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Gypsum in agriculture: An overview

Ohio State University's Warren A Dick and co-authors look at the use of gypsum in the agricultural sector, with a focus on the United States, and dispell some persistent myths...

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In 1918 Dr William Crocker, who was connected to the Gypsum Industries Association in Chicago, US, wrote a history of the use of gypsum in agriculture. Crocker reports that the fertiliser value of gypsum was already known in Germany and France as early as the second half of the 18th Century. Knowledge of gypsum's benefits for agriculture and its use as a fertiliser quickly spread to the US and UK. Benjamin Franklin, the great American statesman and scientist, reportedly introduced gypsum to the US, making the first use of it in the country on his farm near Philadelphia.

In 1808, Dr G Fothergill of Philadelphia provided a report to the Board of Agriculture in the UK on what was known at that time related to gypsum use in agriculture. Dr Fothergill stated, "In the year of 1768 the Reverend A Meyer of the Canton of Berne, by a fortunate accident, discovered the fertiliser value of gypsum and liberally disclosed the secret to neighbouring farmers. To their great surprise, experiments soon convinced them of its efficacy, which they considered little short of magic."

Many of the agricultural benefits summarised by Crocker, in his history of gypsum use in agriculture, are still relevant today. These, and more recently discovered benefits, will be reviewed in this article.

Sources of gypsum for agriculture

The sources of gypsum used in agriculture are mainly from gypsum mines and from scrubbers at coal-fired power plants. The latter is known as flue gas desulphurisation (FGD) gypsum. It represents a type of synthetic gypsum. Other sources of gypsum include recycled new and demolition construction materials such as wallboards, gypsum wastes from the manufacturing of various products such as citric/lactic acid, and as a by-product of water treatment plants.

The global extent of gypsum use in agriculture is difficult to estimate. However, it is very significant, as the mineral is a common soil amendment used for the reclamation of sodic and saline soils. In the US, the agricultural use of FGD gypsum has been recorded for more than 20 years by the American Coal Ash Association (ACAA). The use of this source of gypsum in agriculture rose from 68,875t in 2000 to a high of 1.21Mt in 2014.

However, agricultural use of FGD gypsum remains a small percentage of the total amount of FGD gypsum produced, which has declined from its peak in 2014. For example, in 2019, the ACAA reported that a total of 20.1Mt of FGD gypsum was produced in the US. Of the 12.0Mt of FGD gypsum that went on to be used, the largest use was in the production of gypsum panel products, including wallboard. This use accounted for 8.8Mt of FGD gypsum, around 44% of the total volume produced. By contrast, agriculture only consumed 2.5% of the total volume produced, a volume of around 0.5Mt. Approximately 42% of the FGD gypsum produced

Right: Gypsum pile prior to being spread on an agricultural field. **Source:** Warren Dick.

Benefits of using gypsum in agriculture

1. Remediates soil properties and enhances crop production in naturally occurring sodic/ saline soils or similar types of soil created by improper irrigation;
2. Serves as an excellent source of sulphur and calcium;
3. Enhances soil aggregation, which improves soil aeration and water infiltration into and percolation through the soil profile;
4. Reduces acidic subsoil effects and improves rooting of crops;
5. Reduces soluble phosphorous run-off;
6. Reduces erosion and loss of soil and nutrients from fields;
7. Enhances both inorganic and organic carbon concentrations in the soil;
8. Used as a component of plant growth media;
9. Improves fruit and vegetable quality.

in the US in 2019 was not beneficially recycled, indicating the potential for further development of its use in agriculture.

Benefits of gypsum in agriculture

For agricultural producers, gypsum has many benefits. It is not a magical elixir that can solve every agricultural problem, but a proven resource that can improve many soil and environmental properties, as well as enhancing crop yields and quality. The main benefits are summarised at the top of this page.

One of the common misconceptions about agricultural use of gypsum is that it is a liming agent that substantially changes soil pH. It is true that gypsum will help alleviate soil pH problems, but it does so by different mechanisms than by changing the soil pH itself. One mechanism is that, by opening up the soil and enhancing water percolation, carbonates and sodium can leach out of high pH soils. This will not only reduce salt concentrations, but it will indirectly reduce soil pH. In acidic soils, soluble aluminium is toxic to plant roots. Gypsum will help remove the aluminium from the soil or convert it to a less toxic form, making the soil more conducive to the development of plant roots and overall plant growth, even though soil pH is only slightly altered.

Environmental benefits

Two further advantages of using gypsum as a soil amendment have recently been articulated. One is that the calcium in gypsum, when applied to soils with high amounts of soluble phosphorous, will bind with and precipitate it. This means that the phosphorous is no longer able to leach from the field into surface waters, where it degrades water quality. In addition, the gypsum creates aggregates that promote water infiltration and heavier particles. Both of these effects lead to less soil erosion and movement of phosphorous bound to sediment. The overall effect is to improve water quality coming off of the field.

