2009 Cornell University Short Course

Turfgrass Nutrition

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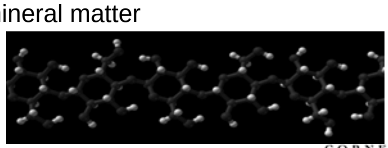
Turfgrass composition

- An average plant is 15 - 40% dry matter and 60 - 85% water
- Dry matter is composed of C,H,O and mineral matter



Essential Mineral Nutrients

- **17 elements**
  - Carbon (C)
  - Hydrogen (H)
  - Oxygen (O)
  - Nitrogen (N)
  - Sulfur (S)
  - Calcium (Ca)
  - Magnesium (Mg)
  - Iron (Fe)
  - Manganese (Mn)
  - Molybdenum (Mo)
  - Zinc (Zn)
  - Copper (Cu)
  - Nickel (Ni)

•Make up over 90% of plant's weight
•Come from the atmosphere and water

Essential Mineral Nutrients

❖ 17 elements

•Macronutrients
  •Must be > 0.1% of plant's weight

- ❖ Oxygen (O)
- ❖ Nitrogen (N)
- ❖ Phosphorus (P)
- ❖ Potassium (K)
- ❖ Sulfur (S)
- ❖ Calcium (Ca)
- ❖ Magnesium (Mg)

- ❖ Molybdenum (Mo)
- ❖ Zinc (Zn)
- ❖ Boron (B)
- ❖ Chlorine (Cl)
- ❖ Copper (Cu)
- ❖ Nickel (Ni)

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Essential Mineral Nutrients

•Macronutrients
  •Divided in to Primary and Secondary Macronutrients

- ❖ Oxygen (O)

Primary
- ❖ Nitrogen (N)
- ❖ Phosphorus (P)
- ❖ Potassium (K)

Secondary
- ❖ Sulfur (S)
- ❖ Calcium (Ca)
- ❖ Magnesium (Mg)

- ❖ Molybdenum (Mo)
- ❖ Zinc (Zn)
- ❖ Boron (B)
- ❖ Chlorine (Cl)
- ❖ Copper (Cu)
- ❖ Nickel (Ni)

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Essential Mineral Nutrients

❖ **17 elements**

- ❖ Carbon (C)

•Micronutrients
  •Typically < 0.01% of plant's weight

- ❖ Potassium (K)
- ❖ Sulfur (S)
- ❖ Calcium (Ca)
- ❖ Magnesium (Mg)

- ❖ Iron (Fe)
- ❖ Manganese (Mn)
- ❖ Molybdenum (Mo)
- ❖ Zinc (Zn)
- ❖ Boron (B)
- ❖ Chlorine (Cl)
- ❖ Copper (Cu)
- ❖ Nickel (Ni)

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Turgrass tissue sufficiency ranges

		Nutrient	Creeping Bentgrass	Perennial Ryegrass	General
Macronutrients	Primary	N, %	4.50 – 6.00	3.34 – 5.10	2.75 – 3.50
		P, %	0.30 – 0.60	0.35 – 0.55	0.30 – 0.55
		K, %	2.20 – 2.60	2.00 – 3.42	1.00 – 2.50
	Secondary	Ca, %	0.50 – 0.75	0.25 – 0.51	0.50 – 1.25
		Mg, %	0.13 – 0.40	0.16 – 0.32	0.20 – 0.60
		S, %	0.20 – 0.50	0.27 – 0.56	0.20 – 0.45
Micronutrients		Fe, ppm	50 – 500	97 – 934	35 – 100
		Mn, ppm	25 – 300	30 – 73	25 – 100
		Cu, ppm	5 – 50	6 – 38	5 – 20
		Zn, ppm	20 – 250	14 – 64	20 – 55
		B, ppm	6 – 30	5 – 17	10 – 60
		Mo, ppm	0.10 – 1.20	0.5 – 1.00	no data

Adapted from Jones, 1980 and Mills and Jones, 1996

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Why must nutrients be applied?

- ❖Nutrient fate
- ❖Plants remove nutrients – leave the system
- ❖Nutrients become unavailable
- ❖Nutrients leach or runoff – leave the system
- ❖Plant demand > plant availability

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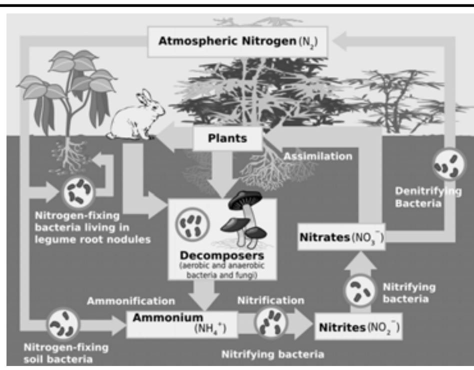

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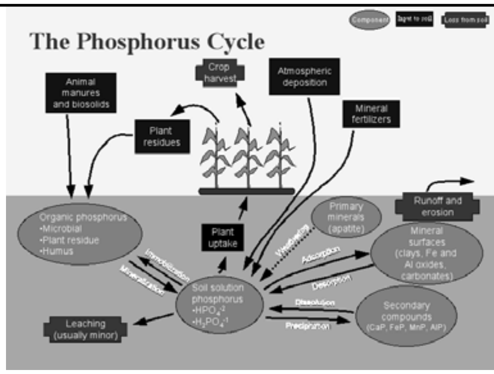
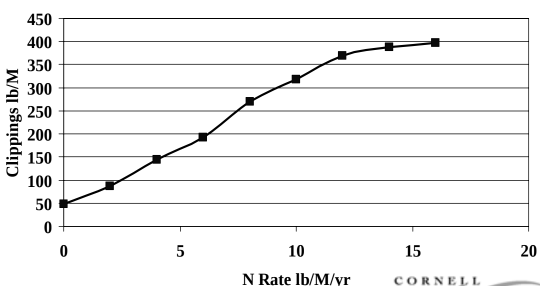


