Foliar Crop Nutrition: What Can We Learn From Turf?

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Fluid Technology Round Up - 2013

Fluid Fertilizer Foundation

Turfgrass Science
University of Nebraska

Welcome To Foliar Feeding

What the heck is a turf specialist doing talking to a roomful of producers?

Talking Points for Foliar Applications

- ***“can’t justify the cost”***
- ***“no better than granular applications”***
- ***“plants can not efficiently take nutrients thru their leaves”***
- ***Granulars/solubles have always been ok, why change?***

Plant Nutrient Application

- Solid fertilizers
- Liquid fertilizers

- Organic fertilizers
- Inorganic fertilizers

- Foliar feeding
- Root feeding

Nutrient absorption

Granular fertilizers

- root absorption

Liquid fertilizers

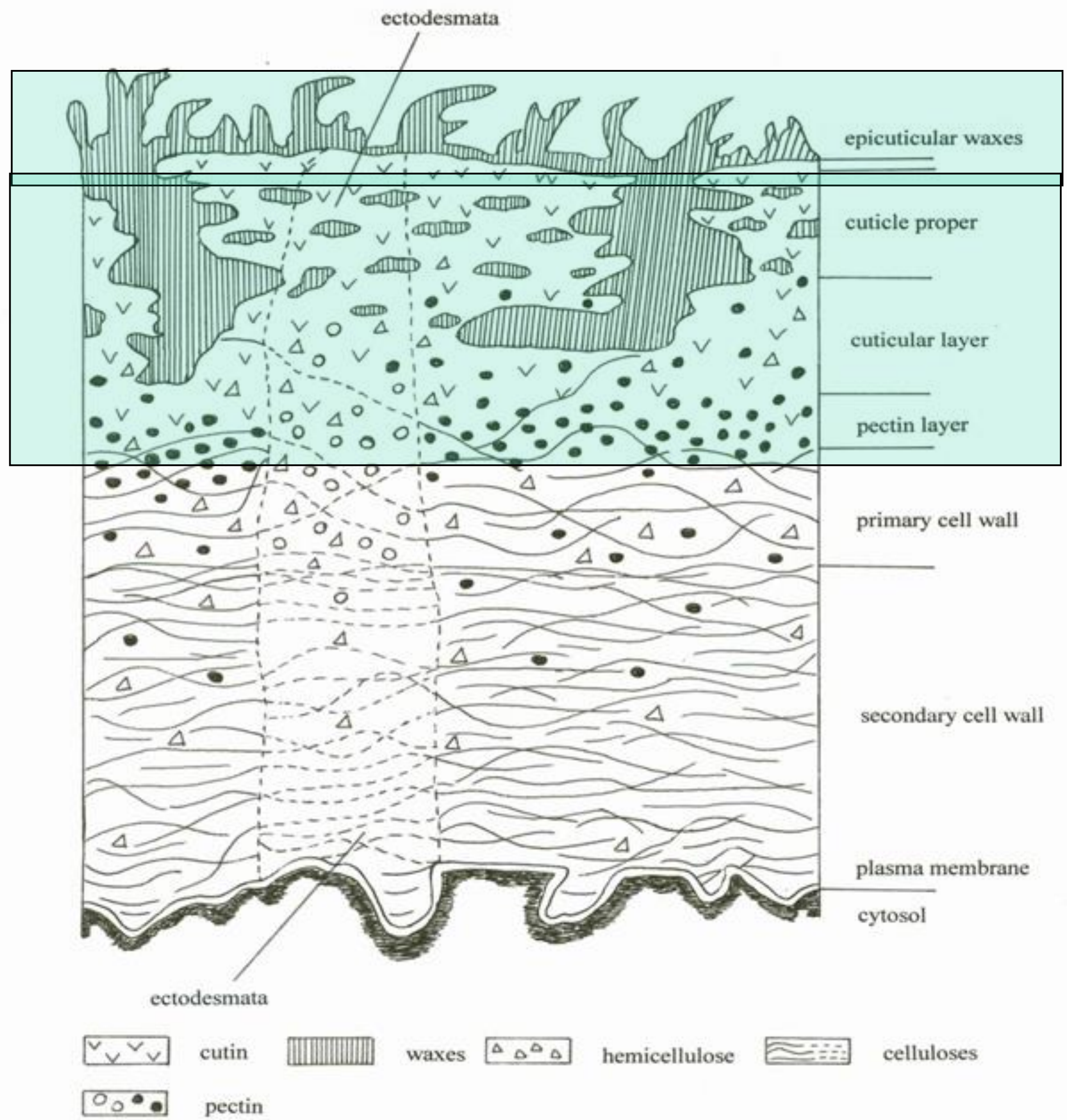
- root and foliar absorption

"True" foliar feeding

-foliar (*total or partial?*)

Foliar Nutrition Research:
A historical perspective

- **Foliar uptake is well documented**


ectodesmata
epicuticular waxes
cuticle proper
cuticular layer
pectin layer
primary cell wall
secondary cell wall
plasma membrane
cytosol
ectodesmata
cutin
waxes
hemicellulose
celluloses
pectin

UPTAKE OF NUTRIENTS VIA CUTICULAR NANOPORES

MONOVALENT GREATER THAN DIVALENT IONS

- **SMALL UNCHARGED MOLECULES MOVE READILY.**
- **HIGH CONCENTRATION MAY OVERCOME REPULSION**
- **PERMEATION GREATER WHEN NUTRIENTS ARE IN SOLUTION THAN WHEN DRIED ON SURFACE.**

DIAMETER OF HYDRATED CATIONS & CUTICULAR PENETRATION RATES

PERMEABILITY COEFFICIENTS OF CATIONS ($k/k_{(Li^+)}$0.5 M)

$K^+ > Na^+ > Mg^{+2} > Ca^{+2} >> Fe^{+3}$

1.67 1.48 0.64 0.36 0.17

McFarlane & Berry 1974

DIAMETER OF HYDRATED CATIONS (nm)

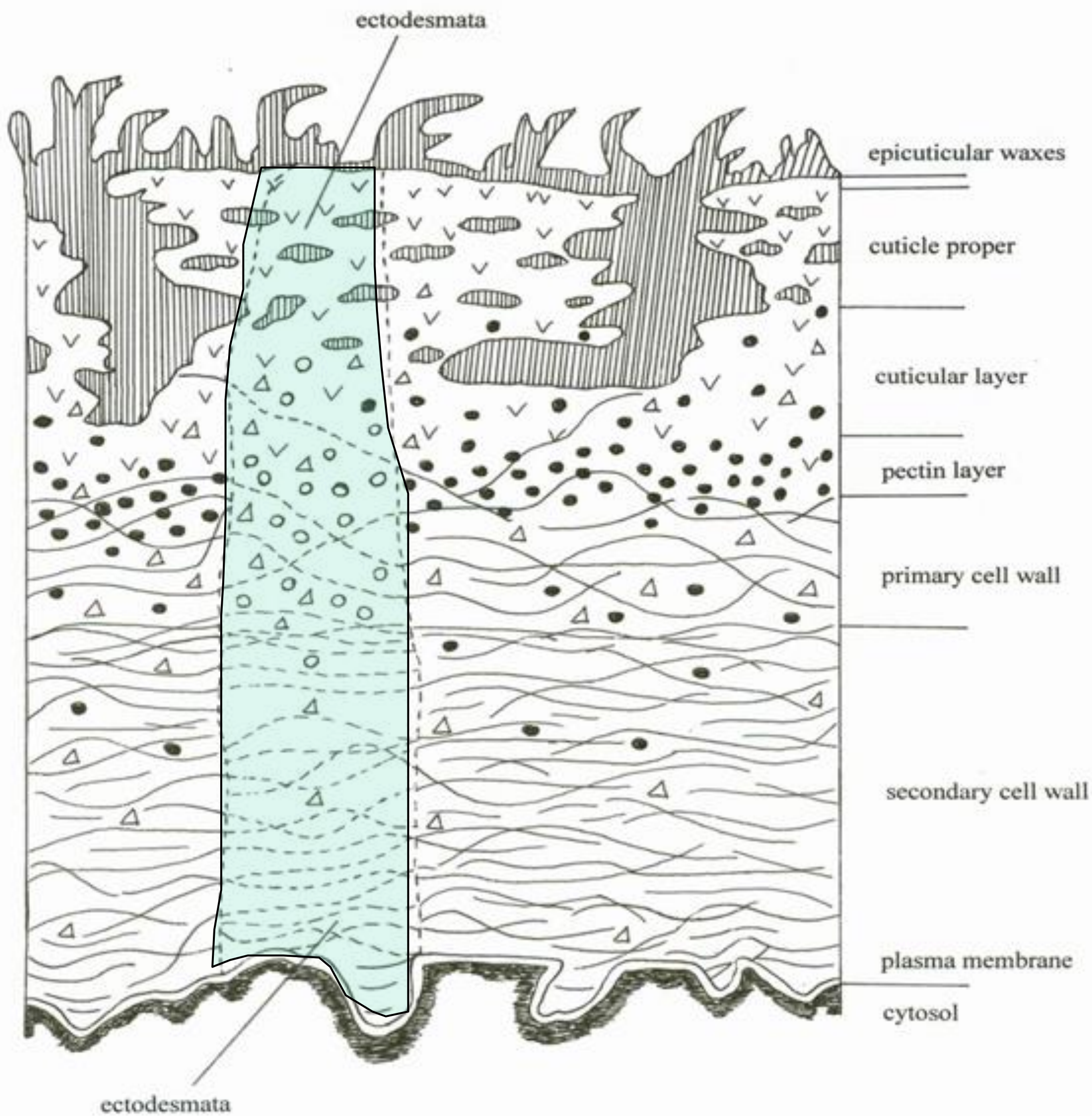
0.62 0.53 0.76 1.00 0.64

Mengel & Kirkby 1978

The rate of cuticular permeation decreases as hydration diameter of monovalent cations (size) increases.

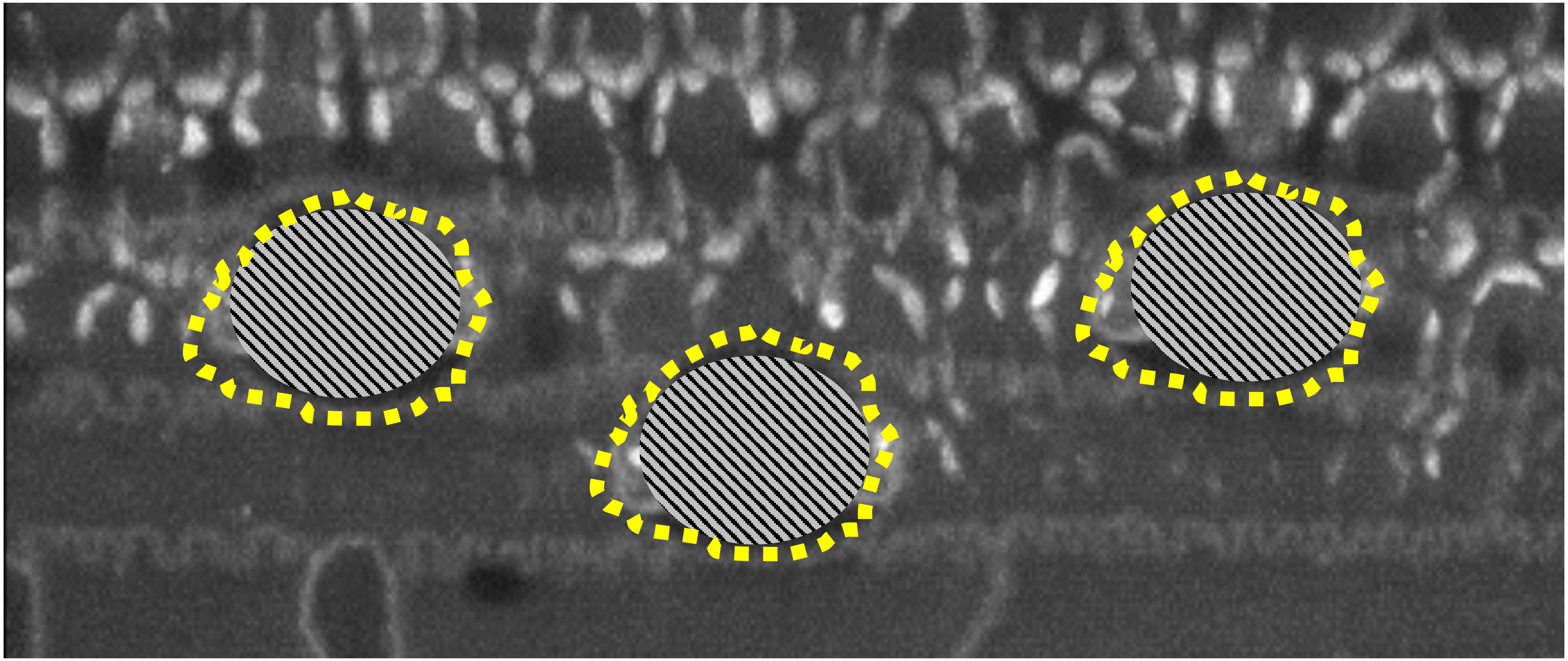
For divalent cations, increased hydration weakens charge strength and promotes greater permeation.

$NH_4+ > K+ > Na+ > Ca_2+ > Mg_2+$



Ectodesmata - pores with a diameter of less than 1 nm. These pores are readily permeable to solutes such as urea (radii 0.44 nm), but not larger molecules such as synthetic chelates.

Grass Leaf Surface



- **The first reports on foliar application of mineral nutrients in plant production date back to the second half of the 18th century**
- **most studies on the uptake of mineral nutrients and their translocation within a plant were carried out after the Second World War (advent of radio isotopes)**

The most studied foliar nutrient is nitrogen - 30 to 99% foliar absorbed

48 hour nutrient recovery in crops - Nitrogen

- **% Soil Applied**
  - ***10 to 40 %***
    - ***sorghum & cotton***
- **% Foliar Applied**
  - ***31 to 99 %***
    - ***tomato, corn & turfgrasses***

Basic Concept

- ✓ **"Non-Root" parts of plants will take up nutrients.**
- ✓ **Some types of fertilizers applied to the leaves of plants can be absorbed quickly and plentifully.**
- ✓ **Foliar absorbed nutrients are quickly available to the plant.**

Why Foliar Feed ?

- ✓ **More control with less risk**
- ✓ **Lower overall nutrient inputs**
- ✓ **Less nutrient leaching past the root system resulting in less potential for groundwater contamination**

Foliar Fertilization

- ✓ "Spoon Feeding"
- ✓ Allows for continuous adjustment of rates.
- ✓ Tank Mixing

Complexing and Chelating Agents

- ✓ Process removes the positive charge from the metals, allowing the neutral or slightly negatively charged, chelated molecule to slide through the pores on the leaf and root surface more rapidly.
- ✓ These pores are negatively charged, so there is a problem with fixation of positively charged minerals at the pore entrance.
- ✓ No barrier for the neutral mineral.

Complexing and Chelating Agents

- ✓ **"Organic Facilitators" have the capacity of binding substantial amounts of metals and other cations.**

Liquid Products

- ✓ **Synthetic/inorganic forms**
- ✓ **Complexes**
- ✓ **Chelates**

Synthetic Chelating Agents

Synthetic chelates used in fertilizer products:

*EDTA

*HEDTA

*EGTA

- ✓ They are very popular and very effective when used in the soil, less effective for foliar applications
- ✓ They only chelate the metals.

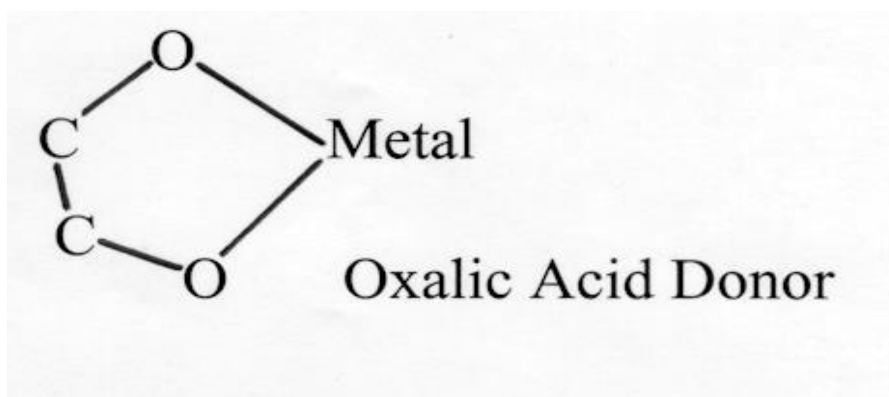
Complex

When a metal ion combines with an electron donor, the resulting substance is said to be a complex or a coordination compound.

(CH_3)-N-COO-metal

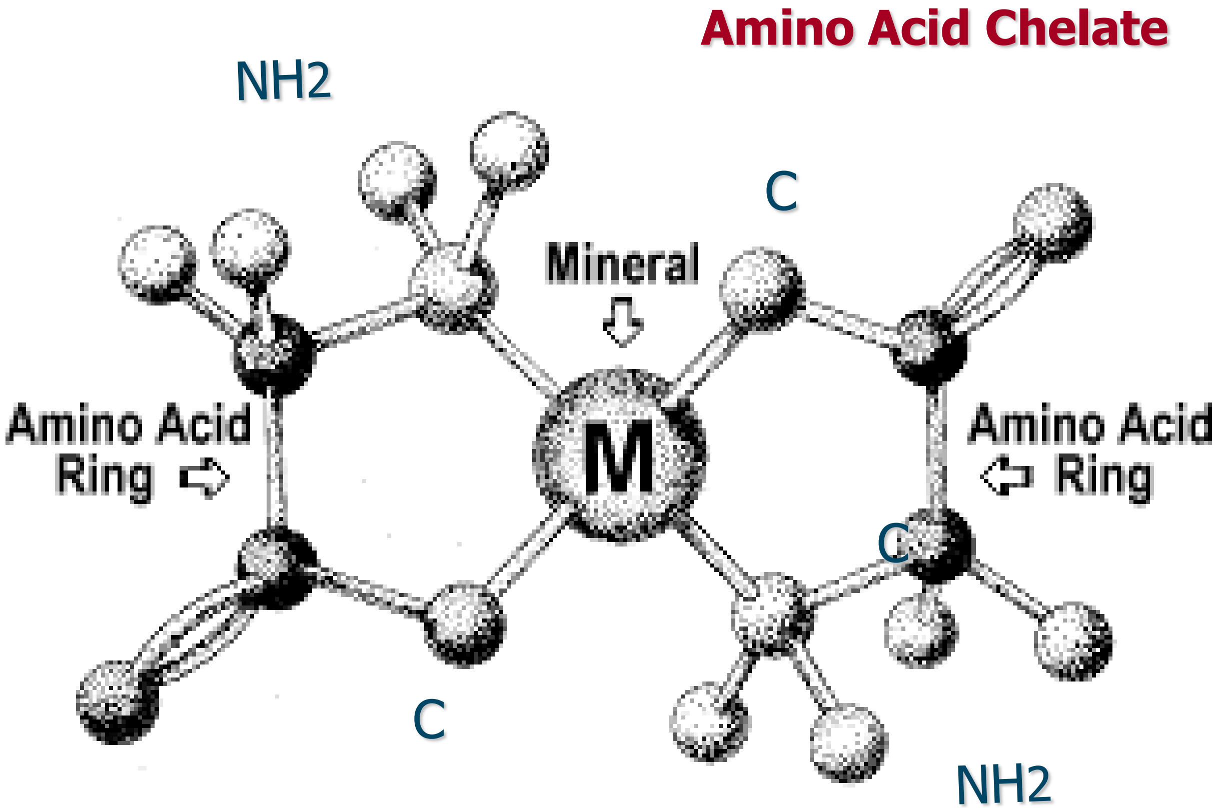
Chelate

The main difference between a metal complex and a chelate is the donor atoms are attached to the metal and each other.



