Is Gypsum Application Beneficial to Soil?

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SOIL, WATER & NUTRIENT MANAGEMENT MEETINGS
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DEPARTMENT OF
Soil Science
UNIVERSITY OF WISCONSIN–MADISON

What is Gypsum?

- Soft mineral - calcium sulfate
- Other names: plaster or plaster of Paris
- Reason for the “Plaster War of 1820”
  - Plaster smuggling from Nova Scotia to newly formed United States (1783)
  - Gypsum trade: 93 tons in 1791 – 43,560 tons in 1818

Canadian Institute of Mining, Metallurgy and Petroleum

Gypsum Chemistry

- Calcium sulfate dihydrate – $CaSO_4 \cdot 2H_2O$

- $CaSO_4 \cdot 2H_2O + heat_{(300^oF)} \rightarrow CaSO_4 \cdot ½H_2O + 1½H_2O$
  - Gypsum plaster or plaster of Paris

- $CaSO_4 \cdot ½ H_2O + heat_{(392^oF)} \rightarrow CaSO_4 + ½H_2O$
  - Anhydrite (mineral)

Sources of Gypsum

- Mined gypsum
- Flue-gas desulfurization (FGD) gypsum
- Recycled gypsum (wallboard & casting)
- Phosphogypsum

Early Uses in Agriculture

- Recorded use as a fertilizer since 2nd half of 1700's.

- Identified as helping plant growth when alabaster workers dusted off clothes in grass patch in France. Similar discovery made in Germany about the same time.

- Used by Benjamin Franklin.

(Crocker, 1922)

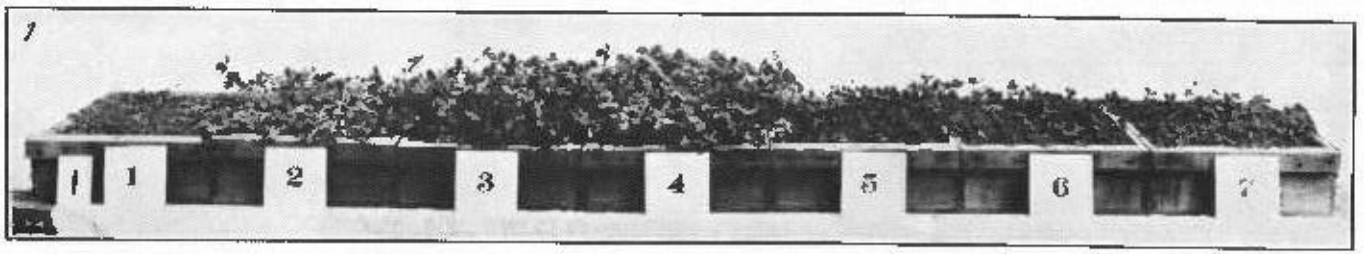
Early Uses in Agriculture

- Greenhouse work published by Hart and Tottingham in 1915 (Journal of Agricultural Research) with a Miami silt loam from the University Hill Farm in Madison.

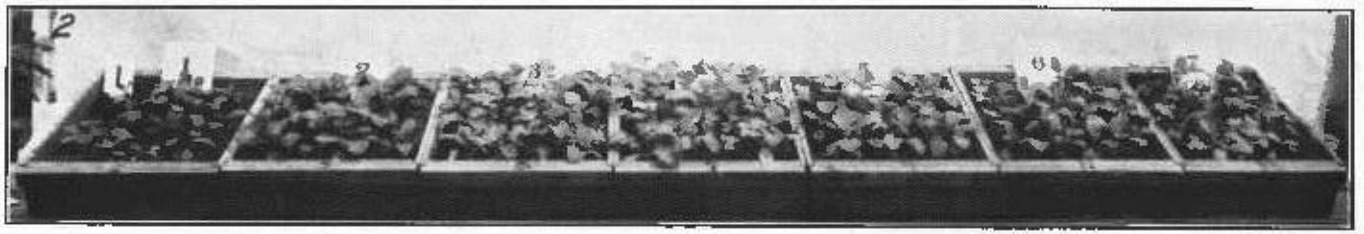
- They concluded that "…for certain plant and types of soil they (sulfates) will be beneficial if their only action is as a source of sulphur."

(Hart & Tottingham, 1915)

