

Raymond C. Ward
Ward Laboratories, Inc
Kearney, NE
www.wardlab.com

There is More Than N P K

- Major Nutrients
 - N, P, and K
- Secondary Nutrients
 - Calcium, Magnesium, and Sulfur
- Micro-Nutrients
 - Zinc, Iron, Manganese, Copper, and Nickel
 - Boron, Chloride, and Molybdenum

Crop Nutrient Uptake

Secondary Nutrients

Nutrient:	Form(s) taken up by plant:
Calcium (Ca)	Ca^{2+}
Magnesium (Mg)	Mg^{2+}
Sulfur (S)	SO_4^{2-} , SO_2^-

Crop Nutrient Uptake

Micronutrients

Nutrient:	Form(s) taken up by plant:
Iron (Fe)	Fe^{2+} (ferrous), Fe^{3+} (ferric)
Zinc (Zn)	Zn^{2+}
Manganese (Mn)	Mn^{2+} , MnEDTA
Copper (Cu)	Cu^{2+}
Boron (B)	H_3BO_3
Chlorine (Cl)	Cl^-
Molybdenum (Mo)	MoO_4^{2-}

Nutrient Crop Removal, lbs/Bu CORN

<u>Nutrient</u>	<u>lb/bu 200 bu/A</u>	
Nitrogen, N	0.75	150
Phosphorus, P2O5	0.33	66
Potassium, K2O	0.23	46
Sulfur, S	0.09	18
Zinc, Zn	0.001	0.2

Nutrient Crop Removal, lbs/Bu

CORN

<u>Nutrient</u>	<u>lb/bu</u>	<u>200 bu/A</u>
Chloride	0.024	4.8
Manganese	0.0006	0.12
Iron	0.0012	0.24
Copper	0.0004	0.08
Boron	0.0006	0.12
Molybdenum	0.00001	0.002

Crop Nutrient Removal, lbs/bu

SOYBEAN

<u>Nutrient</u>	<u>lb/bu</u>	<u>60 bu/A</u>
Nitrogen, N	3.6	216
Phosphorus, P ₂ O ₅	0.77	46
Potassium, K ₂ O	1.2	72
Sulfur, S	0.18	11
Zinc, Zn	0.003	0.18

Crop Nutrient Removal, lbs/bu

SOYBEAN

<u>Nutrient</u>	<u>lb/bu</u>	<u>60 bu/A</u>
Chloride	0.016	1.0
Iron	0.005	0.3
Manganese	0.002	0.12
Copper	0.001	0.06
Boron	0.0006	0.04
Molybdenum	0.00001	0.0006

Nutrient Crop Removal, lbs/Bu

WHEAT

<u>Nutrient</u>	<u>lb/bu</u>	<u>60 bu/A</u>
Nitrogen, N	1.2	72
Phosphorus, P2O5	0.52	31
Potassium, K2O	0.26	16
Sulfur, S	0.12	7
Zinc, Zn	0.003	0.18

Nutrient Crop Removal, lbs/Bu

WHEAT

Nutrient	lb/bu	60 bu/A
Manganese	0.002	0.12
Copper	0.0007	0.04
Boron	0.001	0.06
Molybdenum	0.0004	0.02
Zinc, Zn	0.002	0.12
Chloride	0.07	4.2

Soil Testing

- Measure Nutrient Supply
- Determine Amount of Nutrient to Apply
 - Based on soil test value
 - Based on crop and yield goal
 - Based on crop removal
- Track Soil Test Changes Over Time
 - Are you increasing or decreasing nutrient levels?

Zinc Soil (DTPA) Test and Recommendations

<u>Soil Test ppm Zn</u>	<u>Corrective Rate lb Zn/A</u>
0-0.25	3-12
0.26-0.50	1-7
0.51-.75	0-6
0.76-1.00	0-3
1.01+	None

*Annual rate: Divide Corrective Rate by 6.

