Optimizing Cotton Fertility in a Yield-Limiting Environment

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Childress, TX
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Texas A&M AgriLife Research

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Farmer Concerns

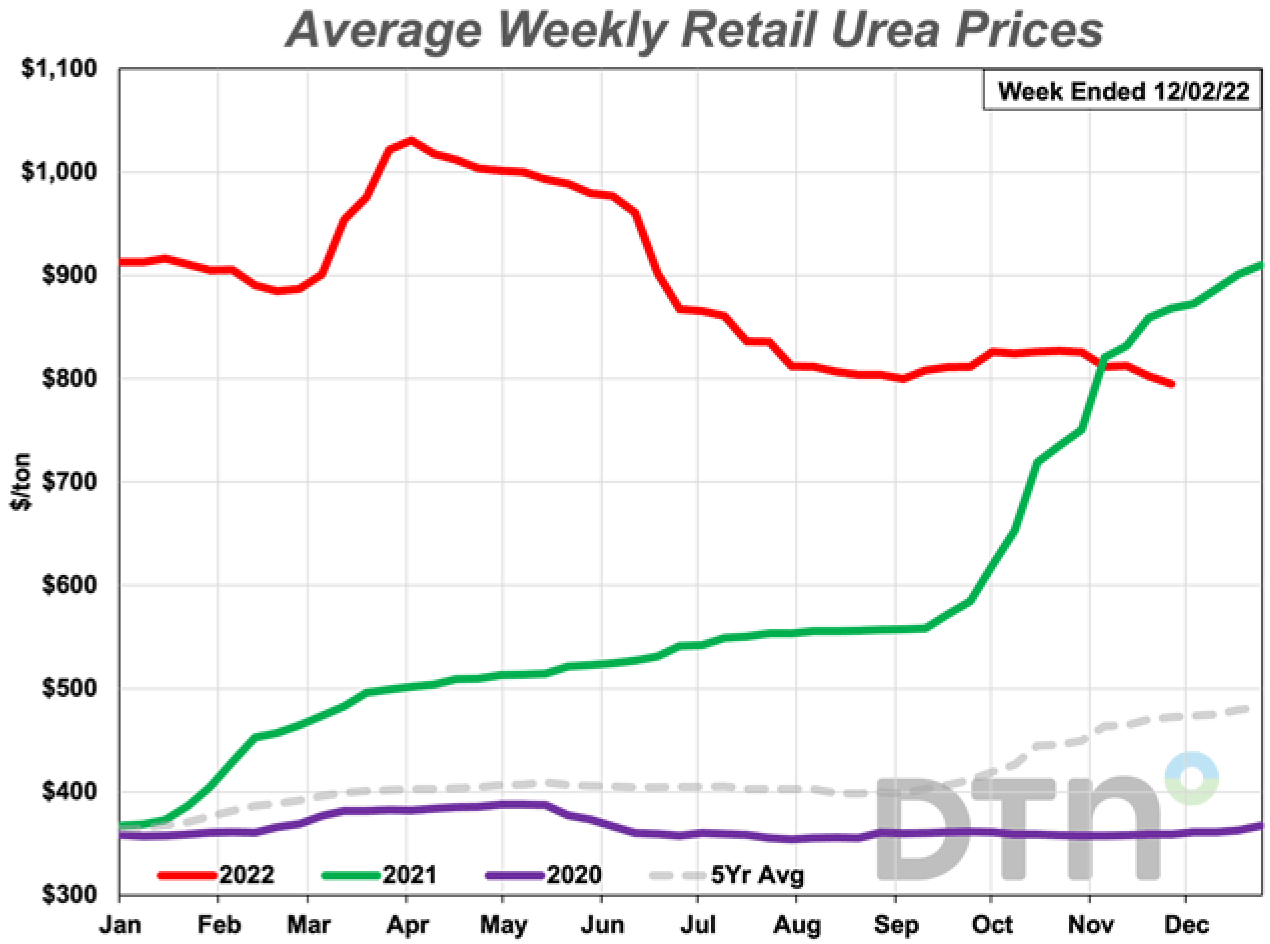
Rising costs

UAN-32: $1.07/lb N

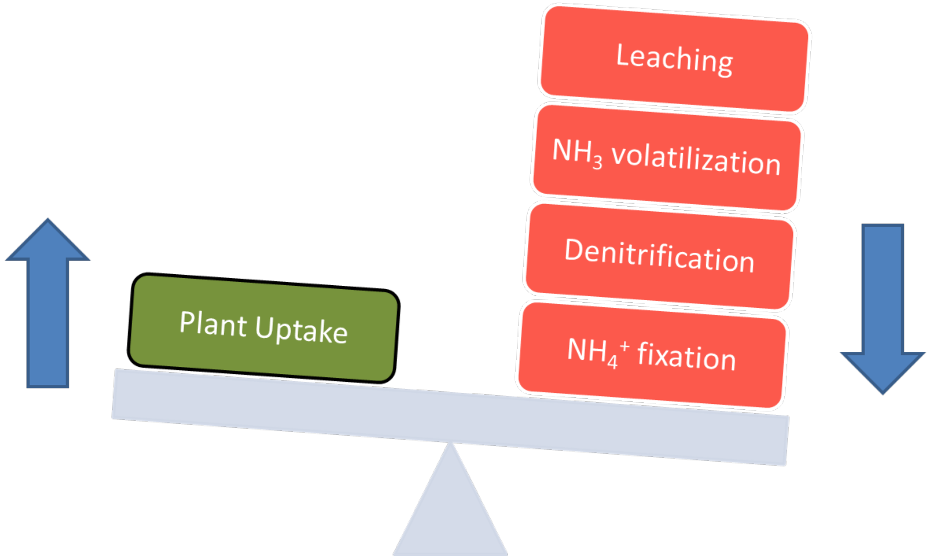
Urea: $0.86/lb N

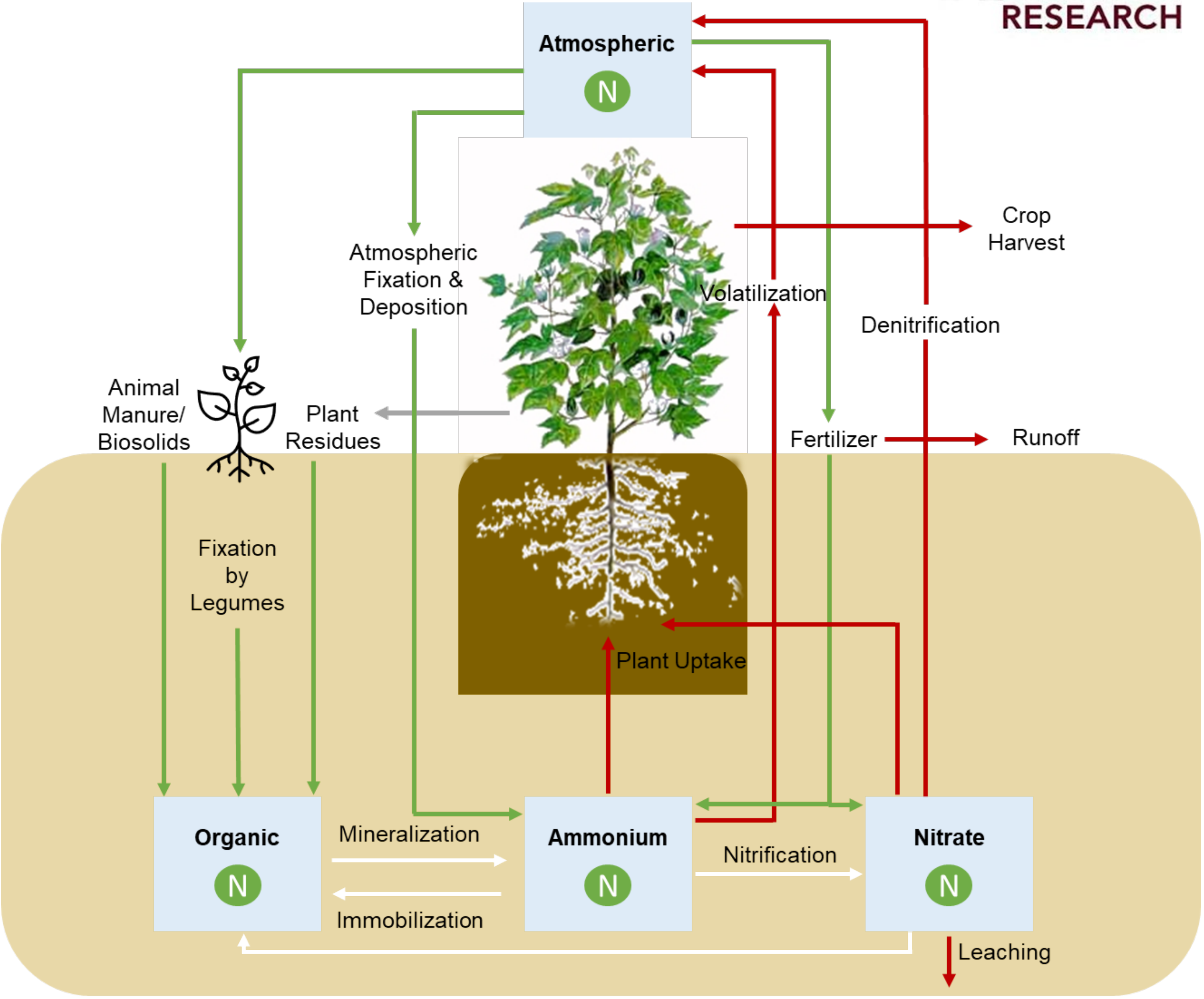
Instability of supply

Environment (?)



Nitrogen is the greatest limiting nutrient





Ammonia Volatilization

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

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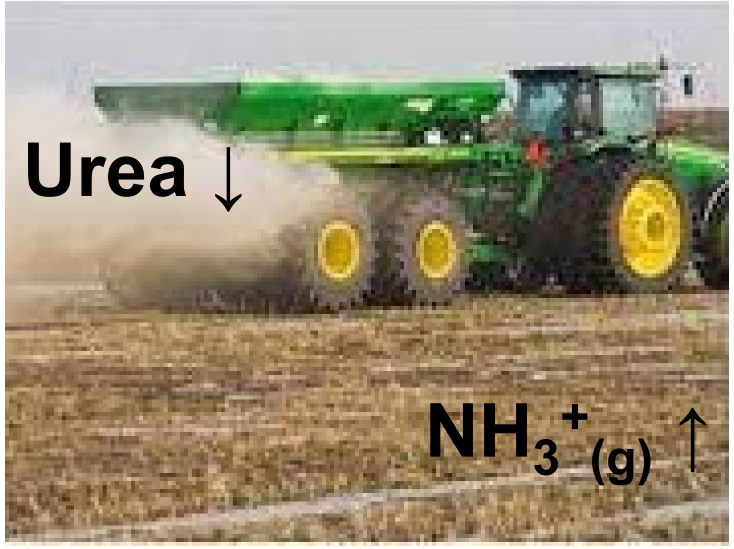
The gaseous loss of ammonia (NH_3) that may occur when ammonium (NH_4^+) is surface applied to a **calcareous soil** or when urea [$(NH_2)_2CO$] is surface applied to **any soil**.

