

Of-heard Questions About Gypsum in a State Extension Office

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Gypsum factoids

- Calcium sulfate dihydrate
- Mineable deposits in many states
- A common mineral in arid soils
- Modestly soluble
- Several by-product sources



Gypsum uses

- ❑ Wallboard
- ❑ Setting agent in concrete
- ❑ Additive for fast-dry clay tennis courts
- ❑ Blackboard chalk
- ❑ Binder in tofu
- ❑ Soil amendment



Gypsum as a nutrient source

- An economical Ca source (22 % Ca)
- Ca fertilization unnecessary in Wis. except for potato
- Wis. soils naturally rich in Ca and most have a liming history
- Crop Ca removal ranges between 25 and 100 lb/a
- Ca is the dominant cation in soils
- Ca responsive soil: < 400 ppm on sands and < 600 ppm Ca on other soils

Potato response to Ca fertilization

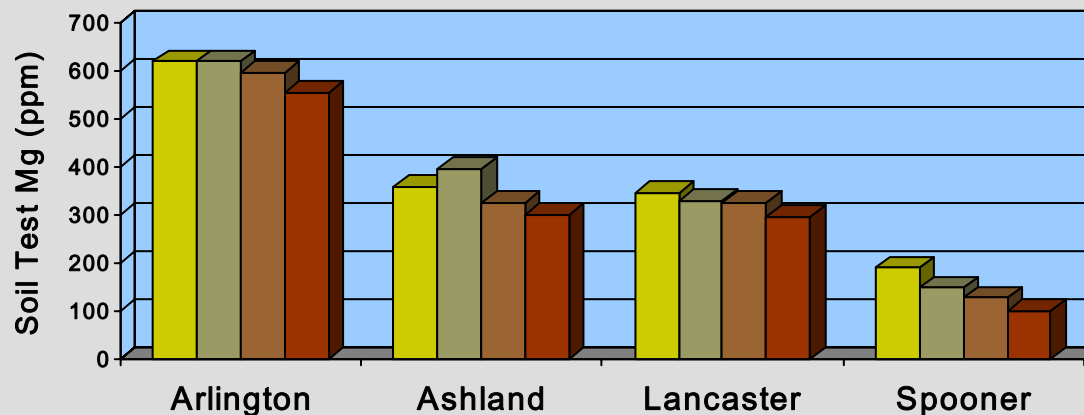
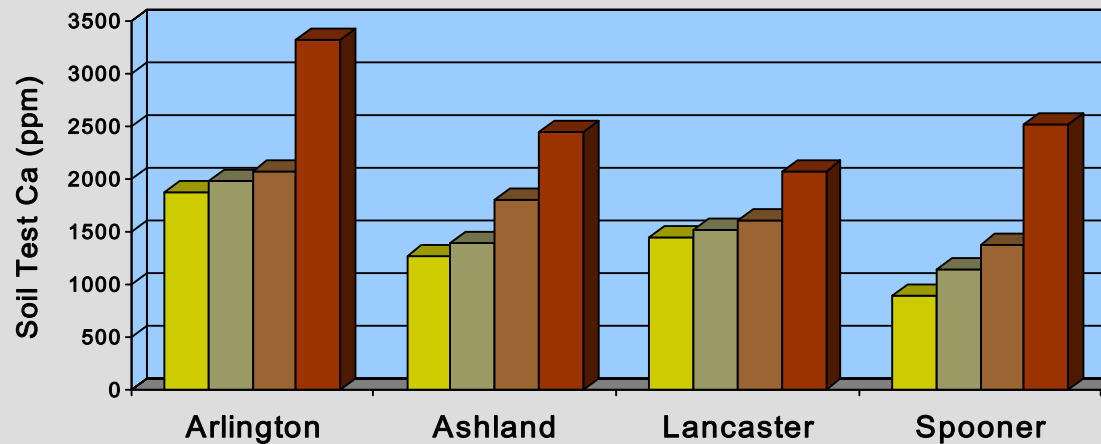
- Often grown on sandy, lower pH soils
- Tuber is a “dead end” structure and does not receive Ca from xylem
- Increasing Ca in the periderm enhances resistance to soft rot bacteria
- Least expensive and safest Ca source

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

Effect of gypsum additions on soil test Ca and Mg

Ca and Mg (adapted from Wolkowski, 2000)