Source: Mississippi State Extension

Turf's perpetual hunger for N



The Primary Macros: Nitrogen

- ❖Functions
  - ❖Proteins
  - ❖Chlorophyll molecule
  - ❖DNA
- ❖ Deficiency symptoms
  - ❖Reduced growth
  - ❖Off-color
  - ❖Low density, invasion of weeds (esp. clover)

N deficient turfgrass

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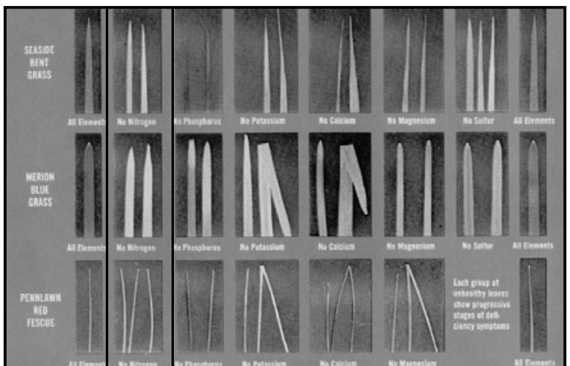

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The Primary Macros: Nitrogen

- ❖Management
  - ❖Tricky because we are always growing N “deficient” turfgrass
  - ❖The “Goldilocks” nutrient

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The Primary Macros: Nitrogen

- Too much
  - N reduces root system
    - Decreases stress tolerance - esp. water
  - Causes excessive thatch development
  - Greatly increases mowing requirement
  - Increases incidence of certain diseases
    - Leaf spot, necrotic ring spot, snow mold

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The Primary Macros: Nitrogen

- Not enough
  - Reduced shoot density
    - Increased weed invasion
    - Increased reliance on pesticides
  - Poor playing conditions
  - Increases incidence of certain diseases
    - Rust, red thread, dollar spot

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The Primary Macros: Nitrogen

- Just right
  - Good green color
  - Moderate growth rate
  - Optimum tolerance to environmental stresses
  - High shoot density and vigorous root system
  - Good recuperative potential

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The Primary Macros: Phosphorus

- ❖Functions
  - ❖ATP energy currency of the cell
  - ❖Membrane components
  - ❖DNA components
- ❖ Deficiency symptoms
  - ❖Reduced growth
  - ❖Dark, purple color

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Phosphorus deficient turf

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The Primary Macros: Phosphorus

- ❖Management
  - ❖P very insoluble in soil
    - ❖Availability is a function of root surface area
  - ❖Establishment
    - ❖root system is not extensive
  - ❖Post establishment
    - ❖responses to P rarely seen and deficiencies (purple color) are even more rare

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FERTILIZATION 145

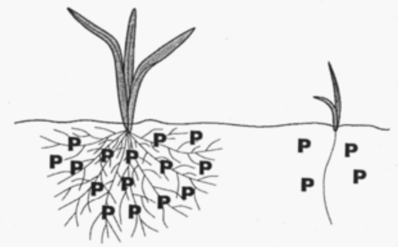


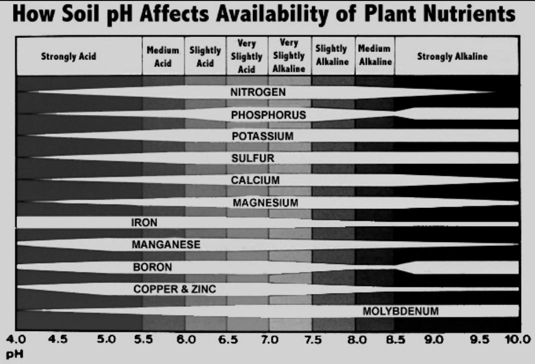
Figure 7.5 Phosphorous is relatively immobile in the soil and does not readily move to the roots of germinating seedlings.

From: Christians, 2003

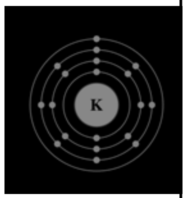
The Primary Macros: Phosphorus

- Management
  - P availability is also sensitive to pH
  - Maximum P availability in soil is at pH 6.5
  - Calcareous soils?
- High P favors Annual Bluegrass
  - Improves drought tolerance
  - Germination

How Soil pH Affects Availability of Plant Nutrients



The Primary Macros: Potassium



- Functions
  - Water regulation
    - Cell growth
    - Opening and closing of stomata
  - Activates enzymes
  - Regulates cell pH
- Deficiency symptoms
  - Reduced growth
  - Yellow leaf margins

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Potassium deficiency in corn

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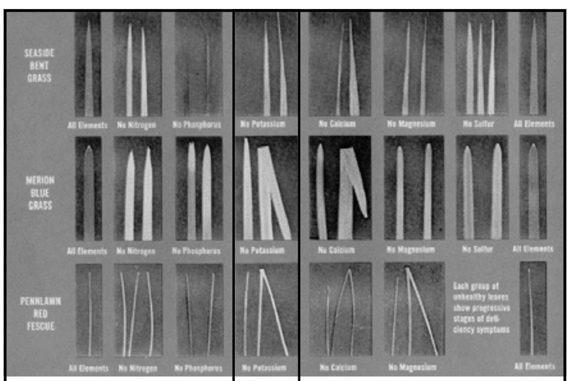

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The Primary Macros: Potassium

- Management
  - K^+ held on cation exchange sites in soil

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The Primary Macros: Potassium

