Midwest Soil Improvement Symposium:

Research and Practical Insights into Using Gypsum

Wisconsin Research Update

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GYPSOIL™ BRAND GYPSUM

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Wisconsin Research with FGD Gypsum

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Gypsum Use in Wisconsin

- An economical Ca and S fertilizer
  - ~ 20 % Ca, ~ 17 % S
- Ca fertilization unnecessary in Wis. except for potato
  - Wis. soils naturally rich in Ca and most have a liming history
- Lower S in precipitation is increasing the potential for S response
  - Consider crop, soil type, location, manure
  - Confirm S need with soil test/plant analysis
- Should we manage soil Ca:Mg ratios?
- Remediating high sodium soils

Potato Response to Ca Fertilization as Gypsum

- Often grown on sandy, lower pH soils
- Tuber is a “dead end” structure and receives limited Ca from plant sap
- Improved yield and tuber quality
- Increasing Ca in the periderm enhances resistance to soft rot bacteria

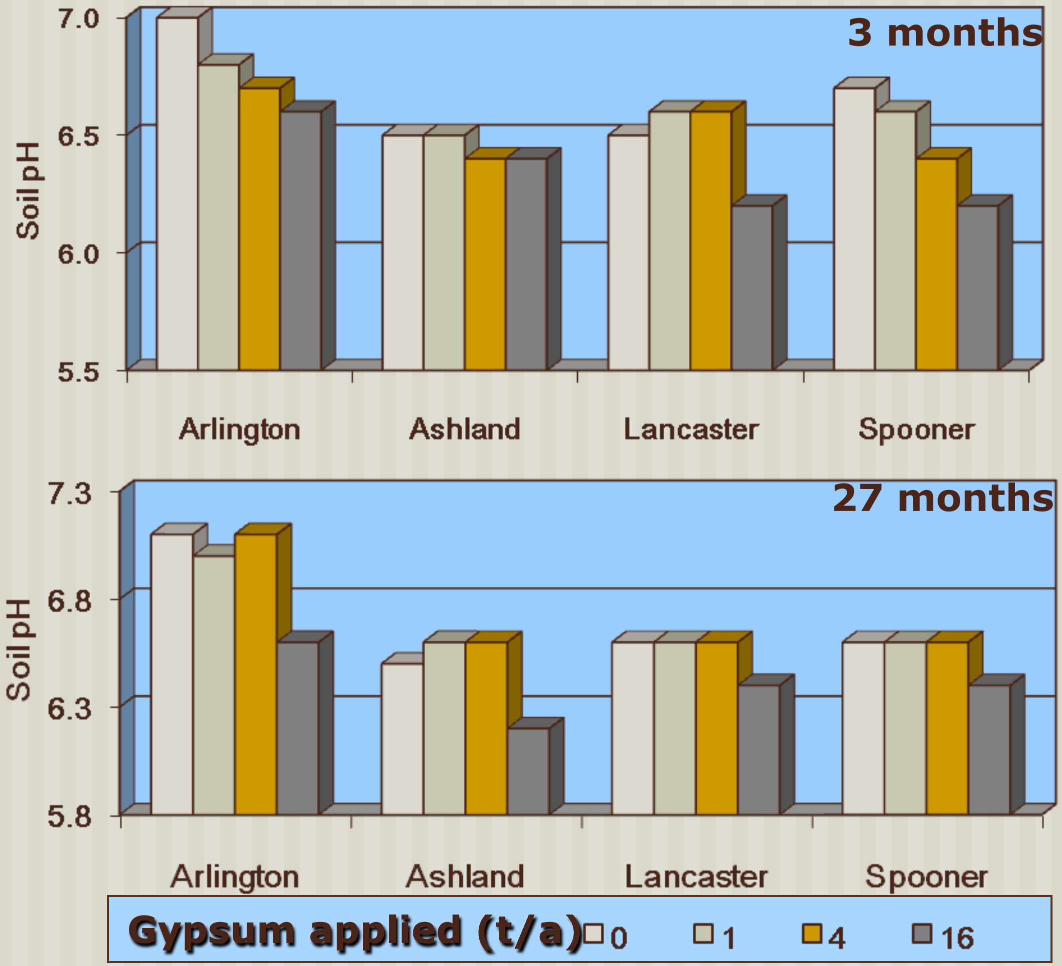
Gypsum Type	Yield	US1A	Tuber Ca
	cwt/a	%	%
None	371	70	0.13
Pelletized	418	72	0.20
Sieved	419	72	0.19