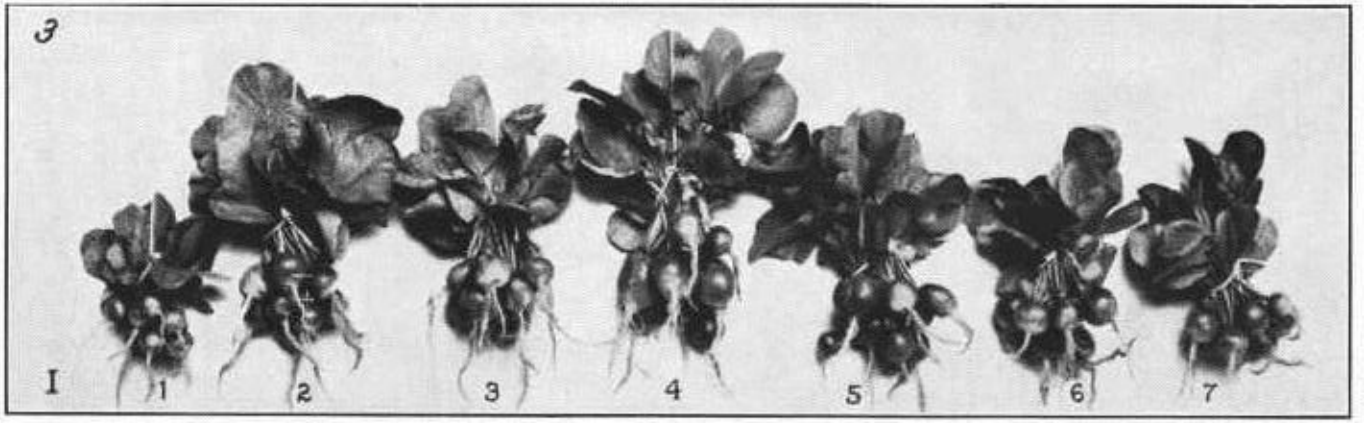
Early Uses in Agriculture



Clover



Radish



Radish

control

N, P, K

N, P, K, Na_2SO_4

N, P, K, $CaSO_4$

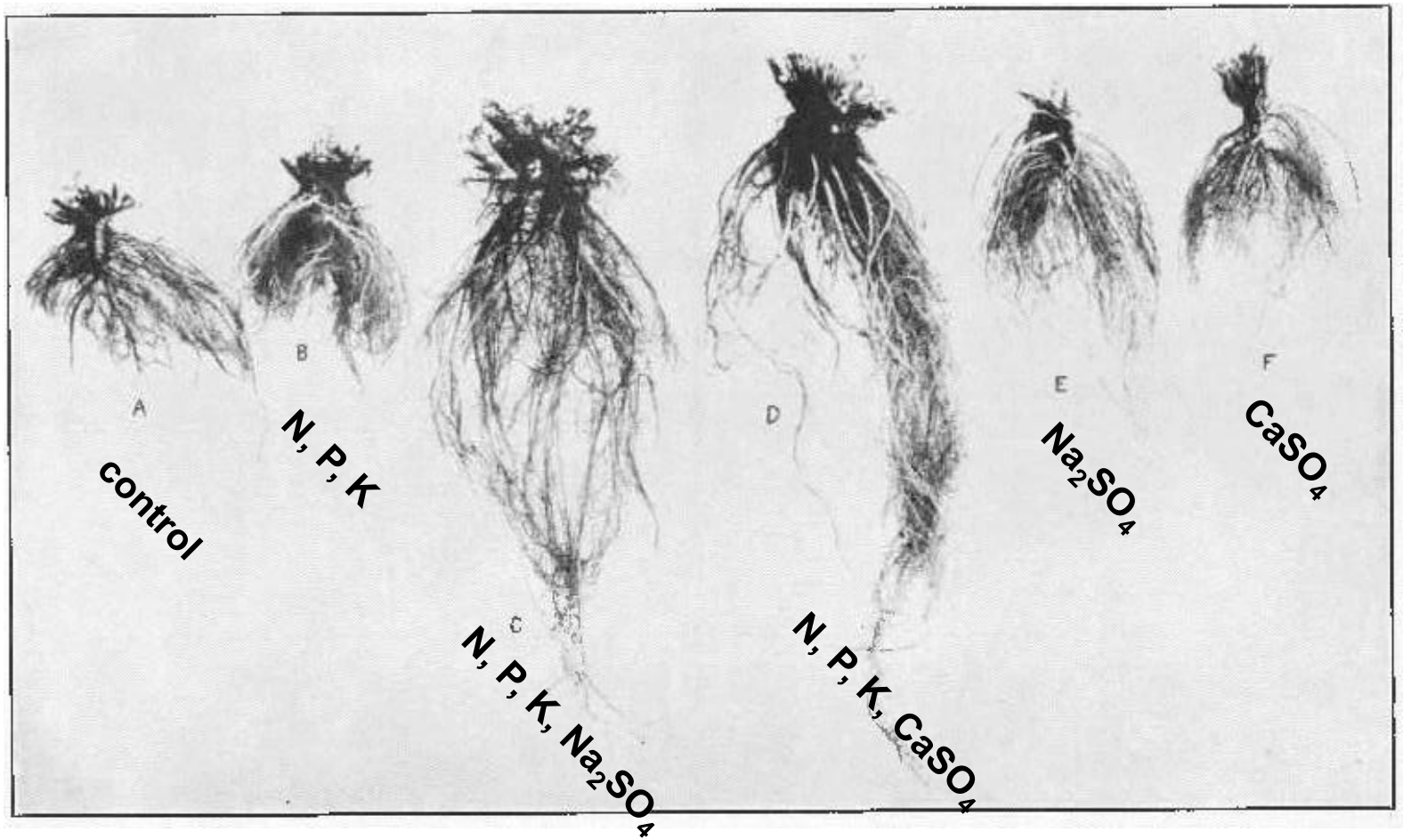
Na_2SO_4

$CaSO_4$

elemental S

(Hart & Tottingham, 1915)

Early Uses in Agriculture



Red Clover

(Hart & Tottingham, 1915)

Early Uses in Agriculture

"In general, the calcium sulphate was more effective than the more soluble sodium sulfate. The special influence of sulphates on root development is pointed out. They were particularly effective with red clover and rape. In the case of red clover, which was more especially studied, the roots were much elongated where shulphates entered into the ration. This must result in a more extended feeding area for the plant and, in addition, increase its ability to withstand periods of drought."