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



Ammonia Volatilization

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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

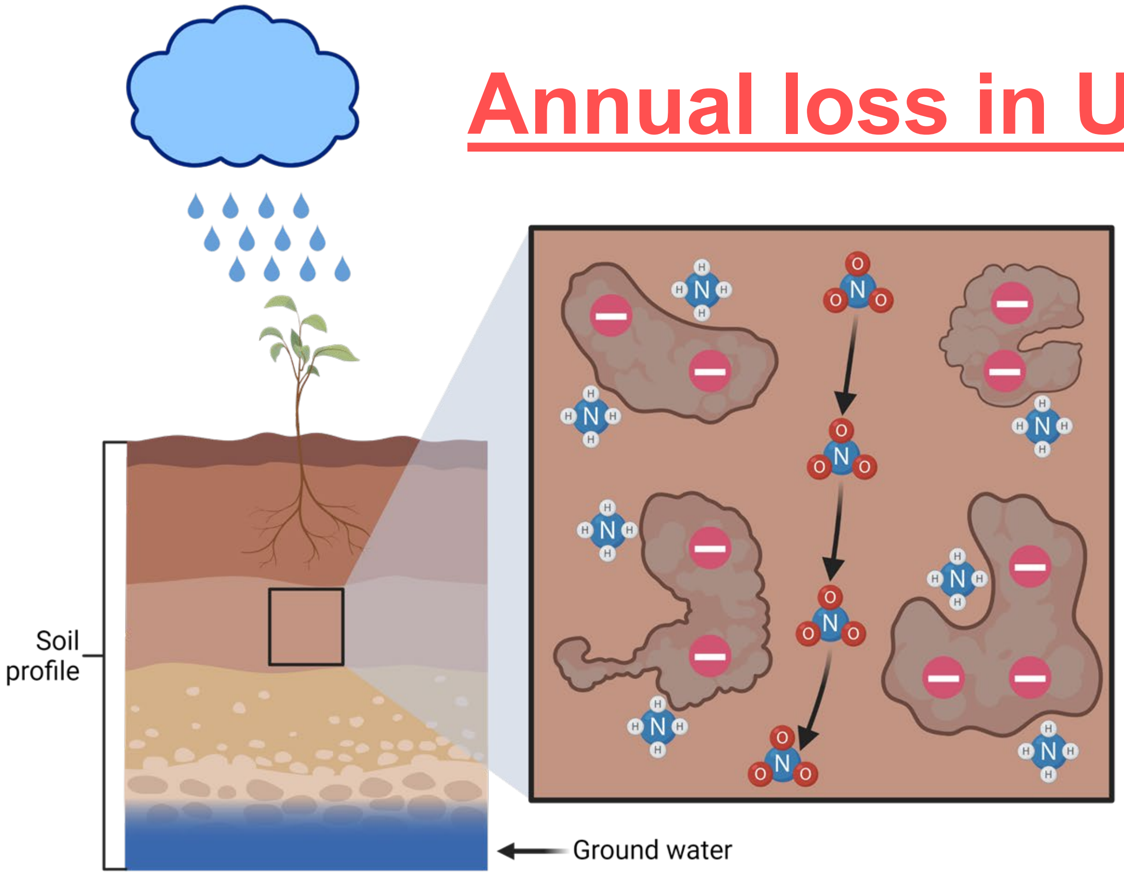
Ways to ↓ Volatilization

- 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)

Nitrogen Leaching

Downward movement of N (NO_3^-) in soil with percolating water.

Annual loss in US: 4.4 to 8.1 x 10^9 lb N



Leaching and Runoff Concerns

Economic: $$$ lost

Health: EPA limit for drinking water is ≤ 10 ppm NO_3-N (44 ppm NO_3)

Ingestion of high NO_3^- waters may result in:

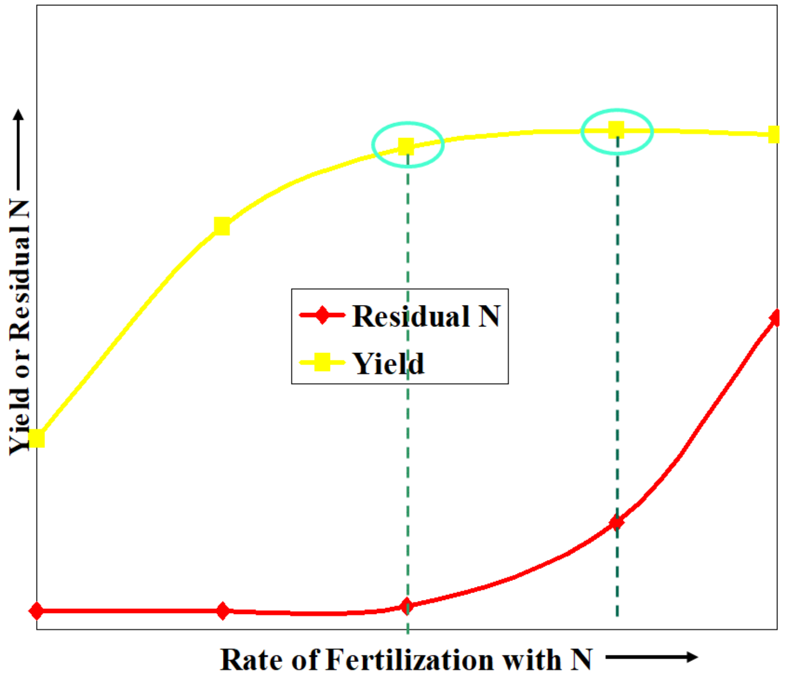
methemoglobinemia ("blue baby" syndrome)

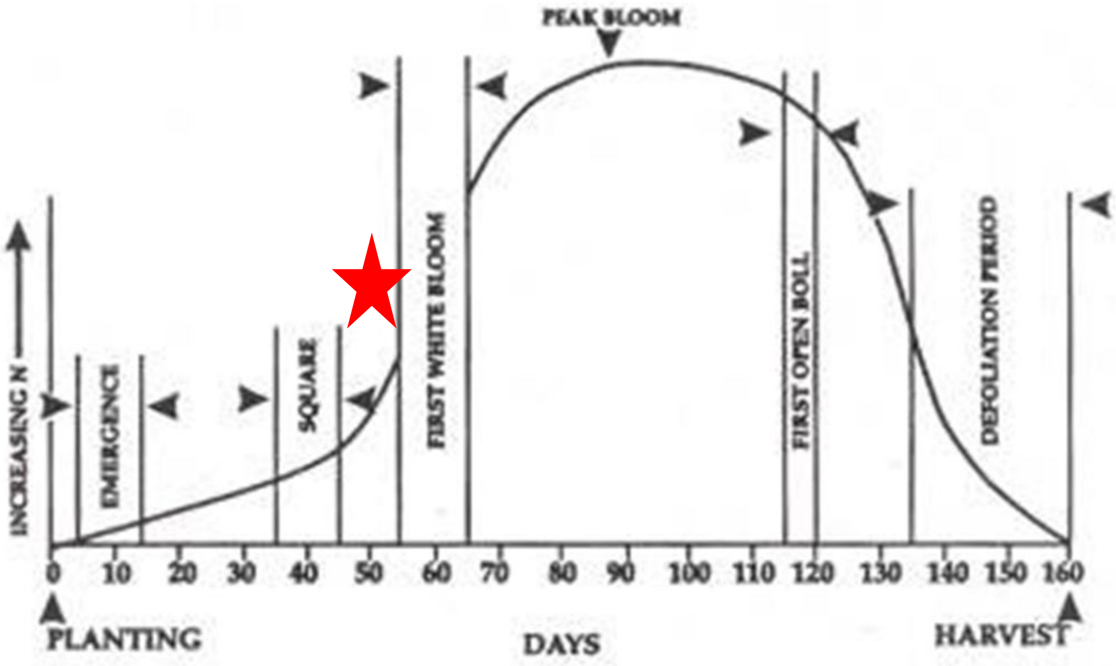
gastrointestinal problems - nitrosamines

Environmental: Eutrophication

Factors Affecting NO_3^- Leaching

- Soil texture (sand > clay)
- Irrigation scheduling
- Other yield limiting factors can decrease N uptake
- Rate of added N
- Timing of application
- Use of nitrification inhibitors