Source: Simmons et al., 1988

Gypsum is Not a Liming Material

- Compounds that contain Ca are not automatically liming materials
- Ca^{2+} displaces H^+ into the soil solution
- The anion in lime (CO_3^{2-}) neutralizes the H^+
- High Al not an issue in Wisconsin soils
- Large gypsum applications can actually lower pH by the “salt effect”

Effect of Gypsum Additions on Soil pH (adapted from Wolkowski, 2000)



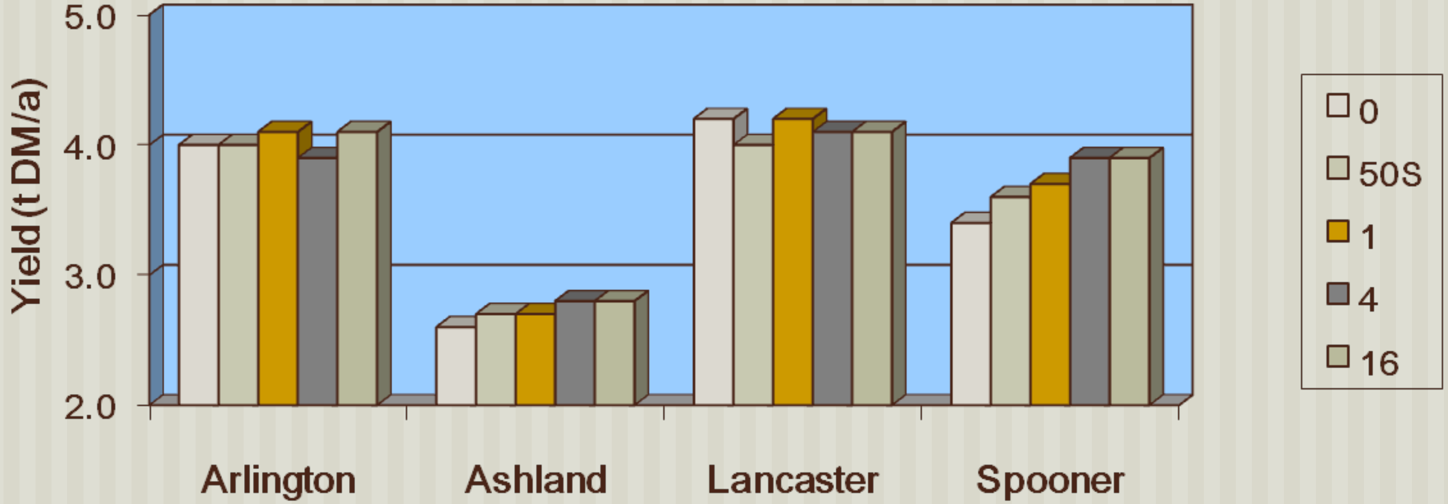
Wisconsin Research Does Not Support Ca:Mg Management

- Result of a soil testing philosophy that suggests the need for a balance of exchangeable cations
- 65 % Ca, 10 % Mg, 5 % K, and 20 % H
- Ideal total Ca:Mg of 5.4
- Gypsum recommended to adjust the ratio
- Modern soil testing philosophy measures exchangeable Ca and Mg
- Several times crop need of Ca and Mg delivered to the root surface by mass flow
- Research has not shown a yield response

Crushed Wallboard Gypsum Study, 1995 – 1997

- Scrap from new construction
- Green building movement
- Estimated "waste" 1 – 1.5 lb/ sq ft
- Alternative to landfilling, but handling issue

Alfalfa yield at four locations, 1996 (Wolkowski, 2000)



Using Gypsum for High Sodium Soils in Wisconsin?

