PLANT-SOIL INTERACTIONS

NICK CHRISTIANS
ADAM THOMS
IOWA STATE UNIVERSITY

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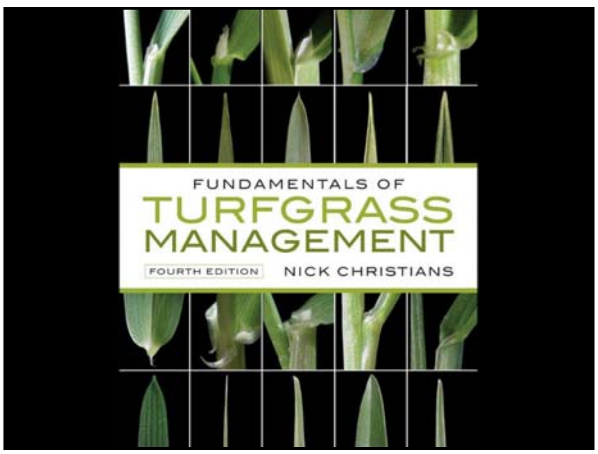

3

TURF SOILS

1. Many soil problems
   - Perennial
   - Traffic
   - Areas unfit for Agriculture
2. SOIL MODIFICATION
   - USGA
   - PAT
3. Few fields with so many scams, misinformation

4

SOIL SCIENCE

1. Soil chemistry
   - Ability to deliver nutrients

2. Soil physics
   - Solid, liquid, and gaseous
   - Form and structure
   - Bulk density
   - Infiltration
   - Porosity
   - Soil modification

5

INTERPRETATION IS THE KEY

- Chemical tests consistent
- Interpretation varies

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BASIC PRINCIPLES

AND TERMINOLOGY

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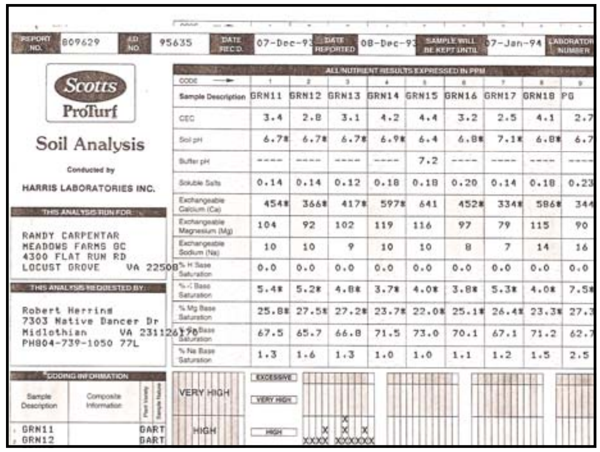


REPORT NO.	809629	I.D. NO.	95635	DATE REC'D.	07-Dec-93	DATE REPORTED	08-Dec-93	SAMPLE WILL BE KEPT UNTIL	07-Jan-94	LABORATORY NUMBER

Scotts ProTurf

Soil Analysis

Conducted by

HARRIS LABORATORIES INC.

THIS ANALYSIS RUN FOR:

RANDY CARPENTAR
MEADOWS FARMS GC
4300 FLAT RUN RD
LOCUST GROVE VA 22508

THIS ANALYSIS REQUESTED BY:

Robert Herring
7303 Native Dancer Dr
Midlothian VA 231126170
PH804-739-1050 77L

ALL NUTRIENT RESULTS EXPRESSED IN PPM

CODE →	1	2	3	4	5	6	7	8	9
Sample Description	GRN11	GRN12	GRN13	GRN14	GRN15	GRN16	GRN17	GRN18	PG
CEC	3.4	2.8	3.1	4.2	4.4	3.2	2.5	4.1	2.7
Soil pH	6.7*	6.7*	6.7*	6.9*	6.4	6.8*	7.1*	6.8*	6.7
Buffer pH	----	----	----	----	7.2	----	----	----	----
Soluble Salts	0.14	0.14	0.12	0.18	0.18	0.20	0.14	0.18	0.23
Exchangeable Calcium (Ca)	454*	366*	417*	597*	641	452*	334*	586*	344
Exchangeable Magnesium (Mg)	104	92	102	119	116	97	79	115	90
Exchangeable Sodium (Na)	10	10	9	10	10	8	7	14	16
% H Base Saturation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% K Base Saturation	5.4*	5.2*	4.8*	3.7*	4.0*	3.8*	5.3*	4.0*	7.5*
% Mg Base Saturation	25.8*	27.5*	27.2*	23.7*	22.0*	25.1*	26.4*	23.3*	27.3
% Ca Base Saturation	67.5	65.7	66.8	71.5	73.0	70.1	67.1	71.2	62.7
% Na Base Saturation	1.3	1.6	1.3	1.0	1.0	1.1	1.2	1.5	2.5

CODING INFORMATION

Sample Description	Composite Information	Plant Variety	Sample Nature
GRN11		BART	
GRN12		BART	

VERY HIGH

HIGH

EXCESSIVE

VERY HIGH

HIGH

8

First three lines filled with information

CEC

pH

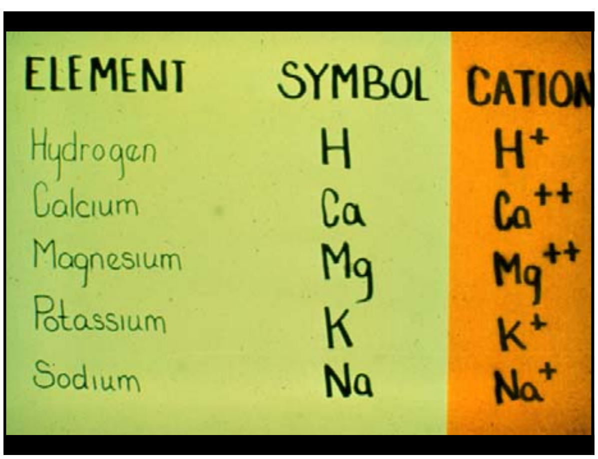
BUFFER pH

9

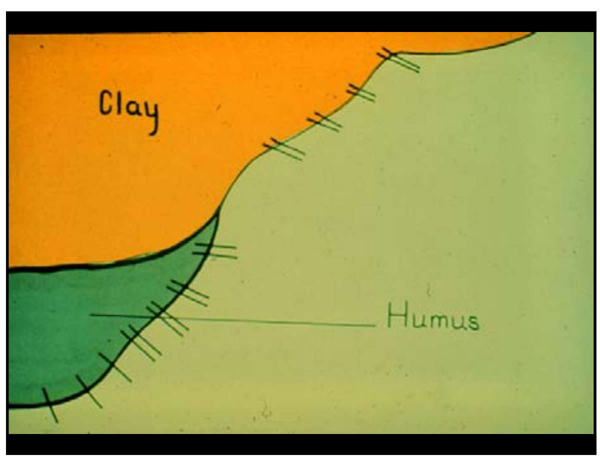
Cation Exchange Capacity (CEC)