Manganese Soil Test (DTPA) and Recommendations

<u>Mn Soil Test, ppm</u>	<u>Rating</u>	<u>Mn Rate Lbs Mn/A</u>
0-0.5	Very Low	12
0.6-1.5	Low	7-12
1.6 – 3.0	Medium	3-6
3.1 - 6.0	High	0-2
6.0 +	Very High	0

Copper Soil Test (DTPA) and Recommendations

<u>Cu Soil Test, ppm</u>	<u>Rating</u>	<u>Cu Rate**</u> <u>Lbs/A</u>
0-0.10	Very Low	3-6
0.11-0.20	Low	1-2
0.21-0.30	Medium	0
0.31-0.60	High*	0
0.61+	Very High	0

- * Specialty crops get Copper up to 0.60 ppm
- ** Corrective application rate

Boron Soil Test and Recommendations

<u>Boron Soil Test, ppm</u>	<u>Rating</u>	<u>Boron Rate Lbs B/A</u>
0 – 0.25	Low	0.5 – 3.0
0.26 – 0.50	Medium	0.0 – 1.7
0.51 +	High	0

Alfalfa, clover, peanuts, cotton and sugar beets require more boron than other crops.

Chloride Soil Tests and Cl Recommendations

<u>Soil Test, ppm Cl</u>	<u>lbs of Cl/A</u>
< 4 ppm Cl	20 lbs/A
4 – 6 ppm Cl	10 lbs/A
> 6 ppm Cl	0 lbs/A

KSU based on average Cl in 0 - 24 inch soil root zone.

Plant Analysis

- Diagnose growth problems within a field
 - Slow crop growth
 - Poor color
- Monitor nutrient level
 - Avoid hidden hunger

Sampling Plant Tissue

- Corn
 - Top leaf with a collar for early sampling
 - Ear leaf at tassel/pollination stage
- Soybeans
 - Most recently matured trifoliates
- Wheat
 - Whole sample at full tiller up to early heading
- Alfalfa
 - Top 1/3 of the plant at bud stage





Ag Testing - Consulting

Account No. : 90010

Plant Analysis Report

WARD, RAYMOND C
WARD LABORATORIES
PO BOX 788
KEARNEY

NE 68848-0788

Invoice No. : 1062219
Date Received : 07/16/2009
Date Reported : 07/17/2009

Lab Number : 2653

Results For : EAST CENTRAL CROP RESIDUE ALLIANCE

Location : CORN

Sample ID : B CLARK

Plant Type : Corn

Stage : Tassel

	Result Dry Basis	Sufficiency Levels			
		Deficient	Low	Sufficient	High
Nitrogen, % N	2.68				
Phosphorus, % P	0.29				
Potassium, % K	2.32				
Calcium, % Ca	0.586				
Magnesium, % Mg	0.242				
Sulfur, % S	0.21				
Zinc, ppm Zn	26				
Iron, ppm Fe	139				
Manganese, ppm Mn	53				
Copper, ppm Cu	9.6				

Brad: N is just slightly low. Added N is not necessary unless yield potential is very good. Then you could apply 20 lbs of N. Ray Ward

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Plant Analysis Report







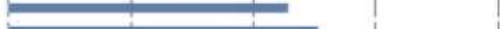
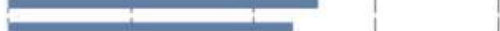


WARD, RAYMOND & JOLENE
FARM ACCOUNT
2545 E 92ND ST
KEARNEY NE 68847

Invoice No. : 1034433
Date Received : 06/30/2008
Date Reported : 07/01/2008

Lab Number : 1734

Results For : RAY WARD
Location : N OF B
Sample ID : CORN

Plant Type : Corn
Stage : 10-14 L

	Result Dry Basis	Sufficiency Levels			
		Deficient	Low	Sufficient	High
Nitrogen, % N	3.00				
Phosphorus, % P	0.39				
Potassium, % K	2.66				
Calcium, % Ca	0.34				
Magnesium, % Mg	0.11				
Sulfur, % S	0.20				
Zinc, ppm Zn	16				
Iron, ppm Fe	111				
Manganese, ppm Mn	100				
Copper, ppm Cu	9.2				

Plant Analysis - Corn

Nutrient	4 to 6 leaf	Ear leaf silk
Nitrogen, %	3.4 - 5.0	2.7 – 3.5
Phosphorus, %	.35 - .80	.25 - .40
Potassium, %	2.7 - 5.0	2.00 – 2.50
Sulfur, %	.16 - .35	.14 - .25
Magnesium, %	.16 - .50	.13 - .35

