Soil Fertility under flooded conditions

Dustin Harrell

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Flooded Soil

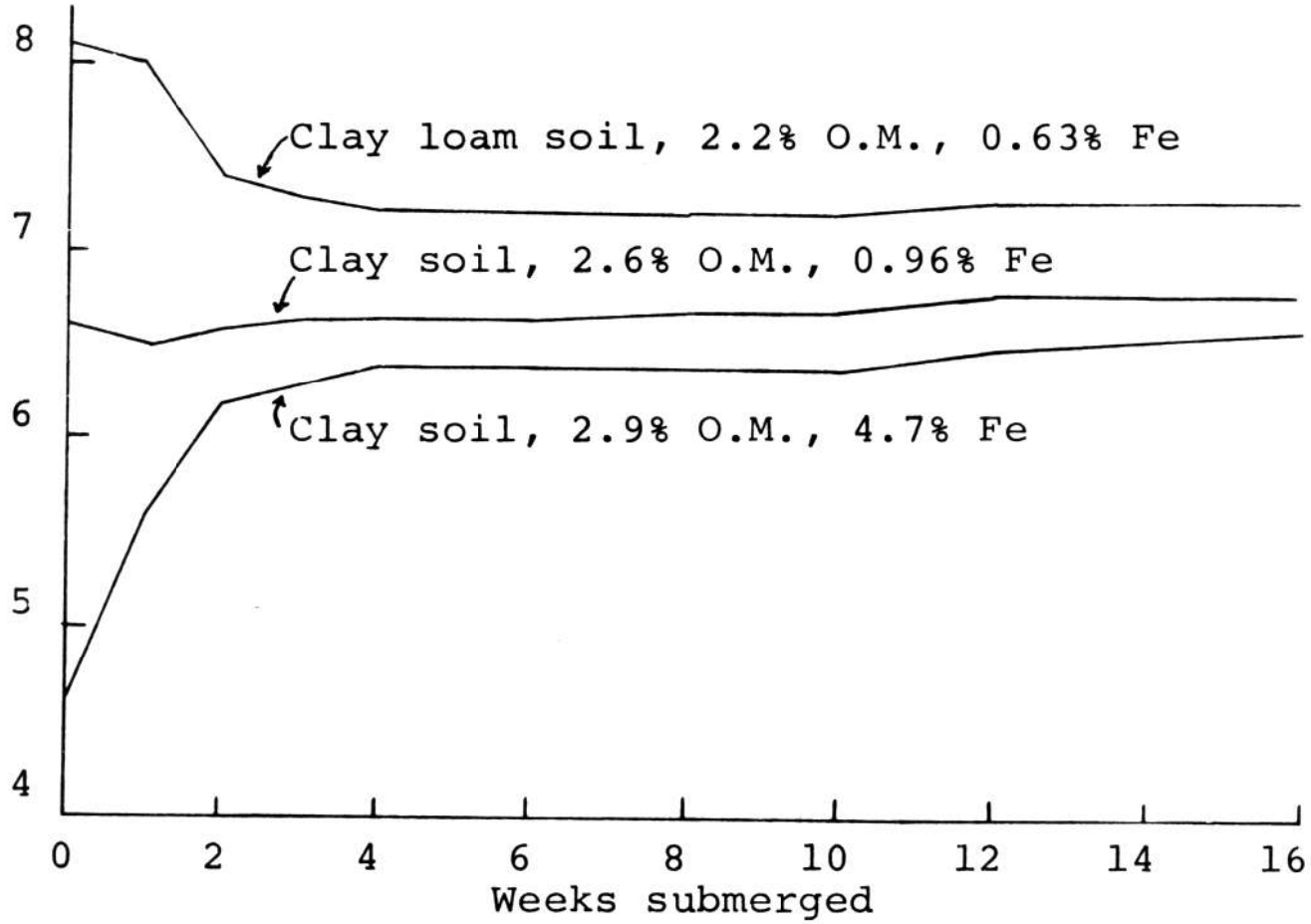
- Changes physical and chemical soil properties
  - Anaerobic (no oxygen)
- Management of fertilizer nutrients changes
  - Phosphorus (P)
  - Sulfur (S)
  - Nitrogen (N)

  - *The Right Way to Grow Rice*

Phosphorus

Dustin L. Harrell

Figure 1. Effect of flooding on soil pH



Taken from The Chemistry of Submerged Soils
Ponnamperuma, Advances in Agronomy, 1972

