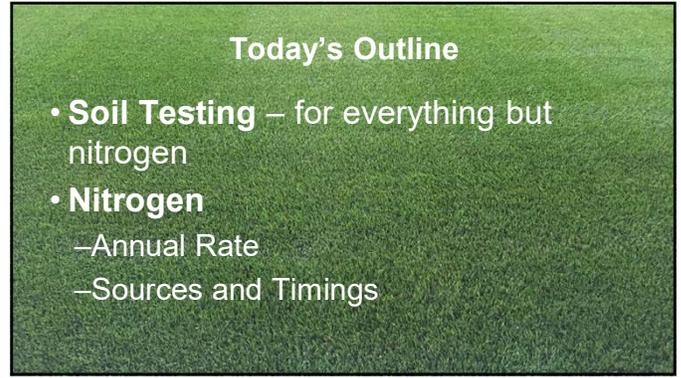




# Fundamentals of Optimized Turf Fertilization

Doug Soldat  
University of Wisconsin-Madison  
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## Today's Outline

- **Soil Testing** – for everything but nitrogen
- **Nitrogen**
  - Annual Rate
  - Sources and Timings

2



## Principles of Soil Testing

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### O.J. Noer (1890-1966)

- Born in 1890 to Norwegian immigrants in Stoughton, WI.
- Captain in Chemical Warfare in WWI
- Wisconsin State Soil Chemist
- World Class Turfgrass Scientist and Agronomist for Milorganite (1924-1960)



"There is a tendency to place undue emphasis upon the value of chemical soil tests.

This is true of some technical workers as well as salesmen.

These methods have a promising future but their present usefulness is limited by imperfect [methods] and for a lack of definite correlation with field experience"

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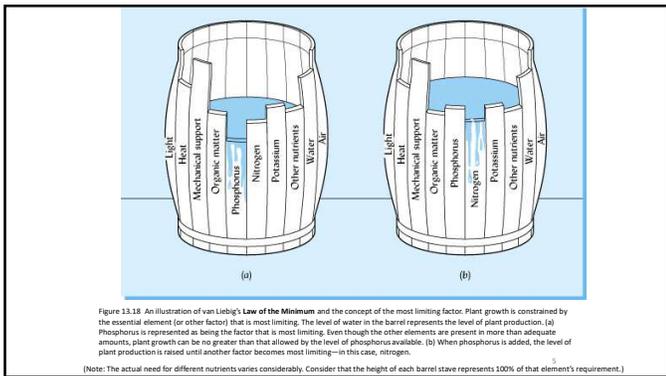


Figure 13.18 An illustration of van Liebig's Law of the Minimum and the concept of the most limiting factor. Plant growth is constrained by the essential element (or other factor) that is most limiting. The level of water in the barrel represents the level of plant production. (a) Phosphorus is represented as being the factor that is most limiting. Even though the other elements are present in more than adequate amounts, plant growth can be no greater than that allowed by the level of phosphorus available. (b) When phosphorus is added, the level of plant production is raised until another factor becomes most limiting—in this case, nitrogen.

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## Important Results

Organic Matter

Soil pH

Plant available P

Plant available K

If pH is ok, then Ca and Mg will be ok

In this area, sufficient sulfur comes from the atmosphere



SOIL TEST REPORT																																																																			
REPORTED TO:				SAMPLE INFORMATION:				ANALYSIS RESULTS																																																											
PAUL SMITH 1202 RANDOM STREET JONES, IN 46421				Report Number: F 990710-0000 Report Date: 03/29/99 Lab Number: 90586 Sample ID: 11 To Be Gross: Fowers				<table border="1"> <thead> <tr> <th>SOIL TESTS</th> <th>AMOUNT FOUND</th> <th>Very Low</th> <th>Low</th> <th>Medium</th> <th>High</th> <th>Very High</th> </tr> </thead> <tbody> <tr> <td>Organic Matter, %</td> <td>9.3</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Phosphorus, ppm P</td> <td>63</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Potassium, ppm K</td> <td>164</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Electronium, ppm Mg</td> <td>605</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Calcium, ppm Ca</td> <td>3550</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Carbon Exchange Capacity, meq/100g</td> <td>24.9</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>pH</td> <td>7.4</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>				SOIL TESTS	AMOUNT FOUND	Very Low	Low	Medium	High	Very High	Organic Matter, %	9.3						Phosphorus, ppm P	63						Potassium, ppm K	164						Electronium, ppm Mg	605						Calcium, ppm Ca	3550						Carbon Exchange Capacity, meq/100g	24.9						pH	7.4					
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6

