Maximizing Crop Yield: Interpreting Soil Analysis and Understanding Fertility Management in Varying Production Systems

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Proper Fertility Programs

- Fertility Management
  1. Soil Sampling
  2. Soil Analysis
  3. Soil Test Interpretation
  4. Recommendations
  5. Application

Proper Fertility Programs

- Fertility Management
  1. Soil Sampling
  2. Soil Analysis
  3. **Soil Test Interpretation**
  4. Recommendations
  5. **Application**

Soil Test pH

Soil Test pH

- pH – negative (-) log of the concentration of hydrogen ions (H^+)
  - $pH = -\log(10^{-7}) = 7$

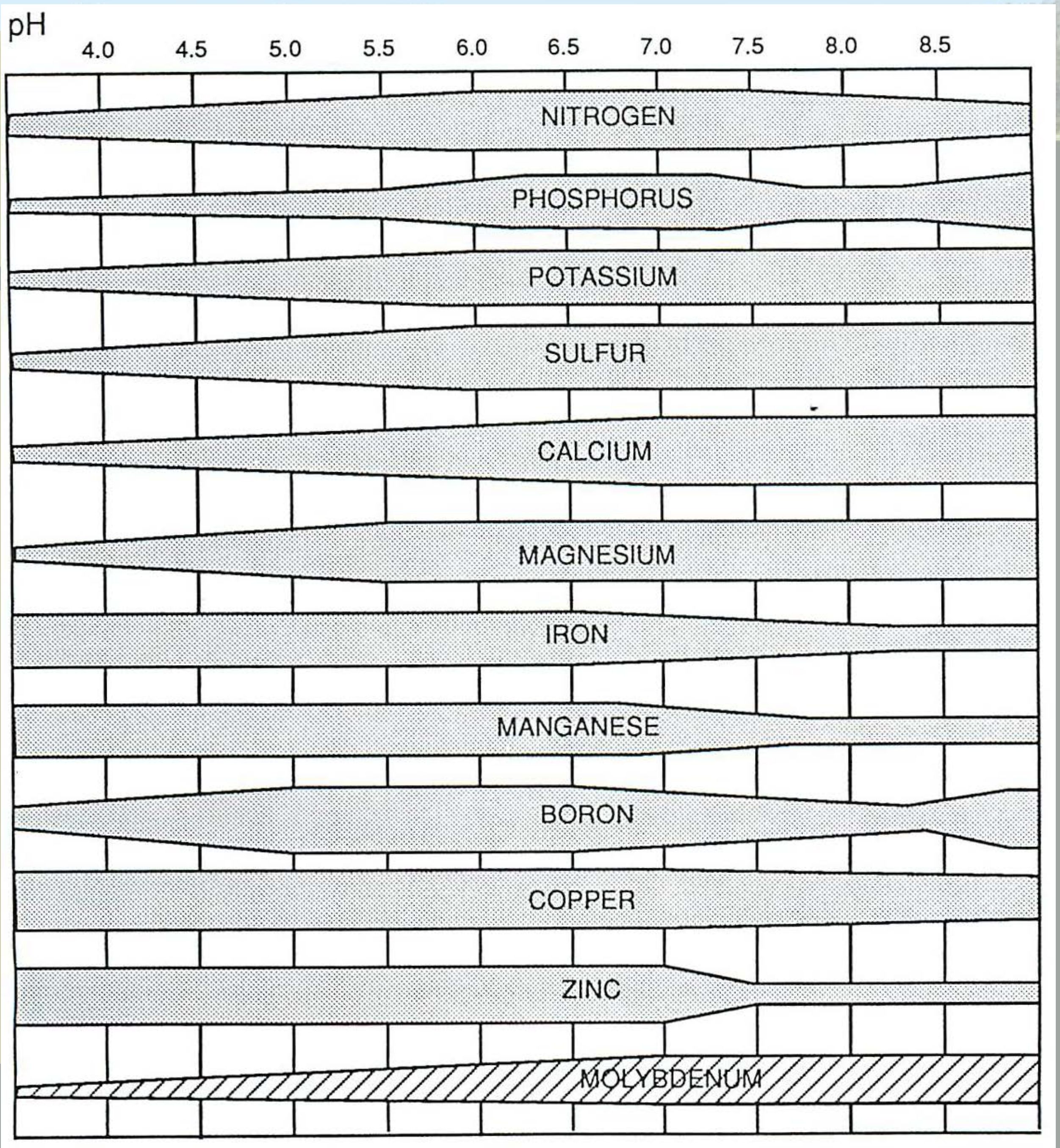
- More H^+ = lower pH (This is why NH_4^+ lowers the pH when reduced to NO_3^-)
- Less H^+ = higher pH

