FGD Gypsum Influences on Soil Surface Sealing, Crusting, Infiltration and Runoff

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October 23-24, 2007 Atlanta, GA

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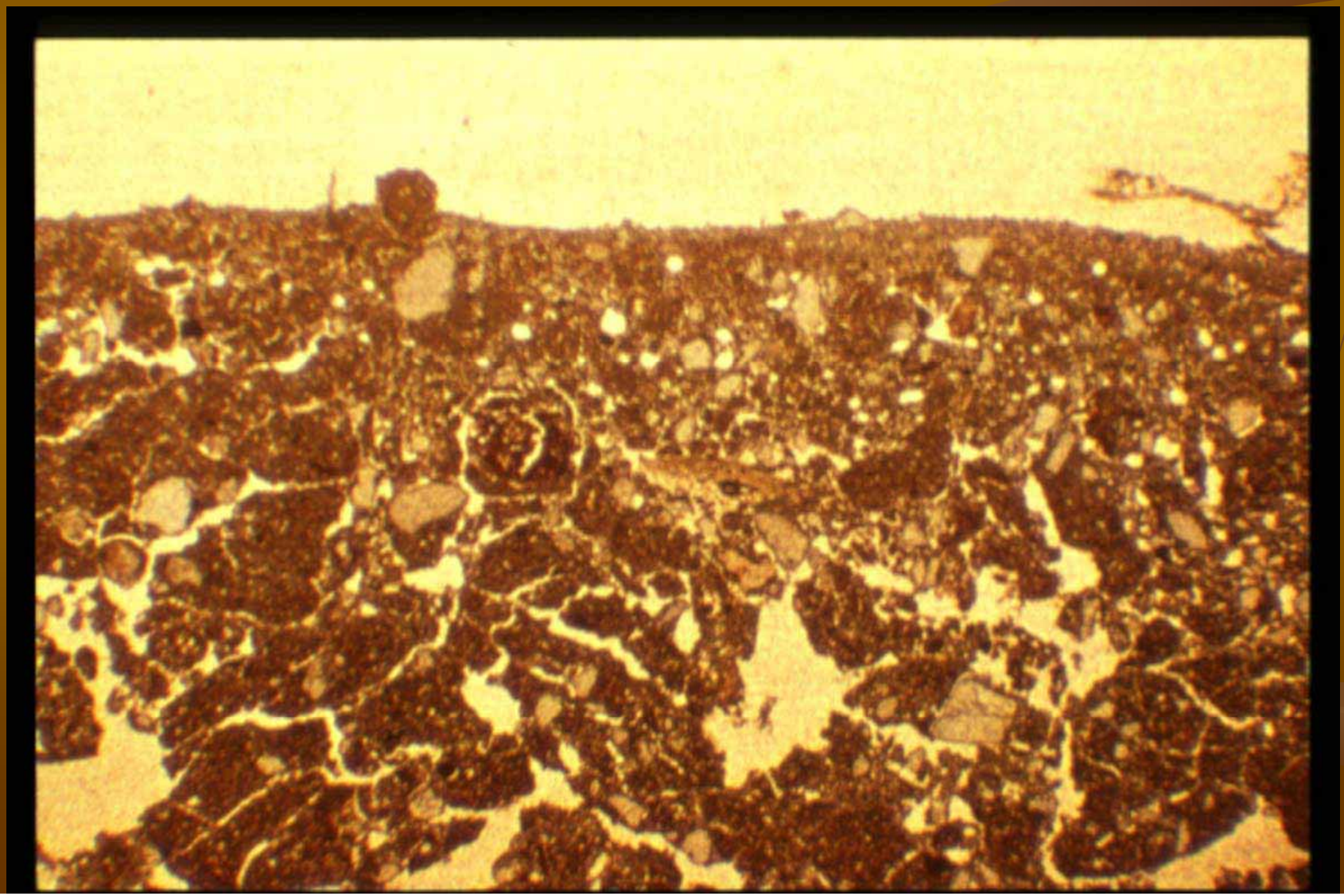
Rainwater is Natural Distilled and Low in Electrolytes