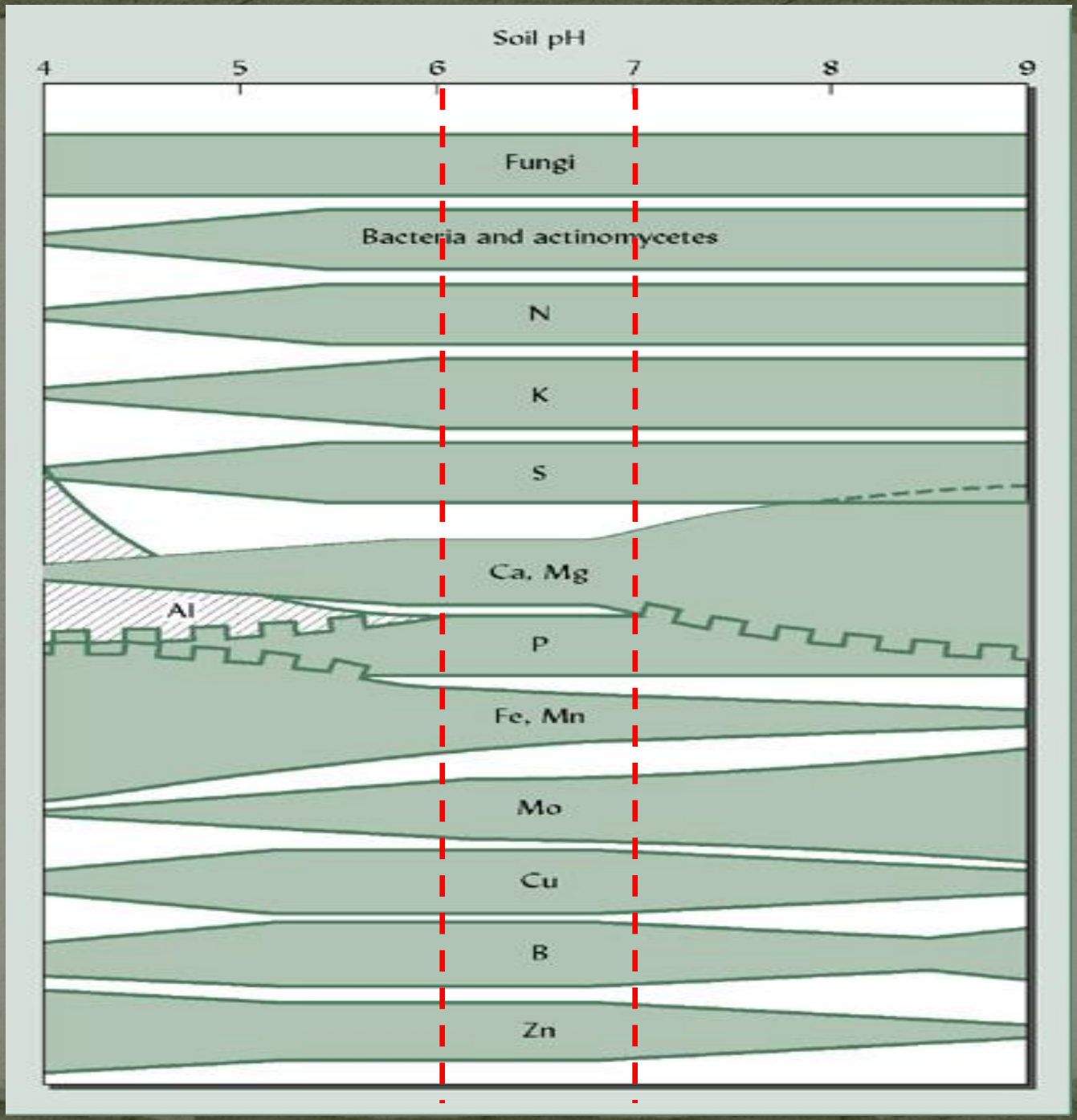
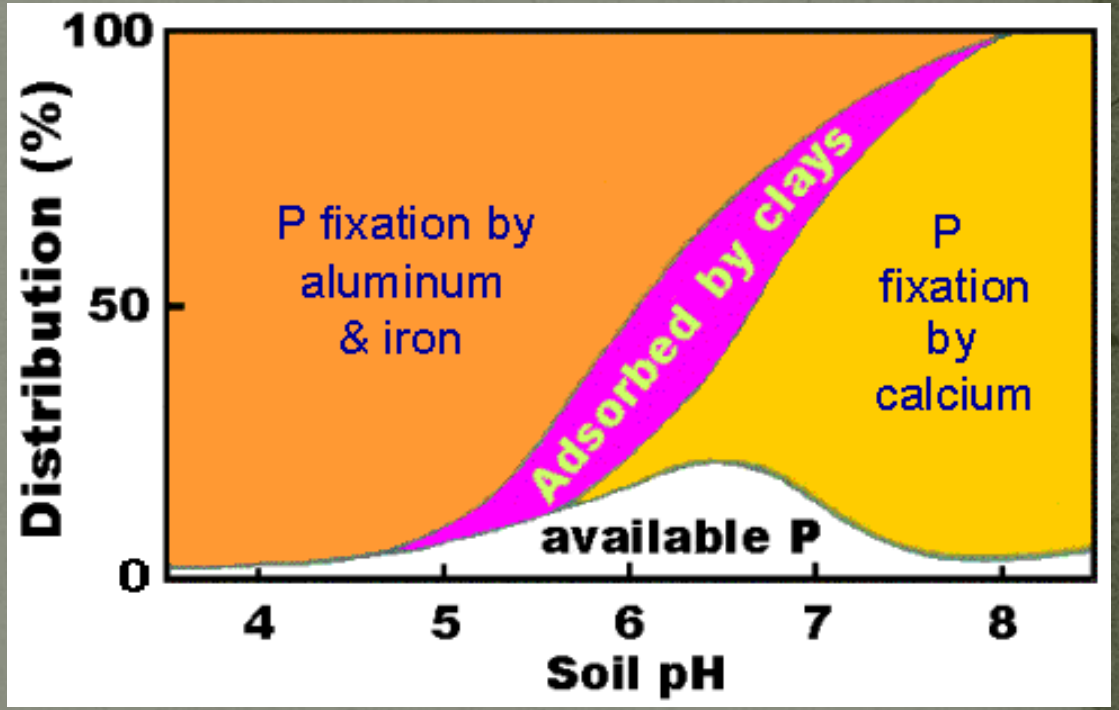

Soil pH
4
5
6
7
8
9
Fungi
Bacteria and actinomycetes
N
K
S
Ca, Mg
Al
P
Fe, Mn
Mo
Cu
B
Zn

Figure 9.22

Phosphorus availability in rice soils

- Acid soils:
  - Fe and Al-P
  - Permanent flood
    - ↑pH
    - ↑ P availability
- Calcareous soils:
  - Ca-P
  - Permanent flood
    - ↓pH
    - P availability slightly increased