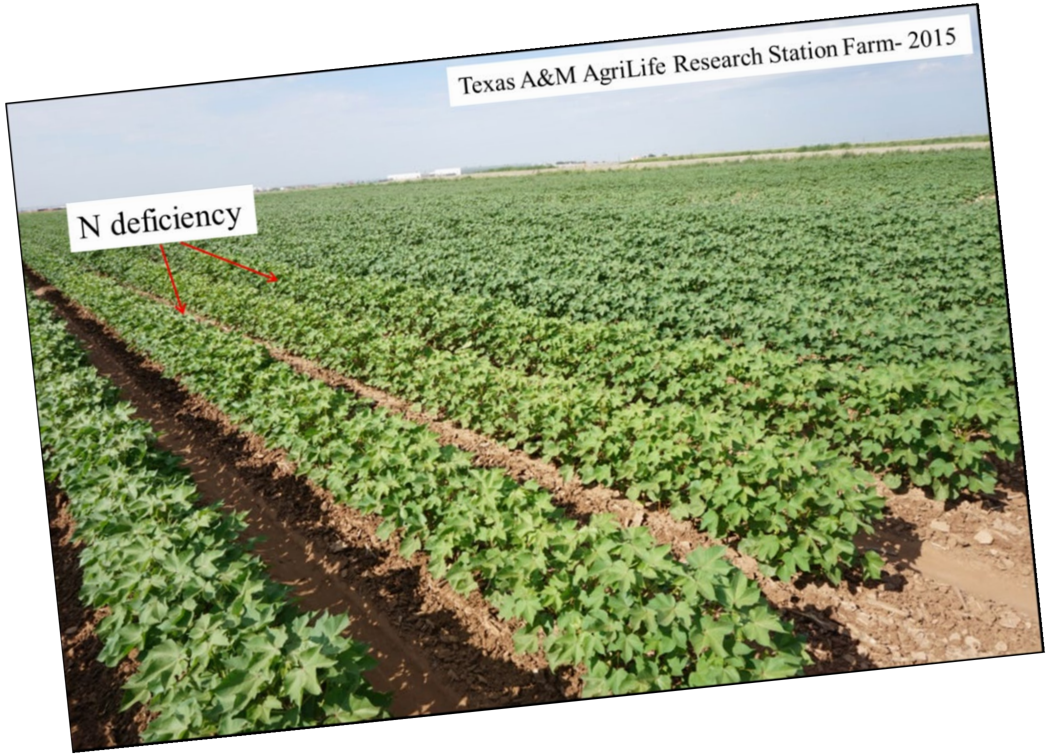


Nitrogen Rates based on Yield Goals

Cotton

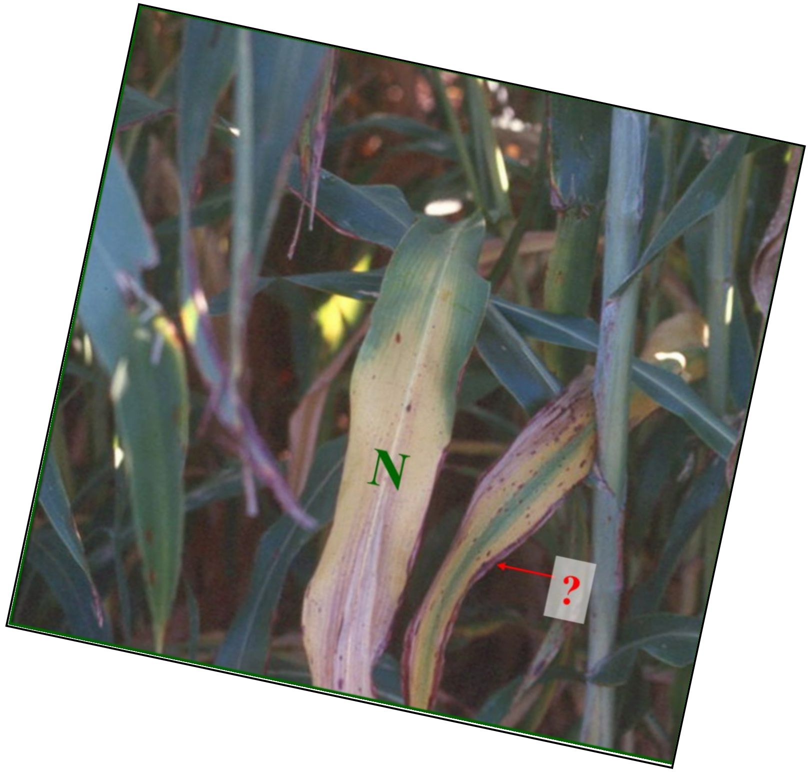
1st bale: 40 lb N/bale

2+ bales: 35-40 lb N/bale



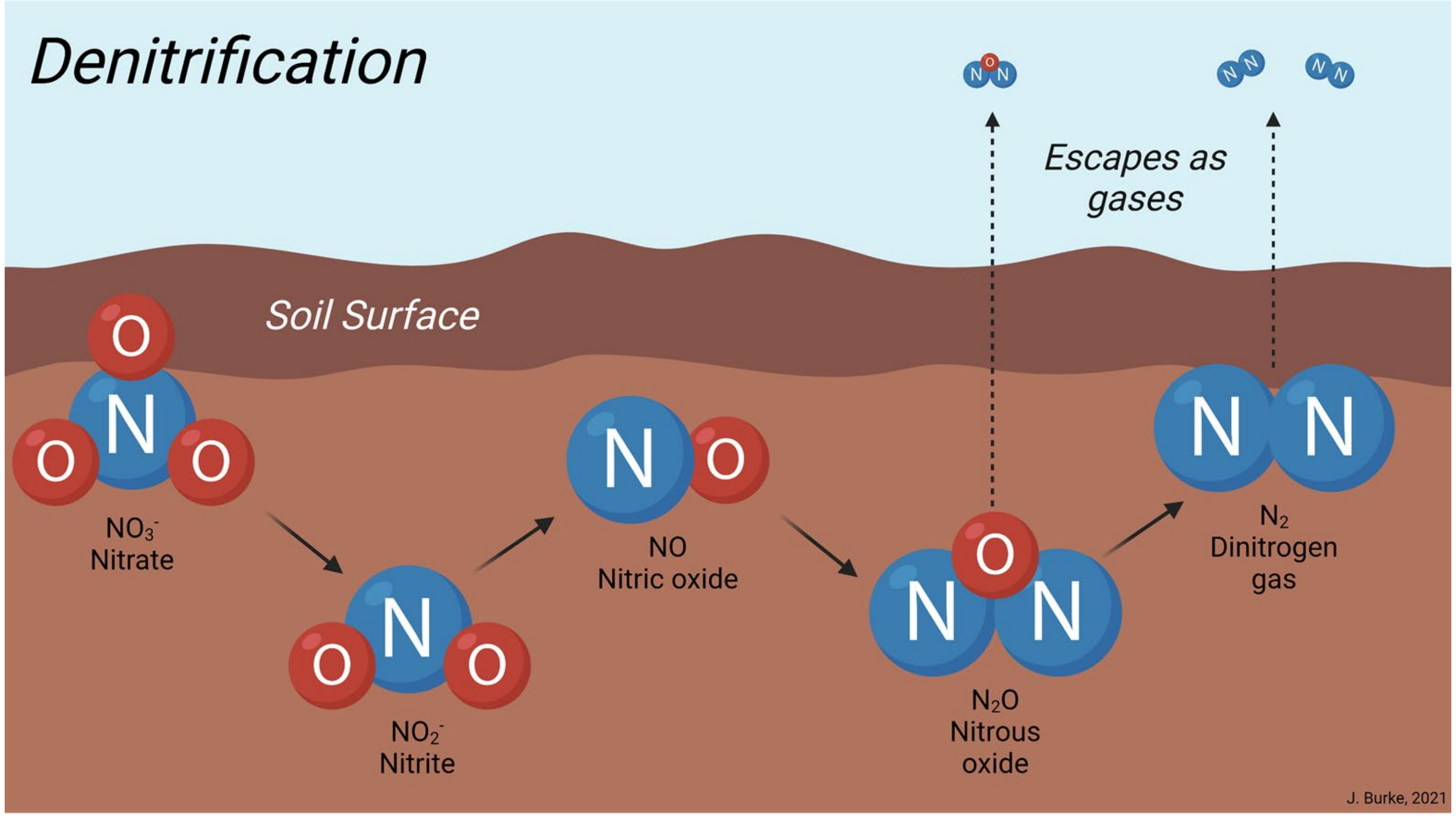
Grain Crops

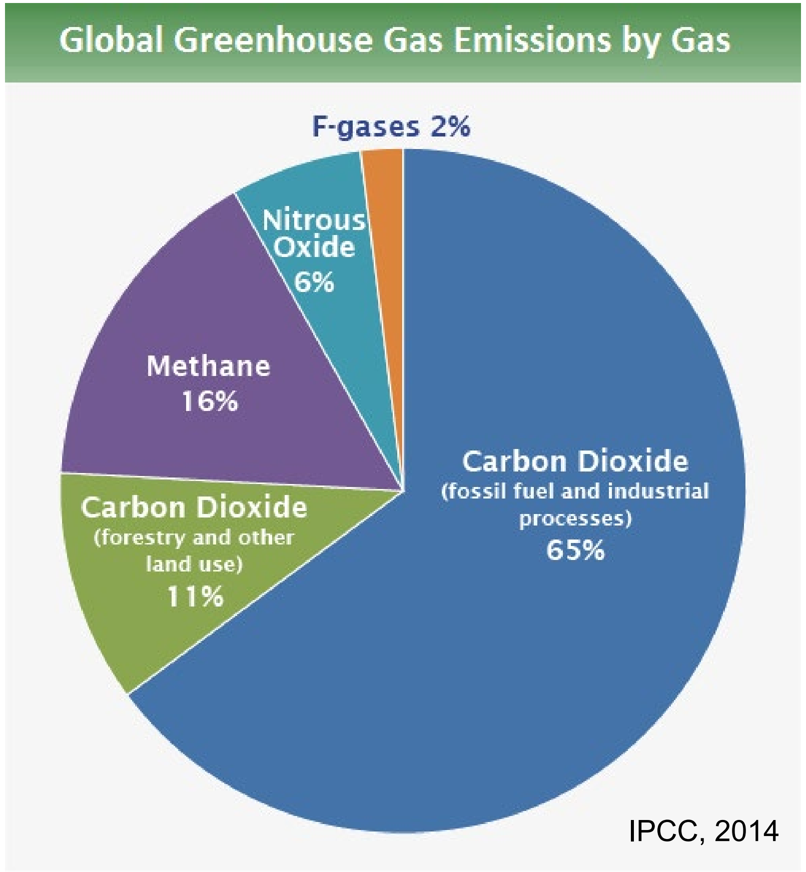
1 lb N/50 lb grain



Denitrification

Bacterial reduction of NO_3^- to NO, N_2O, and N_2 gases under anaerobic (reducing) conditions.