Both Physical and Chemical Processes Occur at the Time Scale of Raindrop Impact

This Leads to Surface Sealing

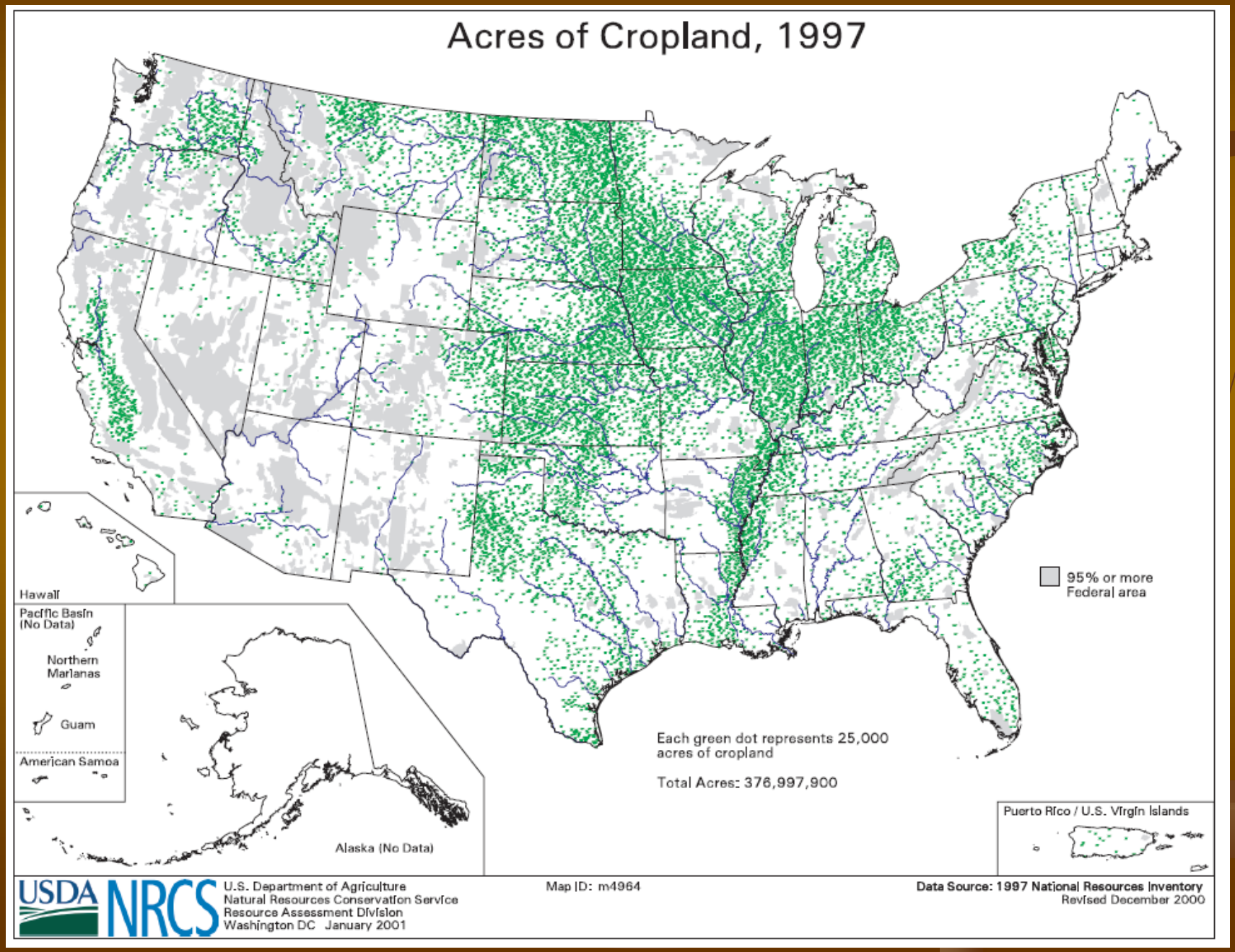


Runoff Causing Soil Erosion and Removal of Chemicals

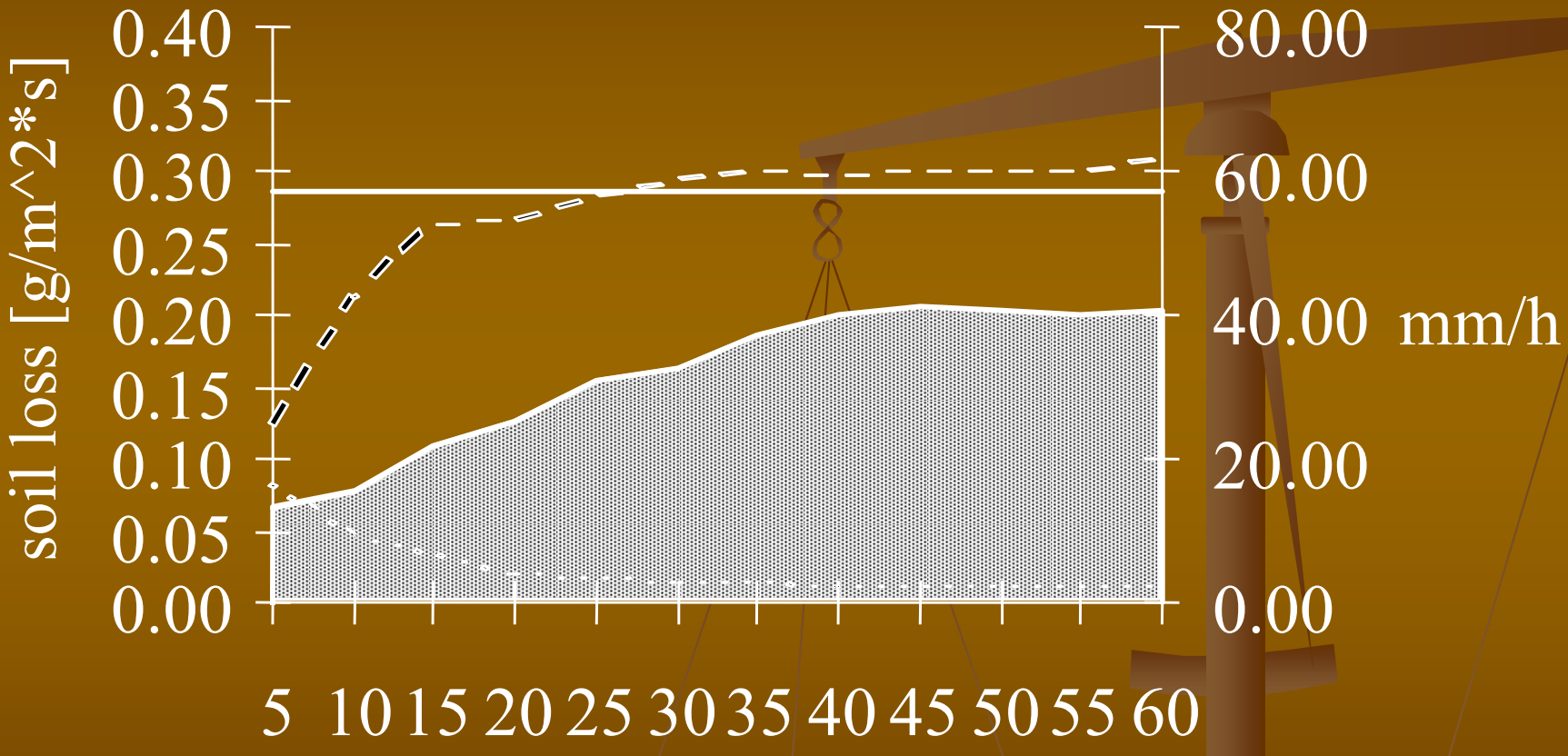
Effect of Degradation by Erosion on Crop Productivity

