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Chloride and Other Soil Secrets

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CHLORIDE RESEACH HISTORY

- Scientists first reported crop responses to Chloride in the mid 1800's
- Chloride has been recognized as an essential plant nutrient since 1954
- Research has been ongoing for the past 20 years by leading universities such as Kansas State, Texas A & M, Montana State, Rutgers, and South Dakota State

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CHLORIDE VS CHLORINE

- Chlorine (Cl_2) is commonly used in solvents, pesticides, and plastics.
- Chlorine (Cl_2) in never found free in nature. It is found as the chloride ion (Cl-).

- Chloride (Cl-) is the only form of chlorine found in nature.
- Chloride (Cl-) is soluble in the soil.

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THE ROLES OF CHLORIDE

- Photosynthesis and enzyme activation
- Transport of other nutrients
- Water movement within the cell
- Stomata activity
- Accelerated plant development
- Reduced plant lodging

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CHLORIDE IS MOBILE…
LIKE NITRATE

Application of chloride close to time of need is probably more effective, particularly on coarse textured soils

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Chloride Soil Testing in Kansas

- A chloride soil test has been offered by KSU and SDSU Soil Testing Labs since the mid 1990's
- Recommended soil depth is 0-24 inches
- Calcium nitrate solution is used to extract chloride from the soil
- Fertilizer recommendations are usually made for corn, sorghum and wheat

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CHLORIDE EFFECTS ON WHEAT YIELD Kansas--2006

Topdressed Cl lb/A	Yield bu/A
0	38
10	43
20	45
30	44
40	45

Ammonium chloride Variety: 2145
Soil Cl: 12 lb/A 2 ft Gordon, KSU

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Chloride Fertilization of Wheat
Average of 8 Varieties

County	Yield Increase with 20 lbs of Cl/A
Saline	9.8 Bu/A
Stafford	6.9 Bu/A

Soil test Cl was low at both locations.

Lamond, KSU

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CHARACTERISTICS OF CHLORIDE SOURCES

AMMONIUM CHLORIDE (NH_4Cl)---high Cl concentration, **available in fluid form**, mixes well with N,P,S, micronutrients

POTASSIUM CHLORIDE (KCl)…not used much on high K soils, makes low analysis fluid, limited concentrations in UAN mixes

MAGNESIUM CHLORIDE ($MgCl_2$)….available in fluid form BUT CANNOT USE WITH PHOSPHATE FERTILIZER

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Topdressed Chloride Can Reduce Leaf Rust, Increase Wheat Yields

Treatment	Cl rate, lb/A	Leaf rust rating 4/13	Leaf rust rating 5/1	Grain yield, bu/A
NH_4Cl	40	30	26.3	41.7
KCl	40	60	27.5	42.0
$MgCl_2$	40	65	28.8	40.9
Check	0	70	67.5	35.4

F-2 leaf on 4/13, Flag leaf on 5/1 — Hill County, TX

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NO CHLORIDE
20 LB/A CHLORIDE


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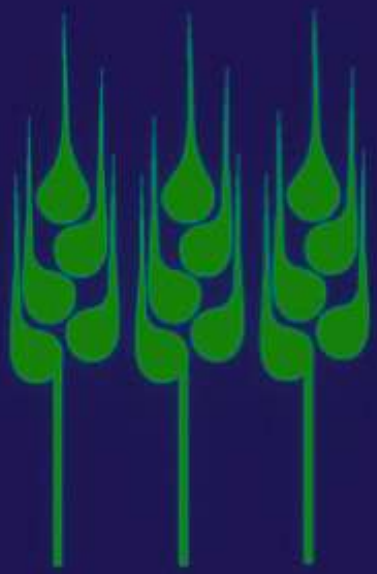
On The Plains
NO CHLORIDE
CHLORIDE
MONTANA STATE

Wheat Diseases Suppressed by Cl Fertilizers

Take-all root rot
Common root rot

Leaf rust
Septoria
Tanspot
Stripe rust



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Plant Analysis: A Useful Diagnostic Tool for Cl

Category	Concentration	Frequency of response, %
Low	≤0.12	78
Transition	0.13-0.40	49
Adequate	>0.40	6

Wheat and barley; whole shoots; boot to flowering stage; based on central and northern Great Plains data.

