ALABAMA COOPERATIVE Extension SYSTEM
Alabama A&M and Auburn Universities

AGRONOMY SERIES

TIMELY INFORMATION

Agriculture & Natural Resources

DEPARTMENT OF AGRONOMY & SOILS, AUBURN UNIVERSITY, AL 36849-5633

S-01-10 **March, 2010**

FGD Gypsum on Alabama Fields

Charles C. Mitchell
Extension Agronomist-Soils & Professor
Auburn University

Gypsum has been used as an agricultural soil amendment for over 250 years. It is a soluble source of calcium and sulfate-sulfur for crops and has been shown to improve soil physical and chemical properties. It has been used as a source of calcium for peanuts at pegging in Alabama at rates up to 1000 pounds per acre. It has been used in potting mixes for calcium and sulfur. Although it is not a liming material, it has been shown to reduce the toxic effects of soluble aluminum in acid subsoils. It has been used for years to reclaim sodic (high sodium) soils in the arid western U.S. where sodium tends to accumulate after years of irrigation. Several tons gypsum per acre is applied and then the land if flooded to leach out the excess sodium and replace it with calcium from the gypsum. This process improves soil aggregation and drainage and enables crops to be grown on the land.

Gypsum is calcium sulfate. Anhydrous gypsum ($CaSO_4$) is used as a drying agent because of its affinity for water. In nature, gypsum is found with water of hydration e.g., $CaSO_4 \cdot 2H_2O$. This form is found naturally in arid regions throughout the world and is the mined formed traditionally used as a soil amendment. The Great Sand Dunes National Park in Colorado and the White Sands National Monument in New Mexico are famous because of their gypsum sands which formed in an arid climate.

What is FGD gypsum?

FGD (flue gas desulfurization) gypsum is a manufactured product/by-product of the coal-fired combustion process. FGD gypsum is formed by scrubbers that remove sulfur dioxide (SO_2) from the flue gas stream when coal is burned to generate electricity. Several process are used but all involve exposing the hot flue gasses to crushed limestone ($CaCO_3$) or hydrated lime [$Ca(OH)_2$]. The lime is converted to gypsum, capturing the SO_2 so it does not become an atmospheric pollutant (Fig. 1). The FGD gypsum is sluiced away from the scrubber using water and stored in a settling pond where it can later be dewatered and used. Some can be immediately dewatered using filter presses, dried, and stored in stacks under sheds.

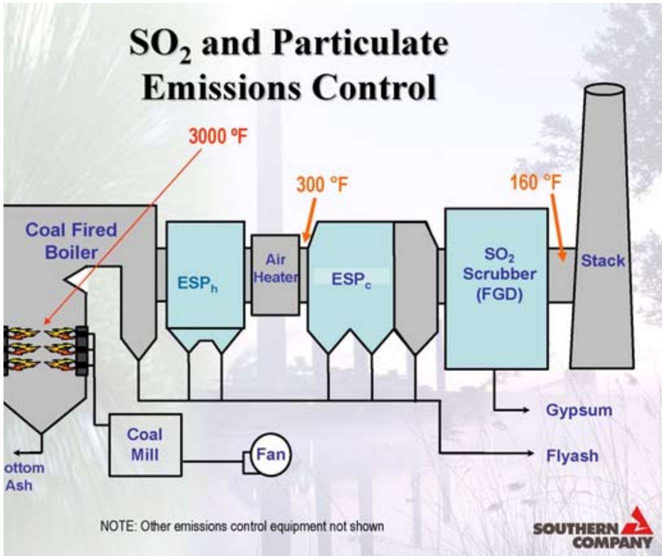

Fig. 1. The emission control process in a coal-fired Generator (Figure from the Southern Company).

How is FGD gypsum different from mined gypsum? Chemically FGD gypsum is the same material as mined gypsum. Because it does not contain natural impurities, it is usually much purer than mined gypsum. Table 1 shows an analysis of an Alabama source of FGD gypsum compared to a purchased source of pelletized agricultural gypsum sold in Alabama for crops. The analyses in Table 1 are based on a dry weight basis. Some sources of FGD gypsum could be wetter than others impacting spreading issues.