(Hart & Tottingham, 1915)

Agronomic Uses of Gypsum

- Source of calcium (Ca)
- Source of sulfur (S)
- Sodic soil remediation
- Acid subsoils

Calcium in Wisconsin Soils

- Not likely to be deficient if liming recommendations followed (pH < 5.0 for calcium deficiency to show for most crops in WI).

- Response to calcium application unlikely even in soils testing low or very low, except when growing potatoes.

- Calcium recommendations for potato production:
  - Soils with: low – 100 lb/ac; very low – 200 lb/ac (no lime req.)
  - If lime is required, 50-100 lb/ac recommended in addition to lime in very low soils

(A2809-Laboski & Peters, 2012)

Liming Value

Material	**Neutralizing agent**	**$CaCO_3$ equivalent (pure material)**
		---- % ----
Dolomitic limestone	$CaCO_3 \cdot MgCO_3$	110-118
Calcitic limestone	$CaCO_3$	100
Wood ash	K_2CO_3, $CaCO_3$, $MgCO_3$	20-90

(A3588-Management of Wisconsin Soils)

Sulfur in Wisconsin Soils

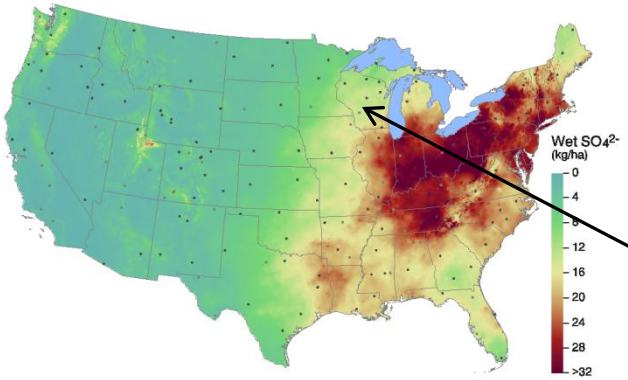
- Some sulfur deficiencies have been reported recently in WI.

- Most likely to occur in crops with a high S demand (alfalfa, canola and brassicas), in sandy soils and soils low in organic matter.

- Soils with low or medium potential for sulfate retention (sands and loamy sands), and with no recent manure applications, would benefit from sulfur application if growing plants with medium or high sulfur needs.

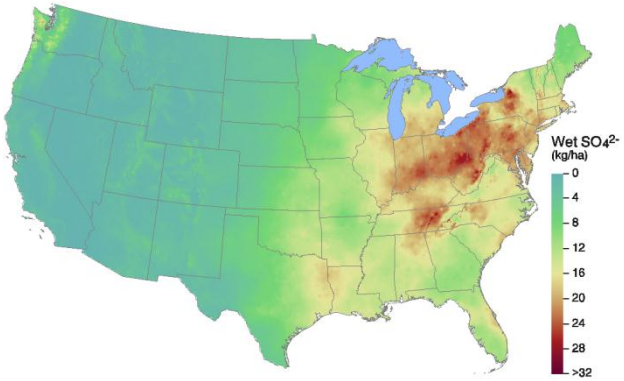
(A2809-Laboski & Peters, 2012)