### Four Requirements for Success

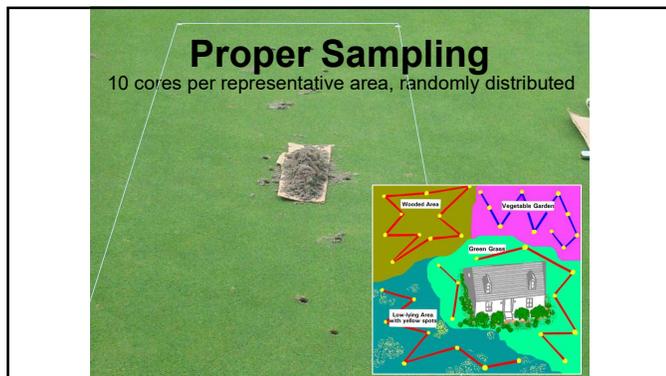
1. **Proper field sampling**  
To obtain representative sample
2. **Proper test selection**  
Several extractants to choose from
3. **Proper calibration**  
Cost and time intensive research
4. **Proper interpretation**  
Making sense of the numbers

7

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8



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### How Deep?



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### How Deep?

Depth	Mehlich 3 Phosphorus
Inches	ppm
0 – 1	205
0 – 2	138
0 – 6	74



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### Guidelines for Sampling Depth

- Lawns, Fairways, Athletic Turf – 6 inches (15 cm)
- Golf greens and Tees – 4 inches (10 cm)



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### Four Requirements for Success

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Making sense of the numbers

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### Soil test selection

- Bray-P1
- Bray-P2
- Mehlich-1
- **Mehlich-3**
- Olsen
- Morgan
- Modified-Morgan
- Ammon. acetate
- Water
- 0.01 M calcium chloride



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### Four Requirements for Success

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15

"There is a tendency to place undue emphasis upon the value of chemical soil tests.

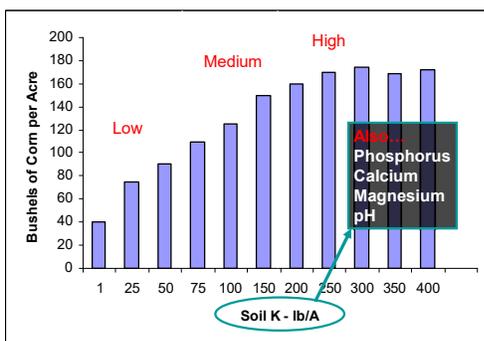
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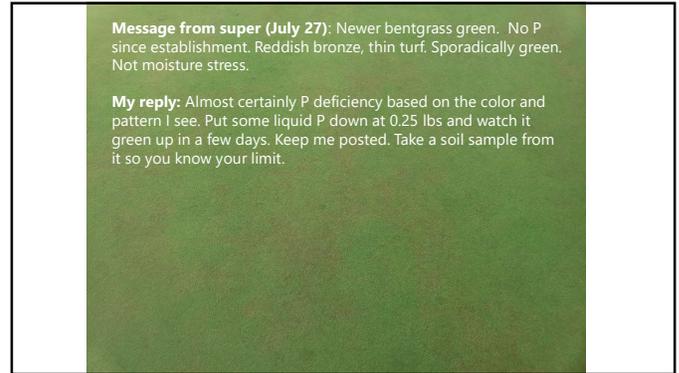
### Phosphorus Soil Test Calibration