- Possible situations
  - Cheese plant or other wastewaters
  - De-icing salt accumulation
  - Brain cramp instances
- Assume CEC of 20 and 15 % Na saturation
  - Apply 2.5 t/a gypsum

What About FGD Gypsum

- Beneficially re-use
  - 100,000's tons produced
  - Drywall or other uses
  - Land application to crops
  - Avoid landfilling
- Source of S and Ca
  - Suggested rates supplies many times crop need
- Improvement in soil condition
  - Improve soil aggregation
  - Increase infiltration
  - Reduce bulk density and compaction
- Reduce P loss

Land Application Considerations

Material	Ca	S	Mg	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Zn
	--------- % ---------			-- ppm --										
FGD	23.0	18.6	0.03	0.56	<0.5	1.30	<0.5	1.16	0.80	<0.3	0.51	0.73	5.51	3.88
Mined	19.1	15.2	1.35	<0.5	<0.5	1.38	0.53	1.33	2.92	<0.3	1.28	1.42	<1.5	0.91

Source: Ohio State Univ. Pub. ANR 20-05

2010 - 2011 FGD Gypsum Studies

- Arlington alfalfa
  - Seeded in 2010
  - Component of national study
  - 0, 1, 2, and 4 t/a as FGD or mined material
  - Yield, soil properties, Hg movement
- Arlington corn
  - No-till vs. chisel, 6 N rates, w/ or w/o FGD
  - Yield and earleaf N concentration
- N. and E. Wis. on-farm studies
  - 0, 0.5, 1, and 2 t FGD/a; 30 lb S/a as fert.
  - Yield, leaf concentration, physical properties, dissolved reactive P

All materials applied post-plant

Alfalfa Yield and FGD Gypsum, Arlington, Wis.

	Seeding Year - 2010		First Hay Year - 2011	
Treatment	Cut 1	Cut 2	Cut 1	Cut 2
	--------------------- ton DM/a ---------------------			
Control	1.2	1.0	1.6	1.5
FGD 1 t/a	1.3	1.2	1.7	1.7
FGD 2 t/a	1.3	1.3	1.8	1.8
FGD 4 t/a	1.3	1.2	1.9	1.7
Fert. 1 t/a	1.1	1.2	1.8	1.6
Fert. 2 t/a	1.1	1.3	1.9	1.7
Fert. 4 t/a	1.2	1.3	1.9	1.8
Source	0.04	0.86	0.23	0.60
Rate	0.60	0.58	0.32	0.27
S * R	0.44	0.77	0.75	0.30

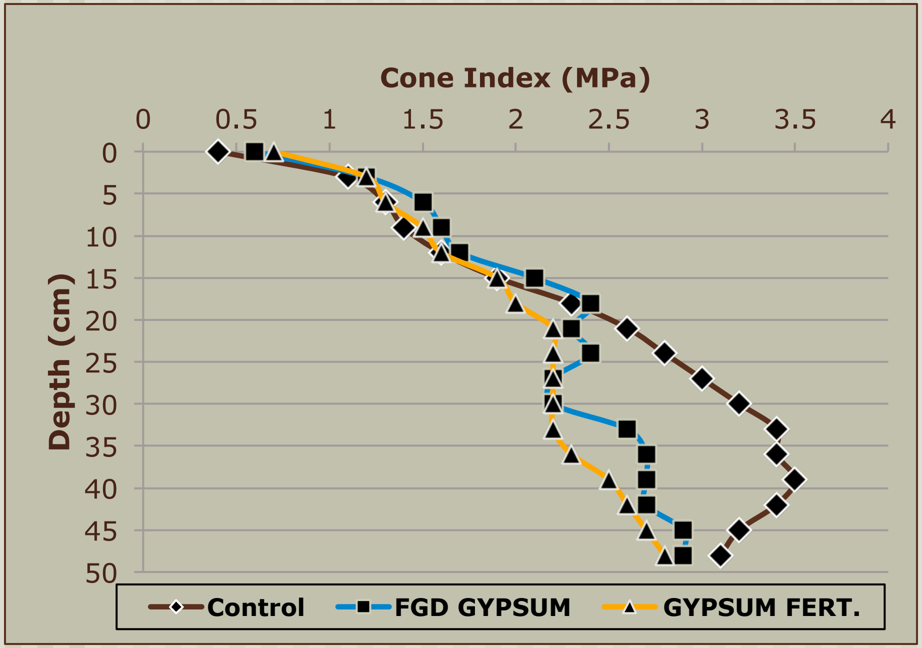
FGD Effect on Physical Properties in Alfalfa, Arlington, Wis.

