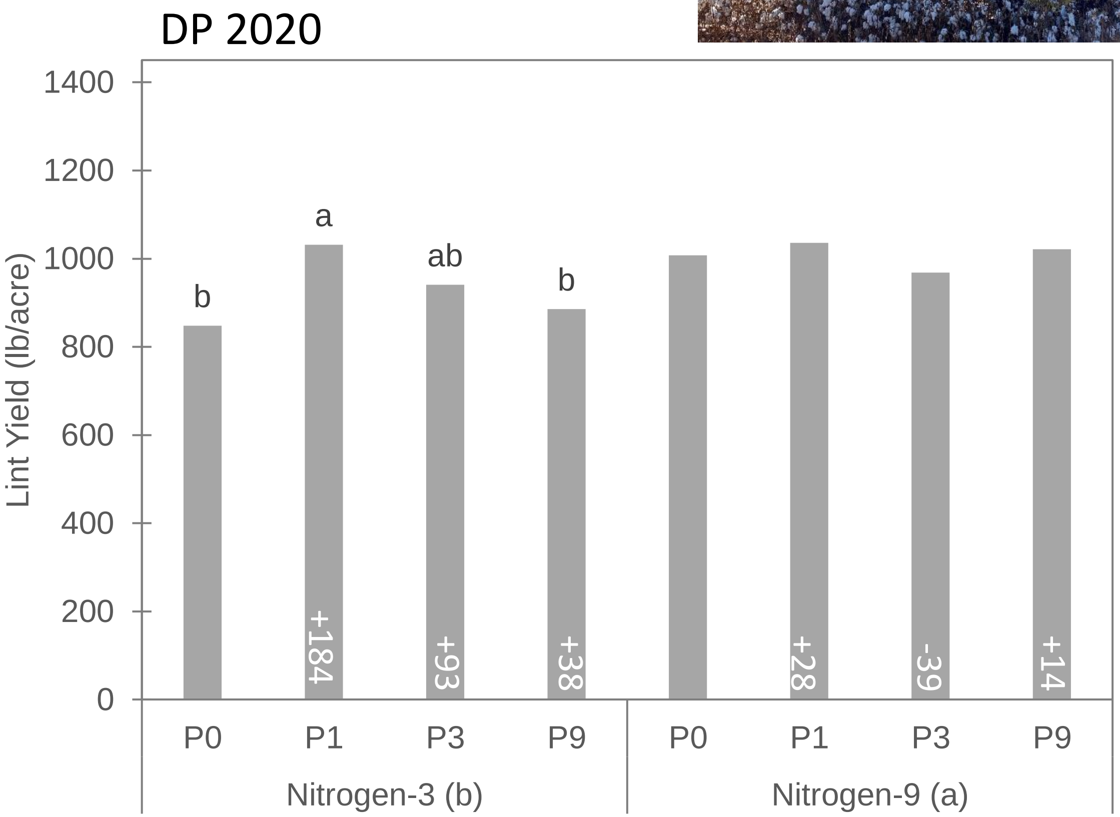
Fertigation Frequency (SDI)

Lint yield (2021)