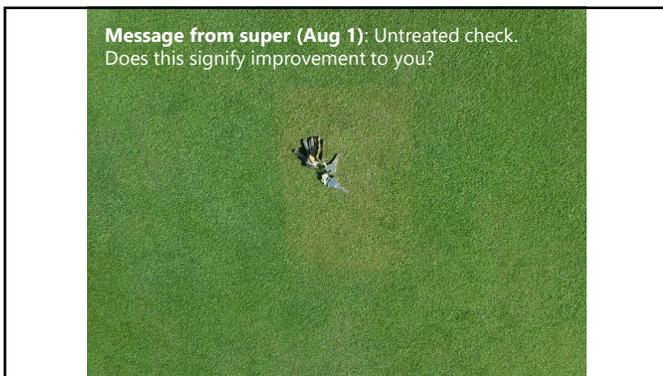
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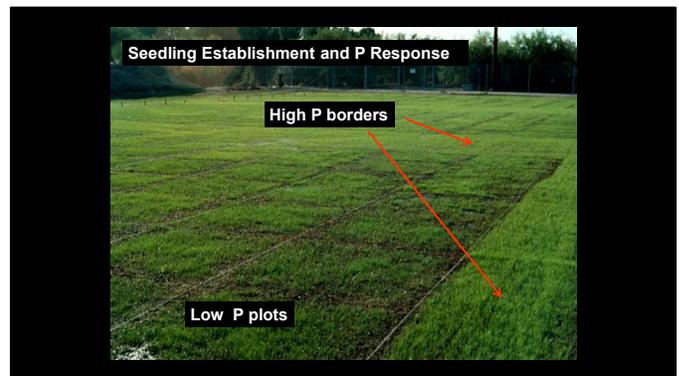
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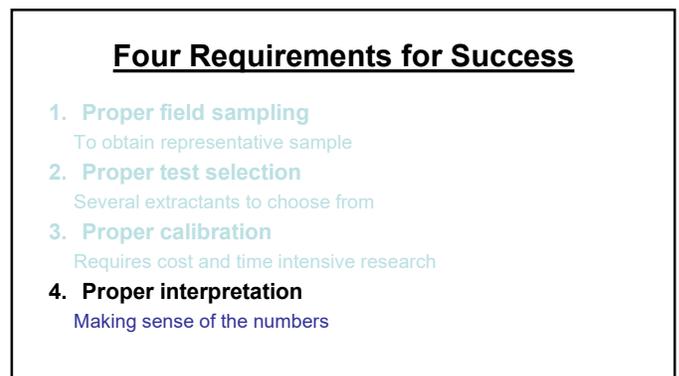
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# Soil Test Interpretation

## Two main interpretation philosophies:

- Sufficiency Level of Available Nutrients (SLAN)
  - **“Feed the plant”**
    - Example: MLSN
- Base Cation Saturation Ratio (BCSR)
  - **“Feed the soil”**
    - Majority of reports

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# Development of the BCSR concept

- The “Ideal” Soil
  - 65 to 85% Ca
  - 6 to 12% Mg
  - 2 to 5% K
  - Remaining H<sup>+</sup>, NH<sub>4</sub><sup>+</sup>

**INFLUENCE OF CALCIUM ON AVAILABILITY OF OTHER SOIL CATIONS**  
 FERNAN E. DEAR AND STEPHEN J. TOOTH  
*New Jersey Agricultural Experiment Station*

Investigation of the nutrient-availability status and needs of 30 of New Jersey's most important agricultural soils led to publication of the following tentative statement (1):

For the best soil, it is suggested that 60 per cent of the exchange cations should be calcium, 10 per cent be magnesium, and 30 per cent be potassium.

This statement emphasizes the importance of Ca per se. It also infers that contribution must be given to the ratio between the amounts of the several exchange cations. This suggests a Ca-Mg ratio of 0.5:1, a Ca-K ratio of 10:1, a Ca-N ratio of 3.0:1, and a Mg-K ratio of 2:1. If a total exchange capacity of 10 me. is assumed, the plus depth of such a soil would contain about 2,000 pounds exchange Ca, 200 pounds exchange Mg, and 300 pounds exchange K.

Data from which the foregoing conclusions were reached were obtained in a series of studies that have been under way since 1940. Some of the results of these studies have been published. The purpose of this paper is to bring the findings up to date.

The first study was designed to determine what constituted an optimum Ca-K ratio for alfalfa when grown on Piedmont sandstone. Its preparation for this work, the exchangeable bases were removed from 100 soil and then restored in 10 and 100 meq. exchangeable amounts of exchange Ca and K. Harvested alfalfa was then analyzed and grown through successive harvests.

It was found in this study (2) that the alfalfa plant could adjust itself to very wide Ca-K ratios in the soil, making good growth at ratios anywhere between 100:1 and 1:10. Hence, within the above-mentioned range, the ratio of exchange

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## Reference

September, 2014

### Minimum Levels for Sustainable Nutrition Soil Guidelines

The Minimum Level for Sustainable Nutrition (MLSN) Guideline is a new, more sustainable approach to managing soil nutrient levels that can help you to decrease fertilizer inputs and costs, while still maintaining desired turf quality and playability levels. The MLSN guidelines were developed in a joint project between PACE Turf and the Asian Turfgrass Center. All soil analyses were conducted at Brookdale Laboratories, New Bremen, OH.