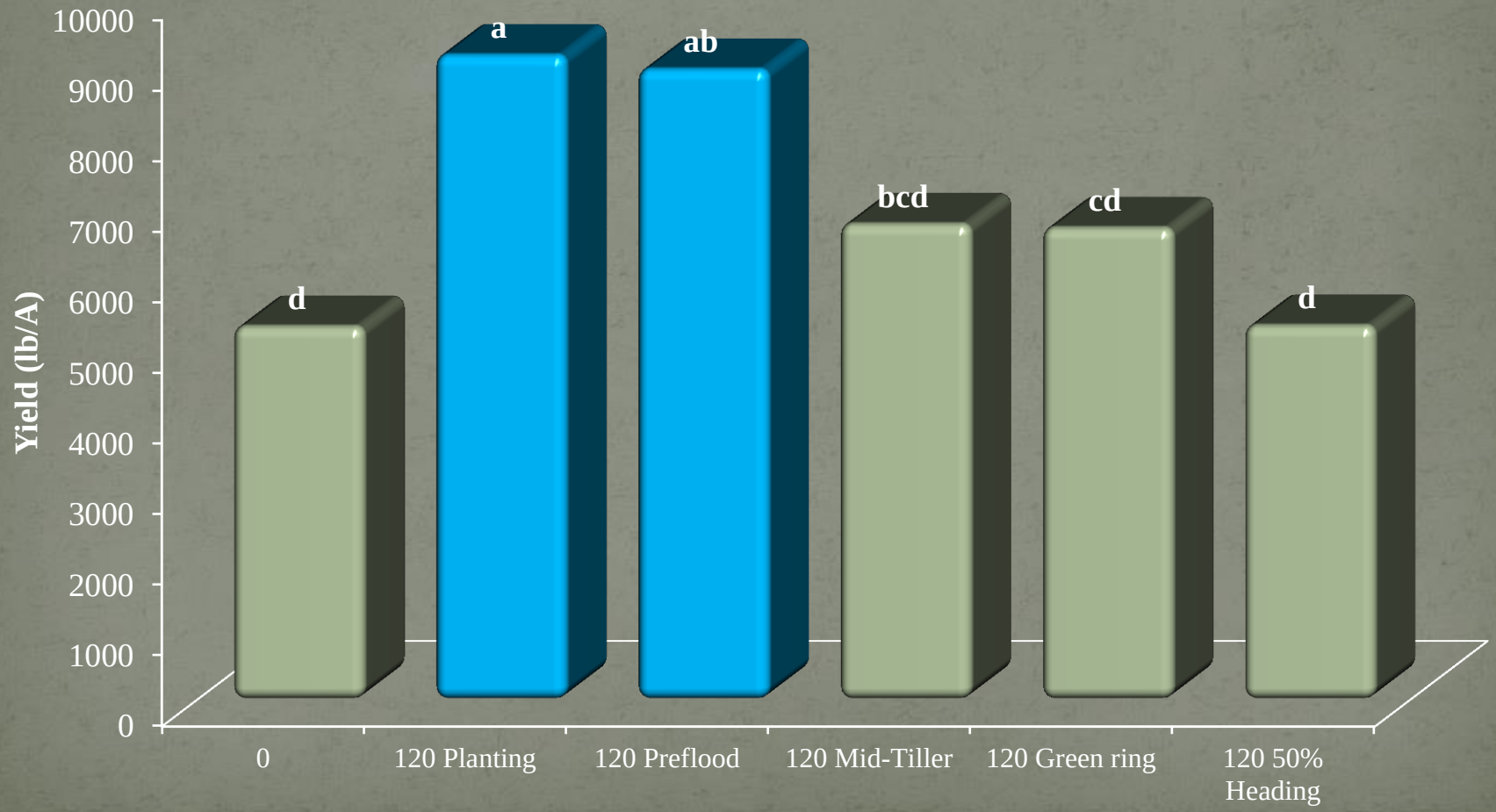


Does the timing of P applications make a difference?

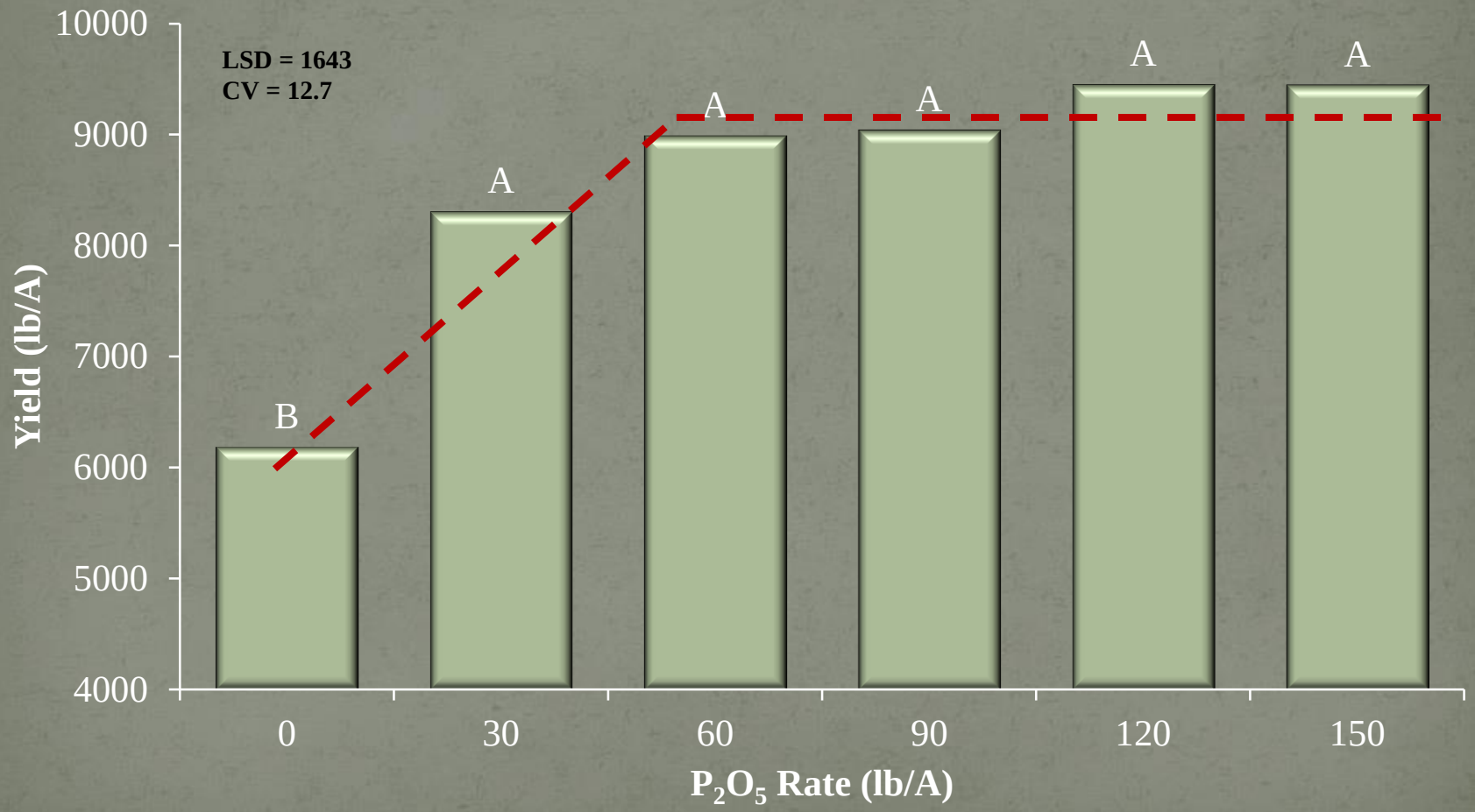
Rice Research Station – fertility and Agronomy Project

Evaluation of P Fertilizer Timing on Yield Miller Bros. Farm – Egan, LA (2011).