Offsite Water Quality Problems

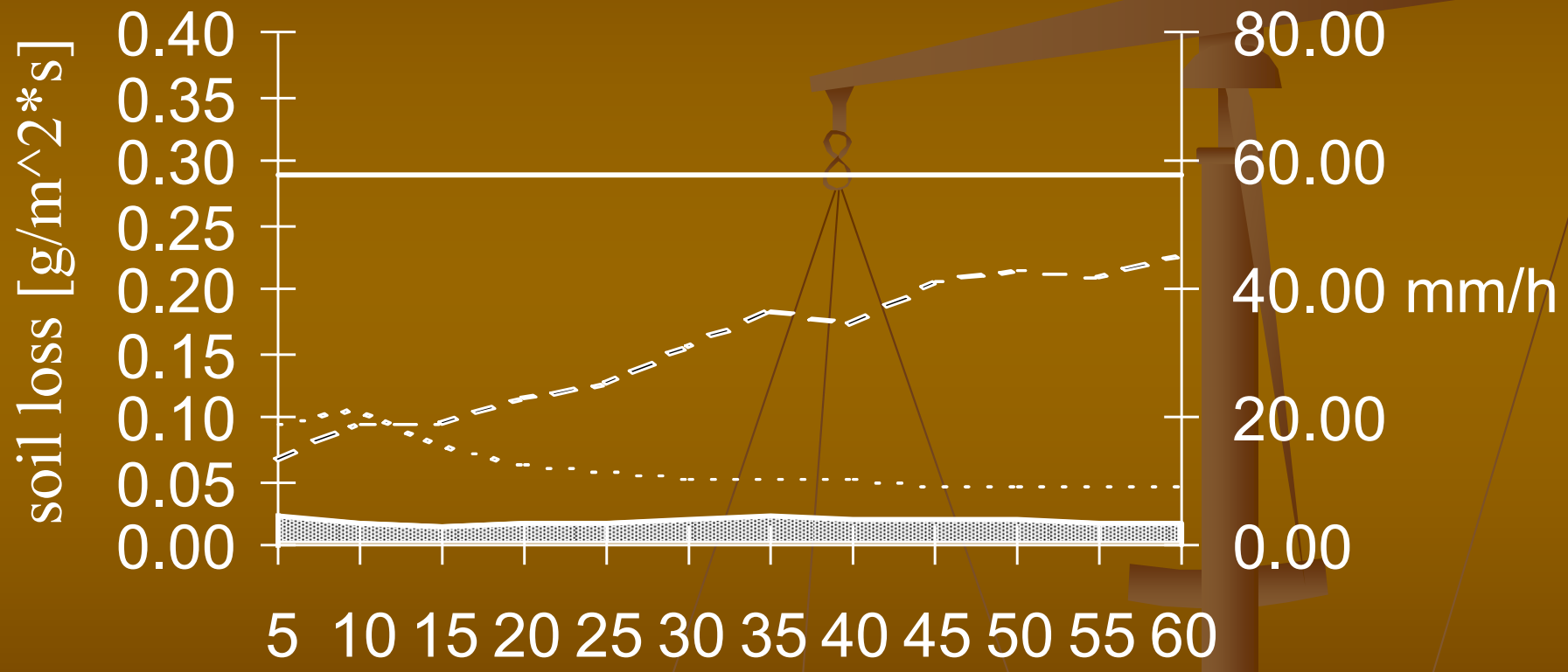
Over 300 million acres 2002



DeWitt, Iowa Site
Fayette silty clay loam



Fayette PAM+FBCBA Treatment



Historical Uses of Gypsum

- Used for over 2000 years by Chinese to coagulate soy milk to make Tofu
- Egyptians used in cement 9000 years ago.
- Greeks and Romans used with volcanic pozzolans to make concrete
- Europeans used gypsum for fertilizer values in 18th Century and brought its use to the USA
- Jefferson and Franklin were among the promoters
- Gypsum use in agriculture in the USA has largely been forgotten except in specialty crops.

Plentiful Low Cost Clean Gypsum from Pollution Control

Synthetic Gypsum as Soil Amendment

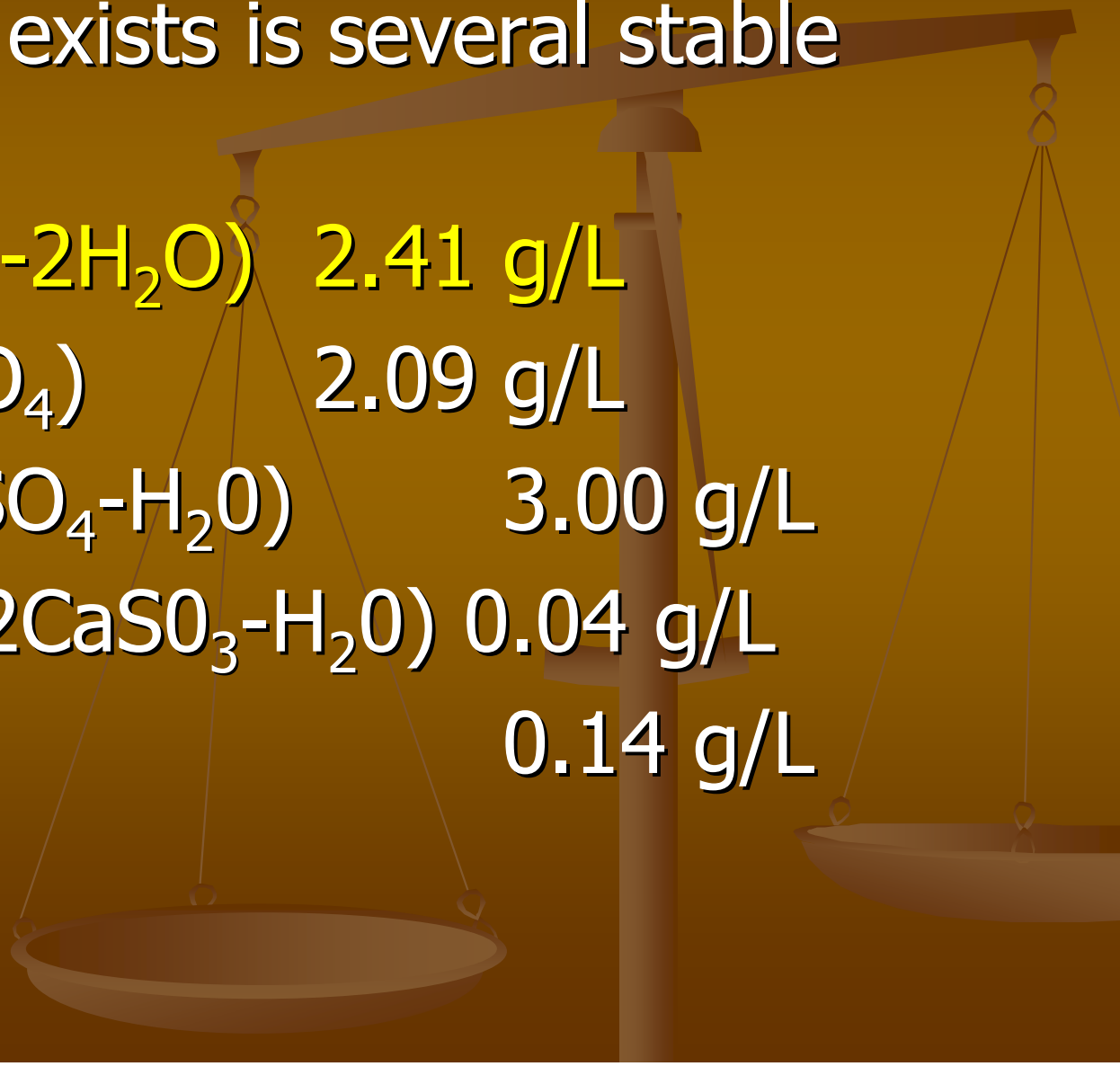
FGD Gypsum Use in USA Source ACAA, 2004

- Wallboard 8,148,078
- Concrete 291,439
- Cement 449,063
- Agriculture 131,058
- Increased use is Agriculture tied to Hg removal

Wallboard Quality FGD Gypsum for Agriculture

Soluble Electrolyte Sources

- Calcium Sulfate exists is several stable mineral forms
- Gypsum ($CaSO_4$-$2H_2O$) 2.41 g/L
- Anhydrite ($CaSO_4$) 2.09 g/L
- Bassanite ($2CaSO_4$-H_20) 3.00 g/L
- Hannebachite ($2CaSO_3$-H_20) 0.04 g/L
- Calcite ($CaCO_3$) 0.14 g/L



Replacement of Na

- Ca from FGD gypsum can be used to reclaim soils that are high in exchangeable Na
- Even small amounts of sodium can have dispersive effects of severe surface sealing when wet and hard crusts formation when dry
- Subsoils with high Na contents have massive to columnar structure and severely limit downward water movement and rooting

Close-up of soil surface showing typical conditions associated with high sodium contents.