Plant Analysis - Corn

Nutrient, ppm	4 to 6 leaf	Ear leaf silk
Zinc	20 - 60	18 - 60
Iron	30 - 300	30 - 300
Manganese	30 - 160	20 - 150
Copper	5 - 20	4 - 20
Boron	7 - 25	4 - 25
Chloride, %	.30 - 1.00	.25 - .60
Molybdenum	.21 - 4.0	.21 - 4.0





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Plant Analysis Report

WARD, RAYMOND C
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KEARNEY

NE 68848-0788

Invoice No. : 1062220
Date Received : 07/20/2009
Date Reported : 07/21/2009

Lab Number : 2742

Results For : G & G FARMS
Location : LIVINGSTONS
Sample ID : 1-STUNTED SOYBEANS

Plant Type : Soybean
Stage : Flower

	Result Dry Basis	Sufficiency Levels			
		Deficient	Low	Sufficient	High
Nitrogen, % N	4.15				
Phosphorus, % P	0.44				
Potassium, % K	2.81				
Calcium, % Ca	1.237				
Magnesium, % Mg	0.458				
Sulfur, % S	0.26				
Zinc, ppm Zn	54				
Iron, ppm Fe	186				
Manganese, ppm Mn	239				
Copper, ppm Cu	8.4				

Two things look off. Low N and High manganese. To to apply 15 to 20 lbs of N per acre. The high manganese may be due to wet soil. As soil dries, manganese should decrease. Ray Ward

Reviewed By : Raymond Ward

1/11/2010

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Plant Analysis Report

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FARM ACCOUNT
2545 E 92ND ST
KEARNEY NE 68847

Invoice No. : 1017510
Date Received : 07/09/2007
Date Reported : 07/10/2007
Lab Number : 927

Results For : RAY WARD

Location :

Sample ID : HOME

Plant Type : Soybean

Stage : Flower

	Result Dry Basis	Sufficiency Levels			
		Deficient	Low	Sufficient	High
Nitrogen , % N	4.07				
Phosphorus, % P	0.37				
Potassium, % K	3.53				
Calcium, % Ca	1.04				
Magnesium, % Mg	0.39				
Sulfur, % S	0.19				
Zinc, ppm Zn	35				
Iron, ppm Fe	171				
Manganese, ppm Mn	86				
Copper, ppm Cu	9.0				
Boron, ppm B	31				
Chloride, % Cl	0.04				
Molybdenum, ppm Mo	0.01				

Plant Analysis - Soybean

Nutrient, %	Flowering Stage
Nitrogen	4.26-5.50
Phosphorus	.26 - .50
Potassium	2.00 – 2.80
Sulfur	.18 - .30
Chloride	.20 - .60

Plant Analysis - Soybean

Nutrient, ppm	Flowering Stage
Zinc	20-50
Iron	50 – 350
Manganese	25 – 200
Copper	6 – 30
Boron	21 – 60
Molybdenum	0.21 – 4.0





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Plant Analysis Report

WARD, RAYMOND & JOLENE
 FARM ACCOUNT
 2545 E 92ND ST
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Invoice No. : 1050524
 Date Received : 05/11/2009
 Date Reported : 05/12/2009
 Lab Number : 1206

Results For : FARM ACCOUNT
 Location : WHEAT
 Sample ID : HOME

Plant Type : Wheat
 Stage : FEEKES8

	Result Dry Basis	Sufficiency Levels			
		Deficient	Low	Sufficient	High
Nitrogen, % N	4.11				
Phosphorus, % P	0.33				
Potassium, % K	4.86				
Calcium, % Ca	0.443				
Magnesium, % Mg	0.167				
Sulfur, % S	0.37				
Zinc, ppm Zn	33				
Iron, ppm Fe	195				
Manganese, ppm Mn	98				
Copper, ppm Cu	6.4				
Boron, ppm B	7				
Chloride, % Cl	0.11				
Molybdenum, ppm Mo	0.95				

Reviewed By : Raymond Ward

1/6/2010

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2545 E 92ND ST
KEARNEY NE 68847

