Science Societies

Gypsum finds a way to get to the root of the acidity problem

By Megan Sever

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A new study aims to establish criteria for when to use gypsum instead of lime in no-till soils and to examine how gypsum might help root growth. Photo courtesy of Warren Dick.

- Many farmers are turning to gypsum—a mineral that is about 150 times more water soluble than limestone—as a fertility option to penetrate deeper in no-till soils.
- A new study aims to establish criteria for when to use gypsum instead of lime in no-till soils and to examine how gypsum might help root growth.
- Study results showed that yields could be increased from 7 to 14% in no-tilled soils with high aluminum saturation in the 20- to 40-cm soil layer.

The goal of most soil fertility management programs is to correct nutrient levels in the top 10 to 20 cm of soil. But to fix nutrient deficiencies where roots grow, fertility treatments need to reach deeper. Yet, getting nutrients to penetrate deeper in no-till soils, or in the middle of a growing season when roots need a boost, is a significant challenge. That's because commonly used fertilizers like lime are not very soluble in water, so they cannot penetrate deeply enough to reach roots. In situations like this, especially where there is acidity below the soil surface, many farmers are turning to gypsum—a mineral that is about 150 times more water soluble than limestone. Gypsum reacts differently with soils than lime, but knowing which one to choose is not always a cut-and-dried case. A new study aims to establish criteria for when to use gypsum instead of lime in no-till soils, especially when the subsoil is acidic, and to examine how gypsum might help root growth to promote increased grain yields.

Acidic soils—those with a pH less than 5.5—cover more than three-quarters of potentially arable land in the world. These soils have "low availability of exchangeable basic cations like Ca^{2+}, Mg^{2+}, and K^{+} and high concentrations of exchangeable aluminum that is toxic to plants," says Osmar Henrique de Castro Pias, an agricultural scientist at the Federal Institute Farroupilha, Julio de Castilhos in Brazil, and lead author of the new study in *Agronomy Journal* (**https://doi.org/10.1002/agj2.20125**). As such, farmers try to increase the pH to bind up the aluminum, so it does not harm the plants.

Lime does just that: It increases the pH, which reduces the toxic effects of aluminum by binding the exchangeable aluminum cations to hydroxide. Because lime works so well, it is the most widely used treatment for correcting soil acidity, Pias says.

Gypsum works differently: It does not change pH levels at all, "so it is not a soil acidity corrective," Pias says, but it does increase the mobility of the basic cations, which subsequently reduces the activity of exchangeable aluminum, thus reducing the toxicity. It also improves water and nutrient uptake by plants at the root level, which allows plants to expand their root systems and thus increase crop grain yields. "It makes soil more friendly for root growth," says Warren Dick, an emeritus soil scientist and gypsum expert at Ohio State University who was not involved with the new study.

Many studies thus far have indicated this process works but with varying inputs and results. So Pias and his colleagues decided to conduct a meta-analysis to assess the response of grain crops to gypsum application in no-till soils.

"Establishing specific criteria for gypsum management" should help both in Brazil and in other tropical or subtropical regions, like Latin American and Africa, with naturally acidic and low-fertility subsoils, Pias says.



Gypsum has a number of benefits such as reducing the effects of soil aluminum caused by acidity, adding sulfur (a required nutrient for proteins), and tying up phosphorus, so not as much leaches out of the soil. Photo courtesy of Warren Dick.

Yield Benefit

Pias and his team evaluated results from no-till, minimally cultivated fields over 129 harvests of six different grain crops, which covered 930 experimental plots that paired soils with and without gypsum application. They found that cereal crops have a "high probability"—77 to 98%—of increasing grain yield with gypsum application. Yields increased on average 14% for acidic soils with water deficiencies and 7% for acidic soils with plenty of water. Other crops, such as soybeans, also increased yields grown in acidic soils with added gypsum especially in times of water deficits.

Gypsum has been known to reduce the effects of soil aluminum caused by acidity since the 1970s, Pias notes. But currently, he says, gypsum is only recommended on

soils with aluminum saturation greater than 20 or 30%. “Our results showed a positive effect in soils with more than 5 and 10% aluminum saturation for cereals and soybeans, respectively.” That positive effect is magnified in years with a water deficit, he says.

How much of that yield benefit is from “knocking down aluminum toxicity” versus affecting the ability of water to penetrate deeper is “not convincingly proved” by this study, says Blake Sanden, an agronomist and farm adviser emeritus with the University of California Division of Agriculture and Natural Resources who has looked at gypsum's effects on pistachio and almond groves, among others. But Dick says this study and many others do show that the gypsum is helping overcome the aluminum toxicity and thus improving the soil. Similar studies on the effects of gypsum on highly weathered acidic soils in Arkansas have shown the same soil improvements, Dick adds.

Other Benefits, Management Considerations

Gypsum has other benefits as well, Dick notes. For one thing, it adds sulfur, a required nutrient for proteins. In the U.S., sulfur is increasingly missing from soils now that acid rain has been dramatically reduced. Gypsum also ties up phosphorus, so not as much of the phosphorus leaches out and moves into other water bodies where it becomes a pollutant, he says. However, “you need to know the proper use of the material,” he cautions. “It's very good, but you can overdo it, or apply it in places you shouldn't … like on a sandy soil with [little] organic matter,” where it would cause nutrients like potassium and magnesium to leach off into water and be lost from the field.

In considering what amendment to add and in what amounts, especially for low-till or no-till farming, Sanden says, it's important to know how the amendment is getting incorporated into the subsurface. “If I go and spread 4 or 5 tons of lime on the surface, I don't get any more than 2 to 3 cm of incorporation just along the seed row with my drill.” Then, he says, “after a small neutralization benefit near the drill row, most the lime

is just sitting there" because so little would solubilize, Sanden says. But if a farmer applies the "same amount of equivalent calcium and spreads out 6 tons of gypsum—because the calcium content in gypsum is lower than that of lime—then as soon as that field gets hit with a rainstorm or irrigation, all of that gypsum will solubilize, moving the free calcium with the water." So, he says, gypsum potentially is putting more calcium deeper in the profile.

It would have been interesting to see a comparison between gypsum and lime, Sanden says. He says he would also like to see a comparison of yields from tilled agriculture with the no-till fields Pias' team studied.

Overall, Sanden says, "I like this type of meta-data analysis." The agricultural community needs to do more of these types of analyses, he says—they "don't need to reinvent the wheel," just do a better job of comparing existing research to figure out what works most efficiently.

Dig deeper

View the original article, "Does Gypsum Increase Crop Grain Yield on No-Tilled Acid Soils? A Meta-Analysis," in *Agronomy Journal* at **https://doi.org/10.1002/agj2.20125**.

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