Soil: Bonn (fine-silty, mixed, superactive, thermic Glossic Natraqualfs)

Resolution-Enhanced Landsat Image (August 1999)

(Shown in False Natural Color (bands 5,4,3))

- A similarly enhanced Landsat image from August 1999 having 1-meter resolution and six Landsat bands.
- In this summer scene the different crops are very distinct.
- The sodic soils are clearly visible, and their extent is more distinct due to the lack of crop growth in the sodic areas.
- Because the sodic soils are distinct, it is likely they can be classified using image processing techniques.

Selected physical and chemical properties of the Bonn soil from Carroll Co., MS.

Soil property	Average of three sites
Exchangeable Ca, cmoles^{+} kg^{-1}	3.4
Exchangeable Mg	1.6
Exchangeable K	0.2
Exchangeable Na	3.5
Exchangeable Na, ppm soil	805
Exchangeable sodium percentage, %	40.1
pH	7.7
Aggregation index	23.2
Sand, %	5.6
Silt	83.4
Clay	11.0
Water dispersible clay	8.5
Sodium adsorption ratio	47.9

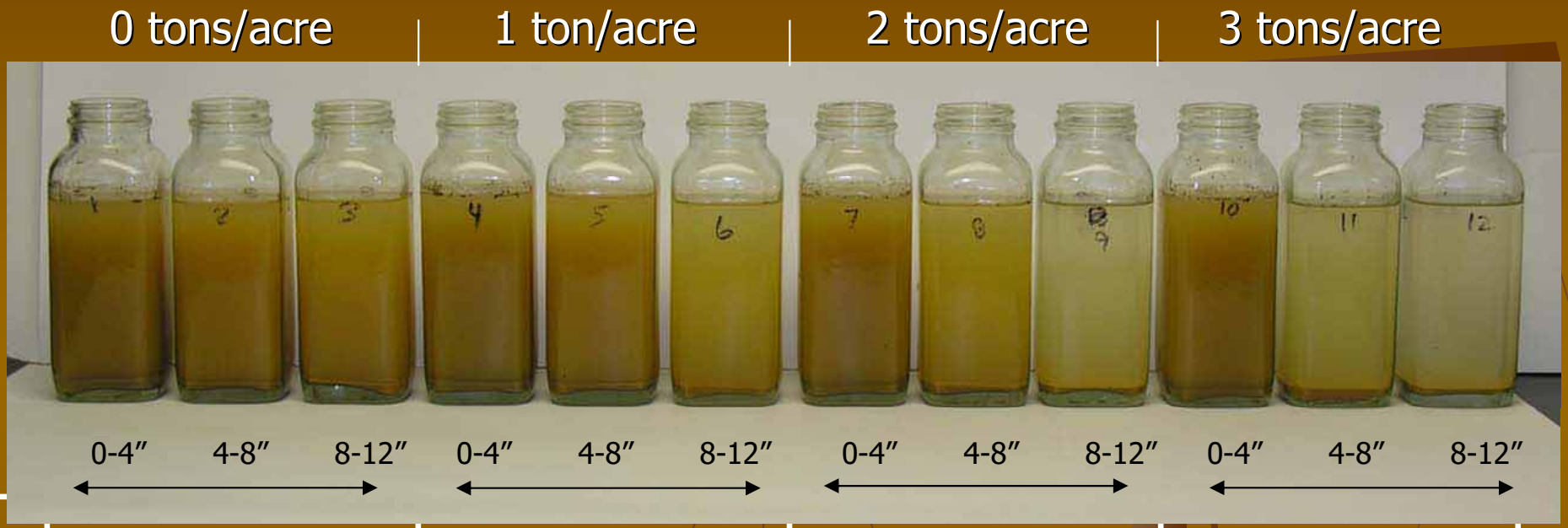
Influence of FGD gypsum (Southern Company), applied at different rates, on the dispersion and flocculation of the Bonn soil.

0	3.36	6.72	13.44
Mg ha^{-1}	Mg ha^{-1}	Mg ha^{-1}	Mg ha^{-1}

The effects of gypsum amounts on soil erosion parameters of the Bonn soil.

Gypsum added	Infiltration	Runoff	Soil Loss
Mg ha^{-1}	mm	mm	Mg ha^{-1}
0	7	50	20.9
3.36	13	44	12.0
6.72	21	36	8.2
13.44	24	32	5.4

