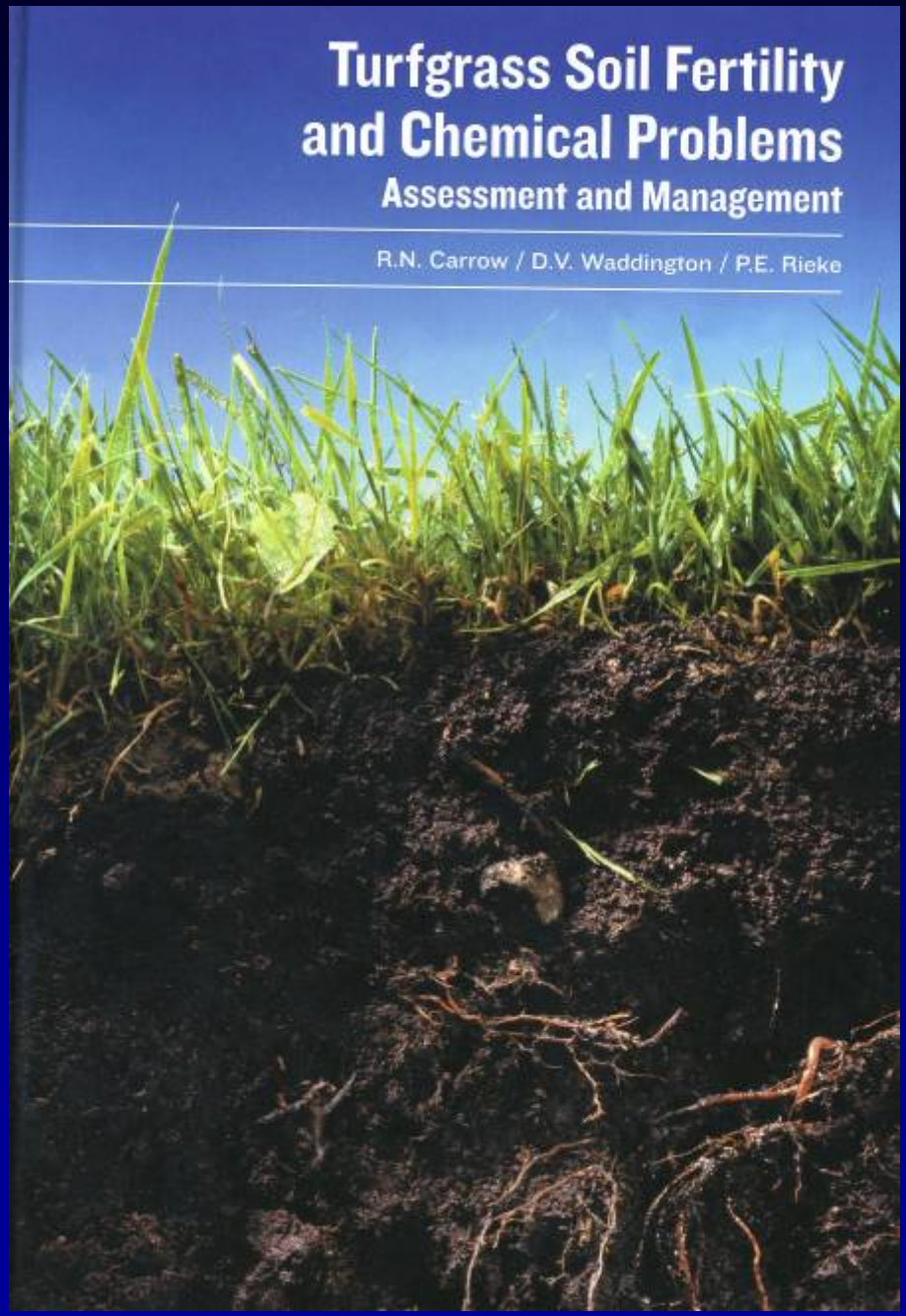
"Turfgrass Soil Fertility and Chemical Problems: Assessment and Management," by R.N. Carrow, D.V. Waddington, and P.E. Rieke. 2001. www.wiley.com $115





Fertilizers and Fertilizer Chemistry



Nitrogen Carriers

- Quick release
- Slow release
- Combinations

Comparison of Nitrogen Carriers

Factor	Quick Release	Slow Release
Cost	Less expensive/lb. N	More costly/lb. N
Initial Plant Response	Rapid	Slow
Burn/salt index	High to Moderate	Low
Duration of response	Short to Moderate	Moderate to Long
Leaching Potential	High to low (depends on amt.)	Low
Efficiency	Generally good	Good over time

Physical Formulations

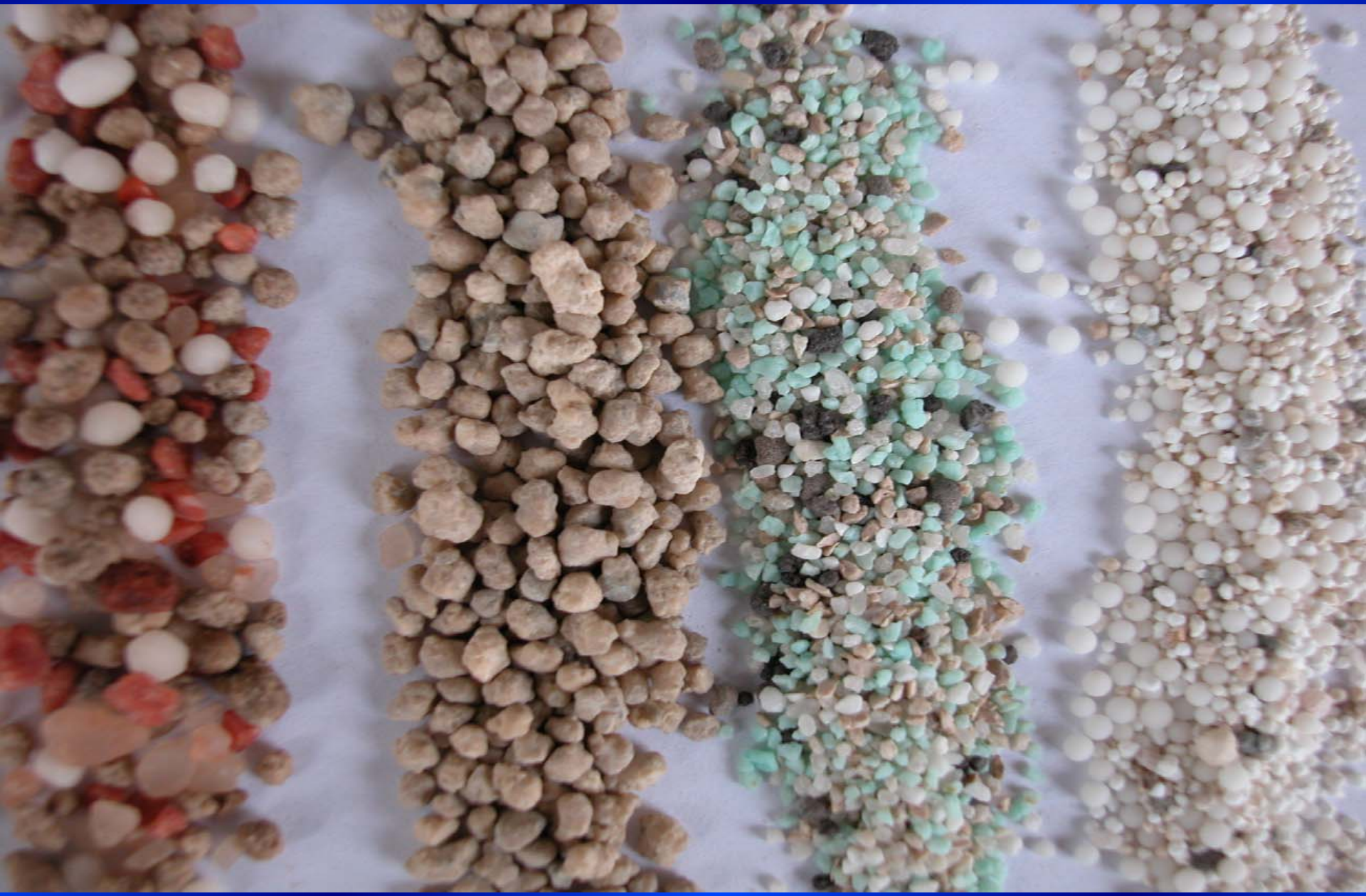
- Granular – size range 0.85-4.75 mm
  - Homogenous = each granule contains all nutrients
  - Blended = different particles for N, P, K, etc.
  - Homogenous vs. blended shouldn't really be a factor assuming uniformity of coverage application

Size Guide Number (SGN)

- Designation used to characterize the size of granular fertilizers
- SGN = the average particle size (to the nearest 0.01 mm) multiplied by 100
- Eg. the SGN for a product with a mean size of 1.9 mm is 190

SGN

- Turfgrass range 80-350
  - –Greens grade: 80-100
  - –Fairway: 125-150
  - –Roughs/High Cut Turf: 210-240



Nitrogen Release Mechanisms

1. Microbial Action
2. Osmosis
3. Hydrolysis
4. Physical Breakdown

1. Microbial Action

- Microorganisms breakdown the fertilizer elements into more basic compounds.
- Soil temperature affects the activity levels of micro-organsims
- Cold temperatures = less activity and less breakdown
- Warmer temperatures = more activity and breakdown
- Methylene ureas and natural organic fertilizers

2. Osmosis

- Chemical elements will naturally move from an area of higher concentration to an area of lower concentration.
- For example, higher concentrations of N, P, K in the fertilizer granule will slowly migrate to the less nutrient-rich soil.

3. Hydrolysis

- Water interacts with the fertilizer, breaking down the compounds and releasing the nutrients into the soil
- Urea and IBDU
  - IBDU slow dissolution

4. Physical Breakdown

- Mowing, foot traffic, and other physical handling of the fertilizer particles will cause nutrients to break down and be released into the soil for plant absorption.
- Breakage of coating results in rapid release

Types of N Carriers

- 1. Fast/quick release - water soluble
  - A. Salt based N carriers - all types dissolve readily when adequate water is present forming either NO_3^- or NH_4^+
  - NO_3^- can be leached
  - NH_4^+ can be held on cation exchange sites

Quick Release N Carriers (Salt Types)

Carrier	Analysis	N Release
Ammonium nitrate (NH_4NO_3)	33-0-0	Water soluble
Ammonium sulfate ($(NH_4)_2SO_4$)	20-0-0	Water soluble
Potassium nitrate (KNO_3)	13-0-44	Water soluble
Monoammonium phosphate - MAP ($NH_4H_2PO_4$)	11-48-0	Water soluble
Diammonium phosphate - DAP ($(NH_4)_2HPO_4$)	18-46-0	Water soluble
Calcium nitrate $(CaNO_3)_2$	16-0-0	Water soluble

Characteristics of Salt Types

- High salt index/high potential for burn
- Rapid response
- Apply at low rates, spoon feeding programs
- Inexpensive

Salt Index

- Measure of the osmotic pressure created in the soil solution by the addition of fertilizers
- Salt index values are based on applications of equal weights of materials, and are expressed relative to the osmotic pressure produced by sodium nitrate (assigned value of 100)

Salt Index

Material	Equal amts. of material	Equal amts. of nutrient (N)
Sodium nitrate	100	6.06
Potassium nitrate	74	5.34
Amm. Sulfate	69	3.25
Amm. Nitrate	105	2.99
MAP	30	2.45
Urea	75	1.62
DAP	34	1.61
Nat. Organic (5%N)	3.5	0.70