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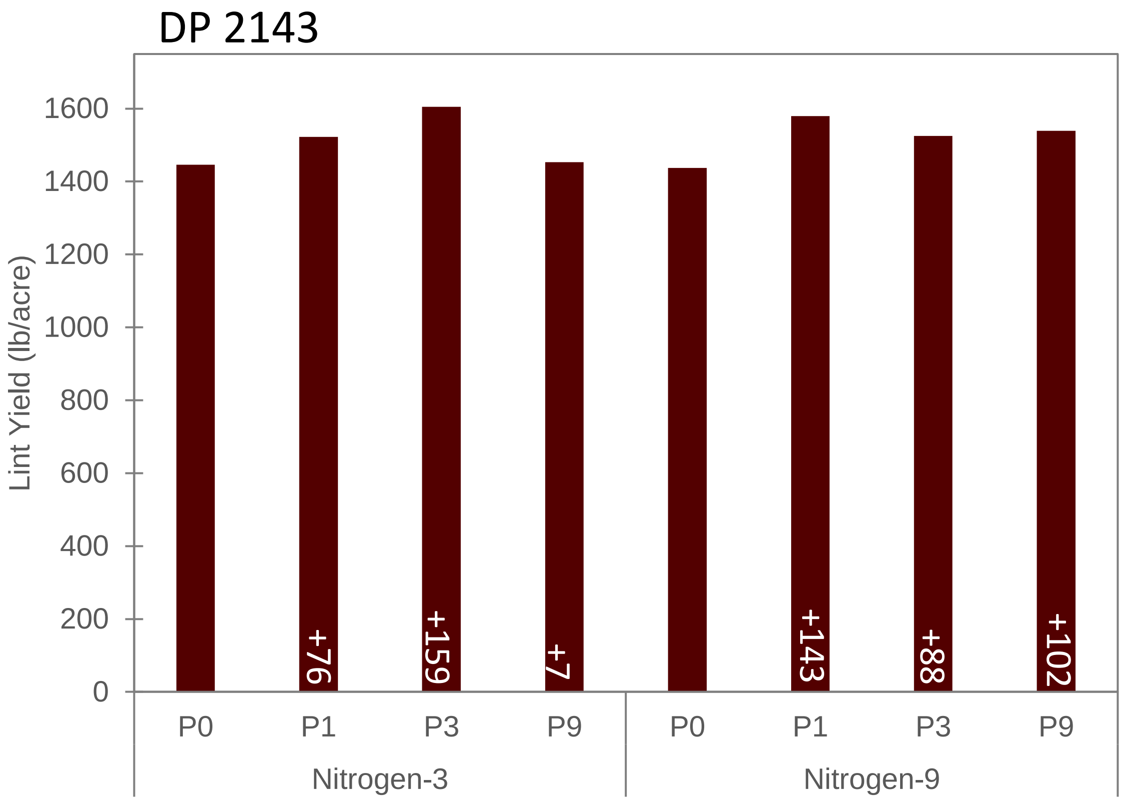
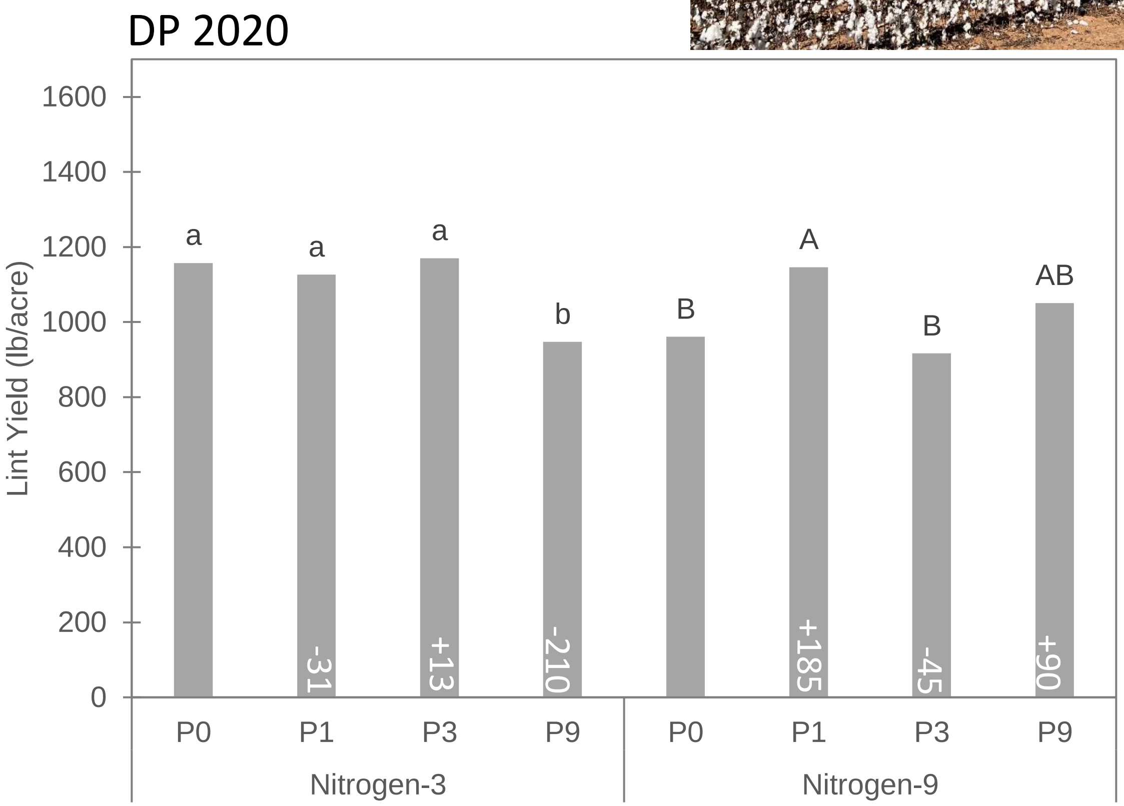
Fertigation Frequency (SDI)
Lint yield (2022)





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Summary

- Different management approaches needed for N and P when fertigating using SDI

- Nitrogen → Increased application frequency
  - Greater yield response
  - Greater N uptake

- Phosphorus → Fewer applications
  - Greater yield response and AUE
  - Reduced P uptake and recovery efficiency
  - Possibly an antagonistic effect between P and Zn uptake

How to make more COST-efficient fertilizer decisions?