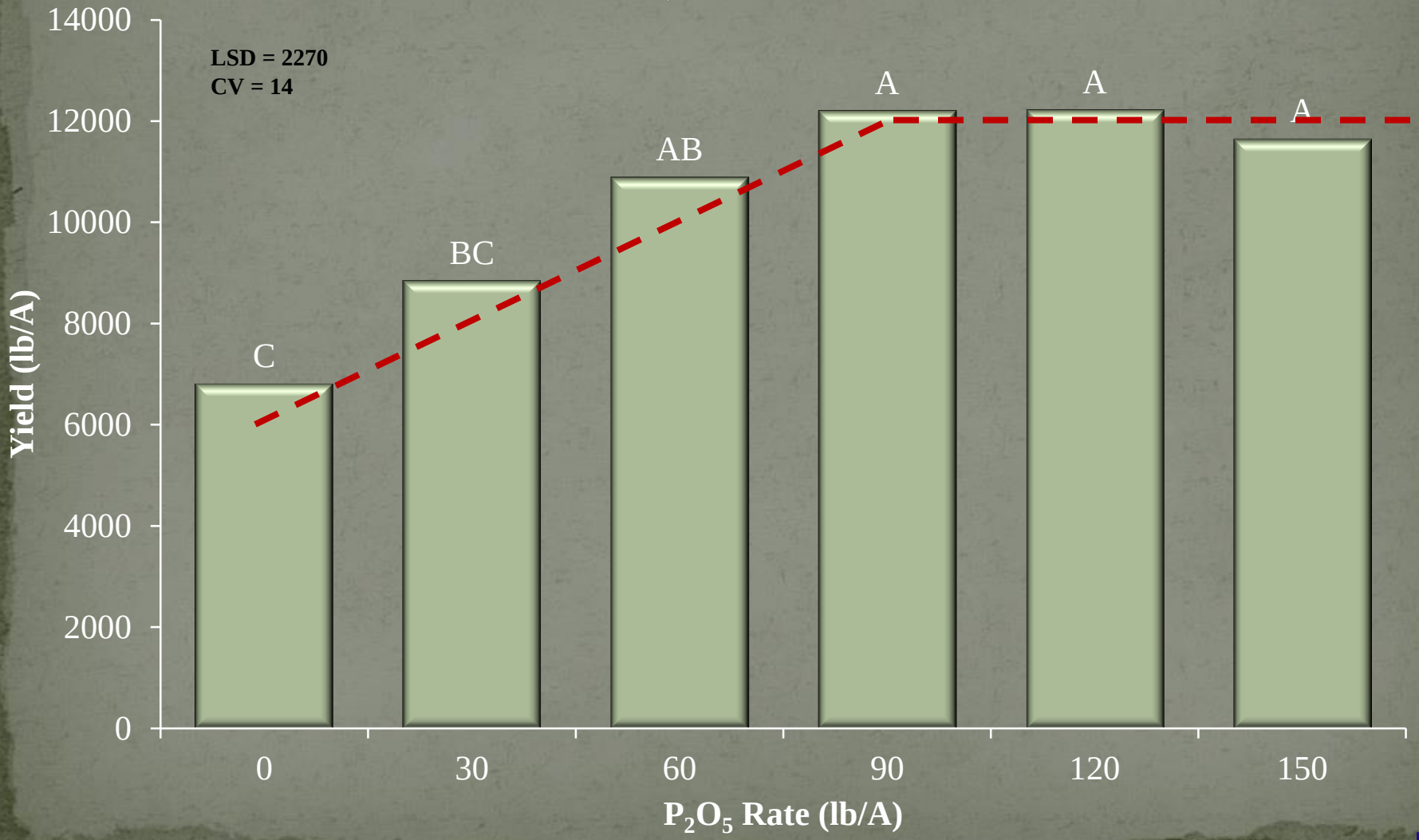
Main Crop Yield



Evaluation of P Rate
Miller Bro. Farms – Egan, LA (2011).



Evaluation of P Rate
Total Yield (Main + Ratoon)



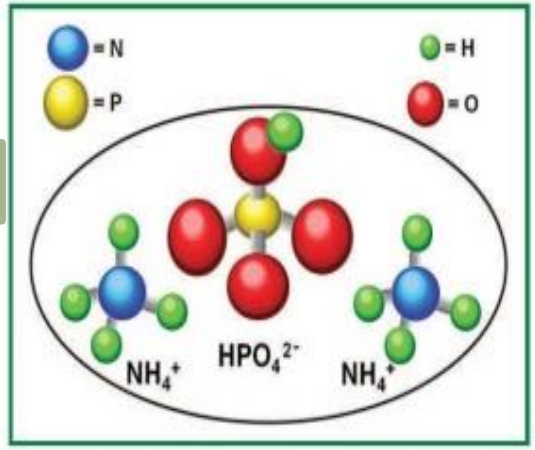
What is the best starter fertilizer for an alkaline (high pH) soil?
DAP, MAP, or TSP-blend?

Diammonium Phosphate (DAP)

Chemical Properties

Chemical formula:	$(NH_4)_2HPO_4$
Composition:	18% N
	46% P_2O_5 (20% P)
Water solubility (20 °C):	588 g/L
Solution pH:	7.5 to 8

18-46-0



Agricultural Use

DAP fertilizer is an excellent source of P and nitrogen (N) for plant nutrition. It is highly soluble and thus dissolves quickly in soil to release plant-available phosphate and ammonium. A notable property of DAP is the alkaline pH that develops around the dissolving granule.

As ammonium is released from dissolving DAP granules, volatile ammonia can be harmful to seedlings and plant roots in immediate proximity. This potential damage is more common when the soil pH is greater than 7, a condition that commonly exists around the dissolving DAP granule. To prevent the possibility of seedling damage, care should be taken to avoid placing high concentrations of DAP near germinating seeds.

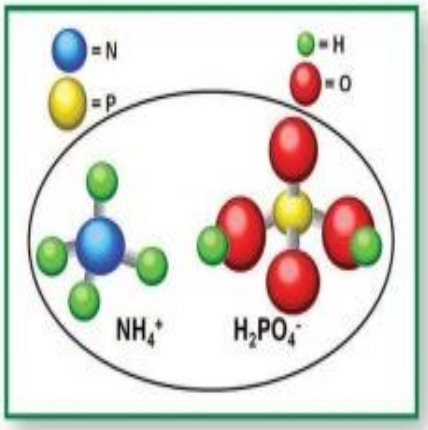
The ammonium present in DAP is an excellent N source and will be gradually converted to nitrate by soil bacteria, resulting in a subsequent drop in pH. Therefore, the rise in soil pH surrounding DAP granules is a temporary effect. This initial rise in soil pH neighboring DAP can influence the micro-site reactions of phosphate and soil organic matter.