Salt Index

Material	Equal amts. of material	Equal amts. of nutrient (K_2O)
Potassium chloride	116	1.94
Potassium nitrate	74	1.58
Potassium sulfate	46	0.85
Potassium mag. Sulfate	43	1.97

Ammonium Sulfate

- 21% N $(NH_4)_2SO_4$
- Highly soluble and leachable
- Subject of volatilization
- Very acidifying - 5.35 kg acidity/kg N
- High salt index - 3.25

Ammonium Nitrate

- 33.5% N
- Very soluble
- Highly leachable
- Subject to volatilization
- Low acidity
  - 1.8kg acid/kg N
- High salt index - 2.99

Types of N Carriers

2. Organic quick release carriers

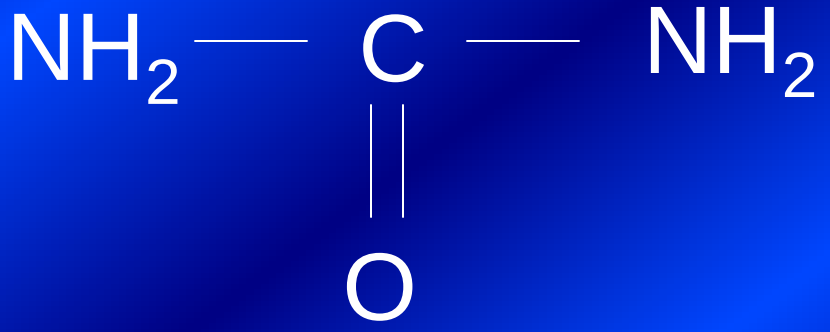
- –Urea
- –Short & long chain methylene ureas that are created by reacting urea with formaldehyde

What is Organic?

- Perception
  - of, relating to, or derived from living organisms
- Webster's Dictionary….
  - of, relating to, or containing carbon compounds

By this definition organic fertilizers include……

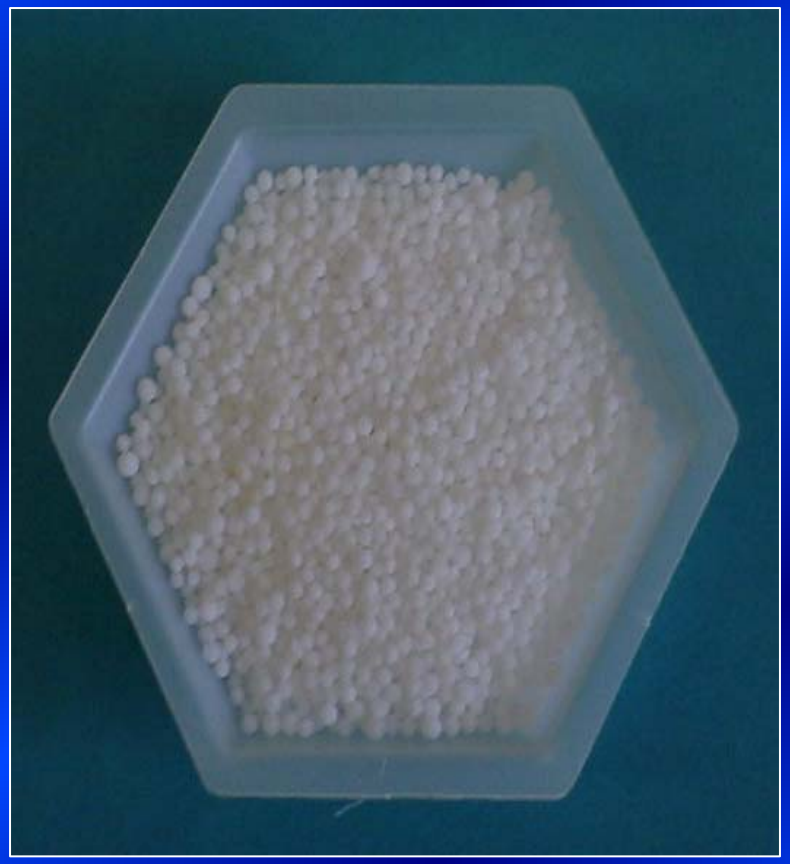
- Urea and many other chemically derived fertilizers such as IBDU, triazone, and methylene ureas



Synthetic Organic Fertilizers

Urea

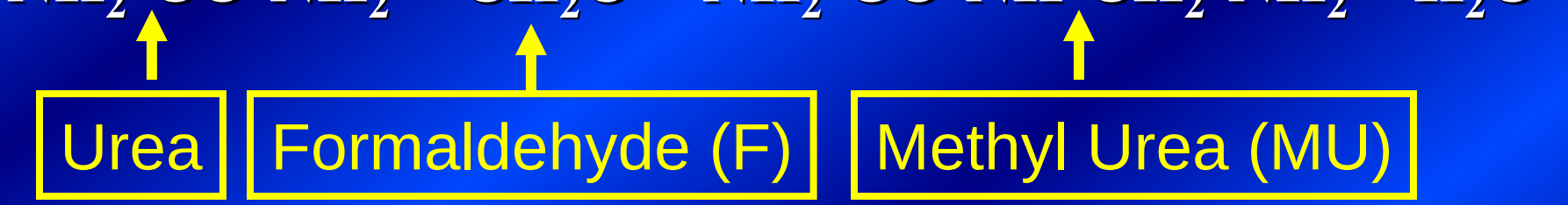
- 46% N
- Soluble Synthetic Organic
- Nonionic, highly leachable
- Subject to volatilization
- Low acidity - 1.8/kg N
- Low salt index - 1.62



Synthetic Organic Quick/Slow Release Carriers (Methylene Ureas)

- MU's are released by soil microbial activity
  - Release affected by soil moisture and temperature – amount of N released is closely matched to plant demand
- Short chain molecules are water soluble
- Longer chain molecules are water insoluble
- Longer chain molecules - N is released by microbial degradation

Urea formaldehyde reaction



$$NH_2\text{-}CO\text{-}NH\text{-}CH_2\text{-}NH_2 + NH_2\text{-}CO\text{-}NH_2 = NH_2\text{-}CO\text{-}NH\text{-}CH_2\text{-}NH\text{-}CO\text{-}NH_2$$

Methyl Urea + Urea = Methylene diurea (MDU)

MDU + Urea = dimethylene triurea (DMTU)

DMTU + Urea = trimethylene tetraurea (TMTU)

TMTU + Urea = tetramethylene pentaurea (TMPU)

TMPU + Urea = pentamethylene hexaurea (PMHU)

N Fractions of Urea Rxn. Products

CWSN – Fraction 1
(Cold Water Soluble N)
Immediate to 2 wks.
(urea, short chain MUs – MDU and DMTU)

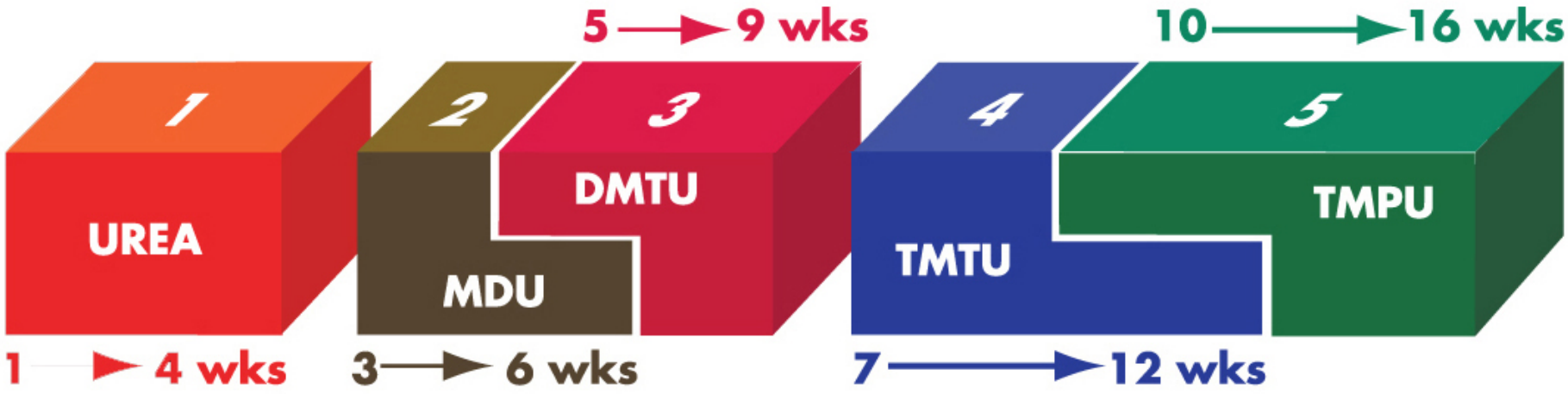
Cold Water Insoluble N or WIN
(Water Insoluble N)

HWSN – Fraction 2
Hot Water Soluble N
2-3 months
(Intmd. chain MUs - Microbial)

HWIN – Fraction 3
Hot Water Insoluble N
months to years
(long chain MUs - Microbial)
(PMHU)

Maximum this fraction

RELEASE PROFILE OF MUTECH



Water Soluble Nitrogen

Slowly Available Water Soluble Nitrogen

Water Insoluble Nitrogen

Ureaformaldehyde Reaction Products

- Known as:
  - Methylene Urea
  - MU
  - Ureaformaldehyde
  - UF

Ureaform

- At least 35% N
- 60% of N as CWIN
- Activity Index (AI)
  - The percent of CWIN that is soluble in Hot Water (HWSN)
- AI not less than 40%
- Marketed as: Nitroform, UF, Blue Chip

Nitroform

- Urea formaldehyde (Ureaform)
- Insoluble organic
- 38% N ; 65-71% WIN
- Biological N release
  - rate influenced by soil temperature
  - 8-12 month release

Methylene Urea Products

- Nutralene (Agrium)
- Nitroform (Agrium)
- Meth-Ex 40 (Lebanon)
- NOVEX (John Deere/Lesco)
- MUtech, MUtech-L (The Andersons)

Nutralene

- Methylene Urea
- 40% N - 36% WIN
- N release: hydrolysis (urea)
- Biological N release
  - 12-16 weeks release
- More rapidly available than UF
- Not as adversely influenced by cool temperatures

Nitroform vs. Nutralene

- Total N: 38%
- Urea N: 4.5%
- CWSN: 6.9%
- CWIN & HWIN: 27%
- High % of long chain MU's

- Total N: 40%
- Urea N: 5.0%
- CWSN: 20.5%
- CWIN & HWIN: 14.5%
- High % of short chain MU's

MESA

- **M**eth **E**x **S**ulfate of **A**mmonia
- Homogenous granule combining Meth-Ex 40 and ammonium sulfate
- NOT a coated product
- MU encapsulates AMS and inhibits its release until particle is watered into soil
- AMS released by hydrolysis and MU by microbial activity

Slow Release N Carriers

- To be classified as slow release N carrier, the slow release components must be identified on the label and constitute at least 15% of the total N in the fertilizer

Definitions

- **Controlled release fertilizer**
  - **Synonymous with delayed release, controlled availability, slow acting, and metered release to designate a controlled dissolution of fertilizer at a lower rate than conventional water-soluble fertilizers such as urea**
- **No official differentiation between slow release and controlled release**
  - **Microbially decomposed N products (UF's) are commonly referred to as slow release**
  - **Coated or encapsulated products = controlled-release**

Slow Release N Carriers

- 1. Synthetic organic N carriers - methylene urea based, provide a mixture of sources to provide both short and long term response

- 2. Natural organic N carriers
  - –Derived from a variety of sources such as animal, plant, sewage, composts
  - –N release is based on microbial degradation

Natural Organics

- by products from plant and animal processing industries or waste products

Natural Organics Claims..