Mineralization and Immobilization

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

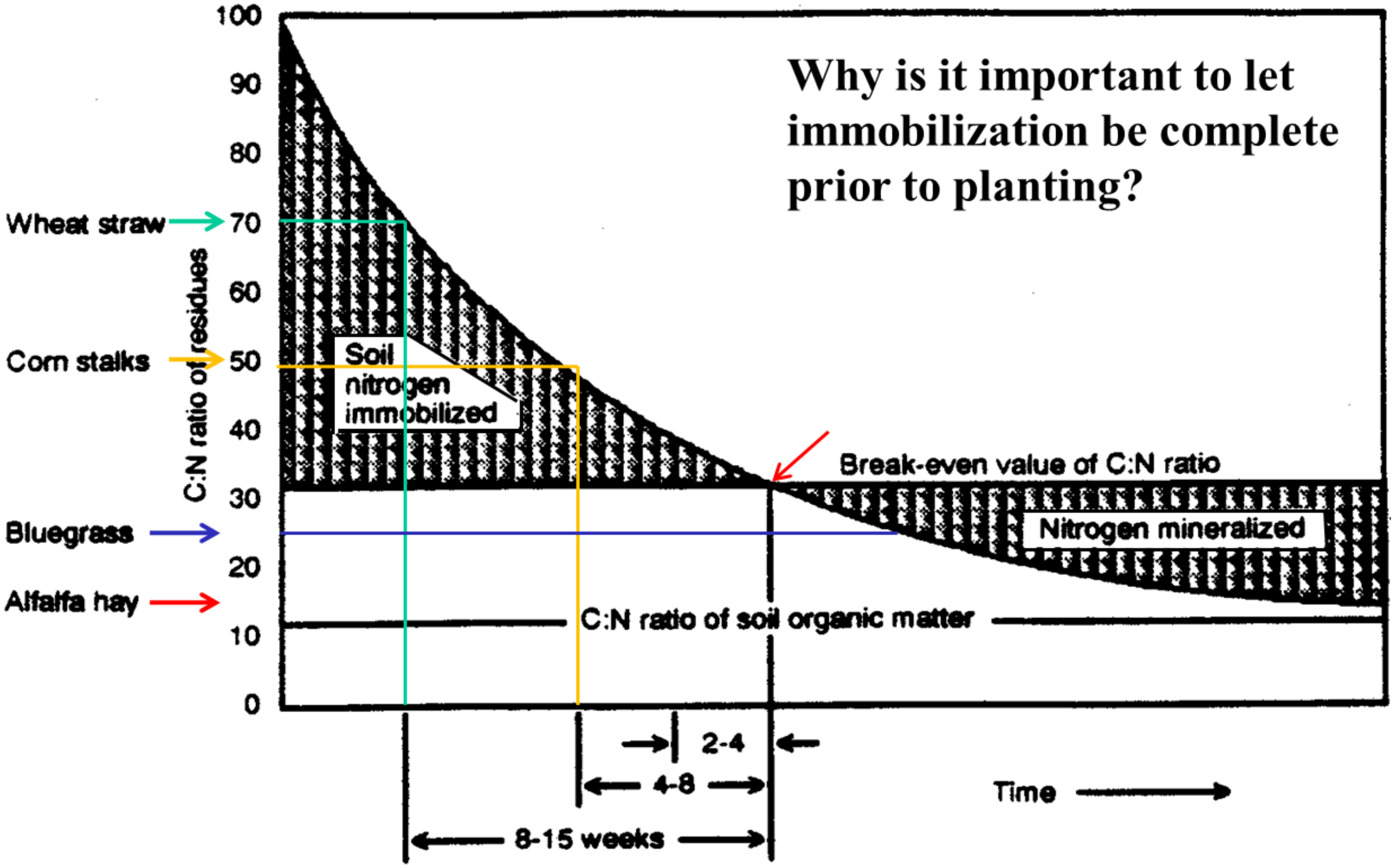
Mineralization – conversion of plant-unavailable organic N to plant-available inorganic N (NH_4^+); C:N < 30:1

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

Practical significance??

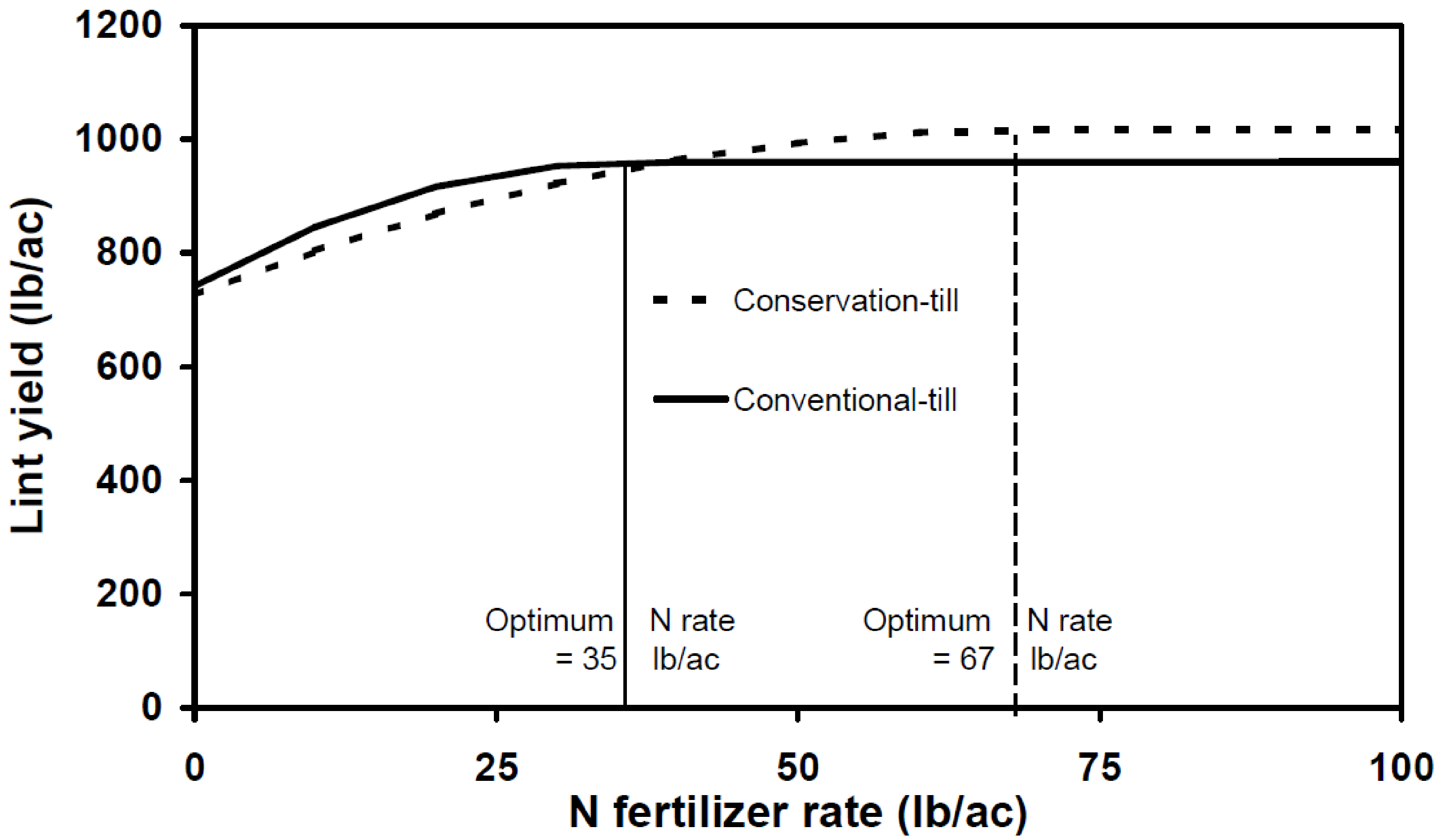
Determining Factor for Net N Mineralization or Immobilization

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

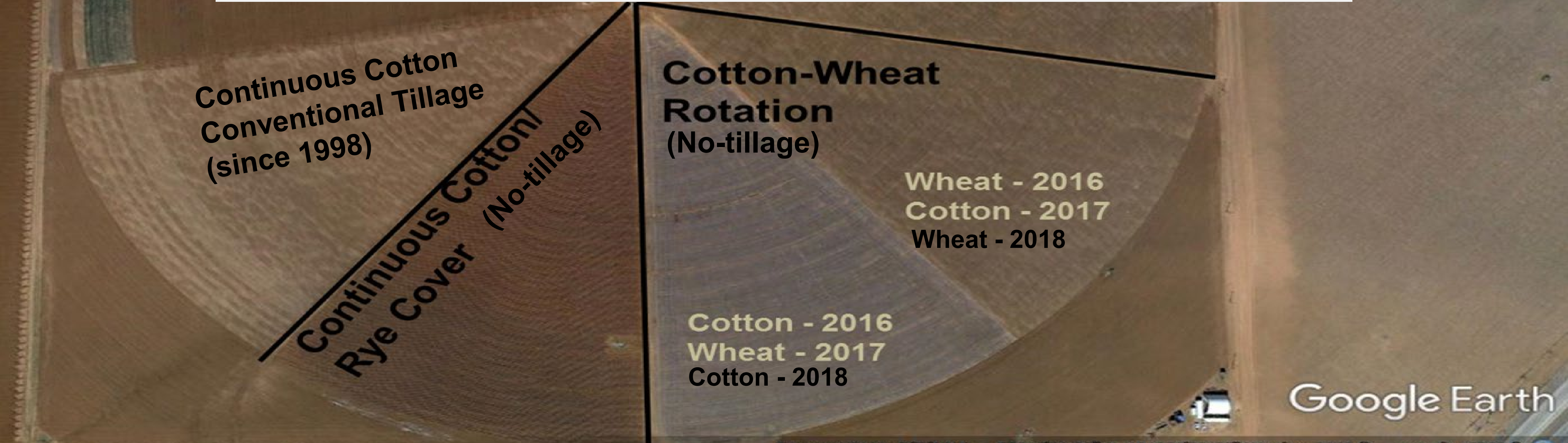
Soil Health and Nitrogen Management

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})
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Nutrient Requirements

