Commercial Fertilizer and Lime Management

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Why worry about fertility?

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Why worry about fertility?

Fertilizer Options?
Fertility Inputs for Forages

Manure

Legumes

Commercial Fertilizer

Bio-Solids

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Why worry about soil fertility?

Avoid negative environmental impacts of improper nutrient management

Save $. Most profitable use of resources

Comply with nutrient management regulations

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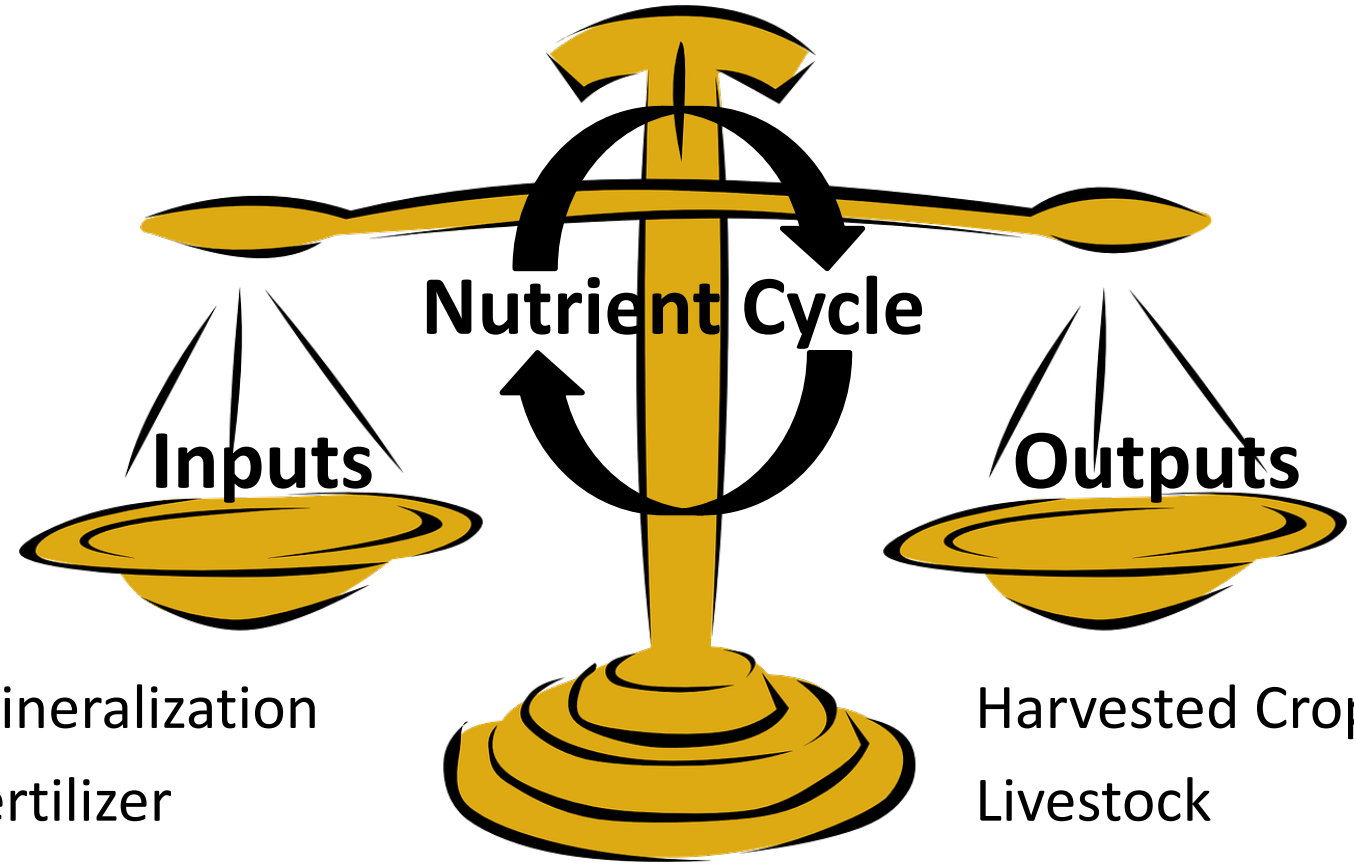
Crop Nutrient Cycle



Mineralization

Fertilizer

Manure

Feed/minerals

N-fixation by legumes

Harvested Crops

Livestock

Livestock products

Loss pathways (gas, runoff, leaching)

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Adequate Soil Fertility is Essential

Source: North Carolina Forage and Grasslands Council

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What is a fertilizer?

- a compound that contains at least 1 plant nutrient
  - ammonium nitrate (NH_4NO_3)
  - potassium nitrate (KNO_3)
- no fertilizer materials are 100% of any nutrient
  Other elements exist with the nutrient in the fertilizer compound
  - pure N is an inert gas
  - pure elemental P would ignite when exposed to the atmosphere
  - pure elemental K burns when it contacts water

Where do N, P and K in fertilizers originate?

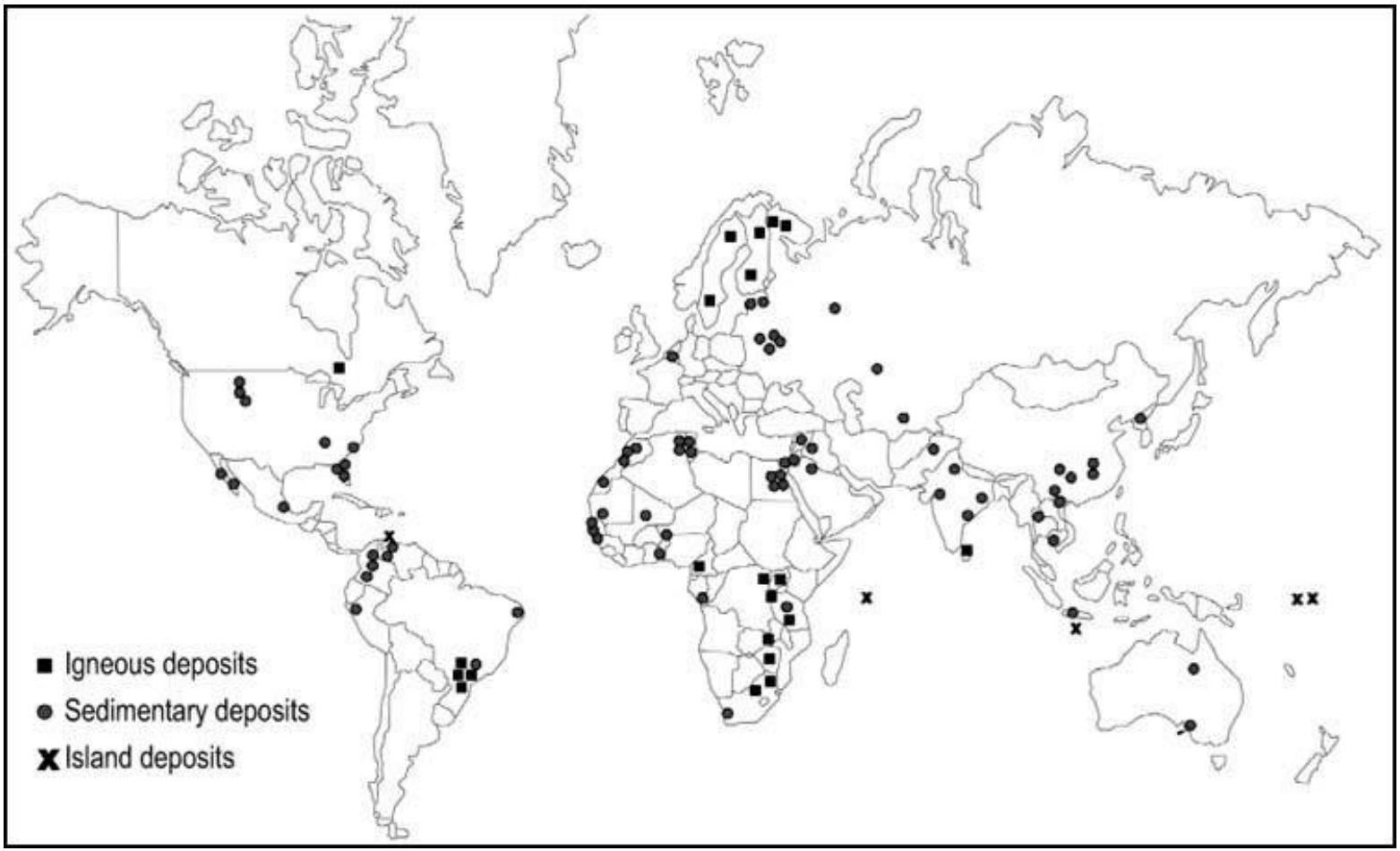
- N originates from the atmosphere
- P originates from rock phosphates
- K originates from K-bearing minerals, usually chlorides or sulfates