- Source of nutrients
- Thatch decomposition through inoculation with bacteria or by stimulation of earth worms…..
- Addition of organic matter…may increase nutrient retention

Natural Organic Products

Milorganite	**6-2-0**
Sustane (turkey litter)	**4-5-3**
Ringer Greens Restore	**6-1-3**
Ringer Turf Restore	**10-2-6**
N-Hance (poultry manure)	**4-5-4**
Turf Cocktail	**4-1-1**
Sustane	**5-2-4**
Natural Science	**15-1-8**

- Many natural organic products contain additional nutrients (not guaranteed in analysis)
- For example: Milorganite – K, Ca, Mg, S, Mn, Zn, Cu, B, Mo

Characteristics of Natural Organics

1. Low Nitrogen content
2. Water insoluble nitrogen
3. Slow N release
4. Presence of other essential plant nutrients
5. N release dependent upon microbial activity
   - Water, oxygen, temperature, pH

Drawbacks/Negatives

- Odor
- Small particle size/dust
- Low N content – need to store large amts.

IBDU – 31%N

- N release is slow due to low solubility – once in solution, readily hydrolyzed to urea and isobutyraldehyde
- Relatively unaffected by
  - –temperature
  - –pH
- Particle size major influence on N release
- Small particles release fast and big particles release slow
- Release increases with soil water content
- 3-4 wk. Delay in response after application

Slow Release N Carriers

Coated N carriers

- –Several coating technologies including sulfur, resins, plastics, waxes, polymers
- –N release occurs with diffusion of water into the granule and diffusion of urea out of the granule into soil solution

Sulfur-Coated Urea

- 32-38% N, depends on coating thickness
- Coating - sulfur and usually a wax coating to seal imperfections in sulfur coating
  - Sulfur content 12-22% (not soluble, make take months to mineralize SCU skeletons)
- N released by gradual diffusion
- Release depends upon
  - thickness & integrity of sulfur coating
  - Release increases as coating thickness decreases and as temp. increases

Sulfur-Coated Urea

- Not all particles are created equal
  - Imperfectly coated – immediate release
  - Intermediate release from imperfect coatings covered with sealant
  - Longer release for perfectly coated or thicker coated particles
  - ‘Lock-off’ = N that is not released, N does eventually release but may take years???

Polymer Sulfur-Coated Urea

- Urea coated with sulfur and then coated with layer of polymer
- Polymer as a sealant and delays water entry into sulfur coating - makes product less susceptible to breakage/abrasion during shipping and spreading
- N released by gradual diffusion
- Release influenced by coating thickness and type, some temperature response

Polymer Sulfur-Coated Urea Products

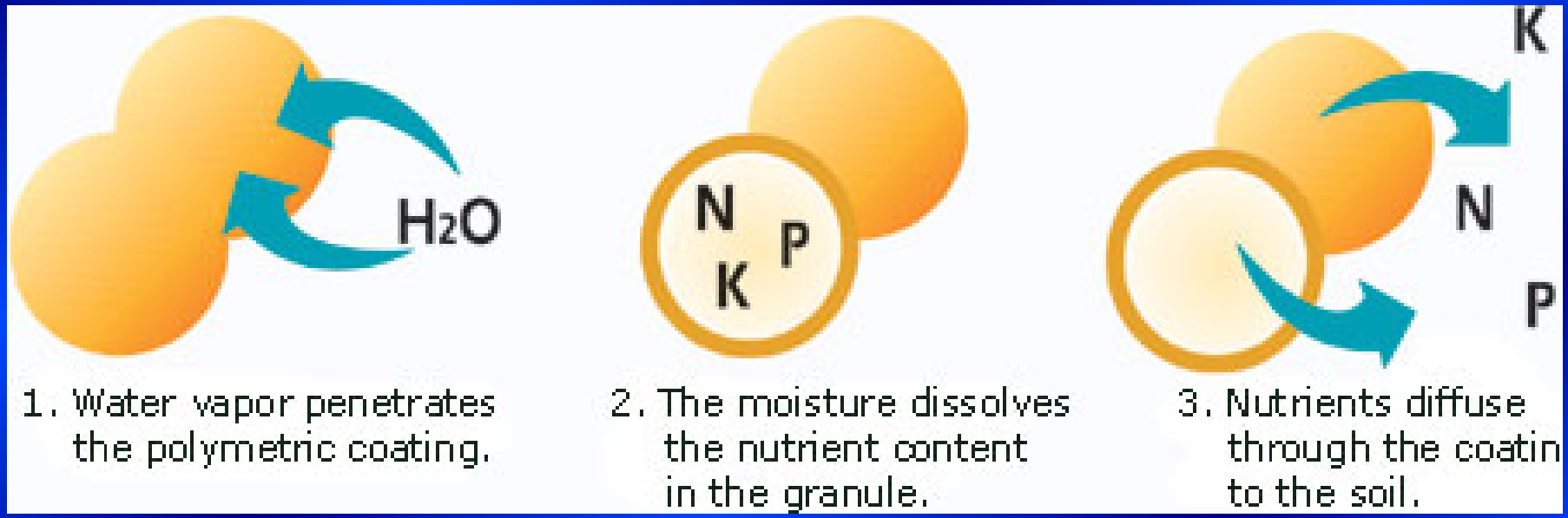
- TriKote (Agrium, formerly Pursells)
- Poly-S (The Andersons)
- NS-52 (The Andersons)
- Poly Plus (John Deere/Lesco)
- XCU (Agrium)

Polymer-Coated N Sources

- Soluble N sources coated with polymers to slow N release
- Synonymous with “Resin-coated” and “plastic-coated”
- Thinner coatings than SCU’s – results in higher N contents
  - 39 to 44% N

Polymer-coated N release

- Release increases with increased temperature
- Release not influenced by:
  - Soil water level
  - Volume of water applied
  - Soil pH
  - Microbial activity



Polymer-Coated Products

- Polyon (Agrium, formerly Pursells)
- Duration CR (Agrium)
- Extend (The Andersons)
- V-Cote (Vigoro)
- MultiCote (Haifa Nutritech)
- Osmocote (Scotts)
- SurfCote (Knox)

Polyon

- 37 to 44% N
- Polyurethane coated urea
- N release influenced by
  - coating thickness
  - diffusion rate
  - soil temperature
- Coating is abrasive resistant
- Regular 240-260 SGN: 37-44%N
- Mini 150-180 SGN: 41-43% N
- Micro 100-110 SGN: 41% N

Nitrification Inhibitors

- Applied to ammonium or urea sources to reduce the rate of conversion to nitrate
- Nitrapyrin – marketed as N-Serve
  - Has some bactericidal effect – part of *Nitrosomonas* bacteria population is killed – registered as pesticide in USA
- Dicyandiamide (DCD) – marketed as Didin
  - Bacteriostatic effect on *Nitrosomonas* bacteria – bacteria are not killed but only depressed or inhibited

Urease Inhibitors

- May be applied to urea to reduce the rate of hydrolysis to ammonium
- Could reduce the potential for volatilization of ammonia
- NBPT: [N-(n-butyl) thiophosphoric triamide)
- PPD: phenyl phosphorodiamidate

Stabilized Fertilizer

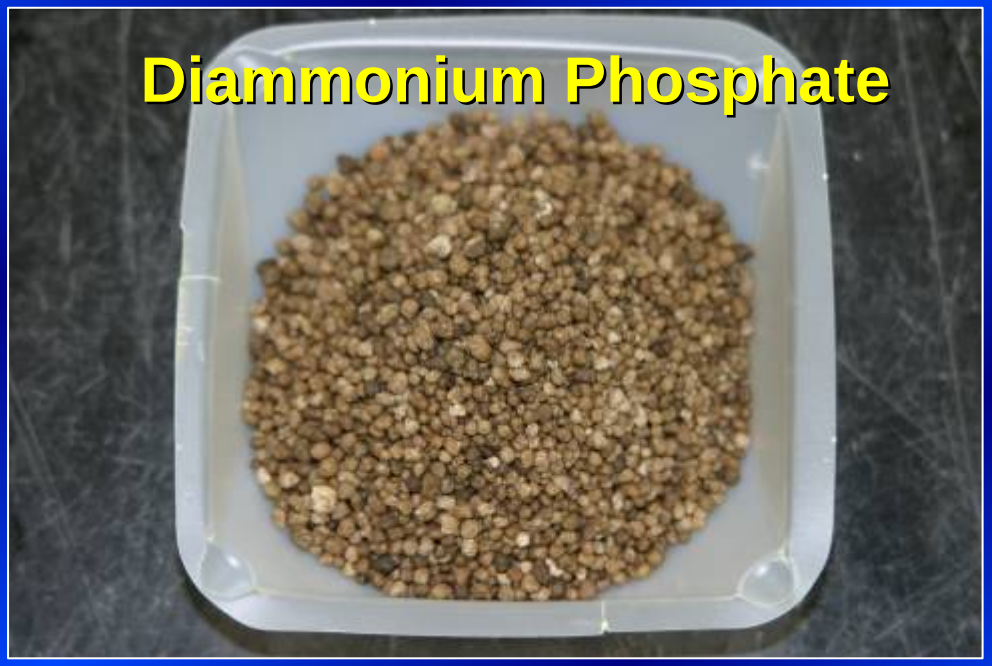
- Stabilized fertilizer – fertilizers amended with nitrification or volatilization inhibitors
- Fertilizer Products:
  - UMAXX (47-0-0)
    - Contains nitrification (DCD) and volatilization (NBPT) inhibitors
  - Lebanon Turf Stabilized Nitrogen (LSN)
    - Contains volatilization (NBPT) inhibitors
- UMAXX: nitrification inhibited for 16 wks.
- Volatilization inhibited for approx. 2 wks.

Phosphorus Carriers

- **Superphosphates (calcium phosphates)**
  - **0-20-0 contains gypsum [$Ca(H_2PO_4)_2CaSO_4$] - (20% Ca, 11% S)**
  - **0-46-0 (triple superphosphate) $Ca(H_2PO_4)_2$ - (13% Ca)**

Phosphorus Carriers

- **Ammonium phosphates**
  - **Monoammonium phosphate (MAP) 11-48-0 ($NH_4H_2PO_4$)**
  - **Diammonium phosphate (DAP) 18-46-0 ($(NH_4)_2HPO4$**
- **Sewage sludges**



Phosphorus Carriers

- Potassium phosphates
- Ammonium polyphosphates (10-34-0)
  - Primarily used in fluid fertilizers
- Phosphoric Acid (0-55-0)
  - Used to manufacture triple superphosphate and ammonium phosphates
  - Can be used in fluid fertilizers
  - Highly acidic – handle with care!
- Magnesium ammonium phosphate (8-40-0)
  - 14% Mg – slow dissolution rate – slow-release source of N, P, Mg

Phosphite Fertilizer Trial

GRIGG BROS.