Effect on bulk density and hydraulic conductivity

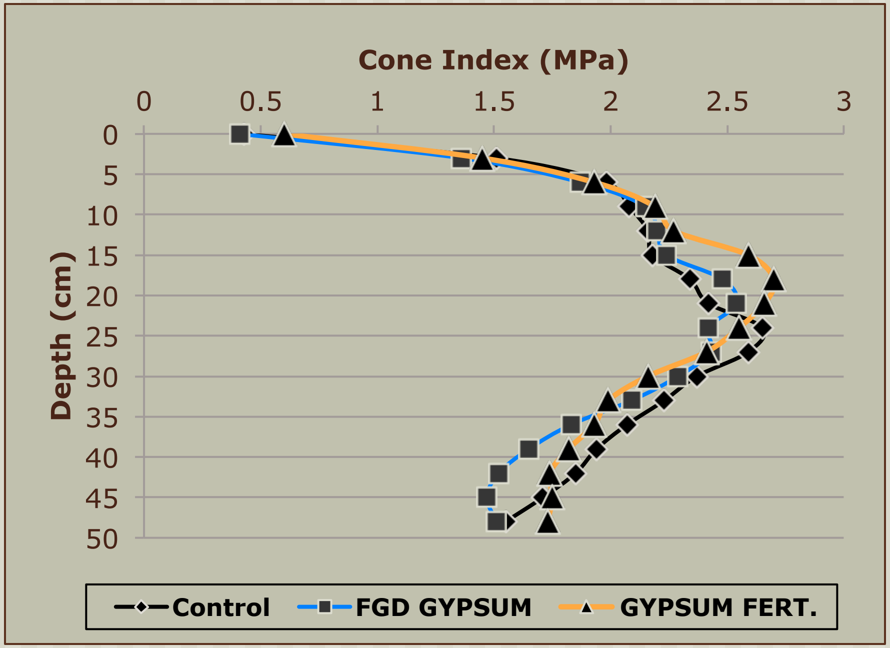
Treatment	Bulk density	Saturated hydraulic conductivity
	g/cc	cc/hr
Control	1.36	3.08
FGD 4 t/a	1.33	4.74
Fert. Gyp. 4 t/a	1.34	3.72
Pr>F	0.85	0.42
LSD	NS	NS

FGD Effect on Physical Properties, Arlington, Wis.