Nitrogen Fertilizer

Haber-Bosch Process

- Revolutionary impacts
  - food production
  - high pressure chemical engineering
  - warfare
- $N_2 + 3\ H_2 \rightarrow 2\ NH_3$
  - 750 – 900°F
  - 200 – 250 bars pressure
  - natural gas is source of hydrogen gas

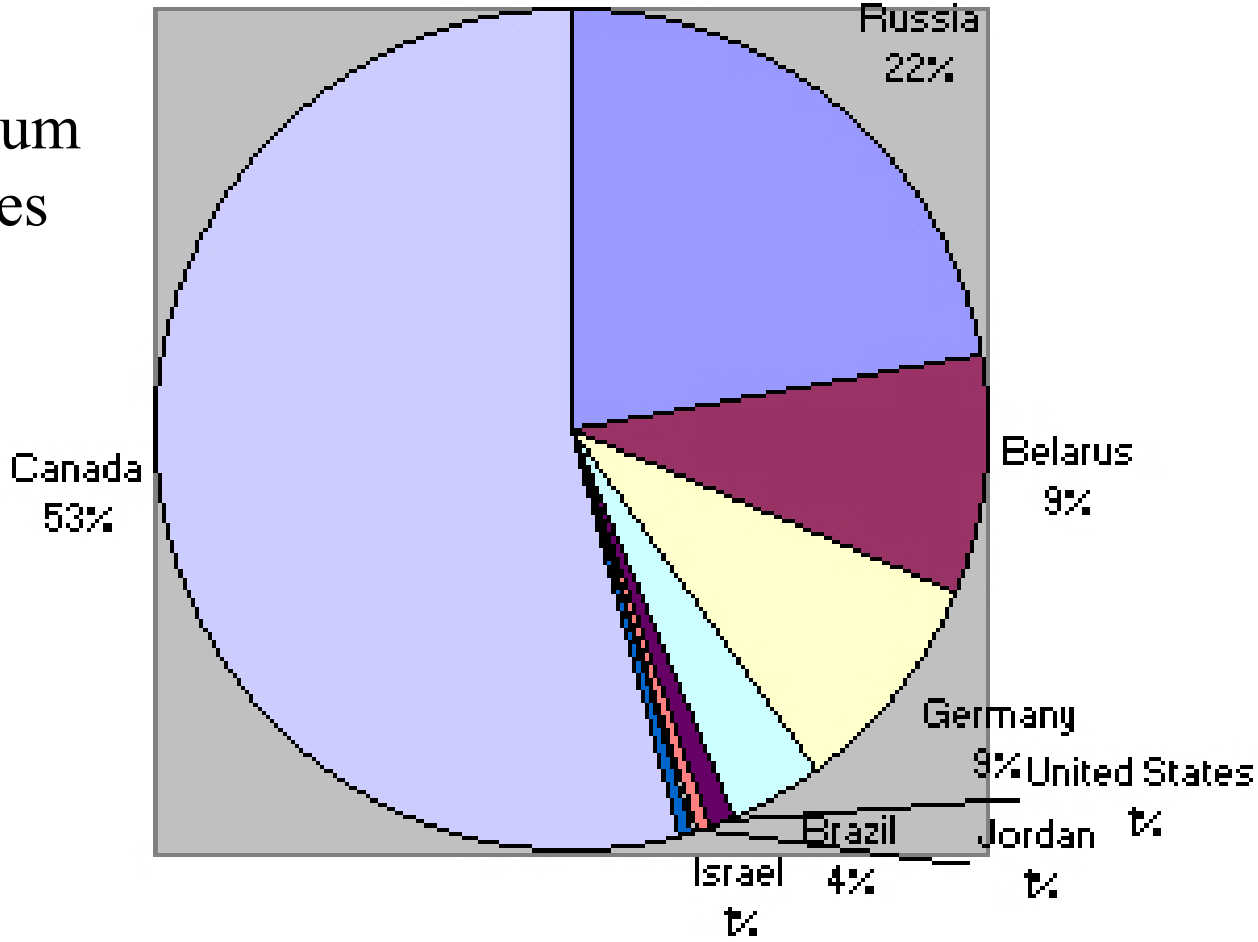
World P Deposits



Long-term Phosphorus Issue

- "We're running out!"
- US has reserves for 25 years
- Morocco has 75% of the world's reserves
  - geographical imbalance could pose a geostrategic ticking time bomb
  - Western Sahara is disputed territory (1975)
- US is importing P from Morocco
  - prolongs US reserves

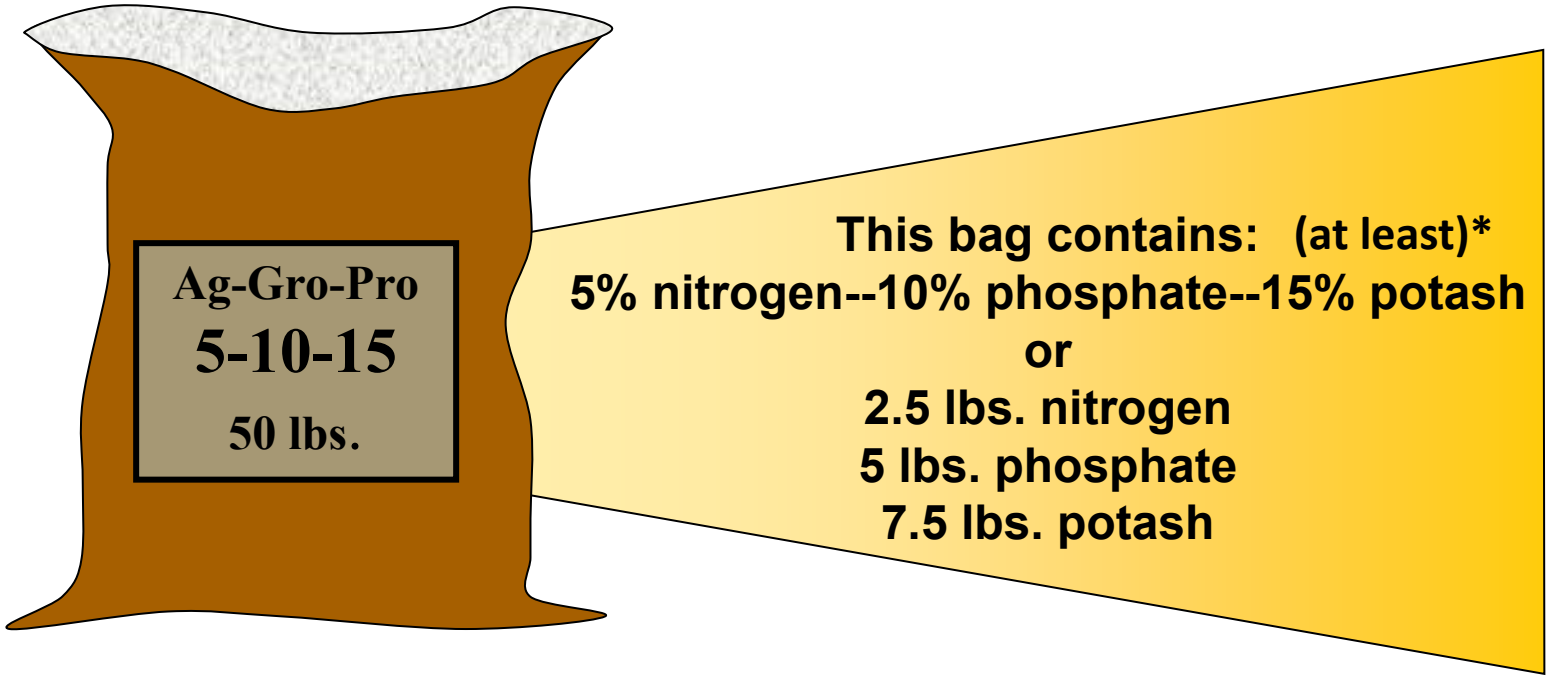
Potassium Reserves



Energy Inputs

- N – 45 GJ/ton (5% of the global consumption of natural gas)
- P – 20 GJ/ton
- K – 8 GJ/ton

How do we describe the nutrient content of fertilizers?