Ca applied (lb/a) 0 320 1280 5120



Gypsum as a nutrient source

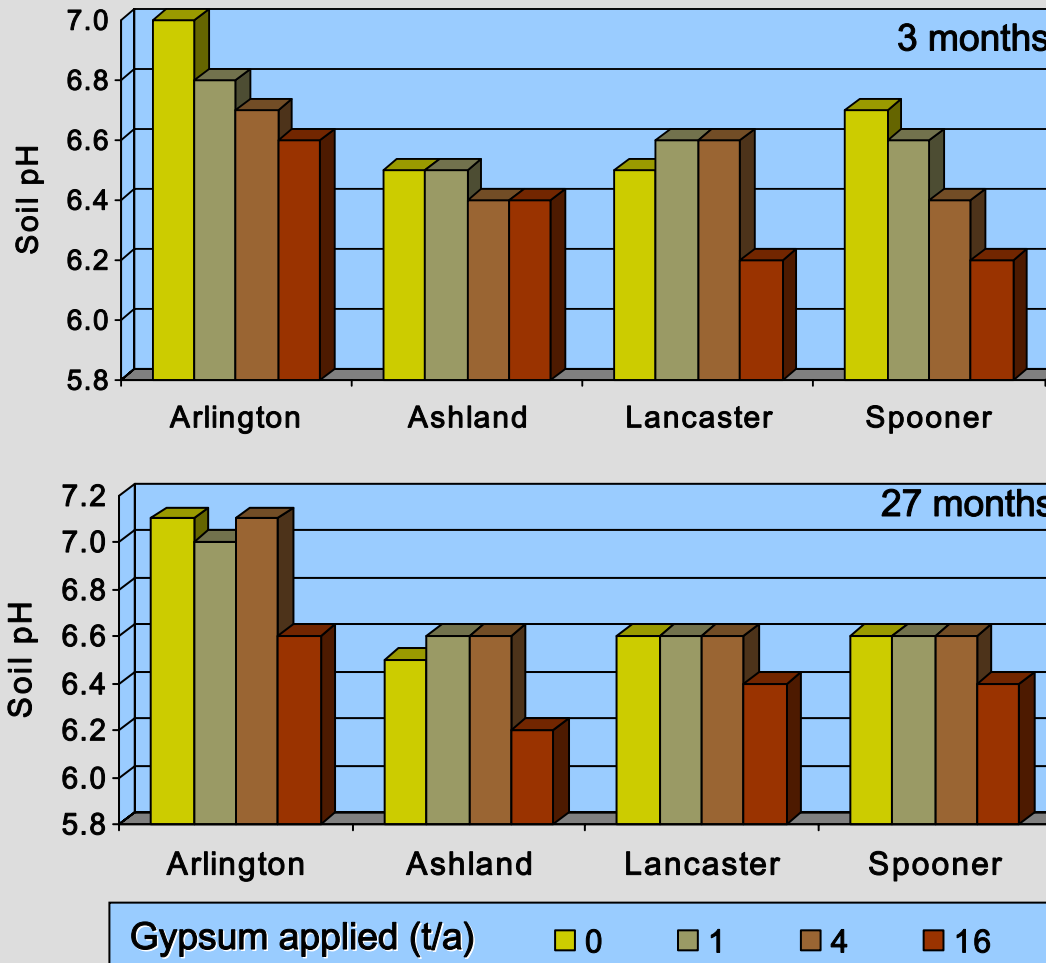
- An economical S source (17 % S)
- S response has historically been regional; more in western and northwest Wisconsin
- Lower S in precipitation is increasing the potential for response
- Most likely for high demand crops and on sandy, low organic matter soils
- Manure contains substantial S
- Confirm S need with soil test/plant analysis

Gypsum is not a liming material

- Compounds that contain Ca are not automatically liming materials
- The anion in lime (CO_3^{2-}) neutralizes the H^+
- Ca^{2+} displaces H^+ into the soil solution
- Gypsum has been used to address low subsoil pH issues that result in high Al
- Large gypsum applications can actually lower pH by the “salt effect”

Effect of gypsum additions on soil pH

(adapted from Wolkowski, 2000)



Gypsum and the never ending saga of Ca to Mg ratios

- Result of a 100 year old 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 or hi-cal lime often recommended to adjust the ratio

Gypsum and the never ending saga of Ca to Mg ratios

- Sand: 250 ppm Ca/50 ppm Mg
Silt loam: 2500 ppm Ca/500 ppm Mg
- Modern soil testing philosophy measures exchangeable Ca and Mg
- Several time crop need of Ca and Mg delivered to the root surface by mass flow
- While soil and plant Ca:Mg is changed, crop yield is not affected by Ca:Mg

Wisconsin soil test guidelines (A2809)

Table 8.4. Soil test interpretation categories for secondary nutrients and micronutrients.

Nutrient	Soil texture code ^a	Soil test category				
		Very low (VL)	Low (L)	Optimum (O)	High (H)	Excessively high (EH)
----- Soil test (ppm) -----						
Calcium	1	0-200	201-400	401-600	>600	—
	2, 3, 4	0-300	301-600	601-1000	>1000	—
Magnesium	1	0-25	26-50	51-250	>250	—
	2, 3, 4	0-50	51-100	101-500	>500	—
Boron	1	0.0-0.2	0.3-0.4	0.5-1.0	1.1-2.5	>2.5
	2, 4	0.0-0.3	0.4-0.8	0.9-1.5	1.6-3.0	>3.0
	3	0.0-0.5	0.6-1.0	1.1-2.0	2.1-4.0	>4.0
Zinc	1, 2, 3, 4	0.0-1.5	1.6-3.0	3.1-20.0	21.0-40.0	>40.0
Manganese ^b	1, 2, 3, 4	—	0-10	11-20	>20	—

^a Soil texture codes: 1 = sandy soils; 2 = loams, silts, and clays; 3 = organic soils; 4 = red soils. See Figure 4.1 for definitions of each texture code.

^b For manganese, soil tests are only used for soils with an organic matter content less than or equal to 6.0%. If soils have organic matter content greater than 6.0 %, then soil pH is used as the basis for determining manganese requirements. See text for more detail.