Sulfur Deposition Trends

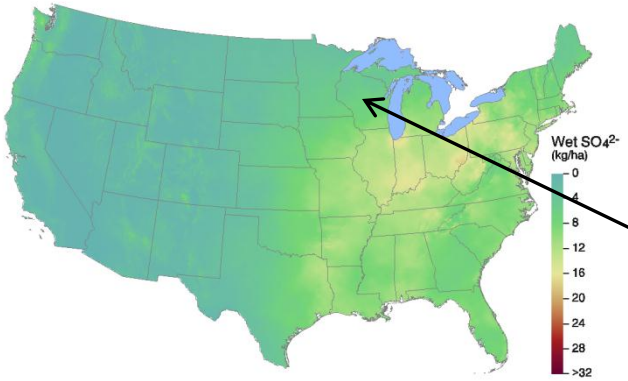


1989-1991

7 – 18 lb/ac



1999-2001



2009-2011

0 – 8 lb/ac

Source: NADP/NTN & PRISM

USEPA/CAMD 10/11/12

US EPA-Clean Air Status and Trends Network

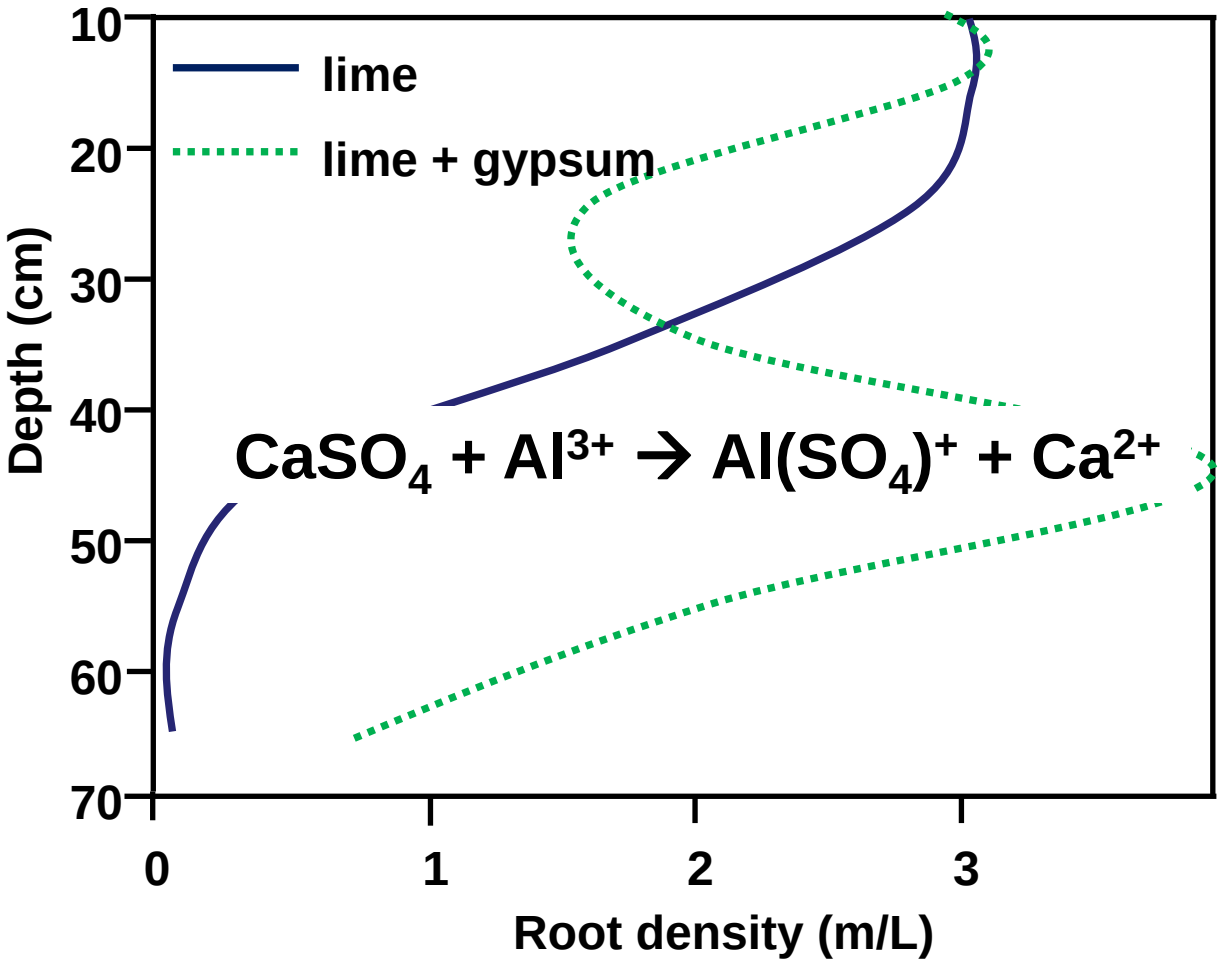
Sodic Soil Remediation

- Soils with a very high concentration of sodium.
- Occurs in arid and semi-arid climates.
- Poor structure (low infiltration, water holding capacity, crusting, etc.) and chemical properties.

Sodic Soil Remediation

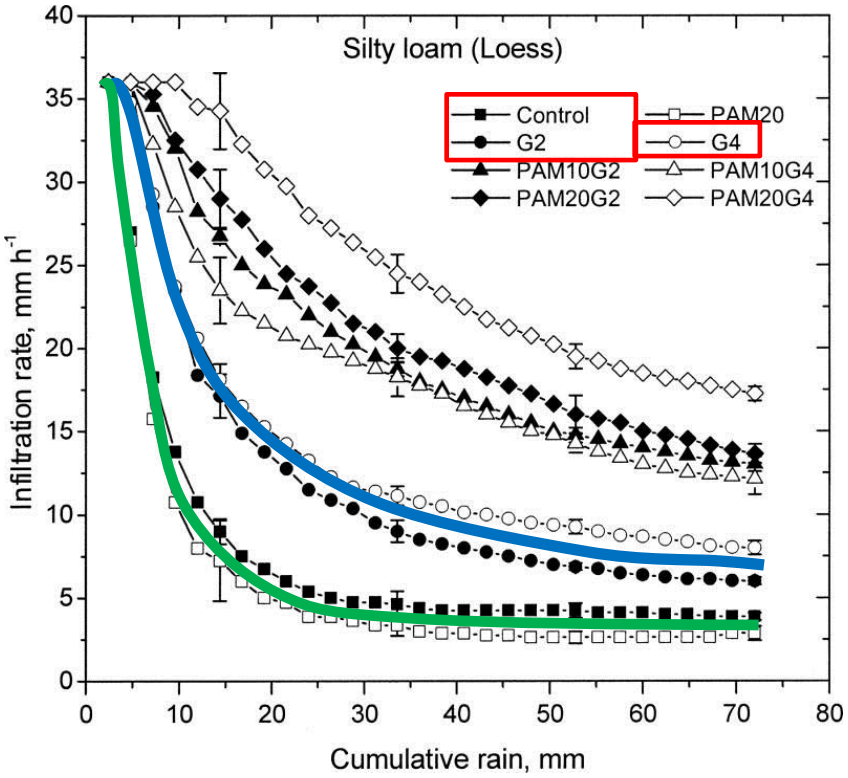
Dept. of Agriculture and Food, Government of Western Australia
(http://grains.agric.wa.gov.au/node/poor-seedbed-soil-structure)