Amino Acid Chelate

Form a very strong bond



Organic products used as complexing and chelating agents:

- humic acids
- fulvic acids
- ligno sulfonates
- glucoheptanates
- derivatives from the wood pulp industry
- hydrolyzed protein mixes
- citric acid
- amino acids

Some have low stability constants; tank mixing can be problematic (precipitate)

Organic Agents

* Advantage over non-organic

- ✓ degradable in the plant or soil
- ✓ provide an energy source to soil micro-organisms, which in turn helps make soil nutrients available to the plant.
- ✓ less phytotoxic

Why Use Properly Formulated Products?

- ✓ **Compatibility and stability mixing with other nutrients and products**
- ✓ **They are better absorbed because they are non-ionic**
- ✓ **Protects nutrient from falling out (precipitating) and assists in plant uptake and translocation**

Buyer Beware

- ✓ Many products are not 100% chelated and although classified by law as a chelate may not be effective
- ✓ some chelating agents are far superior to others

Uptake of Foliar Nutrients on a Putting Green

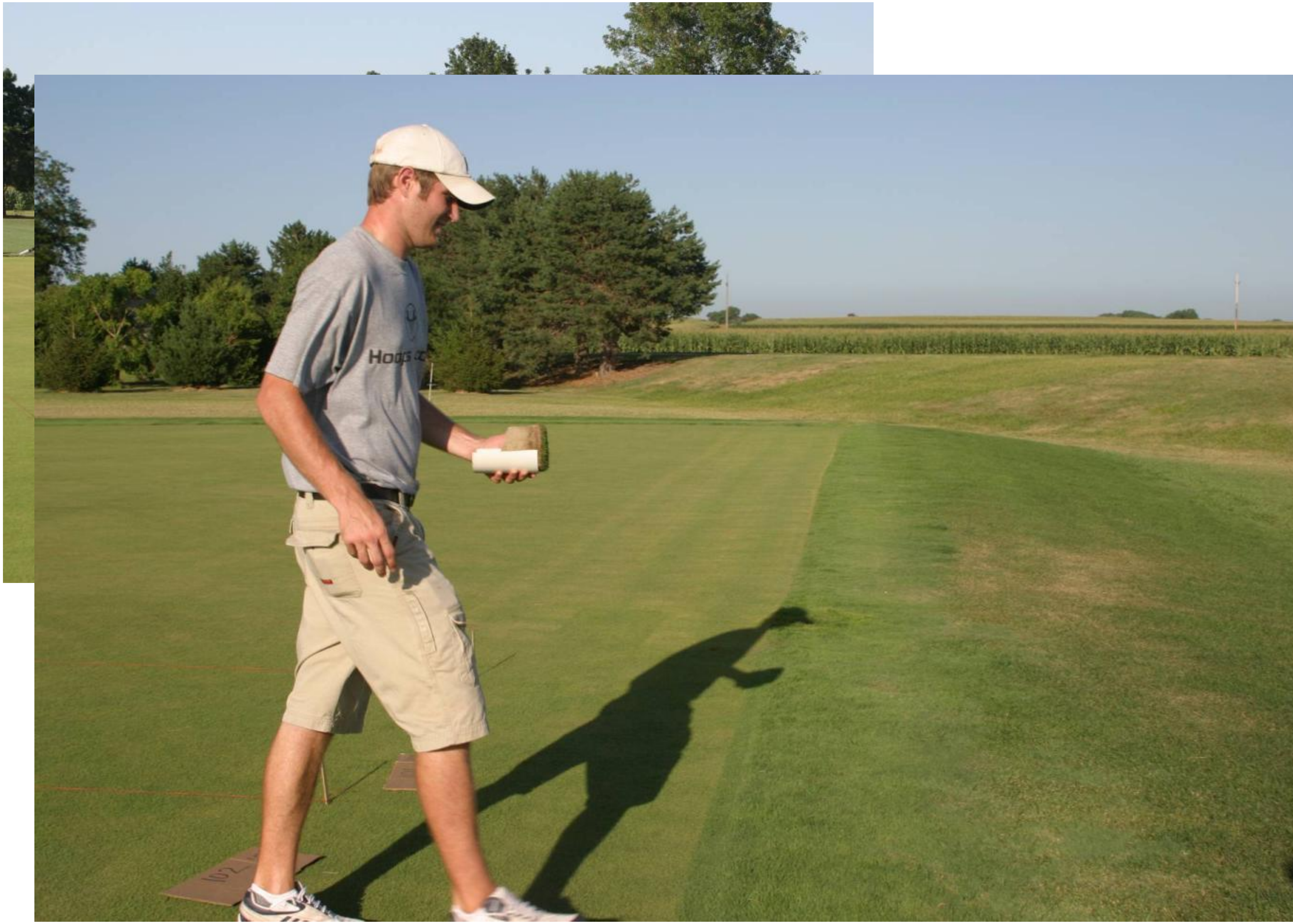
- Conducted in 2005 in Nebraska (L-93)
- Conducted in 2006 in Nebraska, Michigan (Poa & Bent) & South Carolina in 2006/07 (Champion Bermudagrass) Florida 2007 on Paspalum.
- Univ of Nebraska, Michigan State Univ (Kevin Frank), Clemson University (Haibo Liu) & Univ of Florida (John Cisar)
- 3 Treatments
- 2 times of year (cool vs. hot)
- Not with radio-isotopes
  - “uptake by subtraction”

Funded by…………

GRIGG BROS.

California green, L-93, 3 years old, 0.11 mowing height

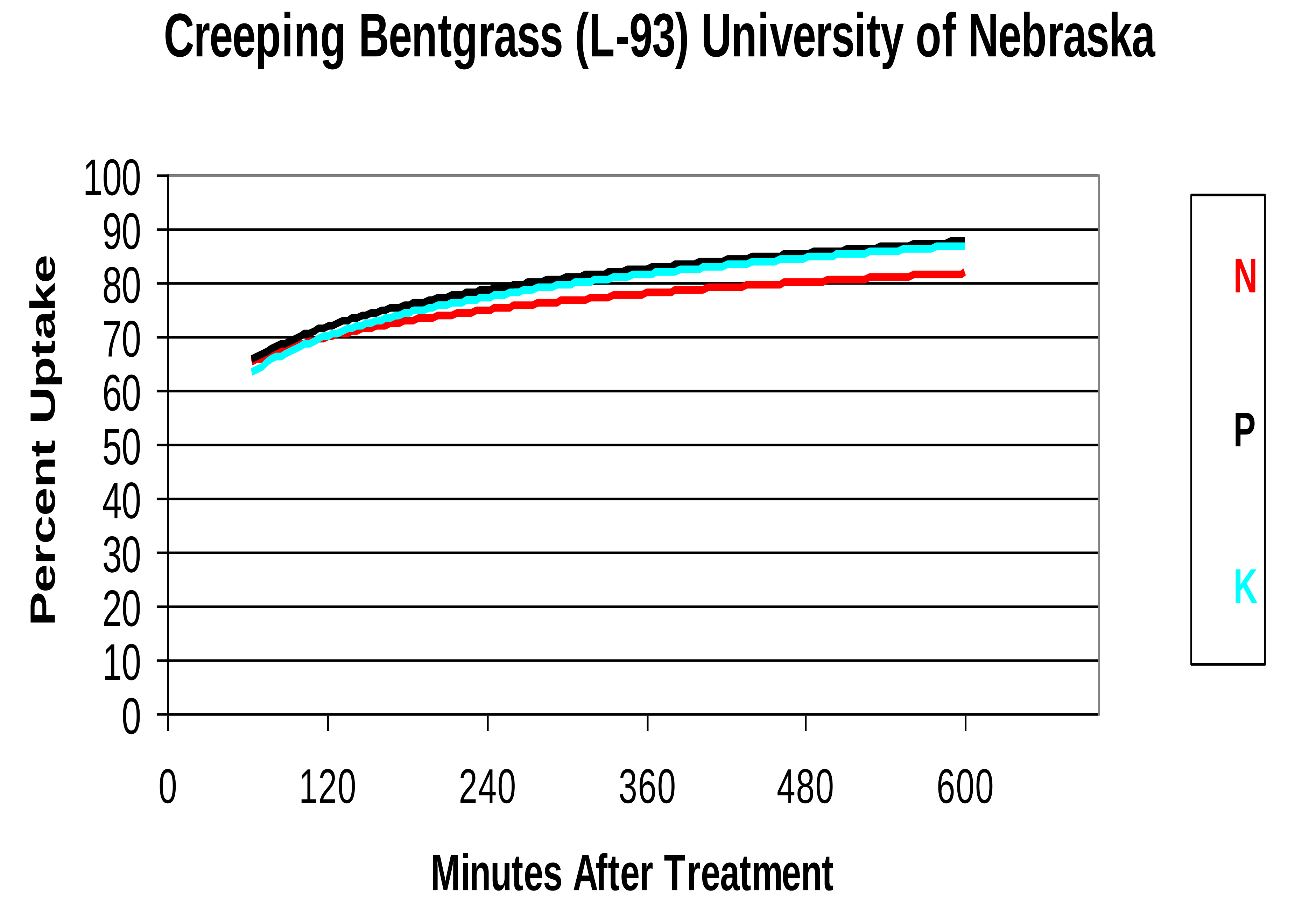
6:50:14
101
START
TIME =




Meadow
Gold
101BZ


VWR

- amount applied per unit area (from food saver)
- amount in untreated (from wash)
-amount in wash
= *(amount absorbed)*


Creeping Bentgrass (L-93) University of Nebraska
Percent Uptake
100
90
80
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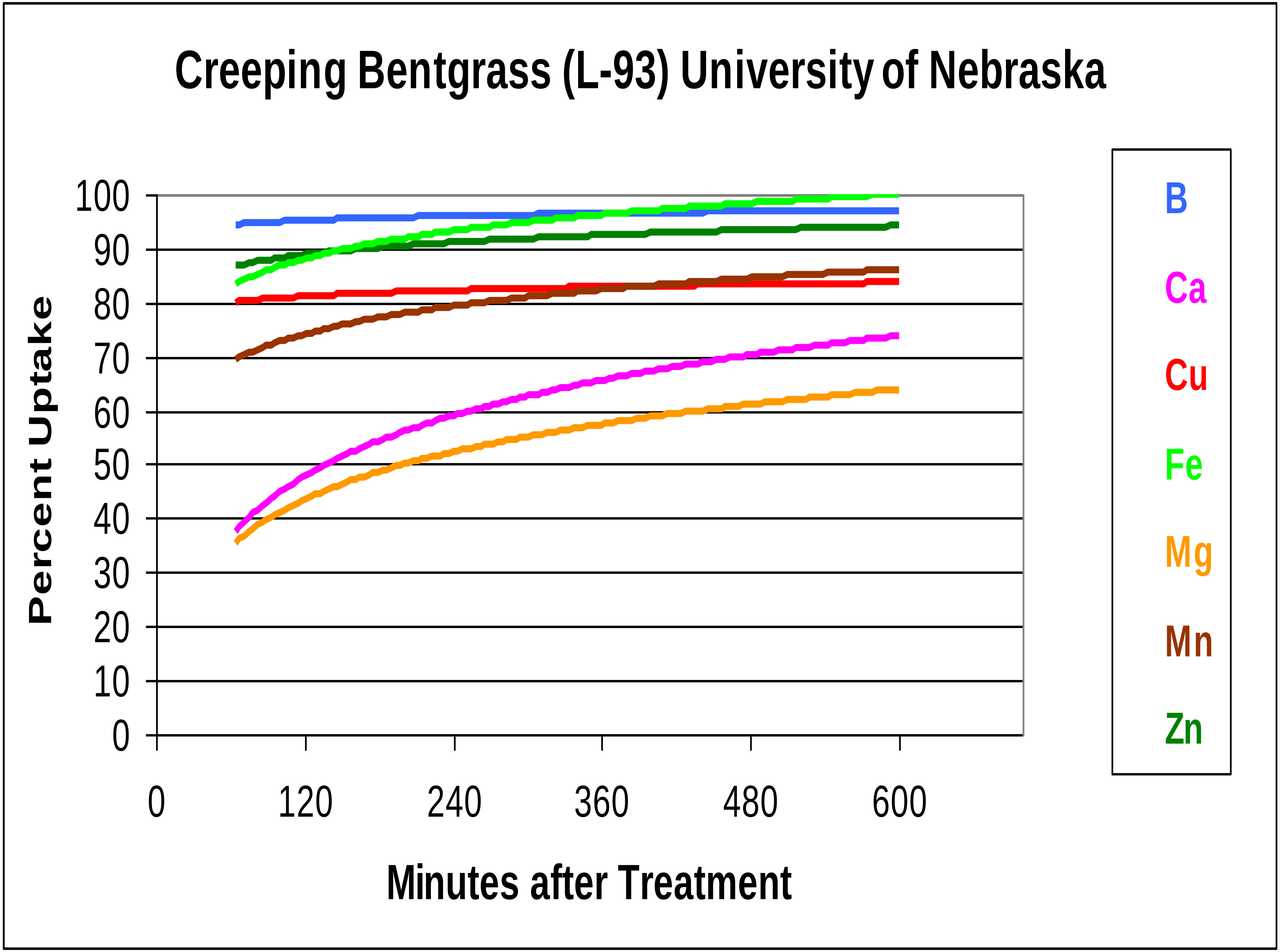
120
240
360
480
600
Minutes After Treatment
N
P
K


Creeping Bentgrass (L-93) University of Nebraska
Percent Uptake
100
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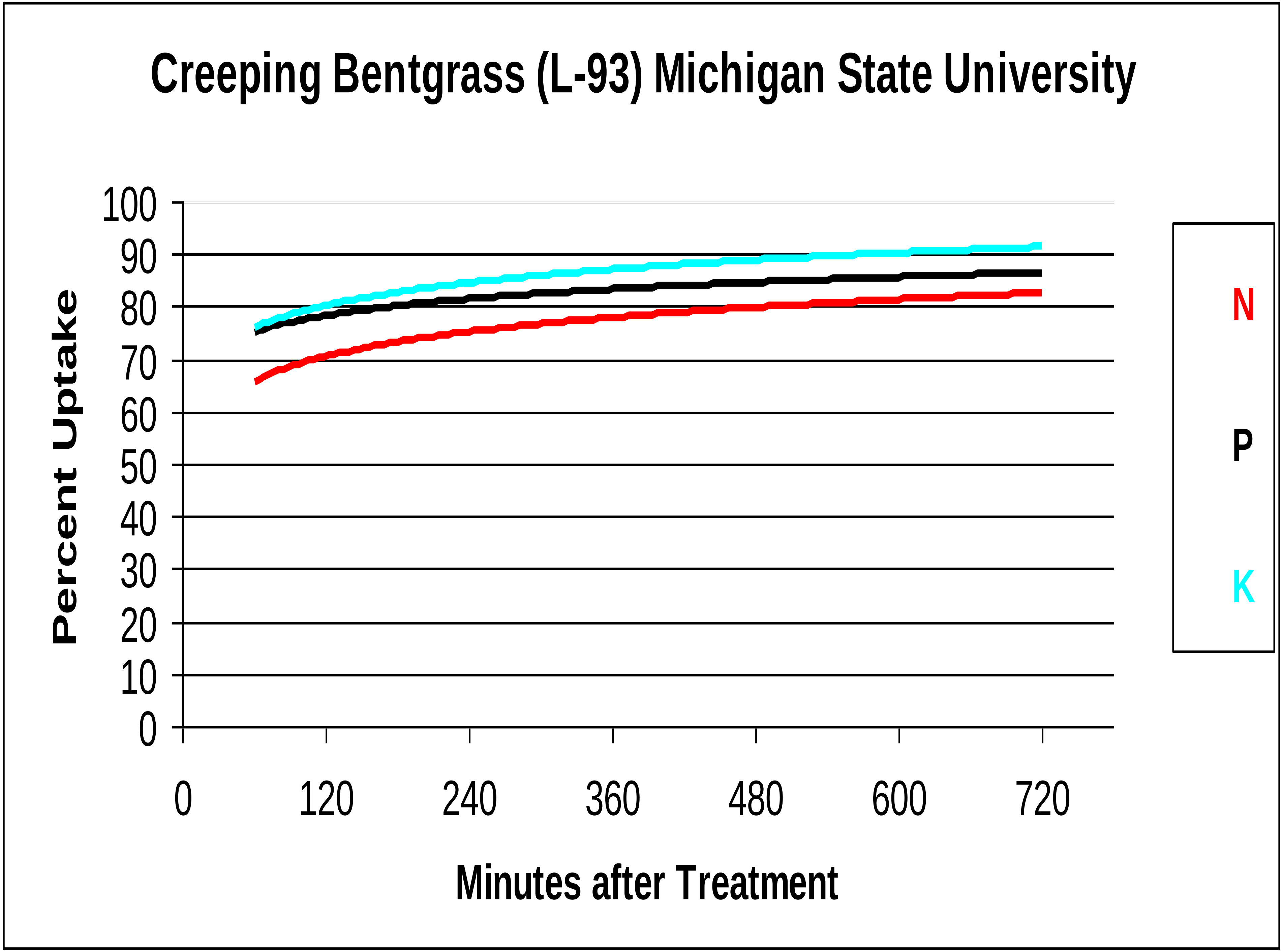
600
Minutes after Treatment
B
Ca
Cu
Fe
Mg
Mn
Zn



Creeping Bentgrass (L-93) Michigan State University
Percent Uptake
100
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120
240
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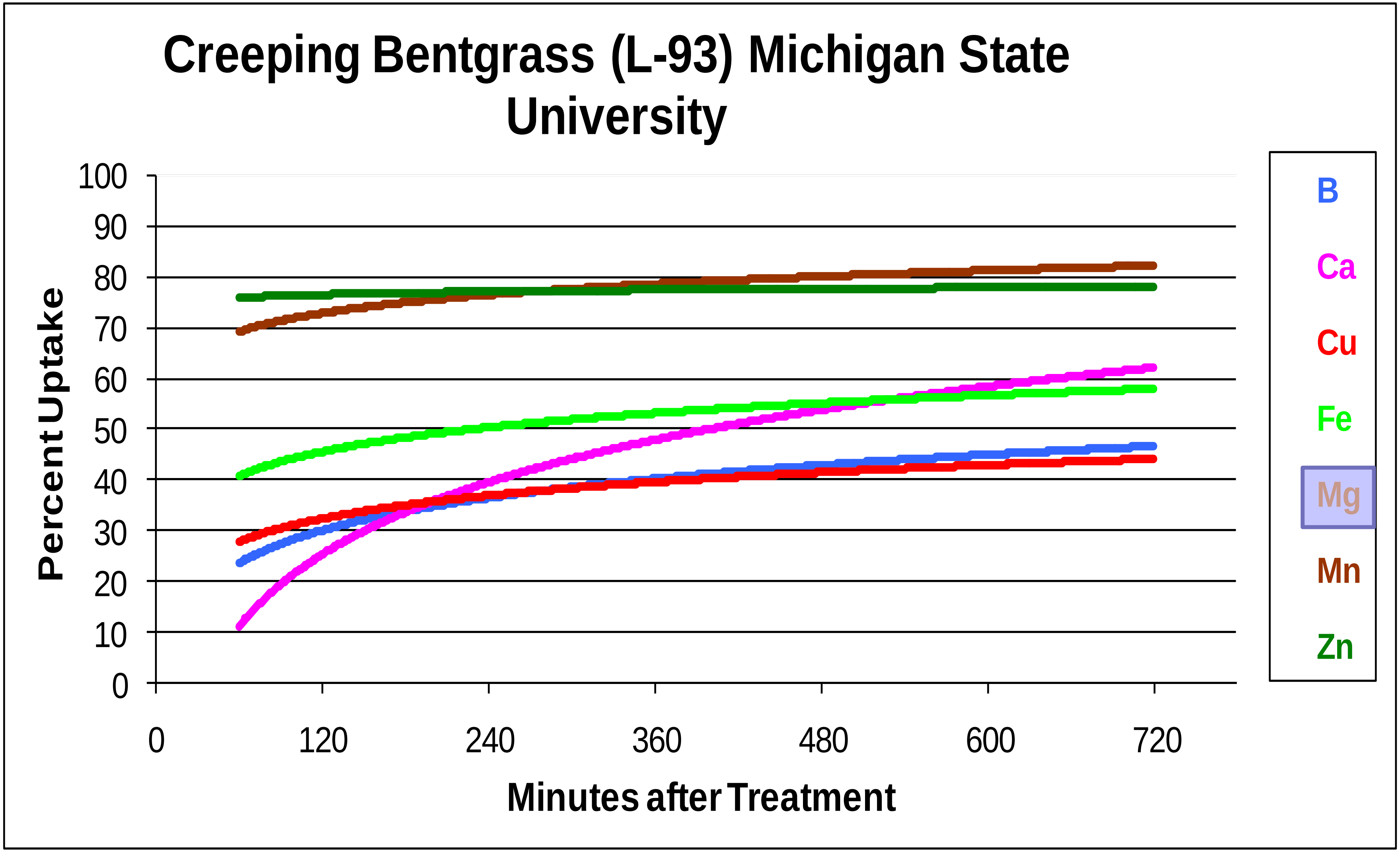
600
720
Minutes after Treatment
N
P
K