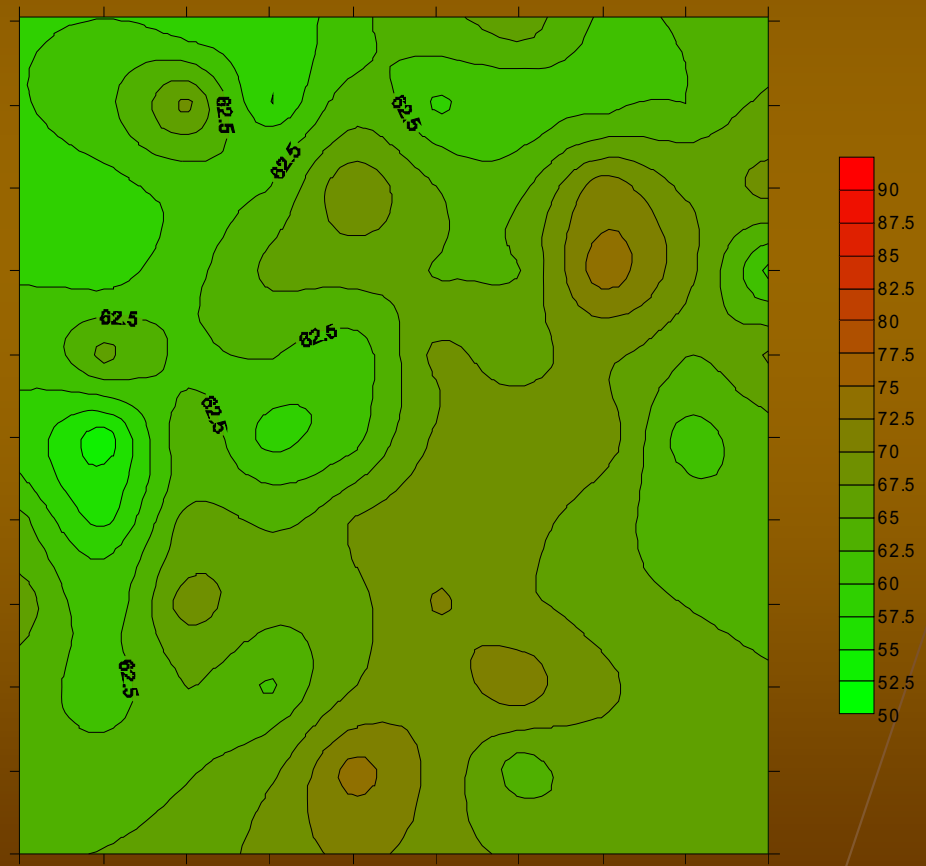
Changes in properties that determine flocculation/soil aggregation using FGD gypsum on no-till cotton, at four application rates and three sampling depths, after one growing season.



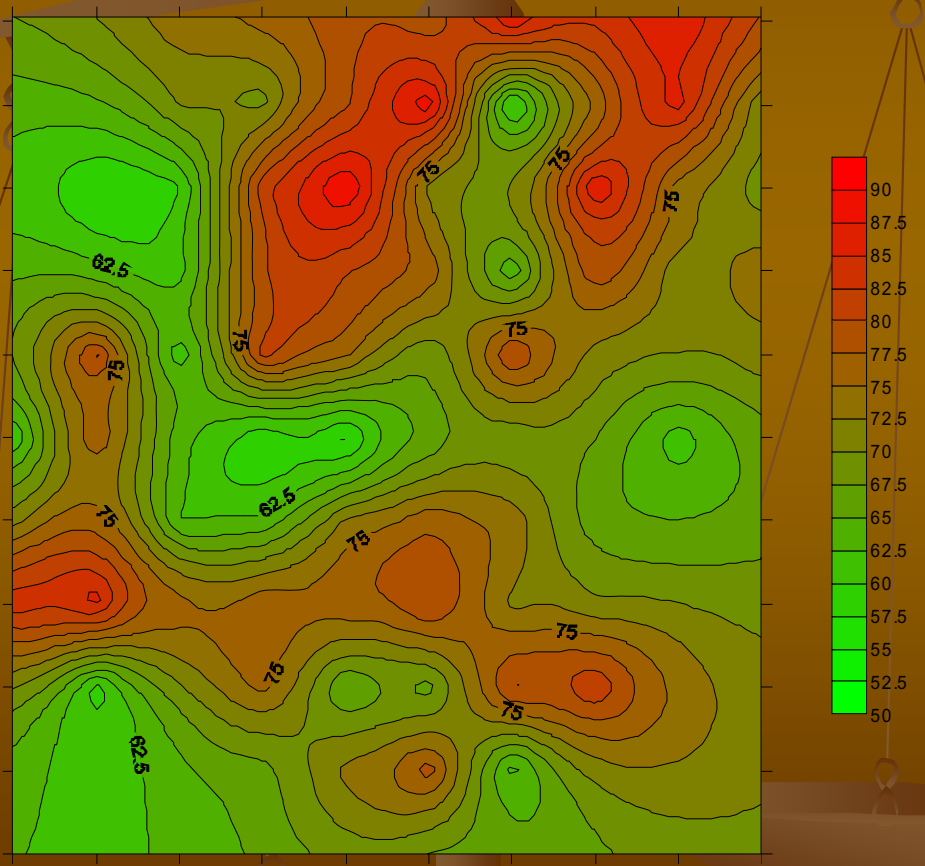
Soil property												
Extr. Ca	8.5	2.6	1.6	5.1	1.9	1.2	7.8	3.4	1.6	7.4	3.4	2.1
Extr. Mg	0.9	1.3	2.1	1.0	1.3	2.1	1.0	1.6	2.3	0.7	1.6	2.7
pH	6.6	4.8	4.7	5.3	4.5	4.6	6.0	4.6	4.6	5.6	4.5	4.4
Clay, %	16.8	24.0	25.4	17.9	23.7	26.6	19.3	24.4	25.0	18.6	25.3	26.4
Total C	11.8	4.2	2.4	11.8	4.8	2.1	11.5	5.2	2.3	14.0	5.3	2.1

The distribution of surface soil aggregation in a no-till cotton field before and after equilibrating samples with FGD gypsum at a rate of 6.72 Mg ha^{-1}.