Wisconsin soil test example

LABORATORY ANALYSIS															
Sample No.	Text Code	Est CEC	Soil pH	O.M. %	P ppm	K ppm	Ca ppm	Mg ppm	B ppm	Mn ppm	Zn ppm	SO4-S ppm	SAI	Density	Buffer pH
1	2	13	6.5	3.0	15	64	1440	400						0.90	7.0
2	2	13	6.1	3.1	26	65	1420	360						0.89	6.9
3	2	15	6.1	3.2	18	61	1550	390						0.86	6.7
4	2	12	6.3	3.2	12	67	1370	380						0.93	6.9
5	2	14	6.6	3.1	4	57	1550	470						0.95	N.R.
6	2	16	7.3	2.6	20	83	1660	590						0.97	N.R.
Adj Avg:		14	6.5	3.0	12	66	1498	432						0.92	6.9

Cropping Sequence	INTERPRETATION						SECONDARY & MICRONUTRIENT INTERPRETATIONS					
	VL	L	OPT	H	VH	EH	Ca	Mg	B	Mn	Zn	SAI
CORN, GRAIN	PPPPPPPPPPPPPP						H	OPT				
SOYBEAN	KKKKKK						H	OPT				
ALFALFA	PPPPPPPPPPPPPP						H	OPT				
CORN, GRAIN	PPPPPPPPPPPPPP						H	OPT				

Phosphorus-P Potassium-K VL- Very Low, L- Low, OPT- Optimum, H- High, VH- Very High, EH- Excessive

Cropping Sequence	Yield Goal	Nutrient Needs			Fertilizer Credits			Nutrients to Apply		
		N	P2O5	K2O	Leg. N	Man. N	P2O5	K2O	N	P2O5
		-----lbs/A-----			-----lbs/A-----			-----lbs/A-----		
CORN, GRAIN	200.0	160	95	95				160	95	95
SOYBEAN	50.0		20	80					20	80
ALFALFA	6.0		105	340	40				105	340
CORN, GRAIN	200.0	160	95	95	120			40	95	95

Lime required for this rotation to reach pH 6.8 is 4.0 T/A of 60-69 lime or 3.0 T/A 80-89 lime.

----- SECONDARY & MICRONUTRIENT RECOMMENDATIONS -----

% BASE SATURATION: CA: 65.2 MG: 31.3 K: 1.5 %ACID SATURATION: 2.1
 N.R. Not required for calculation of lime requirement when the soil pH is 6.6 or higher.
 If corn is harvested for silage instead of grain, apply an additional 30 lb P2O5/A and 90 lb K2O/A to the subsequent crop.
 Some parts of this field are more acid and may require additional lime.
 If lime has been applied in the last two years, more lime may not be needed due to incomplete reaction.
 RX 1234: (H) Response to added Ca is unlikely.
 VR 1234: (OPT) Soil Mg is optimum. Maintain level with dolomitic lime.
 Soil name for this field was not specified. More specific recommendations are possible if the soil name is provided.

Effect of Ca:Mg on plant Ca:Mg, base saturation, and alfalfa yield (adapted from Simson et al., 1979)

----- Ca:Mg -----		-- Base Saturation (%) --		Yield (t/a)
Soil	Plant	Ca	Mg	
2.3	2.2	34	35	3.3
4.8	2.9	49	17	3.4
8.4	3.3	62	12	3.2

Relationship between selected soil test parameters and various experimental measures at Marshfield, 1993

Soil test parameter	Alfalfa yield	Alfalfa stand	Weeds	Alfalfa quality			Earthworms
				CP	ADF	NDF	
pH	**	NS	NS	*	NS	NS	NS
OM	**(-)	**(-)	*	*(-)	NS	NS	*
Exch Ca	NS	NS	NS	NS	NS	NS	NS
Exch Mg	NS	NS	NS	NS	NS	NS	NS
Exch K	**	**(-)	NS	NS	NS	NS	NS
Exch Ca+Mg+K	NS	NS	NS	NS	NS	NS	NS
Ca:Mg	NS	NS	NS	NS	NS	NS	NS



Gypsum as a soil amendment

- Ca is the dominant cation in Wisconsin soils
- Ca promotes colloid flocculation
- i.e. potentially improves structure and enhances related properties
 - Aggregate stability and aeration
 - Infiltration and water holding
 - Tilth
- Well known as an amendment to address high Na in sodic soils