The ability to exchange cations

10



11



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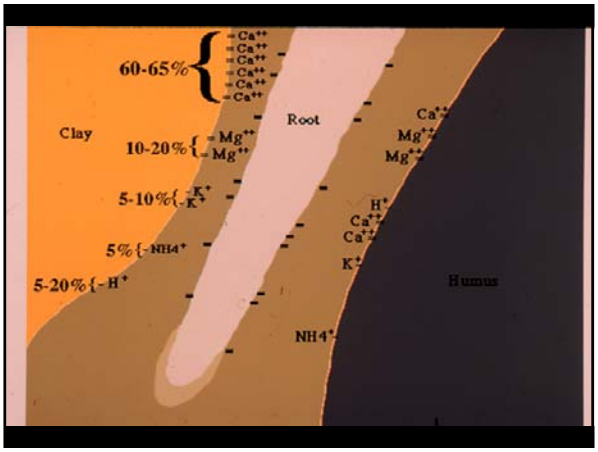


13

CATION EXCHANGE CAPACITY

Soil Type	meq/100g
• Sand	• <1 - 8
• Clay	• 80 - 120
• Organic Matter	• 150 – 500
• Clay Loam Soil	
• Sand-Based	• 25 – 30
	• <1 - 14

14

CATION EXCHANGE CAPACITY

Soil Type	meq/100g
• Sand	• <1 - 8
• Clay	• 80 - 120
• Organic Matter	• 150 – 500
• Clay Loam Soil	
• Sand-Based	• 25 – 30
	• <1 - 14

15

CATION EXCHANGE CAPACITY

1 milliequivalent (meq)

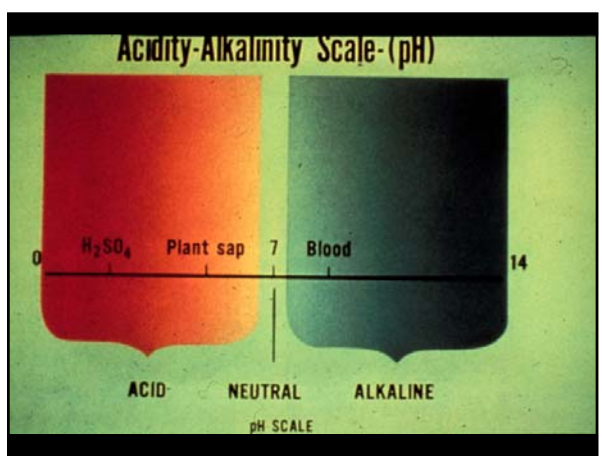
6.02×10^{20}

602,000,000,000,000,000,000

16

pH

17



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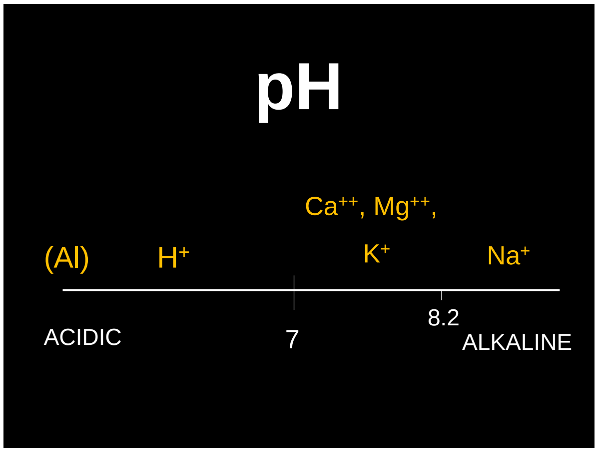
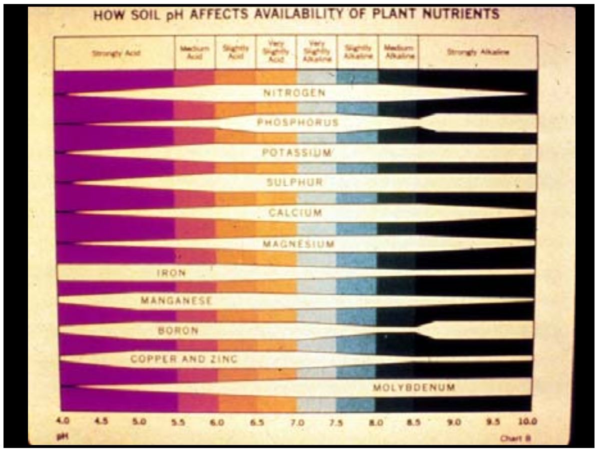