A second environmental benefit involves the well-known mechanisms of how calcium serves as a bridge to bind organic carbon to clay particles. This has two benefits. One is this organic carbon serves as a glue to create aggregates. Many of the pores in these aggregates are too small for microorganisms to live in. Thus, the organic carbon is physically protected from being degraded, representing a soil -based carbon sequestration mechanism. Also, organic carbon bound to clay particles means it is not in a soluble form. This insoluble form is chemically stable.

Finally, there is some evidence that in soils with high pH and high amounts of CO_2, for example the conditions that surround a plant root, a reaction occurs to create inorganic carbonates. This is yet another form of soil-based carbon sequestration.

Economic benefits

Besides the agronomic and environmental benefits, there are also economic benefits. In a survey conducted by Batte and Forster in 2015, a total of 309 responses were obtained from a list of subscribers to the No-Till Farmer magazine. Of this total, 85 responses were obtained from farmers who were known to be agricultural users of gypsum.

This survey found a high level of satisfaction with gypsum as a soil amendment and nutrition source. It was calculated that each US$1 invested in gypsum application to soils resulted in US$1.68 of benefits. Another key finding from this survey is that benefits from gypsum usage are not instantaneous, but that they increase over time. As gypsum use was continued on a field, farmers reported reductions in use of nitrogen, phosphorous, potassium fertilisers and agricultural lime.

Barriers to the use of gypsum in agriculture

In spite of the many benefits of gypsum for agricultural uses, it remains somewhat of a controversial topic for some agricultural professionals. This is due to several reasons. One is due to studies that have shown little or inconsistent beneficial results in terms of improving crop yield and quality. This is not surprising, as many gypsum experiments are conducted on university farms and on soils that would already be considered fertile. Such studies are often conducted for only a year or two. As the benefits of gypsum as an agricultural amendment increase with time, a two year study will not allow the effects to be adequately observed.

There is also scepticism from some quarters that using by-product gypsum on land is really just a means of disposal and that it is not truly beneficial. It is true that some recycled gypsum materials are not suitable for agricultural use because of contamination. Recycled gypsum from wallboard waste can contain nails and paper, which must be properly removed before the gypsum can be beneficially used in agriculture. For the most part, professional recyclers do a good job of cleaning the recycled demolition gypsum.

FGD gypsum may also contain trace elements from the fuel, including mercury and selenium. However, extensive investigation by the Electric Power Research Institute and others has shown that in most cases, the FGD gypsum easily met the environmental standards put forth by the US Environmental Protection Agency (EPA). Although some soils are deficient in boron, this element may also be a concern if found in the gypsum applied to land. This element is unique among micronutrients for plants given that the concentrations at which boron switches from being essential to toxic are extremely close. It is therefore highly important that care be given to the proper use of gypsum as an agricultural amendment, as even one bad example can create negative perceptions.

The USDA has published a beneficial use standard (USDA, 2015), which has spurred on the use of FGD gypsum by farmers. Indeed, several US States have now approved FGD gypsum application as a best management practice and have contributed to its use by providing cost share to farmers to apply gypsum.

One thing still lacking in the US is the release by the EPA of the risk assessment on agricultural use of FGD gypsum. This risk assessment has been completed for quite some time, but it has still not been made publicly available.

Finally, large-scale agronomic uses of gypsum are closely tied to the health of the farm economy. When commodity prices are strong and the farm economy is strong, farmers will make longer term investments to improve farm soils. However, crop producers are often forced to focus on short-term benefits of amendments, especially when the farm economy is weak.

Right: The environmental and economic benefits of agricultural gypsum take time to grow.
Source: Shutterstock.

Right: Spreader filled with gypsum.
Source: Darrell Norton.

Summary and conclusions

Gypsum has a long history of use in agriculture and its benefits to agriculture have become increasingly well known. Both naturally occurring and synthetic gypsum are suitable sources for agricultural use. The source of gypsum for agricultural uses is not so important as its quality in terms of being free from heavy metals and other impurities.

Many soils around the world have become degraded due to erosion and salt accumulation. Gypsum can play a role in remediating such soils. Gypsum can have added benefits for the soil and the environment by enhancing carbon sequestration in the soil. Gypsum can also reduce phosphorous movement from fields by aiding in the control of erosion and by reducing soluble reactive phosphorous in water that leaves a field. The use of gypsum for agriculture in the future is likely to increase provided farmers have access to high-quality gypsum via trusted connections.

Further reading

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