- Management
  - K held on cation exchange sites in soil
  - Recent research suggests turfgrass requires less potassium than previously thought
  - What has been said of K….
    - Improves drought tolerance
    - Improves cold hardiness
    - Increases rooting
    - Resistance to dollar spot
    - Wear tolerance

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Summary of the big 3

- Nitrogen management is extremely important
- Phosphorus is important at establishment
- Potassium is of less importance than we thought – although continue to maintain soil test levels

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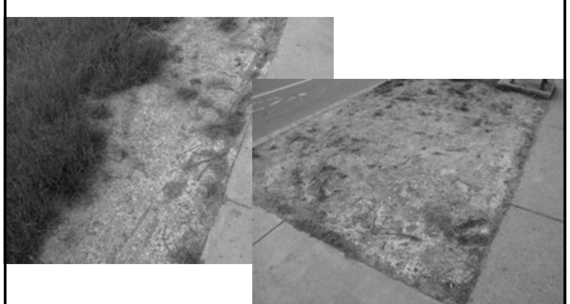
FERTILZIER SOURCE	CALCIUM CARBONATE EQUIVALENT PER 100 LB. MATERIAL	CALCIUM CARBONATE EQUIVALENT PER 1 LB. NUTRIENT
N Sources		
Ammonium sulfate	110	5.4
Monoammonium phosphate	56	5.1
Diammonium phosphate	64	3.6
Sulfur coated urea	119	3.2
Polymer coated urea	80	1.8
Urea	84	1.8
Ammonium nitrate	59	1.8
IBDU	57	1.8
Natural organic	10	1.7
P Sources		
Superphosphate	0	0
Triple superphosphate	0	0
K Sources		
Potassium magnesium sulfate	0	0
Potassium chloride	0	0
Potassium sulfate	0	0
Potassium nitrate	-26	-0.6

Adapted from Carrow et al., 2001

FERTILZIER SOURCE	SALT INDEX EQUAL **MATERIAL** BASIS	SALT INDEX EQUAL **NUTRIENT** BASIS
N Sources		
Sodium Nitrate	100	6.06
Potassium nitrate	74	5.34
Ammonium sulfate	69	3.25
Ammonium nitrate	105	2.99
Monoammonium phosphate	30	2.45
Urea	75	1.62
Diammonium phosphate	34	1.61
Ammonia	47	0.57
Natural organic	3.5	0.70
P Sources		
Superphosphate	8	0.39
Triple superphosphate	10	0.22
K Sources		
Potassium magnesium sulfate	43	1.97
Potassium chloride	116	1.94
Potassium sulfate	74	1.58
Monopotassium phosphate	8	0.24

Adapted from Carrow et al., 2001



Things to consider when choosing a fertilizer source :

- ❖Acidifying Effects
- ❖Salt Index
- ❖Cost
- ❖Release Rate and Mechanism

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Release Rate

❖"The highest priority in developing a fertilization program is for one to fully understand the expected response from the nitrogen sources he intends to use."

- **Powell and Shoulders, 1976, USGA Green Section Record**

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Sources of Nitrogen

- ❖Fast Release
  - ❖Inorganic salts
  - ❖Synthetic organic

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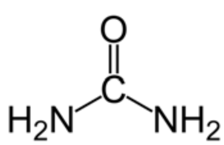
Sources of Nitrogen

- <u>Fast Release</u>
  - Inorganic salts
  - Synthetic organic
- <u>Slow Release</u>
  - Synthetic organic
    - Coated materials
    - Uncoated materials
  - Natural Organic

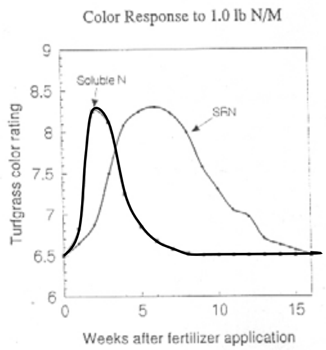
Fast Release

- Inorganic = ammonium and nitrate salts
  - NH_4NO_3, $(NH_4)_2SO_4$, KNO_3, MAP, DAP, etc.
- Synthetic organic = urea



Fast Release: Advantages

- Nitrogen is immediately available for uptake.
- Can be liquid or granular
  - Granular form will dissolve quickly
- Release <u>not</u> dependent on soil temperature or pH



ble N:

: ~ 1 week

:t gone
1 month

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Quick-release: Disadvantages

- Highest burn potential (salt index)
  - Require small, frequent applications
- Prone to leaching losses
- Can produce unwanted growth surge
- Release last < 4 weeks

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Slow-release Fertilizers

- Natural/Organic fertilizers
- Coated fertilizers
- Uncoated fertilizers

For Better Results. Naturally.
Milorganite®

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Slow-release: General information

- ❖SRN accounts for over 2/3 of all N applied on golf courses (Sartain, 2002)
- ❖Releases N gradually
  - ❖Longer lasting response
  - ❖Larger applications
  - ❖Leaching losses decrease

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Slow-release: General information

- ❖Release rates vary
  - ❖Weeks to months
- ❖Release mechanisms dependent on
  - ❖Temperature
  - ❖Soil Moisture
  - ❖pH

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Slow-Release Fertilizers

Natural/Organics

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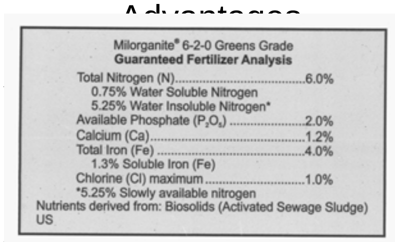
Natural/Organic Fertilizers