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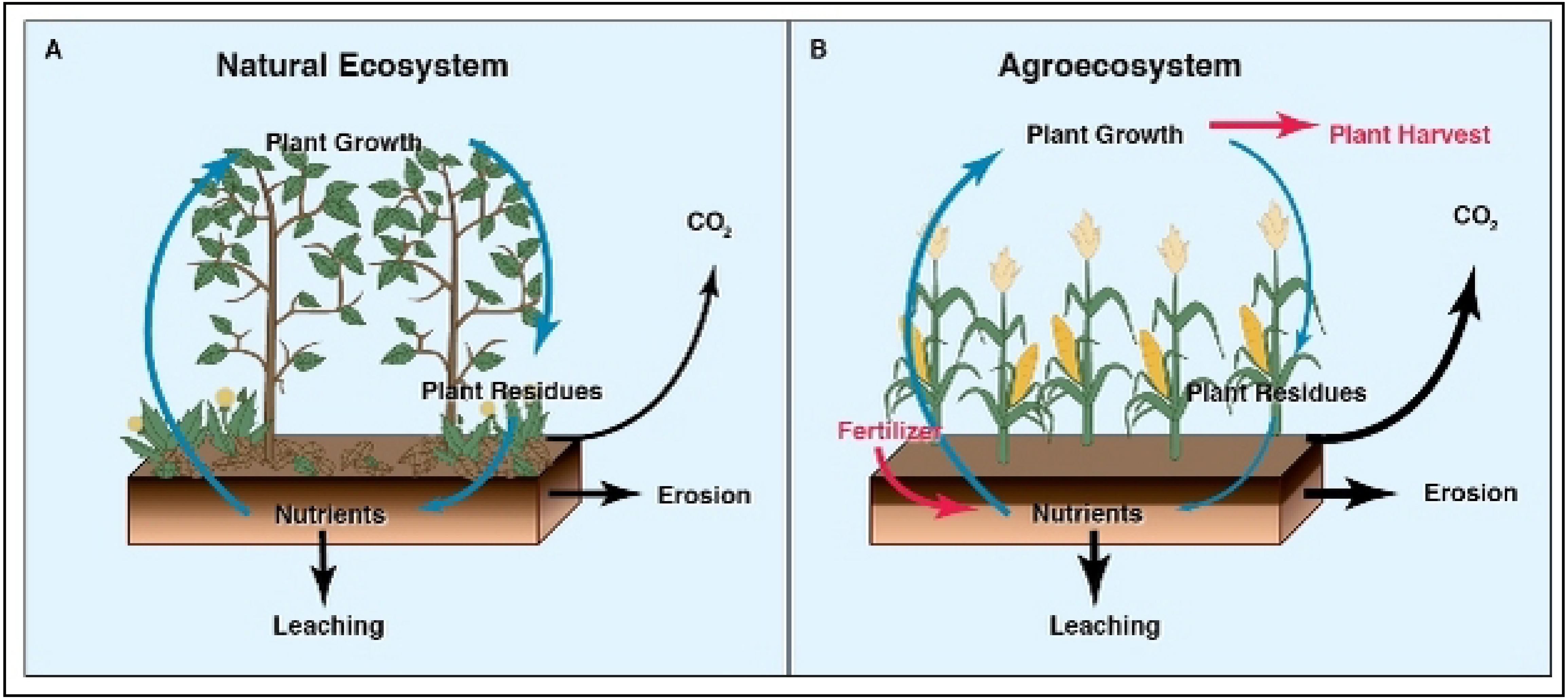
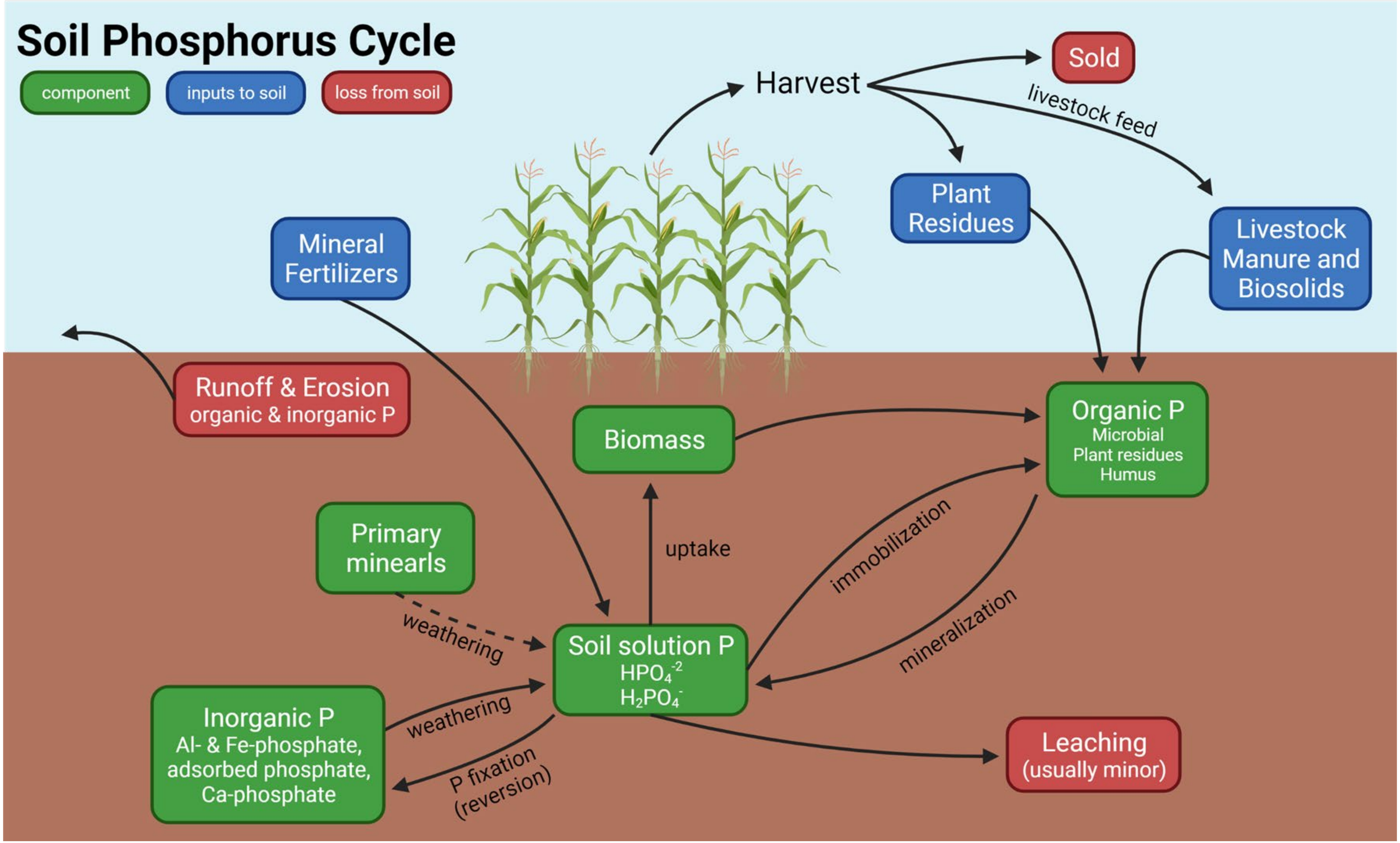
Cotton Nutrient Requirements		
Element	Nutrient	Estimated amounts needed (units/bale)
Primary Nutrients		
N	Nitrogen	45 - 60 lb N/acre
P	Phosphorus	20 - 25 lb P_2O_5/acre
K	Potassium	40 - 45 lb K_2O/acre
Secondary Nutrients		
Ca	Calcium	13 lb/acre
Mg	Magnesium	10 - 14 lb/acre
S	Sulfur	10 - 14 lb/acre
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, soil fertility declines



Over time we have mined our soils……



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

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**

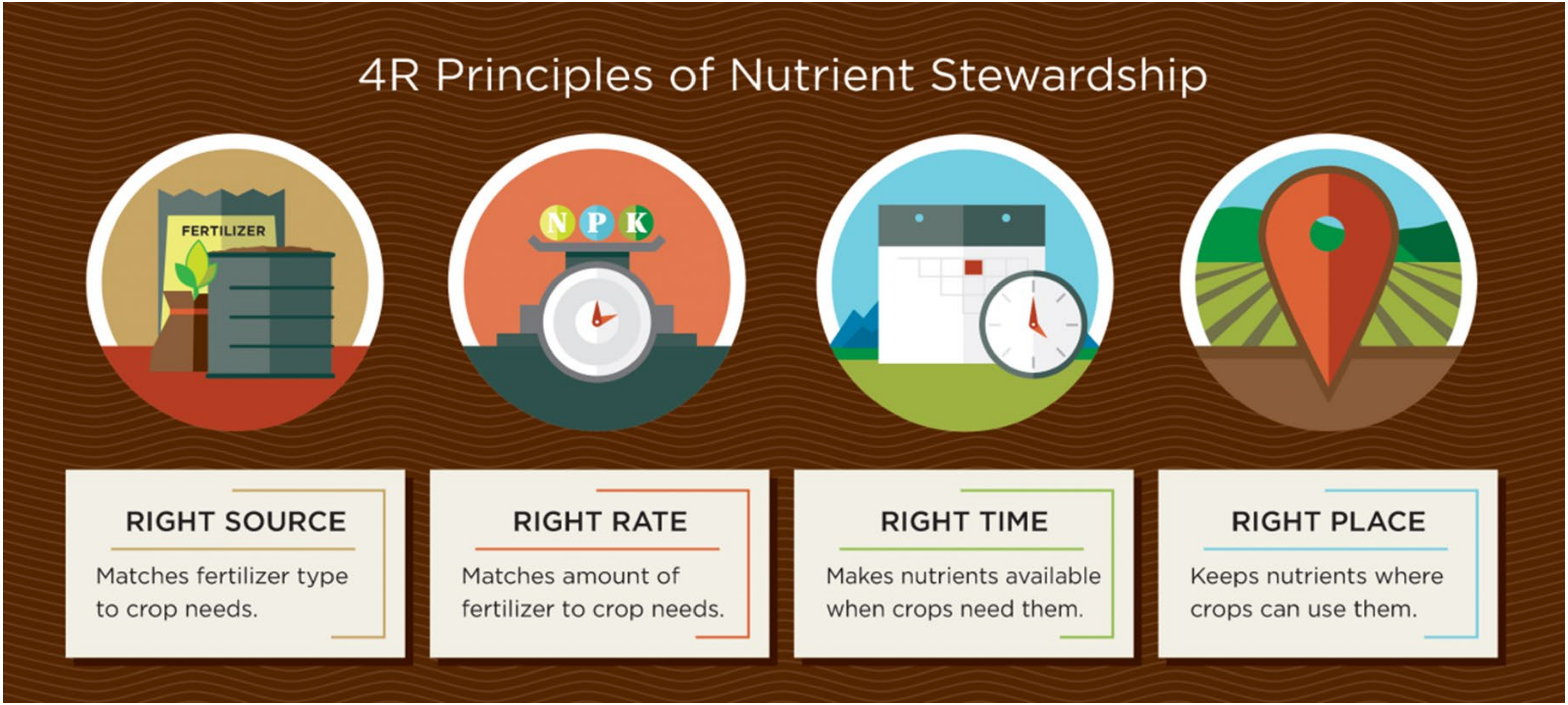
Phosphorus Nutrition

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!