	MLSN Soil Guideline
pH	5.5
Potassium (K ppm)	37
Phosphorus (P ppm)	21
Calcium (Ca ppm)	331
Magnesium (Mg ppm)	47
Sulfur as sulfate (S ppm)	7

Nitrogen requirements are best determined based on turf growth potential, which incorporates site-specific weather and turf type to calculate nitrogen demand (Gelenster and Stowell, 2005, Golf Course Management, p. 108-113, March, 2005).

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SOIL TEST REPORT					
REPORTED TO:	PAUL SMITH 1002 RANDOM STREET JONES, IN 46421				
REPORT NUMBER:	F990710-0000				
REPORT DATE:	03/20/20				
LAB NUMBER:	0009				
SAMPLE ID:	1				
TO BE GROWN:	Fescue				
ANALYSIS RESULTS					
SOIL TESTS	ANALYSIS				
Organic Matter, %	0.3				
Phosphorus, ppm P	61				
Phosphorus, ppm K	164				
Magnesium, ppm Mg	100				
Calcium, ppm Ca	3550				
Cation Exchange Capacity, meq/100g	24.9				
pH	7.4				
ANNUAL NUTRIENT REQUIREMENT					
Line	Nitrogen	Phosphorus	Potassium	Magnesium	Sulfur
0.0	0.3	0.2	0.3	0.0	0.0
3	2	3	2	3	0
SUGGESTED FERTILIZER APPLICATION					
NO. FERTILIZER	DESCRIPTION	ANNUAL APPLICATION RATE			
Option 1	18-10-18 Complete Fertilizer	1.7 qt 17.0			
Option 2		0.0 qt 0.0			
COMMENTS					
Use the fertilizer listed above or another fertilizer of similar NPK analysis. Apply and incorporate the recommended amount prior to planting or seedling in the early spring. For established perennial flowers, spread the fertilizer in the					

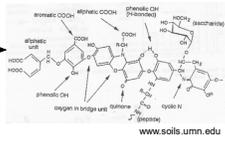
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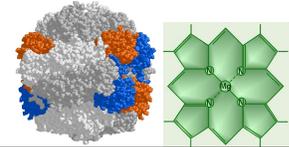
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## Nitrogen

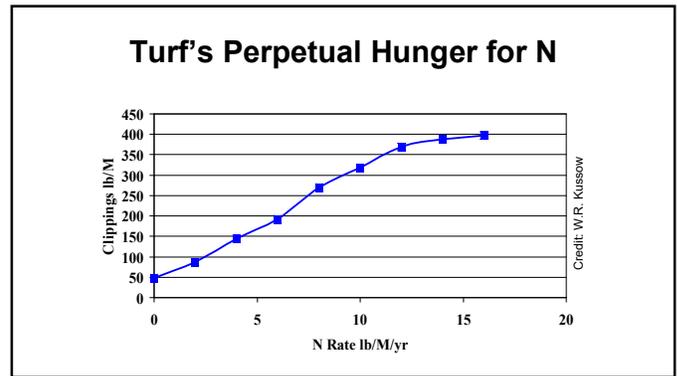
- Forms in Soil
  - Organic (complex)
  - Nitrate ( $\text{NO}_3^-$ )
  - Ammonium ( $\text{NH}_4^+$ )
- Functions
  - Proteins
  - Chlorophyll molecule
  - DNA



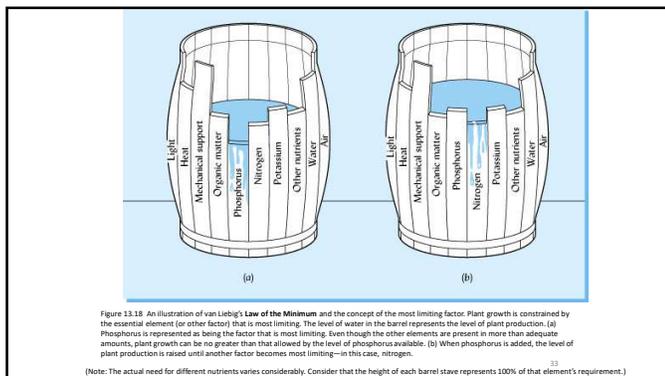
www.soils.umn.edu



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33

## Nitrogen

- The “Goldilocks” nutrient
  - Too much
  - Too little
  - Just right



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## Too Much Nitrogen

- Reduced root growth
  - Decreases stress tolerance - esp. water
- Excessive thatch development
- Increased mowing requirement
- Increases incidence of many diseases
  - brown patch, snow mold, gray leaf spot, take-all patch