- **Potassium phosphite**
  - **a.i. in Alude, Magellan, Vital, Resyst and other fungicides**
  - **Main ingredient in fertilizer products:**
    - **Grigg Brothers P-K Plus (3-21-18)**
    - **K-Phite (0-29-26)**
    - **Ele-Max Foliar Phosphite (0-28-26)**
    - **Nutri Phite P + K (0-28-26)**

Phosphate vs. Phosphonate

- **Phosphate taken up by plants and incorporated into cells – ATP, DNA**
  - **Minimal effect if any on turf diseases**
- **Phosphonate fungicides and fertilizers**
  - **Taken up by plants and incorporated into cells as phosphite ions ($H_2PO_3^-$) – not involved in P metabolism in plant**
  - **Does have fungitoxic effects on plant pathogens**

Phosphite Research Trial

- Compare phosphate vs. phosphite for:

- Turfgrass growth
- Tissue Phosphorus concentration
- Rooting mass

Materials and Methods

- Greenhouse experiment initiated September 7th, 2006
- Silica sand rootzone (no available P)
- Providence creeping bentgrass

Treatments

- All fertilizer treatments applied after germination
- Treatment 1 (control) – all nutrients supplied weekly
- Treatment 2 (phosphate) – all nutrients supplied but less than full rate of $NH_4H_2PO_4$ supplied weekly
- Treatment 3 (phosphite) – all nutrients supplied but less than full rate of $NH_4H_2PO_4$ supplied weekly

- **P deficiency symptoms obvious in treatments 2 and 3 on October 10th**

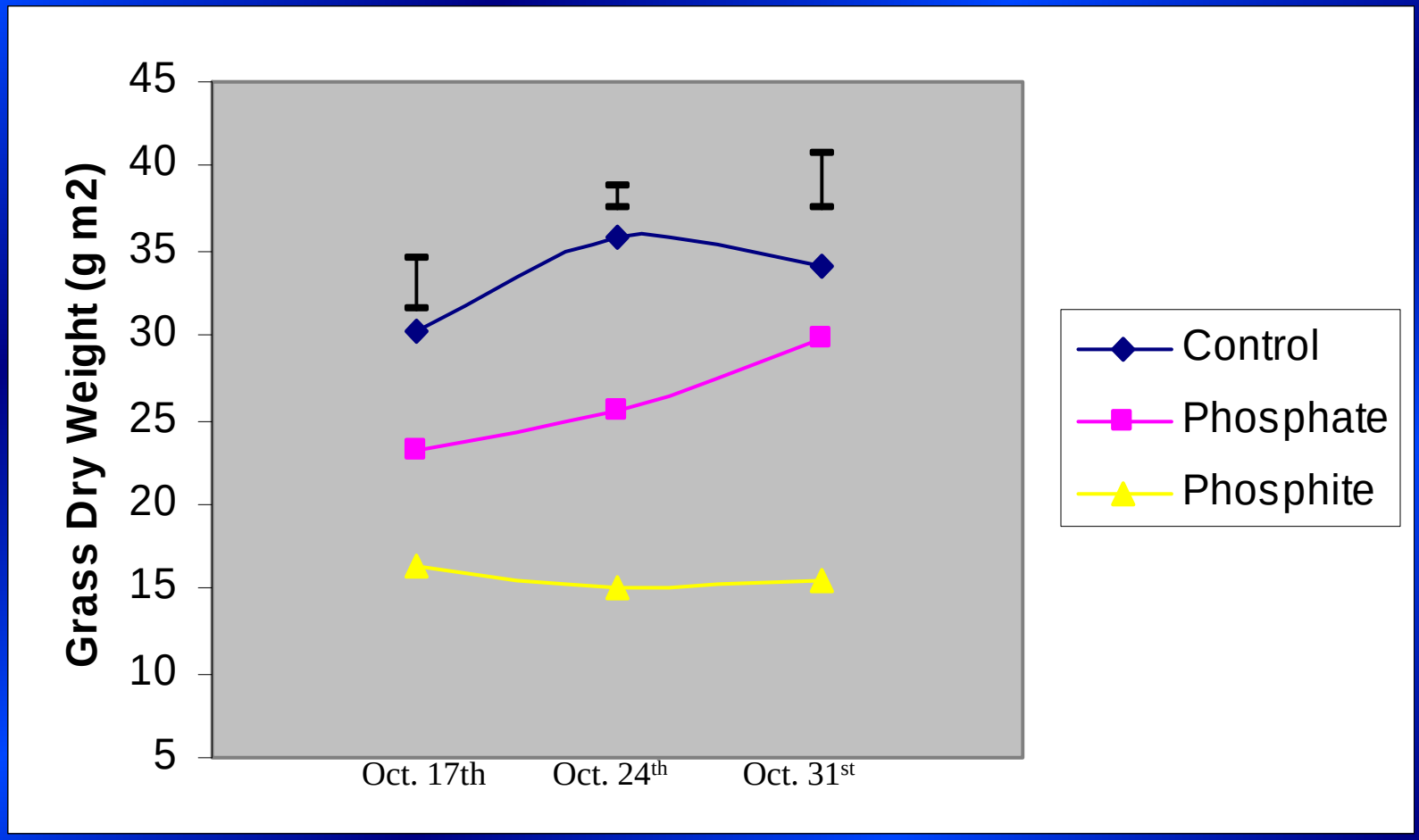
- **Beginning Oct.10th, phosphate treatment 2 received 3-18-18, diluted to give 0.18% phosphate weekly**

- **Beginning Oct.10th, phosphite treatment 3 received 1-0-26, diluted to give 0.18% phosphite weekly**

Data

- Grass dry weights were collected on a weekly basis starting on October 17th
- Leaf tissue phosphorus was measured weekly starting on October 10th
- Dry root weights and turfgrass density were measured at the end of the experiment

Figure 1. Grass Dry Weight

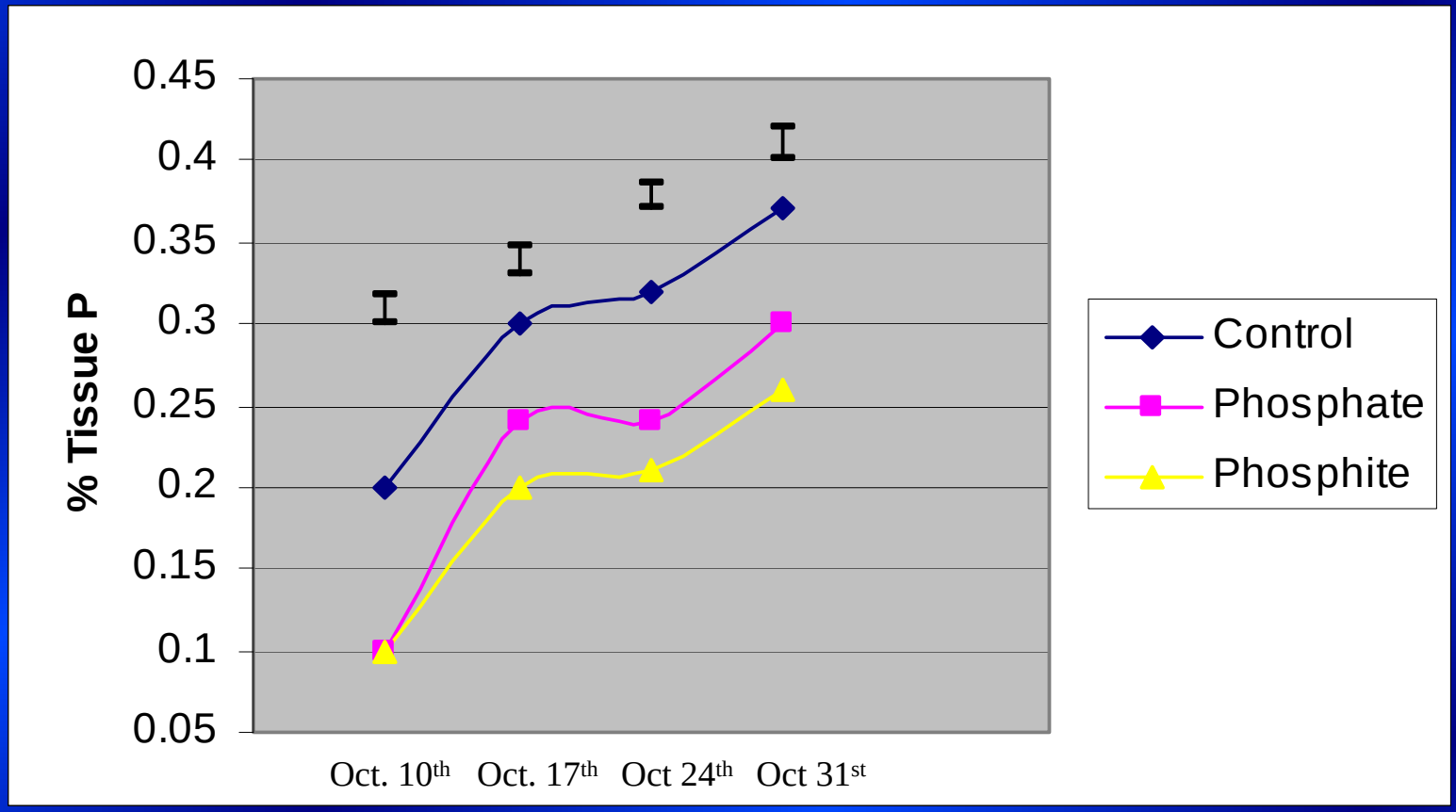


Grass Dry Weights

- **The control treatment had significantly higher grass dry weights compared to both the phosphite and phosphate treatments on all measurement dates**

- **The phosphate treatment had significantly higher grass dry weights compared to the phosphite on all measurement dates**

Figure 2. Tissue P Concentrations



Leaf Tissue Phosphorus

- **The control treatment had significantly higher tissue P concentrations compared to both the phosphite and phosphate treatments on all measurement dates**

- **The phosphate treatment had significantly higher tissue P concentrations compared to the phosphite on all measurement dates**

Table 2. Mean rooting mass (g)