- Sewage Sludge
  - Milorganite
- Poultry and Dairy Compost
  - Sustane, Nature Safe
- Dried blood, Bone meal, Fish meal, Feather meal, Corn gluten meal etc…

Natural/Organic Fertilizers

- Release dependent on:
  - Microbial decomposition
    - Temperature
    - Moisture
    - pH
    - C:N content of fertilizer
- Release ~ 1-3 months

Natural/Organic Fertilizers: Advantages



Milorganite® 6-2-0 Greens Grade
Guaranteed Fertilizer Analysis

Total Nitrogen (N)..6.0%
0.75% Water Soluble Nitrogen
5.25% Water Insoluble Nitrogen*
Available Phosphate (P_2O_5)........................2.0%
Calcium (Ca)...1.2%
Total Iron (Fe)..4.0%
1.3% Soluble Iron (Fe)
Chlorine (Cl) maximum...................................1.0%
*5.25% Slowly available nitrogen
Nutrients derived from: Biosolids (Activated Sewage Sludge)
US

- Often lacking essential nutrients

Natural/Organic Fertilizers: Disadvantages

- ❖No release at low temps
- ❖N content < 6%
  - ❖Need lots of bags (shipping cost)
- ❖Expensive – if not then probably poor quality

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Slow-release fertilizers: Coated products

Sulfur Coats
Polymer Coats
Sulfur + Polymer Coats

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Synthetic Slow-release: Coated fertilizers

- ❖Release dependent on type of coating:
- ❖Sulfur coat
  - ❖Thickness of coat
  - ❖Brittleness of coat
- ❖Polymer coat
  - ❖Thickness, type of polymer
  - ❖Temperature

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Synthetic Slow-release: Coated fertilizers – Advantages

- ❖Controlled release (esp. Polymers)
- ❖Low burn potential
- ❖Sulfur coated urea is relatively inexpensive

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Synthetic Slow-release: Coated fertilizers – Disadvantages

- ❖Polymer coated materials can be expensive
- ❖Sulfur coats can be inconsistent
  - ❖Some are almost quick-release

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Synthetic Slow-release: Uncoated fertilizers

Urea-Formaldehyde (UF) or
Methylene Urea (MU)
Isobutylidene diurea (IBDU)

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Synthetic Slow-release: Uncoated fertilizers – UF and MU

- ❖Produced by reacting urea with formaldehyde
- ❖Results in polymer chains of various lengths and ratios of urea: formaldehyde

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Synthetic Slow-release: Uncoated fertilizers – UF and MU

- ❖Release is dependant on:
  - ❖Temperature
  - ❖Moisture
  - ❖pH
- ❖Very similar to natural organics but…
- ❖Length of chain determines release

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Fertilizer Source	**What happens to the release when …**				
	Temp is low	Temp is high	pH is low (<5)	Soil Moisture is low	Soil Moisture is high

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Fertilizer Source	What happens to the release when …				
	Temp is low	Temp is high	pH is low (<5)	Soil Moisture is low	Soil Moisture is high
Inorganics and urea	**Same**	**Same**	**Same**	**Can burn**	**Can leach**

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Fertilizer Source	What happens to the release when …				
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Natural organic	⇩	⇧	⇩	⇩	**Same**

Cornell Turfgrass

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Natural organic	⇩	⇧	⇩	⇩	**Same**
Synthetic organic (UF, MU)	⇩	⇧	⇩	⇩	**Same**

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Fertilizer Source	What happens to the release when …				
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Inorganics and urea	**Same**	**Same**	**Same**	**Can burn**	**Can leach**
Natural organic	↓	↑	↓	↓	**Same**
Synthetic organic (UF, MU)	↓	↑	↓	↓	**Same**
Sulfur coated N	**Same**	**Same**	**Same**	↓	**Same**

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Sulfur coated N	**Same**	**Same**	**Same**	↓	**Same**
Polymer coated N	↓	↑	**Same**	↓	**Same**

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Sulfur coated N	**Same**	**Same**	**Same**	↓	**Same**
Polymer coated N	↓	↑	**Same**	↓	**Same**
IBDU	**Same**	**Same**	**Same**	↓	↑

Fertilizer Source	Release rate under optimal conditions
Inorganics and urea	1 – 3 weeks
Natural organic	1 – 3 months
Sulfur coated N	1 – 2 months
Polymer coated N	Variable (weeks to all year)
Ureaform	1 – 2 years
Methylene Ureas	2 – 4 months
MDU/DMTU	1 – 2 months
IBDU	1 – 4 months

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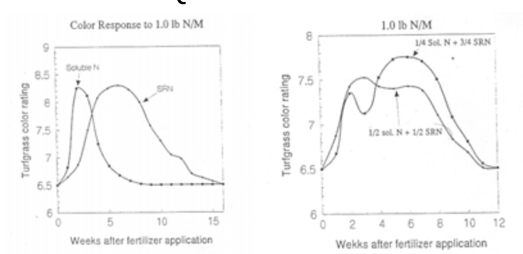
Turf color response to SRN and Quick-release



General Guideline: ½ SRN + ½ quick-release provides most consistent color

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Spreader and Sprayer Calibration

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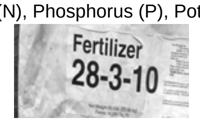
Fertilizer Calculation

- ❖Analysis: N-P-K
  - % Nitrogen (N), Phosphorus (P), Potassium (K)



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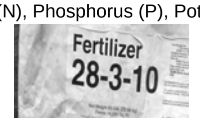
Fertilizer Calculation

- ❖Analysis: N-P-K
  - % Nitrogen (N), Phosphorus (P), Potassium (K)