Monoammonium Phosphate (MAP)

Chemical Properties

Chemical formula:	$NH_4H_2PO_4$
P_2O_5 range:	48 to 61%
N range:	10 to 12%
Water solubility (20°)	370 g/L
Solution pH	4 to 4.5

11-53-0



Agricultural Use

MAP has been an important granular fertilizer for many years. It is water soluble and dissolves rapidly in soil if adequate moisture is present. Upon dissolution, the two basic components of the fertilizer separate again to release NH_4^+ and $H_2PO_4^-$. Both of these nutrients are important to sustain healthy plant growth. The pH of the solution surrounding the granule is moderately acidic, making MAP an especially desirable fertilizer in neutral and high pH soils. Agronomic studies show that there is no significant difference in P nutrition from various commercial P fertilizers under most conditions.

Granular MAP is applied in concentrated bands beneath the soil surface in proximity of growing roots or in surface bands. It is also commonly applied by spreading across the field and mixing into the surface soil with tillage. In powdered form, it is an important component of suspension fertilizers. When MAP is made with especially pure H_3PO_4, it readily dissolves into a clear solution that can be used as a foliar spray or added to irrigation water. The P_2O_5 equivalent content of high-purity MAP is usually 61%.

Triple Superphosphate

Chemical Properties

Chemical formula:	$Ca(H_2PO_4)_2 \cdot H_2O$
Fertilizer analysis:	45% P_2O_5 (0-45-0)
	15% Ca
Water-soluble P:	Generally >90%
Solution pH	1 to 3

Triple superphosphate is available in granular (shown) and non-granular forms.

Agricultural Use

TSP has several agronomic advantages that made it such a popular P source for many years. It has the highest P content of dry fertilizers that do not contain N. Over 90% of the total P in TSP is water soluble, so it becomes rapidly available for plant uptake. As soil moisture dissolves the granule, the concentrated soil solution becomes acidic. TSP also contains 15% calcium (Ca), providing an additional plant nutrient.

A major use of TSP is in situations where several solid fertilizers are blended together for broadcasting on the soil surface or for application in a concentrated band beneath the surface. It is also desirable for fertilization of leguminous crops, such as alfalfa or beans, where no additional N fertilization is needed to supplement biological N fixation.

Sulfur (S)

- Sources
  - Only use SO4-S fertilizers
  - Elemental S (90%)
    - Not imm. Available
    - Must be oxidized
  - Ammonium Sulfate
    - (21-0-0-24)
- Rates
  - Base on soil test

Soil Test Level	Soil test Results	Fertilizer Recommendation
	--ppm--	lb S per acre
Low	<12	20 - 25*
Medium	12 - 16	5 - 15
High	>16	none

*Application of 100 pounds of ammonium sulfate will provide 21 lbs N and 24 lbs S.

Plant avaliable Nitrogen forms

- NH_4^+
  - Plant available
  - Stable under flood
  - Moves by diffusion
  - Correct N source for rice (NH_4^+ forming sources, urea)

- NO_3^-
  - Plant available
  - Not stable under flood
  - Moves by diffusion and mass flow
  - Incorrect N source for rice

Nitrogen

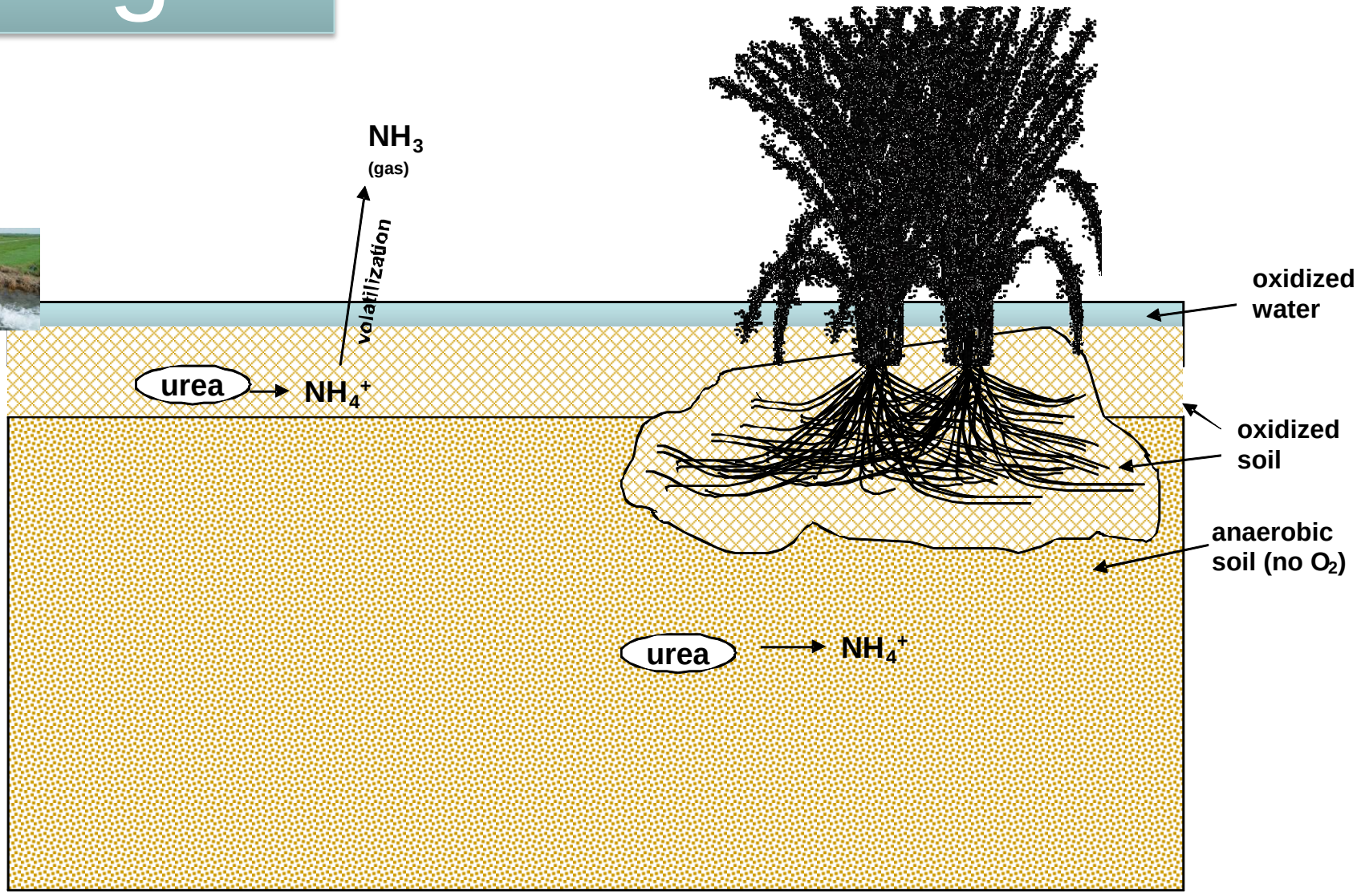
Rules of thumb

1. Only use NH_4^+ or NH_4^+ forming fertilizers

2. Apply first application on **DRY** soil and flood **ASAP**.
   - Approximately 2/3 of seasonal need

3. Apply 2nd application at midseason
   - Remaining 1/3 of seasonal need

Nitrogen


NH_3
(gas)
volatilization
urea
NH_4^+
oxidized water
oxidized soil
anaerobic soil (no O_2)
urea
NH_4^+