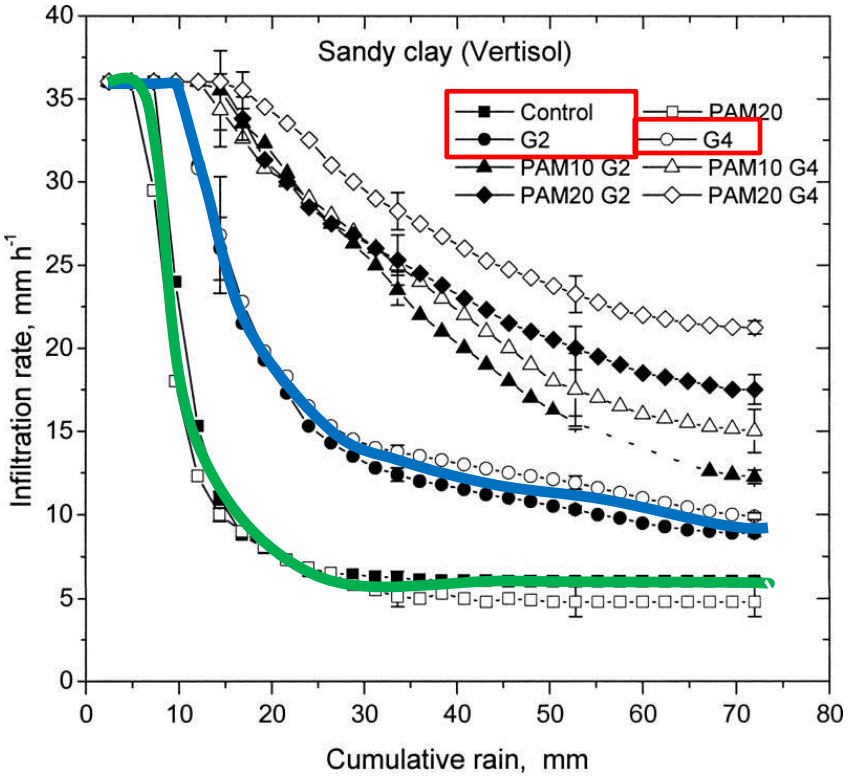
Acid Subsoils & Al^{3+} Toxicity



(Adapted from Farina and Channon, 1988)

Infiltration Rate





control

gypsum

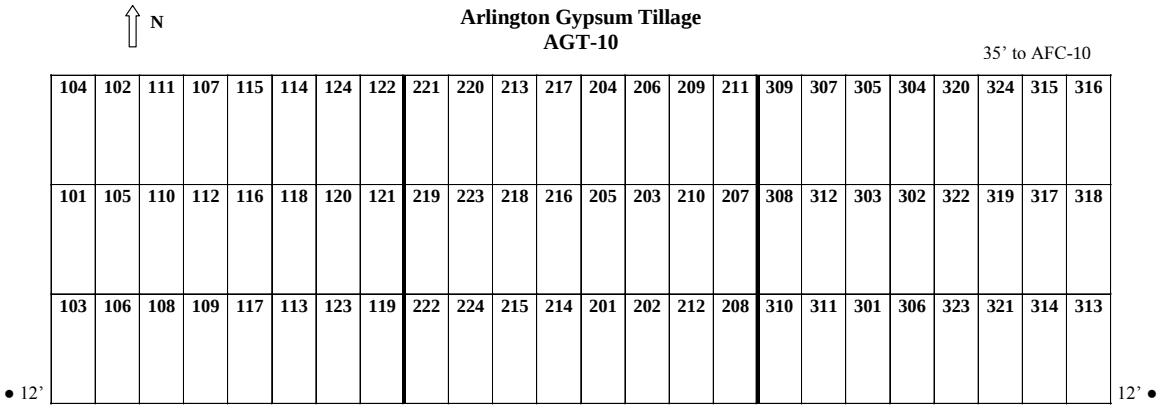
(Yu et al., 2003)

Arlington Study 2010-12

Study investigating the interaction of gypsum application with tillage and N rate to corn.

Treatments:

- Tillage: no-till & chisel/disking
- N rate: 0, 30, 60, 90, 120 & 150 lb N/ac
- Gypsum: none & 1 ton/ac