Phosphorus Nutrition



Phosphorus Source

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Things to keep in mind when selecting P fertilizer

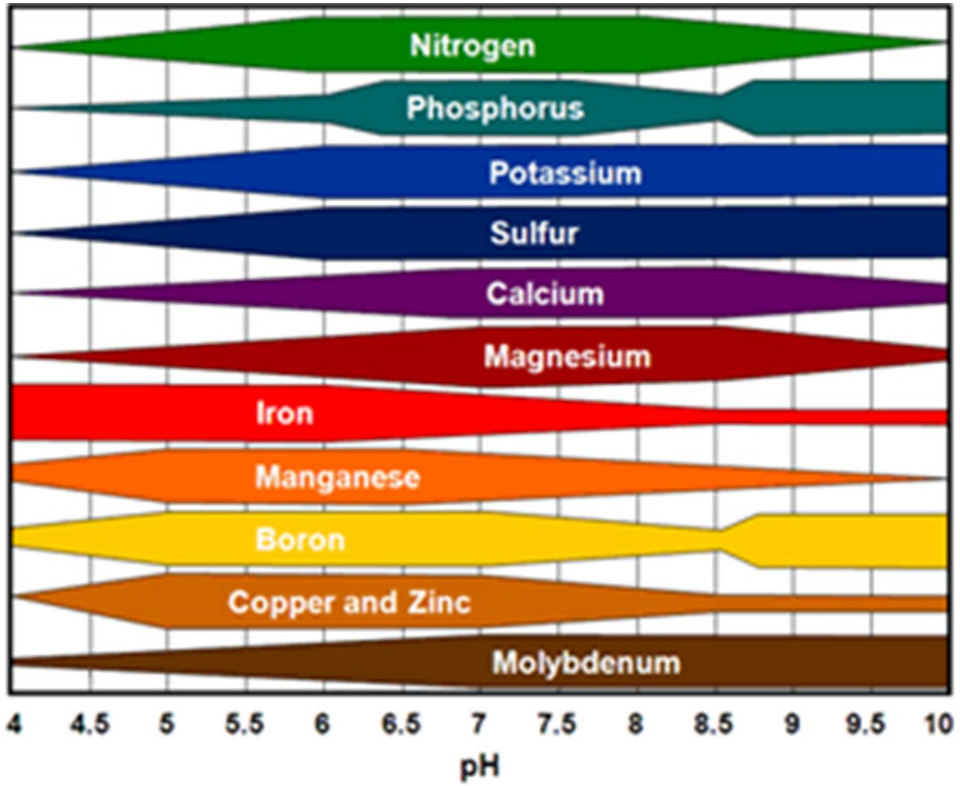
- Most P fertilizer sources perform similarly when equal P rates are applied using comparable application methods

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

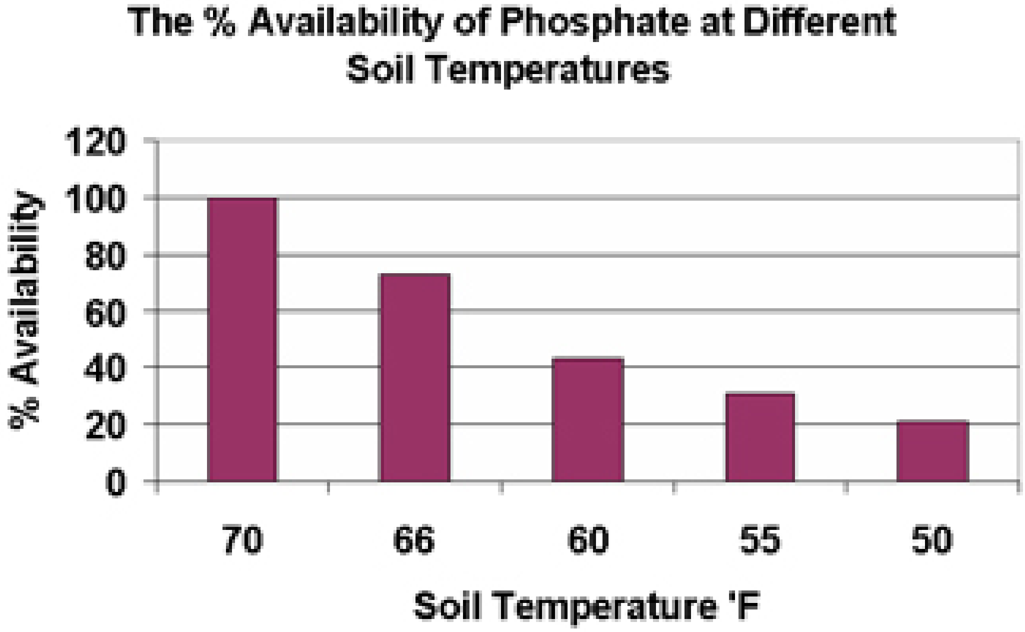
- Best source is generally determined by product availability, preference, dealer service, and price

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



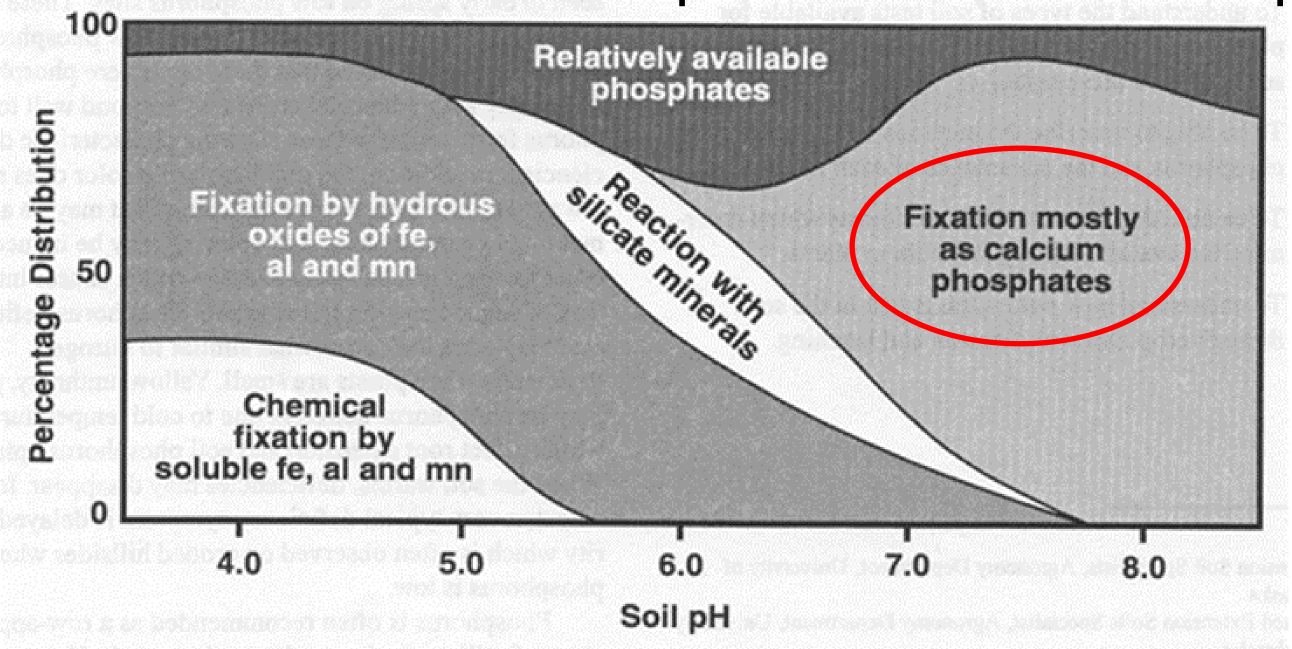
Soil Temperature Effects



Source: The Pennsylvania State University

Phosphorus Placement

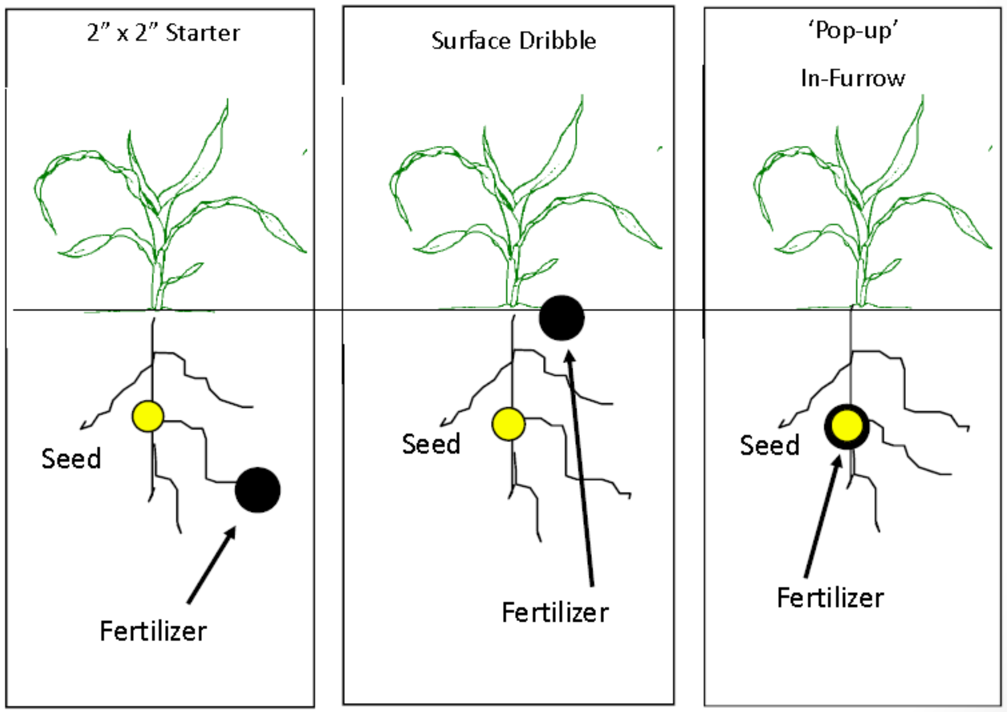
- Phosphorus added to soil quickly becomes fixed in less available forms
- Banding (pre-plant or starter) and fertigation is more efficient than broadcasting pre-plant
  - Calcium carbonates binding or "fixing" most of the phosphorus (as calcium phosphate) when broadcasted – incorporation does not help



