IS THERE A ROLE FOR GYPSUM IN MIDWEST AGRICULTURE?

George Rehm
Department of Soil, Water, and Climate
University of Minnesota
St. Paul, MN

For the past two years, there has been an increased interest in gypsum throughout the Midwest. It's reasonable to ask if this interest is a consequence of improved crop production or the follow-up of increased sales activity.

For many years, gypsum has been used to improve crop production in some parts of the United States. In most of these situations it was used to supply sulfur (S). In some cases, gypsum has been used to supply calcium, an important nutrient for profitable peanut production. There has, however, never been any justification for widespread use of gypsum. A search of the crop production research for the Midwest shows that, with the exception of applying S when S is needed, application of this product has not improved crop production.

Sales Promotion

During the past two years, the promotional materials and statements used to support sales of gypsum have stated several attributes for this material. Briefly stated, the benefits that are attributed to the use of gypsum are:

- the calcium from gypsum can lower the pH of soil from 8.0 to 7.3
- improvement in soil tilth probably because of increased biological activity due to the added calcium and sulfur
- lowering of magnesium accompanied by an increase in calcium can improve the tilth of heavy soils
- soil with more than 22% Mg base saturation and 1% sodium will have poor structure
- improved plant health and productivity
- readily available source of calcium and sulfur
- improves nitrogen utilization and fixation by legumes
- helps manage micronutrient deficiencies such as iron chlorosis in soybeans
- improves soil structure, aeration, drainage, and rootability of plants in conventional and especially in no-till soils

A considerable amount of time and space would be needed to address each of these points. Therefore, some that might have a substantial economical effect on crop production in Midwest agriculture will be discussed in the paragraphs that follow.

Change in Soil pH

Gypsum, calcium sulfate combined with two molecules, is a neutral salt. When added to soils, it dissolves to form calcium and sulfate-sulfur according to the following chemical reaction.

$$CaSO_4 \cdot 2H_2O \rightarrow Ca^{++} + SO_4^{=} + 2H_2O$$

The natural material is 23% calcium and 18% sulfur. In some materials, the S percentage is 17.5%.

Since there is no carbonate or bicarbonate associated with the Ca^{++}. it is not a liming material. Therefore, an increase in soil pH should no be expected when gypsum is added to an acid soil. However, what about a reduction soil pH? There is a claim that the use of gypsum can reduce the pH from 8.0 to 7.3.

To evaluate this claim, personnel of Agvise Laboratories, Northwood, North Dakota, incubated two soils with various rates of gypsum for 45 days. The soils were maintained at room temperature in a moist condition. At the end of the incubation, measurements were taken for pH and soluble salts. The results are summarized in Table 1.

Table 1. The effect of various rates of gypsum mixed with soil on soil pH and soluble salts after 45 days.

	Soil#1		Soil #2	
Gypsum Rate	pH	soluble salts	pH	soluble salts
lb./acre		mmho/cm		mmho/cm
0	7.50	.24	7.77	.81
300	7.53	.32	7.80	.83
6000	7.30	.92	7.70	1.09
18,000	7.30	1.17	7.60	1.39
36,000	7.37	1.31	7.73	1.48

Source: Agvise Laboratories

There was no change in soil pH for either soil. This conclusion should not be surprising. The gypsum does not release hydrogen (H^+) when added to soil.

The measure of soluble salts increased as the rate of applied gypsum increased. This conclusion should be expected. Rates of 6,000, 18,000, and 36,000 lb. per acre are high and addition of high rates of a salt should be reflected in a measurement of soluble salts.

After consideration of the facts of chemistry and the results of a laboratory study, it is easy to reach a conclusion that the addition of gypsum to soils has no effect on soil pH.

Improvement in Soil Structure, Aeration, and Drainage

Any change in these soil properties resulting from the application of gypsum is believed to be a consequence of the replacement of magnesium (Mg) by calcium (Ca) on the exchange sites of the clay size particles.

A search of the literature reveals that there is some research which leads to the conclusion that high rates of magnesium on exchange sites can lead to reduced water infiltration and subsequently a potential for more erosion. The most recent research has been reported by

Dontsova and Norton [1]. In this research project, four typical midwestern soils (Blount, Caltin, Fayette. Miami) were equilibrated with solutions having five Ca:Mg ratios (1:100. 25:75. 50:50, 75:25. 100:0). Measurements of soil clay flocculation, structural stability, infiltration, and soil erosion were taken.

The rainfall simulation studies in the laboratory showed that high amounts of Mg reduced infiltration and increased soil erosion when compared to Ca. This difference was measured with two of the four soils (Blount and Catlin). For the Fayette and Miami soils, the cation used (Ca, Mg) had no effect on these measurements (Table 2).