19



20

LIMING

21

LIME

CALCIUM CARBONATE

$CaCO_3$

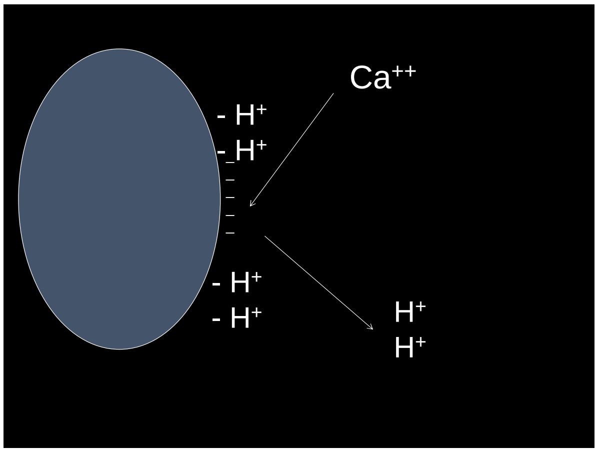
22

LIME

RAISES

pH

23



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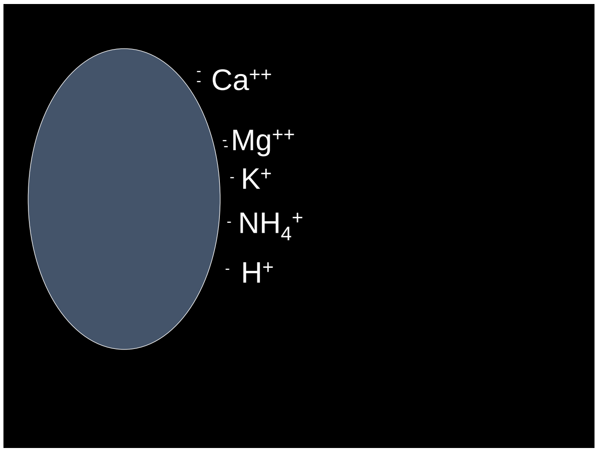
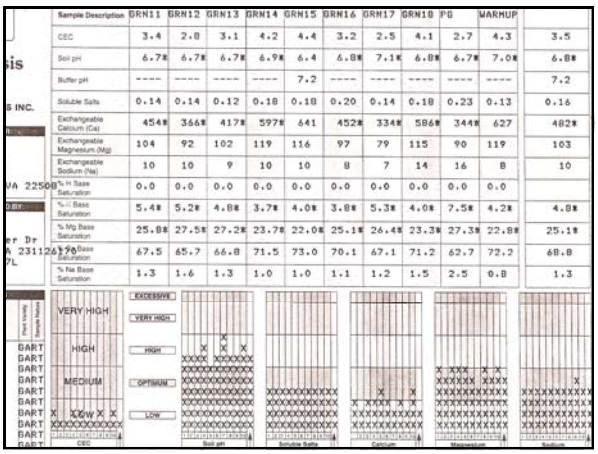


25

BUFFER pH

26



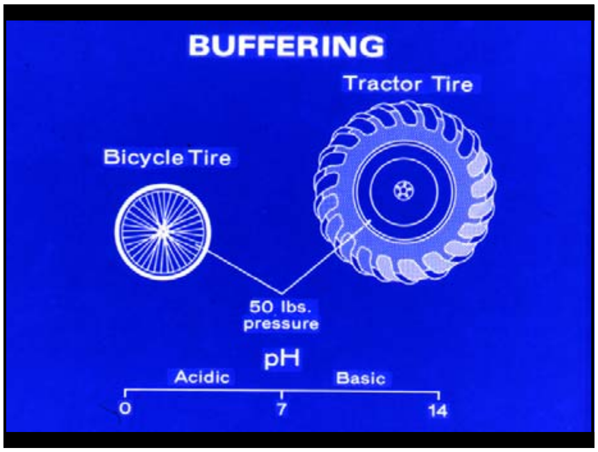
Sample Description	GRN11	GRN12	GRN13	GRN14	GRN15	GRN16	GRN17	GRN18	PG	WARMUP	
CEC	3.4	2.8	3.1	4.2	4.4	3.2	2.5	4.1	2.7	4.3	3.5
Soil pH	6.7*	6.7*	6.7*	6.9*	6.4	6.8*	7.1*	6.8*	6.7*	7.0*	6.8*
Buffer pH	----	----	----	----	7.2	----	----	----	----	----	7.2
Soluble Salts	0.14	0.14	0.12	0.18	0.18	0.20	0.14	0.18	0.23	0.13	0.16
Exchangeable Calcium (Ca)	454*	366*	417*	597*	641	452*	334*	586*	344*	627	482*
Exchangeable Magnesium (Mg)	104	92	102	119	116	97	79	115	90	119	103
Exchangeable Sodium (Na)	10	10	9	10	10	8	7	14	16	8	10
% H Base Saturation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
% K Base Saturation	5.4*	5.2*	4.8*	3.7*	4.0*	3.8*	5.3*	4.0*	7.5*	4.2*	4.8*
% Mg Base Saturation	25.8*	27.5*	27.2*	23.7*	22.0*	25.1*	26.4*	23.3*	27.3*	22.8*	25.1*
% Ca Base Saturation	67.5	65.7	66.8	71.5	73.0	70.1	67.1	71.2	62.7	72.2	68.8
% Na Base Saturation	1.3	1.6	1.3	1.0	1.0	1.1	1.2	1.5	2.5	0.8	1.3

27

BUFFERING

Resistance to Change

28



29

Table 7.3. Amount of $CaCO_3$, or its equivalent, in pounds per acre required to raise the pH to 6.5, based on the buffer pH.

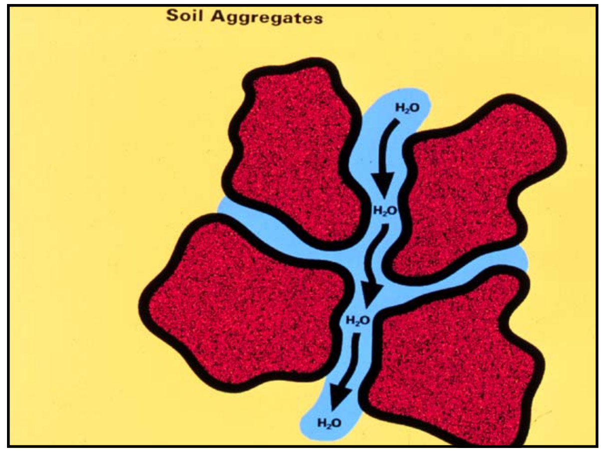
	lb $CaCO_3$/acre required for			
Buffer pH	2-in. Depth	3-in. Depth	6-in. Depth	8-in. Depth
7.0	0	0	0	0
6.9	0	0	0	0
6.8	200	300	600	800
6.7	400	700	1300	1700
6.6	700	1100	2100	2800
6.5	900	1400	2800	3700
6.4	1200	1800	3500	4700
6.3	1400	2100	4200	5600
6.2	1700	2500	5000	6700
6.1	1900	2900	5700	7600
6.0	2200	3200	6400	8600
5.9	2400	3600	7100	9500
5.8	2600	4000	7900	10600
5.7	2900	4300	8600	11500