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EFFECTS OF CHLORIDE FERTILIZATION ON NO-TILL CONTINUOUS WINTER WHEAT

		Grain	Leaf	
Cl	N	Yield	K	Cl
lb/A	lb/A	bu/A	----------%----------	
0	0	29.9	1.40	0.057
10	4	32.5	1.59	0.138
20	7	37.5	1.56	0.166
$LSD_{.05}$		3.9	0.15	0.031

Soil Cl, 0-2 ft, 19 lb/A. Variety: Jagger Claassen, KSU

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ADEQUATE CHLORIDE LEVELS ALLOW SMALL GRAIN CROPS TO ADVANCE PLANT MATURITY AS MUCH AS

5 TO 7 DAYS

KSU Wheat Summary: 1990 to date

- 39 field studies were conducted from 1990 through 2006 examining yield response in wheat to chloride fertilizers.
- All were conducted in the eastern half of the state, under dryland conditions, in areas with high soil K levels and no history of potash use.
- Most included both rates and sources of chloride.
- A statistically significant response to applied chloride was seen in 23 of the 39 studies.

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KSU --N.C. Kansas, Belleville

Chloride Effects on Grain Sorghum

Rate	Yield
lb/a Cl	bu/acre
0	92.2
20	**101.3**
40	102.8

Planting Date: June 4, 2004 Variety: DKS 44-20

Harvest: Oct 20, 2004 Soil Test Cl (0-24”) = 19 lb/a

Ammonium Chloride broadcast immediately after planting

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Response of dryland grain sorghum to applied chloride fertilizer in Kansas 1996-2006

Chloride applied lb Cl-/acre	Grain Yield Bu/A	% Chloride in leaf at boot, percent
0	98.5 b	0.10 c
20	108.2 a	0.24 b
40	109.9 a	0.33 c
LSD 0.05	2.4	0.05
n	20	11

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Sorghum: 1996 to date

- Unlike wheat, no visual chloride deficiency symptoms have been described on sorghum.
- There appears to be a relationship in sorghum between chloride nutrition and stalk quality.
- The first chloride studies on sorghum found, were conducted by Lamond in 1996.
- 23 chloride response trials on dryland sorghum have been reported, by several people, primarily in central Kansas.

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Sorghum Summary

- 19 of the 23 trials reported found a significant response to the application of chloride.
- A combined analysis was conducted using the same process as with wheat.
- A significant response to 20 lbs of chloride, the lowest rate used, was found.

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DRYLAND CORN RESPONSES TO CHLORIDE

South Dakota -- 2006

Treatment Cl lb/A	Yield bu/A
0	76
10	81
20	84
30	82

Ammonium chloride, 2 x 2 SDSU

Soil test Cl: 20 lb/A 2 ft (low)

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Response of Dryland Corn to Chloride Fertilization (KS)

Cl rate	1995	1996		1997		
lb/A	R	R	B	R	B	Average
	Yield difference due to Cl, bu/A					
20	19	2	12.5	2.5	0	7.2
40	15.5	9.5	13.5	7	-2.5	8.6
Average	17.3	5.8	13	4.8	-1.3	7.9

B= Brown Co., R= Riley Co.
Average across sources (KCl and NH_4Cl)

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Response of dryland corn to applied chloride fertilizer in Kansas, 1990-2001.

Chloride applied lb Cl-/acre	Grain Yield Bu/A	Percent Chloride in ear leaf at tassel
0	104.4 b	0.17 c
20	108.9 a	0.27 b
40	111.6 a	0.36 c
LSD 0.05	3.4	0.05
n	11	11

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Corn Summary

- As with wheat and sorghum, only studies using broadcast applications of KCl or NH_4Cl were included.
- Only 6 of the 11 trials found a significant response to the application of chloride.
- A combined analysis was conducted using the same process as with wheat.
- A significant response to 20 lbs of chloride, the lowest rate used, was found.

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SUNFLOWER RESPONSES TO CHLORIDE
South Dakota

Treatment Cl lb/A	Yield lb/A
0	1569
10	1781
20	2037
30	2183
50	1966

Ammonium chloride, 2 x 2 SDSU

Soil test Cl: 20 lb/A 2 ft (low)

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Soil test chloride interpretations and fertilizer recommendations for Kansas.

Category	Soil Chloride in a 0-24" sample lb/acre	ppm	Cl Recommended* lb/acre
Low	<30	<4	20
Medium	30-45	4-6	10
High	> 45	>6	0

*Recommendations for corn, sorghum and wheat only.