Aggregation index before equilibration



Aggregation index after equilibration

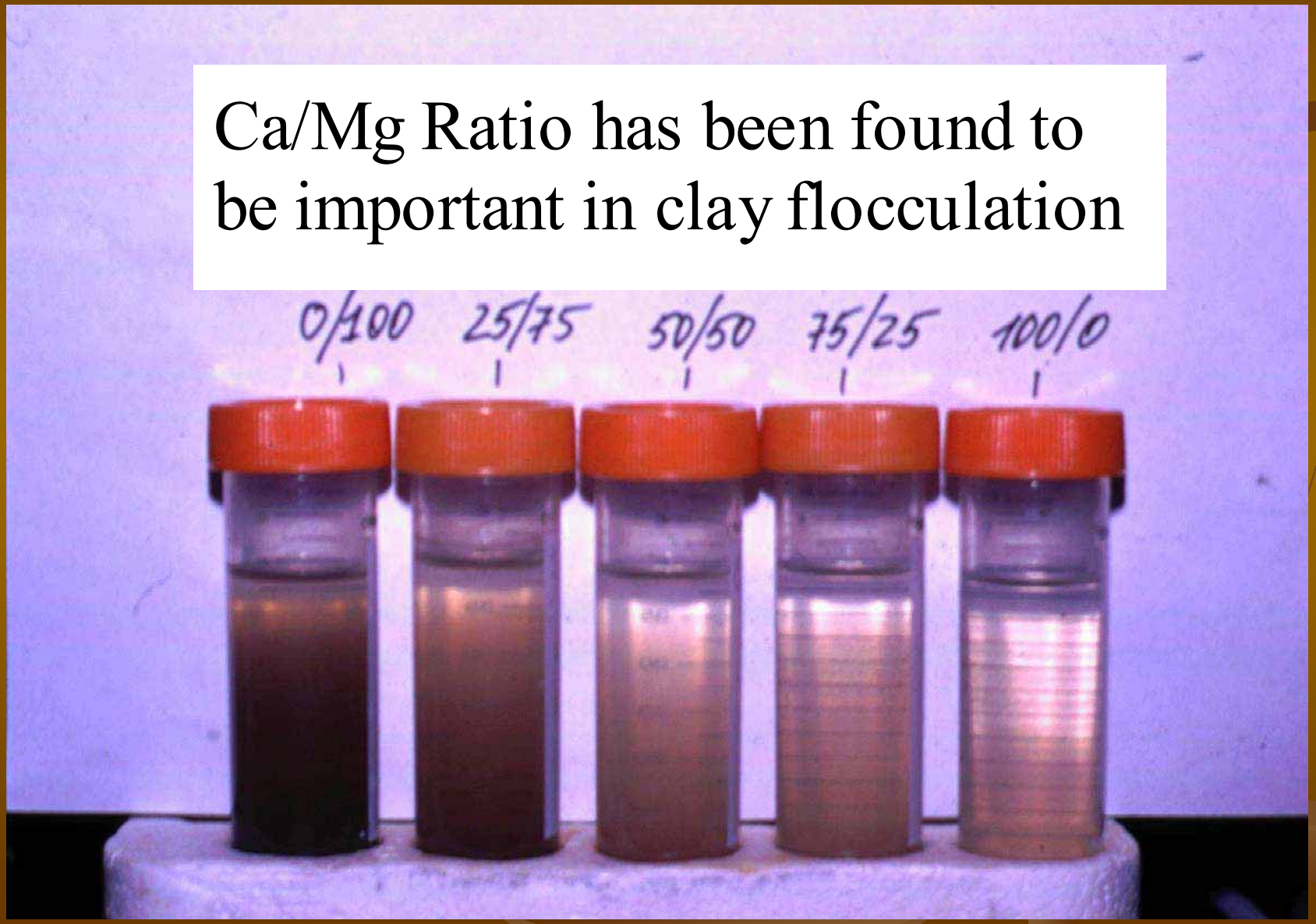


Replacement of Mg

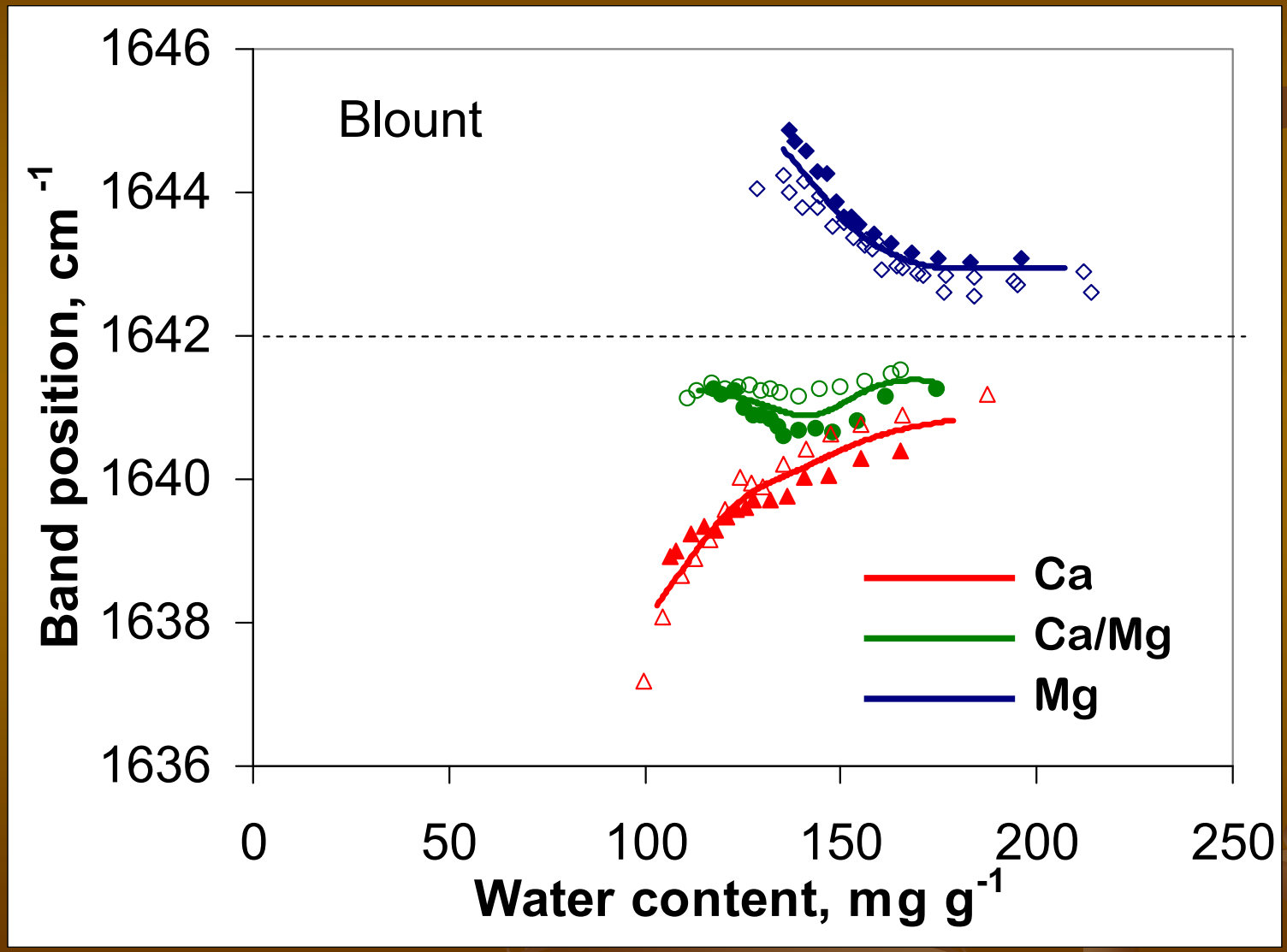
- Similar to Na, Mg has a dispersive effect on soil clays in low electrolyte water compared to Ca.
- Natric Horizon has more exchangeable magnesium plus sodium than calcium plus exchange acidity
- Mg saturated soil was found to have an order of magnitude lesser saturated hydraulic conductivity in a controlled laboratory experiment for the same soil than Ca