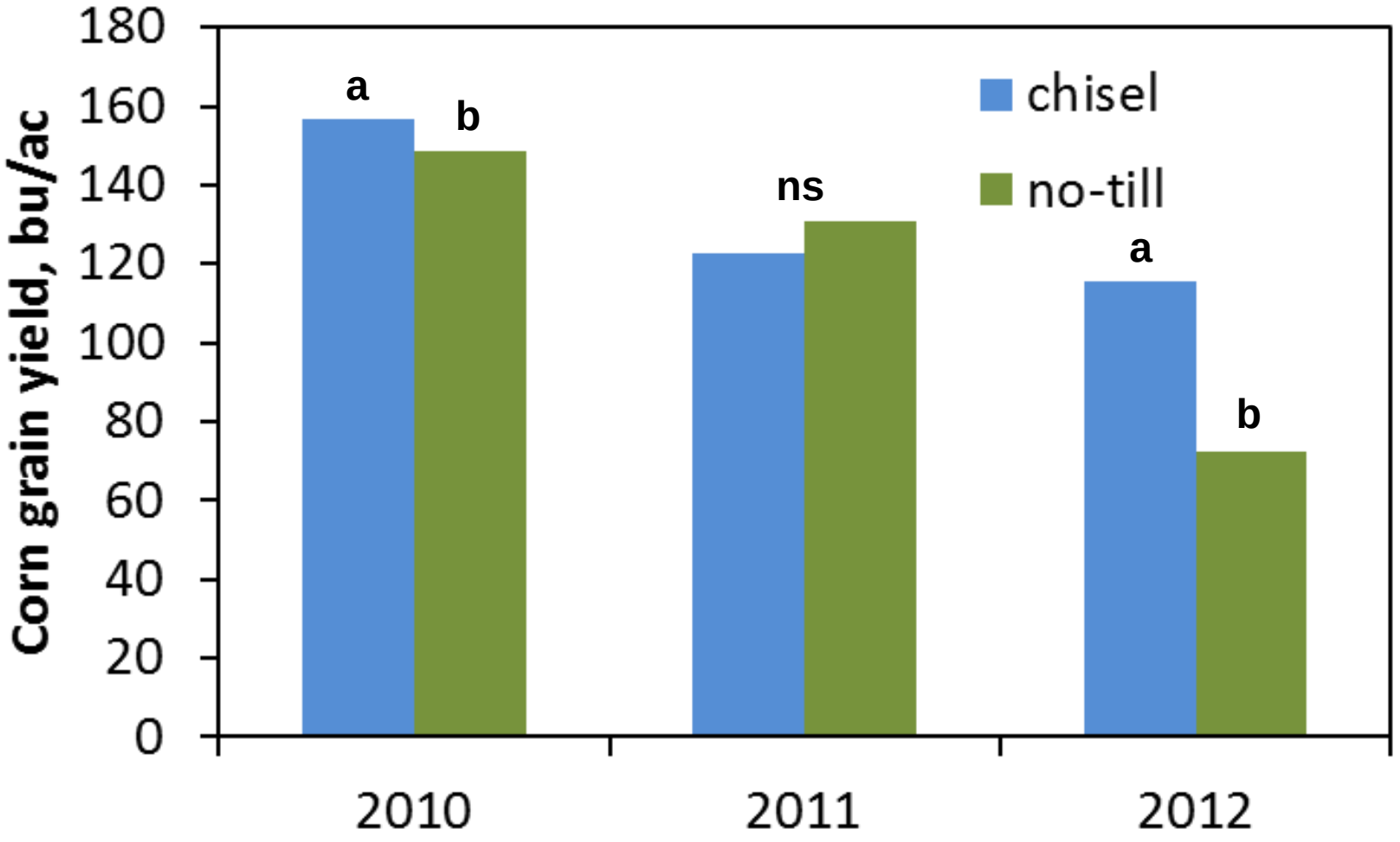


No –till						Chisel					
Trt. No.	N Rate	Gypsum	Trt. No.	N Rate	Gypsum	Trt. No.	N Rate	Gypsum	Trt. No.	N Rate	Gypsum
1	0	0	7	0	1 T	13	0	0	19	0	1 T
2	30	0	8	30	1 T	14	30	0	20	30	1 T
3	60	0	9	60	1 T	15	60	0	21	60	1 T
4	90	0	10	90	1 T	16	90	0	22	90	1 T
5	120	0	11	120	1 T	17	120	0	23	120	1 T
6	150	0	12	150	1 T	18	150	0	24	150	1 T