Creeping Bentgrass (L-93) Michigan State University
Percent Uptake
100
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60
50
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30
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120
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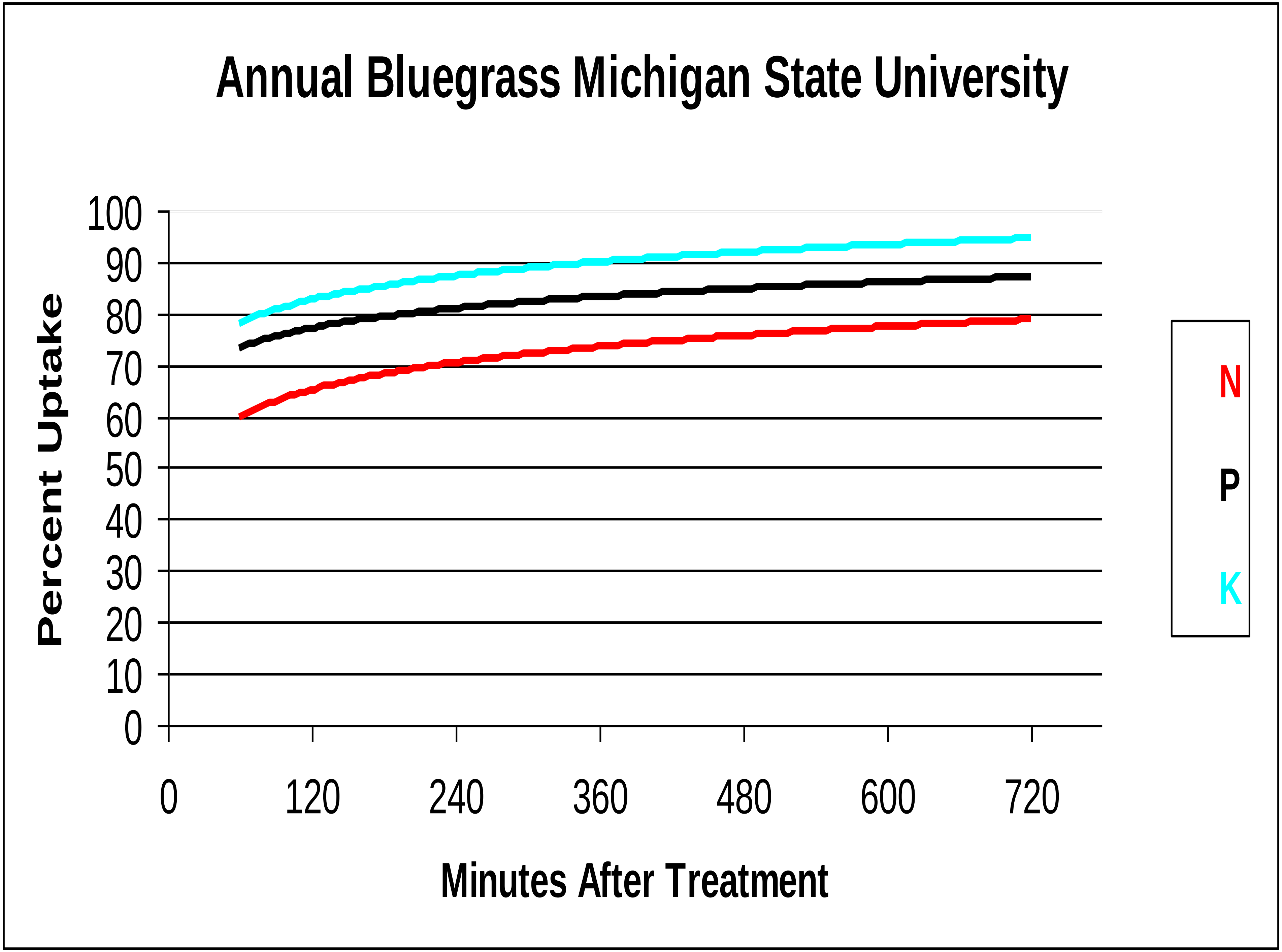
600
720
Minutes after Treatment
B
Ca
Cu
Fe
Mg
Mn
Zn



Annual Bluegrass Michigan State University
Percent Uptake
100
90
80
70
60
50
40
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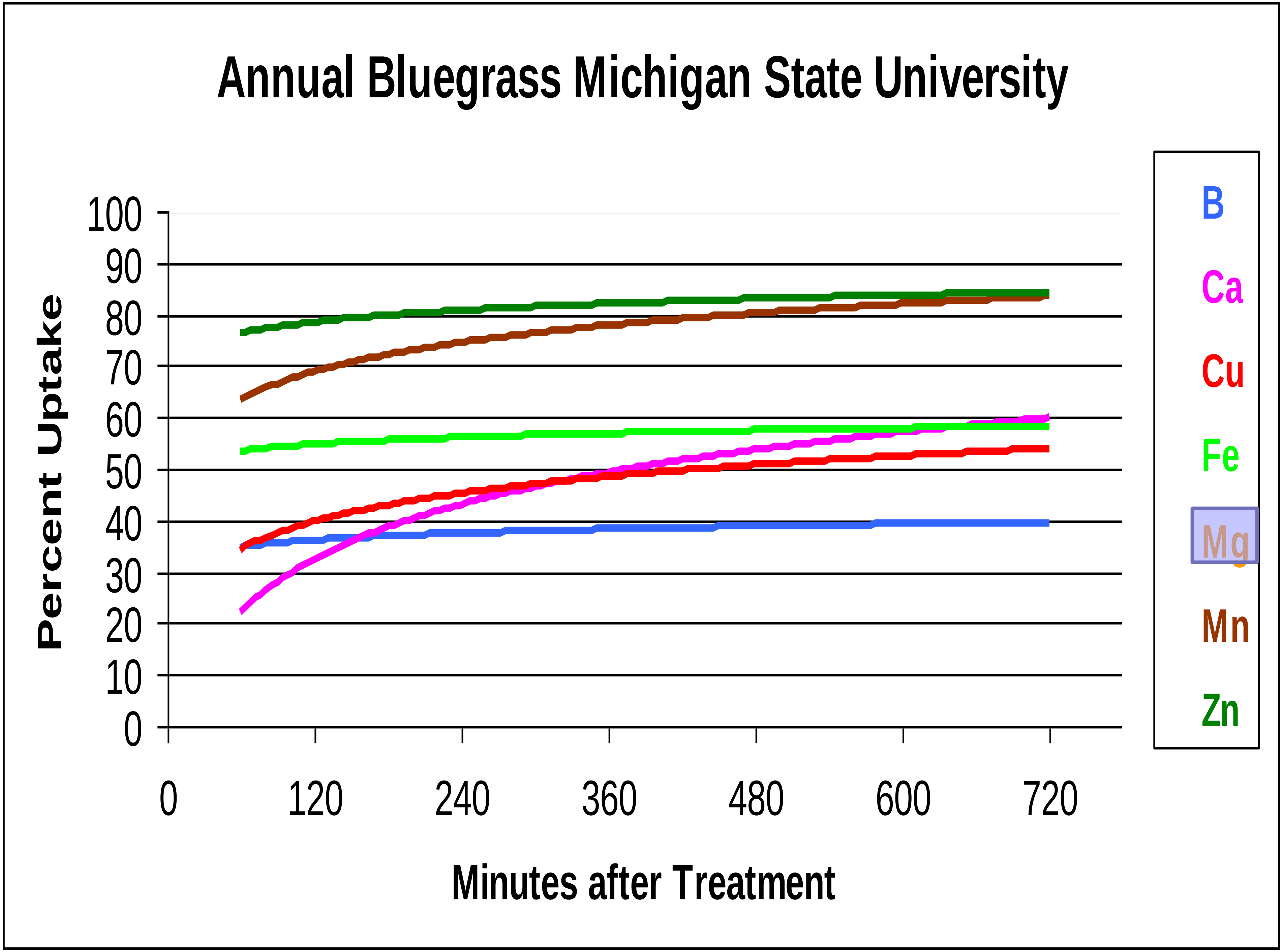
20
10
0
0
120
240
360
480
600
720
Minutes After Treatment
N
P
K



Annual Bluegrass Michigan State University
Percent Uptake
100
90
80
70
60
50
40
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120
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600
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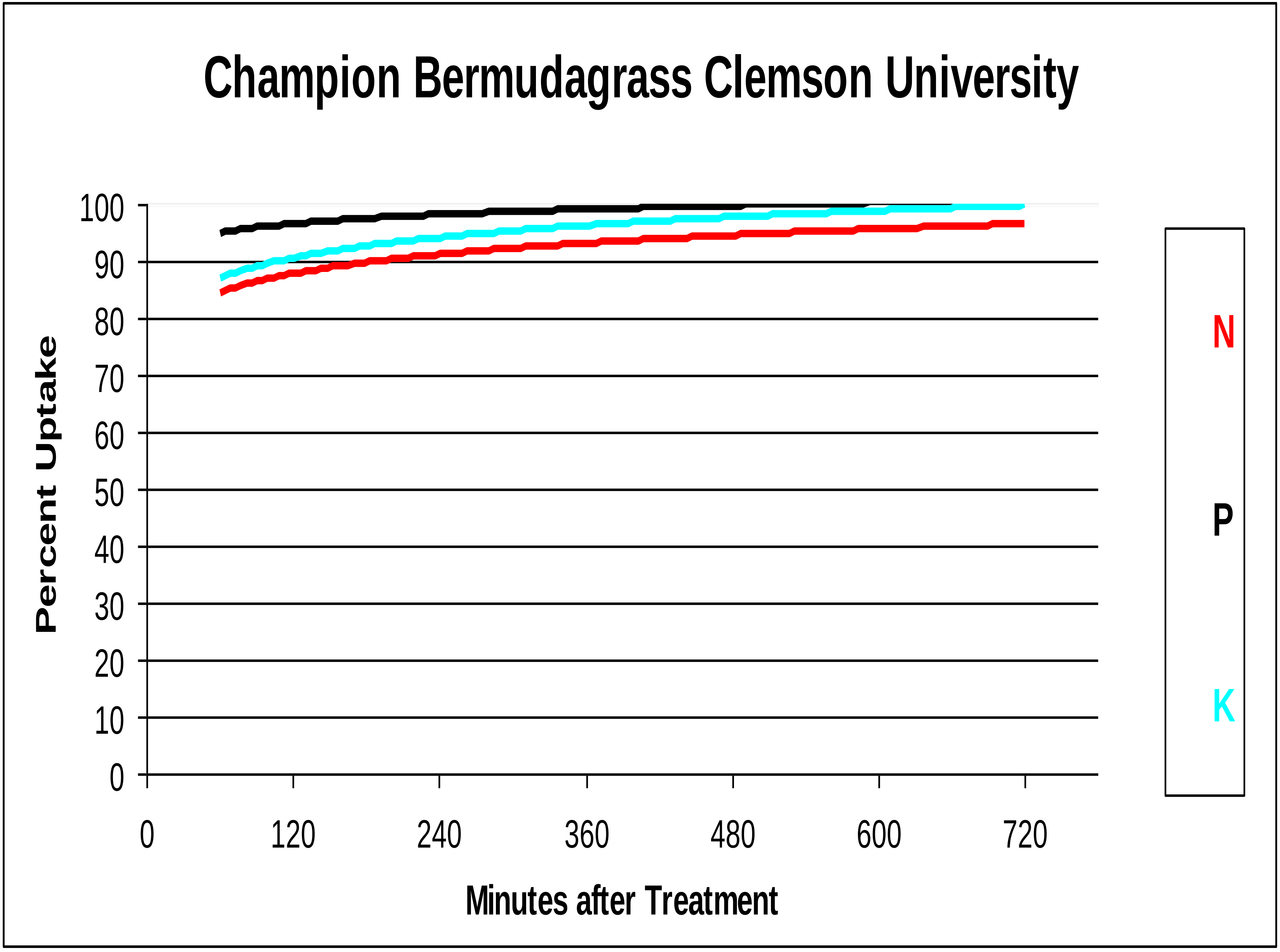
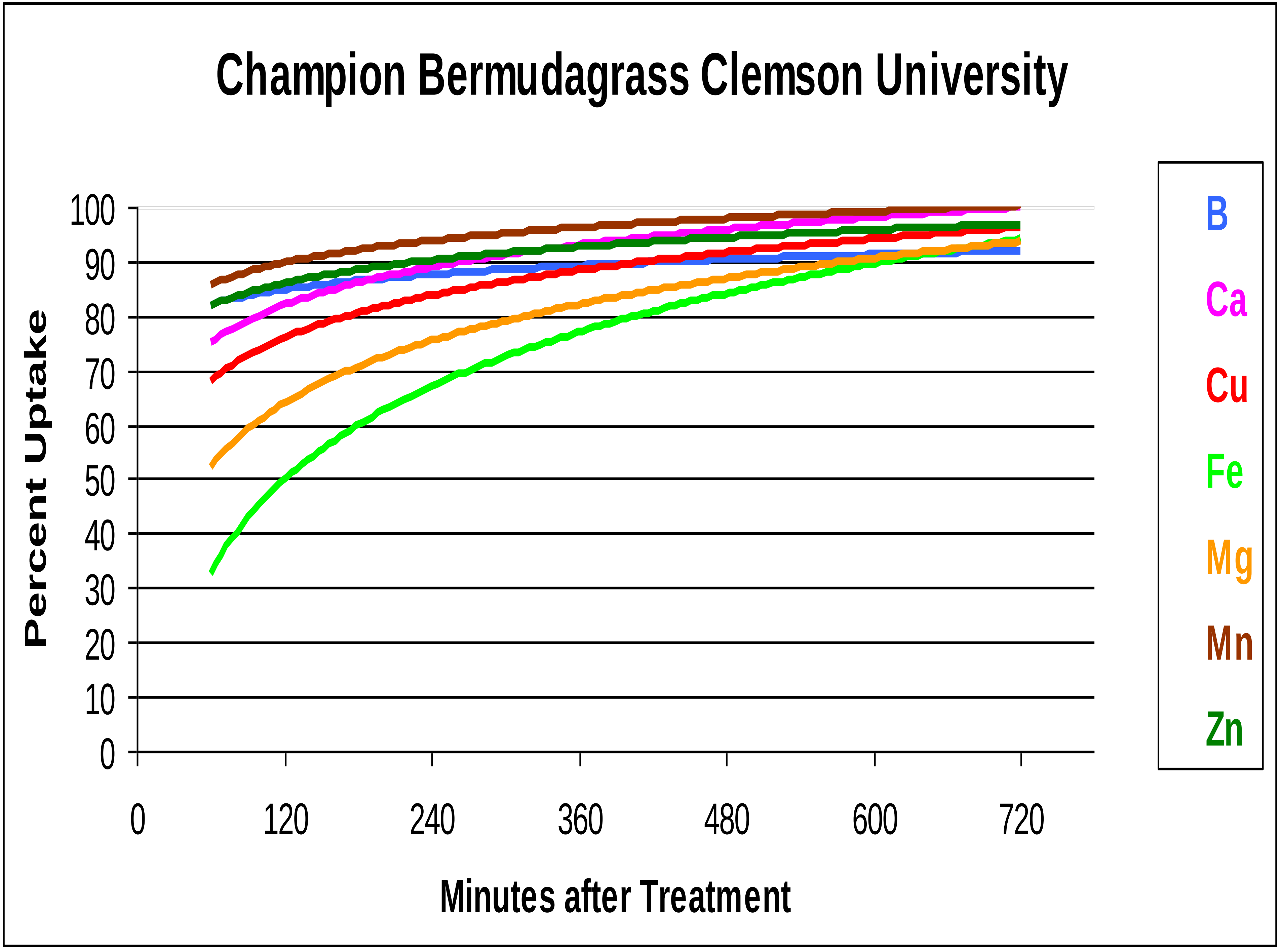
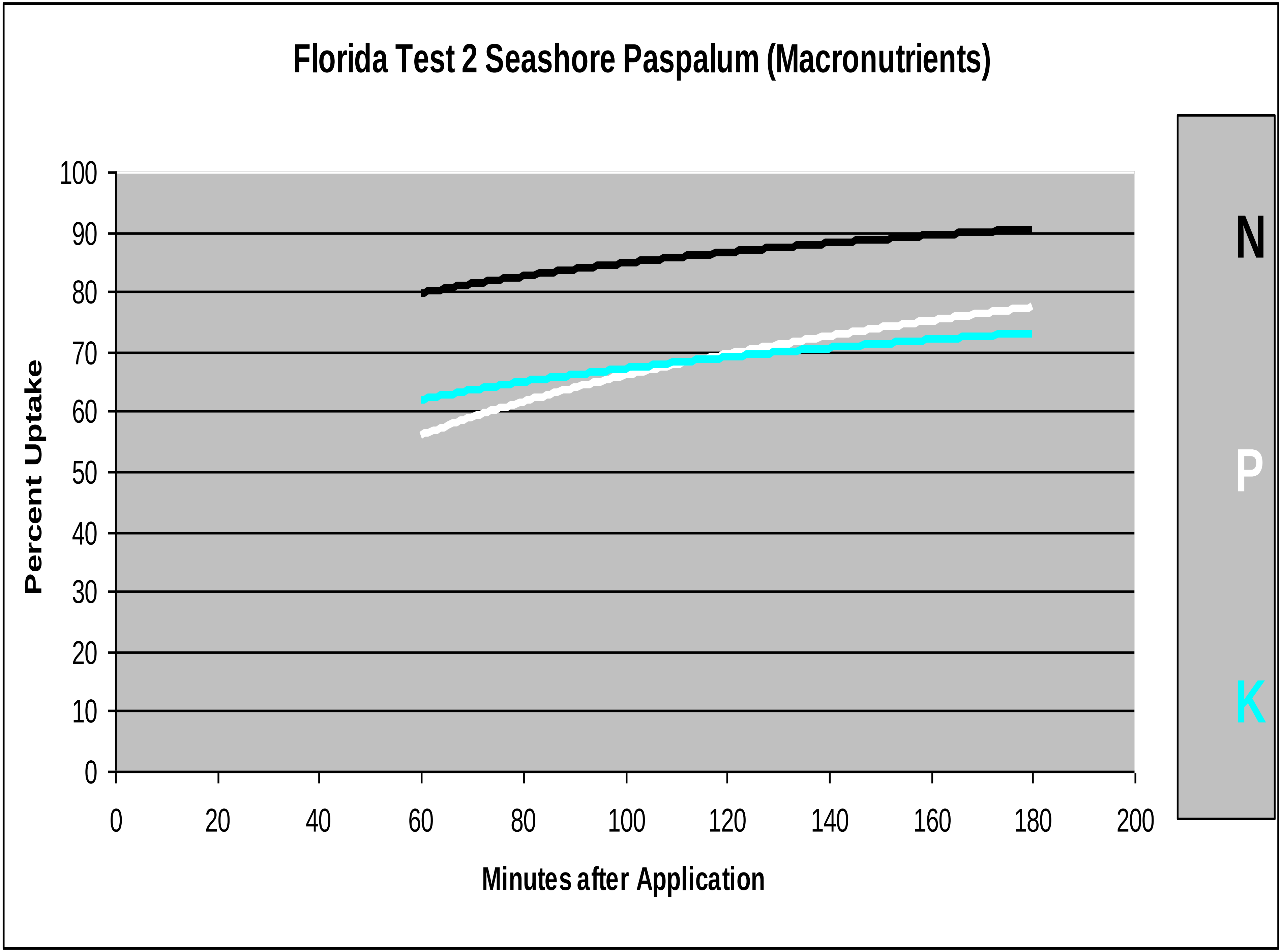
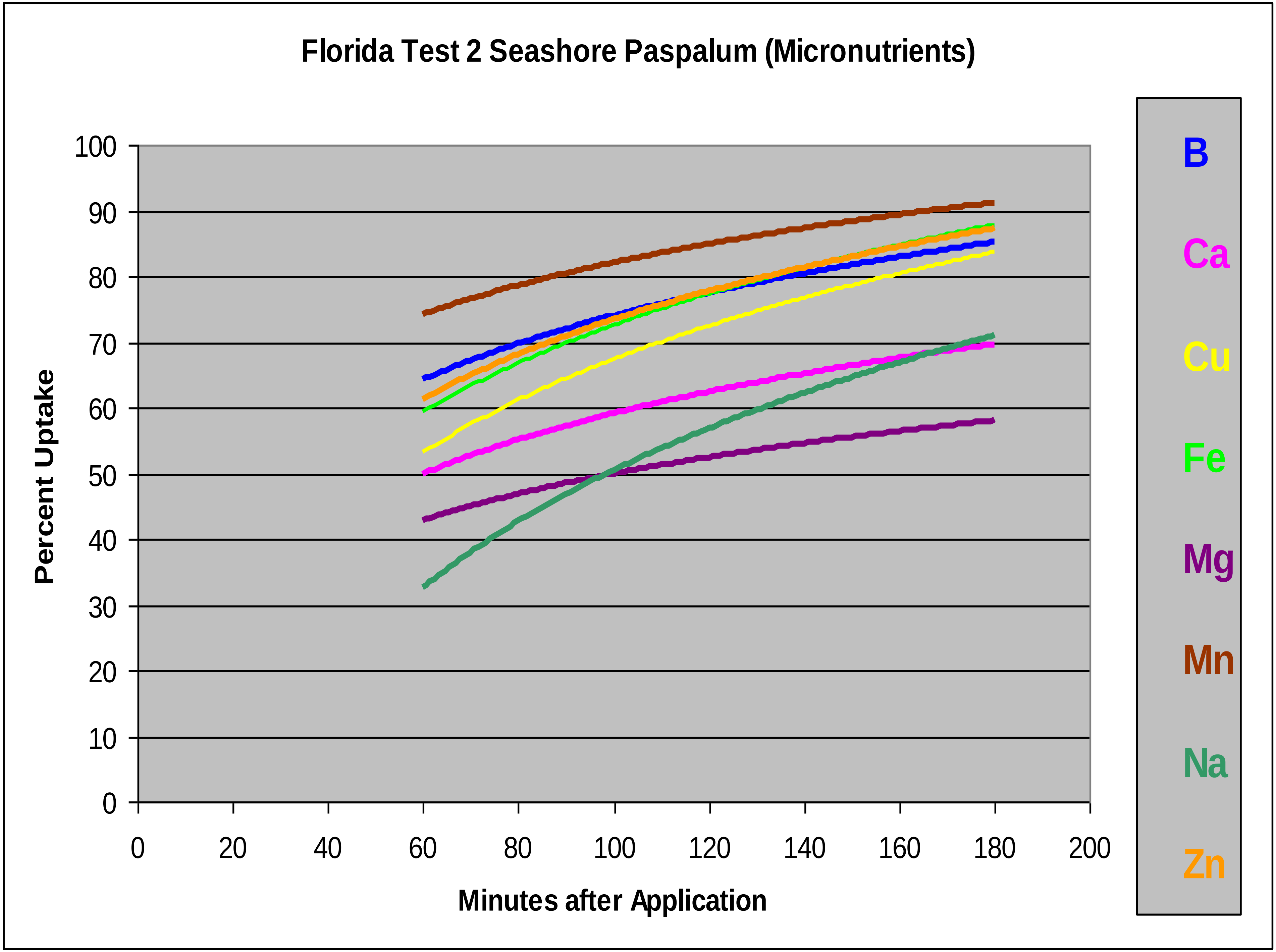
Minutes after Treatment
B
Ca
Cu
Fe
Mg
Mn
Zn