The fertilizer guarantee; at least..

- % nitrogen (total)
- % phosphate, P_2O_5 (citrate-soluble)
- % potash, K_20 (soluble)

$P_2O_5 \times 0.44 = P$ $\quad\quad$ $P \times 2.27 = P_2O_5$

$K_20 \times 0.83 = K$ $\quad\quad$ $K \times 1.20 = K_20$

A cow manure analysis tells you the %K is 0.5. What is the $\%K_2O$ content?

A. 0.22
B. 0.42
C. 0.60
D. 1.14

Sixty (60) pounds of P_2O_5 are equivalent to how many pounds of P?

A. 26.4

B. 49.8

C. 136.2

D. 72.0

Common N fertilizers

Material	Analysis
ammonia	82-0-0
ammonium nitrate	34-0-0
urea	46-0-0
ammonium sulfate	21-0-0
UAN (urea+ammonium nitrate)	28-0-0, 30-0-0 and 32-0-0

Less Common N Fertilizers

sulfur-coated urea (SCU)	40-0-0
ureaform	38-0-0
methylene urea	28-0-0
isobutylidene diurea (IBDU)	30-0-0

Is the efficiency of all N fertilizers the same?

- That depends!

- ammonium-bearing fertilizers or fertilizers that are converted to ammonium (urea)
- volatilization losses possible

Common P Fertilizers

Material	Analysis
superphosphate	0-18-0
triple superphosphate	0-46-0
monoammonium phosphate (MAP)	11-48-0
diammonium phosphate (DAP)	18-46-0
ammonium polyphosphate	10-34-0

Common K Fertilizers

Material	Analysis
muriate of potash	0-0-60
sulfate of potash	0-0-50
potassium-magnesium sulfate	0-0-22-22S-11Mg
potassium nitrate	13-0-44

Types of Fertilizer Materials

- **solid**
  - **granular** – materials are mixed in a liquid state and then dried to produce granules
  - **bulk blend** - produced by the mechanical mixing of granular fertilizers
- **fluid**
  - **solutions** (clear liquids)
  - **suspensions** (slurries)

Bulk-Blended Fertilizers

- small local units often serving a limited area
- 19-19-19 (380 lbs N, P_2O_5, K_20 per ton)
  - urea (502 lbs/ton)
  - DAP (826 lbs/ton)
  - muriate of potash (633 lbs/ton)
  - filler or make-weight material (39 lbs/ton)
- In blended, dry fertilizers, fillers are used to make mixtures which meet the fertilizer guarantee.

So, what's the rest of the stuff in the fertilizer bag?

What makes up the rest of the 100%?

Muriate of potash is actually potassium chloride (KCl). Pure potassium chloride is 52% K and 48% chlorine.

protein, fat, water
seasonings
oatmeal or
breadcrumbs

Is there filler?

KCl
muriate of
potash

Is there filler?

Some application terminology…

- broadcast
- top-dress
- side-dress
- starter
- pop-up
- fertigation
- incorporation
- injection

From Nutrient Recommendation to Product Application Rate

- What is the recommendation?
  - pounds nutrient per acre
- What is the preferred fertilizer product?
  - most economical; what's available
- What is the nutrient content in the preferred product?
  - refer to the label
- What rate of preferred fertilizer product should be applied to meet recommendation?

Calculating the Quantity of Commercial Fertilizer Required to Meet a Nutrient Recommendation

- recommendation in nutrient management plan
  - 90 lb/A of potash (K_20) on soybean field
- no P or N recommended
- preferred product - muriate of potash (0-0-60)
- How much muriate of potash per acre should be applied?

Calculating Quantity of Fertilizer to Meet a Nutrient Recommendation

recommended quantity of nutrient	90 lb/acre
% nutrient in preferred product	60%
nutrient content in preferred product (decimal fraction)	0.60
quantity of preferred product required	90/0.60 = 150

A producer want to apply 60 lbs N/acre to his orchardgrass pasture. If he uses ammonium sulfate (21-0-0), how much material should be applied per acre?

A. 60
B. 200
C. 285
D. 350

A producer wants to apply 60 lbs N/acre to his orchardgrass pasture. Create a blend using ammonium sulfate (21-0-0-24S) to apply 20 pounds of S and use urea (46-0-0) to supply the remaining N.

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Step 1- Solve for the preferred nutrient source

recommended quantity of nutrient (S)	20 lb/acre
% nutrient in preferred product	21%
nutrient content in preferred product (S) (decimal fraction)	0.21
quantity of preferred product (S) required	20/0.24 = 83 lbs. am sulfate
quantity of secondary nutrient (N) supplied	83*.21=17.5 N

A producer wants to apply 60 lbs N/acre to his orchardgrass pasture. Create a blend using ammonium sulfate (21-0-0-24S) to apply 20 pounds of S and use urea (46-0-0) to supply the remaining N.

Step 2- Solve for the secondary nutrient source

recommended quantity of nutrient (N)	60 lb/acre
quantity of (N) supplied from 83 lbs Amm. Sulfate	17.5
quantity of nutrient (N) needed from Urea	60-17.5=42.5
% nutrient in preferred product	46%
nutrient content in urea (decimal fraction)	0.46
quantity of urea required	42.5/0.46 = 92 lbs.

Enhanced Efficiency Fertilizers

21st Century Products

- designed to increase the quantity of nutrient actually taken up by crop (nutrient use efficiency or NUE)
- various mechanisms
  - addition of nitrification inhibitors (kill the nitrifiers temporarily)
  - addition of urease inhibitors (immobilize the enzymes)
  - chemically shield the fertilizer granule
    - protect nutrients from immobilizing ions in soil solution
  - enveloped by a semi-permeable membrane that slows down movement of nutrient into soil
    - improves synchrony of nutrient release with crop uptake

Nitrification Inhibitors

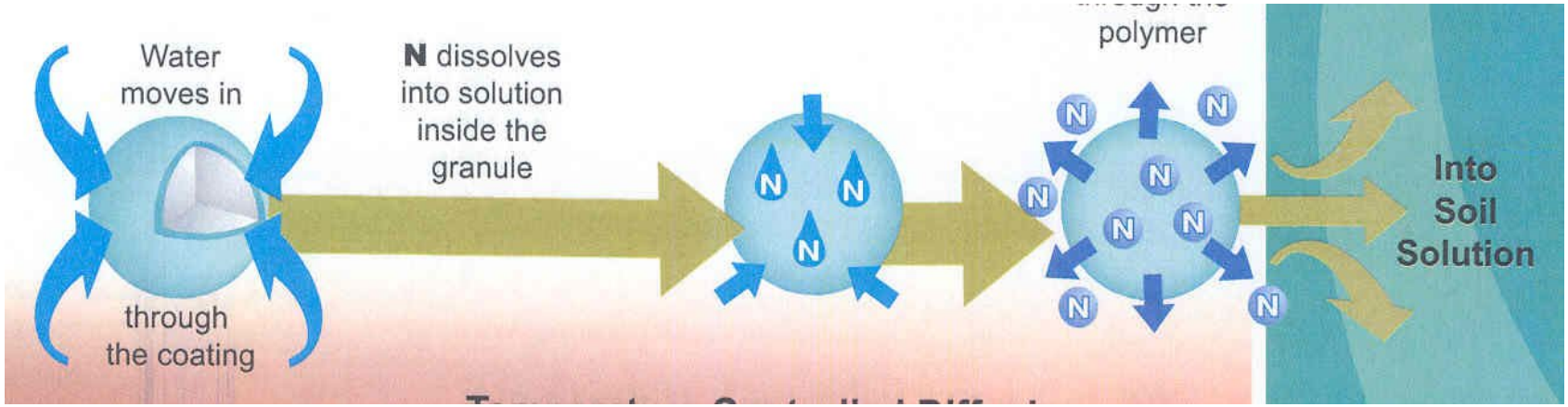
- $NH_4^+ \not\rightarrow NO_2^-$
  - fertilizer additives
  - bactericides that kills targeted organisms, *Nitrosomonas*
    - for example, nitrapyrin
  - organic compound that itself is subject to microbial attack