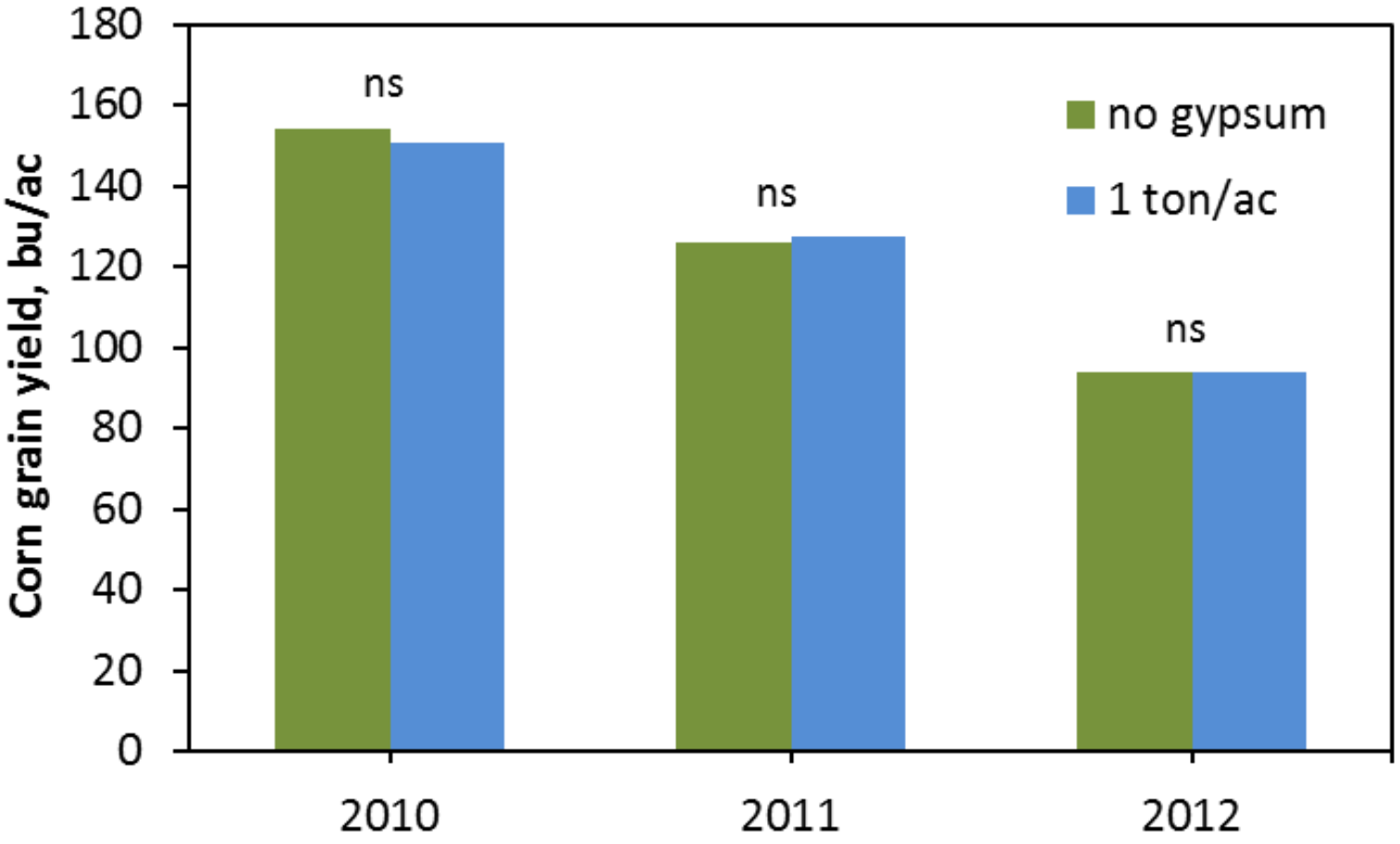
Gypsum, Tillage & N rate

Source	2010	2011	2012
Tillage (T)	**0.095**	0.331	**0.036**
Gypsum (G)	0.340	0.855	0.975
N rate (N)	**<0.01**	**<0.01**	**<0.01**
G x T	0.652	0.916	**0.028**
N x T	0.622	0.587	0.633
N x G	**0.098**	0.120	0.400
N x G x T	0.645	**0.069**	0.535