- ❖Ratio:
  - ❖10-10-10 (1-1-1)
  - ❖20-5-10 (4-1-2)

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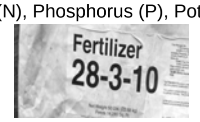
Fertilizer Calculation

- ❖Analysis: N-P-K
  - % Nitrogen (N), Phosphorus (P), Potassium (K)



- ❖Ratio:
  - ❖10-10-10 (1-1-1)
  - ❖20-5-10 (4-1-2)
- ❖Nitrogen expressed on an elemental basis
- ❖P expressed as P_2O_5 (44% P)
- ❖K expressed as K_2O (83% K)

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Calculating P & K

- **P_2O_5** contains 44% P
- **K_2O** contains 83% K

(50 lb)(.10)= 5 lb. N

(50 lb)(.10)= 5 lb. P_20_5
(5 lbs. P_2O_5)(.44) = 2.2 lbs.

(50 lb)(.10)= 5 lb. K_20
(5 lbs. K_2O)(.83) =4.15 lbs.

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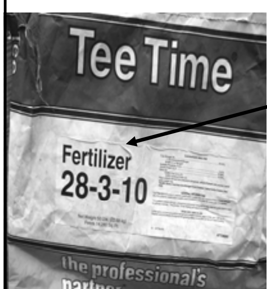
Example



1. **How many pounds of 28-3-10 needs to be applied for a recommended rate of 1 pound of Nitrogen per 1,000 ft^2?**
2. **How many pounds of 28-3-10 must be ordered for 65,500 ft^2 area?**

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Calculations

$$\frac{1 \text{lb N}}{1000 \text{ ft}^2}$$

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Calculations

$$\frac{1\text{lb N}}{1000\ ft^2} \times \frac{1\text{ lb Fertilizer}}{0.28\text{ lbs N}}$$

Calculations

$$\frac{1\text{lb N}}{1000\ ft^2} \times \frac{1\text{ lb Fertilizer}}{0.28\text{ lbs N}} = \frac{3.6\text{ lbs of Fertilizer}}{1000\ ft^2}$$

Calculations

$$\frac{1\text{lb N}}{1000\ ft^2} \times \frac{1\text{ lb Fertilizer}}{0.28\text{ lbs N}} = \frac{3.6\text{ lbs of Fertilizer}}{1000\ ft^2}$$

OR

$$\frac{\text{Desired rate}}{\text{\% Nitrogen}} \qquad \frac{1\text{ lb N}}{0.28} = 3.6$$

Calculations

❖ How much fertilizer for 65,500 ft^2

$$\frac{3.6 \text{ lbs fertilizer}}{1000 \text{ ft}^2}$$

Calculations

❖ How much fertilizer for 65,500 ft^2

$$\frac{3.6 \text{ lbs fert}}{1000 \text{ ft}^2} = \frac{X}{65{,}500 \text{ ft}^2}$$

Calculations

❖ How much fertilizer for 65,500 ft^2

$$\frac{3.6 \text{ lbs fert}}{1000 \text{ ft}^2} = \frac{X}{65{,}500 \text{ ft}^2}$$

65,500 (3.6) = 1000 (X)

Calculations

❖How much fertilizer for 65,500 ft^2

$$\frac{3.6 \text{ lbs fert}}{1000 \text{ ft}^2} = \frac{X}{65{,}500 \text{ ft}^2}$$

$$65{,}500\ (3.6) = 1000\ (X) \rightarrow X = \frac{235{,}800}{1000}$$

X = 236 lbs of Fertilizer

CORNELL Turfgrass

Calculations

❖How much P and K would we apply?

CORNELL Turfgrass

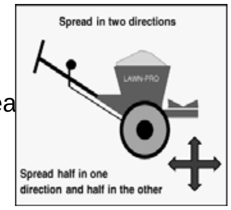
Calibrating Spreaders

❖Application rate depends upon:
-Pace of travel:
-Spreader type: drop vs. cyclone
-Particle size: Fine vs. coarse

CORNELL Turfgrass

Drop Type Spreaders

- Accurate
- Easy to calibrate
- Less drift
- Good for designated area
- Over-lap
- Time (labor)



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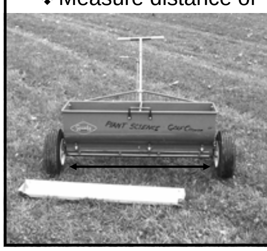
Steps to Calibration

- Measure Hopper Width
- Measure distance of



1) Hopper Width = 3 feet.

2) Area = 1000 ft2

$1000\ ft^2/3$ = 333.3 ft

3) 3.6 lbs. of 28-3-10 must be applied/1,000 ft^2.

4) Therefore 3.6 lbs. must be in the catch tray after traveling 333 ft.

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Cyclone Spreaders

- Less time to apply materials
- Difficult to calibrate
- Difficult in limited designated areas
- Must determine effective spreading width.

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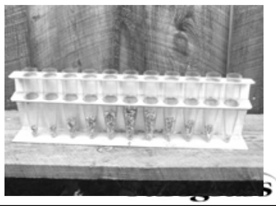
Determining Effective Width

- ❖Each box represents one square foot.
- ❖Boxes are emptied in vials to determine effective application width



Calibration Method

- ❖Same approach as drop spreader

- ❖ **1.) Effective application width is 6 ft.**
- ❖ **2.) 3.6 lbs. of 28-3-10/1,000 ft^2 must be applied.**
- ❖ **3.) 3.6 lbs. should be in the hopper after traveling 167 feet.**

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Sprayer Calibration

- ❖Similar Methods as spreader calibration
- ❖Things that affect output:

Type & size of nozzle
Operating speed
Operating Pressure

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Steps

1. Determine Operating Speed RPM
2. Determine Operating Pressure PSI
3. Measure Boom width & Determine Test area size.
4. Operate & Time Sprayer over known area.
5. Collect water under each nozzle for recorded operating time.