Invoice No. : 1046303
Date Received : 03/05/2008
Date Reported : 03/06/2008

Lab Number : 1044

Results For : GOODSON RANCH LP

Location : NORTH B GOOD

Sample ID : WINTER WHEAT

Plant Type : Wheat

Stage : FEEKES4

	Result Dry Basis	Sufficiency Levels			
		Deficient	Low	Sufficient	High
Nitrogen, % N	4.59				
Phosphorus, % P	0.41				
Potassium, % K	3.02				
Calcium, % Ca	0.44				
Magnesium, % Mg	0.13				
Sulfur, % S	0.35				
Zinc, ppm Zn	32				
Iron, ppm Fe	615				
Manganese, ppm Mn	101				
Copper, ppm Cu	6.0				
Boron, ppm B	14				
Chloride, % Cl	0.73				
Molybdenum, ppm Mo	1.38				

This sample is low in Magnesium. I am not sure if foliar will help. Epsom salts is magnesium sulfate. Apply 2 to 4 lbs of epsom salts per acre as a trial.

Micro-Nutrients

- Micronutrient Availability is partially based on Soil Forming Factors
 - Parent Material
 - Vegetation
 - Climate
 - Time

Micro-Nutrients

- Availability of Micronutrients Based on Cultural Practices
 - No Till
 - Slower mineralization of organic matter
 - Chelation of “metals”
 - Root channels and other macro pores
 - Higher yields