Effect on penetration resistance – Alfalfa study



Nov 2010

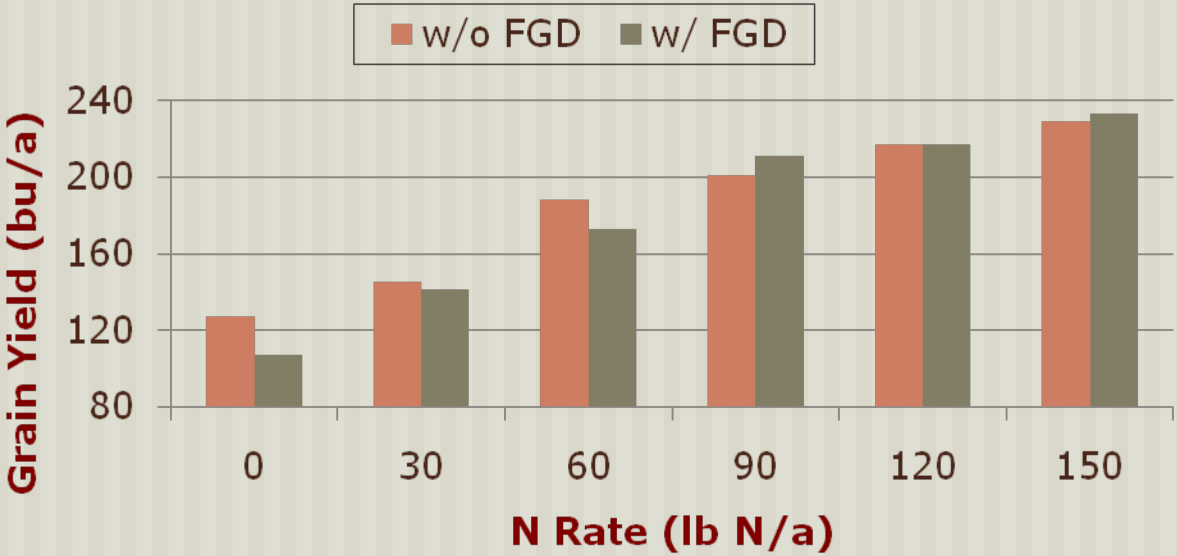


May 2011

FGD Gypsum and N Management, Arlington, Wis. – Grain Yield

OSU study

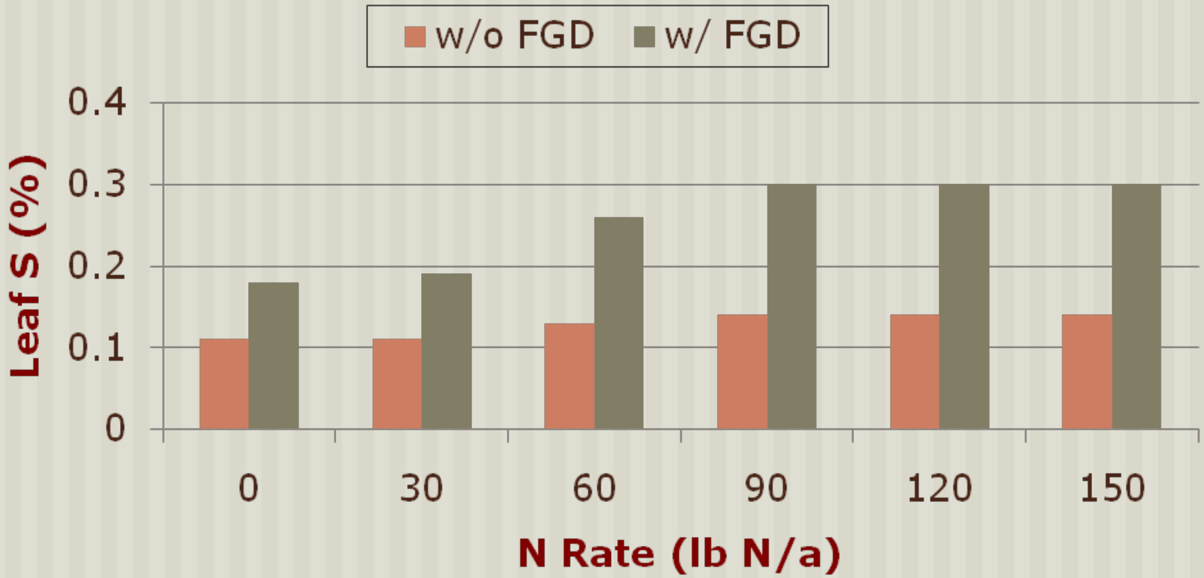
- Improved N use efficiency with gypsum
- Reduced N rates possible



Interactive effect between N rate and FGD gypsum (p=0.10)

FGD Gypsum and N Management, Arlington, Wis. – Earleaf S

Earleaf Critical Range:
0.16 – 0.25 %S



Interactive effect between N rate and FGD gypsum (p=<0.01)

2010 On-farm FGD Gypsum Studies – Soil Properties

Site ID	Web Soil Survey Name	Physical Analysis				
		Sand	Silt	Clay	Texture	Soil test P
E. Wis.		----------- % -----------				ppm
COG	Manawa silty clay loam	47	37	16	Loam	59
JUG	Kewaunee silt loam	31	51	18	Silt loam	23
STG	Kewaunee silt loam	53	33	14	Sandy loam	36
SVG	Namur silt loam	61	29	10	Sandy loam	35
SZG	Sisson fine sandy loam	53	26	14	Sandy loam	49
VHG	Kewaunee silt loam	41	40	19	Loam	63
VWG	Oshkosh silt loam	35	42	23	Loam	62
WEG	Oshkosh silt loam	43	35	22	Loam	83
N. Wis.						
JOG	Amnicon-Cuttre complex	27	34	39	Clay loam	24
PTG	Amnicon-Cuttre complex	19	34	47	Clay	45
SYG	Amnicon-Cuttre complex	34	26	40	Clay loam	7