30

GYPSUM

$CaSO_4$

31



32

SODIUM Na^+

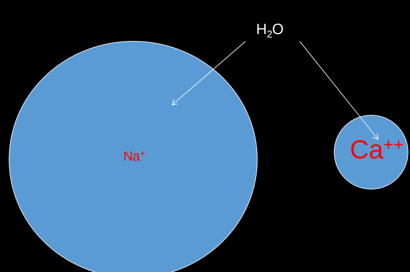
33

SODIUM

- Not an essential element
- Naturally occurring
- Sewage effluents
- Can damage plants
- Monovalent (1+)
- Large hydrated size
- Can damage soil structure

34

HYDRATED SIZE



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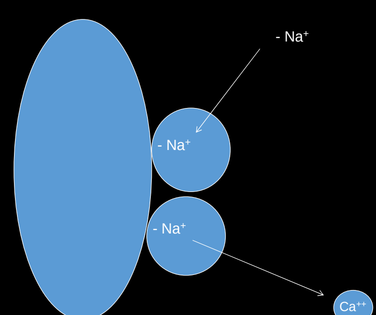

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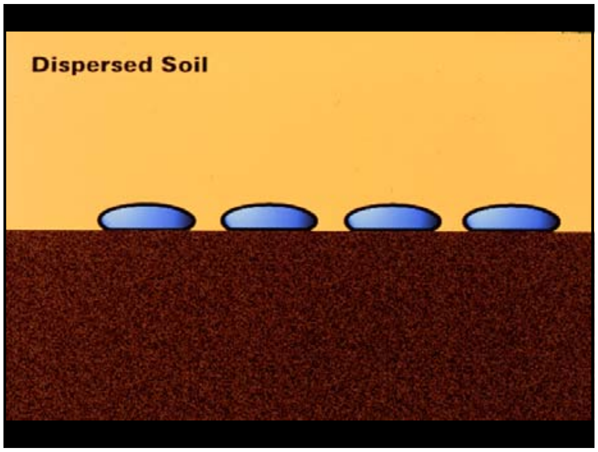

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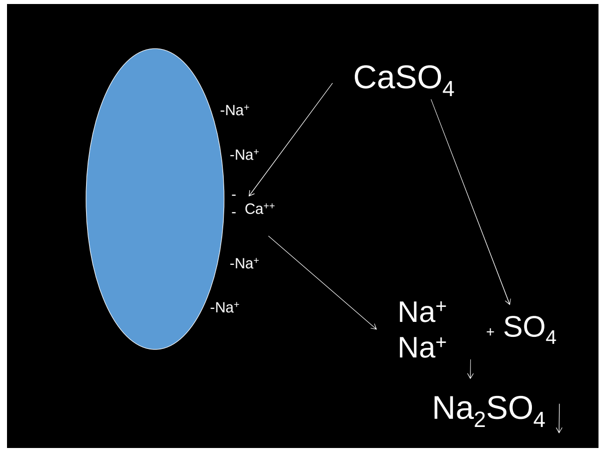

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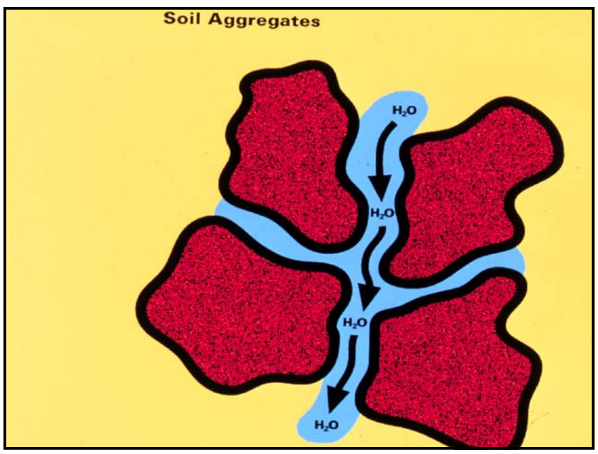


39

GYPSUM

- **Calcium Sulfate $CaSO_4$**
- **Calcium replaces Na^+ on cation ex. sites**
- **Sodium sulfate leaches from soil**
- **Soil structure is <u>Slowly</u> restored**

40

SODIUM ADSORPTION RATIO - SAR

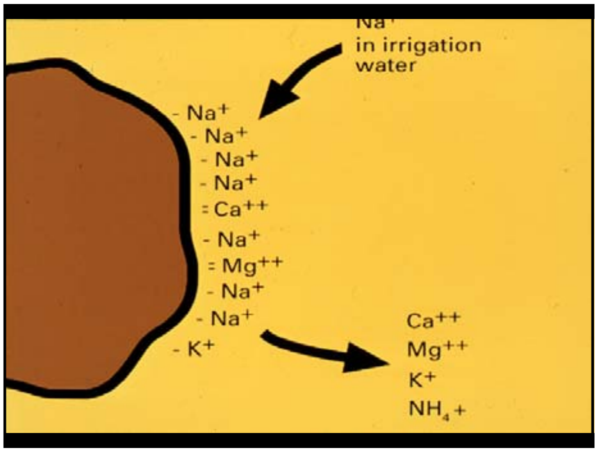
- **Ratio of sodium to calcium and magnesium**
- **Estimate of amount of sodium that will accumulate in irrigated soil**
- **5 to 15 Depending on soil type**