Urease Inhibitors

- urea $\xrightarrow{\text{urease}}$ ammonia + carbon dioxide
- urease inhibitors (UIs) temporarily block the action of urease
- may block urea conversion until rain moves urea into the soil
- not effective all years - depends upon weather
- never effective in conventional till or when urea is banded

Envelop in a Semi-permeable Membrane

- coat with a semi-permeable membrane
  - water must diffuse, dissolve urea, which diffuses out
  - ESN®, Environmentally Smart Nitrogen, a polymer-coated urea
  - diffusion of urea is temperature controlled



http://www.agrium.com/uploads/How_Technology_Works.pdf

Chemically Shield Granules

- protect phosphorus with a chemical shield
  - AVAIL® - "enhance P availability"
  - coated with a chemically-reactive material
  - protects P from reacting with Fe, Al or Ca in the soil solution
- Question?
  - Under what circumstances might it be useful?

Keys to Improving NUE
"The 4 Rs"

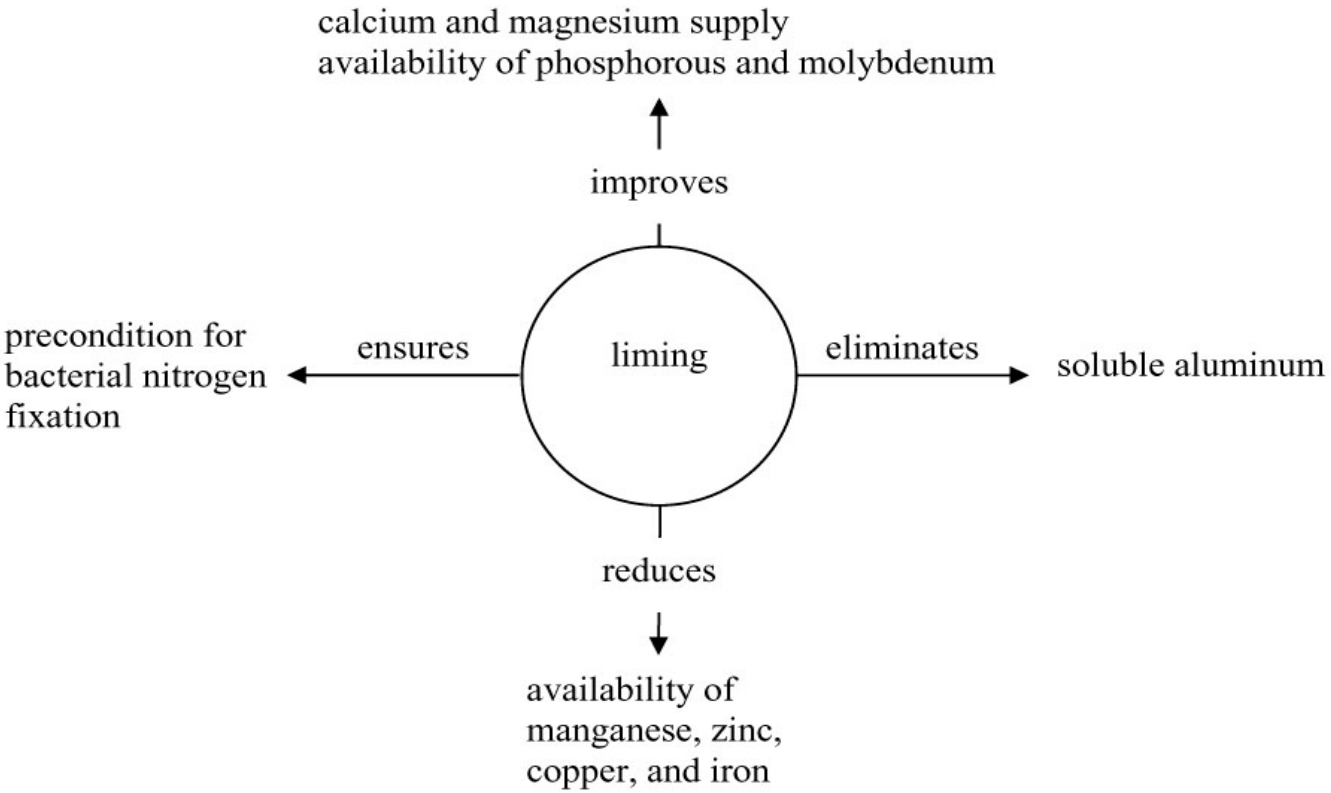
- right rate
- right source
- right time
- right place

IPNI (formerly PPI)

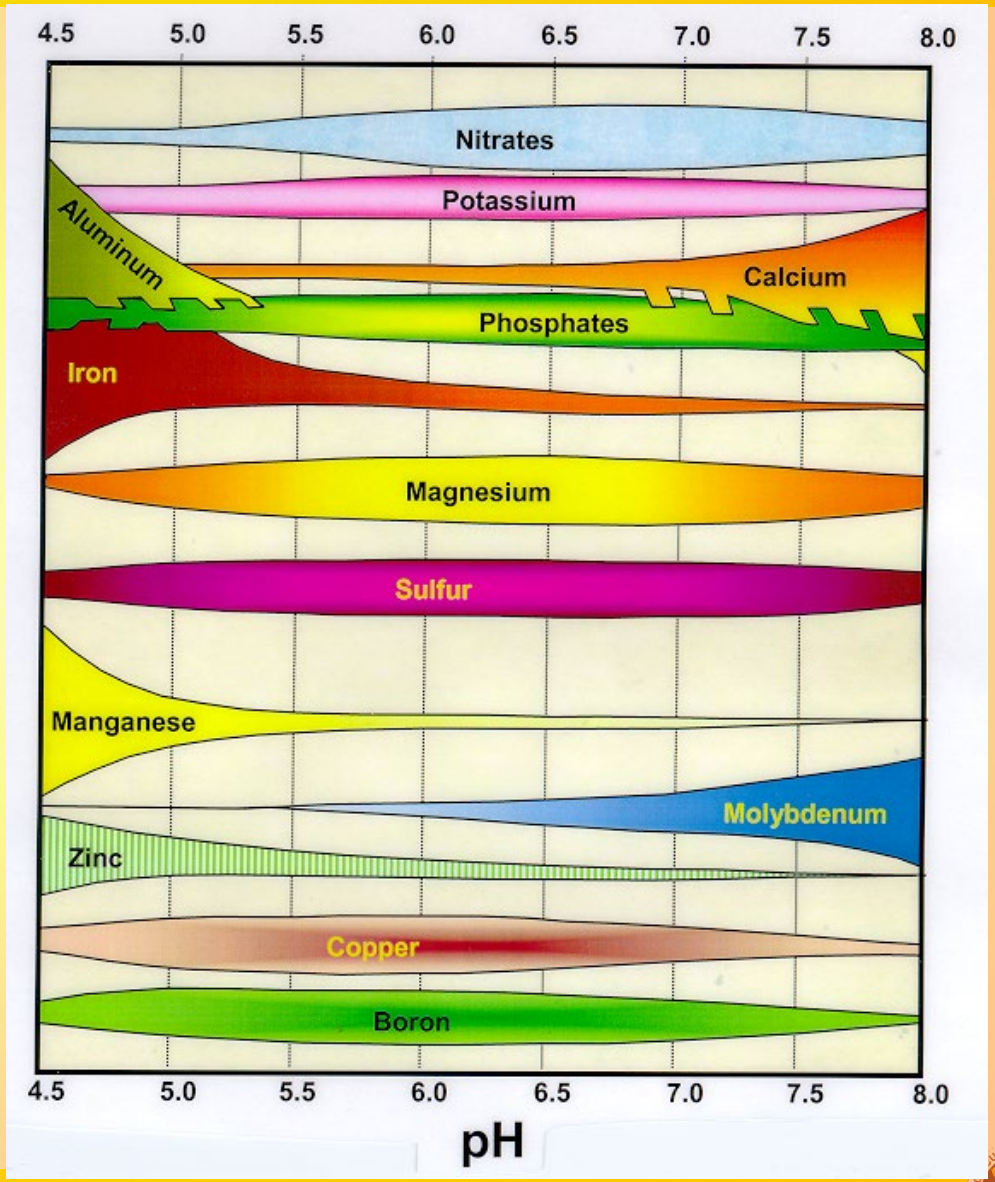
What are Soil Amendments or Conditioners?