Ca Effect on Flocculation

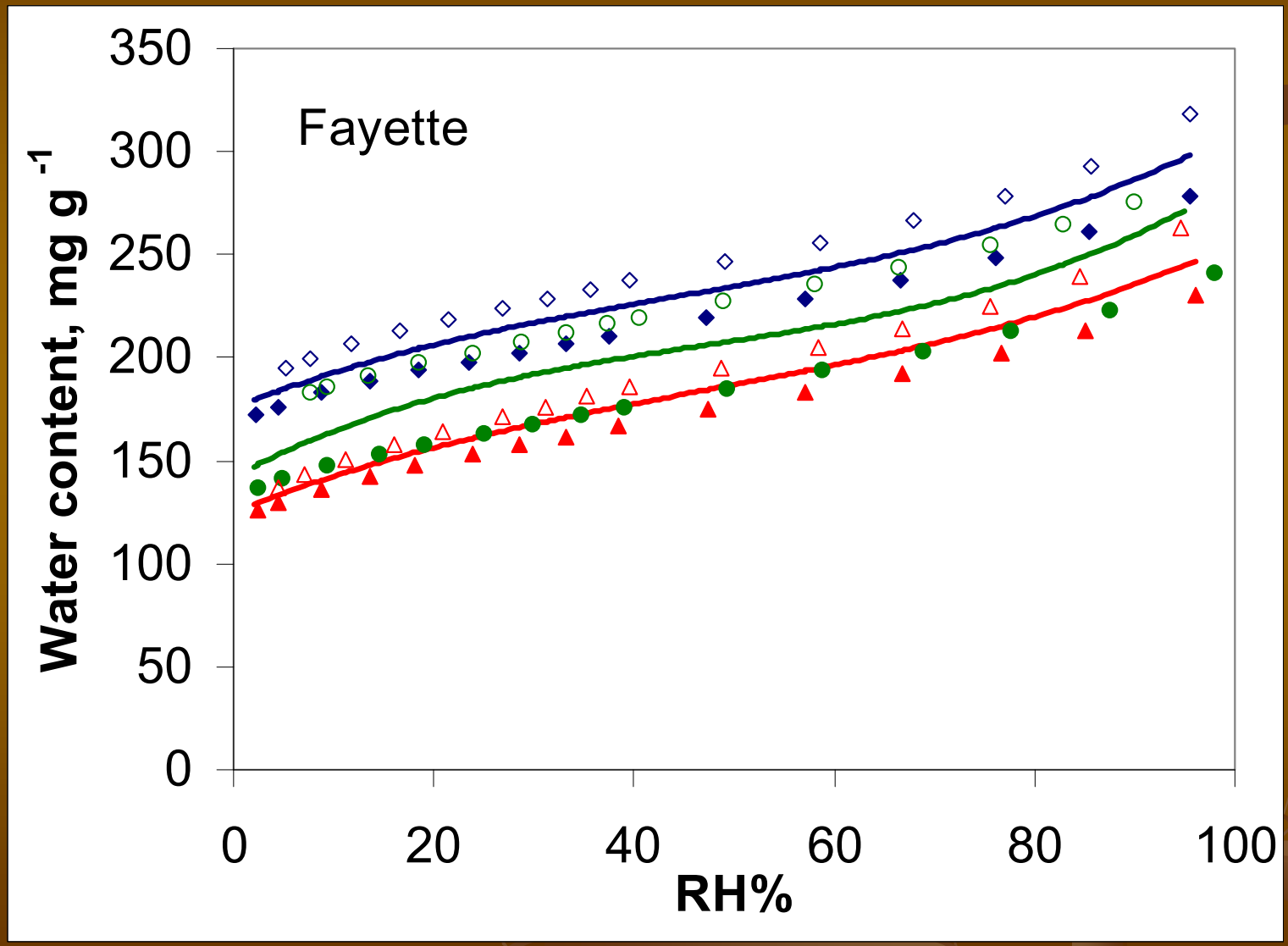
Ca/Mg Ratio has been found to be important in clay flocculation



Ion Effect on Bonding Energy-Illitic Soil



Ion Effect on Water Holding-Smectitic Soil



Soil Structural Differences (Control left Gypsum on right)

Gypsum and Liming

- Gypsum *per se* is not a liming material since it has little or no acid neutralizing capacity which defines Agricultural Lime
- It can remove the source of acidity and toxicity in acid soils
- Sulfate will complex the Al into a nontoxic species
- Greater depth of rooting in these soils and an increase in pH of the subsoil
- increased depth of rooting increases nitrogen use efficiency because roots can take up the NO_3

Biological Aspects in the Rooting Zone, Corn South Dakota

Gypsum Application on Left w/o on Right

Random Corn Ears Amended with Gypsum on Left and Control, Colorado

Vertisol with Severe Cracking (Control)

