Gypsum

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Gypsum Application

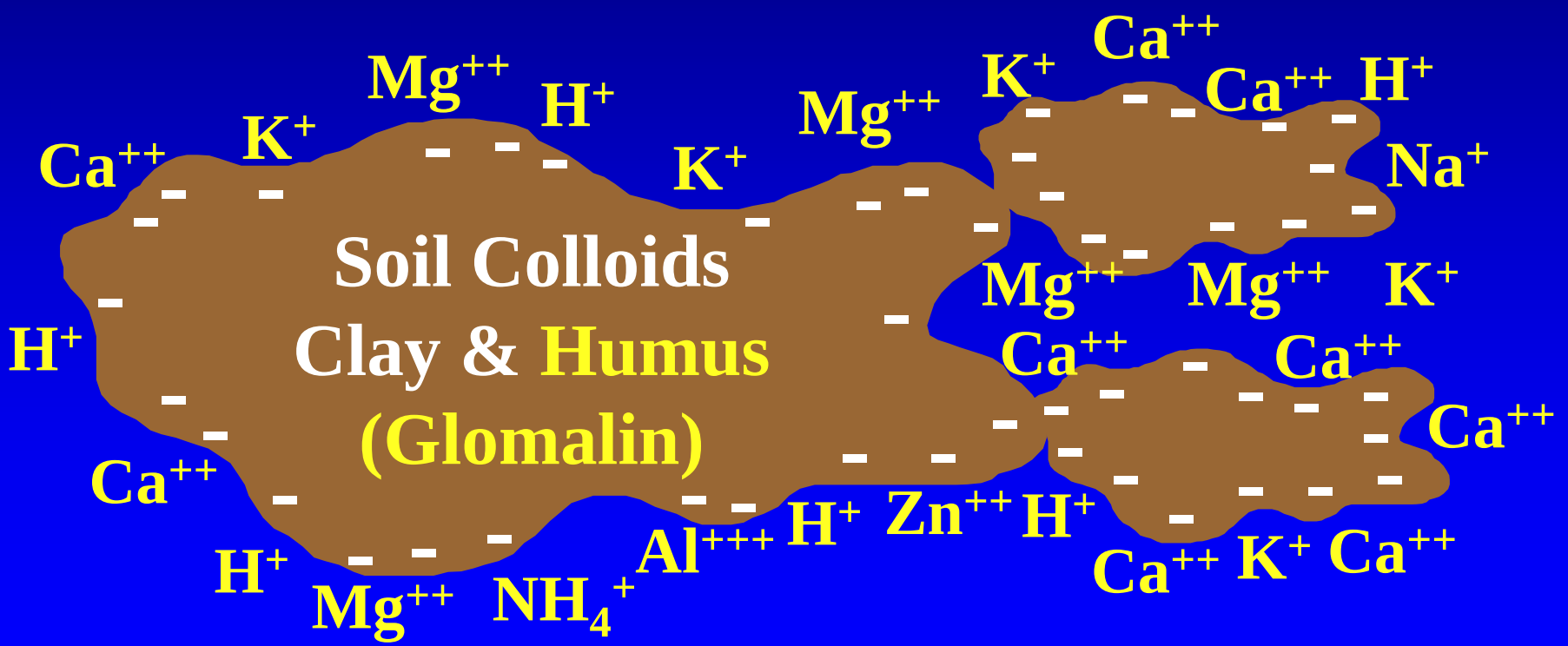
- **Calcium Sulfate**
  - $CaSO_4 \cdot 2H_2O$
    - 16% S
    - 22% Ca
- **When gypsum added to soil**
  - $CaSO_4 \cdot 2H_2O = Ca^{++} + SO_4^{=} + 2H_2O$
  - Does not increase or decrease soil pH

Gypsum Used to Aid in Reclamation of Saline-Sodic and Sodic Soils

- **Saline-Sodic Soils**
  - Soil structure is not dispersed
  - Conductivity > 4 mmhos/cm
  - > 15% exchangeable sodium
  - pH < 8.5
- **Sodic soils**
  - Soil structure is dispersed
  - Conductivity < 4 mmhos/cm
  - > 15% exchangeable sodium
  - pH > 8.5

Why Apply Gypsum to Iowa Soils?

- **Soil Structure (soil aggregation) is influenced by:**



Why Apply Gypsum to Iowa Soils?

- **Iowa Soils have:**
  - **High organic matter**
  - **High (adequate) calcium and magnesium content for soil structure and plant growth**
  - **Low sodium**
  - **Calcareous soils have soil exchange complex saturated with calcium/magnesium and have free lime and sometimes free gypsum**

Exchangeable Cations of Several Iowa Surface Soils

Soil Type	pH	CEC	Ca	Mg	K
		meq/100g	lb exchangeable/acre		
Kenyon	5.9	14.0	3400	624	156
Readlyn	6.3	19.5	5800	1008	156
Klinger	5.8	26.2	8000	1248	156
Dinsdale	5.9	20.5	5840	1008	312
Tama	5.7	20.6	5560	816	390
Muscatine	6.1	28.3	8160	1704	312

Relationship Between Soil Ca:Mg Ratio and Yield

- **Ca:Mg ratio range where greenhouse and field research has shown yield is optimal**

0.5 Ca : 1 Mg to 50 Ca : 1 Mg

(2 times more Mg to 50 times more Ca)
(on a meq basis)

Exchangeable Cations of Several Iowa Surface Soils

Soil Type	pH	CEC	Ca	Mg	K	Ca:Mg Ratio
		- - - - - meq/100g - - - - -				
Primghar	5.8	32.7	22.4	7.4	0.5	3.0
Sac	6.0	29.8	20.6	5.5	0.6	3.7
Kenyon	5.9	14.0	8.5	2.6	0.2	3.3
Dinsdale	5.9	20.5	14.6	4.2	0.4	3.5
Muscatine	6.1	28.3	20.4	7.1	0.4	2.9
Napier	6.6	27.6	23.5	3.2	0.6	7.3

