ALFALFA RESPONSE TO GYPSUM AND CALCIUM SULFITE SLUDGE APPLIED TO ACID SOILS TO REDUCE PHYTOTOXICITY OF SUBSOIL ALUMINUM

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Background. Soil acidity and acidity-affected soil properties inhibit plant growth. Acidity begins rapid solubilization of soil aluminum at pH levels below 5.5. Aluminum availability increases exponentially as soil pH declines below 5.0. Aluminum becomes toxic to root growth on sensitive plants, thereby limiting uptake of water and nutrients. Deep incorporation of limestone for neutralization of acidity in subsoils is uneconomical. Most cool-season forages and some forages that predominantly grow in the warm season are sensitive to high levels of aluminum. Alfalfa, a high nutritive-quality forage, is sensitive to acid soils and the aluminum component. Neutralization of toxic levels of aluminum in subsoils will allow producers to grow alfalfa on a wider range of acid soils. Gypsum, a neutral salt, has been shown to detoxify subsoil aluminum. When gypsum is applied to the surface horizon of a soil that has acid subsoil, the calcium and sulfate are moved into the subsoil through a series of adsorption, fixation, and exchanges aided by gravitational water flow. Movement of these ions into subsoils supplies calcium and sulfur, increases soil ionic strength, reduces the toxicity of aluminum, and in gypsum-responsive soils, slightly raises subsoil pH. The result is that roots of acid-sensitive plants are able to proliferate in previously unavailable zones, enabling them to more efficiently extract water and plant nutrients. Four replications of gypsum and calcium sulfite sludge treatments were applied at rates of 2.3, 4.5, and 6.8 tons/acre to two soils selected for high-subsoil aluminum content. One soil was a Cuthbert fine sandy loam on the Texas Agricultural Experiment Station research farm at Overton. The second soil was a Sacul very fine sandy loam on the Stephen F. Austin State University Todd Beef Farm near Nacogdoches. Each soil was limed and fertilized as needed for alfalfa that was seeded in fall of 1999. Each plot at these field sites was sampled at depths of zero to 6, 6 to 12, 12 to 24, 24 to 36, and 36 to 48 inches before treatment. After treatments were applied, samples were taken from the same depths semi-annually to monitor effected changes in the soil. Alfalfa yield response to treatments is reported.

Research Findings. Tables 1 and 2 show alfalfa dry matter yield as affected by gypsum and calcium sulfite sludge treatments for two years on both soils. In all harvests, dry matter yield was low and was not affected by application of either amendment. Low alfalfa yields are expected with high levels of aluminum, particularly when the aluminum is near the soil surface.

Application. The effectiveness of gypsum or calcium sulfite applied to reduce subsoil acidity will need to be monitored over a longer time in order to see benefits in increased yield.

Table 1. Alfalfa response to gypsum[†] and calcium sulfite[‡] sludge applied to reduce phytotoxic levels of aluminum in subsoils on a Sacul soil site on the Stephen F. Austin State University Todd Beef Farm[§].

Treatment, t/ac	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Total
	Alfalfa yield by harvest and total — Dry matter, lb/ac				
2000					
Check	1,297	2,317	2,220		5,834
$CaSO_4 \cdot 2H_2O$, 2.3	1,230	2,076	2,191		5,497
$CaSO_4 \cdot 2H_2O$, 4.5	1,355	2,049	2,123		5,527
$CaSO_4 \cdot 2H_2O$, 6.8	1,168	1,711	1,969		4,848
$CaSO_3 \cdot ½H_2O$, 2.3	1,202	1,976	2,137		5,315
$CaSO_3 \cdot ½H_2O$, 4.5	880	1,911	1,895		4,686
$CaSO_3 \cdot ½H_2O$, 6.8	1,455	2,143	2,090		5,690
R^2	0.63	0.46	0.37		0.51
C.V.	35.3	24.1	13.8		18.9
2001					
Check	2,159	1,124	911	588	4,782
$CaSO_4 \cdot 2H_2O$, 2.3	1,819	1,281	617	511	4,228
$CaSO_4 \cdot 2H_2O$, 4.5	1,716	1,013	737	528	3,992
$CaSO_4 \cdot 2H_2O$, 6.8	1,864	1,532	559	528	4,483
$CaSO_3 \cdot ½H_2O$, 2.3	1,760	1,117	939	500	4,316
$CaSO_3 \cdot ½H_2O$, 4.5	1,880	1,221	602	414	4,116
$CaSO_3 \cdot ½H_2O$, 6.8	1,857	1,084	686	568	4,195
R^2	0.34	0.27	0.56	0.42	0.33
C.V.	21.2	35.9	31.8	36.8	24.7

[†] Gypsum is calcium sulfate, $CaSO_4 \cdot 2H_2O$ [‡] Calcium sulfite is $CaSO_3 \cdot ½H_2O$ [§] Yields were not statistically different.

Table 2. Alfalfa response to gypsum[†] and calcium sulfite[‡] sludge applied to reduce phytotoxic levels of aluminum in subsoils on a Cuthbert soil site on the Texas Agricultural Experiment Station at Overton.[§]

Treatment, t/ac	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Total
	Alfalfa yield by harvest and total — Dry matter, lb/ac				
2000					
Check	1503	1857	994		4360
$CaSO_4 \cdot 2H_2O$, 2.3	1959	2060	1356		5375
$CaSO_4 \cdot 2H_2O$, 4.5	1361	1516	989		3775
$CaSO_4 \cdot 2H_2O$, 6.8	1296	1346	953		3594
$CaSO_3 \cdot ½H_2O$, 2.3	1116	1466	1190		3772
$CaSO_3 \cdot ½H_2O$, 4.5	828	1068	849		2744
$CaSO_3 \cdot ½H_2O$, 6.8	1443	1503	1267		4213
R^2	0.39	0.28	0.27		0.31
C.V.	61.4	55.2	58.3		55.2
2001					
Check	1976	663	2292	1305	6237
$CaSO_4 \cdot 2H_2O$, 2.3	2093	887	2307	1254	6540
$CaSO_4 \cdot 2H_2O$, 4.5	1456	1077	1684	1154	5301
$CaSO_4 \cdot 2H_2O$, 6.8	1488	926	1886	1251	5550
$CaSO_3 \cdot ½H_2O$, 2.3	1611	698	1823	1064	5196
$CaSO_3 \cdot ½H_2O$, 4.5	1704	355	1359	930	4347
$CaSO_3 \cdot ½H_2O$, 6.8	1493	898	1394	1098	4782
R^2	0.30	0.27	0.47	0.16	0.22
C.V.	34.0	83.1	31.4	35.6	35.2

[†] Gypsum is calcium sulfate, $CaSO_4 \cdot 2H_2O$ [‡] Calcium sulfite is $CaSO_3 \cdot ½H_2O$ §Yields were not statistically different.