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## Not Enough Nitrogen

- Reduced shoot density
  - Increased weed invasion – esp. clover and crabgrass
  - Increased reliance on pesticides
  - May need to completely renovate if weeds win
- Unsafe playing conditions
- Unattractive
- Increases incidence of certain diseases
  - Rust, red thread, dollar spot

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**Guidelines for N Fertilization: Kentucky bluegrass dominated lawns**

Time of Application	Rate of Application – lbs N/M	
	Clippings removed	Clippings returned
May 1 – 15	1.0	1.0
July 1 – 15	1.0	1.0
Sept. 1 – 15	1.0	0.0
After Oct. 15	1.0	1.0
Season Total	4.0	3.0

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**Guidelines for N Fertilization: Parks and Cemeteries**

Time of Application	Rate of Application – lbs N/M
May 1 – 15	1.0
Sept. 1 – 15	0.0 - 1.0
After Oct. 15	1.0
Season Total	2.0 - 3.0

38

**Guidelines for N Fertilization: Fine fescues**

Time of Application	Rate of Application – lbs N/M	
	High Maint.	Low Maint. or shade
May 1 – 15	1.0	1.0
Sept. 1 – 15	1.0	0.0
After Oct. 15	1.0	1.0
Season Total	3.0	2.0

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**Guidelines for N Fertilization: Athletic Fields**

Time of Application	Rate of Application – lbs N/M	
	Irrigated	Not Irrigated
May 1 – 15	1.0	1.0
July 1 – 15	1.0	0.0
Aug. 1 – 15	1.0	1.0
Sept. 1 – 15	1.0	1.0
After Oct. 15	1.0	1.0
Season Total	5.0	4.0

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**Expectations**



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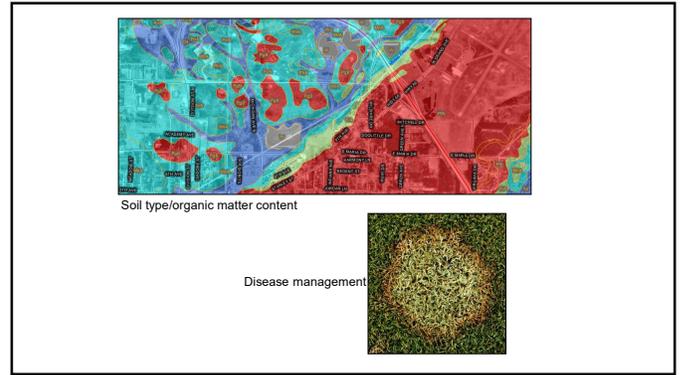
**Use: Traffic and Desired  
Recuperative Capacity**



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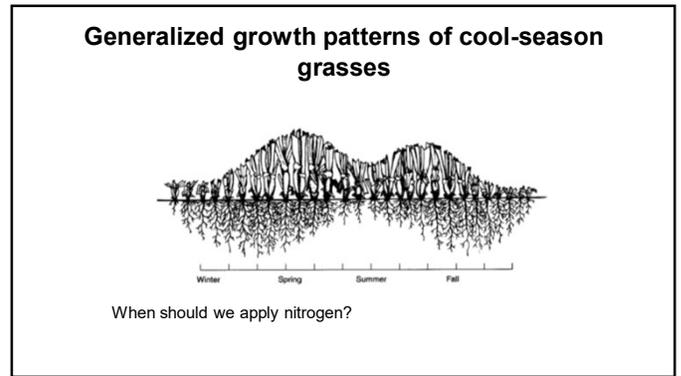
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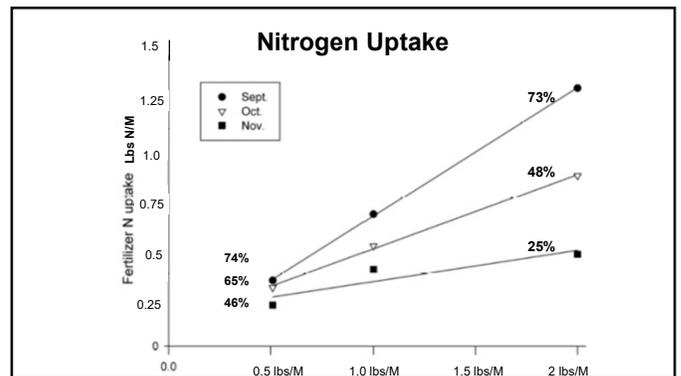