Ranges in Soil Basic Cation Ratios for Five Highest and Lowest Yields

		Range in Ca:Mg Ratios			
Ratio	**Yield Level**	**Corn (75)**	**Corn (75)**	**Soybean (77)**	**Soybean (78)**
Ca:Mg	**Highest Five**	**5.7 - 26.8**	**5.7 - 14.3**	**5.7 - 14.0**	**5.7 - 26.8**
Ca:Mg	**Lowest Five**	**5.8 - 21.5**	**5.0 - 16.1**	**2.3 - 16.1**	**6.8 - 21.5**

McLean et al., 1983; Ohio State Univ.

Ca and Mg Crop Uptake

- Amount of uptake is selected by roots, not soil ratio
- With water use by crops (transpiration)
  - Amount of Ca and Mg supplied to root surface is greater than the amount taken up by crops
    - 250 to 400 lb Ca and 100 to 160 lb Mg moves to root surface
    - 150 bu/acre corn uptake of 26 to 40 lb Ca/acre and 15 to 30 lb Mg/acre

Gypsum Application to Iowa Soils

Corn and Soybean Yield - Average Across Six Sites in Iowa, 2000

	Gypsum Application		Corn		Soybean	
S Rate	Product	Calcium	CaS	S	CaS	S
lb S/acre	lb/acre	lb Ca/acre	- - - - - - - - bu/acre - - - - - - - -			
0	0	0	162	159	50.0	50.1
10	62.5	14	158	160	49.3	49.6
20	125	28	158	159	48.9	49.7
40	250	56	158	159	49.0	49.6
Significance (0.05)			NS		NS	

CaS = Calcium Sulfate; S = Elemental Sulfur. Applied Spring 2000.
Sawyer and Barker, Iowa State University

Gypsum Application to Iowa Soils

Corn and Soybean Yield - Average Across Six Sites in Iowa, 2001

	Gypsum Application		Corn		Soybean	
S Rate	Product	Calcium	CaS	S	CaS	S
lb S/acre	lb/acre	lb Ca/acre	- - - - - - - - bu/acre - - - - - - - -			
0	0	0	147	146	48.0	47.8
10	62.5	14	143	147	48.1	47.6
20	125	28	147	149	47.0	48.5
40	250	56	149	144	46.6	46.9
Significance (0.05)			NS		NS	

CaS = Calcium Sulfate; S = Elemental Sulfur. Applied Spring 2000.
Sawyer and Barker, Iowa State University

Gypsum Application to Iowa Soils

Effect of Sulfur & Calcium on Kenwood 94 Soybean at Western Research Farm, 1996

S Rate	Gypsum	Ca Applied	Yield
lb S/acre	lb/acre	lb Ca/acre	bu/acre
0	0	0	62
10	59	13	58
20	118	26	58
40	236	52	61
60	354	78	56
Sign (0.05)			NS

Gypsum preplant broadcast and incorporated.

Soil S = 3 ppm. Shibles et al., ISRF96-10,1996.

Application of Flue-Gas Scrubber Desulfurization Sludge (Gypsum)

Wynoose silt loam (F. Thicke, Ph.D. Thesis, 1988, Univ. Illinois)

Product Rate	3-yr Corn	4-yr Soybean	Soil pH 3 yr	ex. Ca 1 yr	ex. Mg 1 yr	1 yr Bulk Density
lb/acre	bu/acre	bu/acre		ppm	ppm	g/cm^3
0	159	36	6.8	1608	407	1.42
1,000	159	38	6.9	1615	371	1.41
10,000	156	36	6.8	1705	368	1.45
50,000	142	35	6.7	2110	330	1.38
100,000	145	33	6.9	3960	294	1.39
Stats:	S	S	NS	S	S	NS

Material applied spring 1984, moldboard plow incorporation. Newton, IL

Corn Yield Response to Sulfur & Magnesium Fertilization, Northwest Research Farm, 1995 – 1999

Treatment	S	K_2O	MgO	5-year Mean
	lb/acre			bu/acre
Sulpomag	60	60	30	138
KCl + S	60	60	--	138
Elemental S	60	--	--	138
KCl	--	60	--	135
FLSD(0.05)				NS

A.P. Mallarino et al., 1999 ISRF99-29.31.

Fertilizers spring incorporated each year before corn.

1999 0-6 inch SO_4-S: 5-8 ppm with K only; 30-46 ppm average with applied S.

Effect of Broadcast Potash and Sulpomag on Corn Yield, Webster Soil

Year	Control	KCl	$KMgSO_4$
	- - - - - - bu/acre - - - - - -		
1967	146	160	161
1968	148	161	160
1969	144	139	144
1970	108	130	124
1971	147	157	160
1972	129	150	152
1973	115	129	129
1974	120	133	130
8-yr avg.	132	145	145

Fertilizers applied at 160 lb K/acre annually
Sul-po-mag supplied 199 lb S/acre annually
J. Webb, 1978.

Sul-po-mag supplied 98 lb Mg/acre annually

Managing Ca and Mg on Iowa Soils

- **Critical soil test level (sufficiency)**
  - **No Ca or Mg soil test interpretation for Iowa soils**
  - **Neither generally deficiency in Iowa soils**
    - **May be Mg – K – NH_4 grass tetany concern in some soils**
- **Ca and Mg are managed by limestone application from local quarry to acidic soils**

NCR Publication 533
Soil Cation Ratios for Crop Production

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