On-farm FGD Gypsum Studies – Earleaf S

	Site						
Treatment	COG	STG	SVG	SZG	SYG	JOG	PTG†
	------------------------------- % -------------------------------						
Control	0.18	0.20	0.19	0.23	0.24	0.32	0.30
30 lb S/a	0.18	0.20	0.22	0.23	0.20	0.31	0.30
FGD 0.5 t/a	0.18	0.26	0.30	0.25	0.21	0.33	0.32
FGD 1 t/a	0.18	0.33	0.33	0.23	0.25	0.36	0.31
FGD 2 t/a	0.18	0.33	0.36	0.25	0.37	0.38	0.31
Pr>F	0.99	<0.01	<0.01	0.26	0.02	0.56	0.99
LSD	NS	0.03	0.04	NS	0.09	NS	NS

On-farm FGD Gypsum Studies – Crop Yield

	Site						
Treatment	COG	STG	SVG	SZG	SYG	JOG	PTG†
	------------------------------ bu/a ------------------------------						
Control	157	210	195	178	148	179	47
30 lb S/a	166	226	208	169	159	164	49
FGD 0.5 t/a	138	213	212	177	170	158	56
FGD 1 t/a	144	213	220	176	181	170	44
FGD 2 t/a	135	217	217	191	194	164	48
Pr>F	0.76	0.79	0.10	0.33	0.49	0.44	<0.01
LSD	NS	NS	NS	NS	NS	NS	4

Gypsum as a Soil Amendment

- **Ca + S Fertilization**
- **P Runoff Reduction**
  - **High P soils have loss potential**
  - **WI has sensitive waters**
  - **Great Lakes of particular concern**

- **Gypsum helps by**
  - **Reducing P solubility**
  - **Improving aggregation**

2010 - 2011 FGD Gypsum Studies

- N. and E. Wis. on-farm studies
  - 0, 0.5, 1, and 2 t FGD/a applied post-plant
  - Five sites planted to corn in 2010
  - Five sites planted to corn in 2011

2010 - 2011 FGD Gypsum Studies

- Monitor soil condition, looking for
  - Reduced bulk density and compaction
  - Increased soil aggregation
  - Increased infiltration rates
  - Reduced P availability

2010 On-farm FGD Gypsum Studies – Pre-application Soil Properties

Site ID	Mapped Soil Series	Physical Analysis				
		Sand	Silt	Clay	Texture	Soil test P
E. Wis.		--------- % ---------				ppm
COG	Manawa	47	37	16	Loam	59
VHG	Kewaunee	41	40	19	Loam	63
WEG	Oshkosh	43	35	22	Loam	83
N. Wis.						
JOG	Amnicon-Cuttre	27	34	39	Clay loam	24
SYG	Amnicon-Cuttre	34	26	40	Clay loam	7

2010 On-farm FGD Gypsum Studies – Bulk Density Results

	Site				
Treatment	COG	WEG	VHG	SYG	JOG
	-------------------- g/cm^3 ---------------------				
Control	1.32a	1.42a	1.27a	1.10b	1.11a
FGD 0.5 t/a	1.35a	1.44a	1.25a	0.99a	1.21b
FGD 1 t/a	1.35a	1.44a	1.27a	1.02ab	1.19b
FGD 2 t/a	1.35a	1.50a	1.26a	1.09b	1.19b
Use of different lower case letter indicates significant difference at p=0.10					