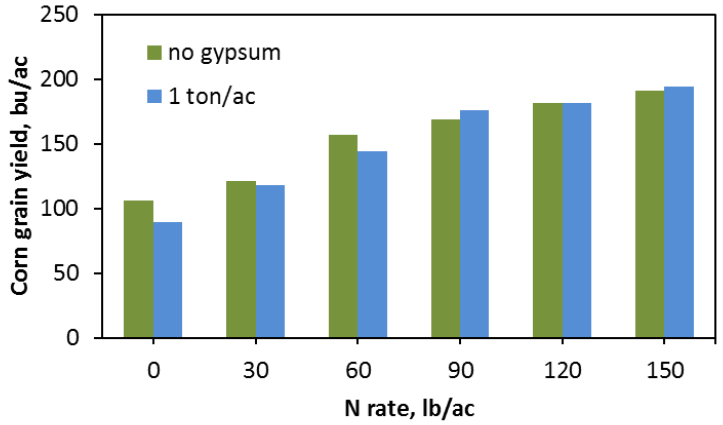
Tillage Effect



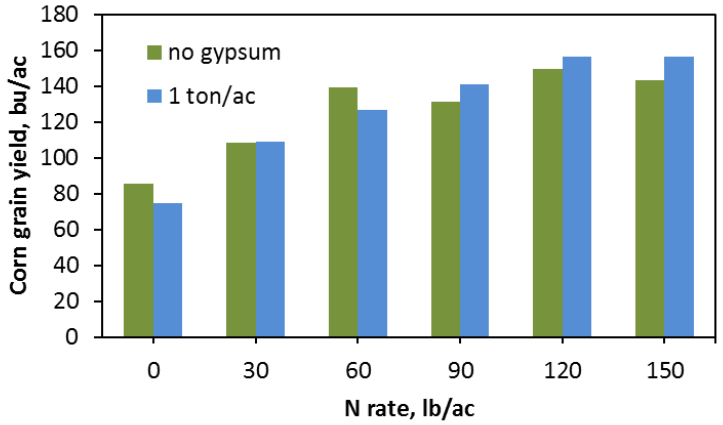
Gypsum Application



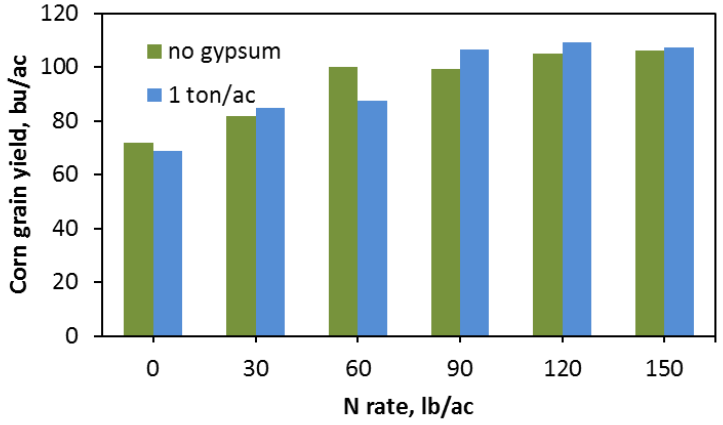
Gypsum & N rate



2010

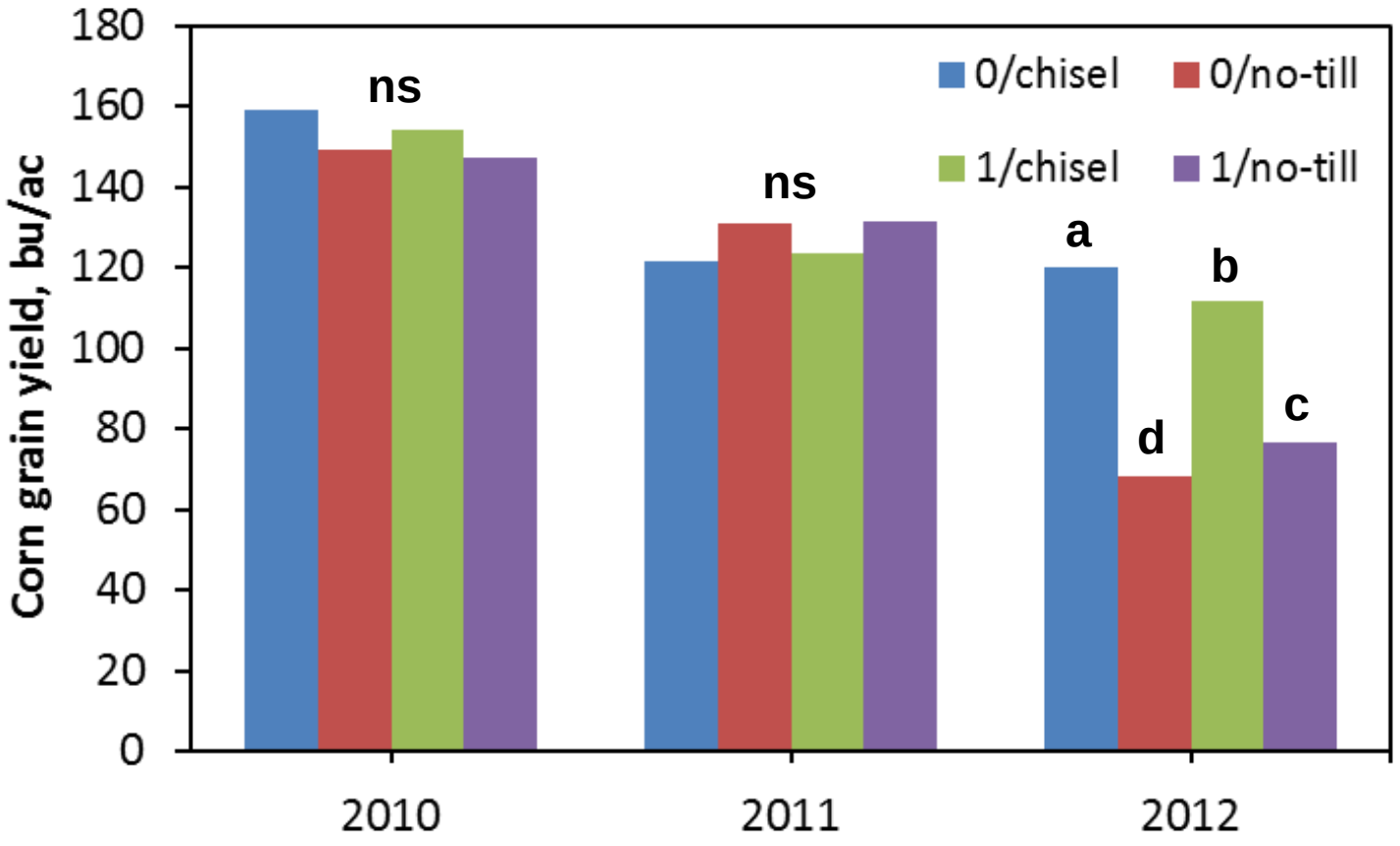


2011



2012

Gypsum & Tillage



Nutrient Losses

- Work conducted in the early 1990's described reductions in P losses from soil, mainly dissolved P.

- More recent work has also reported reductions in NH_4-N and total N from runoff losses with gypsum application.

(Coale et al., 1994; Stout et al., 1999; Stout et al., 2003; Brauer et al., 2005; Cox et al., 2005; Favaretto et al., 2006; Tubail et al., 2008; Murphy & Stevens, 2010)

Closing Remarks

- There is a long history of gypsum use in agriculture.
- Crops with high sulfur or calcium requirements will benefit the most from gypsum application, especially in sandy soils and soils with low organic matter in Wisconsin.
- Gypsum can potentially reduce nutrient losses, mainly dissolved phosphorus and shows promise for other nutrient forms.

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