- Definition: materials with no nutrient claim but which enhance plant growth or improve the physical or chemical conditions of a soil
- If they contain nutrients, must be integrated into NM plan
- Examples: chicken processing waste, vegetable processing waste, whey, etc.

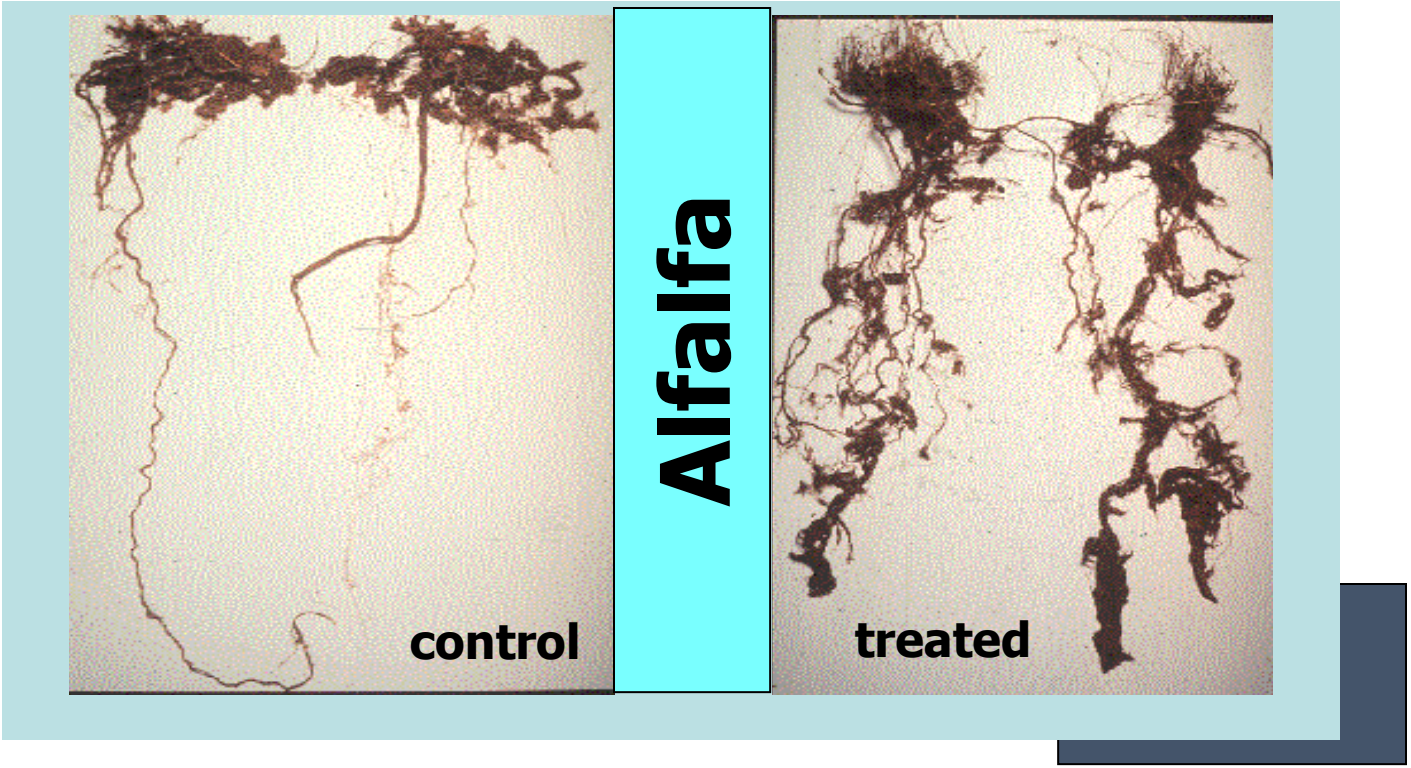
Why Liming to Reduce Soil Acidity is Helpful…



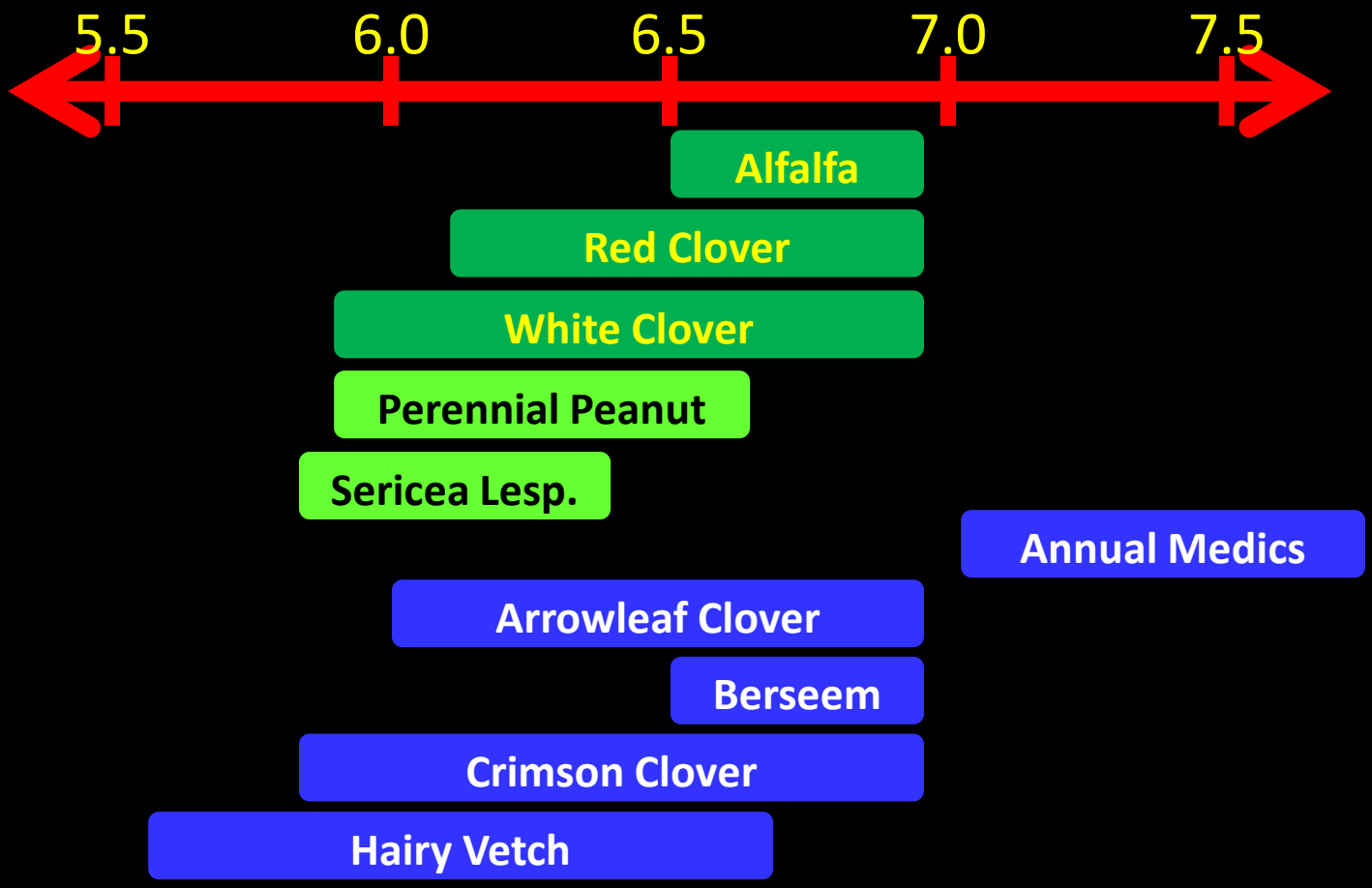
Effect of soil pH on plant nutrient availability