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WHAT'S THE CORRECT RATE OF CHLORIDE NEEDED?

- SOIL TEST AT A DEPTH UP TO 24 INCHES
- YIELD RESPONSE HAS BEEN RECORDED AT 6 PPM OR LESS; OR LESS THAN 45 LBS OF Cl/A
- IN NEARLY ALL KANSAS STATE UNIVERSITY CHLORIDE PLOTS, A RATE OF **20** POUNDS OF ACTUAL CHLORIDE PER ACRE MAXIUMIZED YIELDS VERSES DOLLARS SPENT

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SOURCES OF CHLORIDE

Ammonia chloride (NH_4Cl)

Potassium chloride (KCl)

Magnesium chloride ($MgCl_2$)

Calcium chloride ($CaCl_2$)

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CHARACTERISTICS OF CHLORIDE SOURCES

AMMONIUM CHLORIDE….high Cl concentration, available as a fluid form, mixes well with N,P,S, micronutrients

POTASSIUM CHLORIDE…not used much on high K soils, makes low analysis fluid, limited concentrations in UAN mixes

MAGNESIUM CHLORIDE….available in fluid form but VERY reactive to PHOSPHATE fertilizers

CALCIUM CHLORIDE…. Available in fluid form but VERY reactive to PHOSPHATE fertilizers, more so than $MgCl_2$.

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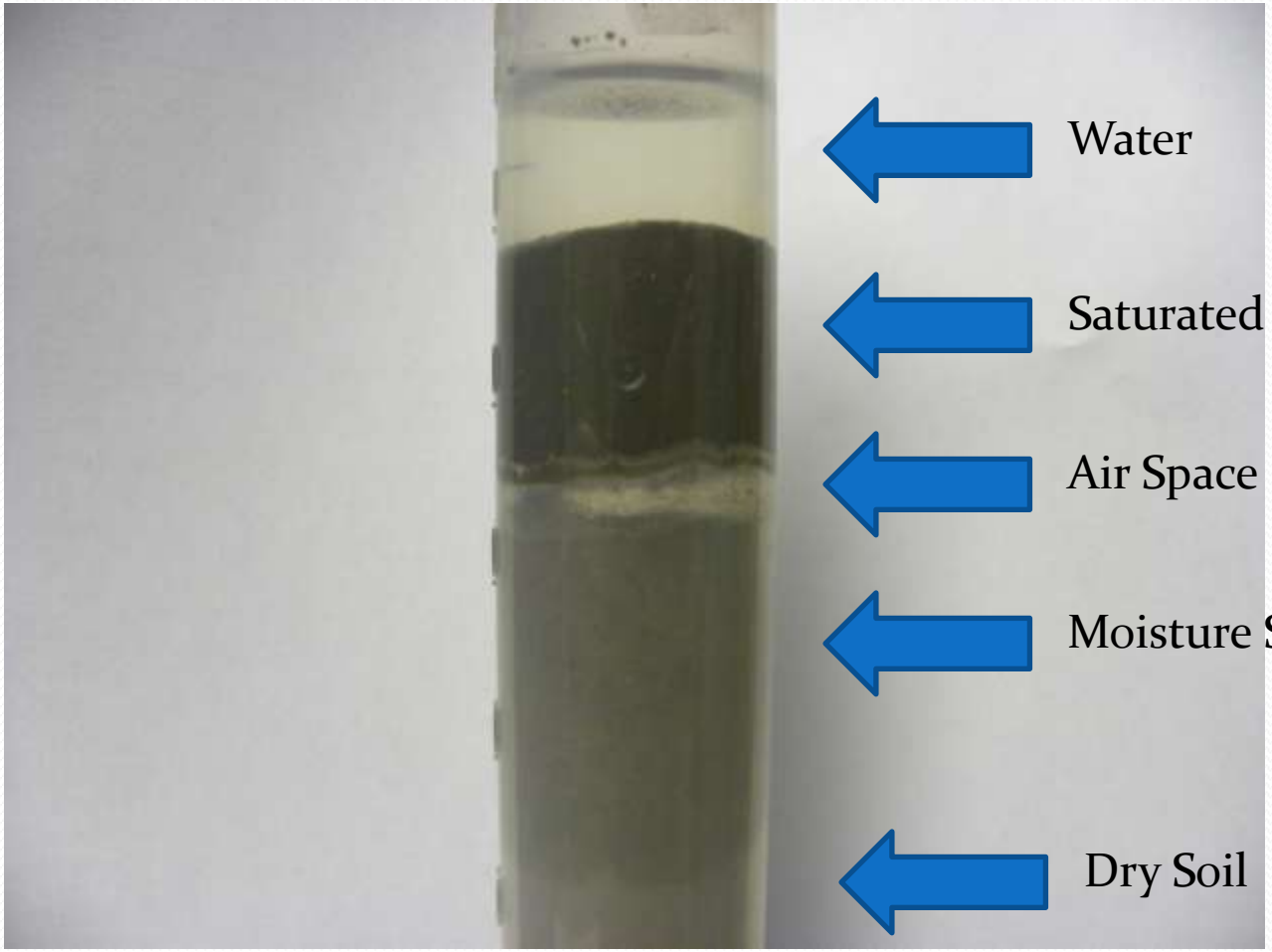
Poor Soil Structure Prevents Water Movement