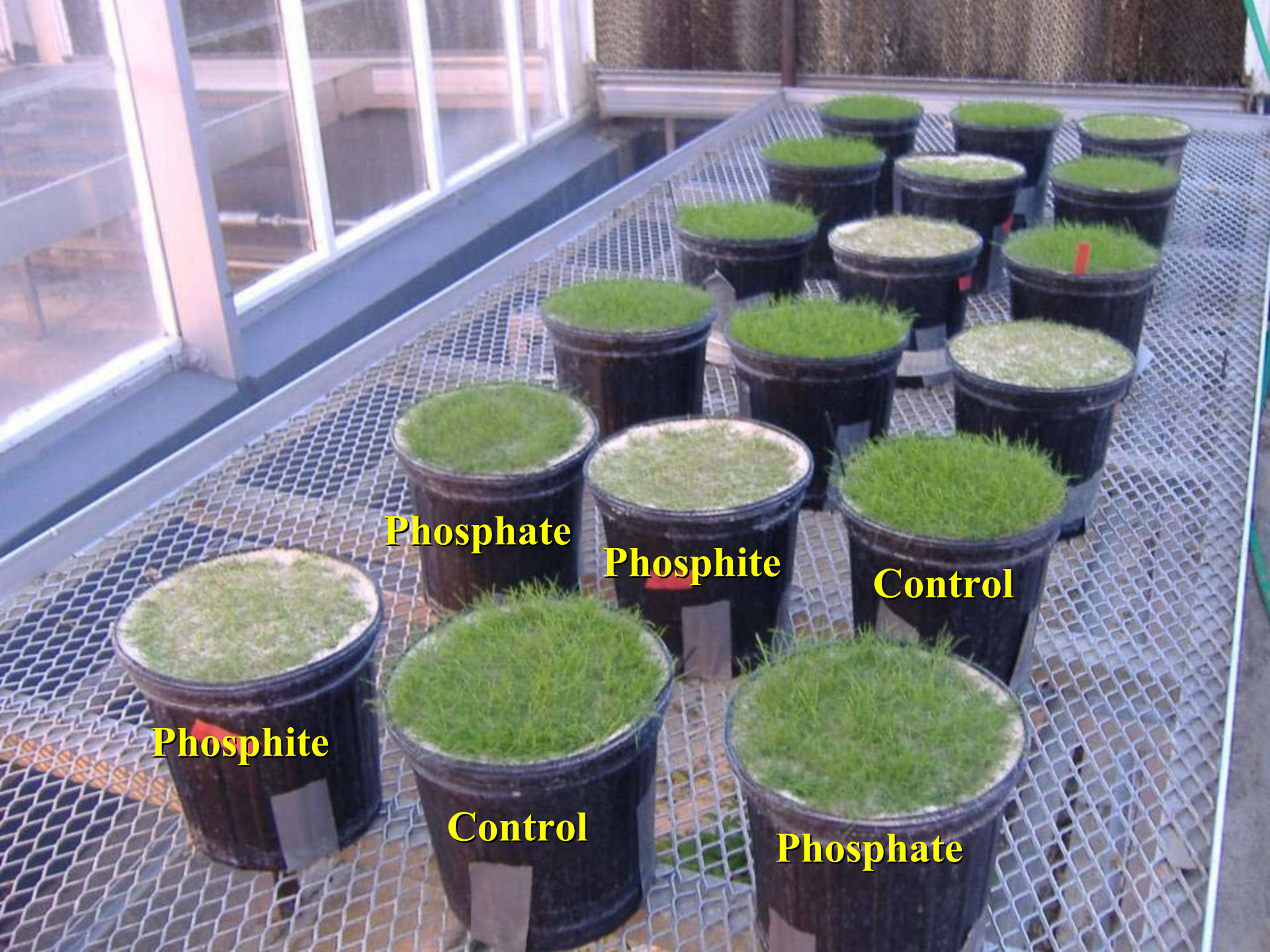
Treatment	df	October 31st
Control	2	1.09a†
Phosphate	2	1.02a
Phosphite	2	0.64b
LSD		0.15

† Means followed by the same letter within a column are not significantly different according to Fisher's LSD (P=0.05).

Root Mass

- Both control and phosphate treatments had significantly higher root mass weights than the phosphite treatment

- No significant difference in root mass weight was found between the control and phosphate treatment


Phosphate
Phosphite
Control
Phosphite
Control
Phosphate

Conclusion

- **Phosphite applications appear to have limited if any influence on turfgrass growth and development with respect to phosphorus metabolism**

Conclusion

- Research has shown phosphite applications to have an influence on disease incidence and overall turfgrass quality

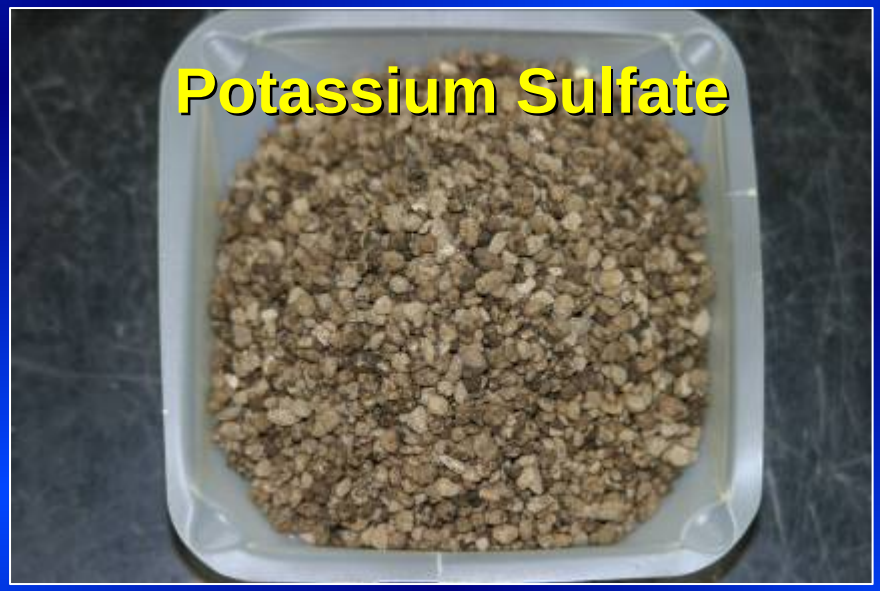
Potassium Carriers

- Muriate of potash/potassium chloride (KCL)
  - 0-0-60 to 0-0-62
  - Low cost, high salt index, burn potential

Muriate of Potash

Potassium Carriers

- Potassium sulfate/sulfate of potash (K_2SO_4)
  - –0-0-50 to 0-0-52, 17% S
- Potassium nitrate (KNO_3) 13-0-44



Potassium Carriers

- Potassium magnesium sulfate (0-0-22)
  - Sul-po-mag, trade name
  - 11% Mg, 22% S ($K_2SO_4MgSO_4$)
- Complete fertilizers
- Coated potash sources
- Potassium phosphates, potassium hydroxide

Calcium Carriers

- Liming materials – limestones, calcium hydroxide, calcium oxide, slag
- Gypsum ($CaSO_4 \cdot 2H_2O$) primary use is on sodic soils, 22% Ca, 18% S
- Calcium phosphates 0-22-0 contains 18-21% Ca
  0-46-0 contains 12-24% Ca
- Calcium nitrate

Magnesium Carriers

- Dolomitic liming materials $CaCO_3 \bullet MgCO_3$
- Epsom salts $MgSO_4 \bullet 7H_2O$ 10% mg, 13% S
- Sul-po-mag, sulfate of potash & magnesium, potassium magnesium sulfate 22% K_2O, 11% Mg, 22% S
- Magnesium oxide 55% Mg

Sulfur Carriers

- **Elemental S – usu. 90% S, various forms:**
  - **Powder, ground, sulfur suspensions (flowable), reconstituted**
  - **Must be oxidized to SO_4^-**
- **Sulfate carriers**
- **Sulfur coated ureas, ammonium thiosulfate (12% N, 26% S)**

Iron

- Not a component of chlorophyll
- Iron is a component of structures important in the synthesis of chlorophyll
- Iron in the soil is usually insoluble and unavailable to the plant

Iron

- Grasses acquire iron from the soil by making and releasing phytosiderophores from the roots

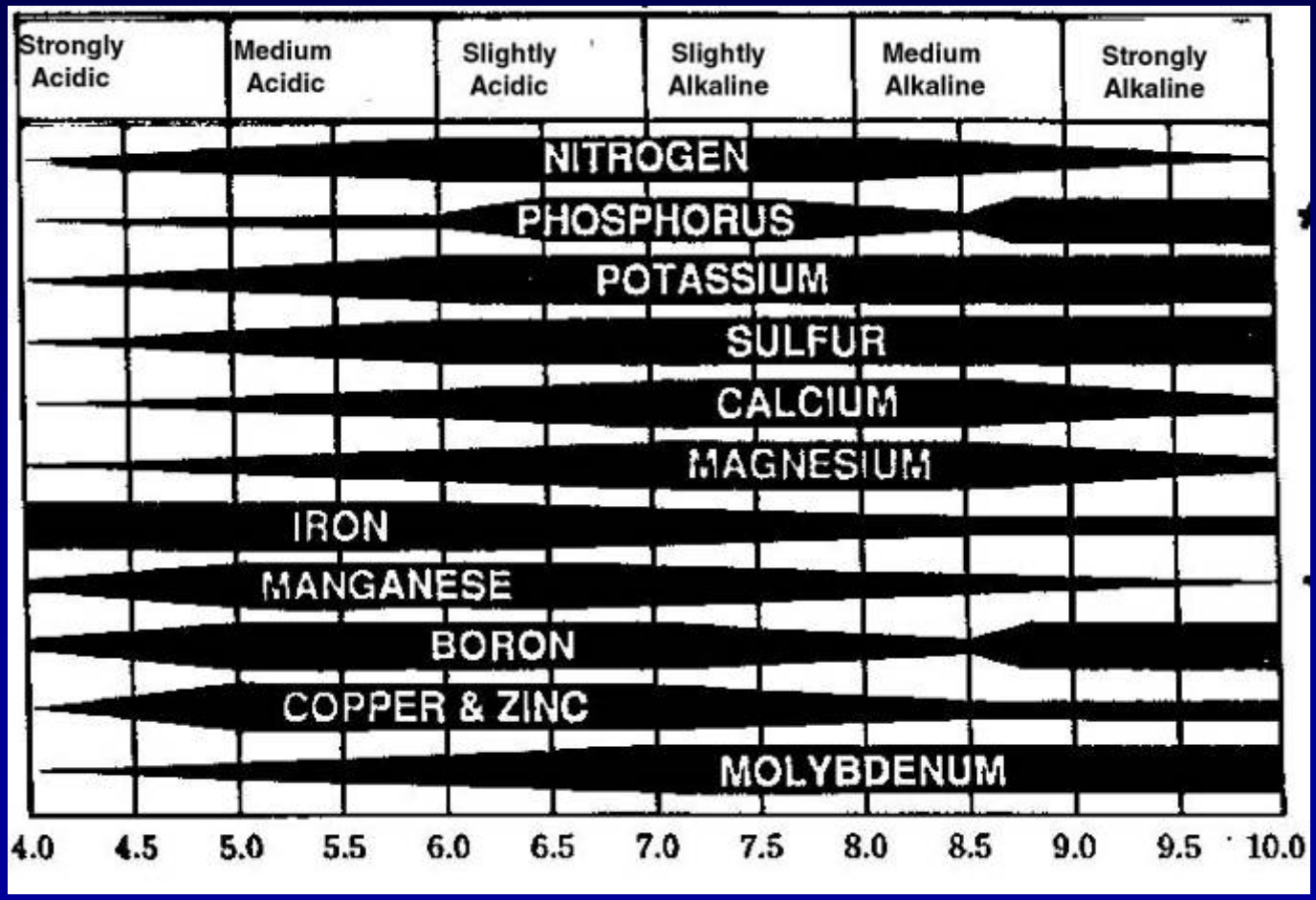
- Phytosiderophores chelate (bind) the insoluble oxidized iron (Fe^{+3}) and carry it into the plant

Iron

- Non deficient turf: enhance color
- Deficient turf: rarely occurs on cool season turf

THE EFFECT OF SOIL pH ON NUTRIENT AVAILABILITY

Soil pH greatly affects nutrient availability. By noting that the width of the bar is directly proportionate to that nutrient's availability, you can tell that potassium, for example, becomes less available at pH levels below 6.0. So, deficiency problems may actually be soil pH problems.



