Response of Coastal Bermudagrass to Gypsum Applications

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ABSTRACT

Field studies were conducted from 1998 to 2000 at two locations in Fayette County to evaluate the effects of power plant by-product gypsum in comparison with agricultural gypsum on yield and quality of Coastal bermudagrass [*Cynodon dactylon* (L.)]. By-product gypsum and agricultural gypsum increased yearly coastal bermudagrass yield over the untreated check in only one year at one location over the 3-year test period. No differences in crude protein content of bermudagrass were noted between untreated check and gypsum treatments.

KEYWORDS: Forage, Protein content, Quality, Yield.

Coal is utilized in production of a large portion of the energy produced by the United States. The Clean Air Act of 1990 was designed to reduce sulfur dioxide emissions from coal fired generation power plants. As a result of the scrubbers installed to reduce these emissions, by-product gypsum is produced at many of these power plants. In Texas, by-product gypsum is generated in significant tonnages that create a disposal problem for many power plants (Jason Underbrink, Boral Material Technologies, Inc., personal communication).

Gypsum (calcium sulfate) is a common source of calcium and sulfur for many crops (Grichar et al. 2000; Heath et al. 1985). It has a relatively high solubility and therefore is quickly available to plants. Because gypsum is a neutral salt, it does not increase soil pH. Corn (*Zea mays* L.) and cotton (*Gossypium hirsutum* L.) have responded to gypsum under acid soil conditions (Caldwell et al. 1988, 1990; Toma et al. 1999).

Gypsum is routinely recommended as a source of calcium for peanuts (*Arachis hypogaea* L.) and potatoes (*Solanum tuberosum* L.) (Grichar and Boswell 1990, Grichar et al. 2000, Grichar et al. 2001). High yielding and good quality peanuts require adequate Ca in the top 3 in of soil during pegging and pod filling (Cox et al. 1982, Gascho et al. 1993). Gypsum also has been reported to reduce disease incidence in various crops (Filonow et al. 1988, Hooker 1981, Messenger et al. 2000).

Applications of gypsum significantly reduced root rot in avocado (*Persea americana* Mill.) in California as well as Australia (Broadbent and Baker 1974, Falcon et al. 1984, Messenger et al. 2000). Garren (1964) first reported that high rates of calcium added to soil in the form of gypsum effectively reduced pod rot. Further study (Hallock and Garren 1968) suggested the calcium content of peanut pods was important in suppression of pod rot caused by that *Pythium myriotylum*. Pods containing > 0.20% calcium had less disease than

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those containing < 0.15% calcium. Gypsum has been reported as being effective in reducing the incidence and severity of bacteria potato soft rot (Hooker, 1981; Wright, 1995).

Very little work exists concerning the use of gypsum to increase quality and yield of pasture grasses. Suhayda et al. (1997) reported that gypsum decreased soil pH, electrical conductivity and chloride and sodium levels while water infiltration and calcium levels were increased. They also reported that gypsum increased height and yield of three grass species (*Aneurolepidium chinense, Puccinellia temiflora,* and *Hordeum brevisubulatum*). Improvements in plant growth and survival with calcium appeared to be due to reduced chloride levels and increased calcium availability in the soil, and to changes in soil structure leading to improved water infiltration rates (Suhayda et al. 1997).

Dorsett et al.[1] reported that gypsum obtained from a power plant provided 6 to 30% higher 'Coastal' bermudagrass forage yields than the untreated check depending on harvest date and product. Although soil sulfur levels were not changed, forage sulfur levels increased as gypsum rates increased. The objective of this study was to compare the effects of power plant by-product gypsum with regular agricultural gypsum on coastal bermudagrass yield and quality.

MATERIALS AND METHODS

Field studies were conducted from 1998 through 2000 at two locations in Fayette County to determine the effects of two sources of gypsum on coastal bermudagrass yield and quality. Agricultural gypsum obtained from a local distributor[2] was compared with gypsum obtained as a by-product of a coal-generated power plant[3] located near La Grange, TX. Representative samples of agricultural gypsum and by-product gypsum and soil samples from the 0 to 6-inch depth at each study location were collected prior to study initiation and submitted to the Texas Agricultural Extension Service Soil Test Laboratory for analysis.