Champion Bermudagrass Clemson University
Percent Uptake
100
90
80
70
60
50
40
30
20
10
0
0
120
240
360
480
600
720
Minutes after Treatment
N
P
K


Champion Bermudagrass Clemson University
Percent Uptake
100
90
80
70
60
50
40
30
20
10
0
0
120
240
360
480
600
720
Minutes after Treatment
B
Ca
Cu
Fe
Mg
Mn
Zn


Florida Test 2 Seashore Paspalum (Macronutrients)
Percent Uptake
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
Minutes after Application
N
P
K



Florida Test 2 Seashore Paspalum (Micronutrients)
Percent Uptake
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
Minutes after Application
B
Ca
Cu
Fe
Mg
Mn
Na
Zn

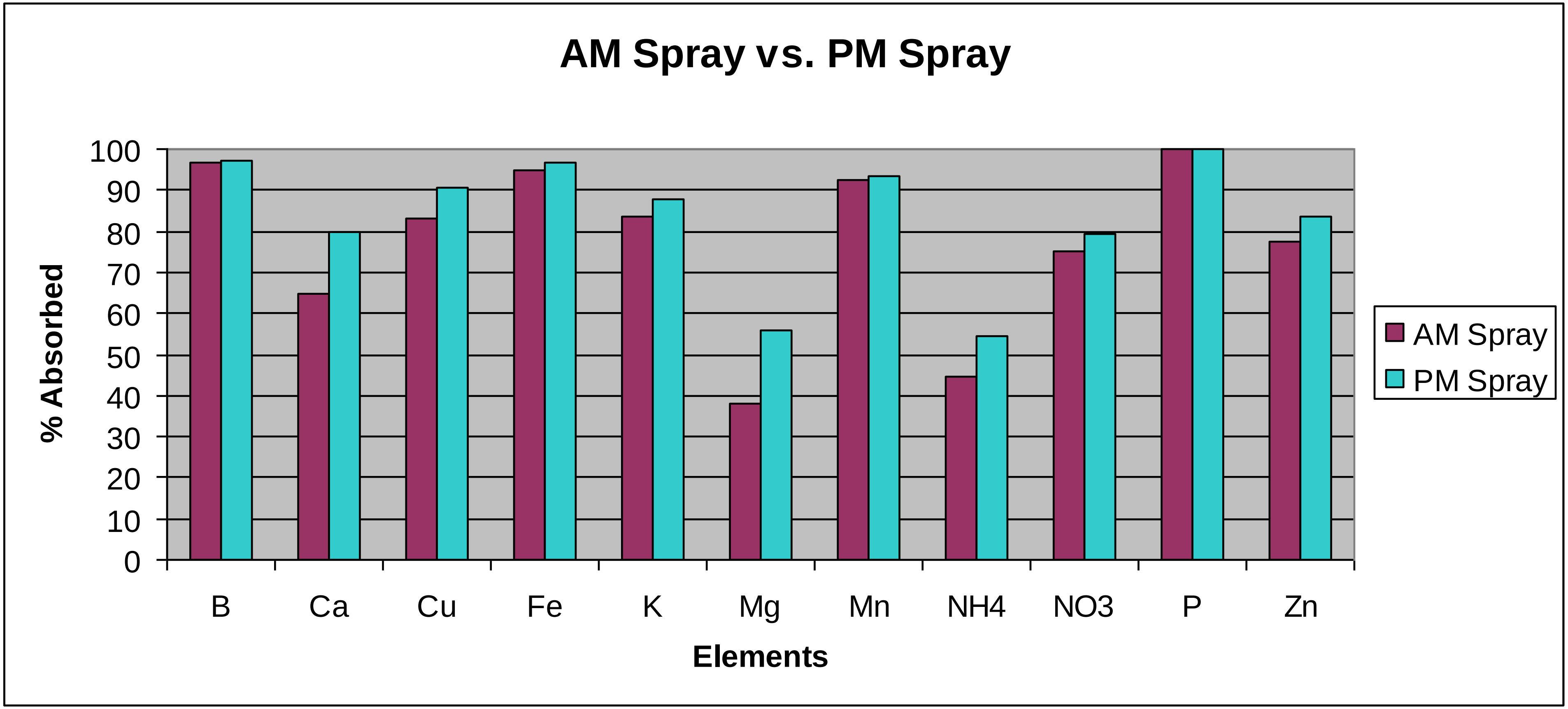
Increase in absorption for foliar vs soluble for nutrients statistically different

	N	Fe	Mn	Cu	B	Ca*	Mg*
Bent UNL	*4.4X*	*1.3X*	*2.8X*	*1.4X*	*19.2X*	*72%*	*61%*
Bent MSU	*1.3X*	*5.3X*	*3.5X*	*NS*	*4.0X*	*62%*	*NA*
***Poa* MSU**	*1.4X*	*8.0X*	*7.9X*	*NS*	*4.0X*	*61%*	*NA*
Bermuda	*1.1X*	*1.6X*	*9.8X*	*NS*	*3.0X*	*97%*	*92%*

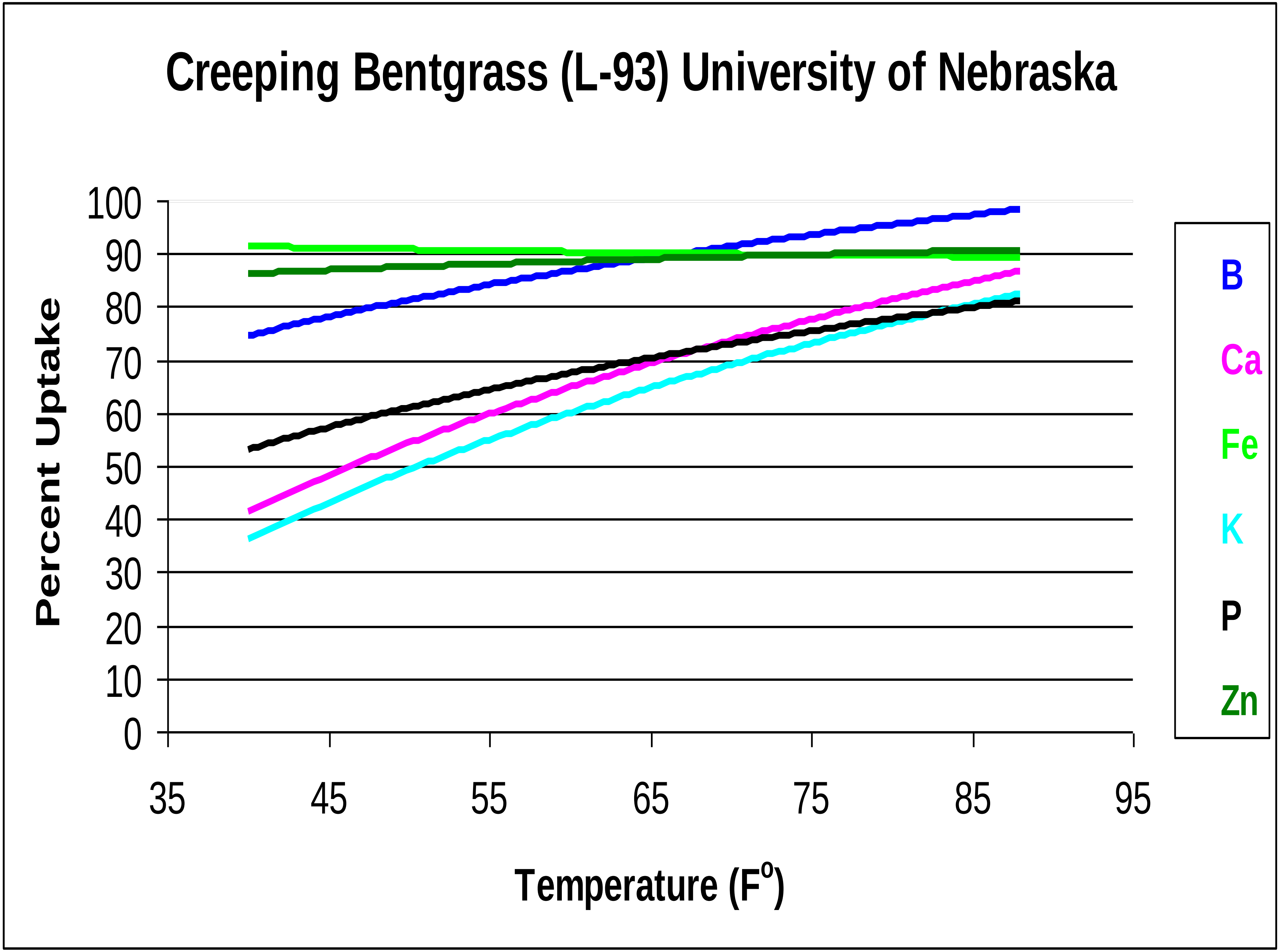
***Not in soluble product; data indicates maximum absorption**
NA = not applied

In all elements the increase in efficiency was always attributed to the foliar product (of the products tested)

Does spraying time affect absorption?



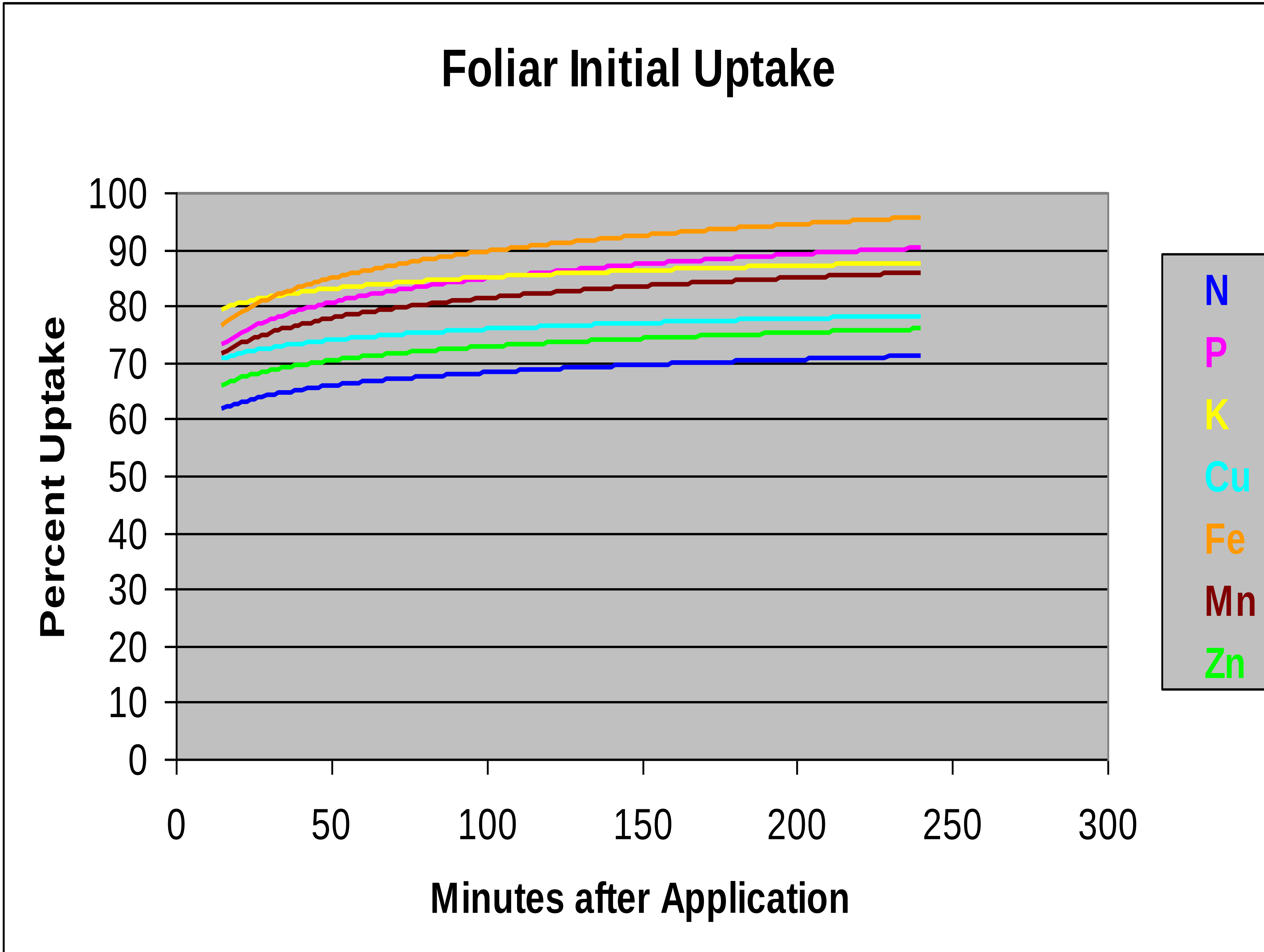
AM Spray = 52^{O} F, PM Spray = 71^{O} F

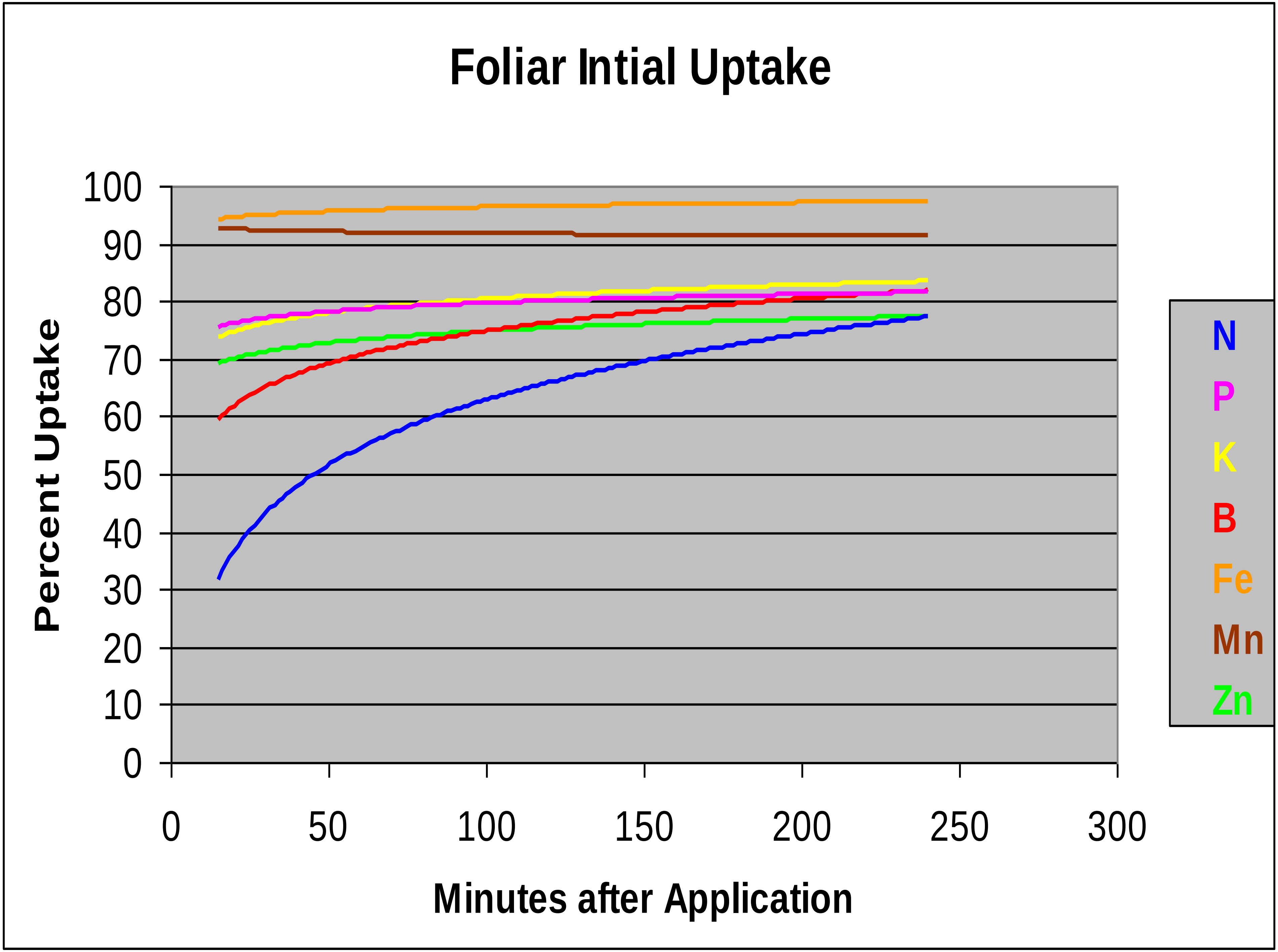


Creeping Bentgrass (L-93) University of Nebraska
Percent Uptake
100
90
80
70
60
50
40
30
20
10
0
35
45
55
65
75
85
95
Temperature (F^{o})
B
Ca
Fe
K
P
Zn