Iron Carriers

- Ferrous sulfate $FeSO_4 \bullet 7H_2O$ (19% Fe)
  - 1-3 ounces in 2-5 gal H_2O/1000
- Ferrous ammonium sulfate
  - $(NH_4)_2SO_4 \bullet FeSO_4 \bullet 6H_2O$ (14% Fe)
- Iron oxides
- Milorganite (5% Fe) and other organic sources

Iron Oxide

- 50% Fe
- Widely used as Fe source in granular fertilizer, cannot be applied in solution
- Not soluble in soil with pH 5.5 or greater
- Not recommended as Fe source in conditions where Fe is deficient

Iron Carriers

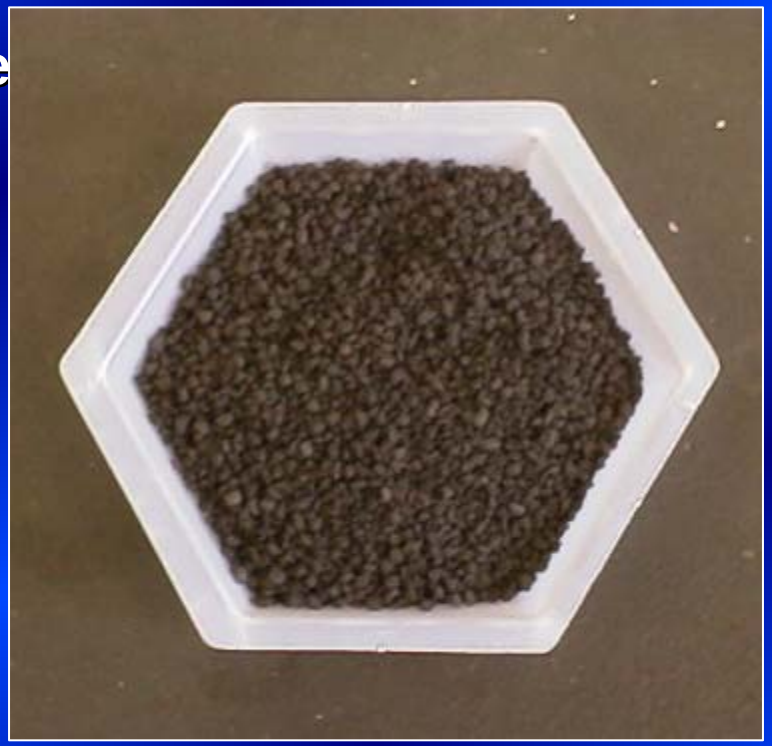
- Chelate is an organic compound formed when a cation or anion is bound by a ring structure of either naturally occurring or artificial chelating agents
  - "clawlike" chemical that capsulates an element
- Chelated iron (follow label rates)
  - Sequestrene 330
  - NaFe EDTA on neutral to slightly acid soils
  - NaFe HEDTA on acid soils
  - NaFe EDDHA on soils ph 4-9
  - NaFe DTPA on soil about pH 7
  - Citric acid
- Added to complete fertilizers or combination micronutrient product

Fe-EDTA

- NaFe-EDTA - 14% Fe
- Best on neutral to acid soils
- May be soil applied or as foliar spray
- Foliar better
- Minimal staining

Granusol

- Fe Sucrate - 50% Fe
- 4-5% water soluble Fe
- Iron oxide reacted with carbohydrate (molasses)
- Produced good Centipede growth and color at pH 8.0 – good response at high pH
- “Iron Safe” contains Fe sucrate



Sequestrene 330

- 10% Fe
- Sodium Ferric diethylene-triamine pentaacetate (DTPA), chelated
- Good Fe source on soils with pH 6.5-7.5
- May be applied to soil or as foliar spray

Iron Humate

- 25 - 28% Fe
- Produced as a by-product of water purification
- Not recommended as Fe source in unmodified form
- Degrades very slowly in soil (slow release Fe)
- “Perk” contains ferrous sulfate and iron humate

Lebanon TURF PRODUCTS
Our reputation is growing yours.

TECHNICAL DATA SHEET

SGN 145

PERK® 4-0-10
Stress Relief Formula

Type A unique, homogeneous formulation of essential turfgrass nutrients engineered to avoid stimulating growth. Over 50% of the formula is derived from organically complexed iron.

Guaranteed Analysis

Nitrogen (N)	**4.0%**
4.0% Ammoniacal Nitrogen	
Soluble Potash (K_2O)	**10.0%**
Magnesium (Mg)	1.5%
1.5% Water soluble Magnesium (Mg)	
Sulfur (S)	10.0%
10.0% Combined sulfur (S)	
Iron (Fe)	10.0%
1.1% Water soluble Iron (Fe)	

NUTRIENT SOURCES
Ammonium sulfate, Sulfate of potash, Sulfate of potash-magnesia, Ferrous sulfate, and Iron humate.

Size Midsize -10+20 145 SGN 57 lbs per cubic foot A full-weight, high density product

Uses Lebanon PERK® Stress Relief Formula 4-0-10 with 10% Fe and 1.5% Mg promotes good turfgrass color through good health and nutrition without unwanted growth. When used on turf mowed at one-half inch or less, apply a test plot to make sure unwanted spotting or staining does not occur before applying to the entire turf area.

Coverage

Fe/M Rate	Lbs per 1,000 sq ft	Lbs required to Cover One Acre	Acres Covered by One Ton	Sq Ft Covered Per Bag	Product Required for 25 Acres
0.5	5.0	218 lb	9.2	10,000	109 bags
0.75	7.5	327 lb	6.1	6,650	163 bags
1.0	10.0	436 lb	4.6	5,000	218 bags

Features

1. Provides the essential turfgrass nutrients potash, iron, and magnesium with lower nitrogen levels so good plant nutrition is achieved without unwanted growth.
2. Primary emphasis on potash increases turf's ability to resist the stress of hot weather.
3. Unique iron package is based upon 50+% iron humates and fulvates, organically complexed iron which has been documented to increase the CEC of sandy soils and also acts as a slow-release source of iron.
4. University studies have shown that higher levels of iron will cause stress to *Poa annua* while stimulating bentgrass.
5. Humic acids have significantly improved photosynthesis (but not chlorophyll levels) and also increased enzyme activity and root mass in bentgrass.
6. This product has a high tendency to disperse when contacted with moisture or irrigation.
7. Magnesium is included for better micronutrient balance and good turfgrass color.

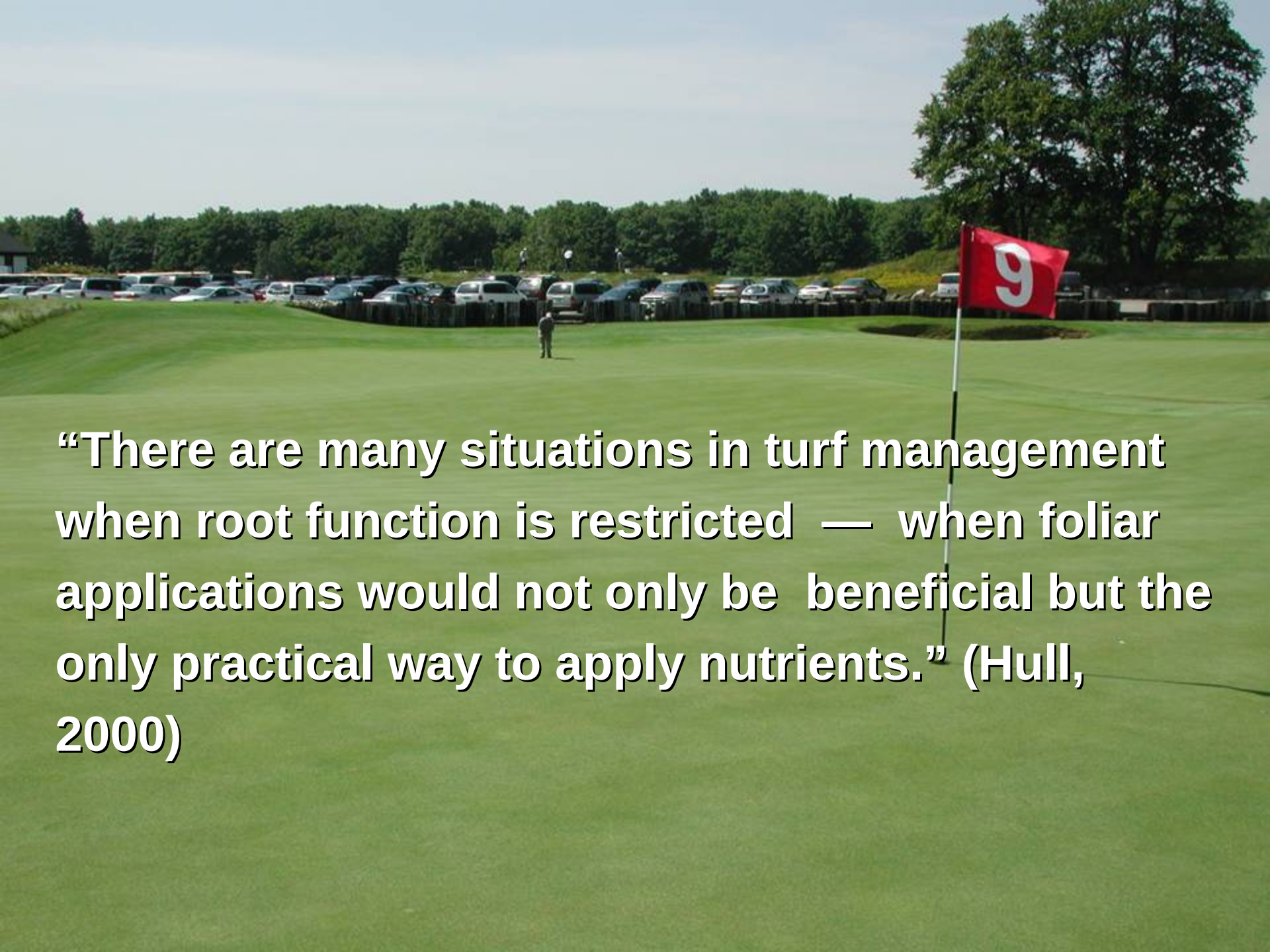
Manganese Carriers

- Manganese sulfate $MnSO_4 \bullet 4H_2O$ (27% Mn)
- Manganese chelates MnEDTA (5-12% Mn)
- Manganese oxide

Other Carriers

- Zinc
- Copper
- Boron
- Normally not applied individually but as part of fertilizer ‘packages’

How nutrients are taken up by the plant



“There are many situations in turf management when root function is restricted — when foliar applications would not only be beneficial but the only practical way to apply nutrients.” (Hull, 2000)

When is there *something* restricting root absorption?