Test sites were installed in established stands of coastal bermudagrass at the Cooper Farm Resource Area and Grey Farm for the duration of the study. The Cooper Farm is a 180 acre piece of south-central Texas farmland developed by the Lower Colorado River Authority (LCRA) as a natural science laboratory, in hopes of developing and demonstrating ways to allow wildlife to survive and thrive in an area that is heavily agriculture. The test area was located in one of the Coastal bermudagrass pastures at the site. The Grey Farm is a privately owned ranch. These farms were located approximately four to five miles apart in a radium of about three miles north/northeast of LaGrange.

Soil at the Cooper Farm site was a sandy loam with 69% sand, 19% silt, 12% clay and pH 4.6. The Grey Farm site was a sand with 87% sand, 9% silt, and 4% clay with pH 4.6. Soil nitrate, magnesium, and sodium levels were low at both sites. Phosphorus and potassium levels were low to moderate at both locations. Calcium levels were high at the Cooper Farm but low at the Grey location, while sulphur levels were low at both locations.

[1]D. J. Dorsett, L. Nickel, and H. D. Pennington. 1995. Evaluation of coal generated by-product gypsum as a soil amendment on improved hybrid bermudagrass. Report for Monex Resources, Inc. (Now Boral Material Technologies, Inc.). San Antonio, TX 78216.

[2]Hoe-Down, Standard Gypsum Corp., 1650 Gypsum Mine Rd., Fredricksburg, TX 78624.

[3]Boral Material Technologies, Inc., San Antonio, TX 78216.

By-product gypsum at 500, 1000, 1500, and 2000 lbs/ac and agricultural gypsum at 500, 1000, and 2000 lbs/ac were hand applied to plots during the spring of each year. An untreated check was included for comparison. Weeds were controlled with Grazon P+D at 3.0 pt/ac applied to plots during the spring at each location. Fertilizer was applied according to soil test recommendations at spring green-up and again after the second cutting. A schedule of events is presented in Table 1 and monthly rainfall received in the study area is shown in Table 2.

Table 1. Schedule of events for gypsum study at two locations in Fayette County, TX.

	Location					
	Cooper			Grey		
Event	1998	1999	2000	1998	1999	2000
First fertilizer application	31 Mar	12 Apr	20 Apr	31 Mar	7 Apr	20 Apr
Second fertilizer application	-	13 Jul	17 May	11 Jun	2 Jun	17 May
Gypsum application	6 Apr	12 Apr	20 Apr	6 Apr	12 Apr	20 Apr
First grass cutting	15 Jul	26 Apr	5 Apr	6 May	24 May	27 Mar
Second grass cutting	-	2 Jun	17 May	11 Jun	24 Jun	11 May
Third grass cutting	-	13 Jul	28 Jun	15 Jul	27 Jul	20 Jun
Fourth grass cutting	-	-	-	6 Dec	10 Nov	-

Table 2. Monthly rainfall for 19982000 and 55 yr average for LaGrange, TX.

Month	1998[a]	1999	2000	Average
	------------------------------------inches------------------------------------			
January	2.43	0.94	4.52	2.76
February	5.93	0.54	2.24	2.88
March	1.65	3.84	2.31	2.26
April	0.81	9.89	1.70	2.99
May	0.25	5.47	5.38	4.86
June	1.04	4.70	5.75	3.94
July	1.23	3.93	0.50	2.23
August	3.47	0.70	0.85	2.55
September	7.93	0.37	0.29	4.65
October	13.75	0.51	4.06	3.71
November	8.20	0.38	8.84	3.14
December	3.0	1.34	4.13	2.74
Total	49.69	32.61	40.57	38.71

[a/]Studies initiated in April 1998

Plot size was 10 ft wide by 30 ft long. The treatment design was a randomized complete block with four replications. Plots were harvested with a Lawn-Genie forage Harvester.[4] Individual plot weights were obtained at harvest. A subsample (~ 1.0 lb) was

[4]Matthews Co., Crystal Lake, IL 60014

collected to determine weight and then dried in a forced air dryer at 170°F for 96 h. Dry matter weights were then used to calculate forage yield on a per acre basis. Dry forage samples were then sent to the Texas Agricultural Extension Service Soil and Plant Testing Laboratory for analysis of quality and nutrients.