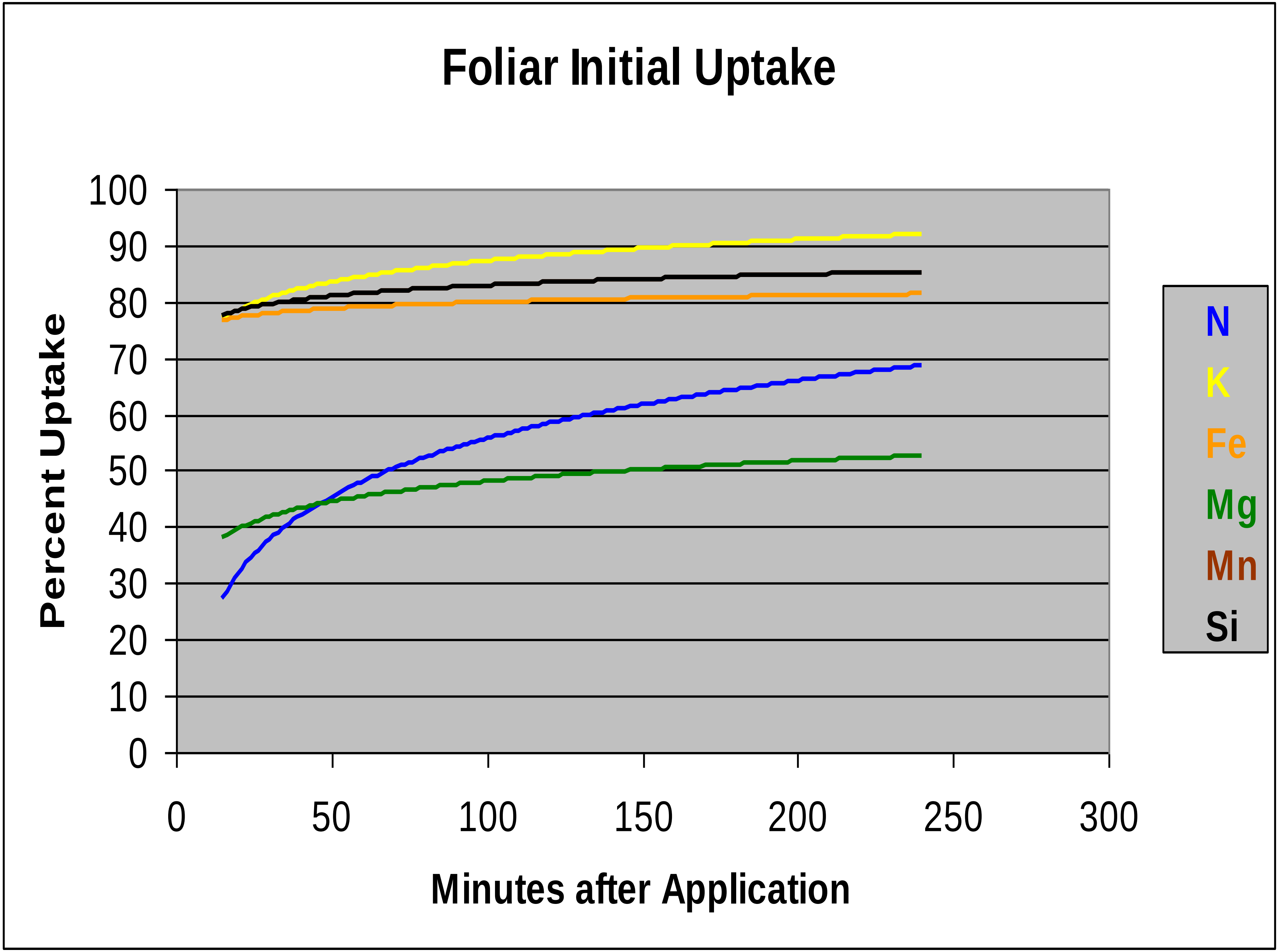
Work was also done in greenhouse under controlled conditions

How quickly can the nutrient get into the leaf?

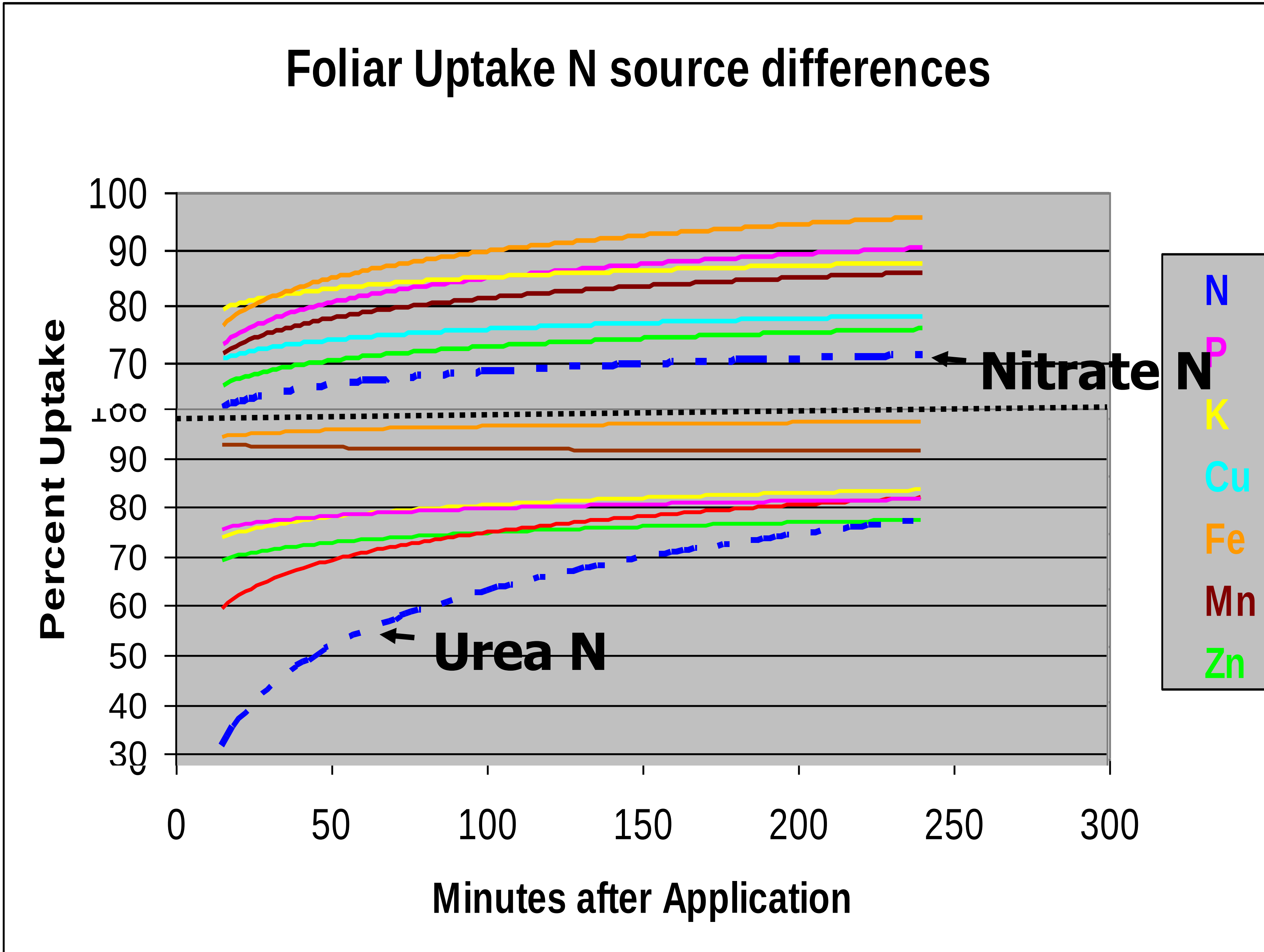

Foliar Initial Uptake
Percent Uptake
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
Minutes after Application
N
P
K
Cu
Fe
Mn
Zn



Foliar Intial Uptake
Percent Uptake
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
Minutes after Application
N
P
K
B
Fe
Mn
Zn



Foliar Initial Uptake
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
Percent Uptake
Minutes after Application
N
K
Fe
Mg
Mn
Si


Foliar Uptake N source differences
Percent Uptake
Minutes after Application
100
90
80
70
60
50
40
30
0
50
100
150
200
250
300
Nitrate N
Urea N
N
P
K
Cu
Fe
Mn
Zn

How quickly does the nutrient get into the leaf?

- **Intake is rapid, often within 15 minutes**
- **Carrier will influence speed**

Summary of our turf work:

- Temperature
- Summer/Fall
- Time of day
- Element
- Source
- Spray Volume
- Shade
- cultivar
- Nutrients applied to turf can be_foliar absorbed

Agronomic Law of Minimum

- 13 essential elements besides C, H, O_2 are required-
- Growth and health will be limited by the lowest optimum level present
- No element may substitute for any other
- Roots at times and under certain conditions are limited in their uptake of nutrients

General information about foliar fertilization

- In general our cultured plants take up necessary nutrients from the soil.
- The basis for plant nutrition is dependent on location, cultural practices and fertilization of the soil.
- A healthy rootzone comes first. Foliar nutrition is a supplement to soil nutrition, not a substitute for it.

General information about foliar fertilization

- But even if there is optimum fertilization of the soil there is not always a continuous supply of nutrients to the plant.
- Circumstances exist where foliar fertilization is a necessary addition to soil fertilization

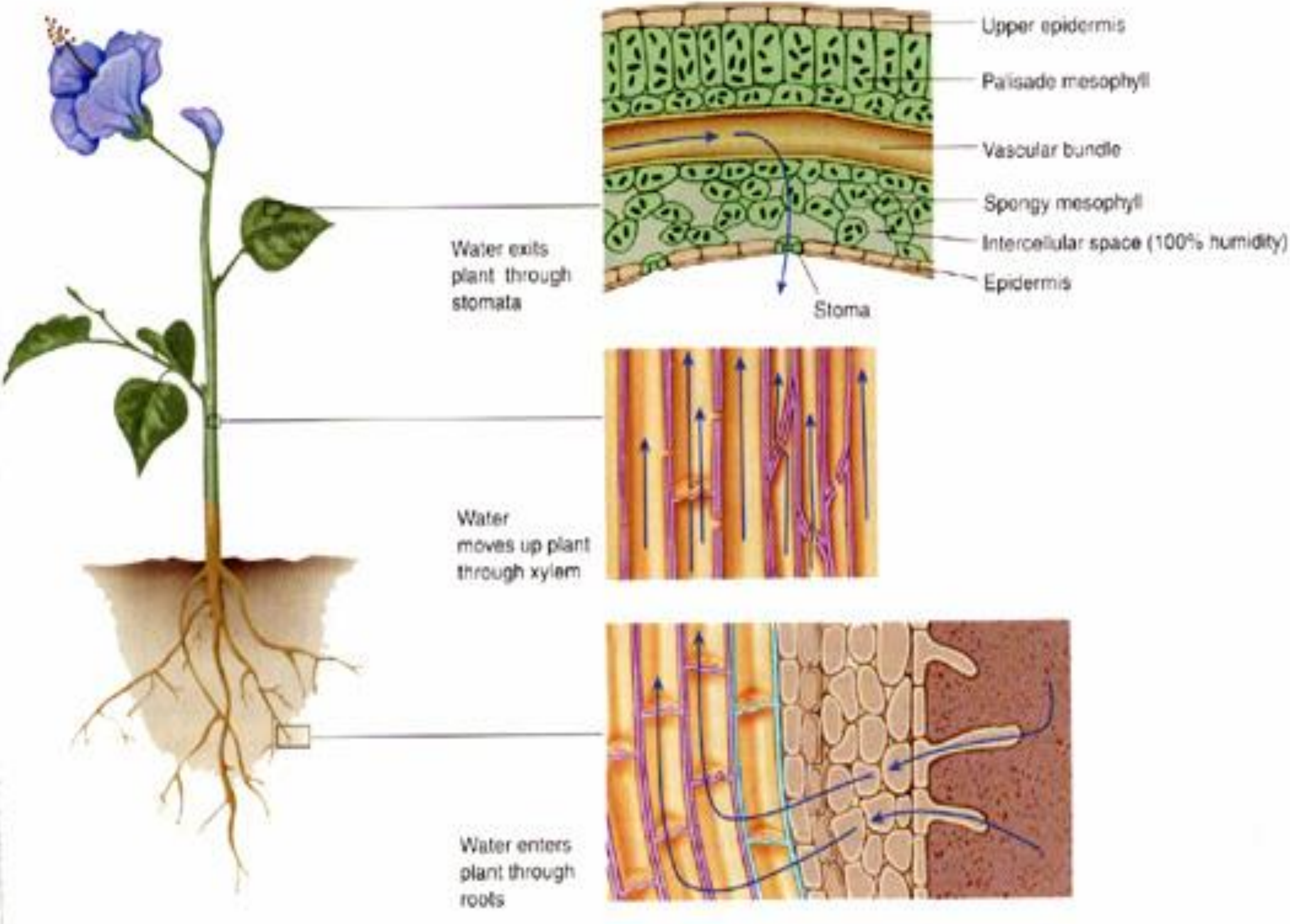
- **Foliar fertilization is by far the most effective way to apply secondary and trace elements. The readily-available nutrients are more easily utilized, because foliar absorption is a physical and chemical process and not a biological process as is the case with most granular fertilizers.**

Nutritional Foliar Sprays

H.B. Tukey, Jr., PhD / S.H. Wittwer, PhD

"Produce quick, visible results and can increase the effectiveness of fertilizer applications to the soil, reducing total amounts of fertilizer applied."

Work With Radioactive Isotopes: 1952-56
For Ph D degree at Michigan State University


Upper epidermis
Palisade mesophyll
Vascular bundle
Spongy mesophyll
Intercellular space (100% humidity)
Epidermis
Stoma
Water exits plant through stomata
Water moves up plant through xylem
Water enters plant through roots

Summary of Tukey's Work:

- Foliar fertilizer, among other things, increases chlorophyll production and photosynthesis in the leaves, which in turn increases the uptake of soil applied fertilizer - in response to increased need for water by the leaf - bringing more nutrients to the plant via the vascular system.

Foliar Feed When….

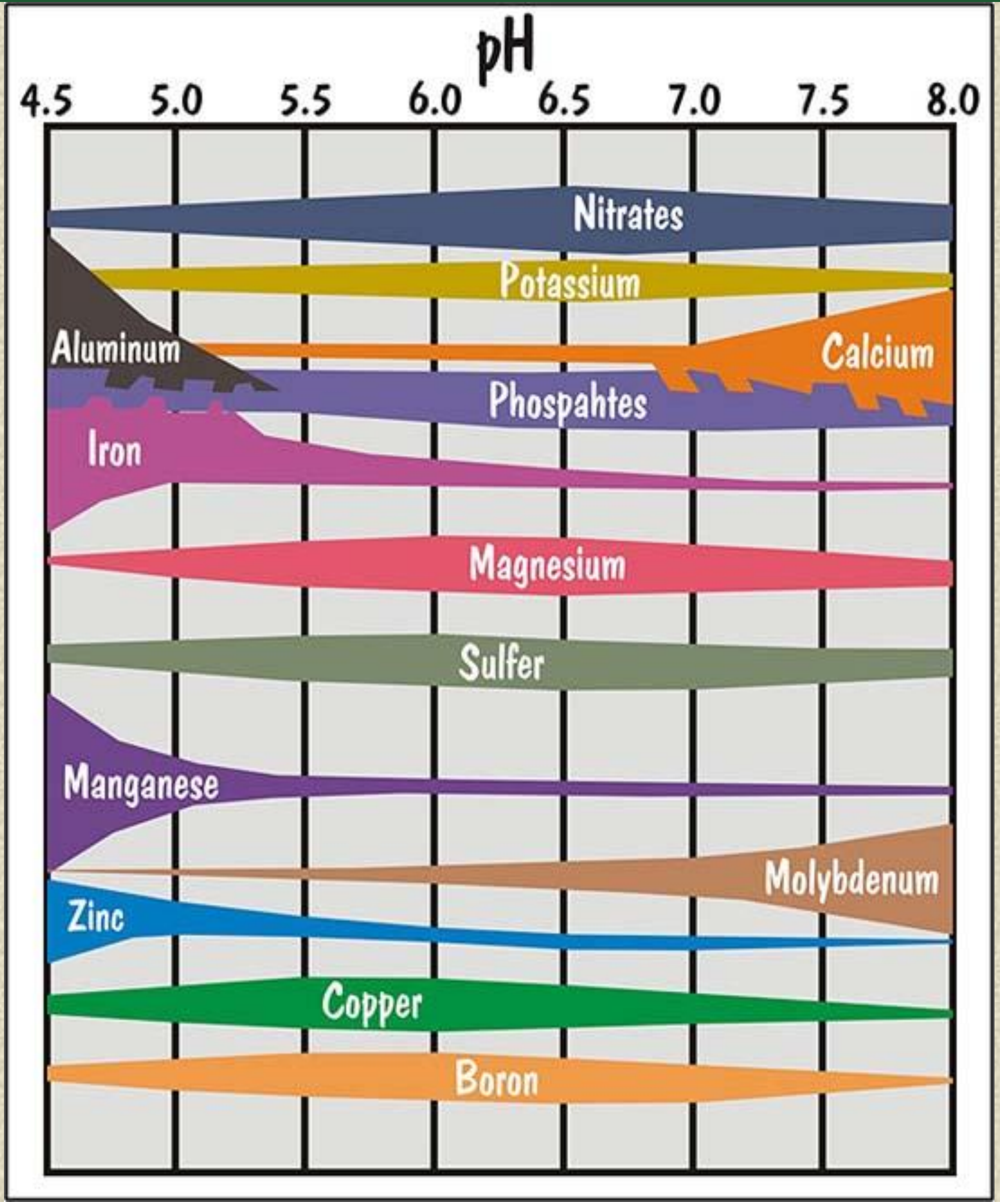
- Poor root structure
- Plant is under stress
- You need to push growth quickly
- You have pH problems in the soil