- Dry soil
- Summer root decline/heat stress
- Insect feeding

Foliar Uptake Research

- Three locations in 2006
  - Michigan State Univ.
    - L-93 creeping bentgrass
    - *Poa annua*
  - Univ. of Nebraska
    - L-93 creeping bentgrass
  - Clemson University
    - Champion bermudagrass

Uptake of Foliar Nutrients

- 3 Treatments
  - TruFoliar (Grigg Brothers)
  - Andersons 20-20-20
  - Untreated
- 2 Environments
  - May 16: 70 F
  - July 31: 96 F

Grigg Fertilizer Program

- Gary's Green Ultra (13-2-3 + Fe)
  - 9 oz./M
- Sili-Kal B (8-0-4)
  - 6 oz./M
- P-K Plus (3-21-18 + micros)
  - 6 oz./M
- Mg Chelate (5%)
  - 1 oz./M

Andersons (20-20-20)

- Applied at 0.125 lbs. N/M

Ammoniacal nitrogen 2.8%
Nitrate nitrogen 5.0%
Urea 12.2%
Phosphate 20%
Potassium 20%
Boron 0.02%
Copper 0.07%
Iron 0.05%
Manganese 0.05%
Zinc 0.05%


101
START
TIME =
6:50:14


Meadow Gold
NORTH CAROLINA CAMPS
PICKLE LAKE
101BZ

amount applied per unit area

– amount in untreated (from wash)

– amount in wash

= ***(amount absorbed)***

this equals total amount of foliar uptake
but does not account for that retained in cuticle

% Absorption Summary (6 hr after application) Michigan Results

		N	P	K
Grigg Foliar	Bent	*62*	*90*	*82*
	Poa	*75*	*90*	*85*
Andersons	Bent	*45*	*85*	*68*
	Poa	*65*	*80*	*68*

% Absorption Summary (6 hr after application)
Michigan Results

		Fe	Cu	Zn	B	Ca	Mg	Si / Mo	Mn
Grigg Foliar	Bent	*95*	*90*	*95*	*90*	*40*	*70*	XX	*96*
	Poa	*80*	*88*	*95*	*85*	*78*	*60*	XX	*95*
Andersons	Bent	*40*	*80*	*85*	*65*	XX	XX	XX	*65*
	Poa	*65*	*80*	*80*	*45*	XX	XX	XX	*20*

% Absorption Summary (6 hr after application)
L-93, Michigan vs. NE

		N	P	K
Grigg Foliar	NE	*88*	*80*	*84*
	MI	*62*	*90*	*82*
Andersons	NE	*88*	*80*	*84*
	MI	*45*	*85*	*68*

% Absorption Summary (6 hr after application)
Michigan vs. NE

		Fe	Cu	Zn	B	Ca	Mg	Si / Mo	Mn
Grigg Foliar	NE	*90*	*92*	*80*	*70*	*70*	*60*	XX	*90*
	MI	*95*	*90*	*95*	*90*	*40*	*70*	XX	*96*
Andersons	NE	*40*	*70*	*70*	*5*	XX	XX	XX	*40*
	MI	*40*	*80*	*85*	*65*	XX	XX	XX	*65*

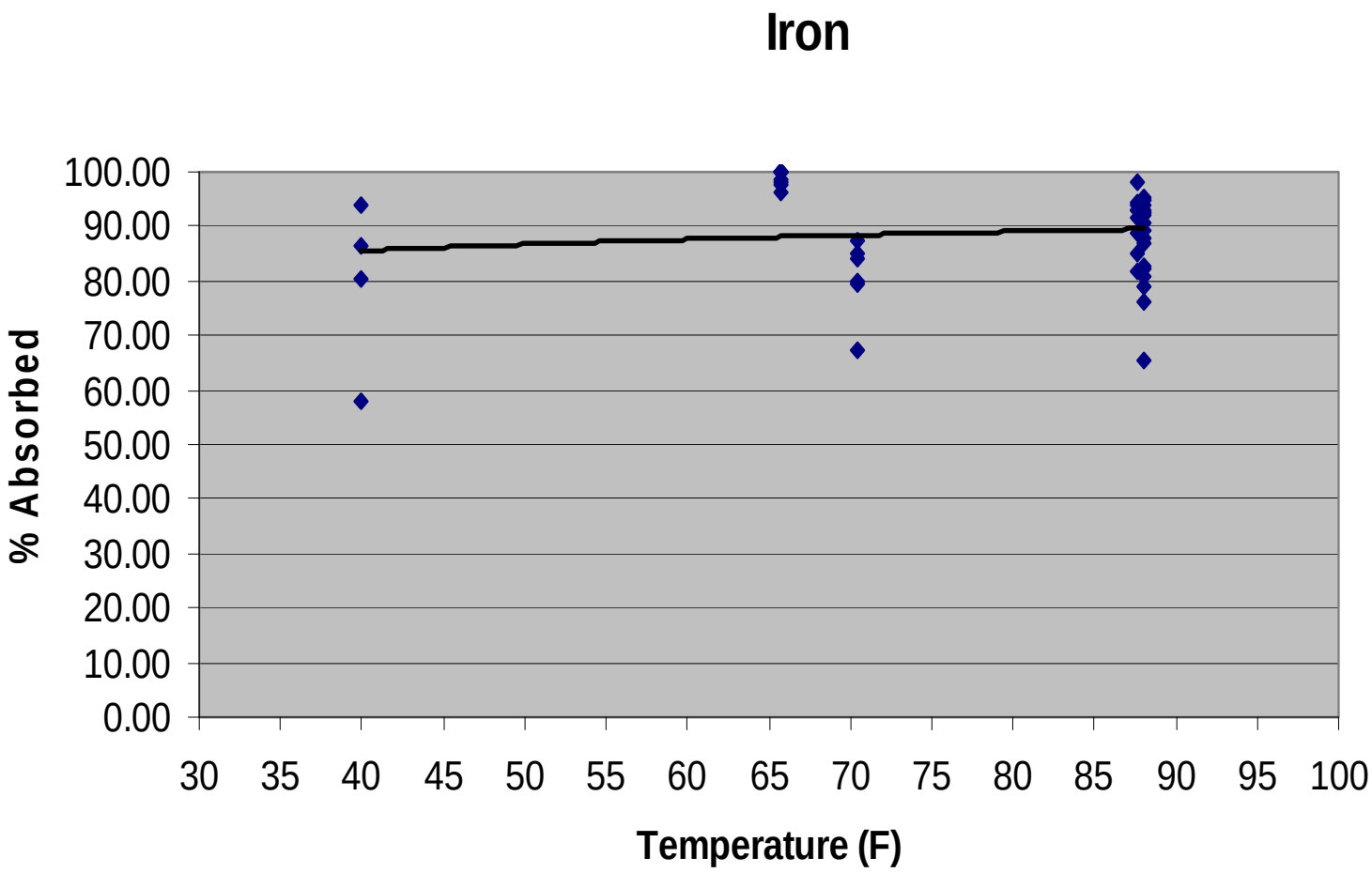
% Absorption Summary (6 hr after application)
Champion Bermudagrass, Clemson, SC

		N	P	K
Grigg Foliar	93^0 F	*88*	*98*	*98*
	79^0 F	*98*	*98*	*98*
Andersons	93^0 F	*84*	*98*	*98*
	79^0 F	*90*	*98*	*96*

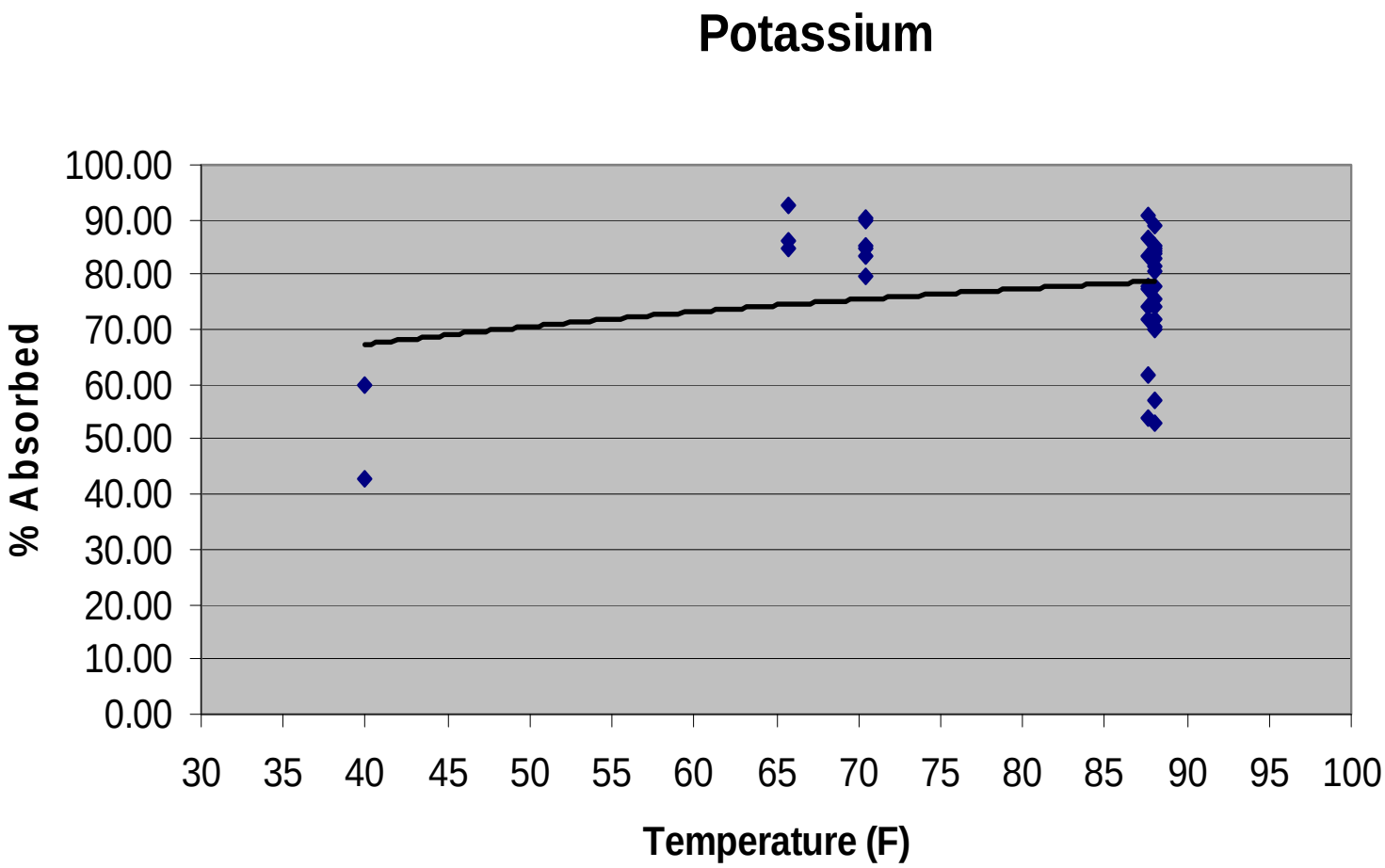
% Absorption Summary (6 hr after application)
Champion Bermudagrass, Clemson, SC

		Fe	Cu	Zn	B	Ca	Mg	Si / Mo	Mn
Grigg Foliar	93^0 F	*80*	*99*	*98*	*92*	*94*	*78*	XX	*90*
	79^0 F	*72*	*89*	*92*	*90*	*92*	*77*	XX	*98*
Andersons	93^0 F	*60*	*99*	*98*	*40*	XX	XX	XX	*10*
	79^0 F	*45*	*92*	*88*	*30*	XX	XX	XX	*10*