- Suitable pH for most crops typically range from 6 - 7.5.

Soil Test pH

- NH_4^+ volatilization losses increase with increased pH

- Phosphorus
  - pH < 5.5 – $H_2PO_4^-$ forms less soluble compounds with iron (Fe) and aluminum (Al)
  - pH >7.5 – HPO_4^{2-} forms less soluble compounds with calcium (Ca) and magnesium (Mg)

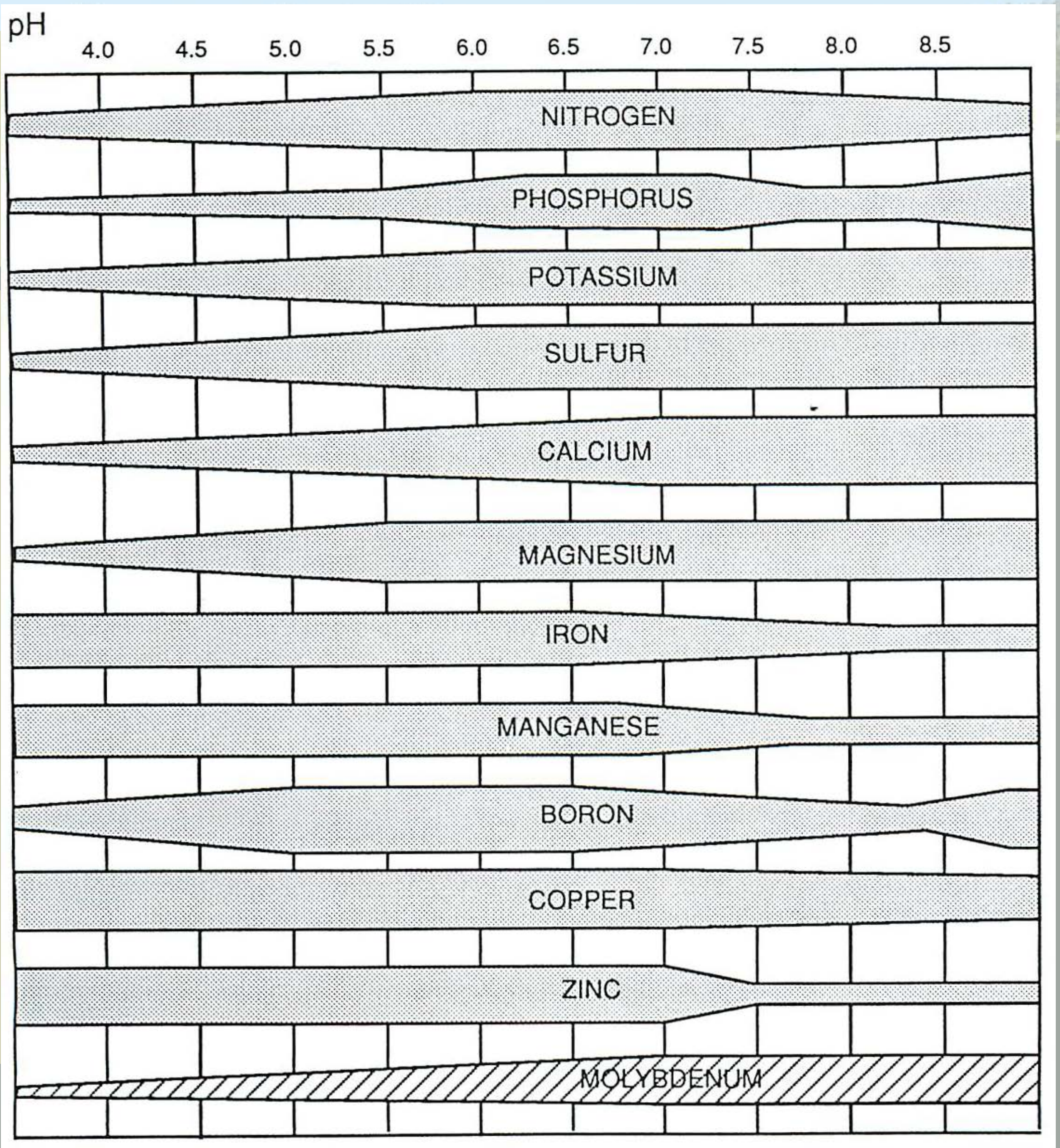


Soil Test pH

- Molybdenum – Required for nitrogen fixation and becomes increasingly unavailable at pH<6.2

- Iron – Fe^{3+} ions react within hours to become unavailable at pH>7.5

- Toxicity
  - Manganese at pH<5.2
  - Aluminum at pH<5.0



Soil Test pH – Liming Considerations

- Lime quality
  - Calcium Carbonate Equivalent (CCE)
  - Fineness Factor
  - **Effective Calcium Carbonate**

Calcium Carbonate Equivalent		
Lime Material	**Chemical Composition**	**CCE (%)**
Calcium Carbonate	$CaCO_3$ (pure)	reference
Calcitic Lime (Ag Lime)	$CaCO_3$	80-100
Dolomitic Lime	$CaMg(CO_3)_2$	95-100

Fineness Factor	
Particle Size	**Availability**
> 8 mesh	0.0%
8 – 60 mesh	0.5%
< 60 mesh	1.0%

Soil Test pH – Liming Considerations

- For best results lime should be incorporated to improve distribution and soil-lime contact

- No-Till Lime Applications (Beegle, 1998)
  - Lime applied 3 year intervals at 3 tons A^{-1}
  - Only 0-2” sample was affected with 1 application
  - 4 applications (12 years) was needed to increase pH to adequate levels at 4-6”.
  - **Fix pH issues before committing to no-till systems**