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PHOTOSYNTHESIS

- **$6H_2O + 6CO_2$ ----------> $C_6H_{12}O_6 + 6O_2$**

- **Six molecules of water plus six molecules of carbon dioxide produce one molecule of sugar plus six molecules of oxygen**

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GLUCOSE

- 40 % CARBON (C)
- 53 % OXYGEN (O)
- 7 % HYDROGEN (H)

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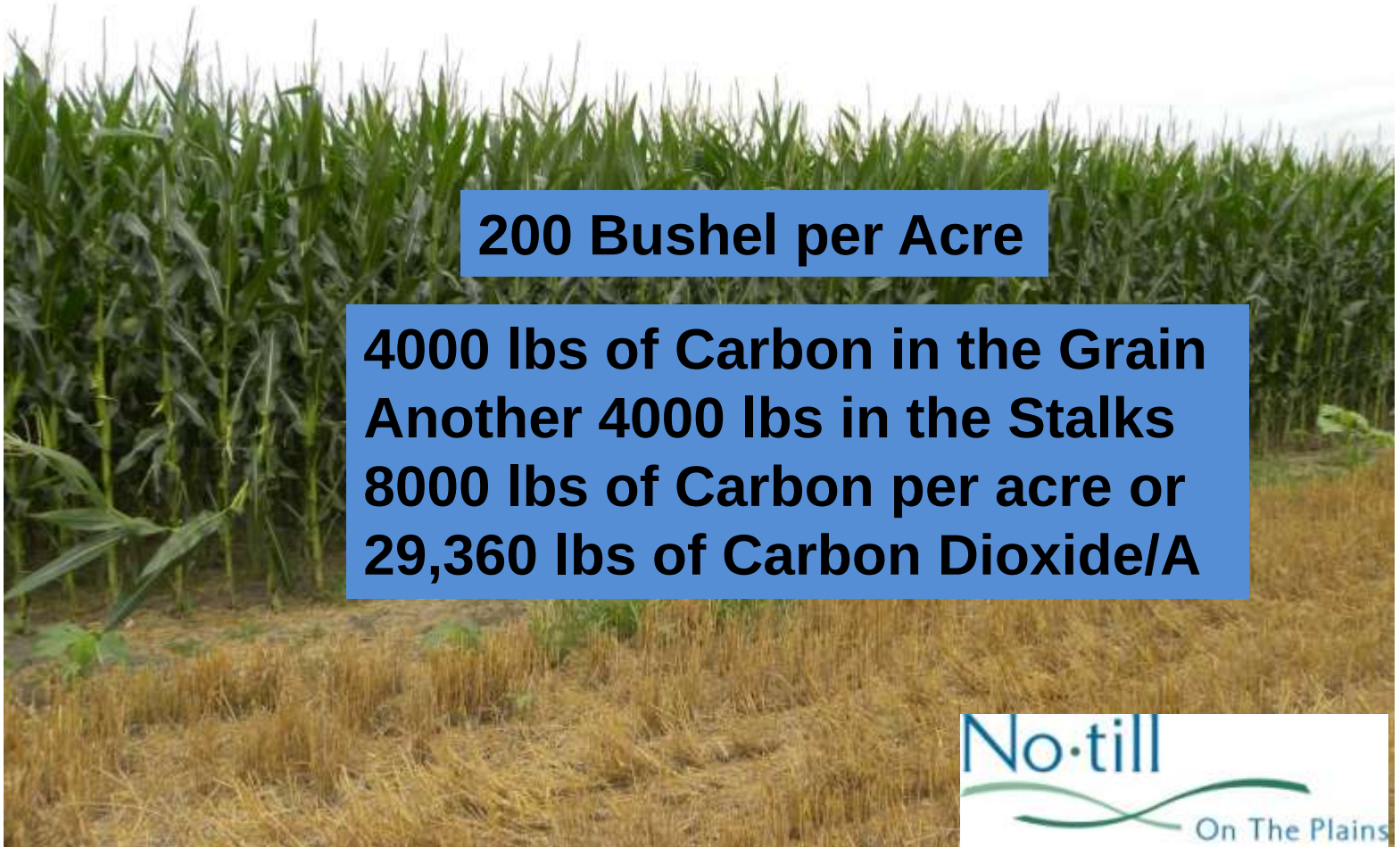
How Much Carbon ?