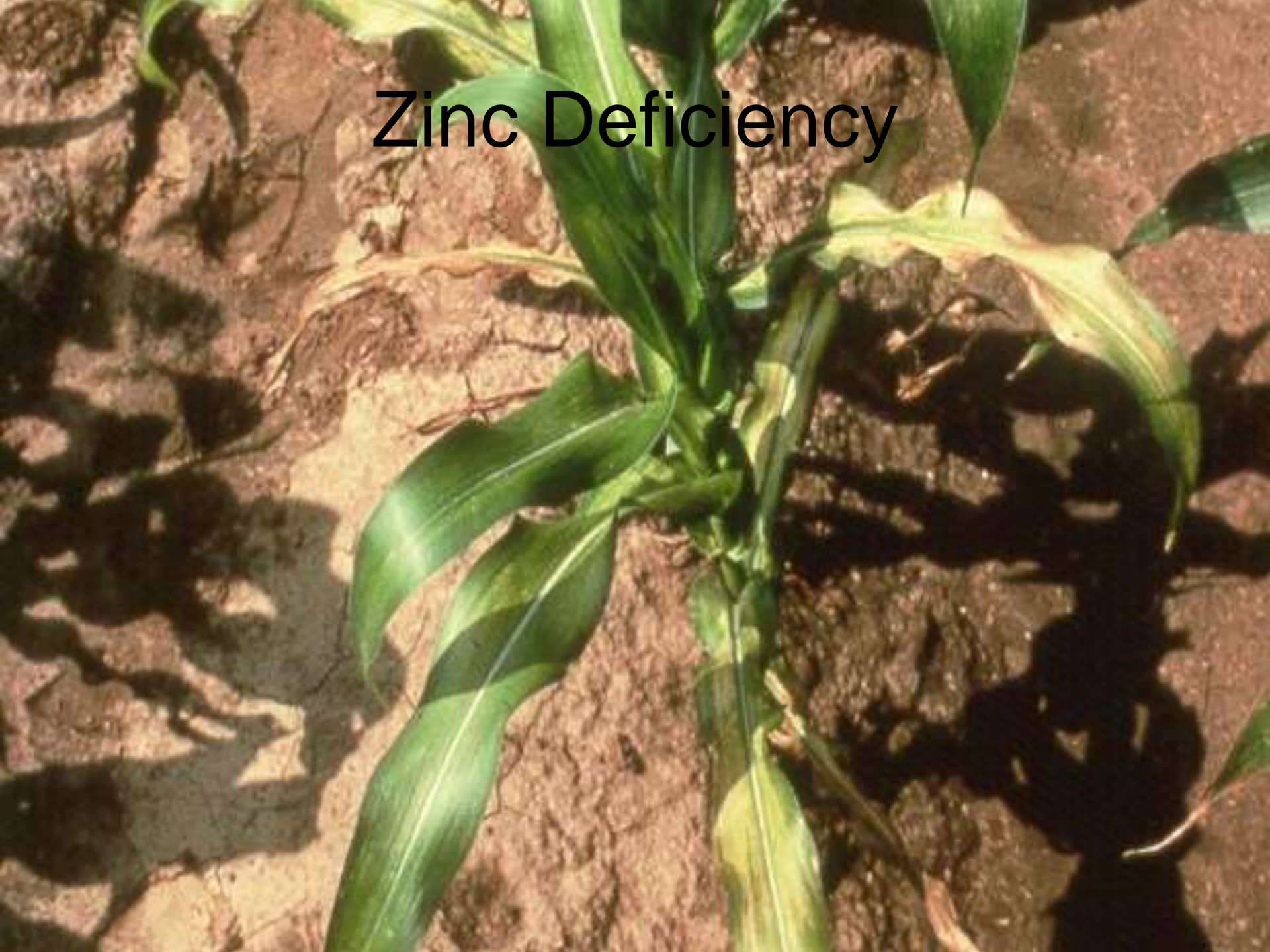
Deficiency Symptoms

- Copper
 - Leaves are dark green, plant is stunted
- Iron
 - Yellowing occurs between the veins of young leaves
- Manganese
 - Yellowing pattern is not as distinct as with iron
- Nickel
 - Firing of upper leaves
- Zinc
 - Shortened internodes, yellowing on mid-leaves across veins

Deficiency Symptoms

- Boron
 - Terminal buds die, lower leaves misshapen, shortened internodes
- Chloride
 - Wilting and reduced leaf growth
- Molybdenum
 - Appear as N deficiency, stunted growth, and chlorosis

Zinc Deficiency



Zinc Deficiency Iowa State U



Zinc Deficiency - Soybeans





Zinc Deficiency Wheat



Zinc and 10-34-0

- Do not mix more than 1 pound of Zn with 30 lbs of P₂O₅.
- Or 1 pound of Zn with 7 gallons of 10-34-0.
- Polyphosphate sequesters zinc, so ammoniated zinc or chelated zinc will react the same in the soil.

Iron Deficiency



Iron Deficiency



Manganese Deficiency



Manganese Deficiency



Copper Deficiency Wheat



Chloride Deficiency



Chloride Deficiency



Boron Deficiency in Corn



Molybdenum Deficiency



Molybdenum Application

- Foliar Treatment
 - 2 ounces of Sodium Molybdate per acre in 30 gallons of water as a foliar
- Seed Treatment
 - 1/2 ounce of Sodium Molybdate per bushel

Calcium:Magnesium Ratio

In summary, the Ca:Mg ratio concept is unproven and should not be used as a basis for fertilization or liming practices.

Having sufficient levels of Ca and Mg is the proper method of evaluation, rather than trying to manipulate ratios.





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Sulfur, % S	0.20				
Zinc, ppm Zn	16				
Iron, ppm Fe	111				
Manganese, ppm Mn	100				
Copper, ppm Cu	9.2				

Factors in Addition to Soil pH Which Influence the Frequency of Liming

- **Soil texture**
- **Rate of N fertilization**
- **Rate of crop removal of Ca and Mg**
- **Amount of lime applied**
- **pH range desired**

Indicators of Possible S Deficiency

- 1) No-Till Farming
- 2) Organic Matter Content
- 3) Soil Texture
- 4) Soil Test Level
- 5) Irrigation Water Sulfate Concentration

Carbon/Organic Matter

- Organic Matter is about 58 % C
- Ratio becomes 170 OM : 8 N : 1 S
- 1 % OM in 8 inches of Soil is 24,000 lbs/A
- This Quantity of OM Holds About 1100 lbs of N and 140 lbs of S per Acre.
- This is true for other plant nutrients

Sulfur Recommendation Example

Corn 200 bu/A Yield Goal

Sulfur Requirement is .18 to .26 lb S/bu

Total S Required is 36 to 52 lbs/A

Sulfate Soil Test is 8 ppm S

$8 \times 2.4 = 19 \text{ lbs S/A}$

Recommendation is 17 to 33 lbs S/A

Sulfur Deficiency



Sulfur Plots



Sulfur Deficiency - Corn



Sulfur in Wheat



Potassium deficiency



Thank You