ESN
SmartNitrogen
Instinct
FACTOR
UREASE INHIBITOR
KEEP OUT OF REACH OF CHILDREN
CAUTION
NutriSphere-N
ARBORITE
N-Fixx
AGROTAIN
N-Serve
NZONE MAX
YaraVera
AMIDAS
AGROTAIN ULTRA
AGROTAIN PLUS
SUPER U
NZONE

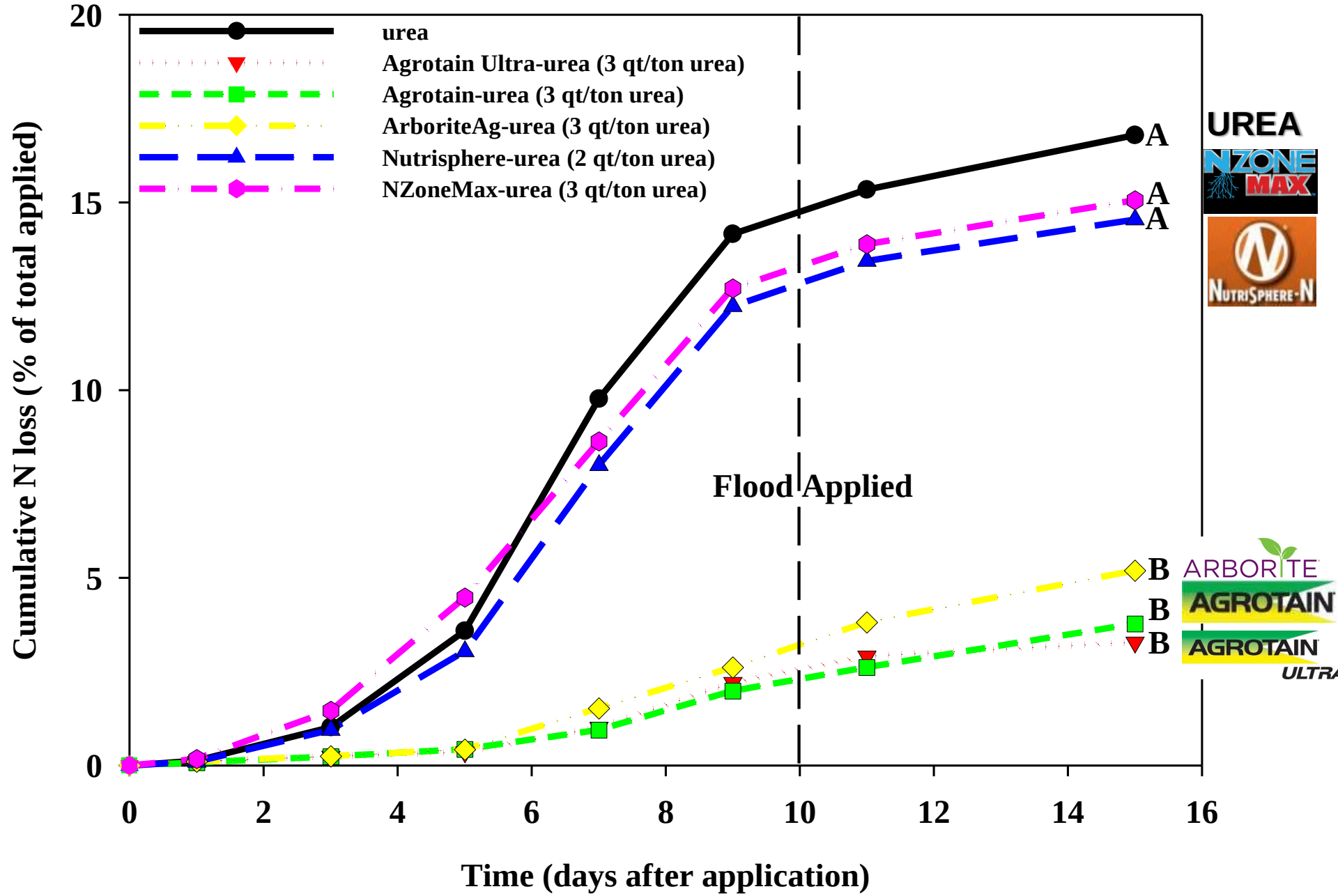
When a rice soil cannot be flooded in 3 to 5 days, the LSU AgCenter only recommends treating urea with a urease inhibitor (contains NBPT).

- Quantify ammonia volatilization losses and associated yield loss of N sources and treated urea products

Trial 5 (2013)

- 6 N sources Evaluated
  - Agrotain
  - Agrotain Ultra-urea
  - Arborite AG-urea
  - NZONE Max – urea
    - AgExplorer
    - "NZONE Max is a nitrogen management aid that increases nitrogen availability and uptake in addition to reducing nitrogen loss"
    - Ca-Heteropolysaccharides , Ca-Aminoethylpiperazine, and Alkylarylpolyoxyethylene glycols
  - NutriSphere-N
    - SFP
    - "Manages Nitrogen Volatilization and Nitrification"
    - Active Ingredient - Partial calcium salt of maleic-itaconic copolymer

2013 Evaluation of Urea, Agrotain-urea, Agrotain Ultra-urea, Arborite AG-urea, Nutrisphere-urea, N-Zone MAXX-urea



Conclusions of 2013 volatilization Trials

- Urease Inhibitor Products Containing NBPT did significantly reduce volatilization losses
  - Agrotain and Agrotain Ultra
  - Arborite AG
  - N-Fixx
  - Factor

- 3:1 blend Urea/AMS, Amidas, NZoneMaxx, and did not reduce ammonium volatilization as compared to untreated urea alone (1 year data).
- 3:1 blend Urea/AMS and Amidas are beneficial fertilizer sources when S is limiting (1 year data).

What happens when a field is drained and reflooded?