When Micronutrients Such as Mn , Fe or Zn are Locked in the Soil

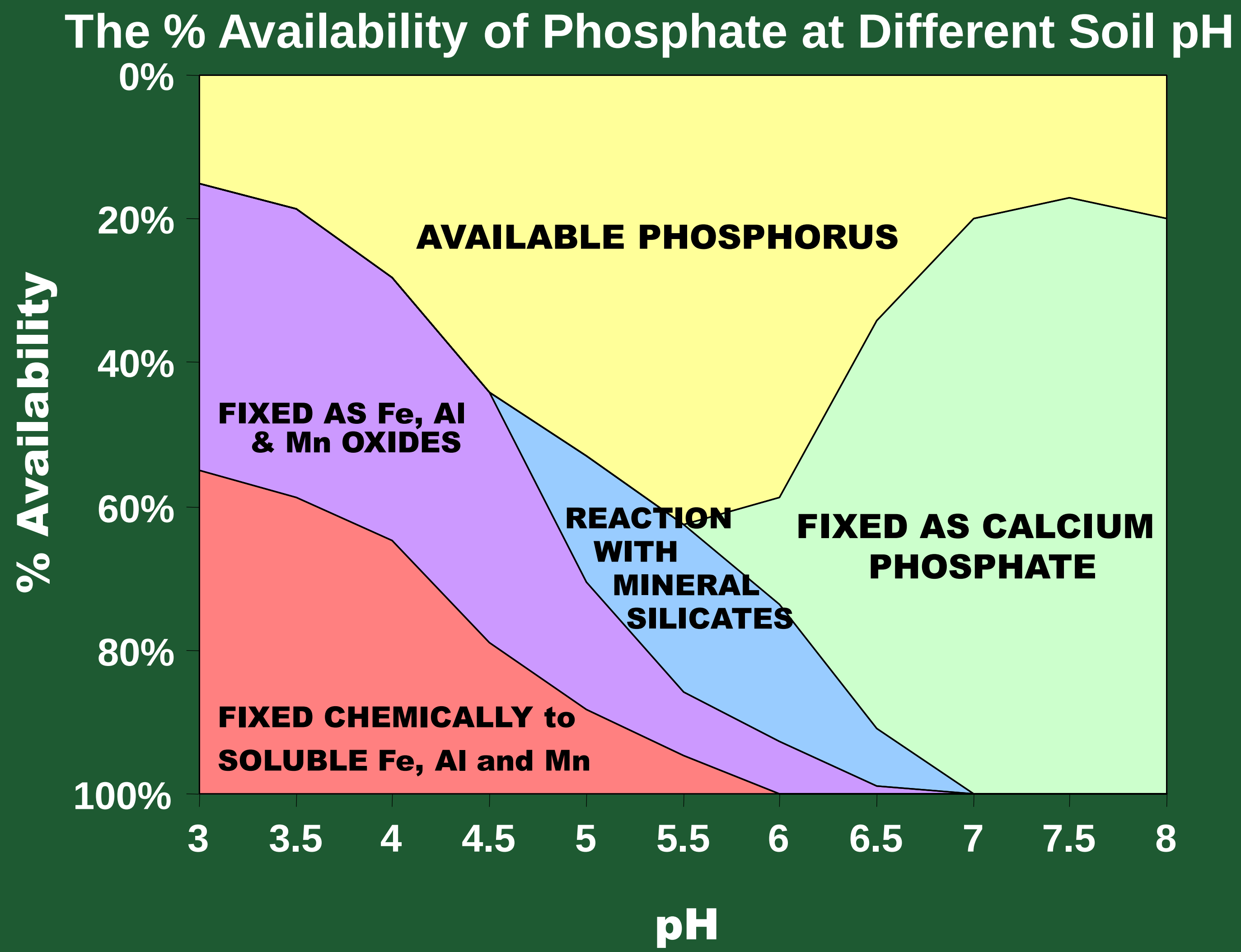
- **Alkaline conditions cause some micro-nutrients, particularly iron, manganese and zinc, to form insoluble compounds and become unavailable to plants. You can correct this condition by adjusting the soil pH to make it more acid, but this adjustment may take weeks, months or years to release the nutrients and if the water is also high in pH it may never happen.**
- **A foliar feeding of micronutrients will feed the plants until the soil nutrients become available again.**
- **This is the most common use of foliar feeding.**

Why Foliar Feed ?

- ✓ **Better response If your optimum *soil pH is out of balance***
  - **Fe, Mn, Zn and other minors in high pH soils**



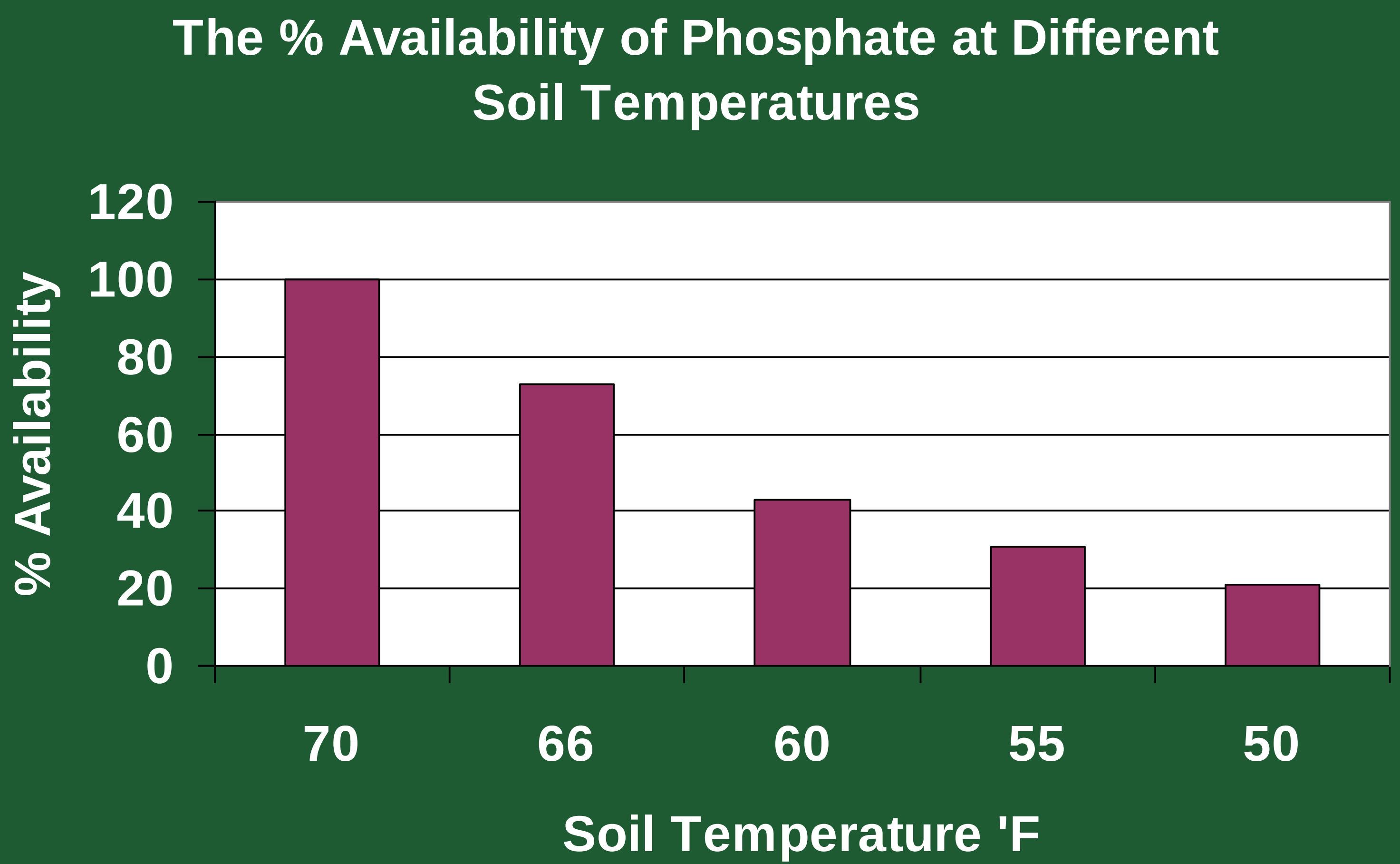
Soil pH Effects



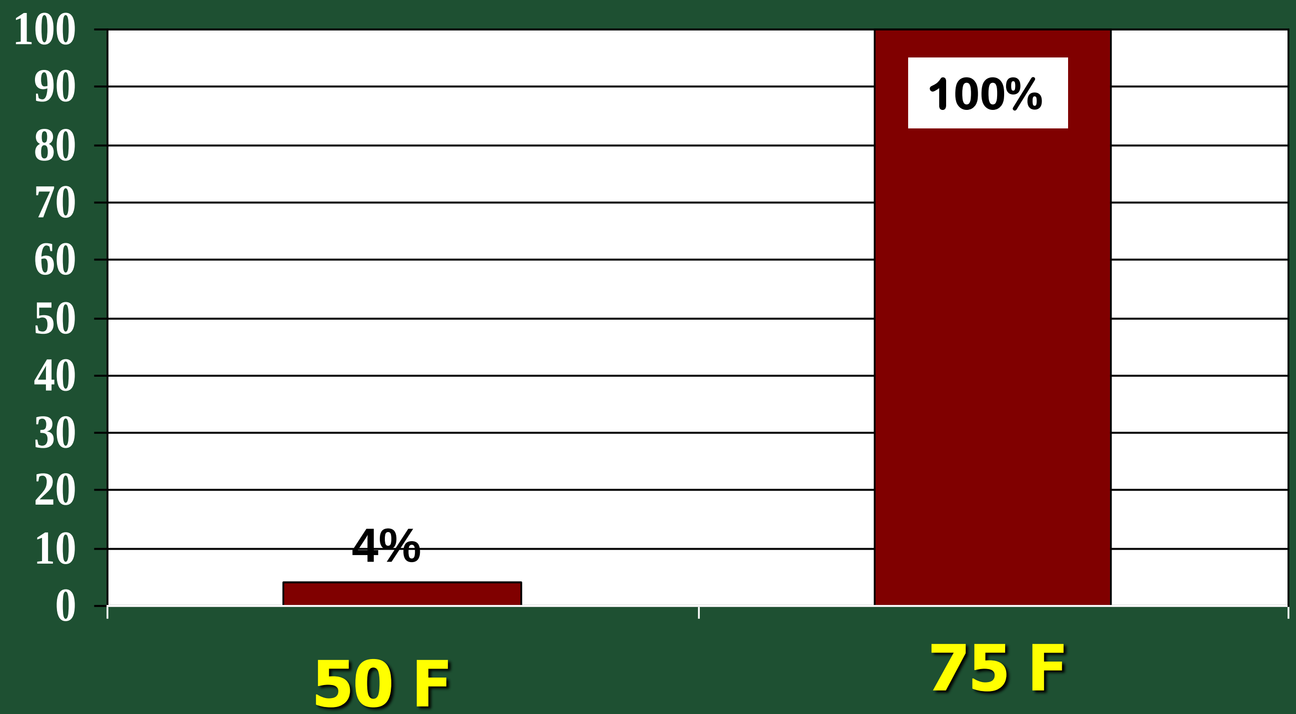
When The Soil is too Cold For Conversion of Nutrient Elements into Usable Forms

- ✓ Early spring and late fall growth is limited by cold soil, even when the air is warm.
- ✓ Under such conditions, soil microorganisms are not active to convert nutrients into forms available for roots to absorb. Yet, if the nutrients were available, the plant could grow.
- ✓ A nutrient spray to the foliage will provide the needed nutrients immediately to the plants, allowing the plant to begin growth before the roots are able to absorb nutrients from the soil.

Soil Temperature Effects

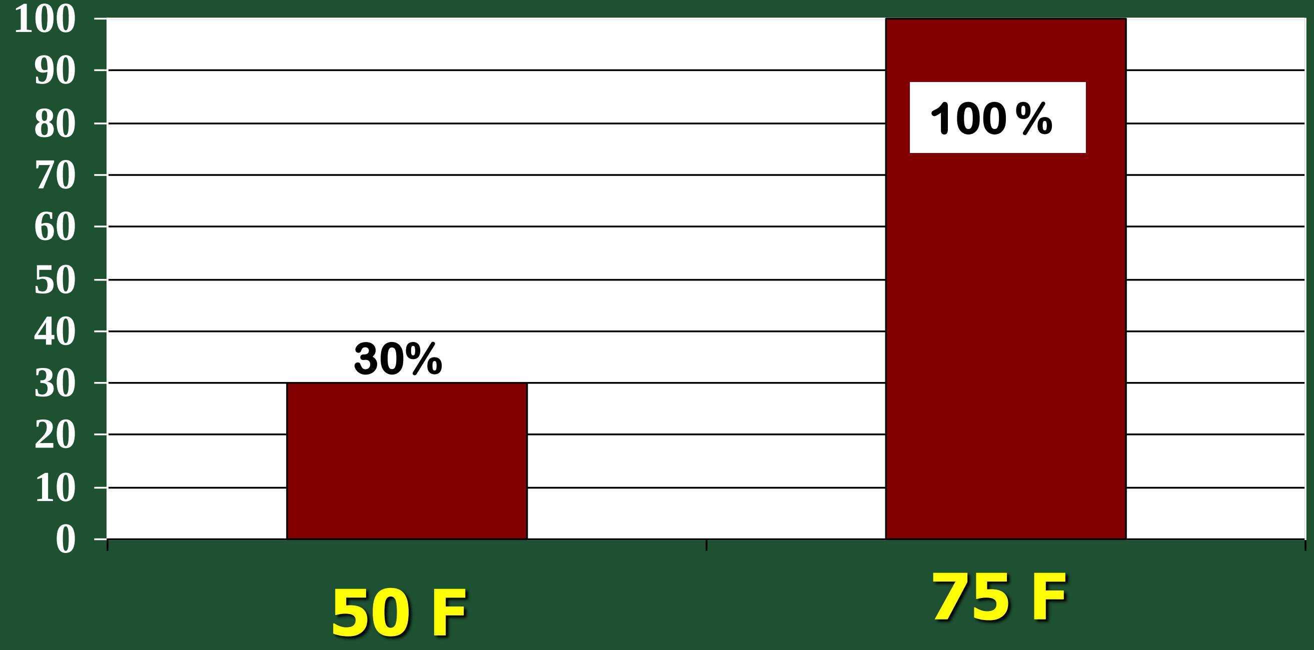


Temperature Influence on Zinc Uptake



As turf is grown in cooler soils the need for starter nutrients such as zinc increases.

Temperature Influence on Potassium Uptake

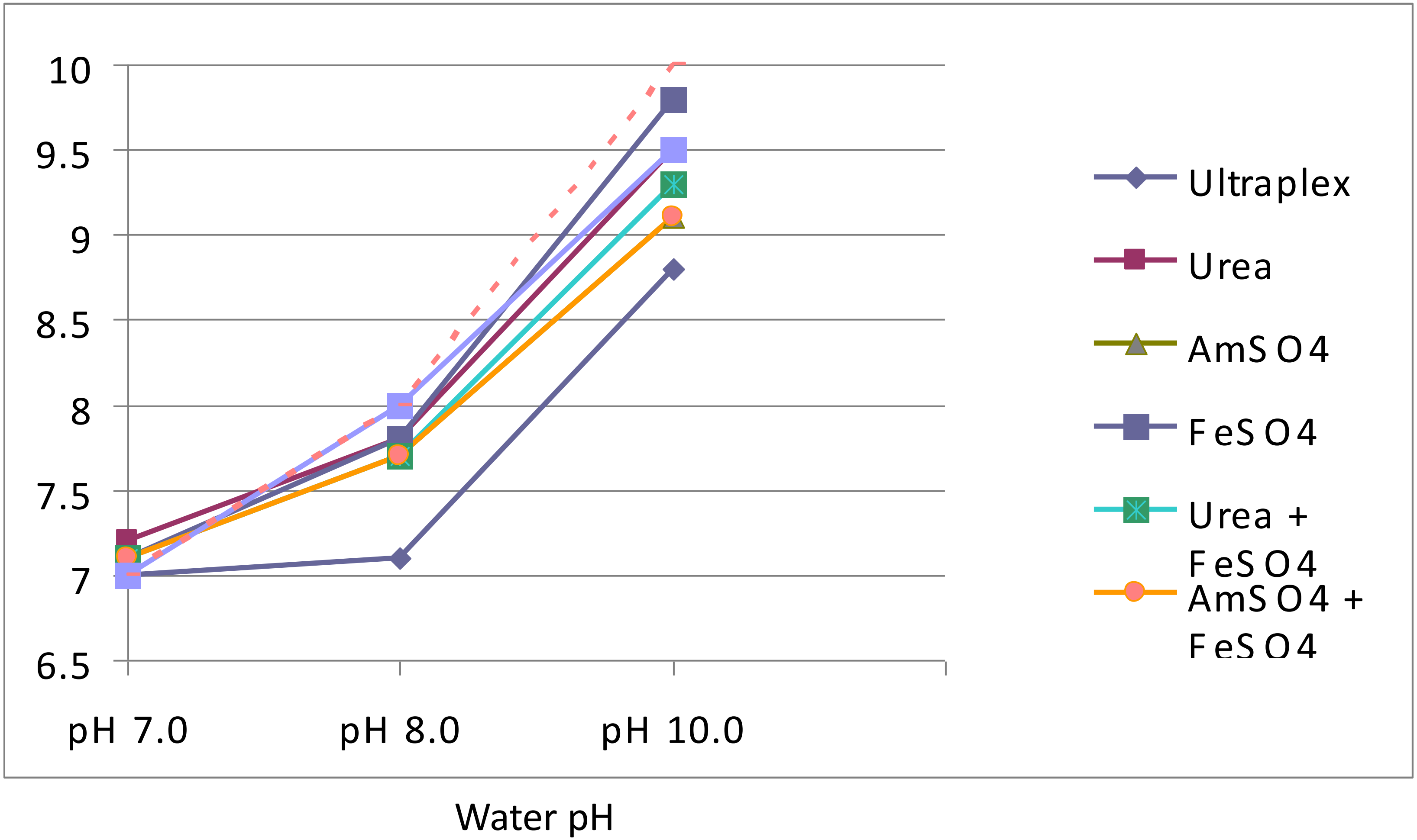


Cold wet spring and fall soils restrict the uptake of Potassium

Spray Solution Effects

- **Surfactants/Adjuvants**
  - Beneficial to critical
- **pH**
  - Slightly acidic to neutral

Liquid fertilizer effects on spray solution pH



SECONDARY UTILITY ADJUVANTS

Acidifying Agent. An acidifying agent is defined as "a material that can be added to spray mixtures to lower the pH" (ASTM 1995). Typically, acidifying agents are dilute solutions of strong acids. They will rapidly lower the pH of the spray solution. However, because they are strong acids, the pH of the spray solution will rise if alkaline-based products are added to the spray solution.

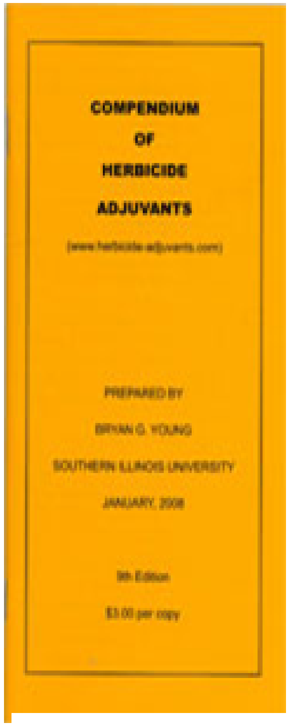
Buffering Agent. A buffering agent is defined as "a compound or mixture that, when contained in solution, causes the solution to resist change in pH, with a characteristic limited range of pH over which it is effective" (ASTM 1995). Both buffering agents and acidifying agents will reduce spray solution pH. A buffering agent will maintain a pH range of the spray solution when other acid- or alkaline-based materials are added to the spray solution, whereas an acidifying agent will not maintain the spray solution pH. Buffering agents have a characteristic pH range that they will maintain, and they vary in buffering capacity.

Compendium of Herbicide Adjuvants, 9th Edition, Bryan Young, PSAS, Southern Illinois University - Windows Internet Explorer

http://www.herbicide-adjuvants.com/

Compendium of Herbicide Adjuvants, 9th Edition

- SIU Weed Science Homepage
- Adjuvant Products by Name
- Adjuvant Products by Category
- Adjuvant Products by Manufacturer
- Crop Based Adjuvant Products
- Adjuvant Products Added Since Printing
- Glossary of Terms
- Names and Addresses of Mfg/Dist
- About Adjuvant Product



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www.herbicide-adjuvants.com

Buffering Agent or Acidifier

This information was provided by the adjuvant manufacturers/distributors.