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Example

Boom width=17 ft.

Operating speed=1,500 rpm in first gear

Operating pressure= 30 psi

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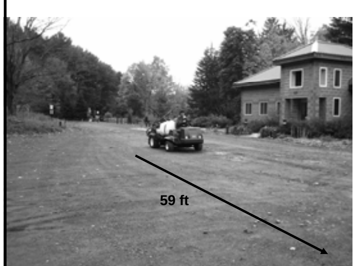
Time Travel Distance



-Boom width = 17 ft

-Calibrating for 1,000 ft^2

$\frac{1,000\ ft^2.}{17\ ft.}$ = **59 ft.**

-Speed = 1,500 rpm

Time = 14 seconds

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Measure Sprayer Output

❖Hold containers under every nozzle for 14 seconds at operating psi.

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Measure Sprayer Output

❖Record every nozzle output

❖Take average output for the nozzles

  ❖Ex. 14 oz

❖Replace or repair any nozzle that puts out more or less than 5% of average

  ❖14 x 0.95 = 13.3 oz

  ❖14 x 1.05 = 14.7 oz

CORNELL Turfgrass

Measure Sprayer Output

❖ Average output =

  ❖14 oz x 16 nozzles = 224 oz

$$\frac{224 \text{ oz}}{128 \text{ oz/gallon}} = 1.75 \text{ gallons/1000 sq ft}$$

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Tank Mix/Application Example

- Given Information:
  - -Liquid fertilizer (Brand X) label states a rate of 3 fl. oz/1,000 ft^2.
  - -Sprayer output is 1.75 gal./1,000 ft^2.
  - -Tank size is 300 gallons.

How much fertilizer must be added to 300 gallon tank?

CORNELL Turfgrass

Solution

$$\frac{3\text{ oz. fertilizer}}{1.75\text{ gallon}} = \frac{X}{300\text{ gal}}$$

$$1.75(X) = 3(300); \rightarrow \frac{900}{1.75} = 514\text{ oz.}$$

X = **<u>514 oz. or 4 gallons</u>** of fertilzer added to the 300 gallon tank

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Another Example

- Given the same facts, how much water and fertilizer X needs to be mixed to control an area of 65,500 ft^2?

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Solution

- **How much water must be added to tank?**

$$\frac{1.75 \text{ gal. output}}{1{,}000 \text{ ft}^2} = \frac{\text{water needed (X)}}{65{,}500 \text{ ft}^2}.$$

1,000(X) = 1.75(65,500);

$$\frac{114{,}625}{1{,}000} =$$ **114.6 gallons of water**

Solution

- How much fertilizer X must be added to the tank?

$$\frac{3 \text{ oz. fertilizer}}{1.75 \text{ gal. output}} = \frac{X}{114.6 \text{ gal. water}}$$

1.75(X) = 3(114.6); $\frac{343.8}{1.75}$ = **196 oz.**

Summary

- 196 oz. of fertilizer X
- 114.6 gallons of water
- 65,500 ft^2 area
- Fertilizer label rate of 3 oz. per 1,000 ft^2.

5-10-31

LESCO® PROFESSIONAL TURF FERTILIZER
For use in Rotary Spreaders Only

50 lb COVERS 15,500 sq ft

DIRECTIONS FOR USE: This LESCO product is a professional quality turf fertilizer for use on all lawn areas. The best results with this product are obtained when it is applied to actively growing grass, and watered into the turf soon after application. Avoid mowing immediately following application to prevent pick-up.

For best results, sweep or blow the fertilizer off walks and painted surfaces following application to avoid discoloration.

GUARANTEED ANALYSIS

TOTAL NITROGEN (N) 5.00%
3.90% Ammoniacal Nitrogen
1.10% Urea Nitrogen
AVAILABLE PHOPHATE (P_2O_5) 10.00%
SOLUBLE POTASH (K_2O) 31.00%
IRON (Fe) Total 10.00%
0.10% Water Soluble Iron (Fe)
DERIVED FROM: Urea, Ammonium Phosphate, Muriate of Potash, Iron Sucrate.
CHLORINE (Cl) Max 25.00%

CORNELL Turfgrass

Phosphorus Fertilizer Sources

- ❖Rock Phosphate
- ❖Superphosphate (0-20-0)
- ❖Triple superphosphate (0-46-0)
- ❖Ammoniated phosphates
  - ❖Monoammonium phosphate (MAP) 11-48-0
  - ❖Diammonium phosphate (DAP) 18-46-0

CORNELL Turfgrass

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CORNELL Turfgrass

Potassium Fertilizer Sources

- Potash – burn wood, leach ashes with water and evaporate water to get K salts, mostly K_2CO_3
- Most K fertilizers are taken from salt mines
- KCl – potassium chloride – muriate of potash (0–0–60)
  - Inexpensive
  - High Salt Index

CORNELL Turfgrass

Potassium Fertilizer Sources

- K_2SO_4 – potassium sulfate – sulfate of potash (0–0–50)
  - Lower salt index
  - For establishment look for this source
- KNO_3 – potassium nitrate (13–0-44)
  - Very high salt index!