Aluminum Toxicity – Low Soil pH



Legumes and Their Optimum Soil pH



Soil pH and Root Growth

- Acidic conditions also reduce root growth and development
- Not as able to extract nutrients and water from soil
- Less mineralization of organic nitrogen
- Less nitrogen fixation

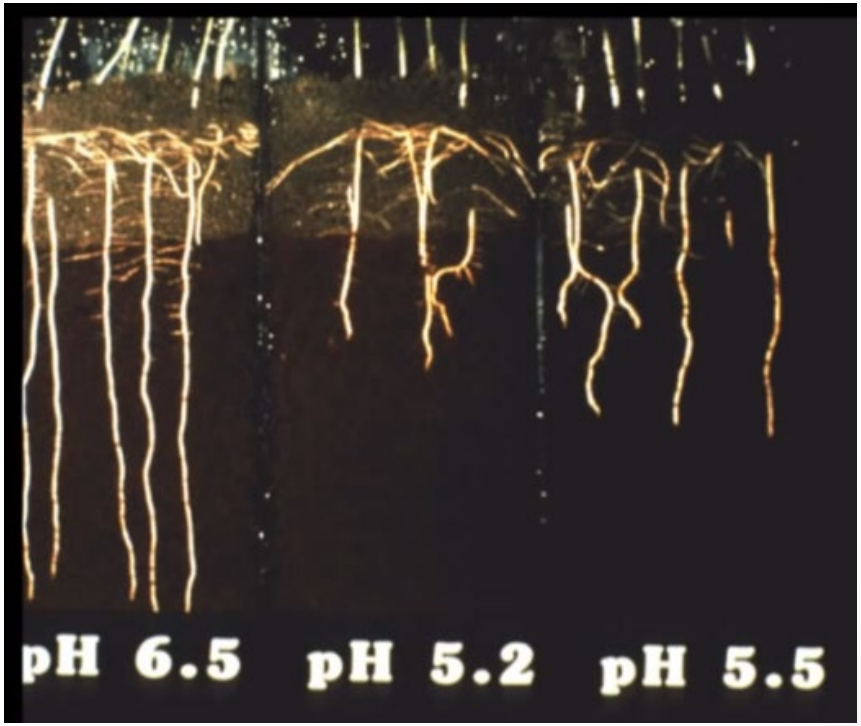


Image: Hancock, UGA

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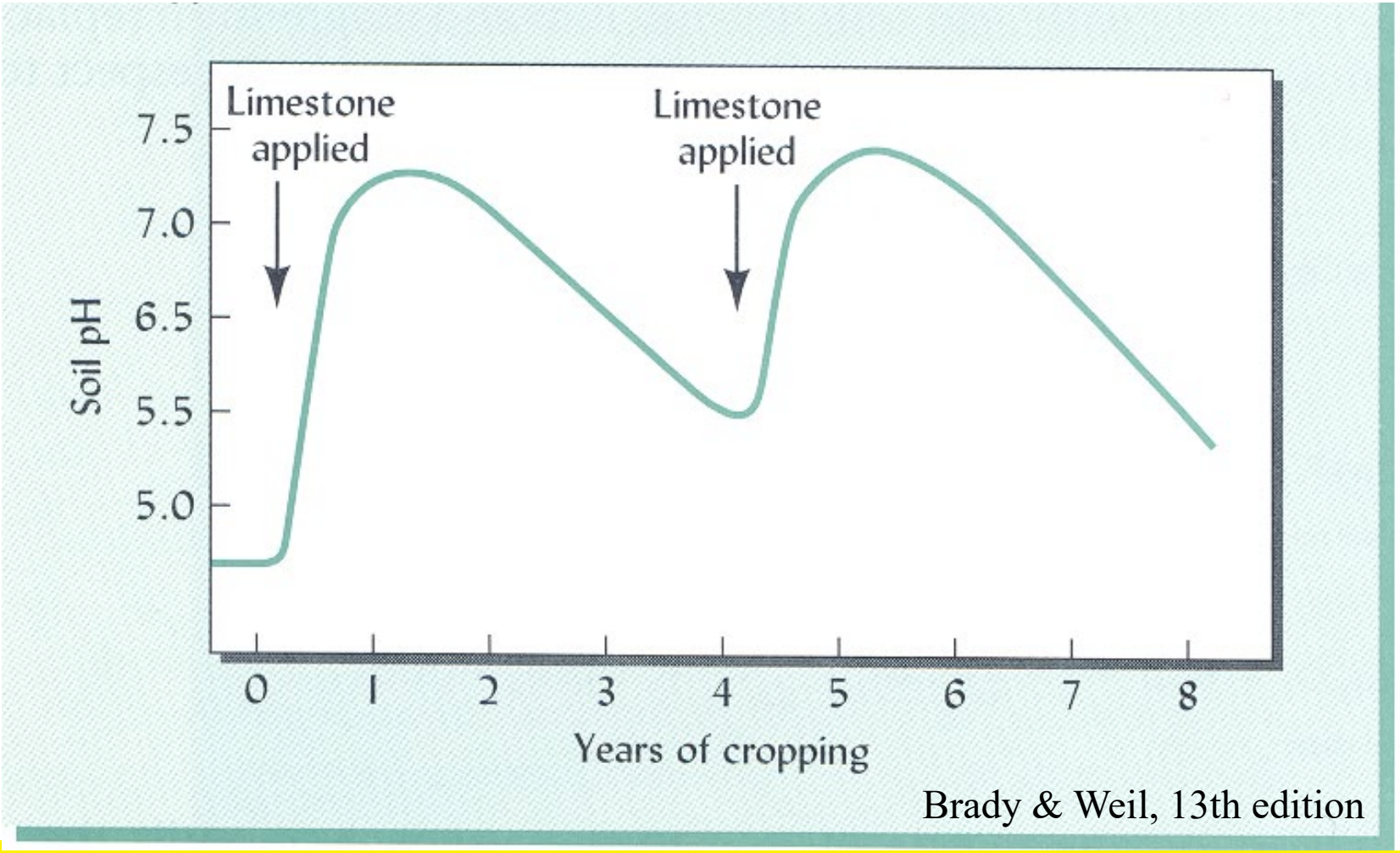
Effect of Ammonium Fertilizers on pH:

$NH_4^+ + 2O_2$ ------ $2H^+ + NO_3^- + H_2O$

Nitrogen source	*Composition*	*Lime required (lb $CaCO_3$ / lb N)*
Anhydrous ammonia	82-0-0	1.8
Urea	46-0-0	1.8
Ammonium nitrate	34-0-0	1.8
Ammonium sulfate	21-0-0-24	5.4
Monoammonium phosphate	10-52-0	5.4
Diammonium phosphate	18-46-0	3.6
Triple super phosphate	0-46-0	0.0

Adapted from Havlin et al., 1999.

How often is lime required?



Brady & Weil, 13th edition

Adjusting Soil pH

- Lime materials are used to neutralize acidity and raise pH.
- Acid-forming materials are used to produce acidity and decrease pH.
  - elemental sulfur, iron sulfate, aluminum sulfate

Is lime required?