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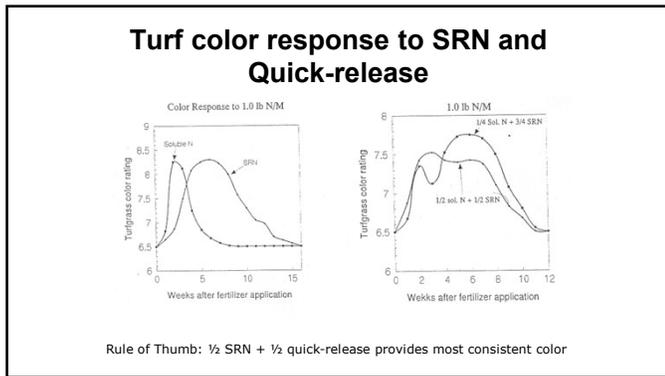
**Generalized Timings**

- **Early Spring:** forces rapid growth, carbohydrate depletion, decreases summer stress tolerance
- **Late Spring:** sustains green color and growth from early spring mineralization/late fall N
- **Summer:** Use lower rates of soluble fertilizer, soil can provide substantial N
- **Early Fall:** Recover from summer stress, increase density, maintain green color, can force too much growth with large apps
- **Late Fall:** Not much update occurs when growth slows, use lower rates (<0.5 lbs N/M)

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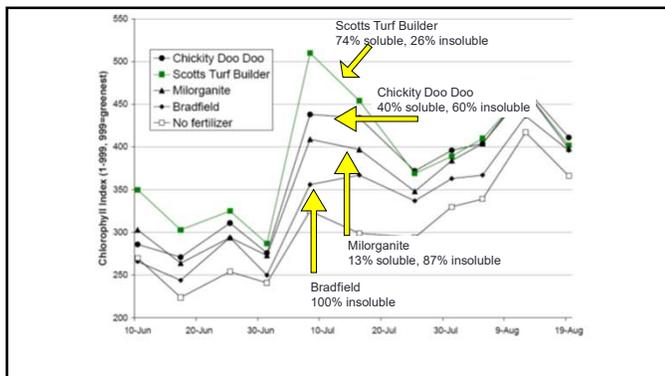
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### Slow-release: General information

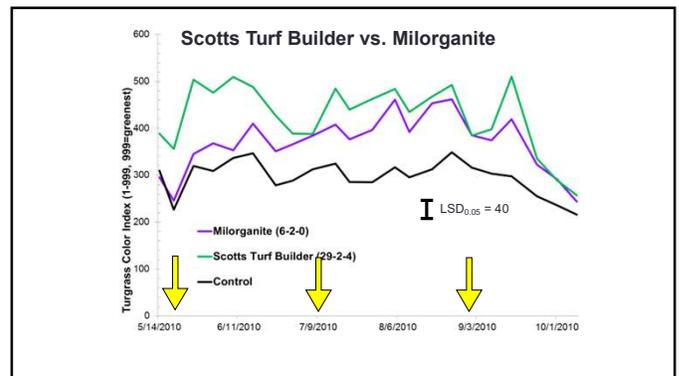
- Release rates vary
  - Weeks to years
- Release mechanisms vary
  - Microbial decomposition
  - Temperature
  - Soil Moisture
  - pH



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### Synthetic Slow-release: Coated fertilizers

- Sulfur Coated Urea
- Polymer Coated Urea

UREA SOLUTION RELEASE

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### Polymer Coated Urea Is Quite Effective