Corn Stalk Residue
200 bu Grain/A

- How do I get rid of the residue?
  - Remember – The residue contains the plant nutrient “Carbon”
- “IDEA” Get rid of the residue while the next crop is growing and capture CO_2!

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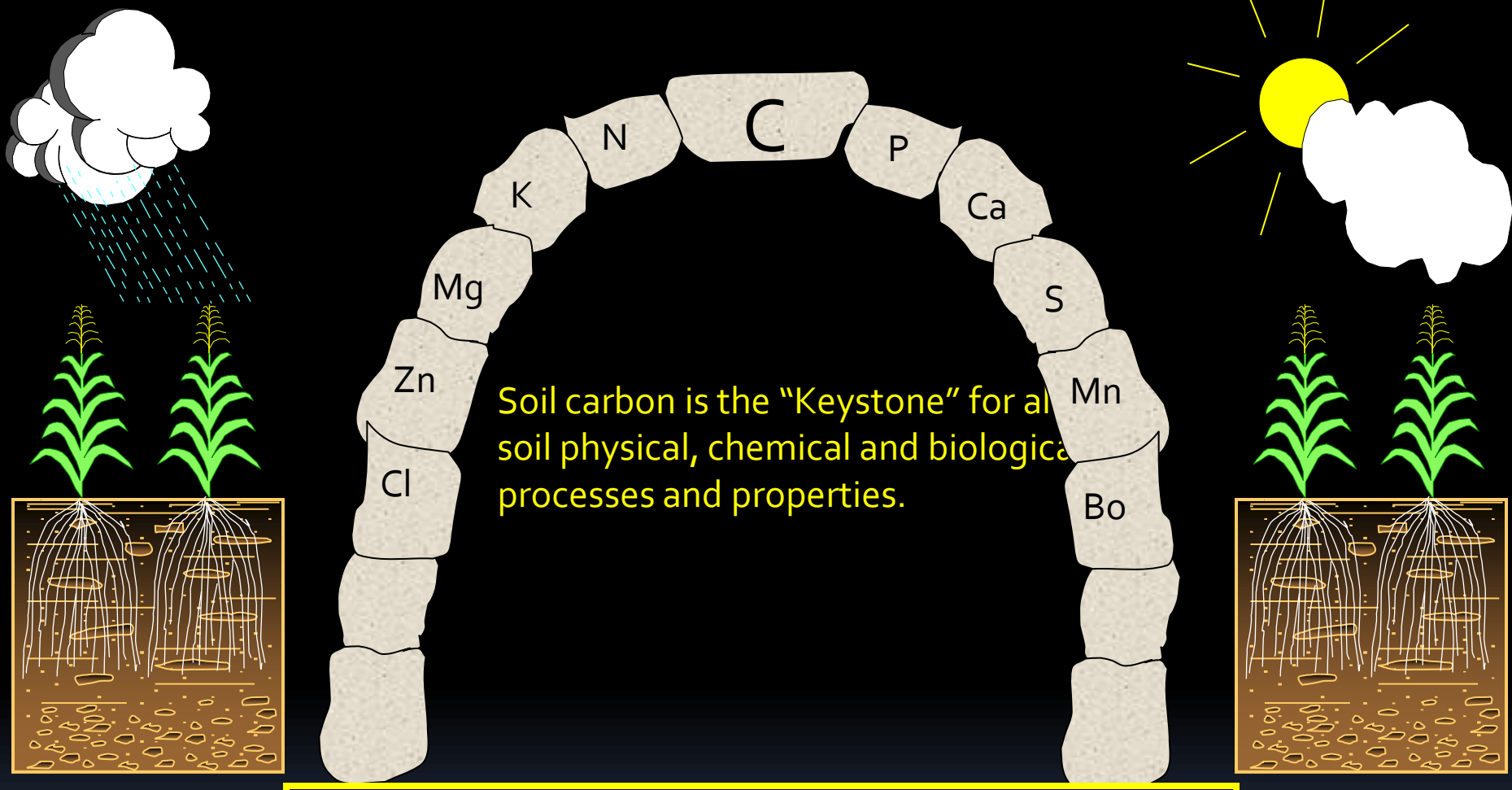
No. 1 Environmental Enemy in Production Agriculture