- Depends upon
  - –crop and its optimal pH range
  - –pH of the soil solution (active acidity)

How much lime is required?

- Depends upon
  - target pH of crop
  - pH of soil solution
  - reserve acidity

- "lime requirement" (LR) is a process or chemical test which estimates the amount of pure, fine limestone needed

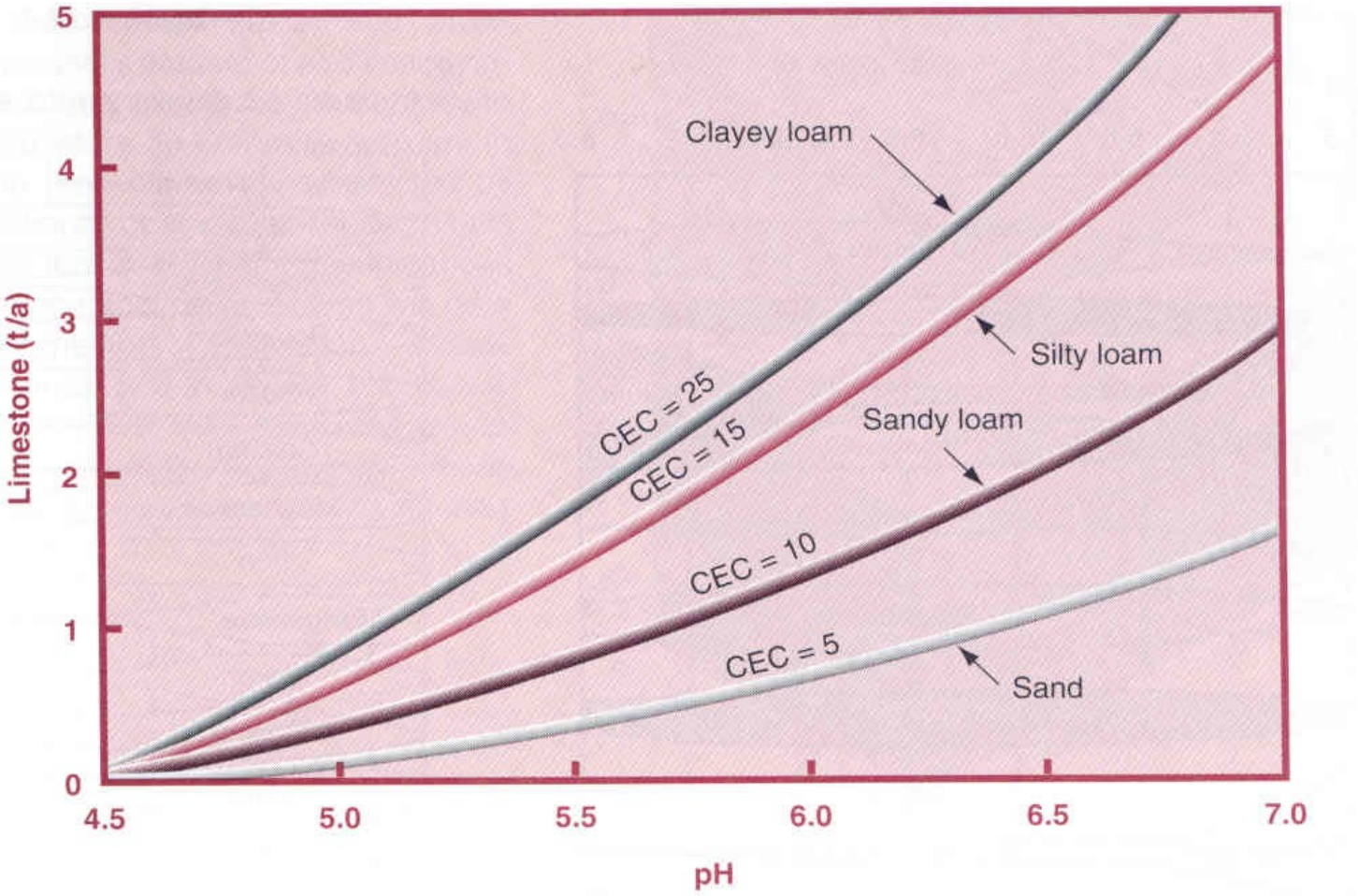
UME Process for LR

- pH
- target pH of crop
- estimate of reserve acidity
  - soil texture (range of clay contents)
  - physiographic province (info about the kind of clay)

Soil Tests for LR: Soil-Buffer Equilibrations

- mix soil and a carefully-designed buffer solution
- equilibrate (15 – 30 min.)
- measure pH of soil-buffer mixture
- the more the soil lowered the pH of the buffer mixture, the greater the lime requirement

Texture and Lime Requirement



When should lime be applied?

- 2-6 months before most sensitive crop, but…

…application simultaneous to planting will work

lime rate (tons/A)	alfalfa yield (pounds/A)
0	303
1	1,229
3	1,817
6	2,262

(Alley, Va Tech)

Liming Materials

Common Names	Chemical Name	Chemical Formula	CCE
Limestone Calcite Hi-cal lime	Calcium Carbonate	$CaCO_3$	100%
Burned lime Unslacked lime Quick lime	Calcium Oxide	CaO	179%
Slaked lime Hydrated lime Builders' lime	Calcium Hydroxide	$Ca(OH)_2$	136%
Dolomitic lime Dolomite Hi-mag lime	Calcium Magnesium Carbonate	$CaMgCO_3$	109%
Marl	Calcium Carbonate	CaCO3	40-90%

What part of the liming materials is responsible for increasing pH?

While most liming materials are Ca-based its not the calcium that raises the pH.

Rather it's the CO_3^{2-} that comes with the Ca which raises the pH:

