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Does Use of Gypsum Improve Soil Structure in Kentucky?

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Gypsum is sometimes recommended as a soil amendment in order to improve structure. Although this practice is often used for reclamation of sodic soils (Na⁺ saturated) in the western USA, it's value in improving soil structure in Kentucky is questionable. The following discussion explains why.

What is gypsum

Gypsum is the naturally occurring or man-made compound, calcium sulfate dihydrate (CaSO₄·2H₂O). In addition to being mined, it is also commonly available as a by-product from lime scrubbers used to clean sulfur from coal-burning power plants or from the phosphate fertilizer industry. It readily dissolves in water to a maximum calcium concentration of about 600 parts per million (ppm), and a maximum sulfur concentration of about 480 ppm. This contrasts to only 20 to 40 ppm maximum concentration of calcium resulting from mixing pure calcium carbonate (lime) in water.

How does gypsum improve soil structure

Soil structure is related to the capability of individual soil aggregates to maintain their physical form when saturated with water. Capability to maintain structural stability is strongly influenced by the cation exchange capacity and the nature of the ions adsorbed. This influence is most important on soils with a high content of expanding-type clays which swell and shrink with alternate cycles of wetting and drying. Shrinking and swelling of these clays greatly influences soil structure and relates to the kind of cations which are dissolved in the soil solution and are adsorbed on the clay surfaces. If the soil solution is dominated with sodium (Na⁺) and Na⁺ is adsorbed on the surface of expanding-type clays, the individual clay particles show maximum expansion and furthermore, repel each other and become dispersed in wet soil. When dispersed, stability of soil aggregates is greatly diminished and when the soil dries, a massive structure of undesirable physical characteristics develops (crusts, hard, does not absorb water readily). However, if the dominant cation dissolved in the soil water and adsorbed on the surface of expanding-type clays is Ca²⁺, soil aggregates maintain their stability and do not disperse when the soil is water saturated. As a result, structural stability is maintained as the soil dries.

For soils dominated with adsorbed Na⁺ (sodic soils) use of a highly soluble source of Ca²⁺ is useful in improving structure since Ca²⁺ will replace Na⁺ on the clay surfaces and reduce aggregate dispersion when the soils are wetted.
Does gypsum improve soil structure in Kentucky

Soils in Kentucky do not contain appreciable quantities of adsorbed Na+, except for localized areas which sometimes receive overflow of brine adjacent to or downstream from oil wells. Additionally, most Kentucky soils are not as high in expanding clay content as are sodic soils which can be reclaimed with gypsum. The two most important characteristics of soils in Kentucky which improve structural stability are organic matter content and content of amorphous iron and aluminum oxides which coat soil particles. Both of these characteristics act as "cement" to keep soil aggregates intact when the soil is water saturated. The influence of these two factors in maintaining stability of soil structure is far greater than the tendency for aggregates to disperse when soluble Ca2+ content of the soil is low. Soils in Kentucky are unlikely to disperse unless they are "overworked", the soil pH approaches and/or exceeds 8.0, and the soil solution is depleted of Ca2+. With the exception of "overworking", these conditions rarely occur in Kentucky. In fact, investigations in the University of Kentucky Department of Agronomy show Kentucky soils to contain 60 to 200 ppm of dissolved Ca2+ when soil pH is around 6.0. Since it takes only 10 to 20 ppm of dissolved Ca2+ to maintain aggregation even at pH values near 8, the use of gypsum on soils which already contain much more dissolved Ca2+ than this, is for all practical purposes, useless and expensive.

How does gypsum compare with limestone

Keeping pH of acid soils properly adjusted is strongly recommended for plant growth in Kentucky. This can effectively and economically be accomplished by use of good-quality agricultural limestone or other liming materials. Use of lime in adequate amounts lowers soil acidity and provides enough soluble Ca2+ in soil solution to meet plant growth requirements and to prevent dispersion of soil colloids. Additionally, the solubility of iron, manganese, and aluminum in soil solution is diminished from proper use of lime on acid soils, while solubility of phosphorus is improved. Improved soil structure is also indirectly related to use of lime on acid soils since the resulting better plant growth provides for greater amounts of organic matter accumulation in the soil.

In contrast to lime, gypsum has no liming value. It is neither a base nor even a neutral salt since it is slightly acid. As a result of its high solubility, gypsum enriches the soil solution with both Ca2+ and sulfate (SO42-). This can cause problems when applied at rates approaching 1T/A (4.6 lbs/100 ft2) under certain soil conditions. In this case, acidity of the soil solution can actually be temporarily increased instead of decreased. Additionally, the SO42- from gypsum can increase soil solution content of aluminum, iron, and manganese, creating a greater potential for their concentration to be toxic to plants.

Summary

Calcium content of soil solution is usually high enough to maintain structural stability within the range of clay mineral types found in Kentucky soils. Also, with the exception of sodium contamination around oil wells, sodium content of Kentucky soils is not high enough to cause dispersion and thereby break down structural aggregates in the soil. Because of this, it would be very unlikely for use of gypsum to improve soil structure in Kentucky. Since gypsum is not a liming material, it does not decrease soil acidity, and if used in sizeable amounts, may in fact contribute to temporarily increased soil solution acidity. Structure in Kentucky soils can best be maintained or improved by not over-tilling the soil and by increasing the amount of organic residues returned to the soil each year. If pH of acid soils need adjusting, a good-quality liming material should be used.