Intensive Tillage

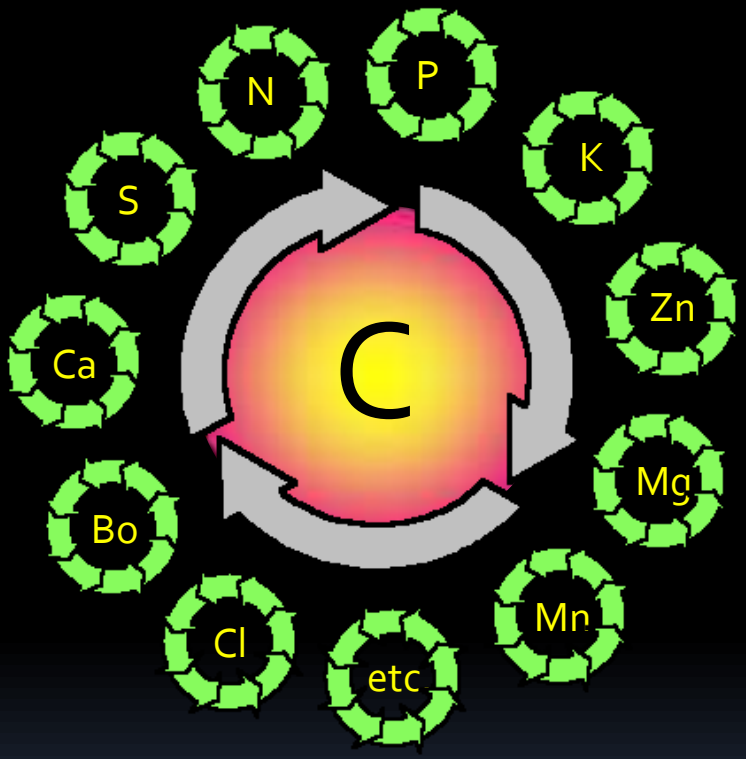
Carbon is a "keystone" in nutrient cycling!



Management platform

fertility, variety, irrigation, species, cover crop, manure, rotations, tillage, soil type, erosion, timing,

Nutrient Balance and Carbon Sequestration.



Net carbon sequestration requires other nutrients.