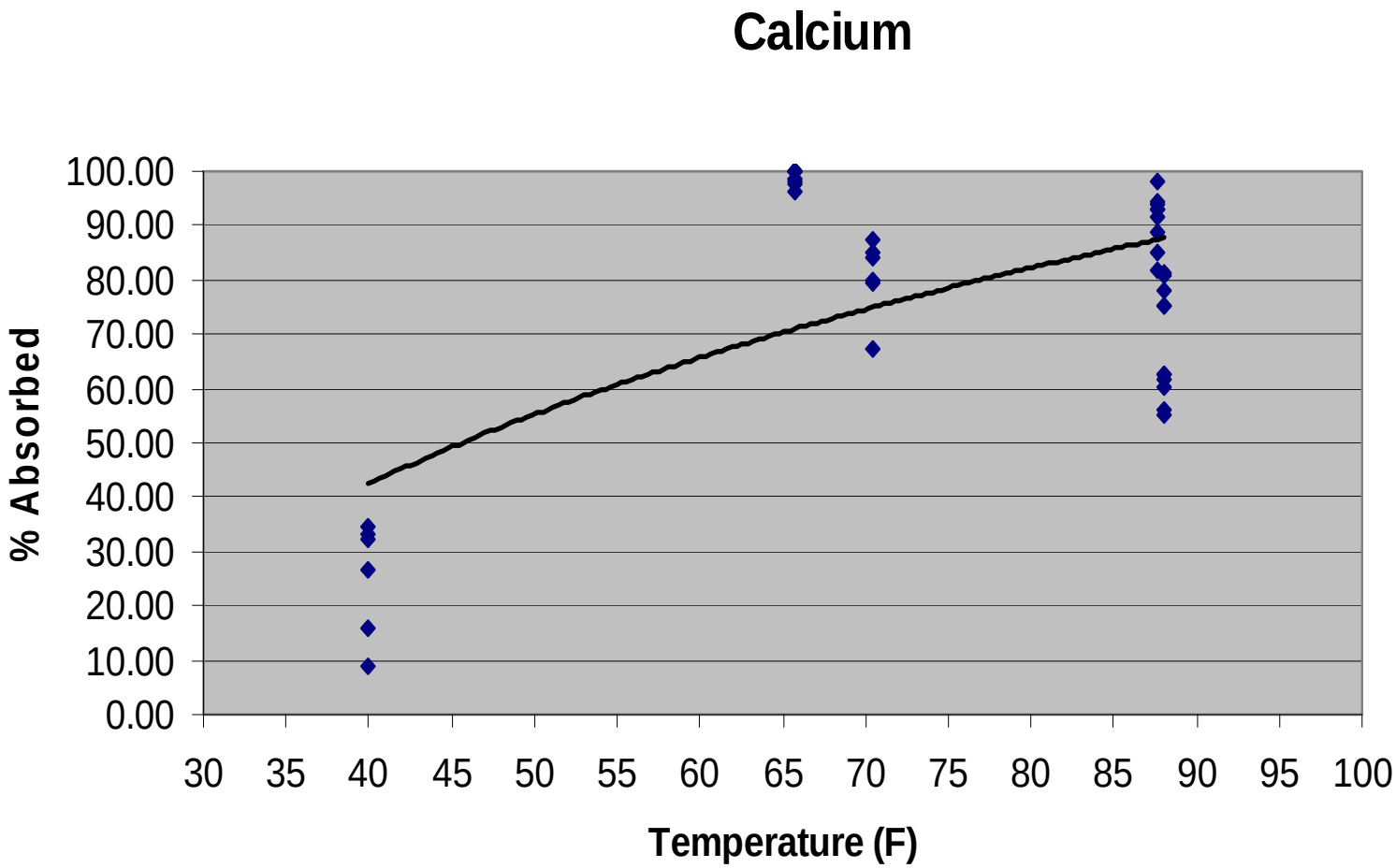
Temperature Effects (bentgrass)



Temperature Effects (bentgrass)

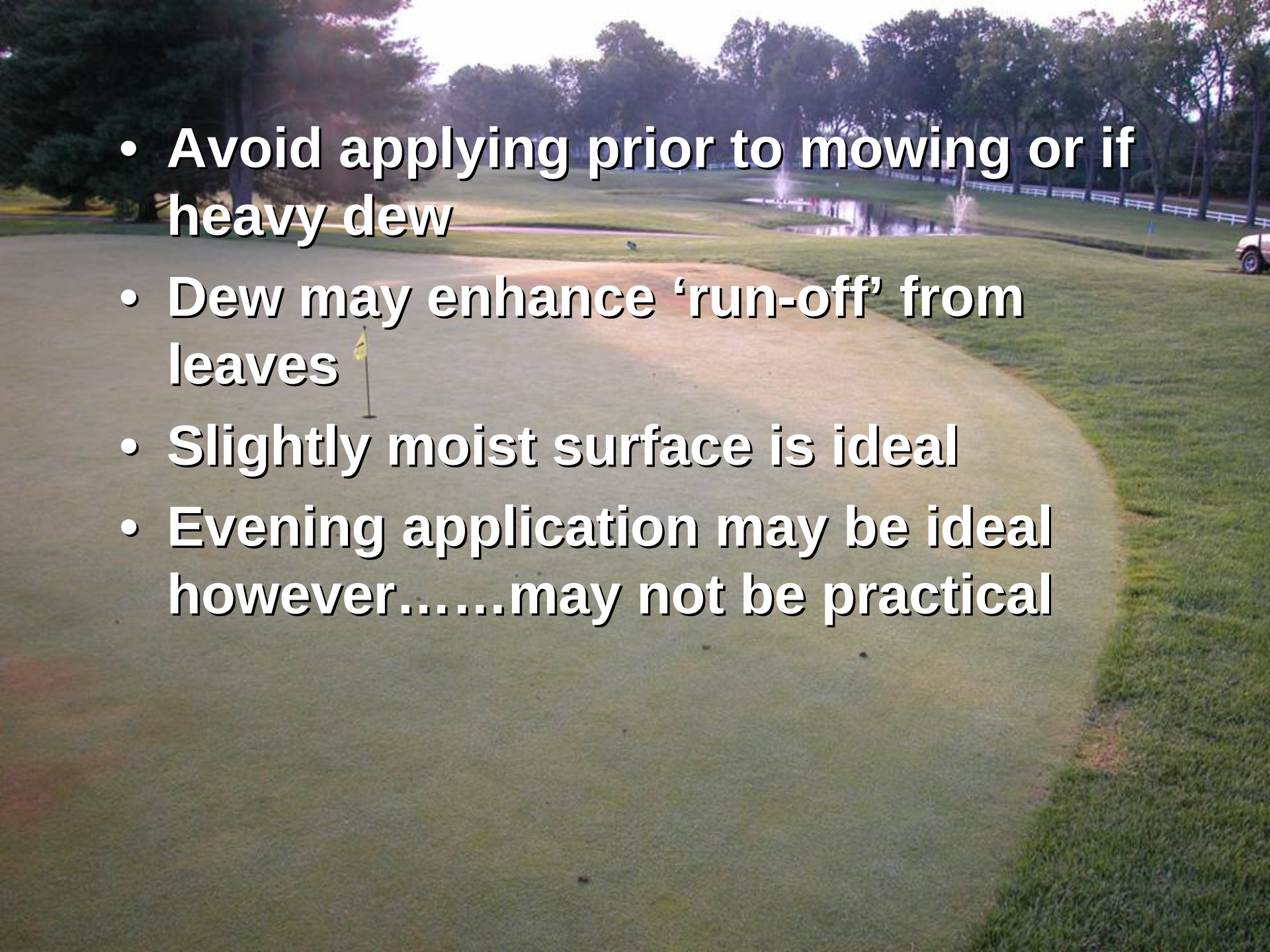


Temperature Effects (bentgrass)



Best Time to Apply Foliar's

- Foliar absorption requires time
- Minimum of 3 hrs. or > for absorption
  - Avoid irrigation/rainfall



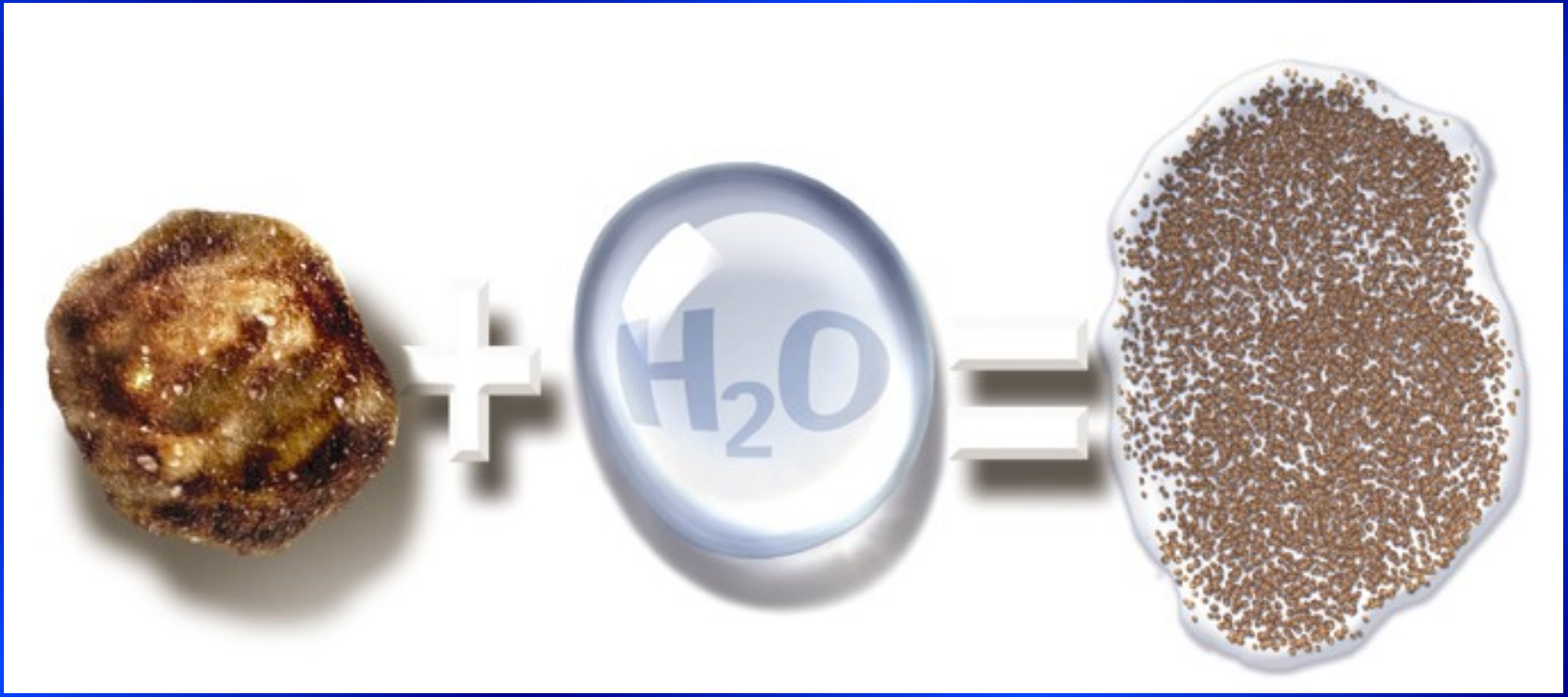
- Avoid applying prior to mowing or if heavy dew
- Dew may enhance ‘run-off’ from leaves
- Slightly moist surface is ideal
- Evening application may be ideal however……may not be practical

Spray Volume

- Foliar: < 1 gal. water/1000 $ft.^2$
  - Flat fan nozzle
- Liquid: > 1 gal. water/1000 $ft.^2$
- Fungicides: 2 gal. water/1000 $ft.^2$

New Granular Technologies

Contec DG®



- Can apply at low rates (0.1 lb. N/1000 ft.^{2})

Philosophies of Evaluation of Soil Tests

- SLAN (sufficiency level of available nutrients)
  - Estimates the nutrient supplying power of the soil and then ranks whether this level is sufficient to meet the plant needs
- BCSR (base cation saturation ratio)/Albrecht theory
  - Compare relative levels of basic cations
  - Suggested %
    - 60-80% Ca
    - 5-15% Mg
    - 2-5% K

- **BCSR (base cation saturation ratio)**
  - **Suggested ratios**
    - **Ca:K** — **below 10:1, Ca deficiency may occur**
      above 30:1, K deficiency may occur
    - **Mg:K** — **below 2:1, Mg deficiency may occur**
      above 10:1, K deficiency may occur
    - **Ca:Mg** — **below 3:1, Ca deficiency may occur**
      above 3:1, Mg deficiency may occur