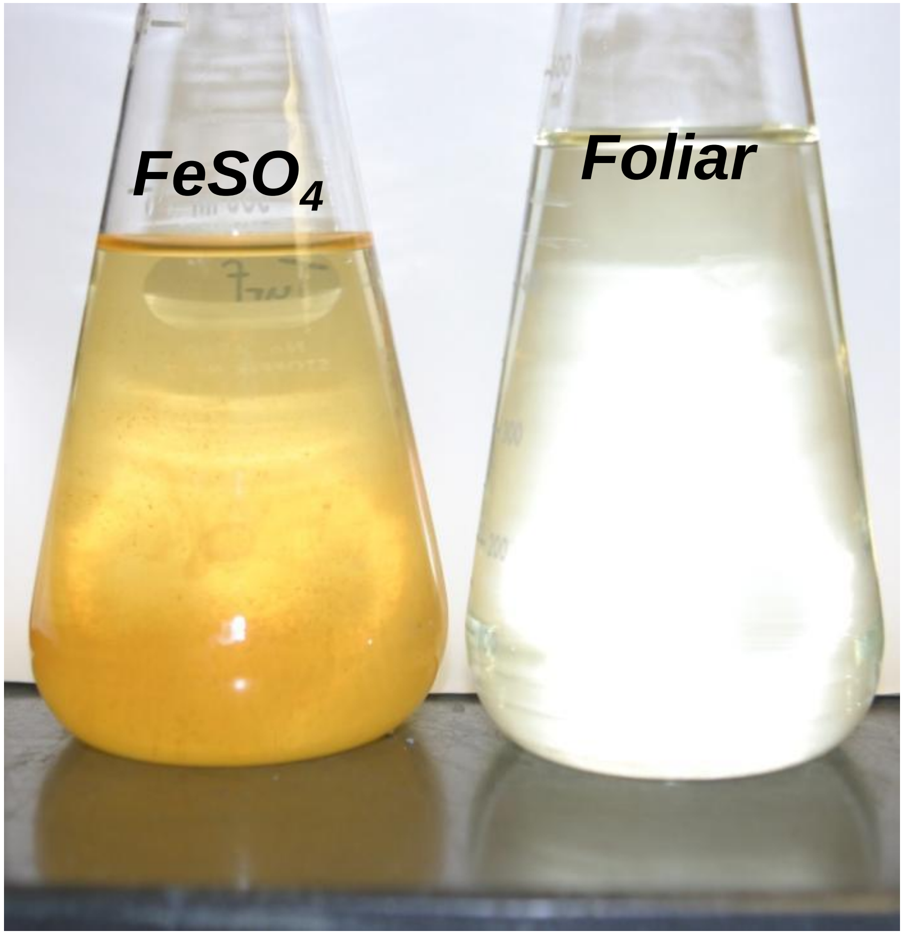
There were **62** products that matched your request.

Pages: 1 2 [>>]

PRODUCT NAME (linked to labels)	MANUFACTURER/ DISTRIBUTOR	ADJUVANT CATEGORY	PRINCIPAL FUNCTIONING AGENTS	USE RANGE	COMMENTS
ADURO	Estes, Inc.	Water Conditioning Agent *and* Nonionic Surfactant *and* Buffering Agent or Acidifier	Ethoxylated fatty amine-glycerol acid complex, polyoxyethylene ether blend, pH adjusting agents and deposition agents	1 - 4 pints / 100 typical	All in 1 glyphosate additive
AERO DYNE-AMIC	Helena Chemical Co.	Methylated or Ethylated Vegetable Oil *and* Nonionic Surfactant *and* Buffering Agent or Acidifier	Proprietary blend of ethoxylated alkyl phosphate esters, polyalkylene modified polydimethylsiloxane, nonionic emulsifiers and methylated vegetable oils	For aerial use only at 2-8 qt/100 gal	Provides pH reduction and buffering, NIS and oil blend. See label for rates.
AMS-XTRA Label/MSDS	Drexel Chemical Co.	Buffering Agent or Acidifier *and* Nitrogen Source	Ammonium sulfate solution, dimethylpolysiloxane	1-2.5 gal/100 gal	Contains defoaming agents
AQUA-KING MAX	Estes, Inc.	Nonionic Surfactant *and* Buffering Agent or Acidifier	Nonylphenol polyethylene glycol ether, glycol and free fatty acids, organic phosphatic acids, dimethylpolysiloxane	1-4 pt/100 gal	Aquatic Labeled, pH Buffering
BALLAST	Winfield Solutions, LLC	Buffering Agent or Acidifier	Alklyarylpolyethoxyethanol phosphates and organic phosphatic acids	1-12 oz/100 gal	
BRANDT PROLEC Label/MSDS	Brandt Consolidated, Inc.	Buffering Agent or Acidifier *and* Water Conditioning Agent *and* Nonionic Surfactant *and* Deposition (Drift Control) and/or Retention Agent	Phospholipids, ethylformic acid and fatty acid ethoxylated	4-16oz/100 gal for acidification; 0.5-2 pts/100 gal for surfactant; 1-2 qts/100 gallon for drift reduction	
BRONC MAX	Wilbur-Ellis Company	Water Conditioning Agent *and*	AMS/ammonium alkyl aryl sulfonates, polycarboxiylic acid	1-8 pt/100 gal	AMS replacement

Precipitate Formation

- $FeSo_4$ = precipitate at pH = 8 & 10
- Foliar (buffered) solution no precipitate
- Weight equaled ca. 60% of what was initially dissolved
- In 100 gallons = ca. 0.25 lbs



How do you know if you need a buffering agent?

- Recommended on label
- pH >7.5
- Tank mixing multiple products

How do you know your spray solution pH?

- Measure it, but how?
  - How accurate do you need to be?
  - When should you test?
- For some water sources, pH fluctuates with season, test frequently

Home » pH Paper, Pkg. of 100

pH Paper, Pkg. of 100

SAVE 10% when you buy 5 or more!

Add to Cart (Select Quantity Below)

A science class favorite, this package of 100 pH test papers lets you learn about acids and bases. Chemical reactions cause the paper's color to change when exposed to varying levels of acid and base. This color change can be matched against the 1-14 scale color chart provided to determine the pH of the solution at hand.

More than just a lab experiment, recent studies have shown the pH of the body is important to one's overall health and well being. This pH test paper can also be used on collected samples of your own bodily fluids (saliva, urine) to determine your pH.

Browse:
More pH Testers...
More Chemistry 101...

(8 customer reviews)

Gift Wrap Available

Click here to tell a friend about this item.

Item #	Description		Price	Qty
3021313	Litmus Paper, Pkg/100,	1-4 5+	$1.95 $1.76	

Putting it all together…………

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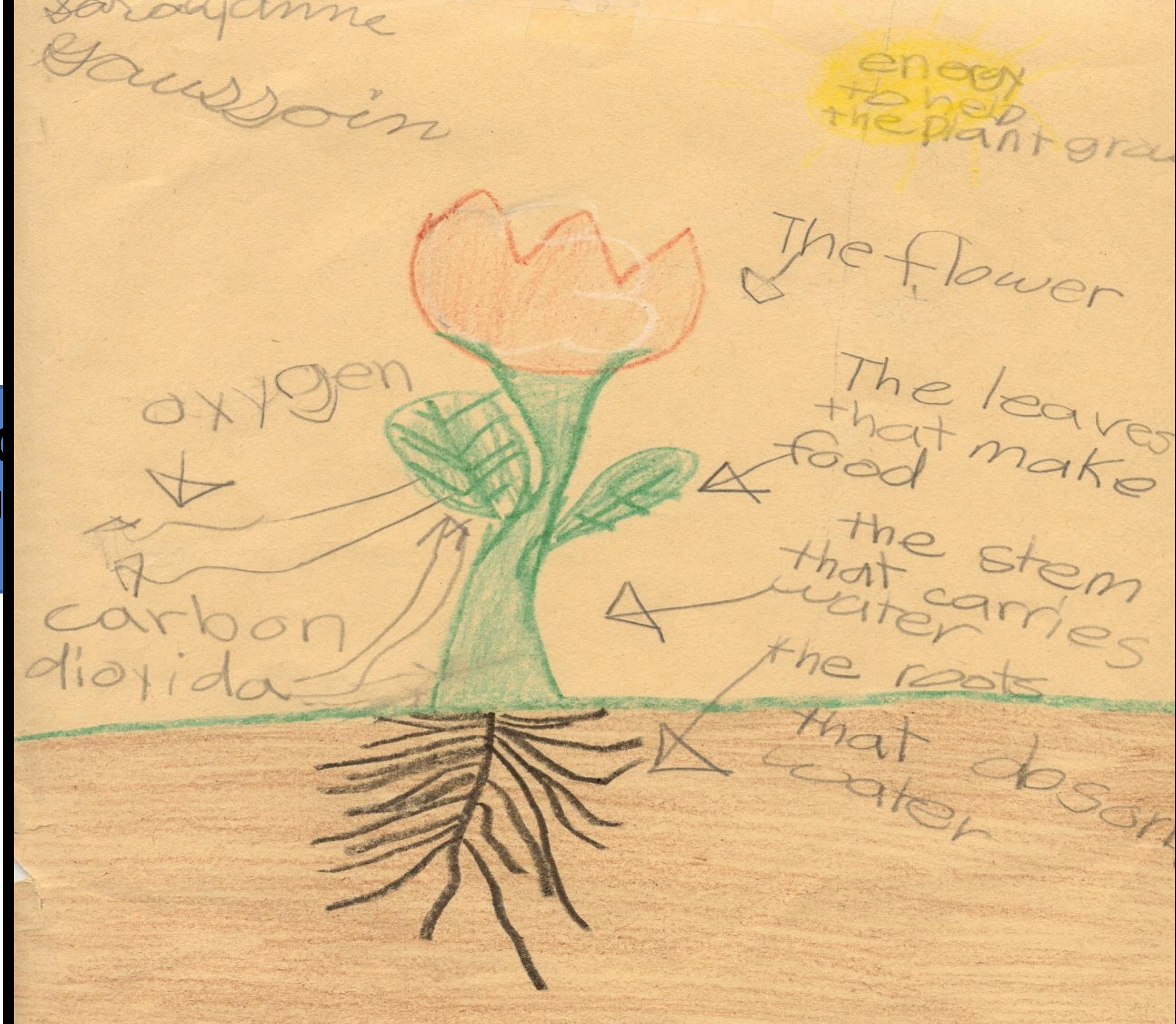

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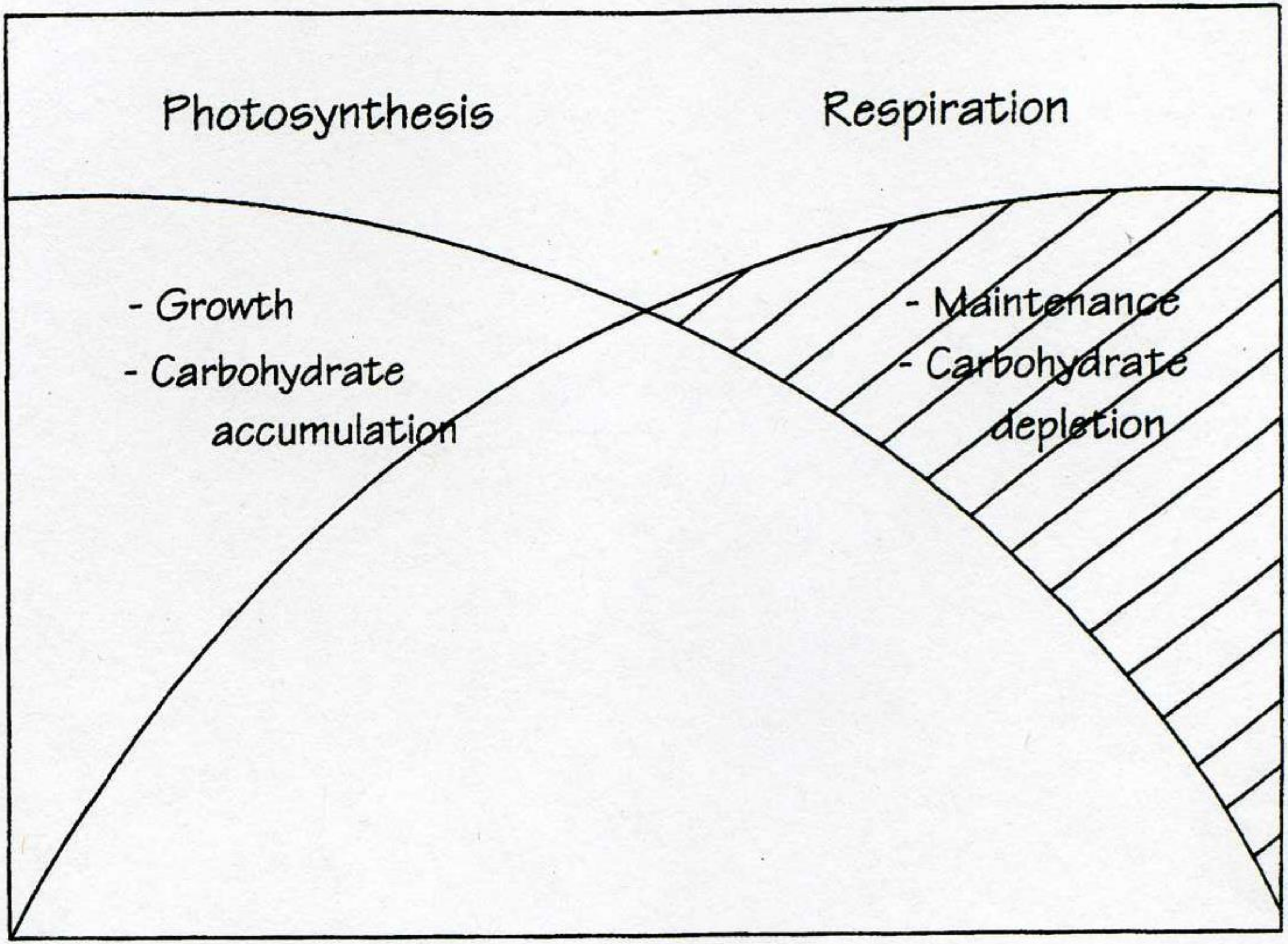
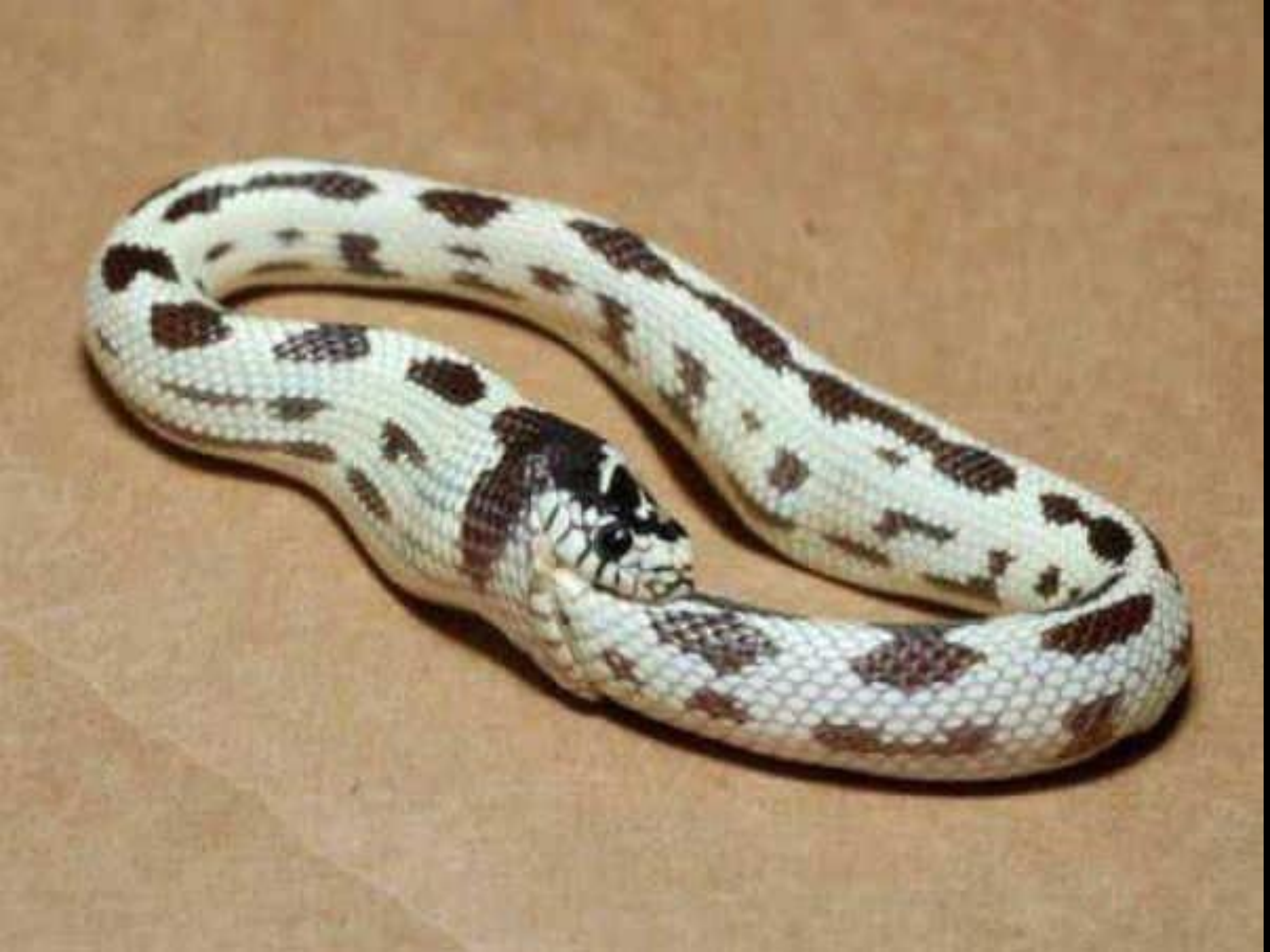
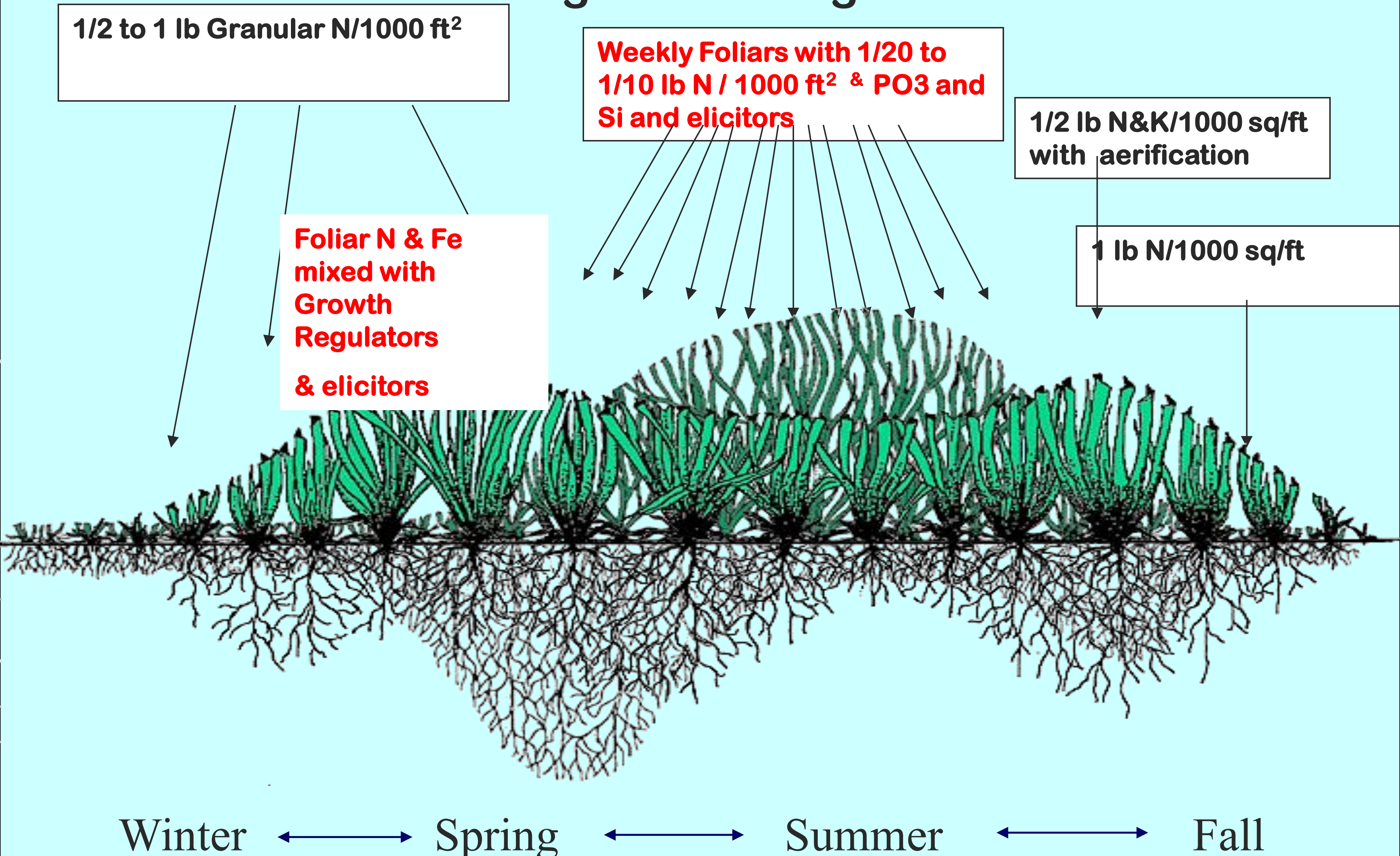
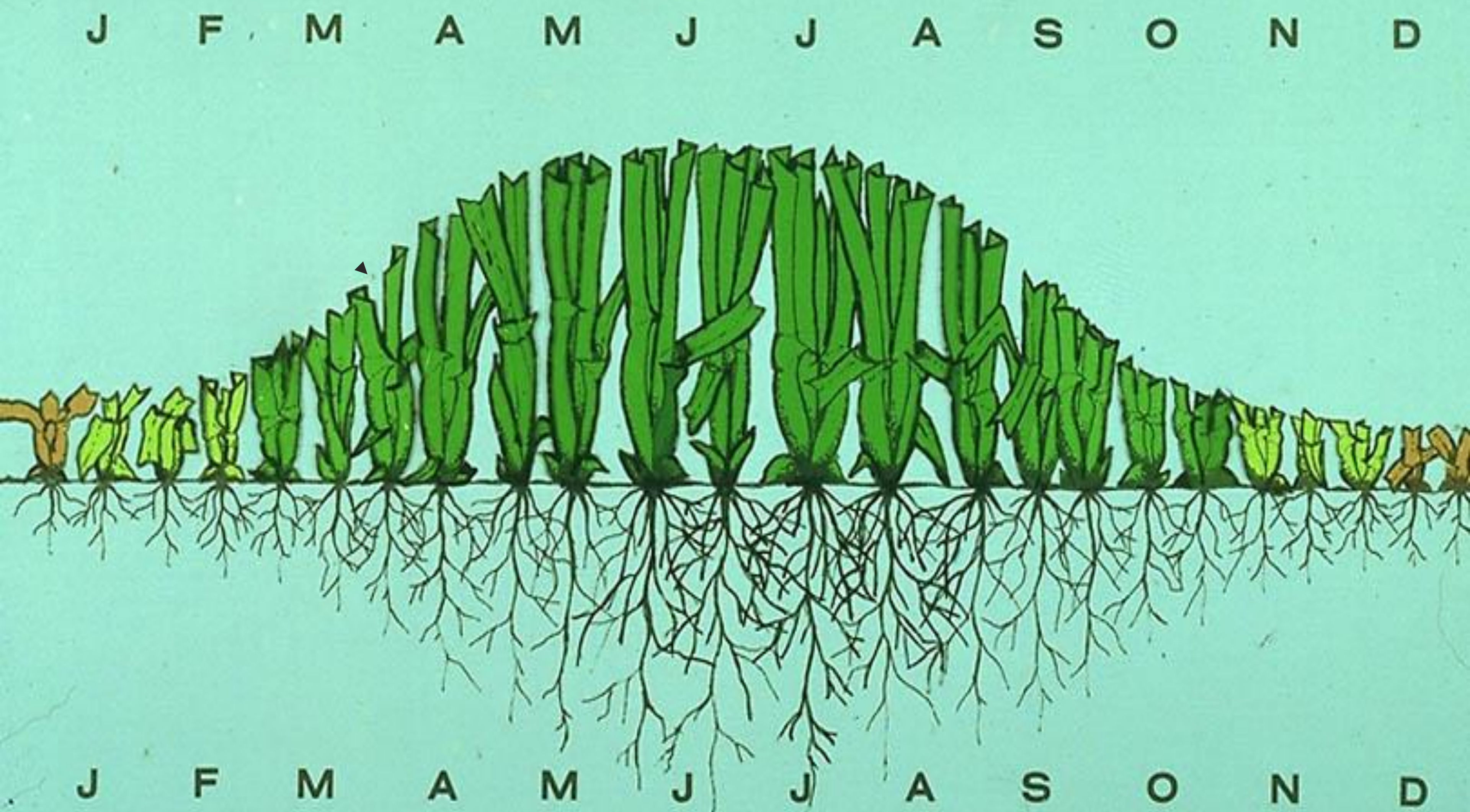