Are there any harmful properties in FGD gypsum? Most FGD gypsum has been used in the manufacture of dry wall/ gypsum board, plaster, and cement. In the midwestern U.S. where scrubbers have been used on coal-fired generating plants much longer than in the South, land application of FGD gypsum has been practiced for decades. Only recently has there been interest in land application in the Deep South as more and more scrubbers are used to remove sulfur from flue gasses. Phosphogypsum, which is a gypsum by-product of the phosphate mining industry, has been shown to contain traces of radium which can break down into radon gas. For this reason, the US Environmental Protection Agency (US-EPA) will not allow land application of phosphogypsum. This does not apply to FGD gypsum. However, there is some concern that traces of mercury (Hg) in coal could be trapped by the gypsum. Note the very low levels of mercury in Table 1. Of course this varies depending upon the source of coal used. Studies are on-going to determine if the small concentrations of mercury are a biological concern. So far, there is no evidence that mercury will limit land application.

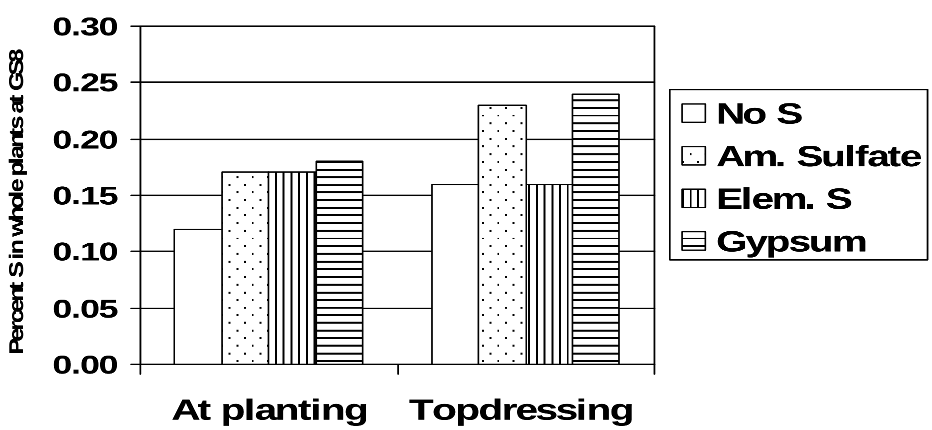

Fig. 2. Sulfur concentration in wheat samples as affected by S source applied **at planting** in the fall or at **topdressing** in the spring. Values below about 0.15% in the spring are considered S deficient. (unpublished data from Mitchell, Auburn University)

What are the benefits of using FGD gypsum on row crops, fruits and vegetables, pastures, and hayfields in Alabama?

Source of calcium. It can be used exactly as agricultural (mined) gypsum is currently used as a source of calcium for peanuts at pegging. In fact, it could be applied preplant at rates higher than currently recommended because it is anticipated to be less expensive than mined gypsum. Because gypsum goes into solution rather slowly, FGD gypsum can provide continual release of calcium and sulfur to the soil for more than just the year it is applied (Chen and Dick, 2010). It has also been shown to help control blossom end rot in tomatoes, peppers, eggplant, and melons and could be used anywhere extra calcium is needed by the crop.

Source of sulfur. Sulfur deficiencies have been observed on wheat, corn, cotton and some forage crops on sandy, Alabama soils. All gypsum sources provide readily plant available sulfate-S for crops. Studies at Brewton and Headland in the late 1980s showed that gypsum was as effective as ammonium sulfate as a source of sulfate-S for wheat.

Improves soil structure. Soil structure is the arrangement of soil particles into aggregates. Aggregates are mineral and organic particles that are weakly held together to create pore spaces in soils. Pores improve soil infiltration and drainage, reduce erosion, and encourage deeper rooting of crops. Organic matter is very beneficial for this purpose but since so many cultivated Alabama soils are low in organic matter, crusting is often a problem. Crusts form when rainfall breaks down aggregates on the soil surface and the soil particlestend to disperse creating a hard crust when the soil dries. Application of gypsum may encourage aggregate formation. This is why it is used on sodium-saturated, irrigated soils in the arid western U.S. Sodium tends to cause the soil clay to disperse, creating hard, packed soils with poor drainage. When high rates of gypsum are added to these soils, calcium replaces the sodium and the clays tend to aggregate forming large pores. When the soil is flood irrigated, the water moves through the soil, carrying the excess sodium (Na^+) below the rooting zone and thus reclaiming sodic soils. Up to 10 tons gypsum per acre may be used to reclaim sodic soils.