Na^+

Zn^{2+}

Cation Exchange Capacity

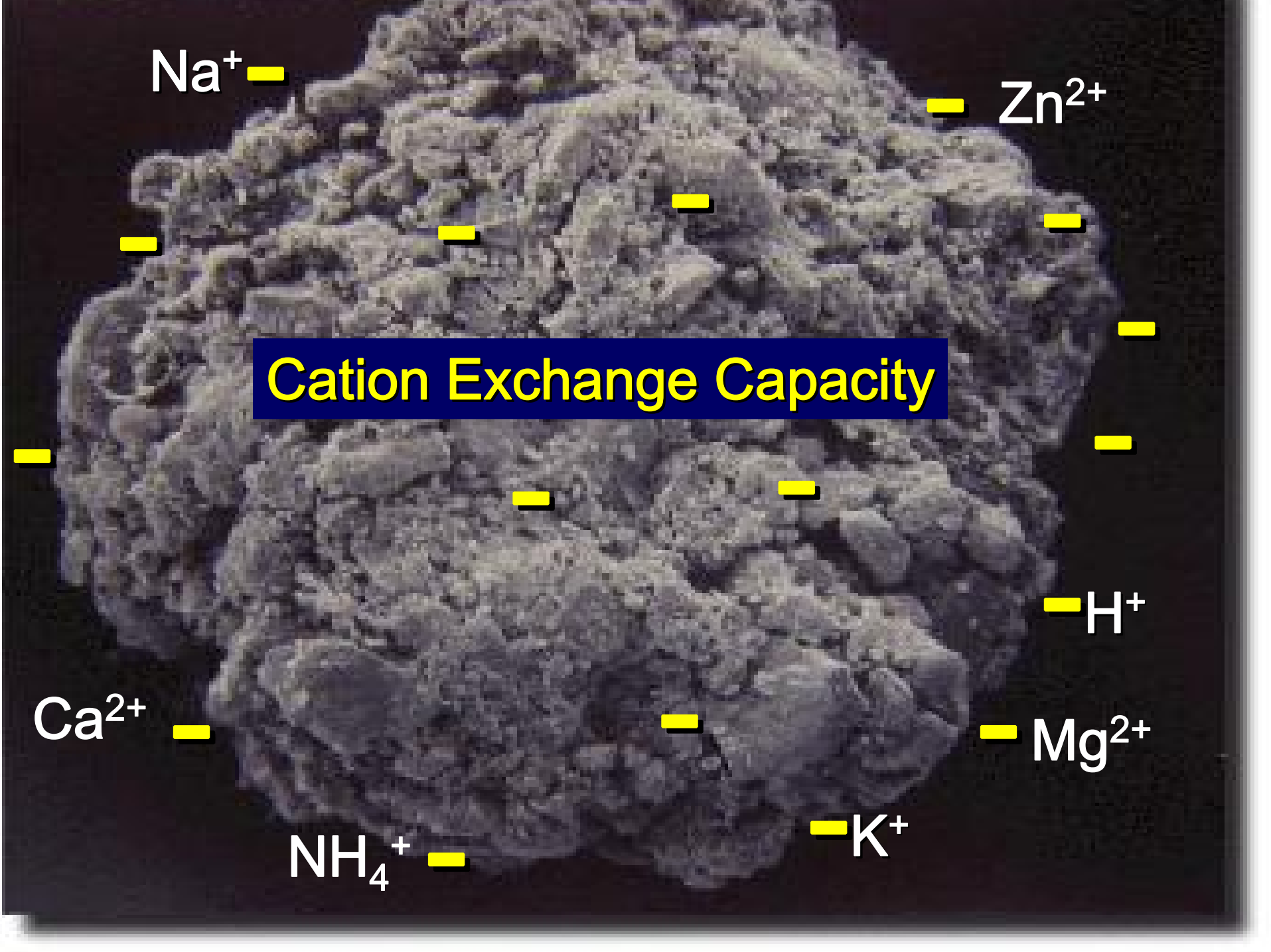
Ca^{2+}

H^+

Mg^{2+}

NH_4^+

K^+



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





By-product sources of gypsum

- Phosphate fertilizer production
- FGD (Flue Gas Desulfurization)
- Scrap wallboard
- Issues include:
 - Metal or radioactivity contamination
 - FGD Sulfite content
 - Storage, handling, transportation



Arlington FGD study (preliminary results)

- Part of a larger project
- Compare FGD vs. mined product
- Applied and seeded alfalfa in 2009
- Measure
 - Yield, stand, soil test, tissue content
 - Soil physical properties
 - Hg movement in soil