7 – 10 units of C per unit of N

50 –60 units of C per unit of P

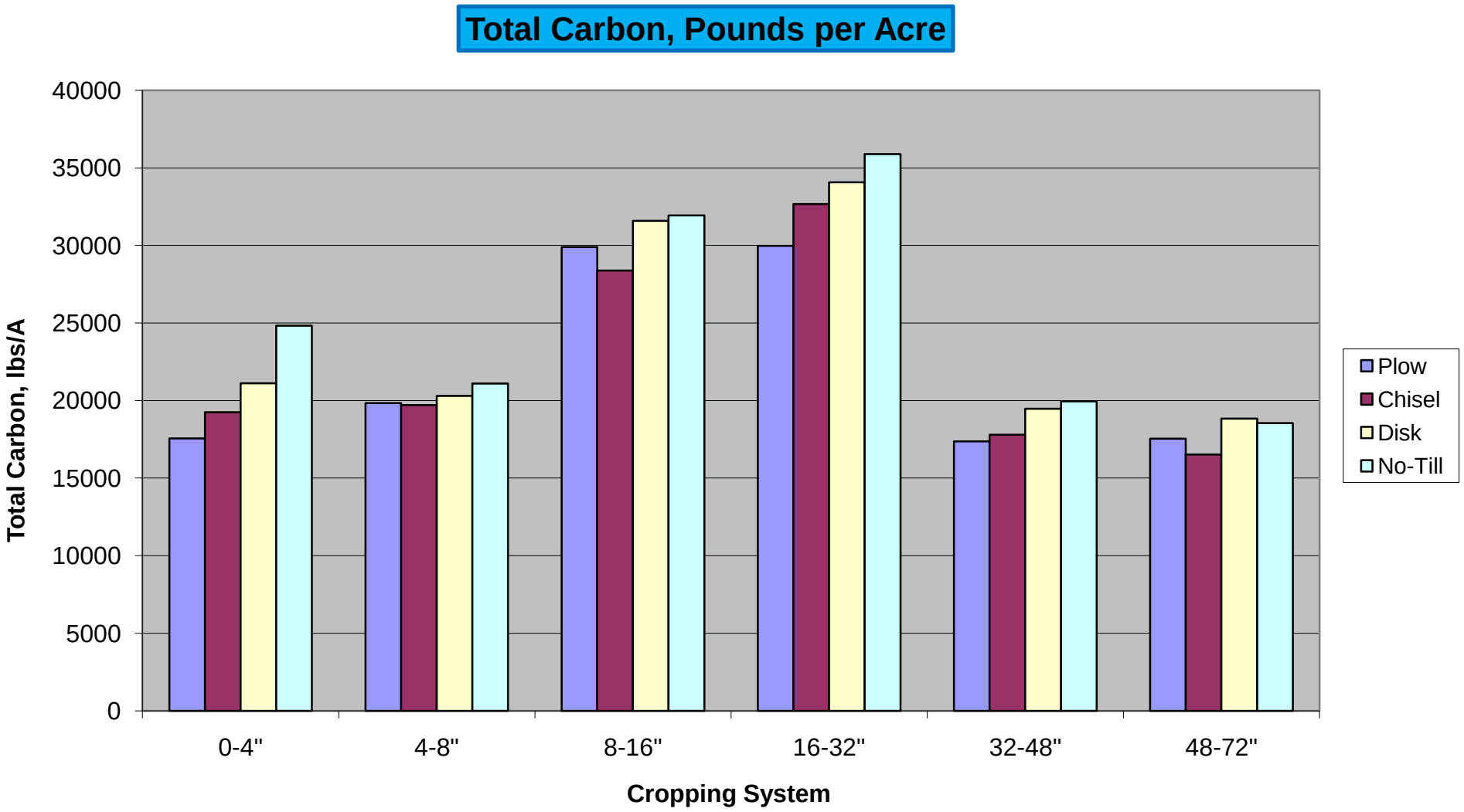
70 – 80 units of C per unit of S

Balanced fertilization is needed for both crop uptake and carbon sequestration!

Rattan Lal, 27 Jan., 2000

ROGERS MEMORIAL FARM

PAUL JASA, UN-L



Boron in Plants

- **Boron** is involved in the production of new cells in meristematic tissue.
- Boron is highly toxic to germinating seeds of corn and soybeans. Boron fertilizers should never be applied as a "starter fertilizer" in or near the row at planting time.

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Boron Deficiency

- Since it is not mobile in the plant, deficiency symptoms are cessation of growth at the terminal bud, followed by yellowing and death of young leaves.
- Severely impaired fruit and seed set are late season symptoms on many crops.
- Boron deficiency is commonly confused with potato leaf hopper damage in alfalfa

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Boron Deficient Alfalfa

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Boron Deficiency in Corn

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Correcting Boron Deficiency

- Boron is highly toxic to germinating seeds of corn and soybeans. Boron fertilizers should never be applied as a "starter fertilizer" in or near the row at planting time..
- Application of boron:
  - Broadcast applications of 1-2 pounds of B as granular borate.
  - Foliar application of 0.1-0.5 pounds soluble borate.

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Boron Soil Test and Recommendations

Boron Soil Test, ppm	Rating	Boron Rate Lbs B/A
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.

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Molybdenum

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Correcting Molybdenum Deficiency

- Liming
- Seed treatment with 1-2 ounces of ammonium molybdate.
- Foliar applications of ammonium molybdate of 2-4ounces per acre.
- Due to the toxic nature of molybdenum to ruminant animals, molybdenum fertilization needs to be managed very carefully.