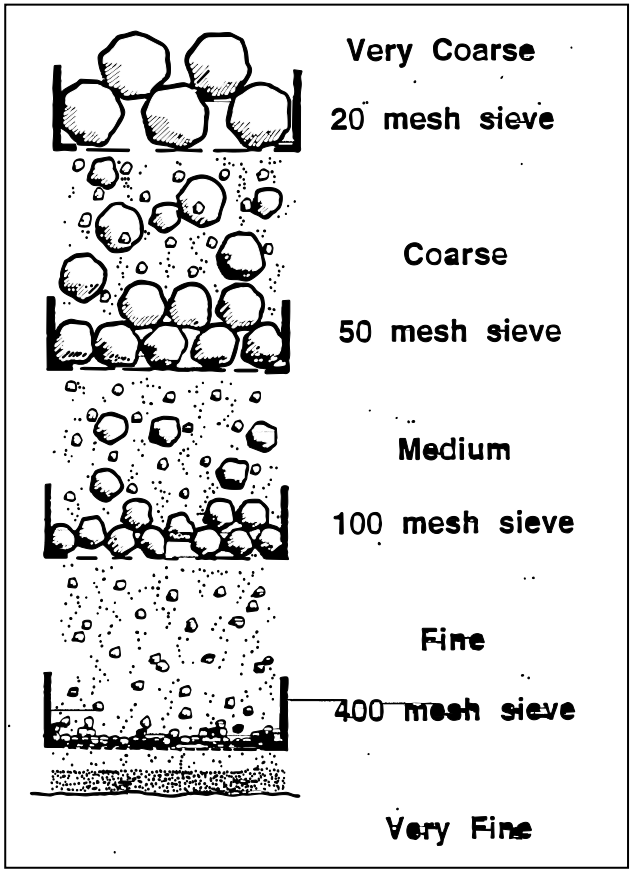
1) 'Hydrolysis' by CO_3^{2-}

$$CO_3^{2-} + H_2O \rightarrow HCO_3^- + OH^-$$

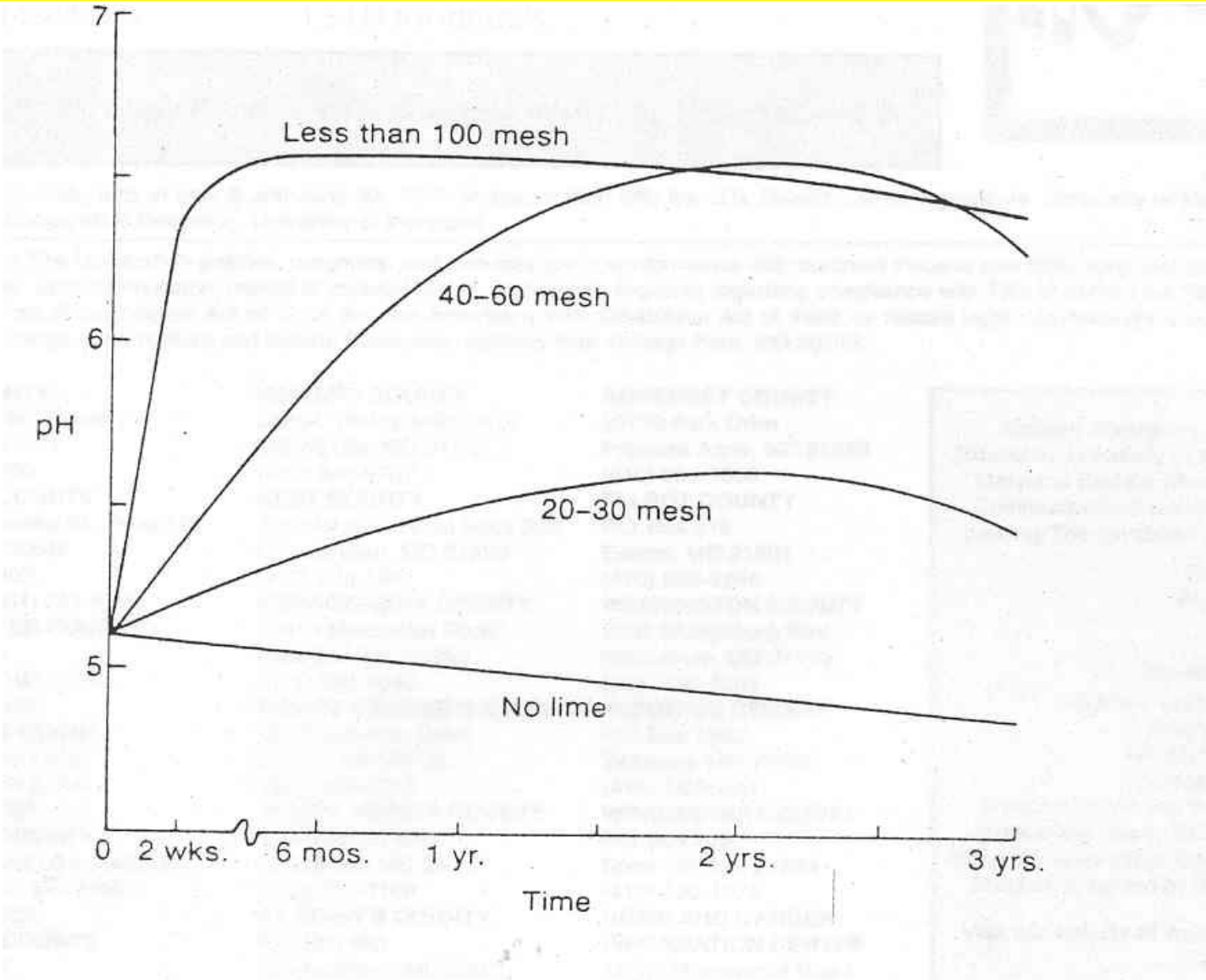
2) The released OH- removes a H+

$$OH^- + H^+ \rightarrow H_2O$$

Particle Size is Also Important and Regulated



Maryland's lime law requires labeling % passing 20, 60 and 100 mesh screens


7
6
5
pH
Less than 100 mesh
40–60 mesh
20–30 mesh
No lime
0
2 wks.
6 mos.
1 yr.
2 yrs.
3 yrs.
Time

Exercise #1: **Using lime A with a recommended application rate of 2,000 lbs. lime/acre, what is the adjusted application rate after correction for particle size analysis?**

Sieve Analysis or Mesh Size Analysis

95% passes through 8-mesh sieve
81% passes through 60-mesh sieve

Fineness Factor

Percent retained by 8-mesh sieve: 100% - 95% = 5%
Percent retained by 60-mesh sieve: 95% - 81% = 14%
Percent passing through 60-mesh sieve: 100%-5% - 14% = 81%

5% retained by 8-mesh X 0% effectiveness =0%
14% retained by 60-mesh X 50% effectiveness =7%
81 passes through 60-mesh X 100% effectiveness =81%

Fineness Factor = 0% + 7% + 81% = 88%

Corrected Application Rate

2,000 pounds lime #1/acre X 100 = 2,272 pounds lime #1 per acre
88% fineness factor

Exercise #2 **Calculate the EFFECTIVE NEUTRALIZING VALUE (ENV) of an ag lime with the following characteristics:**

CCE = 90% * 98% passes 8-mesh sieve, 76 passes 60-mesh sieve

Fineness Factor

Percent retained by 8-mesh sieve: 100% - 98% = 2%
Percent retained by 60-mesh sieve: 98% - 76% = 22%
Percent passing through 60-mesh sieve: 100% - 2% - 22% = 76%

2% retained by 8-mesh X 0% effectiveness =0%
22% retained by 60-mesh X 50% effectiveness =11%
76 passes through 60-mesh X 100% effectiveness =76%

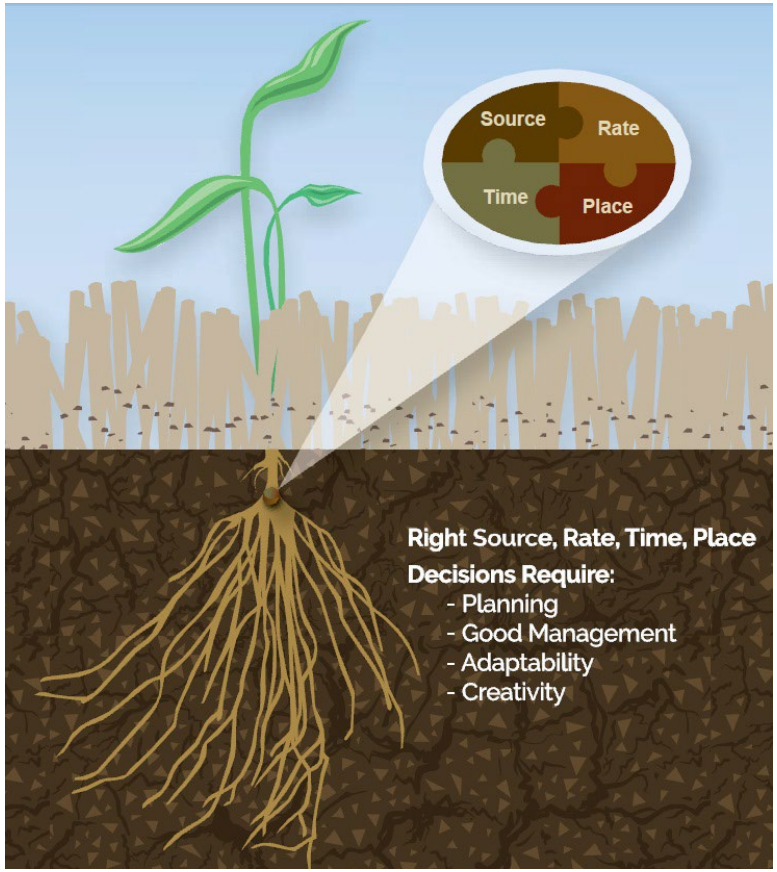
Fineness Factor = 0% + 11% + 76% = 87%

Effective Neutralizing Value (ENV) = CCE x Fineness Factor
ENV = 90% X 87% = 78.3%

Application rate corrected for ENV:

$$\frac{\text{2,000 lbs./a lime rate}}{\text{78.3\% ENV}} \times 100 = \text{2,554 lbs./a lime rate}$$

Questions?


Source
Rate
Time
Place
Right Source, Rate, Time, Place
Decisions Require:
- Planning
- Good Management
- Adaptability
- Creativity