N_2 (gas) N_2O (gas)

NH_3 (gas)

volatilization

urea → NH_4^+ → NO_2^- → NO_3^-

nitrification

diffusion

N_2 (gas) ← N_2O (gas) ← NO_3^-

denitrification

urea → NH_4^+

oxidized water

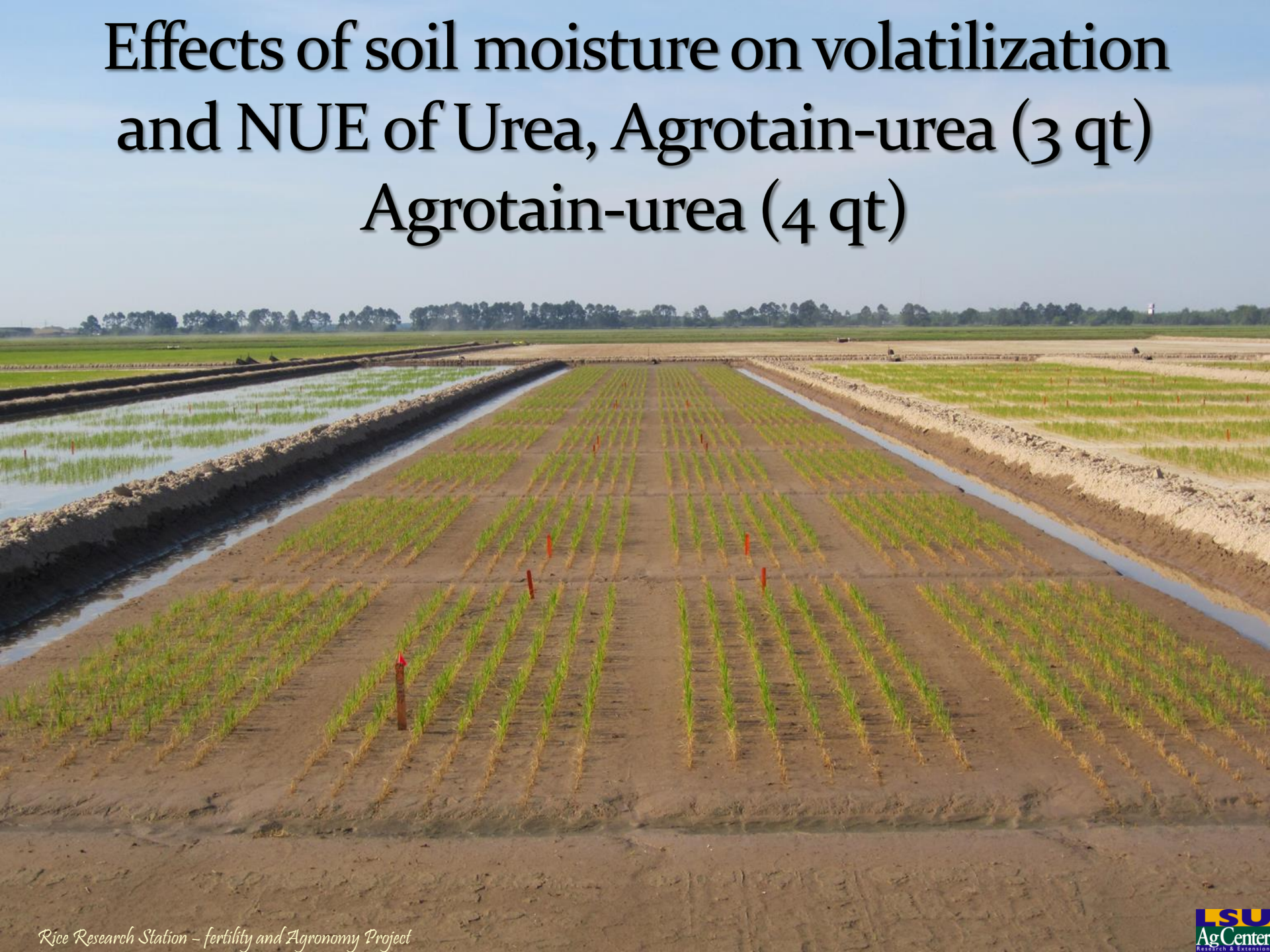
oxidized soil

anaerobic soil (no O_2)

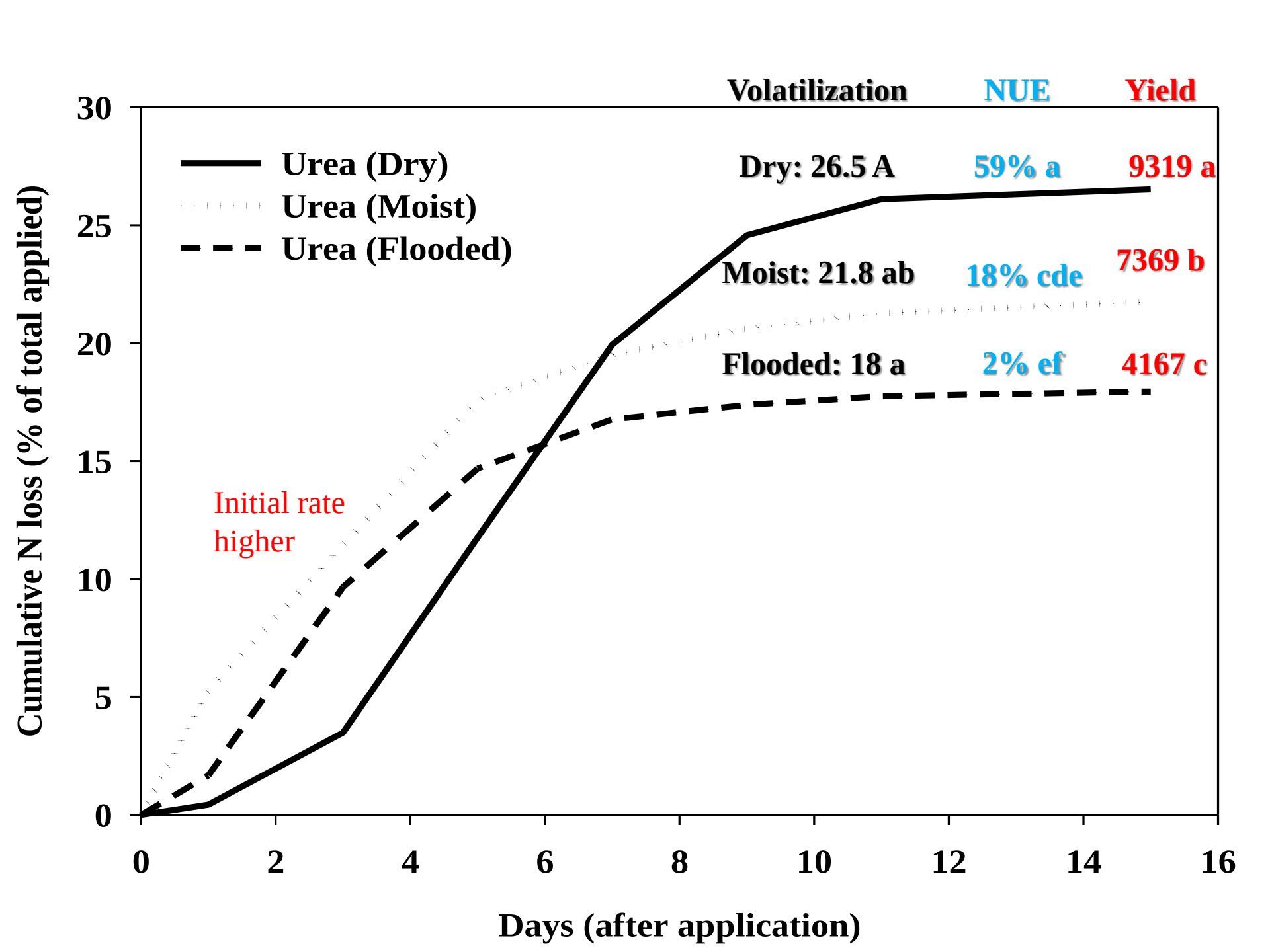
How important is it to apply pre-flood N on a DRY soil?