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Where Does Molybdenum Deficiency Occur?

- On low pH, weathered soils in SE and SC Kansas.
- Molybdenum deficiencies are showing up more in no-till cropping systems across the Great Plains.
- Recent reports suggest low molybdenum in seed may be contributing to Mo deficiencies.

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Molybdenum Deficiency Symptoms

- Molybdenum deficient plants appear stunted, light green and N deficient.

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Manganese Soil Test (DTPA) and Recommendations

Mn Soil Test, ppm	Rating	Mn Rate Lbs Mn/A
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

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Copper Soil Test (DTPA) and Recommendations

Cu Soil Test, ppm	Rating	Cu Rate** Lbs/A
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

- * Some specialty crops need copper up to 0.60 ppm
- ** Corrective application rate

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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

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WARD
Laboratories, Inc.

Ag Testing - Consulting

Account No. : 90010

Plant Analysis Report

WARD, RAYMOND C
WARD LABORATORIES
PO BOX 788
KEARNEY NE 68848-0788

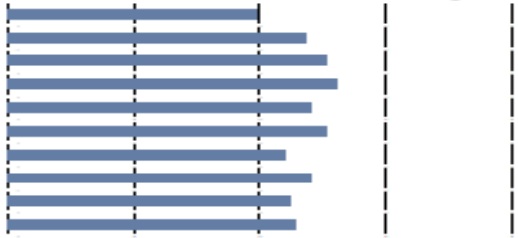
Invoice No. : 1062219
Date Received : 07/16/2009
Date Reported : 07/17/2009

Lab Number : 2653

Results For : EAST CENTRAL CROP RESIDUE ALLIANCE
Location : CORN
Sample ID : B CLARK

Plant Type : Corn
Stage : Tassel

	Result Dry Basis
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

Reviewed By : Raymond Ward **1/11/2010** **Copy 1** **Page 1 of 1**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On The Plains

WARD
Laboratories, Inc.

Ag Testing - Consulting

Account No. : 90013

Plant Analysis Report

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

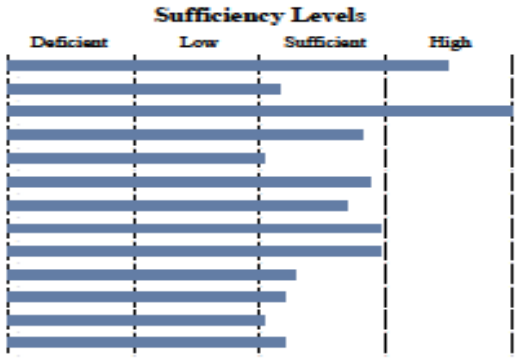
Invoice No. : 1050524
Date Received : 05/11/2009
Date Reported : 05/12/2009

Lab Number : 1206

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

Plant Type : Wheat
Stage : FEEKES8

	Result Dry Basis
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** **Copy :1** **Page 1 of 1**

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WARD Laboratories, Inc.

Ag Testing - Consulting

Account No. : 90013

Plant Analysis Report

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

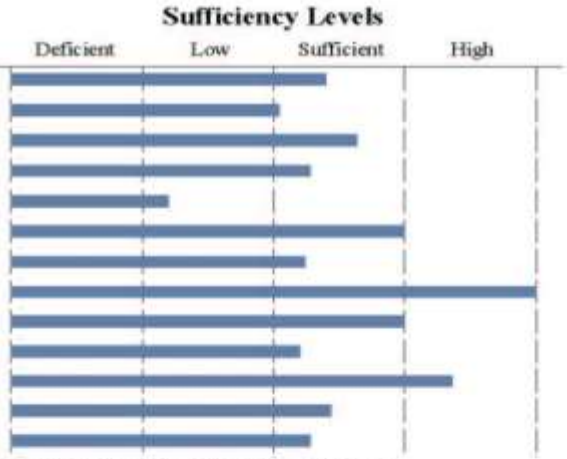
Invoice No. : 1046303
Date Received : 03/05/2008
Date Reported : 03/06/2008

Lab Number : 1044

Results For : GOODSON RANCH LP
Location : NORTH B GOOD
Sample ID : WINTER WHEAT

Plant Type : Wheat
Stage : FEEKES4

	Result Dry Basis
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 espsom salts per acre as a trial.