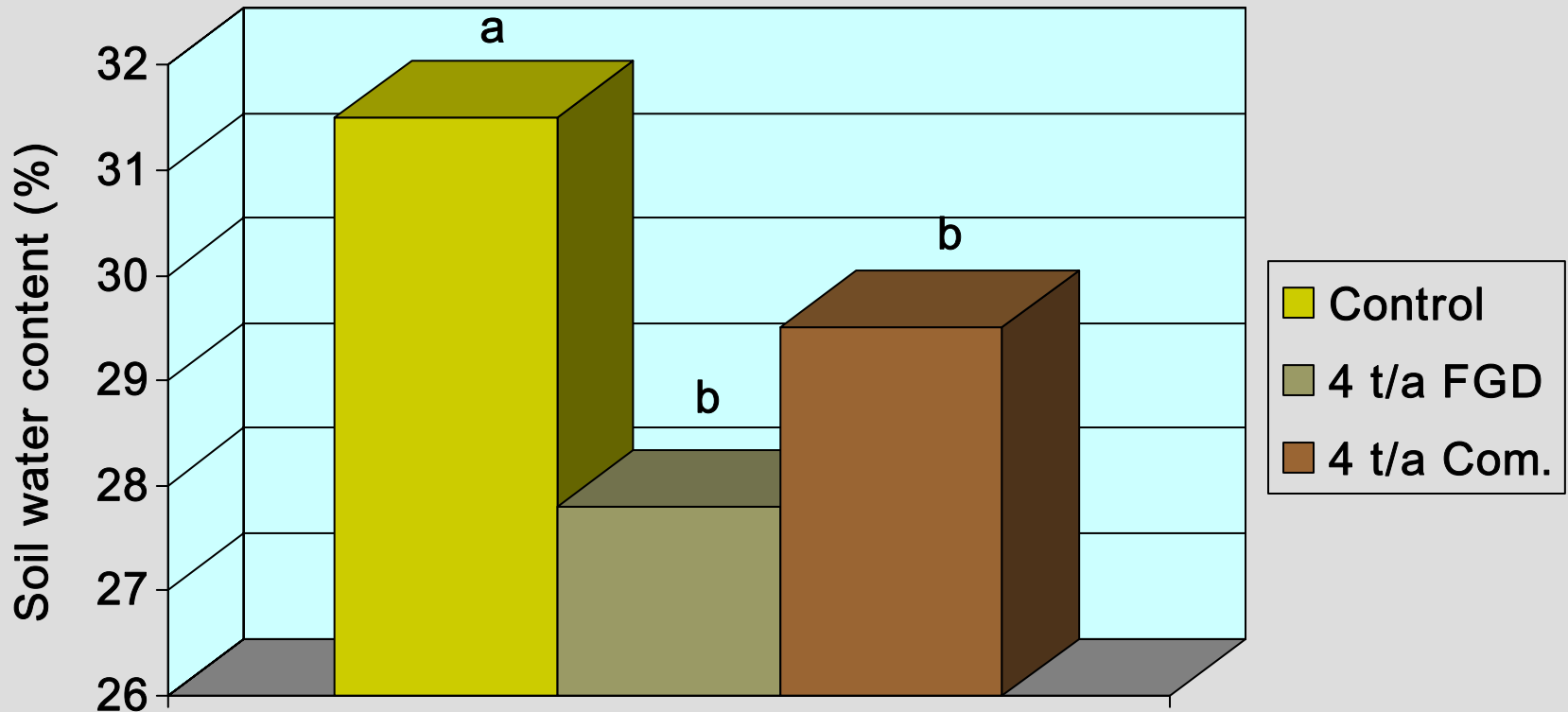
Arlington FGD study



Effect of FGD gypsum on alfalfa yield, stand, and soil test (Arlington, WI 2009)

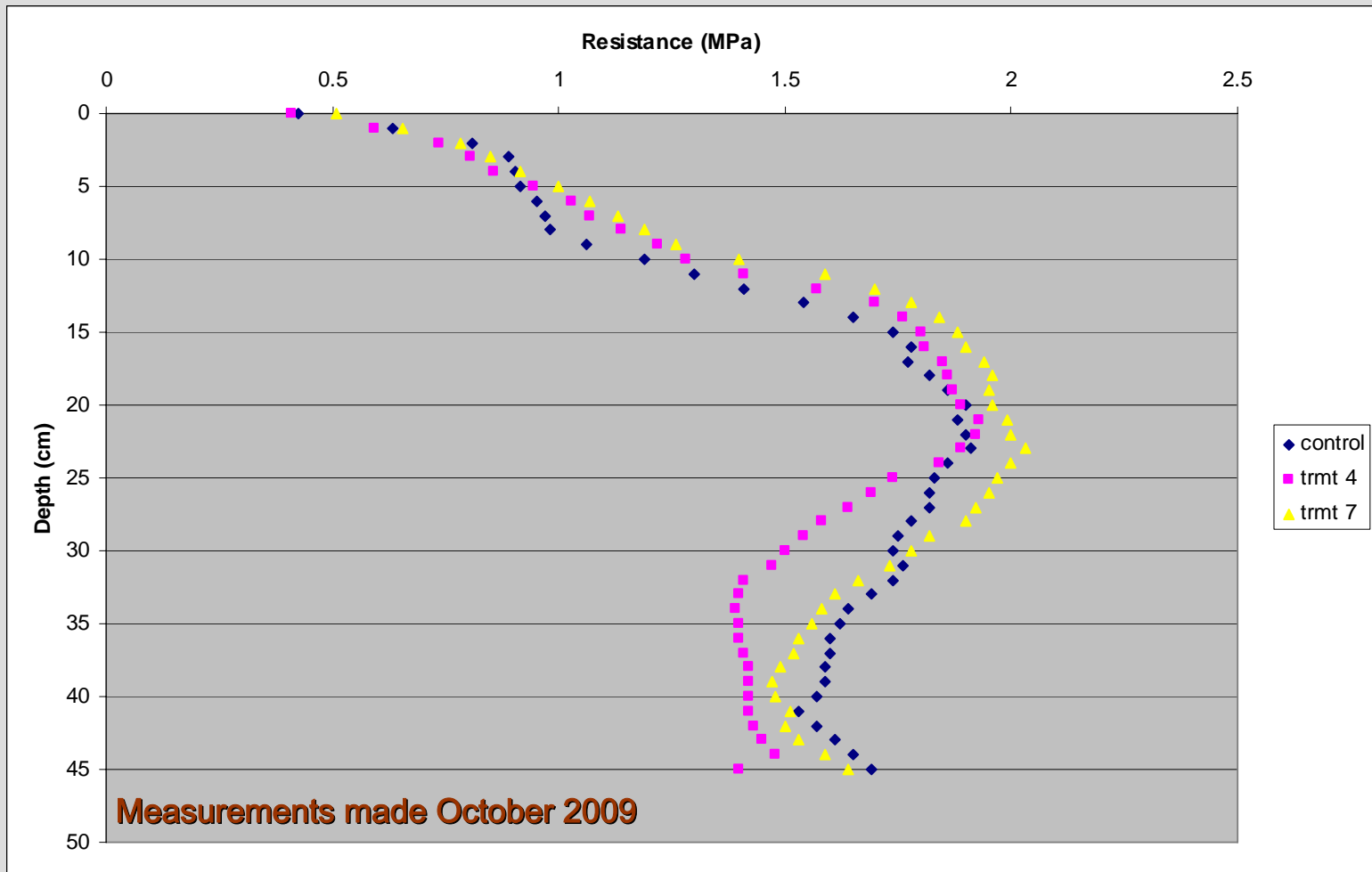
Treatment	Yield	Stand	Soil test Ca	Soil test Mg
t/a	t/a	plts/sq ft	----- ppm -----	
0	0.88	7.6	1848	556
1 FGD	0.83	6.4	2061	561
2 FGD	0.85	8.1	2006	456
4 FGD	0.83	7.8	2345	542
1 GYP	0.73	8.9	1958	573
2 GYP	0.76	7.1	1906	480
4 GYP	0.70	7.9	2215	535
Source	0.14	0.28	0.24	0.82
Rate	0.87	0.93	0.02	0.15