Busting Myths

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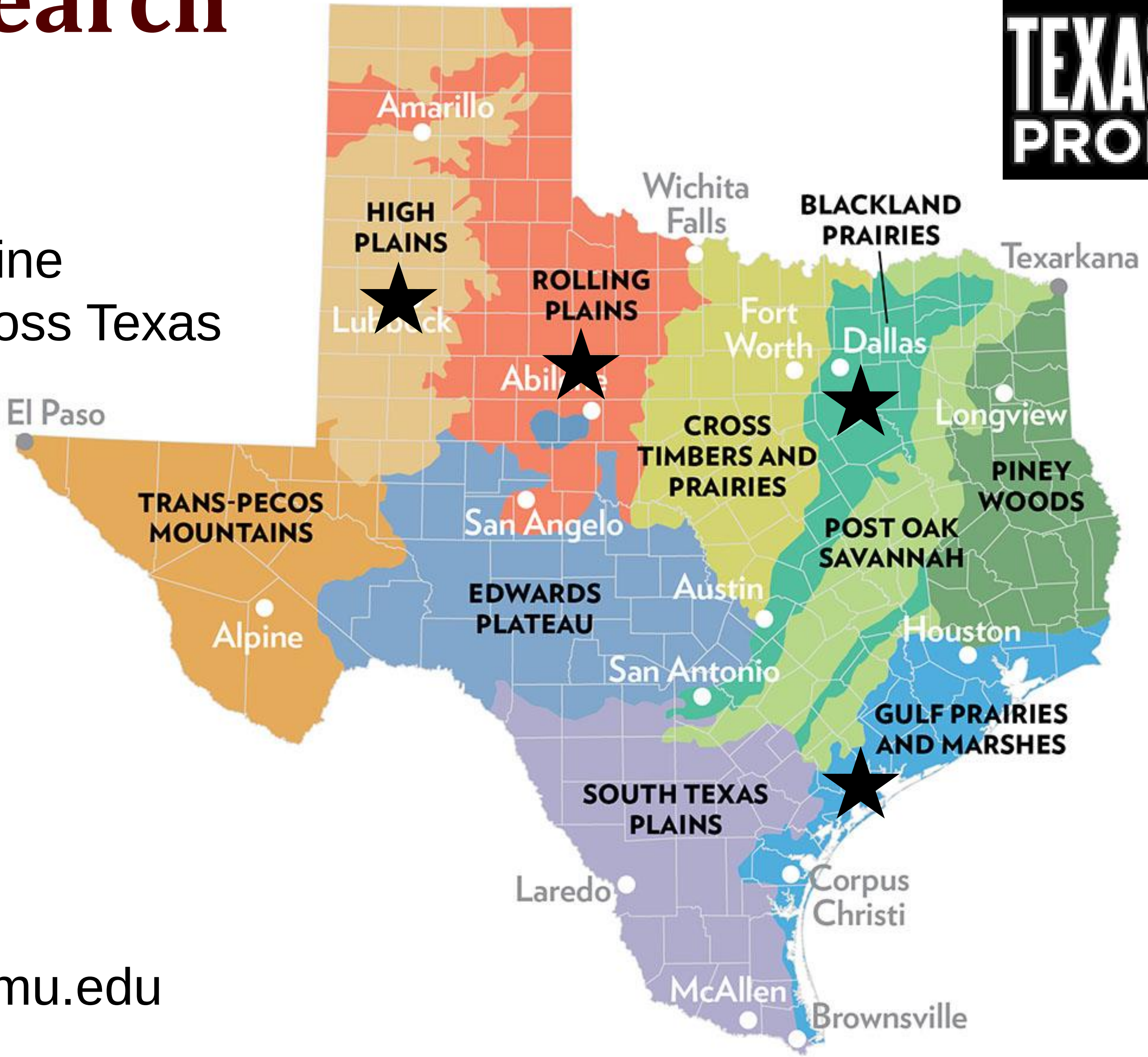
- Fertilizers kill soil microbes…. **FALSE**
- Inorganic fertilizers make soil unhealthy… **FALSE**
- More is always better… **FALSE**
- Foliar fertilizers can replace soil applied… **FALSE**
- Fertilizer is not needed when using biologicals… **FALSE**

2023 Research

Need your help!
Project aimed at establishing baseline carbon values across Texas



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SORGHUM CHECKOFF

cotton

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TEXAS A&M AGRILIFE EXTENSION

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Texas Tech University Department of Plant & Soil Science

Final Thoughts on Fertility

- Proactive strategies to increase fertilizer use efficiency
  - 4Rs of Nutrient Management
    Right *Source*
    Right *Rate*
    Right *Time*
    Right *Placement*
  - Fertilizer rates based on irrigation capacity, yield goals, and crop removal
  - Implementing conservation management may require adjustment of N fertilization
  - Read labels, do your own math, and keep it simple…

"Ever vigilant"