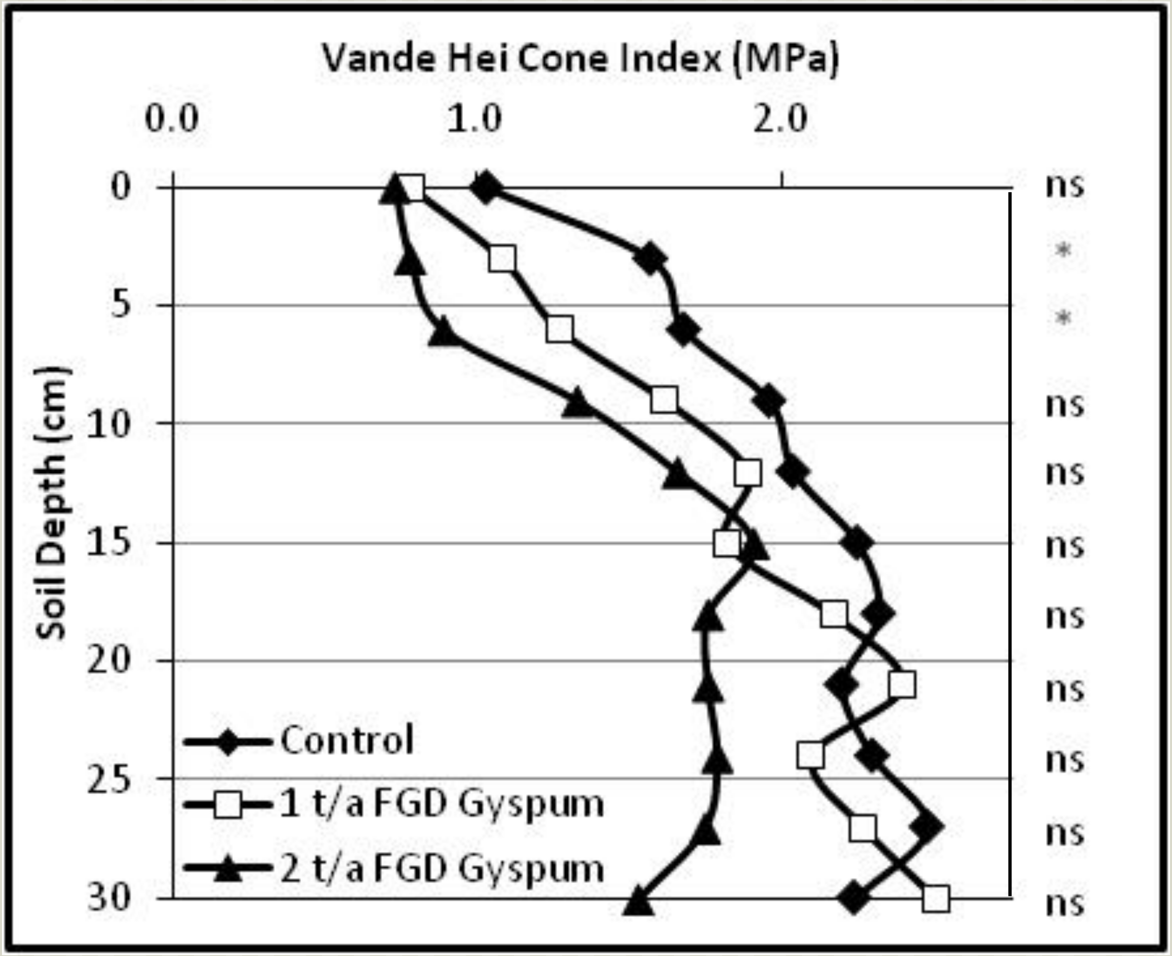
2010 On-farm FGD Gypsum Studies – Infiltration Results

	Site				
Treatment	COG	WEG	VHG	SYG	JOG
	------------------- cm/hr --------------------				
Control	0.32a	0.19a	0.48a	2.69a	2.08a
FGD 0.5 t/a	0.49a	0.69a	0.26a	3.77b	2.02a
FGD 1 t/a	0.56a	0.27a	0.60a	3.63b	1.10a
FGD 2 t/a	0.52a	0.69a	0.53a	1.02a	1.41a
Use of different lower case letter indicates significant difference at p=0.10					

2010 On-farm FGD Gypsum Studies – Penetrometer Results (surface 2.5 cm)

	Site				
Treatment	COG	WEG	VHG	SYG	JOG
	------------------- MPa resistance --------------------				
Control	0.85a	0.54a	1.03b	0.27a	0.53a
FGD 1 t/a	1.07a	0.51a	0.78a	0.43a	0.66a
FGD 2 t/a	0.62a	0.58a	0.73a	0.25a	0.40a
Use of different lower case letter indicates significant difference at p=0.10					