Effect of gypsum application on the soil water content of a Plano silt loam



Measurements made October 2009, 0 – 2 "

Effect of gypsum application on the penetrometer resistance of a Plano silt loam

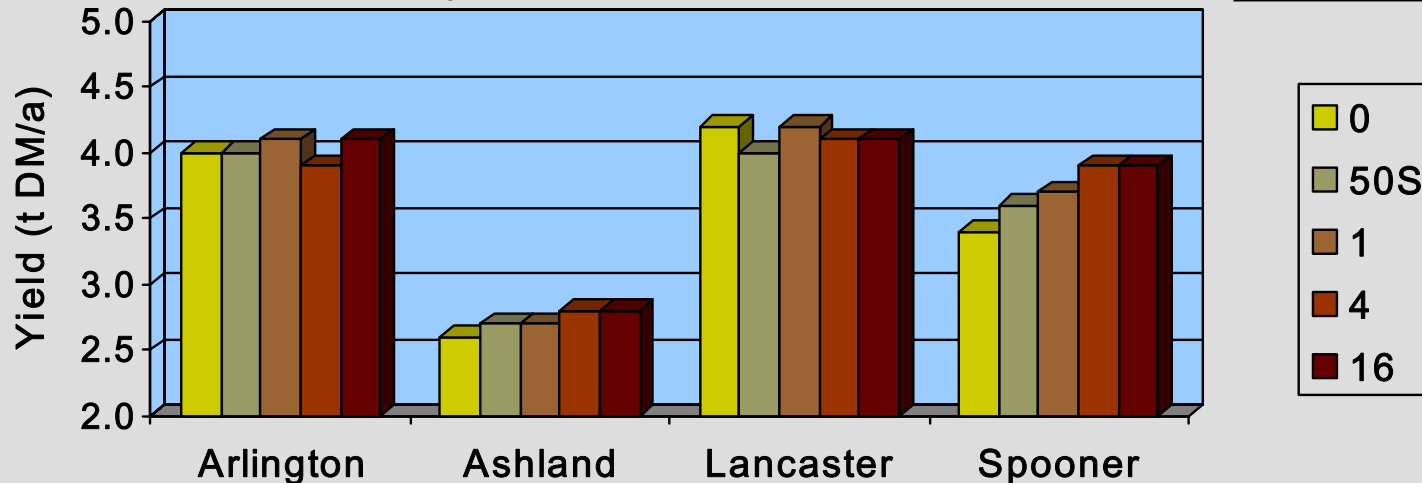


Crushed wallboard

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



Alfalfa yield at four locations, 1996

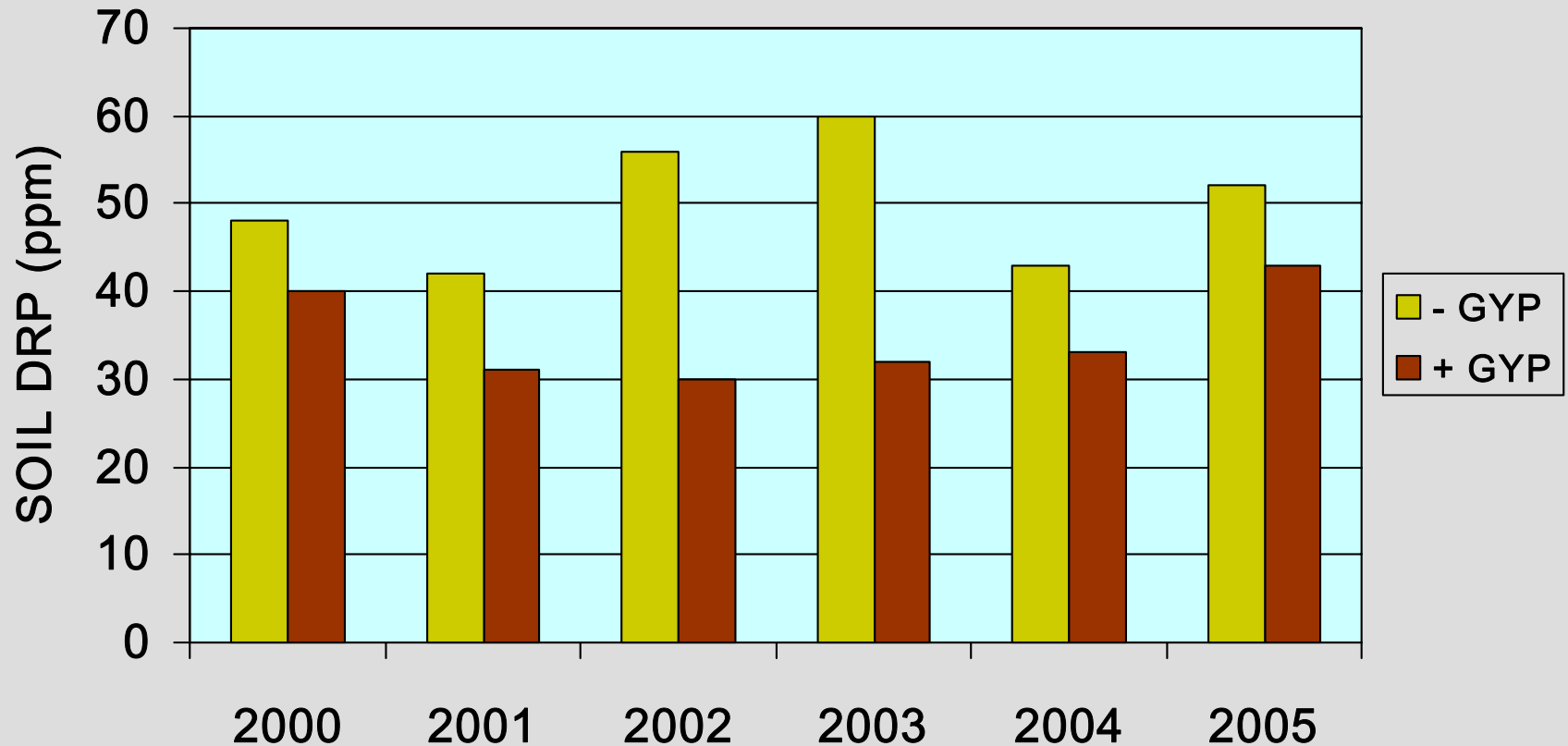


Gypsum application and P runoff