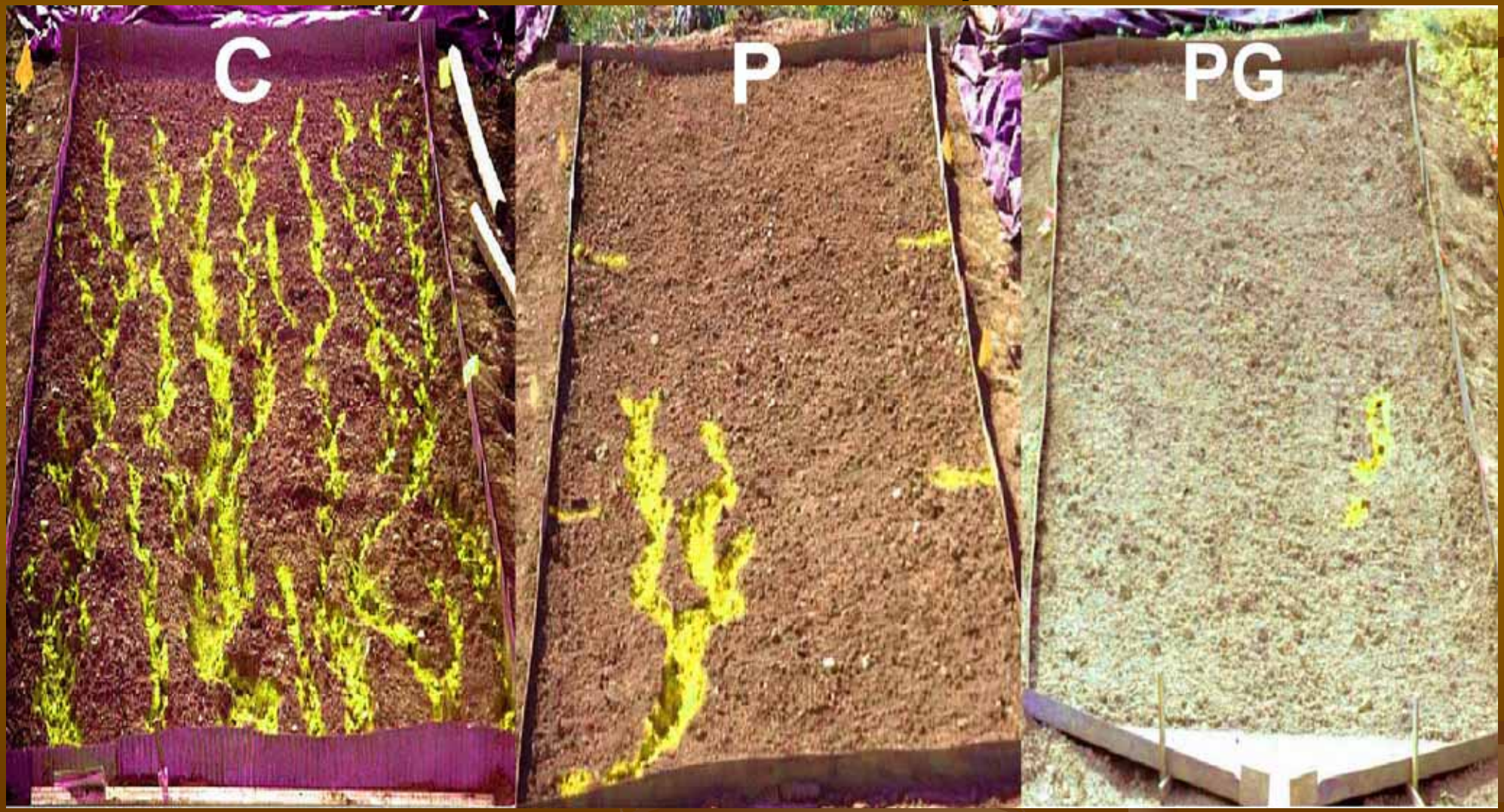
Vertisol Amended with Gypsum

Conventional No-tillage on Vertisol in Villadiego, MX

Modified No-till System to with Gypsum application, Villadiego, MX

Gypsum applied to the field on the bottom and control on the right.

Effect of Gypsum and PAM on Soil Erosion by Concentrated flow on Steep Road Construction Slopes



Water Stress Reduced with Gypsum and PAM

Aggregate Stabilization

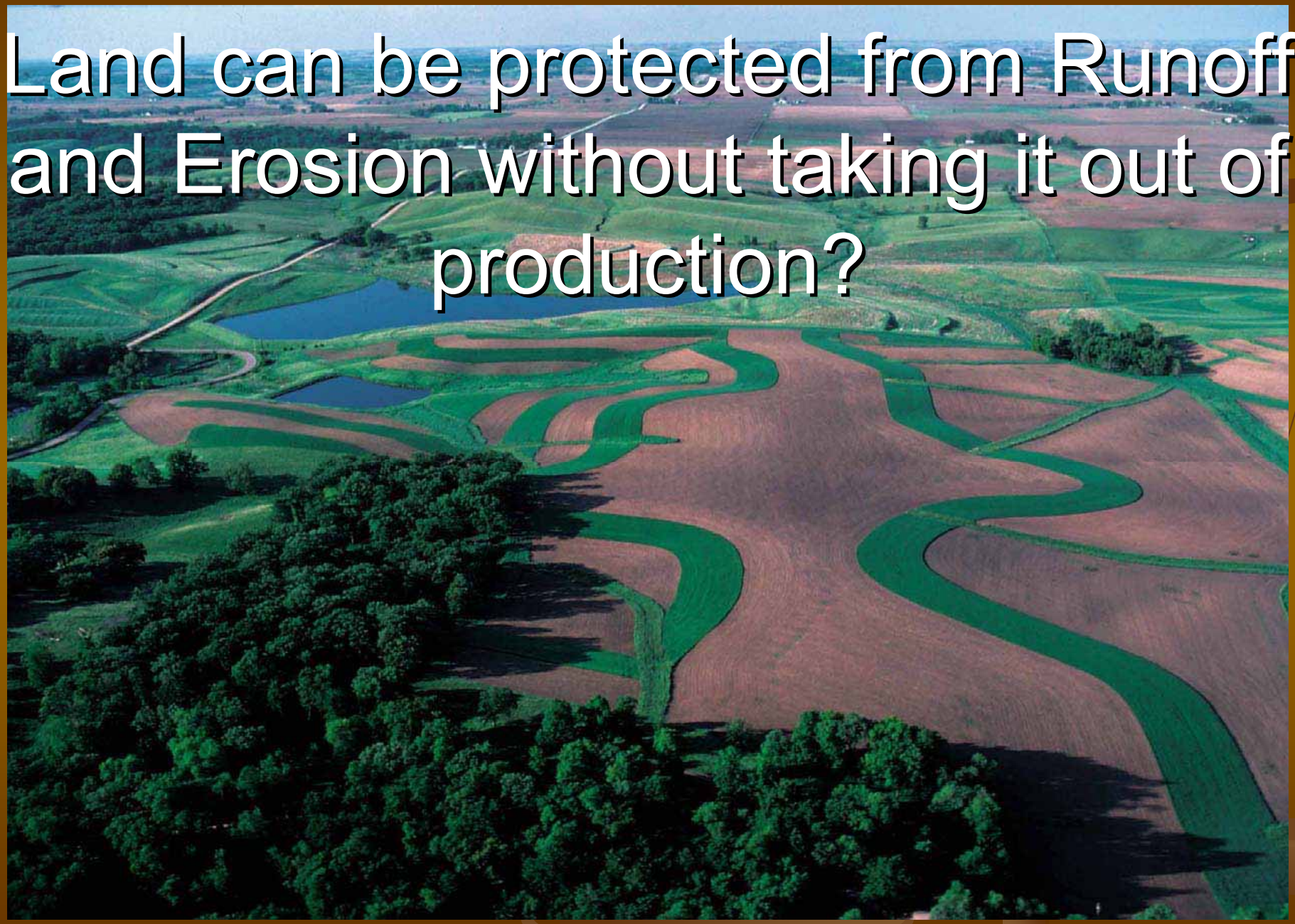
Nutrients Needed by Plants

- CHO PKNSCaFe Mg BMnCuZnMo.....

Conclusions

- FGD gypsum is an excellent electrolyte source to prevent surface sealing, improve infiltration and control erosion
- Soluble Ca from FGD can remove the detrimental effects of Na and Mg, decrease dispersion and improve soil structure.
- Improved soil structure leads to improved yields through a greater root volume and improved water use efficiency.
- Effectiveness can be improved by coapplication of FGD gypsum with other soil amendments such as PAM.

Land can be protected from Runoff and Erosion without taking it out of production?



Questions