Photosynthesis
Respiration
- Growth
- Carbohydrate
accumulation
- Maintenance
- Carbohydrate
depletion

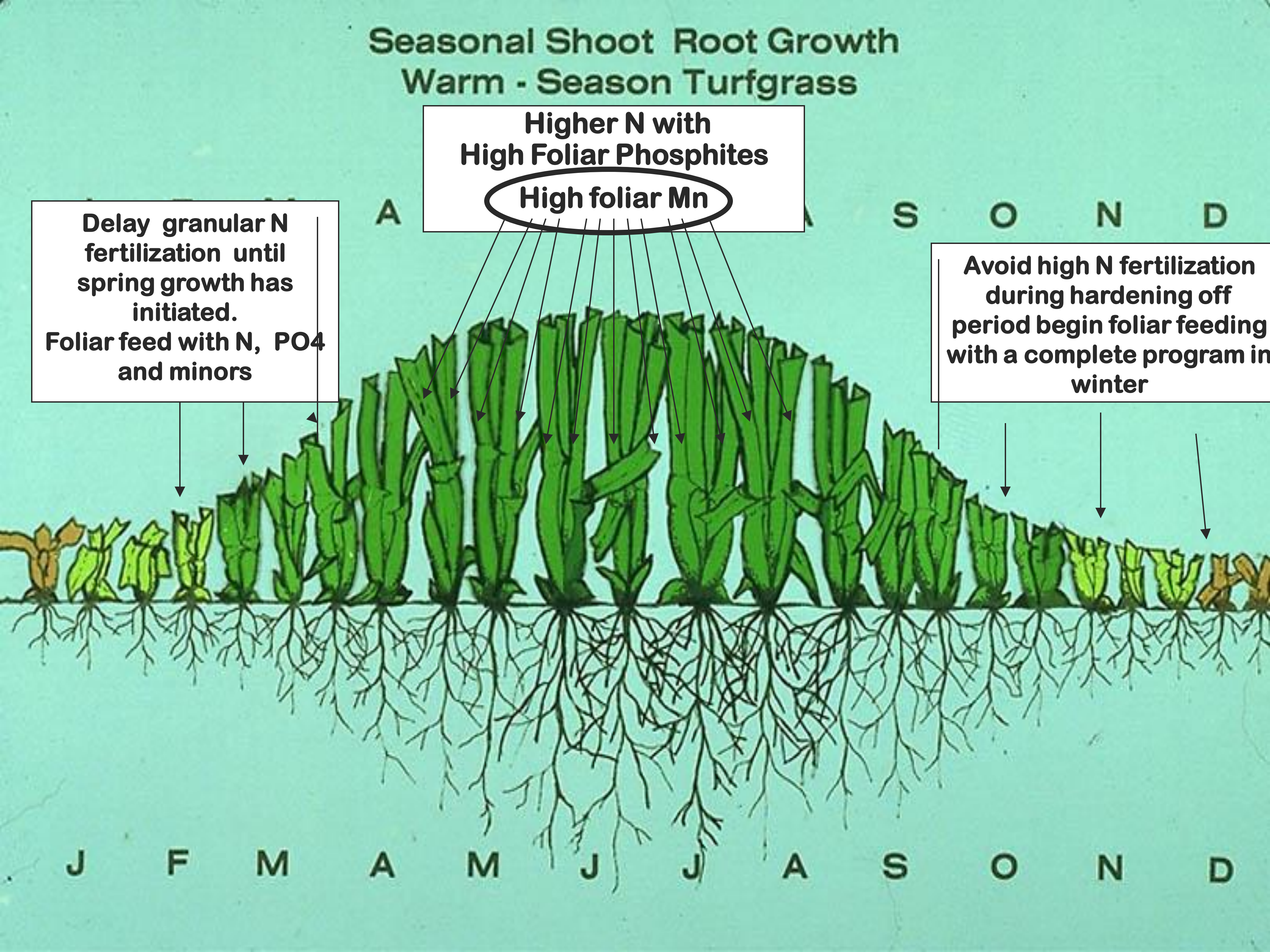


Annual Bluegrass / Bentgrass Greens



Seasonal Shoot Root Growth
Warm - Season Turfgrass




Seasonal Shoot Root Growth
Warm - Season Turfgrass
Higher N with
High Foliar Phosphites
High foliar Mn
Delay granular N fertilization until spring growth has initiated.
Foliar feed with N, PO4 and minors
Avoid high N fertilization during hardening off period begin foliar feeding with a complete program in winter
A
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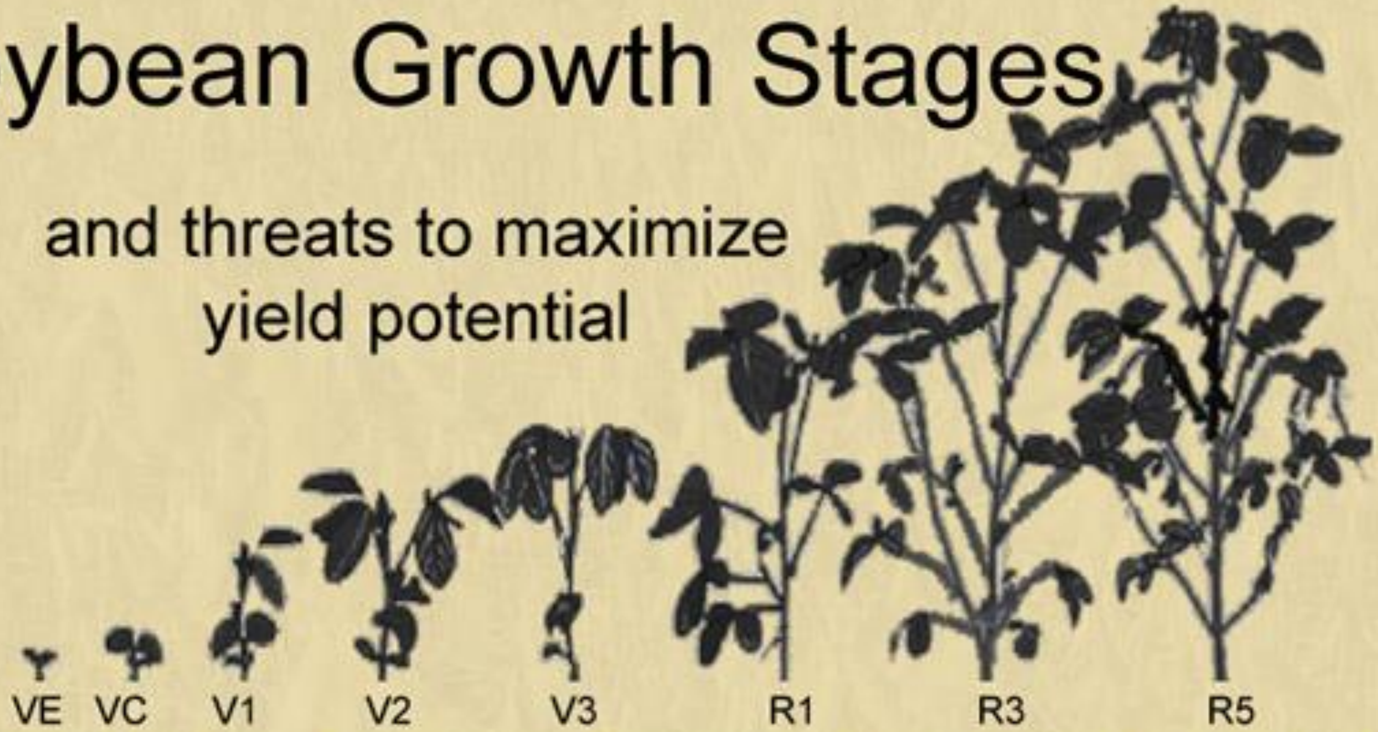
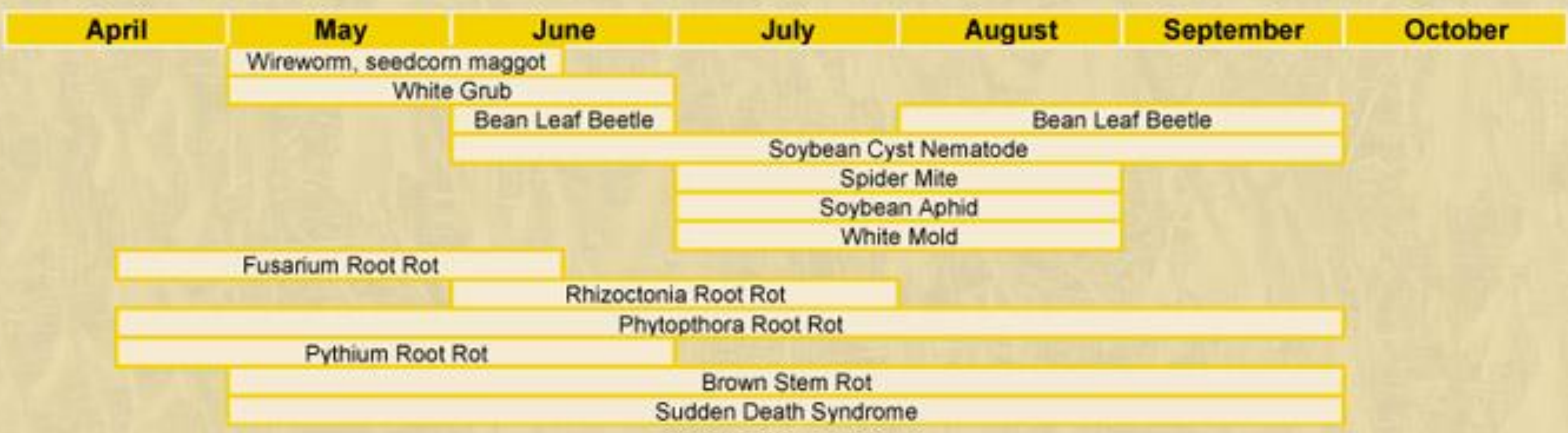
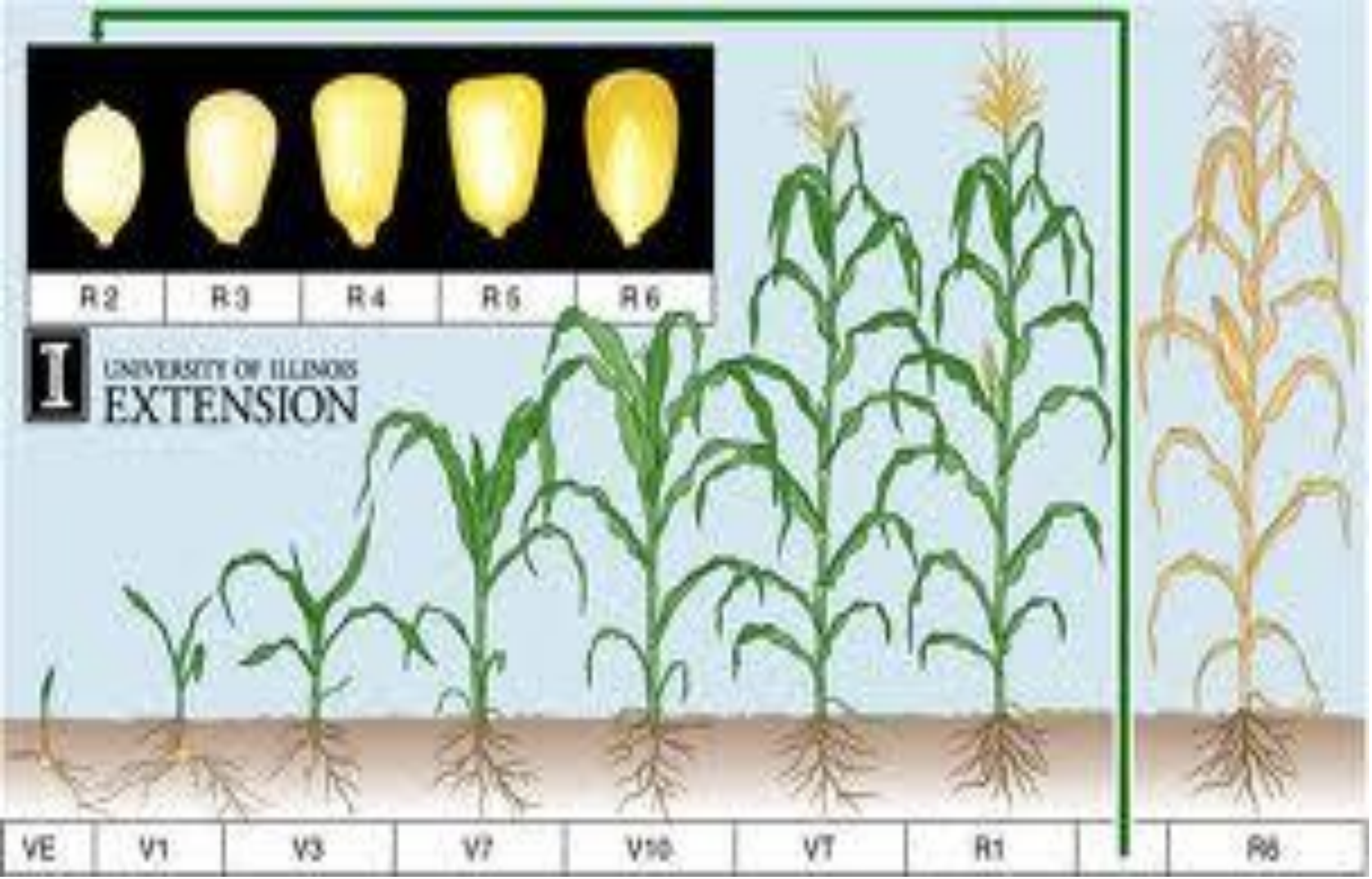
Soybean Growth Stages

and threats to maximize yield potential



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R6

Take Home

- **Embrace new technologies while staying true to basic agronomic principles**
- **There are agronomic benefits of low dose, foliar fertilizer application -specifically as a supplement to an already existing, sound, granular program.**

Take Home

- There are inherent nutrient uptake inefficiencies from the soil based on limitations of the environment (soil - physical, chemical, biological).
- Foliar nutrition makes sense when root growth is compromised or plants are under stress.

Bottom Line for Foliar Nutrition

- The work in agronomic crops is not as far along as the work in turf systems
- Most University specialists are skeptical, as they should be, concerning recommendations
- Be open minded about the possibilities.

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Dec-09-2013

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Turf iNfo for the North Central US

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2013 | 2012 | 2011 | 2010

Control weeds in dormant buffalograss now
C&P : Nov-21-2013

Improving success of dormant seeding
C&P : Oct-30-2013

Keep mowing and don't set the mower down
C&P : Oct-30-2013

Late seeding and winterkill risk
C&P : Oct-06-2013

Stay up to date! Turf iNfo will be updated frequently throughout the growing season. To sign up for *automatic Turf iNfo updates* email turf@unl.edu. Provide your first name, last name and email address with "ADD" in the subject line.

Education Events & Field Days

- 2014 Nebraska Turf Conference, Jan. 7-9, LaVista Conference Center. BROCHURE : REGISTER

NTEP (National Turfgrass Evaluation Program)

- Nebraska Turfgrass Association
- Backyard Farmer

Thanks and have a great holiday season!!