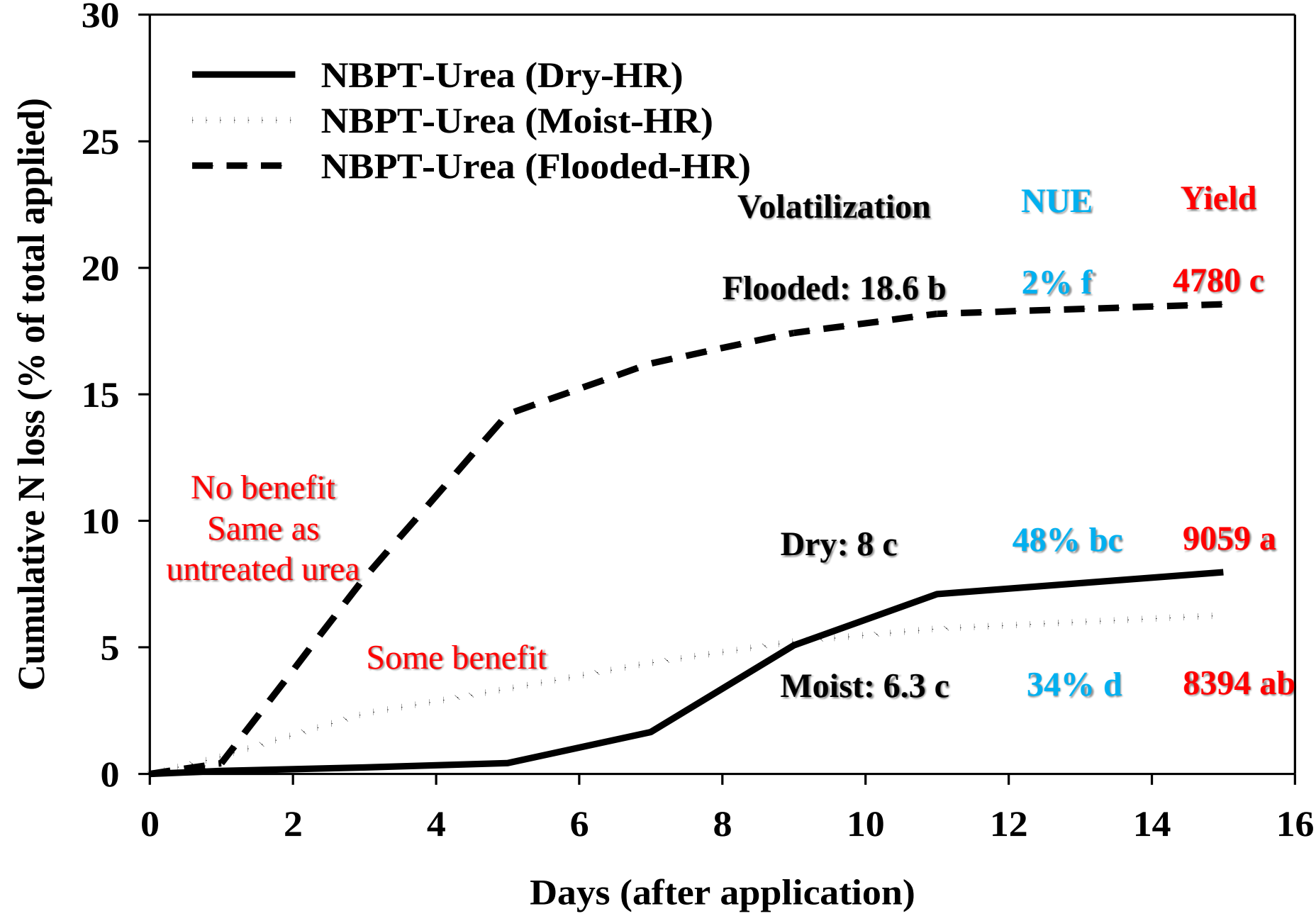
- What happens when you apply urea on dry, moist and flooded soils?
- Will using NBPT product help reduce volatilization? Can I add a higher rate?
  - (Agrotain, N-Fixx, Factor, Arborite AG)
- How much total N loss will I have?
  - Volatilization + nitrification/denitrification losses
  - Total Nitrogen Use Efficiency (NUE)

Effects of soil moisture on volatilization and NUE of Urea, Agrotain-urea (3 qt) Agrotain-urea (4 qt)



Rice Research Station – fertility and Agronomy Project


Volatilization
NUE
Yield
Urea (Dry)
Urea (Moist)
Urea (Flooded)
Dry: 26.5 A
59% a
9319 a
Moist: 21.8 ab
18% cde
7369 b
Flooded: 18 a
2% ef
4167 c
Initial rate higher
Cumulative N loss (% of total applied)
Days (after application)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16


NBPT-Urea (Dry-HR)
NBPT-Urea (Moist-HR)
NBPT-Urea (Flooded-HR)
Volatilization
NUE
Yield
Flooded: 18.6 b
2% f
4780 c
No benefit
Same as
untreated urea
Dry: 8 c
48% bc
9059 a
Some benefit
Moist: 6.3 c
34% d
8394 ab
Cumulative N loss (% of total applied)
Days (after application)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16

The Right Way to Grow Rice

Applying the *Right Source*
at the *Right Rate*
at the *Right Time*
and in the *Right Place*

Questions

- Thank you
  - James Leonards
  - Jacob Fluitt
  - Ron Regan