41

SODIUM ADSORPTION RATIO - SAR

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

42

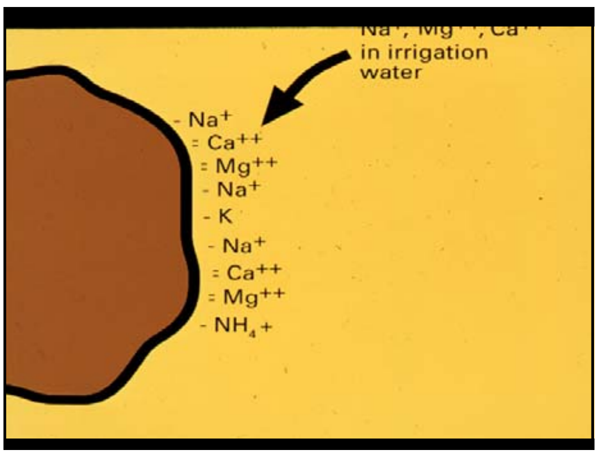


43

CALCIUM AND MAGNESIUM

- **Divalent (++)**
- **Smaller hydrated size**

44



45

BICARBONATES

- Can react with Ca and Mg
- Results in higher SAR

46

ADJUSTED SAR -SAR_{ADJ}

- Adjusted for bicarbonates
- Bicarbonates remove Ca and Mg
- The wider the difference between SAR and SAR_{ADJ}, the greater the bicarbonate problem

47

ACID INJECTION

48

SULFURIC ACID REACTS WITH BICARBONATES

$$H_2SO_4 + HCO_3 \rightleftharpoons HSO_4 + H_2CO_3$$

$$H_2CO_3 \rightleftharpoons H_2O + CO_2$$

49

ACID INJECTION

- Sulfuric acid
- Reacts with carbonate and bicarbonate
- Prevents the removal of Ca and Mg from solution
- Prevents increase in SAR

50

SULFUROUS GENERATORS

51

52

SOIL TESTING

53

17 ESSENTIAL ELEMENTS

- CARBON C
- HYDROGEN H
- OXYGEN O
- PHOSPHORUS P
- POTASSIUM K
- NITROGEN N
- SULFUR S
- CALCIUM Ca
- IRON Fe
- MAGNESIUM Mg
- BORON B
- MANGANESE Mn
- COPPER Cu
- ZINC Zn
- MOLYBDENUM Mo
- CHLORINE Cl
- NICKEL Ni

54

17 ESSENTIAL ELEMENTS

- CARBON C
- HYDROGEN H
- OXYGEN O
- PHOSPHORUS P
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55

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- BORON B
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- ZINC Zn
- MOLYBDENUM Mo
- CHLORINE Cl
- NICKEL Ni

56

MACRONUTRIENTS

- 1000 mg/kg or more
- C, H, O, N, P, K, S, Mg, AND Ca

MICRONUTRIENTS

- Less than 100 mg/kg
- Mo, Cu, Zn, Mn, B, Fe, Cl, and Ni

57

C. HOPKNS
CaFe Mn B Mg CuZn Mo Cl Ni

C. Hopkns café managed by my cousin Mo the Clown for a nickel

58

TAKE A REPRESENTATIVE SAMPLE

- Collect from several locations
- Depth depends on lab
- Combine and mix samples
- Take a sub-sample, approximately 1 cup
- How often?

59

SOIL TESTING

- SLAN--sufficiency level of available nutrients
- BCSR--basic cation saturation ratio
- MLSN minimum level for sustainable nutrition

60

SLAN

- Oldest method
- 80 Years + Research
- Interpretation varies with crop, soil type, climate etc.
- Public labs

61

YIELD CURVE

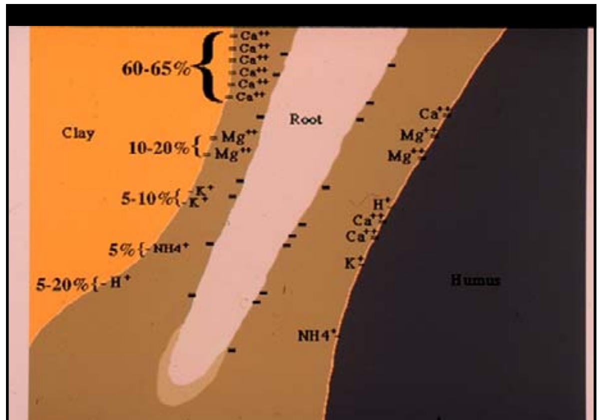
62

BCSR

Basic Cation Saturation Ratio

- Based on an ideal ratio of cations on exchange sites
- Newer method
- Less research
- Private labs
- Tends to overestimate
- Do not use for turfgrass

63



64

Minimum Level for Sustainable Nutrition

- **Developed recently by PACE Turf and Asian Turfgrass Center**
  - Dr. Larry Stowell and Dr. Micah Woods
- **Replacement for SLAN**
- **Set minimum required for optimal turf growth**
  - Baseline soil nutrient concentrations
    - Keep soil levels above this value
  - Gives minimum values instead of a range
  - Tells how much to apply
  - Incorporates turf “growth potential”

65

Why Use MLSN?

- **Focus on sustainability**
- **Reduce inputs**
- **Reduce maintenance costs**
  - (or redirect costs, more on this later)
- **Maintain expected turf performance**
- **Show reception to environmental concerns**
- **Plant health and soil health**

66

Minimum Level for Sustainable Nutrition

- Apply all nutrients at ratio determined by MLSN
- Why a ratio? Nutrient uptake driven by nitrogen
- Only apply what the plant can use
  - Amount determined by clipping nutrient content

Nutrient	Tissue ppm	Ratio:N
N	40,000	1
P	5,000	0.125
K	20,000	0.5
Ca	4,000	0.1
Mg	2,000	0.05

This gives us a nutrient use ratio:

N:P:K → 8:1:4

67

Minimum Level for Sustainable Nutrition

- We need three quantities:
- A. What nutrient amount does the turf use?
  - Site-specific estimate from growth potential
- B. What amount is required in the soil?
  - Soil reserve, the MLSN guideline level
- C. What amount is *IN* the soil? MLSN Soil Survey Guideline Level Results
  - Soil test result numbers

	MLSN Soil Guideline
pH	>5.5
Potassium (K ppm)	37
Phosphorus (P ppm)	21
Calcium (Ca ppm)	331
Magnesium (Mg ppm)	47