Table 2. Infiltration, runoff and soil loss for Ca and Mg treated soils.

Soil	Treatment	Infiltration Rate	Runoff Rate	Soil Loss Rate
		mm/hr	mm/hr	$kg/m^2/hr$
Blount	Ca	5.7 a*	57.6 b	0.233 a
	Mg	2.7 b	61.0 a	0.458 a
Catlin	Ca	31.1. a	29.0 b	0.114 a
	Mg	16.8 b	45.9 a	0.357 a
Fayette	Ca	4.1 a	58.3 a	0.352 b
	Mg	2.9 a	60.7 a	0.492 a
Miami	Ca	2.4 a	60.4 a	0.509 a
	Mg	2.5 a	59.1 a	0.415 a

* Means for the treatments for each soil followed by the same letter are not significantly different at the .05 confidence level.
Source: Dontsova and Norton (2002)

This detailed study was conducted under laboratory conditions. The study was not conducted with growing crops. Therefore, the impact of magnesium saturation on crop yield cannot be reported.

From an evaluation of the data, the researchers concluded that "this research presents evidence that it is beneficial to manage soils to high Ca:Mg ratios if they are prone to sealing."

If magnesium saturation can have a negative effect on some soil properties under laboratory conditions, it's reasonable to ask if magnesium addition to soils has a negative effect on crop production. Research conducted by faculty at Iowa State University provides a good answer to this question.

In one trial. potassium was supplied for corn as either 0-0-60 or K-Mag. The fertilizers were applied each year for eight years at a rate to supply 160 lb. K/acre.

In addition to K, the K-Mag also supplied magnesium (98 lb./acre) and sulfur (199 lb./acre)each year. Average grain yields for the eight years of the study are summarized in Table 3.

[1] Dontsova, K.M. and L.D. Norton. 2002. Clay dispersion. infiltration. and erosion as influenced by exchangeable Ca and Mg. Soil Sci. 167: 1-10.

Table 3. Corn yield as affected by K sources used to supply 160 lb. K/acre annually.

K Source	Yield (8 year average)
	bu./acre
None	132
0-0-60	145
K-Mag	145

Source: J. Webb, Iowa State University

The response to applied K was substantial. The source of K, however, had no effect on yield. These results provide good evidence that added magnesium does not have a negative effect on corn production. If use of magnesium was detrimental, yields should have been reduced by the annual application of K-Mag.

Field Studies

The effect of broadcast gypsum on crop yield was evaluated in South Dakota in 2002. Treatments and corresponding yields are summarized in Table 4.

Table 4. Effect of rate applied gypsum on crop production is South Dakota in 2002.

	Crop Yield		
Gypsum Applied	Corn	Soybean	Wheat
Lb./acre	----- -----	----- bu./acre -----	----- -----
0	129	39.1	44
300	133	39.9	44
1500	141	35.0	43
LSD (.05)	NS	NS	NS

The sites selected had high levels of soluble salts. Yet, the application of gypsum had no positive effect on yield.

Gypsum As A Soil Amendment

Gypsum has value – in certain situations. The use of this material has been shown to be of value in reclaiming sodic (high sodium) soils. Excessive sodium on the exchange sites of clay particles will cause the clay to dispense thereby filling soil pores with clay. As a result, water infiltration is reduced, root development is restricted, and the soil becomes compact and hard when dry.

The calcium from gypsum replaces the sodium on the exchange sites. If there is enough water movement through the root zone, the displaced sodium can be flushed from the soil profile. Therefore, gypsum and good internal drainage are both necessary to reclaim the sodic soils. The rates of gypsum needed for reclamation are in the range of 1 to 3 tons per acre. In addition, soils in the Midwest that have a high sodium content are not well drained. Therefore, use of gypsum to reclaim small acreages of these soils is not promising.

Gypsum As A Sulfur Fertilizer

For many years, gypsum was used to supply sulfur to crops, when needed. The effect of use of sulfur in a fertilizer program for corn production on sandy soils has been positive. An example of that response when the sulfur was applied in a band at planting is shown in Table 5.

Table 5. Response of corn to sulfur fertilizer applied in a band below and to the side of the seed at planting.

S Applied	Yield
	bu./acre
0	142
6	152
12	160
18	171

Therefore, gypsum has a role as a source of sulfur for crop production in Midwest agriculture. However, soils that require S in a fertilizer program do not dominate the crop production systems in the Midwest. Consequently the use of gypsum for this purpose is limited.

Is There A Role For Gypsum In Midwest Agriculture?

Yes – but limited.

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Program Chair:
John E. Sawyer
Iowa State University
Ames, IA 50011
(515) 294-1923

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