CORNELL Turfgrass

Calcium and Magnesium Sources

- Seldom required when pH is above 5
- In cases where we want to increase Ca without increasing pH we can use gypsum
- Ca and Mg are usually present as impurities in N, P, and K fertilizers

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Sulfur Sources

- Component of many N, P, and K fertilizers
  - Superphosphate
  - Sulfur-coated urea
  - Sulfate of potash
- Atmospheric deposition is a main source

CORNELL Turfgrass

Micronutrient or Trace Element Sources

- Micronutrients: Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B), Molybdenum (Mo), Chlorine (Cl), and Nickel (Ni)
- Normally sufficient in most soils – soil testing is unreliable at this point
- Dangerous to apply: over-application is easy and can result in toxicity (although Fe is pretty safe)

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Micronutrients

- Iron (Fe)
  - Cofactor for chlorophyll formation
  - Chlorosis at high pH
- Magnesium
  - Deficiencies at low pH
  - Center of chlorophyll molecule
  - Enzyme activity
  - Test for deficiency with Epsom salt
    - 1 teaspoon / 1 pint of water

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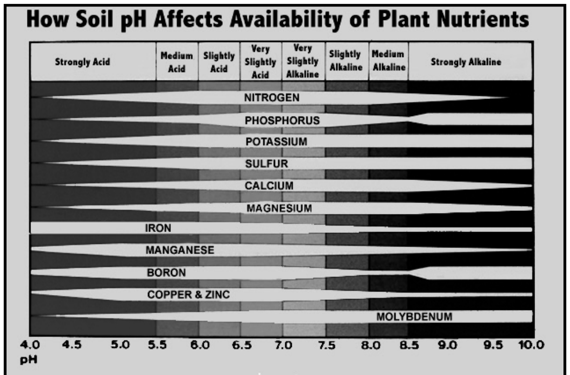

CORNELL Turfgrass

How do you measure a fertilizer response in a turf setting?

How do you measure a fertilizer response in a turf setting?

- Aesthetics characteristics:
  - color: dark green
  - shoot density: dense
  - uniformity: consistent

CORNELL Turfgrass

How do you measure a fertilizer response in a turf setting?

- ❖ Aesthetics characteristics:
- ❖ Functional characteristics:
  - * withstand traffic stress (wear, compaction)
  - * recuperate from damage (insects, diseases, traffic, heat/drought/cold)
  - * remains dense to prevent erosion and runoff

CORNELL Turfgrass

How do you measure a fertilizer response in a turf setting?

- ❖ Aesthetics characteristics:
- ❖ Functional characteristics:
- ❖ Growth or yield:

  Not directly!

  - ❖ Unless you are in seed or sod production

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Nitrogen Requirements

- ❖ Things to know:
  - * grasses

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GUIDELINES:SPECIES
Annual Nitrogen Rates

	lbs./1000 ft^2/year
❖ **Kentucky bluegrass**	**3-4**
❖ **Perennial ryegrass**	**3-4**
❖ **Tall fescue**	**2-5**
❖ **Fine fescue**	**1-2**

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Nitrogen Requirements

❖ Things to know:
* soils
* irrigation
* degree of sunlight (sun vs. shade)

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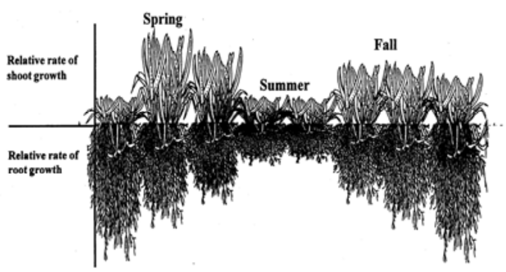
Seasonality of cool season shoot and root growth



Turfgrass

Nitrogen Requirements

Things to Know:

* expectation of site
* compaction/traffic
* environmental concerns

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How to determine amounts

❖ Color & density
❖ Growth rate
❖ Indicator pests

❖ Soil tests?
❖ Foliar test (2 to 6 % N)

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Standard Nitrogen Fertilization Rates

Site	lbs. N/1000 ft²/year
Golf-greens	
sand	2.5-4.0
soil	2.0-3.0
tees	3.0-5.0
fairways	2.0-4.0
roughs	0-2.0

CORNELL Turfgrass

Standard Nitrogen Fertilization Rates

Site	lbs. N/1000 sq.ft./year
Athletic fields	
low budget/expectations	1.0-2.0
med. to high budget/exp.	
soil	3.0-5.0
sand	4.0-6.0

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Timing of application (season)

- Periods of high demand
  - Early fall
  - Mid-late spring
  - Late fall

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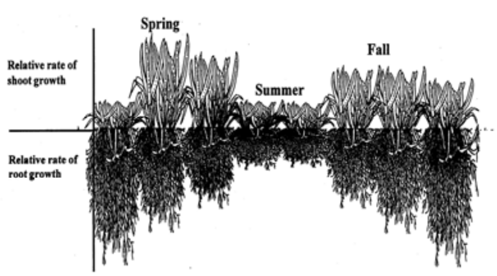
Timing of application (season)



Cool-Season Grass Fertilization

- As a general rule use a ratio of
  - 4:1:2 or 3:1:3
    (N-P-K)
- Exceptions
  - Establishment
  - Late fall fertilization
  - If soil tests gives sufficient levels

CORNELL Turfgrass

Cool Season Fertilization Fall (Aug 15-Sept 15)

- **Most important time for fertilization**
- Improves density
- Recovers from summer stress
- **Accumulates carbohydrates**
- Cool temperatures for optimum growing.

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Late Fall: November 1st

- Apply when above ground growth has stopped, but plant is still green.
- Carbohydrate accumulation
- Good response in Spring
- Increased density

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Objective of late fall fertilization

- Supply N after growth has stopped, but photosynthesis is still occurring.
- Nutrients are stored
- Reduces need for early spring fertilization.
- Use fast release nitrogen for benefit.