Source: www.paceturf.org

68

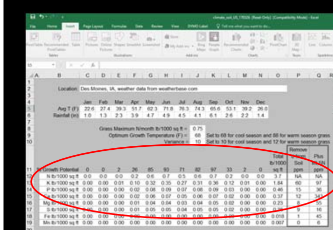
Turf Use / Growth Potential

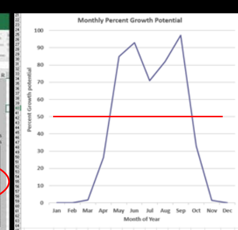
- Growing degree day model for turf growth
- Site specific estimates of what the plant needs
- www.paceturf.org

69

Turf Use / Growth Potential

- Get local weather data





70

MLSN Calculation Example 1

- Des Moines, IA
- Turf Use + Soil Minimum - Soil Test = Amount Required

Nutrient	Removed/Used by Plant	MLSN Minimums	Test Results	Amount Required
N	NA	NA	3.7*	3.7*
P	15	21	95	15+21-95= **-59**
K	60	37	125	60+37-150= **-28**
Ca	12	331	1,890	12+331-1890= **-1547**
Mg	8	47	275	8+47-275= **-220**

- * Soil tests do not measure available Nitrogen

71

MLSN Calculation Example 2

Turf Use + Soil Minimum - Soil Test = Amount Required

Nutrient	Removed/Used by Plant	MLSN Minimums	Test Results	Amount Required (ppm)
N	NA	NA	4.7*	4.7*
P	25	21	30	25+21-30= **16**
K	105	37	40	105+37-40= **102**
Ca	20	331	205	20+331-205= **146**
Mg	10	47	75	10+47-75= **-18**

Application of 1 lb nutrient per 1000 ft^2 = 33 ppm in top 4 inches

Divide ppm required by 33 to get lbs per 1000 ft^2

72

MLSN Calculation Example 2

- Application of 1 lb nutrient per 1000 ft^2 = 33 ppm in top 4 inches
- Divide ppm required by 33 to get lbs per 1000 ft^2

Nutrient	Amount Required (ppm)
N	4.7*
P	25+21-30= **16**
K	105+37-40= **102**
Ca	20+331-205= **146**
Mg	10+47-75= **-18**

Phosphorus MLSN:

$$\frac{\text{Lbs Phosphorus}}{1000\ ft^2} = \frac{16 \text{ ppm from soil test}}{33 \text{ ppm Conv. Factor}} = \frac{0.48 \text{ lb P}}{1000\ ft^2}$$

$$\frac{0.48 \text{ lb P}}{1000\ ft^2} \times \frac{2.29 \text{ lb } P_2O_5}{1.0 \text{ lb P}} = \frac{1.10 \text{ lb } P_2O_5}{1000\ ft^2}$$

Using 0-55-0: $\frac{1.10 \text{ lb } P_2O_5}{0.55} = \frac{2.0 \text{ lb 0-55-0}}{1000\ ft^2}$

73

MLSN Calculation Example 2

- Application of 1 lb nutrient per 1000 ft^2 = 33 ppm in top 4 inches
- Divide ppm required by 33 to get lbs per 1000 ft^2

Nutrient	Amount Required (ppm)
N	4.7*
P	25+21-30= **16**
K	105+37-40= **102**
Ca	20+331-205= **146**
Mg	10+47-75= **-18**

Phosphorus SLAN:

$$\frac{\text{Lbs Phosphorus}}{1000\ ft^2} = \frac{50\text{-}30 \text{ ppm from test}}{33 \text{ ppm Conv. Factor}} = \frac{\mathbf{0.6 \text{ lb P}}}{1000\ ft^2}$$

$$\frac{0.6 \text{ lb P}}{1000\ ft^2} \times \frac{2.29 \text{ lb } P_2O_5}{1.0 \text{ lb P}} = \frac{\mathbf{1.39 \text{ lb } P_2O_5}}{1000\ ft^2}$$

Using 0-55-0: $\frac{1.39 \text{ lb } P_2O_5}{0.55} = \frac{\mathbf{2.52 \text{ lb}} \text{ 0-55-0}}{1000\ ft^2}$

74

MLSN Calculation Example 2

- Application of 1 lb nutrient per 1000 ft^2 = 33 ppm in top 4 inches
- Divide ppm required by 33 to get lbs per 1000 ft^2

Nutrient	Amount Required (ppm)
N	4.7*
P	25+21-30= **16**
K	105+37-40= **102**
Ca	20+331-205= **146**
Mg	10+47-75= **-18**

Potassium MLSN:

$$\frac{\text{Lbs Potassium}}{1000\ ft^2} = \frac{102 \text{ ppm from soil test}}{33 \text{ ppm Conv. Factor}} = \frac{\mathbf{3.1 \text{ lb K}}}{1000\ ft^2}$$

$$\frac{3.1 \text{ lb K}}{1000\ ft^2} \times \frac{1.2 \text{ lb } K_2O}{1.0 \text{ lb K}} = \frac{\mathbf{3.7 \text{ lb } K_2O}}{1000\ ft^2}$$

Using 0-0-50: $\frac{3.7 \text{ lb } K_2O}{0.50} = \frac{\mathbf{7.4 \text{ lb}} \text{ 0-0-50}}{1000\ ft^2}$

75

MLSN Calculation Example 2

- Application of 1 lb nutrient per 1000 ft^2 = 33 ppm in top 4 inches
- Divide ppm required by 33 to get lbs per 1000 ft^2

Nutrient	Amount Required (ppm)
N	4.7*
P	25+21-30= **16**
K	105+37-40= **102**
Ca	20+331-205= **146**
Mg	10+47-75= **-18**

Potassium SLAN:

$$\frac{\text{Lbs Potassium}}{1000\ ft^2} = \frac{110\text{-}40 \text{ ppm from test}}{33 \text{ ppm Conv. Factor}} = \frac{\mathbf{2.1 \text{ lb K}}}{1000\ ft^2}$$

$$\frac{2.1 \text{ lb K}}{1000\ ft^2} \times \frac{1.2 \text{ lb } K_2O}{1.0 \text{ lb K}} = \frac{\mathbf{2.5 \text{ lb } K_2O}}{1000\ ft^2}$$