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Soil Test Availability: P & K

Soil Test Availability Rating

Rating	Expected Yield Potential	Fertilization
Very Low	<50%	Plant response expected
Low	50-75%	Plant response expected
Medium	75-95%	Plant response expected
High	100%	Fertilization may be needed to maintain “high” rating
Very High	100%	No fertilization needed

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Phosphorus

- Soybean requirements
  - Removal – 0.8 lb P_2O_5 bu^{-1} A^{-1}
  - Total Uptake – 1.2 lb P_2O_5 bu^{-1} A^{-1}

- Crop Deficiencies
  - Symptoms occur in old growth
  - Leaves are dark green or purple color with leaf cupping
  - Typically delays bloom and maturity
  - Especially noticeable with cool, wet soils

Phosphorus

- $H_2PO_4^-$ is the predominant ion available to plants in acid soils
  - pH < 5.5 - forms less soluble compounds with iron and aluminum
- HPO_4^{2-} is the predominant ion available in soils at pH > 7
  - pH > 7.5 - forms less soluble compounds with calcium and magnesium

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Phosphorus Retention

- Factors affecting P retention
  - pH – forms less soluble compounds at both low and high pH with iron and aluminum or calcium and magnesium, respectively
  - Soil texture – retention most often occurs in clay fraction of soils; precipitation of Fe and Al oxides
  - Time – initial fast reaction; one hour after water-soluble P is added, a weak acid cannot extract most of the P, one year later this amount is even less