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Cool Season Fertilizer Late Spring

- High nutrient demand
- Reduced flush of growth

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Cool Season Fertilizer Early Spring

- Quick color response
- Rapid plant growth
- Damage recovery from winter

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Cool Season Fertilizer
Early Spring

- ❖Depletes carbohydrate reserves (decreases summer stress tolerance)
- ❖Average consumer puts too much fertilizer in Spring

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Summer

- ❖Use moderate to low rates
- ❖Improves recovery from wear
- ❖Tolerance to some diseases
- ❖Excessive fertilization can reduce stress tolerance
- ❖Use slow release forms of nitrogen

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Total Fertilizer by Year

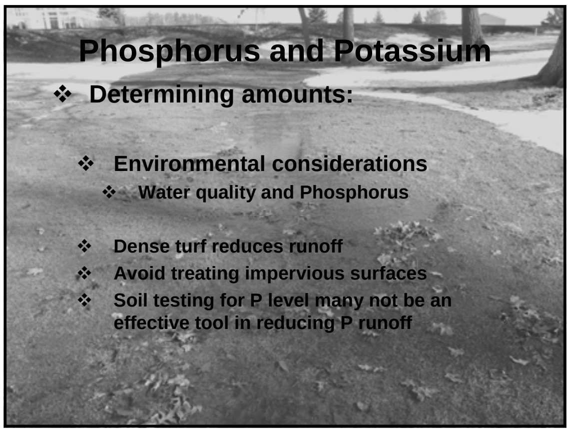
Early Spring	Late Spring	Summer	Early Fall	Late Fall
0.5 lb N/M	0.5-1.0 lbs N/M	Maybe a little slow release	1-2 lb N/M	1-1.5 lbs N/M Fast Release

- ❖Amounts depend on turf use and needs.

CORNELL Turfgrass

Warm season Fertilization

- ❖Apply throughout growing season at regular intervals
  - ❖**1 lb Nitrogen / 1000 / growing month**



Phosphorus and Potassium

- ❖ Determining amounts:
  - ❖ Soil Testing
  - ❖ Foliar testing
    - ❖ Phosphorus (0.3 to 0.55 %, dry weight)
    - ❖ Potassium (1 to 2.5 %, dry weight)

Other macronutrients and micronutrients

- Calcium-often no response, can suppress K uptake
- Magnesium-can have chlorotic leaves when excessively high levels of Ca present
- Sulfur-limited response in very acid soils or in areas with limited air pollution
- Of the micronutrients, only iron gives a consistent response (dark green color), other could be deficient on sandy higher pH sites low in organic matter.

CORNELL Turfgrass

Nutrient sufficiency level

Table 11–2. Elemental tissue content sufficiency ranges and common turfgrass deficiency symptoms.

Element	Tissue content sufficiency range (Jones, 1980)	Deficiency symptoms
N	27.5–35.0 g kg^{-1}	General yellow-green or chlorotic color. Older leaves initially go off color and dieback from tip. Shoot density and tillering decrease.
P	3.0–5.5 g kg^{-1}	Leaves progress from dark green to purplish to reddish purple color. Stand may appear wilted and exhibit poor spring green-up and growth.
K	10.0–25.0 g kg^{-1}	Older leaves exhibit yellowing first, followed by dieback at top and then along leaf margin. Early spring chlorosis observed.
Ca	5.0–12.5 g kg^{-1}	Younger leaves exhibit symptoms first, with reddish brown color along leaf margins.
Mg	2.0–6.0 g kg^{-1}	Older leaves turn red to cherry red along margins.
S	2.0–4.5 g kg^{-1}	Similar to N deficiency although mid-vein may remain green.
Fe	35–100 mg kg^{-1}	Younger leaves exhibit symptoms first, typically an interveinal chlorosis—leaves may appear almost white under severe deficiency.
Mn	25–150 mg kg^{-1}	Interveinal chlorosis of younger leaves. Necrotic spots may develop on leaves.
Zn	20–55 mg kg^{-1}	Stunted leaves. Some chlorosis. Puckered leaf margins.
Cu	5–20 mg kg^{-1}	Tips of younger leaves dieback. May get white-tip. Growth may be stunted.
B	10–60 mg kg^{-1}	Reduced growth and stunting.
Mo	Not known	Similar to N deficiency. May get some interveinal chlorosis.
Cl	Not known	Not commonly observed in turf.

Building Your fertilizer Program

- Things to consider:
  - grasses
  - expectation of site
  - soil conditions:
    - initial fertility (soil test)
    - pH
    - drainage

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Building Your fertilizer Program

- Things to consider:
  - site conditions:
    sun/shade
  - environmental factors

Building Your fertilizer Program

- Things to consider:
  - fertilizers sources
    - release rate, costs
  - burn potential
  - application rate

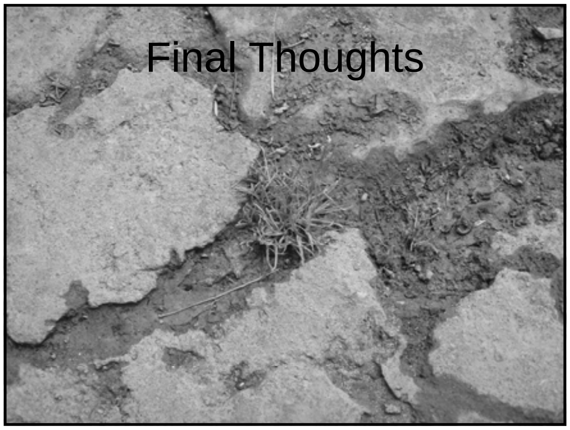
Building Your fertilizer Program

- Things to consider:

  What are you going to apply?

  How much are you going to apply?

  When are you going to apply?


Final Thoughts