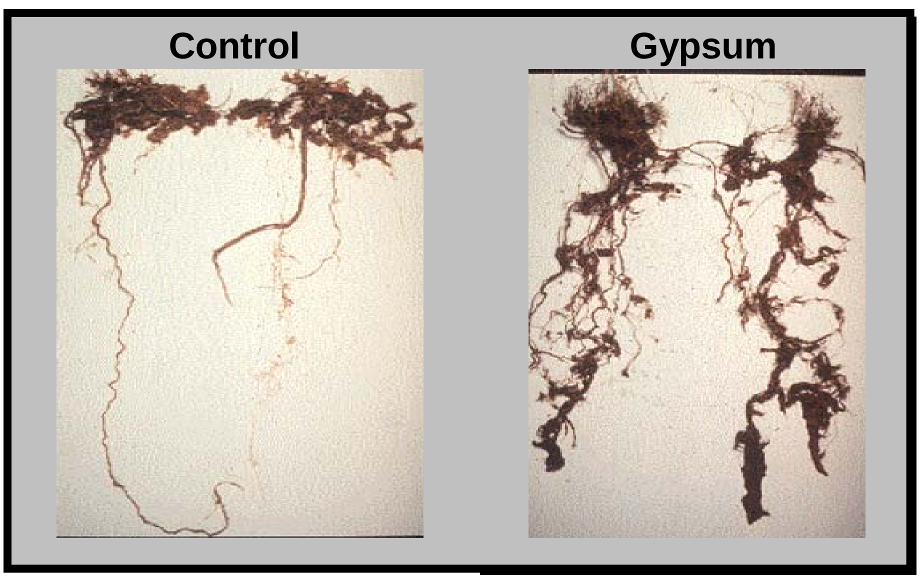

Fig. 3. Effect of gypsum application on alfalfa root growth into acidic subsoils. Photo from Southern Company, 2007.

Improves soil chemical properties. The main problem associated with acid soils of the Southeastern U.S. is aluminum (Al^{3+}) toxicity in sensitive crops. The lower the soil pH, the greater the concentration of soluble and plant-available Al. Ground agricultural limestone is applied to raise the soil pH so crops can be grown. However, ground limestone must be physically mixed with the soil to be highly effective. Limestone is rather insoluble in water and must contact acidity on the soil surfaces in order to react. Many subsoils may be acidic, and these cannot be limed. Although gypsum is not a liming material, application of gypsum to soil surfaces may reduce the toxic effects of Al in deeper soil horizons. This allows deeper rooting of sensitive crops so the roots can take up water and nutrients from subsoil layers (Fig. 3). Gypsum reacts with Al^{3+}, thus removing it from the soil solution and greatly reducing its toxic effects.

$$CaSO_4 + Al^{3+} \longrightarrow Al(S0_4)^+ + Ca^{2+}$$

As already discussed, gypsum is the most commonly used amendment for sodic soil reclamation because it prevents soil dispersion. Even in low sodium soils, gypsum has been shown to provide a level of electrolyte in the soil solution so that soil can maintain sufficient permeability and prevent crusting. Calcium (Ca^{2+}) in gypsum replaces Na^{+} and Mg^{2+} thus promoting flocculation and improved soil structure.

How is it transported and spread?

FGD gypsum is transported and spread very much like ground limestone using the same equipment. It can be stockpiled near the edge of the field where it is to be spread. Keep in mind that gypsum is slightly water soluble so it must be protected from persistent rains. Outdoor piles should be covered. However, exposed piles will crust over so a light rain or two probably won't affect spreading. Trucks for spreading ground limestone or poultry litter will work best because of the rate applied (1 to 4 tons per acre) and because moist gypsum can bridge over in smaller spreader buggies like those used for fertilizer.

What research is being done in Alabama with a FGD gypsum?

Southern Company. Dr. Malcolm Sumner, Reagents Professor Emeritus in soil chemistry at the University of Georgia, and Mr. Lamar Larrimore, Southern Company, have conducted over 50 on-farm demonstrations since 2002 using FGD gypsum from the Southern Company which includes Alabama Power Company. Crops have included peanuts, cotton, tomatoes, cantaloupes, forages, turf grasses and trees. They report 20 to 30% yield increases at many sites.

USDA Soil Dynamics Laboratory. Dr. Allen Torbert, Dr. Dexter Watts, and others with the USDA Soil Dynamics Laboratory at Auburn University are conducting research sponsored by EPRI (Electric Power Research Institute) with FGD gypsum from TVA at the Sand Mountain Research and Extension Center. They are focusing mainly on forage crops but are also looking and any potential environmental and health concerns (e.g. Hg) from the use of FGD gypsum.

Auburn University. Dr. Charles Mitchell is working with USDA Soil Dynamics Lab on an EPRI-funded project looking at FGD gypsum from Power South on cotton in South Alabama. They also are conducting some on-farm demonstrations with FGD gypsum. Water quality and mercury are being monitored at one site in Escambia Coiunty.

Auburn University. Dr. Julie Howe, Assistant Professor of Soil Chemistry, and others are conducting research with FGD gypsum as a source of calcium for peanuts.