Using 0-0-50: $\frac{2.5 \text{ lb } K_2O}{0.50} = \frac{\mathbf{5.0 \text{ lb}} \text{ 0-0-50}}{1000\ ft^2}$

76

Calculation Results: MLSN vs SLAN

Nutrient	Amount Required (MLSN, ppm)	MLSN	SLAN
N	4.7*	**3.8 – 6.2**† lb N/M	**4.2 – 4.8**‡ lb N/M
P	25+21-30= **16**	**1.10 lb** P_2O_5/M	**1.39 lb** P_2O_5/M
K	105+37-40= **102**	**3.7 lb** K_2O/M	**2.5 lb** K_2O/M

† Calculated in relation to MLSN P and K

‡ Calculated in relation to SLAN P and K

77

MLSN Positives

- **Adaptive to future research**
  - Turf nutrient understanding will evolve
- **Adaptive to site and climate**
- **Reduce/redirect costs**
- **Maintain high quality**
- **Environmentally responsible**

78

MLSN

- Good start, Going in the right direction
- Basically SLAN for turf based on turf quality
- Turf quality not always the best guide
- MSLN 6 YEARS, SLAN >86 YRS

79

MLSN Limitations

- **Disease control**
  - Diseases reduced by N
    - dollar spot, rust, red thread
- **Site application history**
  - **If you know you need X, apply X!**
- **Budget consequences**
- **Supply company opposition**

80

HOW ABOUT PASTE EXTRACT?

81

Paste Extract Tests

- Water-soluble test for short term results
- Tells what nutrients are soluble in soil
- Factors influencing paste tests
  - Weather (amount of rain), irrigation, poor water quality, high bicarbonate levels, recent fertilizer applications, topdressing etc.
- Great tool for accessing soil salinity

82

Paste Extract Tests

- Should be used with standard soil tests every time
- Expect low extraction values for fertility
- Bicarbonates will show up (they dissolve easily in water)- they don't cause structure problems or sealing in the soil
- Data is lacking between turf quality and soluble nutrients

83

THE USEFULNESS OF A SOIL TEST DEPENDS ON PROPER INTERPRETATION

84

LABS TEND TO OVERESTIMATE HOW MUCH P IS NEEDED AND UNDERESTIMATE HOW MUCH K IS NEEDED

85

PHOSPHORUS P

FUNCTION

- ENERGY TRANSFER
- STARCH DECOMPOSITION
- GENETIC MATERIAL
  - GRASSES ARE VERY EFFICIENT USERS OF P

86

PHOSPHORUS (BRAY P1)

PPM		LB/A	KG/HA
• 0 - 5	VERY LOW	0 - 10	0 - 11
• 6 - 10	LOW	12 - 20	13 - 22
• 10 - 20	ADEQUATE	20 - 40	22 - 45
• 20 - +	HIGH	40 - +	45 - +

87

PHOSPHORUS

P SUFFICIENCY LEVEL BY EXTRACTANT(CARROW)					
	ppm P				
	Very low	Low	Medium	High	
BRAY P1	0-4	5-15	16-30	>31	
MEHLICH III	0-12	13-26	27-54	>55	
OLSEN	0-6	7-12	13-28	>29	
NUMBERS VARY SOMEWHAT FROM LAB TO LAB.					

88

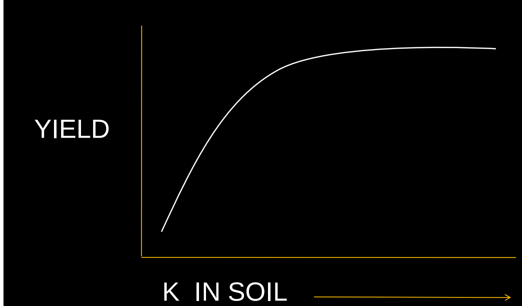
POTASSIUM K

- MYSTERY ELEMENT
- NOT A PART OF BIOCHEMICALS
- ACTS AS COFACTER
- STOMATAL CONTROL

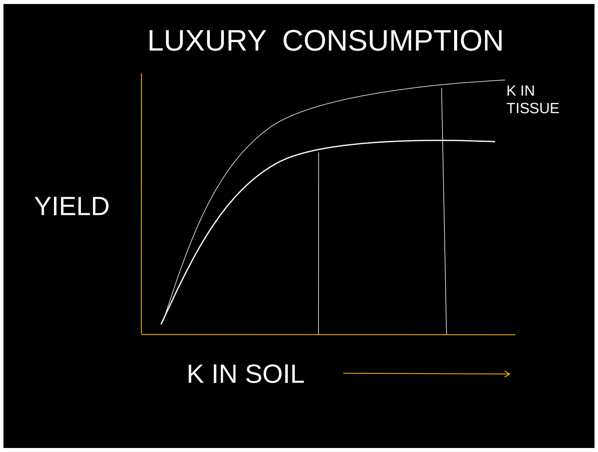
STRESS

89

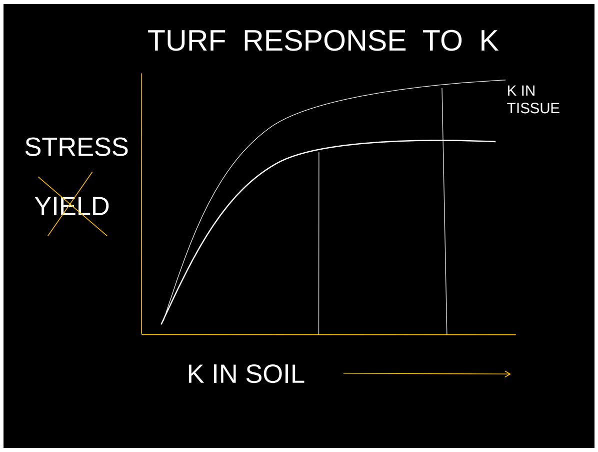
POTASSIUM RESPONSE



90



91



92

POTASSIUM

PPM		LB/A	KG/HA
0 - 40	VERY LOW	0-80	0-90
41 - 175	LOW	81-350	91-392
175 -250	ADEQUATE	350-500	392-560
250- +	HIGH	500-+	560-+

93

RECOMMENDATIONS

- Maintain potassium within sufficiency range:
  - Soil K = 100 to 250 lb/acre or 50 to 125 ppm (Mehlich-III)
  - Tissue K = 2 to 3%
- If a deficiency in soil K exists, potassium can be applied biweekly at 0.2 to 0.3 lbs K_2O/ 1000-sq ft to build up soil K
- To maintain soil K level, potassium can be applied biweekly at 0.1 lbs K_2O/ 1000-sq ft

94

HOW ABOUT Ca, Mg, S and the MICRONUTRIENTS?