Phosphorus

- No-Till
  - Broadcast applications will often only increase soil test level P in surface 1” and increase the proportion bound in less soluble compounds
  - Can be banded with small amounts of NH^{4+} or sulfur to slightly reduce the pH in the immediate area to improve availability

Potassium

- Soybean requirements
  - Removal – 1.4 lb K_2O bu^{-1} A^{-1}
  - Total Uptake – 4 lb K_2O bu^{-1} A^{-1}
- Soybean Deficiencies
  - Symptoms occur in old growth
  - Interveinal chlorosis and along leaf margins
  - May occur under waterlogged soils, dry soils, or during peak seed fill when K use is maximized late in the season

Photo Credit: University of Missouri Extension

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Potassium

- Fall vs Spring Applications
  - Fall applications should be avoided in coarse-textured soils, especially those with Cation Exchange Capacity (CEC) < 6 meq/100grams
- No-Till – Surface applications are effective with little to no incorporation

Depth (inches)	No-Till	Moldboard Plow
	---------- ppm K ----------	
0-2	170 (47%)	132 (39%)
2-6	104 (29%)	113 (33%)
6-12	86 (24%)	95 (28%)
Blevins et al., 1986		

Soybean Uptake and Removal

Yield Level	Phosphorus (P)		Potassium (K)	
	Uptake	Removal	Uptake	Removal
40	48	32	160	56
60	72	48	240	84
80	96	64	320	112

Nutrient Removal - Scenario

- Corn and Soybean rotation (1:1) – 7 years

Corn (160 bu A^{-1})		Soybean (60 bu A^{-1})	
P_2O_5 Removal	K_2O Removal	P_2O_5 Removal	K_2O Removal
211 lb A^{-1}	139 lb A^{-1}	144 lb A^{-1}	252 lb A^{-1}
Total Removal			
P_2O_5		K_2O	
355 lb A^{-1}		391 lb A^{-1}	
Soil Test ppm Reduction			
P_2O_5		K_2O	
13 – 30 ppm		25 – 49 ppm	