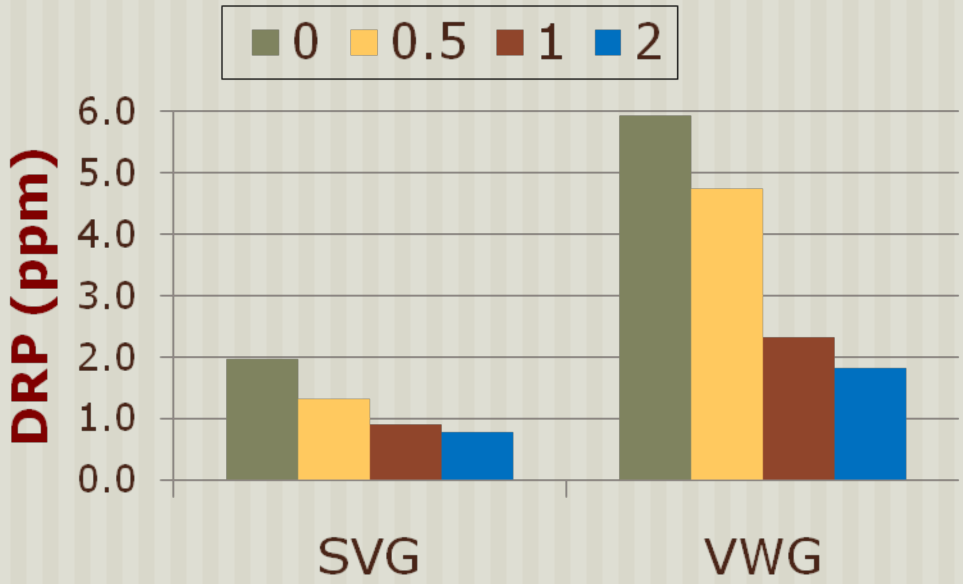
2010 Vande Hei Full Penetrometer Data

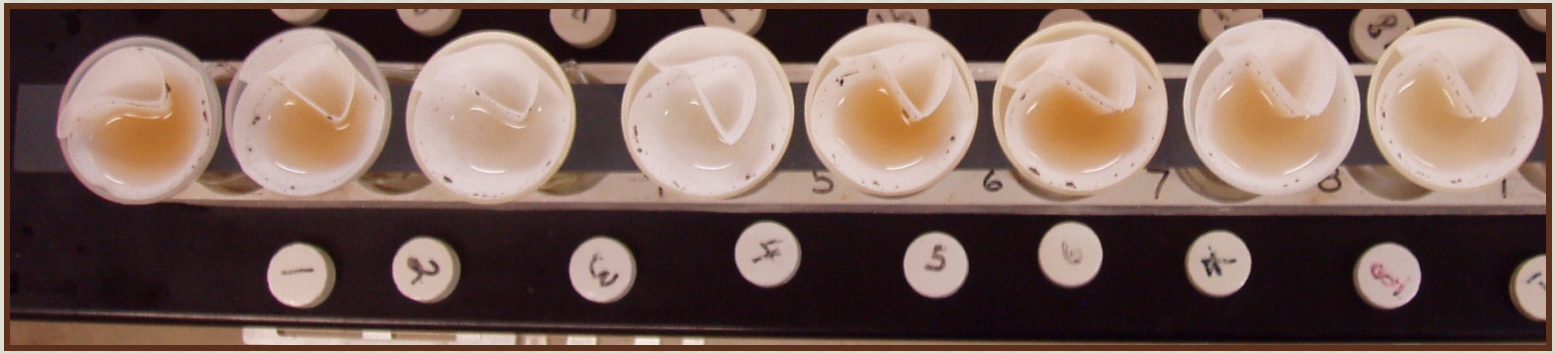


2010 On-farm FGD Gypsum Studies – Aggregate Stability Results from JOG site

	Aggregate Size Categories (mm)					
Treatment	> 4	2-4	0.5-2	0.25-0.5	0.125-0.25	< 0.125
	------- Weight of Aggregates (g) --------					
Control	23a	14a	8.2a	1.5a	1.0a	0.5a
FGD 0.5 t/a	28a	9.5a	8.8a	1.6a	1.0a	0.5a
FGD 1 t/a	31a	9.4a	6.8a	1.3a	0.7a	0.4a
FGD 2 t/a	31a	10a	6.3a	0.7a	0.4a	0.2a
Use of different lower case letter indicates significant difference at p=0.10						

On-farm FGD Gypsum Studies – Soluble P





Summary

- FGD gypsum is an excellent source of S and Ca for crops
- FGD gypsum did not consistently influence crop yield or soil properties
- Limited analysis shows high rates of gypsum may reduce DRP in soils
  - 5 of 11 sites at 30 days after application
  - 3 of 11 sites at 90 days after application

Summary

- FGD gypsum did not consistently influence soil physical properties
  - Greatest effect seems to be at sites with greatest clay content
  - Long-term effect on soil physical conditions should be studied
- At this time there are no specific UWEX recommendations for FGD gypsum use