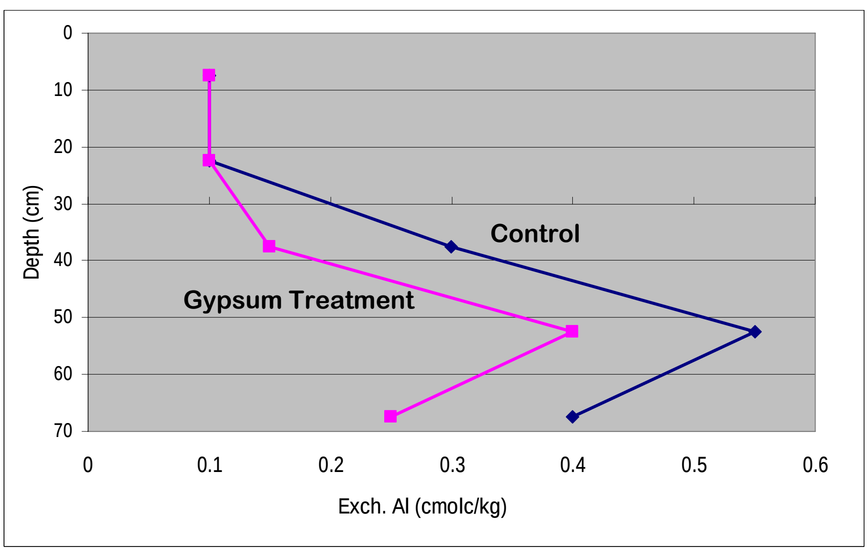

Fig. 4. Effect of FGD gypsum on exchangeable Al in a soil profile. (Photo from Larrimore, 2007, Southern Company)

Summary
FGD gypsum has been shown to improve crop growth by (1) adding Ca and sulfate-S to soils, (2) improving soil physical conditions and (3) improving soil chemical conditions. In 85 sites with gypsum on peanuts, there was a positive increase in income where gypsum was used on peanuts (Sumner, slide presentation). Measuring increased yields from FGD gypsum from improvements in soil structure and reduced Al toxicity in subsoils may not be immediate. In 2009, no yield increase in cotton was measured from the application of up to 8 tons FGD gypsum per acre after planting in both a replicated test and in an on-farm test. On the other hand, there has not been any negative effects from applying up to 8 tons of FGD gypsum per acre. Normal rates would be 1 to 5 tons per acre and a single application should be sufficient for several years.

References

Chen, L. and W.A. Dick. 2009 (draft). Gypsum as an agricultural amendment management guide. The Ohio State University. Wooster, OH.

Kovacs, F., and J. Molnar. 2003. Basic properties of flue-gas desulfurization gypsum. Acta Montanistica Slovaca. Hungary.

Larrimore, L. 2007. Summary of crop and environmental info for gypsum use in agriculture. Presentation by the Southern Company to Auburn University on October 30, 2007.

Sumner, M.E. 2003. Use of flue gas desulfurization gypsum on pastures. Project newsletter. Watkinsville, GA.

A stockpile of FGD gypsum produced by Power South Electric Cooperative's Charles R. Lowman Power Plant near Leroy, Alabama.

Table 1. Total analysis of an FGD gypsum from Alabama and a pelletized, commercial agricultural gypsum purchased in the state. All analyses by Ohio State University.

Analysis (units)	FGD gypsum	Agric. gypsum
pHw	7.7	7.3
Elec. Conductivity (uS/cm)	6570	7940
% $CaCO_3$ equivalent	8.5	49.7
P (mg/kg)	<1	<1
K (mg/kg)	183	800
Ca (%)	18.2	18.3
Mg (%)	0.12	4.40
S (%)	14.9	8.67
Al (mg/kg)	479	1369
B (mg/kg)	7	12
Cu (mg/kg)	<0.4	<0.4
Fe (mg/kg)	636	2788
Mn (mg/kg)	3	164
Mo (mg/kg)	1.0	1.3
Na (mg/kg)	<13	1194
Zn (mg/kg)	18	32
As (mg/kg)	<1.2	<1.2
Ba (mg/kg)	299	61
Be (mg/kg)	<0.09	<0.09
Cd (mg/kg)	<0.04	0.13
Co (mg/kg)	<0.15	0.31
Cr (mg/kg)	4.9	6.5
Hg (mg/kg)	2.7	<1.5
Hg (ug/kg)	640	16
Li (mg/kg)	268	48
Ni (mg/kg)	1.9	5.4
N (%)	0.008	0.161
C (%)	0.261	6.501