RESULTS AND DISCUSSION

Gypsum composition. Chemical analysis of the two gypsum sources indicated that by-product gypsum contained greater concentrations of boron, chloride, fluoride, magnesium, potassium, and sodium (Table 3). Concentrations of Ca and S were similar for the two products, thus any differences in plant uptake likely would be attributed to variations in solubility. Moisture levels were higher in by-product gypsum compared to agricultural gypsum.

Table 3. Chemical composition of by product gypsum and agricultural gypsum.

Component	By-product gypsum	Agricultural gypsum
	----------mg/kg----------	
Aluminum	<0.05	<0.05
Arsenic	<0.01	<0.01
Barium	0.09	0.06
Boron	0.25	0.12
Calcium	590.0	570.0
Cadmium	<0.005	<0.005
Chromium	<0.01	<0.01
Copper	<0.02	<0.02
Iron	<0.02	<0.02
Lead	<0.005	<0.005
Magnesium	12.00	<0.05
Manganese	<0.01	0.01
Mercury	<0.0002	<0.0002
Molybdenum	<0.02	<0.02
Nickel	<0.02	<0.02
Phosphorus	<1.0	<1.0
Potassium	3.7	<1.0
Selenium	<0.01	<0.01
Silver	<0.01	<0.01
Sodium	41.0	0.92
Vanadium	<0.02	<0.02
Zinc	0.06	0.1
Chloride	40.0	<1.0
Sulfate	1580.0	1500.0
Sulfur (%)	14.3	16.3
pH	7.3	8.0
Moisture (%)	20.0	1.0

Bermudagrass yield. *Grey Ranch*. Four bermudagrass cuttings were obtained in 1998 and 1999 while three cuttings were obtained in 2000. No differences in total bermudagrass yield between the untreated check and gypsum treatments were noted in 1998 and 2000 (Table 4). In 1999, yields in the by-product gypsum plots were significantly greater than those in the untreated check regardless of rate. By-product gypsum yields also were significantly greater than those of ag gypsum applied at 1000 and 2000 lbs, and a similar trend was observed for the 500 lb rate. Although total rainfall for 1999 in the LaGrange area was below normal (Table 2), rainfall during April through July was above average and supported total forage production in excess of > 30,000 lbs/ac.

Table 4. Effect of gypsum on total annual coastal bermudagrass dry matter production at Grey Ranch.

Treatment	Rate lb/ac	Yield[1/]		
		1998(4)	1999(4)	2000(3)
		-----------------------------lbs/ac-----------------------------		
Check	-	17,552a[2/]	31,667c	21,162a
By-product gypsum	500	21,142a	36,760a	21,878a
By-product gypsum	1000	16,828a	37,404a	23,949a
By-product gypsum	1500	15,312a	37,667a	19,998a
Ag gypsum	500	15,729a	34,285abc	21,884a
Ag gypsum	1000	17,208a	31,963bc	19,290a
Ag gypsum	2000	15,780a	32,306bc	20,265a

[1/] Numbers in parentheses represent the number of cuttings for that year.
[2/] Means within a column followed by the same letters are not significantly different at the 5% probability level by Duncan's New Multiple Range Test.

Cooper Farm. In 1998, only one cutting was obtained while in 1999 and 2000 there were three cuttings per year. In 1998 and 2000 there were no differences in yield between any of the gypsum treatments and the untreated check (Table 5). In 1999, bermudagrass plots which received by-product gypsum at 1500 lbs/ac or ag gypsum at 1000 lbs/ac yielded over 19,900 lbs of bermudgrass on a dry weight basis. Plots which received by-product gypsum at 500 lbs/ac yielded < 16,000 lbs/ac of bermudagrass on a dry weight basis (Table 5).

Table 5. Effect of gypsum on total annual coastal bermudagrass dry matter production at Cooper Farm.