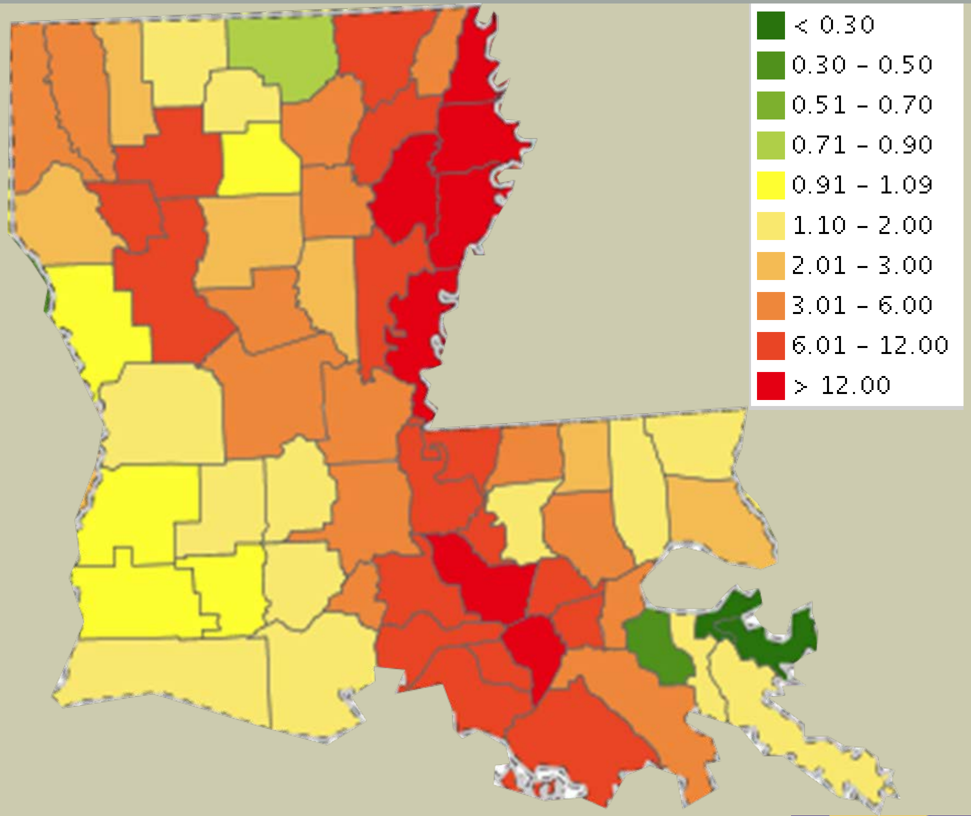
Nutrient Removal - Soil Test Range

- P_2O_5
  - 12 – 28 lb to raise soil test levels 1ppm
- K_2O
  - 8 – 16 lb to raise soil test levels 1ppm

Soil Test P ratings (Mehlic 3) (ppm/recommendation P_2O_5 lb A^{-1})				
	VL	L	M	H
	0-10/80	10-20/60	20-35/30	>35/0
Soil Test K ratings (Mehlic 3) (ppm/recommendation K_2O lb A^{-1})				
	VL	L	M	H
Clay-Loam	0-159/80	159-227/60	227-341/30	341-364/0
Silt-Loam	0-91/80	91-136/60	136-182/30	182-205/0

Nutrient Removal

- Less than 30% of LA soybean acres received K or P in 2015.
- Top 15 soybean parishes (2012)
  - K - Removal:Replacement = 6:1
  - Net Balance = -54 lb K_2O A^{-1}



Adapted from: *nugis.ipni.net*

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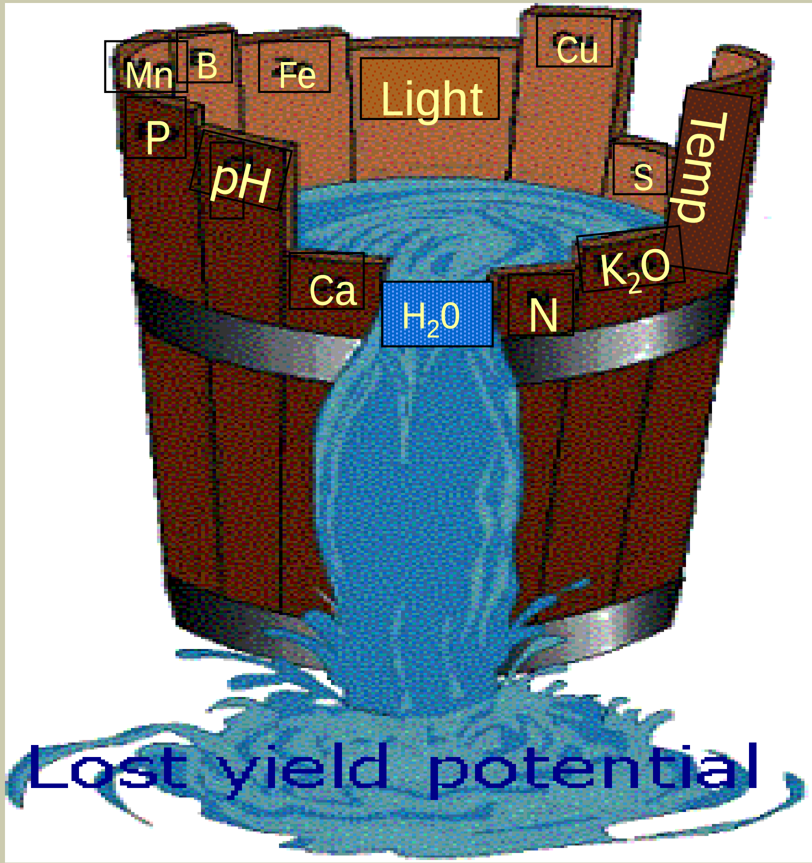

Our goal is to ensure that the most limiting factor is one out of our control.

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