- Suggested remedial application of gypsum
- Potential two-fold impact
 - Improved aggregation and infiltration
 - Ca precipitation of dissolved reactive phosphate (DRP)
- DRP is small fraction of soil P
- Still must maintain farm conservation framework
- Minimal evaluation on Wisconsin soils



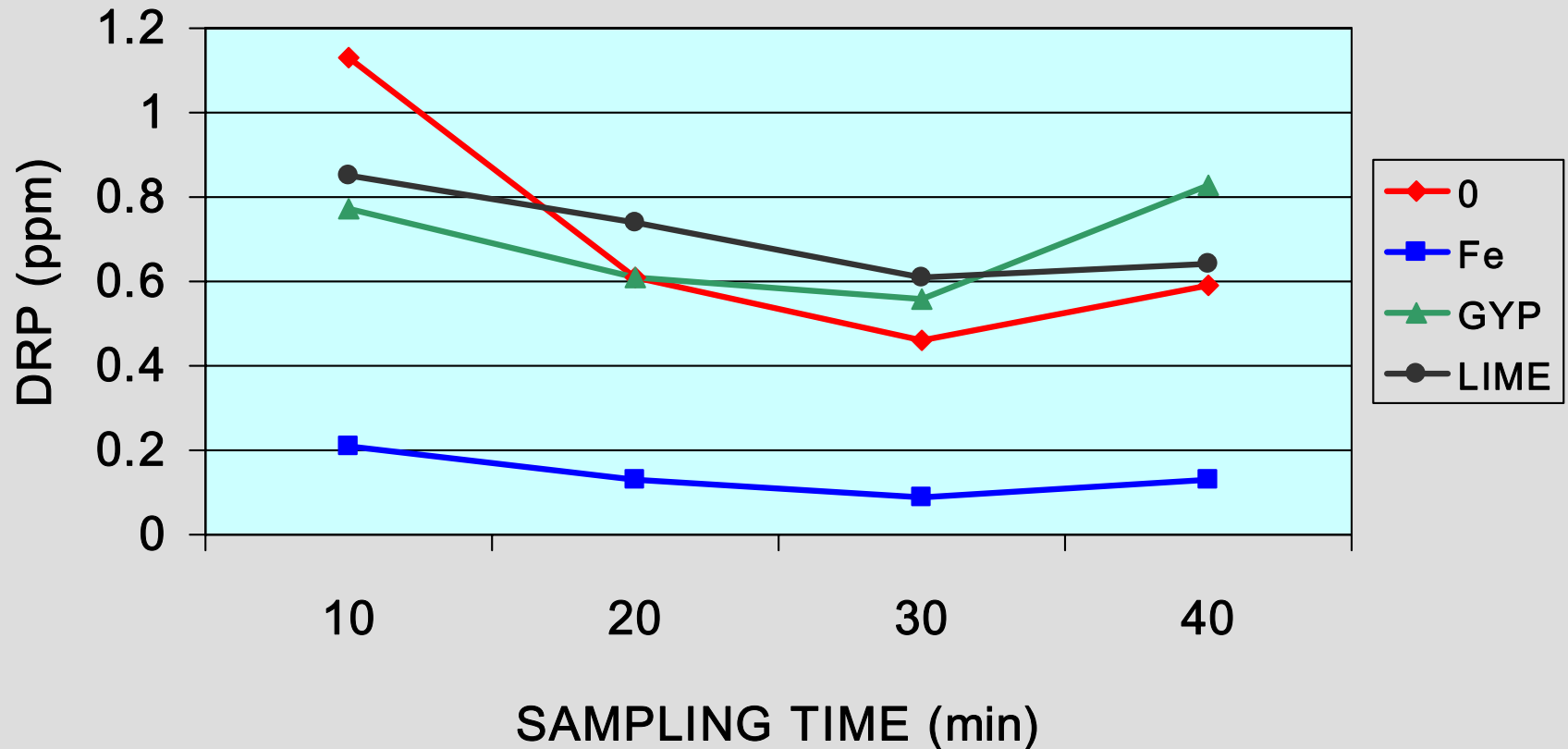
Effect of gypsum application on the soil DRP concentration (Brauer et al., 2005)