95

CALCIUM (Ca)

- Cell wall formation
- Cell division
- Osmotic balance
- Membrane stabilization

96

CALCIUM (Ca)

- 0.30 TO 1.25 % IN TISSUE
- YOUNGER LEAVES TURN REDDISH-BROWN
- FADES TO RED
- LOW pH CONDITIONS
- Liming solves problem

97

SOIL TESTING ISSUES

- New emphasis on Ca in 90's
  - Ca applied to Calcareous ($CaCO_3$) sands
- Ca/Mg ratios
  - Gypsum ($CaSO_4$)
  - Other expensive amendments
- Calcareous sands for greens and sports fields
  - Soil test methods?

98

MAGNESIUM (Mg)

- Center of chlorophyll
- Symptom – Chlorosis
- Low pH & Low CEC

99

MAGNESIUM (Mg)

- 0.15 to 0.50 % in tissue
- > 0.15 % in tissue deficient
- Soil test levels varies with CEC
  - Less than 4 meq
    - Mehlich 1   (30 to 60 ppm)
    - Mehlich 2 (70 to 140 ppm)
    - Ammonium acetate (80-140 ppm)
  - Higher CEC
    - Double the numbers (Carrow 2001)

100

SULFUR (S)

- 0.10 TO 0.50 % IN TISSUE
- YELLOWING OF YOUNGER LEAVES
- SLOW GROWTH
- RARE IN MOST OF U.S. BECAUSE OF HIGH SULFUR COAL
  - 12 to 15 lb/ac in Midwest
- MAY SEE IT IN RARE SITUATIONS

101

IRON (Fe)

- COFACTOR FOR CHLOROPHYLL FORMATION
- SYMPTOM - CHLOROSIS
- HIGH pH
- MOST COMMON OF ALL MICRONUTRIENT DEFICIENCIES

102

IRON (Fe)

- 100 to 500 ppm in tissue
- Soil tests inaccurate
- Very small amounts applied to tissue (0.3 to 0.5 lb Fe/ac)

103

SUMMER INDUCED CHLOROSIS

- David Devetter, MS Student
- Develops during high temperature periods
- Not observed in spring and fall
- Usually on sand, also can be on soil
- It is an iron problem

104

OUR OBSERVATIONS

- Summer-induced iron chlorosis
  - Appears from late July to early September
  - Goes away if left untreated
  - Bentgrass and bluegrass
  - Widespread
    - Multiple countries
    - Golf courses
    - Sports fields
    - Home lawns

  * While common on sand soils it is present in finer textured soils as well

105

Chlorosis

106

107

Conclusions

- Summer-induced chlorosis was caused by an iron deficiency
- Soil temperature may play a role in summer-induced iron chlorosis
- Summer-induced iron chlorosis can be treated with iron fertilization
- Higher rates of iron lead to more color recovery
- Treating before symptoms occur does not work
- Control of chlorosis depends on timing of iron fertilization

108

MANGANESE

- Activator of at least 35 plant enzymes
- Formation of chlorophyll
- Root growth
- Cofactor for lignin formation
- 20 to 500 ppm in tissue
- Soil tests misleading

109

MANGANESE

- YELLOWING SIMILAR TO IRON DEFICIENCY
- VEINS REMAIN GREEN - TIPS MAY REMAIN GREEN
- LEAVES DROP (lignin)
- Take All Patch--Rutgers work

110

Zinc (Zn)

- Catalyst of enzymes
- Regulates gene expression
- Membrane function
- Stress management
  - Saturation
  - High temperature
- 20 to 55 ppm in tissue sufficient
- 15 to 20 ppm deficient

111

Zinc (Zn)

- Deficiency rare
- Toxicity?
- Grant Spear graduate project
  - Soil test labs-18 to 20 ppm in soil toxic

112

SUMMARY

- CREEPING BENTGRASS CAN TOLERATE MUCH HIGHER LEVELS OF ZN THAN ONCE THOUGHT

- LEVELS TERMED EXCESSIVE BY SOIL TESTING LABS ARE WELL WITHIN THE TOLERANCE LEVELS OF CREEPING BENTGRASS

113

COPPER (Cu)

- Catalyst in photosynthesis and resp.
- Carbohydrate formation
- Lignin formation
- 5 to 38 ppm in tissue
- Deficiencies in high pH soils (rare)

114

COPPER (Cu)

MIKE FAUST MS PROJECT ‘98 TO ‘99

- 0 to 600 ppm Cu
- Cu reduced Bentgrass rooting at 200 ppm and above. Approximately 50% reduction at 600 ppm

115

BORON (B)

- Membrane and cell wall formation
- Sugar transport, carbohydrate metabolism
- Respiration
- Little needed (5 to 10 ppm in tissue)
- Deficiencies rare
- Very narrow range between deficiency and toxicity
- Sewage effluent (1 to 2 ppm can be toxic)

116

MOLYBDENUM (Mo)

- Enzyme reactions
- Sulfur metabolism
- Function of P in plant
- 0.1 to 1 ppm in tissue
- Deficiency
  - older leaves pale green
- Toxicity by mines in mountains

117

Chlorine (Cl)
Nickel (Ni)

118

SUMMARY

USING SOIL TESTS TO DEVELOP A FERTILITY PROGRAM

THINGS TO BE AWARE OF

119

Questions?

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120