Treatment Name	# of apps	Annual N Rate lbs N/M	Average Turf Quality 1-9, 9=best	Average NDVI (x100) 0-100, 100=best	Average Clipping Mass ----- g -----
Urea (46-0-0)	4	4	7.59 ab	78.8 a	24.2 ab
Stabilized N (46-0-0)	4	4	7.66 a	79.0 a	24.5 ab
XCU (43-0-0)	4	4	7.66 a	78.7 a	22.6 ab
EXP 90 (43-0-0)	2	3	7.34 abc	77.9 ab	19.9 b
Polyon 43 (43-0-0)	2	3	7.34 abc	77.4 ab	21.9 ab
Duration 90 (44-0-0)	2	3	7.66 a	79.0 a	26.3 a
EXP 180 (42-0-0)	1	2.5	7.48 abc	78.6 ab	24.7 ab
Polyon Blend (42-0-0)	1	2.5	7.23 bc	76.9 b	21.5 ab
Duration 180 (43-0-0)	1	2.5	7.18 c	77.5 ab	21.7 ab
Untreated Control	0	0	5.09 d	69.7 c	5.8 c

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## Stabilized Nitrogen Fertilizers

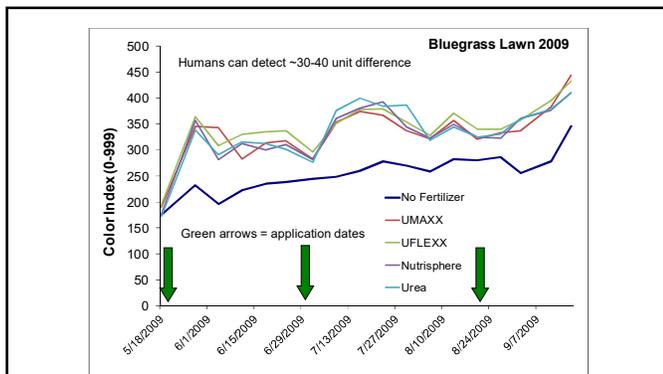
- Contain a **urease inhibitor**, slows conversion of urea to ammonium and decreases volatilization
  - NBPT (N-(n-butyl) thiophosphoric triamide)
  - Nitripyrin
  - butenedioic-methylenesuccinic acid copolymer
- Contain a **nitrification inhibitor**, slows conversion of ammonium to nitrate
  - DCD (dicyandiamide)
  - PPD (phenyl phosphorodiamidate)
  - butenedioic-methylenesuccinic acid copolymer

55

## Stabilized Turf Fertilizers

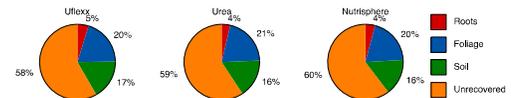
- Agrotain
  - UMAXX – (DCD, NBPT + urea)
  - UFLEXX – (DCD, NBPT + urea)
  - HYDREXX – (DCD, NBPT only)
- Nutrisphere-N
  - Urea + butenedioic-methylenesuccinic acid copolymer

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## <sup>15</sup>N Total Recovery



Henning et al. 2010 - Univ. of Illinois

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## Urease and Nitrification Inhibitors

- Grass uses about 0.02 lbs N/day (0.10-0.15 lbs N/week)**
- Some claim that a fertilizer (presumably at 1 lb N/M) will last for 16 weeks (112 days)
  - 1 lbs/M ÷ 112 days = 0.009 lbs N/day (half)
- For a 1 lb N/M application of a quick release product, 8 weeks is the upper limit of reasonable response – anything longer will need a larger application, coupled with a real slow-release mechanism

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## Bowman et al., 1989

- Applied 1 lb N/M as ammonium sulfate to bluegrass, ryegrass, tall fescue, and bentgrass
- Watered in immediately with 0.1 inch
- Soil sampling indicated that 70-80% of N was absorbed by the plant in the first 24 hours – almost all of it by 48 hours.

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### When to use stabilized N?

- When volatilization of urea is a concern
  - No ability to water in after application
  - High pH soils
- Bowman et al. (1987)
  - 36% of N was lost through volatilization with no irrigation
  - Only 3-8% after 0.4 inches applied
  - Most volatilization occurred in thatch layer

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### Price Differences Can Be Enormous

- 19 – 0 – 15 (Anderson's DG) = \$48 for 40# bag
- 46 – 0 – 0 (feed grade urea) = \$19 for 50# bag
- Cost per pound N
  - 19-0-15 = \$6.31
  - 46-0-0 = \$0.83

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