~ 2 t gypsum applied annually 1999 - 2001

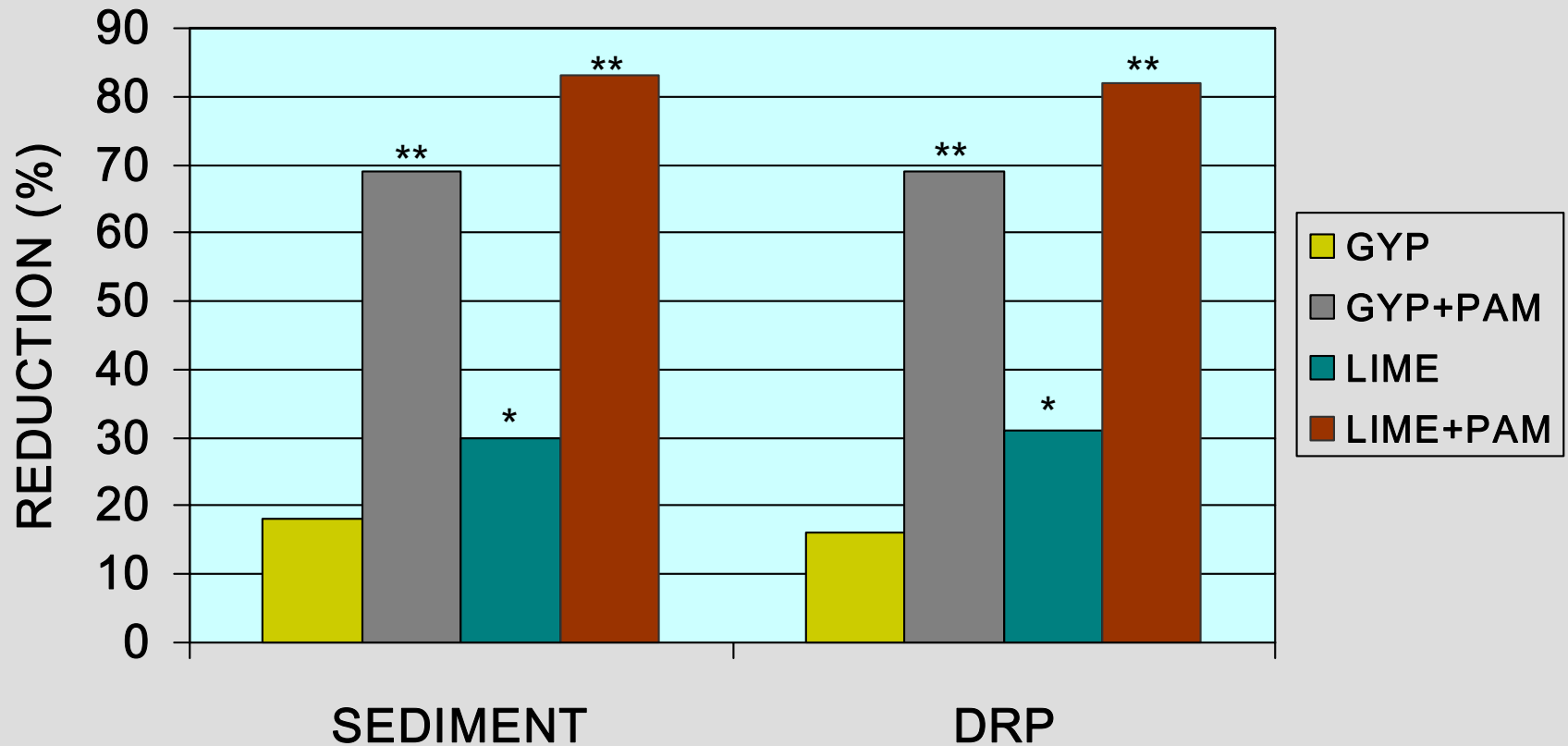
Effect of amendment on the P runoff concentration

(Torbert et al., 2005)



6 t composted manure/a applied to Bermuda grass

Effect of gypsum and lime application reduction of sediment and P in runoff (Lepore et al., 2009)



Plano silt loam



Summary

- Gypsum is an excellent source of Ca and S
- Various by-product material are acceptable
- There continues to be no support for the management of Ca:Mg
- Relatively large applications of gypsum can change soil properties
- There is some evidence that gypsum or other Ca sources can influence P loss
- More research is needed before a recommendation can be given