Phosphorus Placement

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>

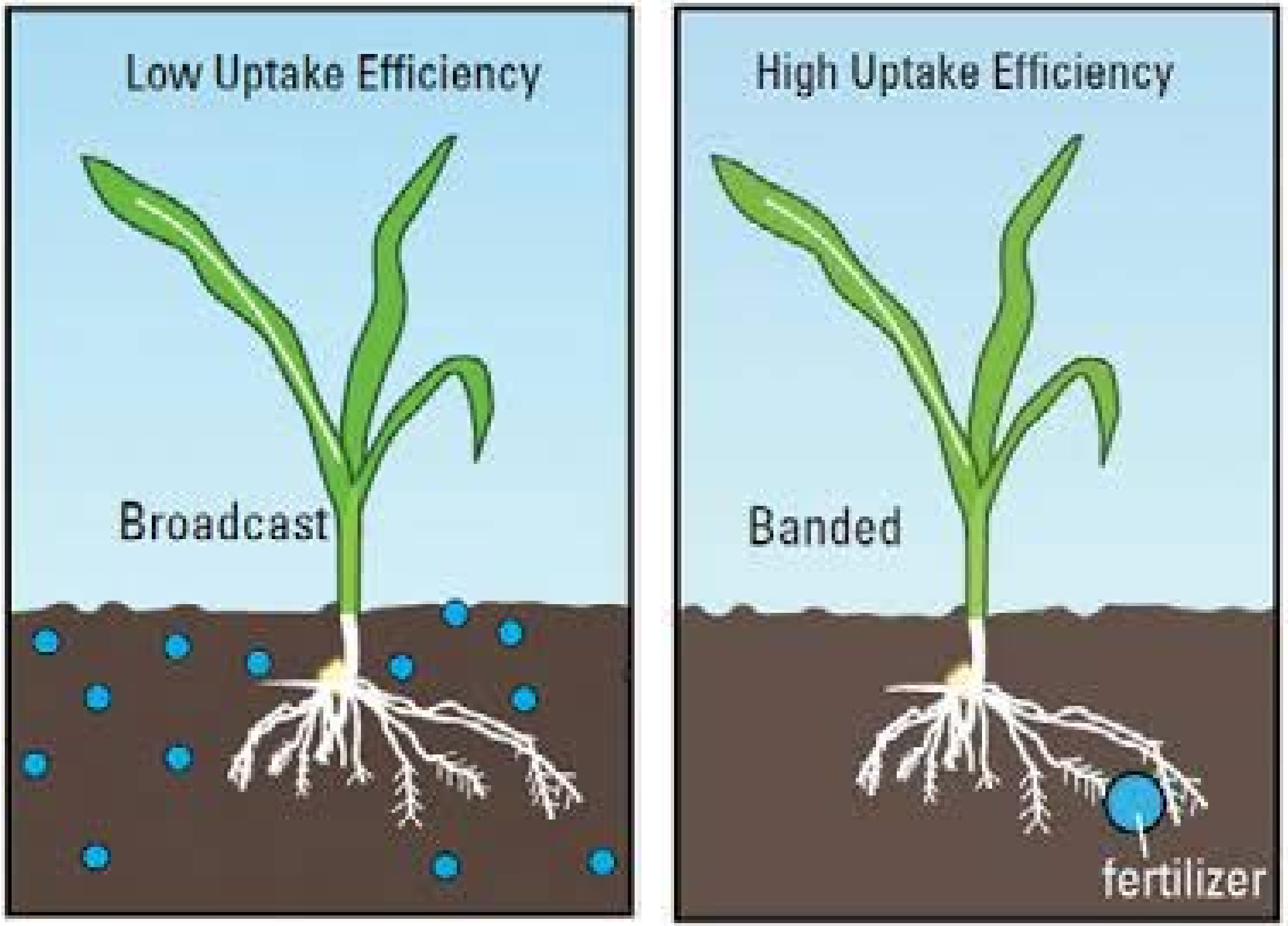
10-34-0:
< 10-15 gal/A in 2"x2"
< 3 - 4 gal/A in-furrow
(12 – 16 lb P_2O_5/A)

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

Phosphorus Placement

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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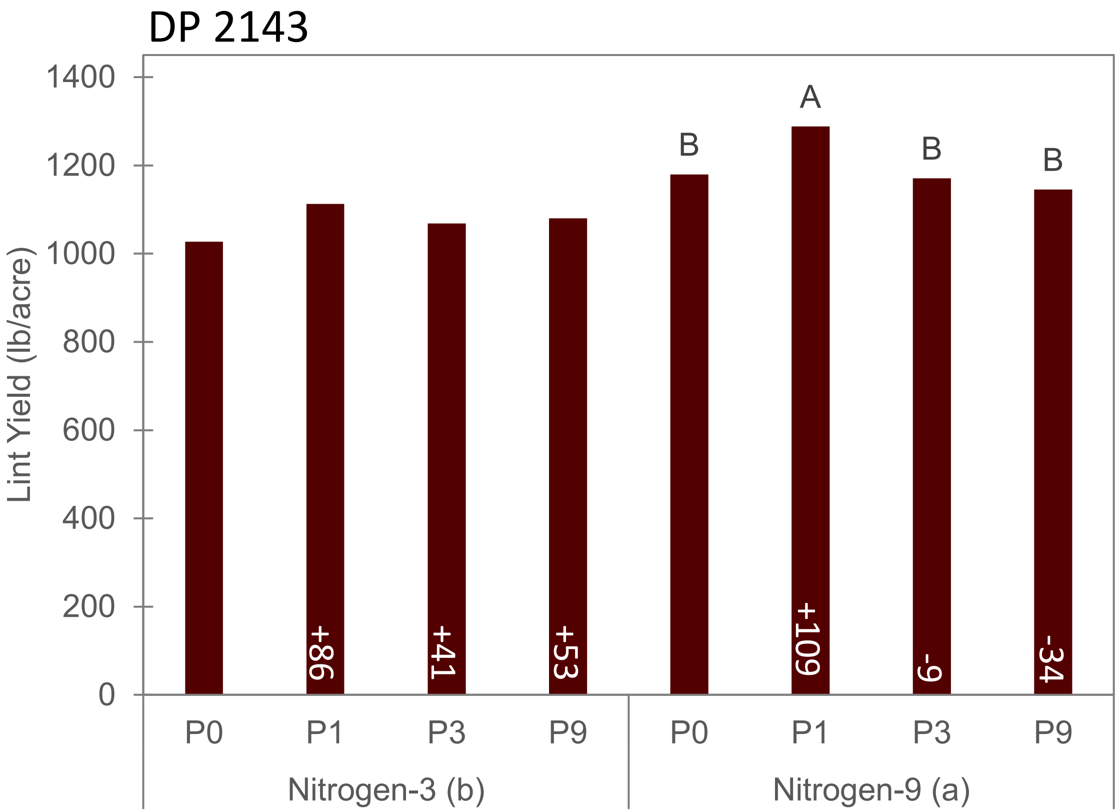
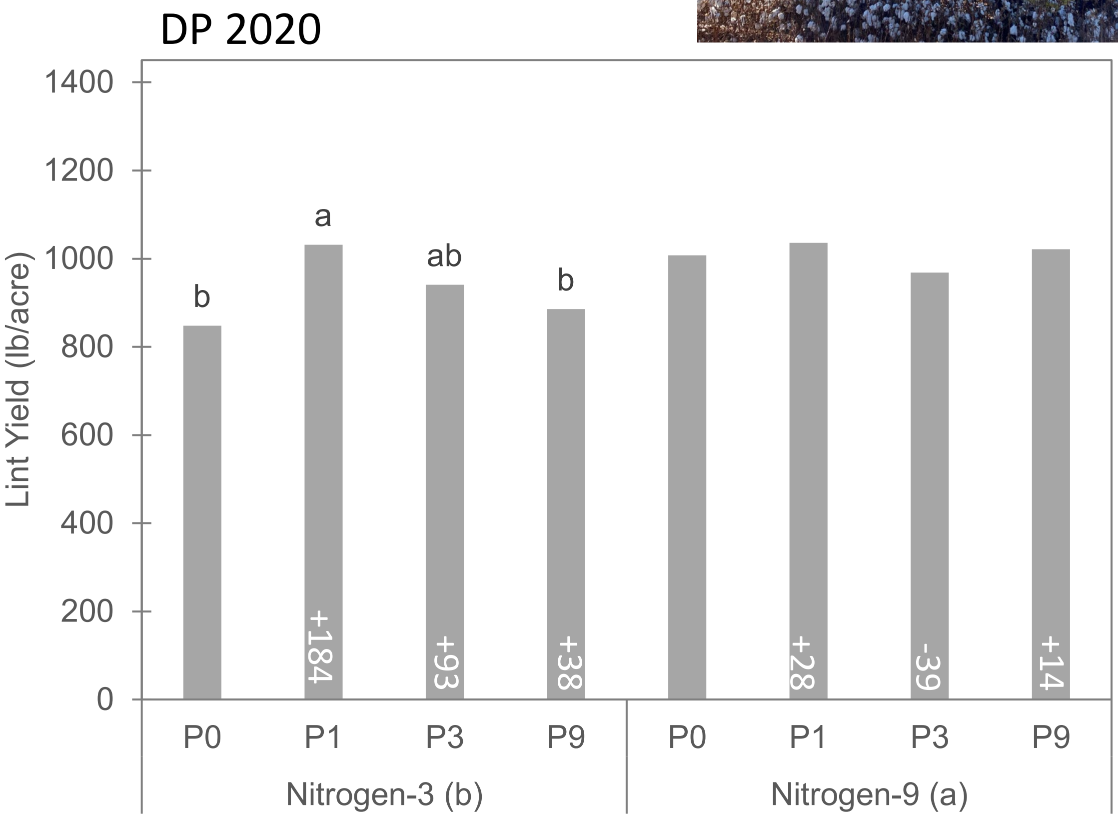
Fertigation Frequency (SDI)

Lint yield (2021)