Treatment	Rate lb/ac	Yield[1/]		
		1998(1)	1999(3)	2000(3)
		-----------------------------lbs/ac-----------------------------		
Check	-	742a	17,961ab	22,064a
By-product gypsum	500	700a	15,722b	21,179a
By-product gypsum	1000	696a	17,740ab	23,141a
By-product gypsum	1500	694a	19,991a	24,531a
Ag gypsum	500	707a	18,667ab	21,196a
Ag gypsum	1000	816a	20,427a	24,370a
Ag gypsum	2000	760a	18,477ab	21,187a

[1/] Numbers in parentheses represent the number of cuttings for that year.
[2/] Means within a column followed by the same letters are not significantly different at the 5% probability level by Duncan's New Multiple Range Test.

Crude protein content. *Grey Ranch*. Only three cuttings resulted in differences in percent crude protein (Table 6). In 1998, the 11 June and 6 December cuttings receiving by-product gypsum at 500 lb/ac produced less crude protein than other gypsum applications. Crude protein contents were extremely low for the December cutting due to harvest delays as a result of heavy rains in October and November (Table 2). At the June 20, 2000 cutting, by-product gypsum at 500 and 1000 lb/ac produced higher crude protein contents than all other treatments (Table 6).

Table 6. Crude protein content of coastal bermudagrass from Grey Ranch.

		Harvest dates [a,b]									
		1998				1999			2000		
Treatment	Rate lb/ac	May 6	June 11	July 15	Dec 6	May 24	July 27	Nov 10	Mar 27	May 11	June 20
		%									
Check	-	16a	15a	16a	8a	19a	19a	9a	21a	18a	15b
By-product gypsum	500	15a	14b	15a	7b	18a	18a	9a	21a	17a	16a
By-product gypsum	1000	15a	16a	15a	9a	18a	18a	9a	21a	17a	16a
By-product gypsum	1500	16a	15a	16a	9a	18a	18a	9a	21a	17a	15b
By-product gypsum	2000	17a	15a	16a	9a	18a	18a	9a	21a	18a	15b
Ag gypsum	500	15a	15a	15a	8a	19a	19a	9a	20a	18a	15b
Ag gypsum	1000	17a	16a	16a	9a	19a	19a	9a	20a	17a	15b
Ag gypsum	2000	17a	15a	16a	9a	18a	18a	9a	20a	17a	14b

[2/] Means within a column followed by the same letters are not significantly different at the 5% probability level by Duncan's New Multiple Range Test.
[b]June 24, 1999 harvest date not included.

Cooper Farm. The crude protein content of the 26 April, 1999 cutting was extremely low because of the earliness of the cutting to remove the dead growth from the previous winter (Table 7). Only the 13 July, 1999 and the 5 April, 2000 cuttings resulted in differences in crude protein content. For the 13 July cutting, by product gypsum at 1500 and 2000 lbs/ac and agricultural gypsum at 2000 lb/ac resulted in lower crude protein contents. Similarly, for the 5 April cutting by-product gypsum at 1500 lb/ac and agricultural gypsum at 2000 lb/ac had lower crude protein contents than other gypsum treatments.

Table 7. Crude protein content of coastal bermudagrass from Cooper Farm.

		Harvest dates [a, b]					
		1998	1999			2000	
Gypsum Treatment	Rate lb/ac	July 15	Apr 26	June 2	July 13	Apr 5	June 28
		%					
Check	-	11a	8a	11a	17a	20a	13a
By-product	500	11a	8a	10a	17a	20a	14a
By-product	1000	11a	8a	11a	17a	19a	13a
By-product	1500	10a	7a	10a	16b	18b	13a
By-product	2000	10a	8a	9a	16b	20a	13a
Ag	500	10a	8a	10a	17a	20a	14a
Ag	1000	10a	8a	10a	17a	19a	14a
Ag	2000	11a	8a	10a	16b	18b	13a

[2/] Means within a column followed by the same letters are not significantly different at the 5% probability level by Duncan's New Multiple Range Test.
[b]May 17, 2000 harvest date not included.

Other minerals. Forage calcium and sodium levels were not affected by treatment at either location or any harvest date (data not shown). Dorsett et al.[1] also noted no change in calcium uptake in the hay. However, they found that as the rate of by-product gypsum increased, the sulfur level in the forage increased.

CONCLUSIONS

Application of by-product or ag gypsum did not improve on coastal bermudagrass yield or quality. In addition, although concentrations of several elements were greater in by-product gypsum compared to commercial agricultural gypsum, few differences in tissue concentrations were observed.

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