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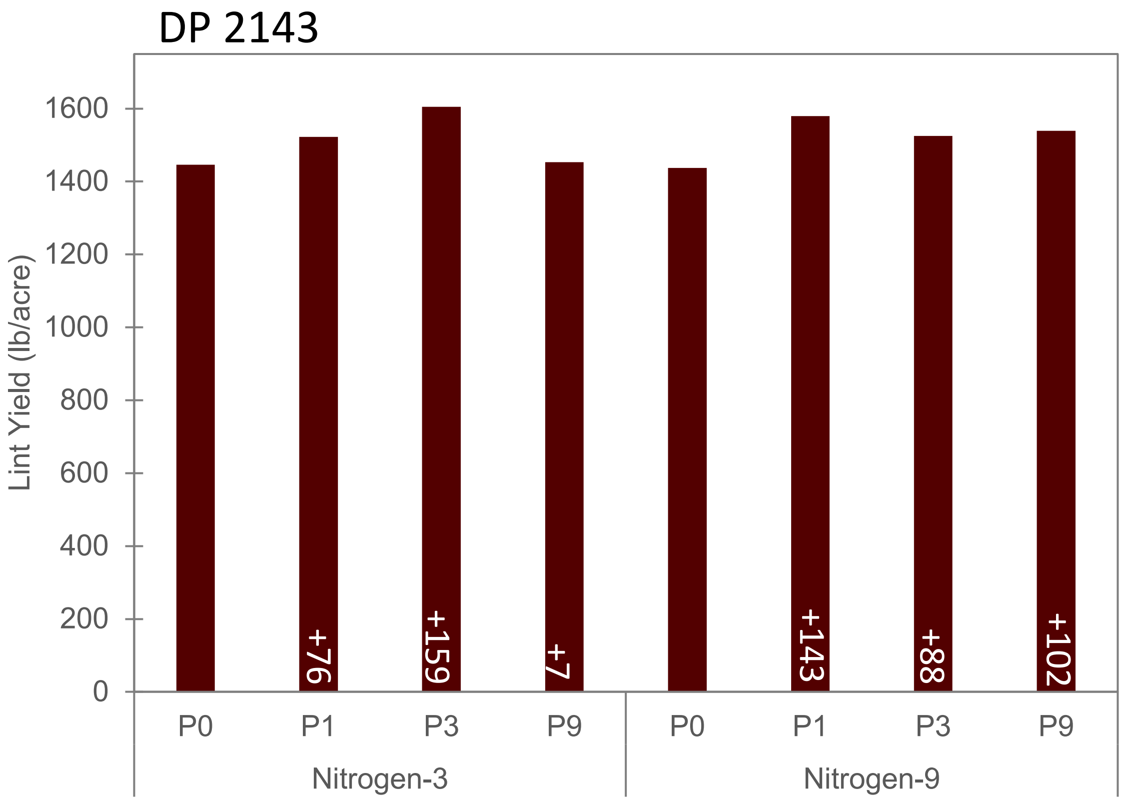
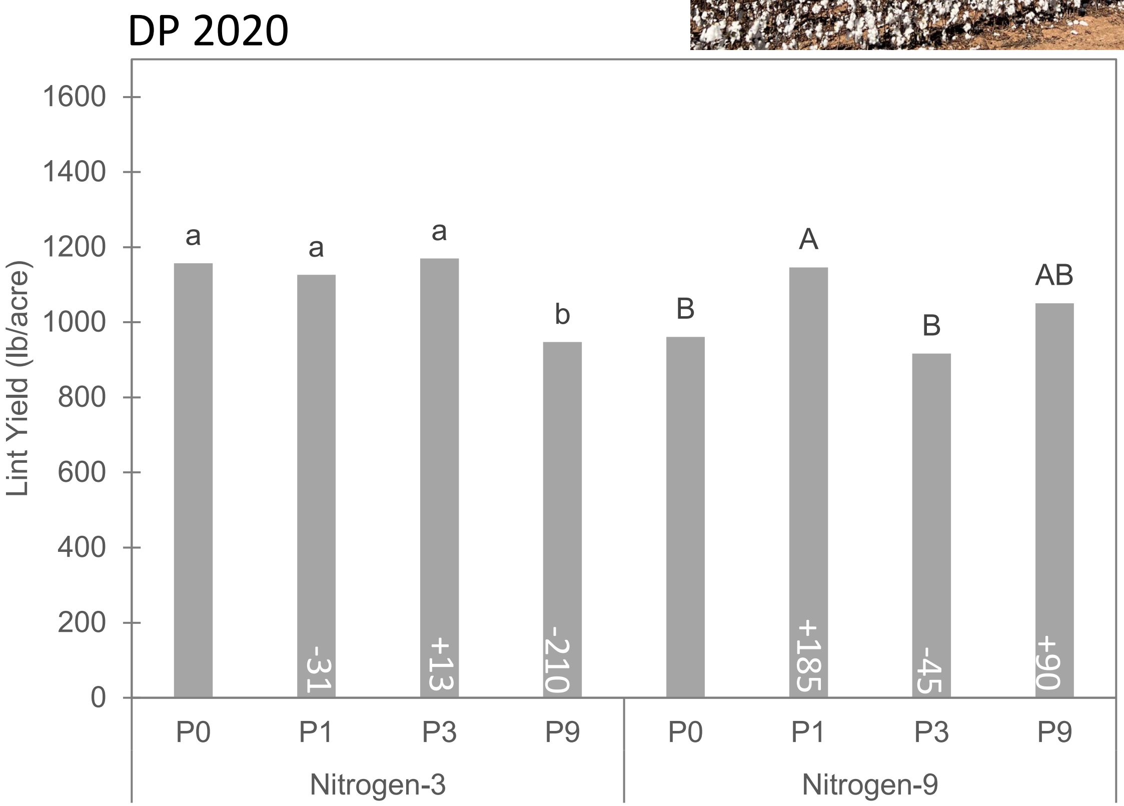
Fertigation Frequency (SDI)

Lint yield (2022)





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Potassium and Cotton

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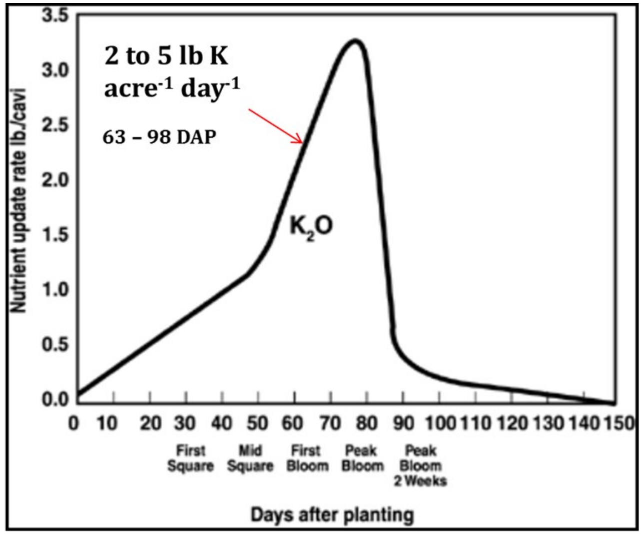
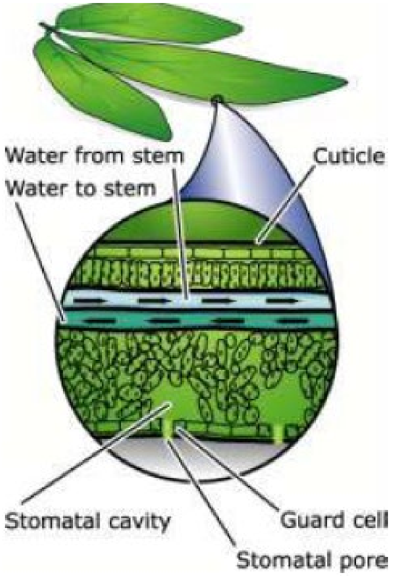
- ***Quality Nutrient***
  - Fiber maturity



Source: Mullins and Burmester, 1990

- Required by plants in amounts *second* only to N
  - *Cotton can require greater K than N*

- Mitigates drought and biotic stress
  - Regulates leaf stomata and controls water use
    - In an area dependent on irrigation (dwindling supply), K could be key



IPNI

Potassium and Cotton

K deficient plants are more prone to foliar/root diseases

Source: Gaylon Morgan

Lubbock, 2017
Mid-season K def.
and Verticillium wilt

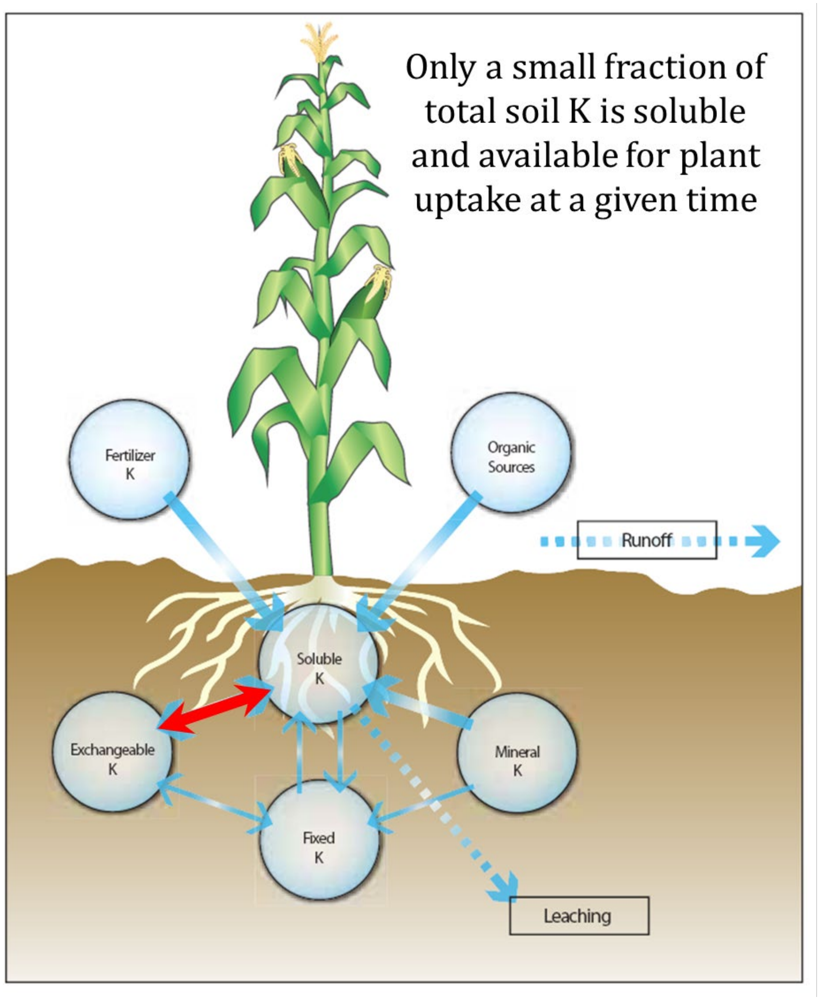
Plant Available K

- Increased reports of K deficiency symptoms across the Cotton Belt
- Soil analysis often indicates sufficient K; however, uptake may be low

Wellington, TX

Plant Available K

- Availability and uptake of K complicated by many interacting factors
  - Soil factors
  - Plant factors
    - Greater production and greater K demand with today's cotton varieties
  - Fertilizer and management practices



Phosphorus and Potassium

New Deal, TX (2017, 2018 and 2020)

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- Ammonium polyphosphate (10-34-0, pH 6.0) SD via coulter at PHS
- Intelliphos 45 (pH 1.2 – 1.6) and Intelliphos 32 (pH 1.9 – 2.2) applied through SDI (fertigation) at PHS

Product	**Prod Rate** (gal/A)	**P_2O_5** (lb/A)	**K_2O** (lb/A)	**Lint Yield** (lb/A)		**P_2O_5-NUE (over check)** (lb lint/lb P_2O_5)
Control	0	0	0	1534		--
10-34-0	9	34	0	1539	(+5 lb)	0.2
Intelliphos 45 (3-38-0)	2	10	0	1486	(-48 lb)	< 0
	4	19	0	1608	(+74 lb)	4
	6	29	0	★ 1654	(+120 lb)	4
Intelliphos 32 (0-24-8)	2	5	2	1514	(-21 lb)	< 0
	4	10	3	★ 1632	(+98 lb)	10
	6	15	5	★ 1649	(+115 lb)	8

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Final Thoughts…

- 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"

How to make more efficient fertilizer decisions?

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