United States Department of Agriculture

NRCS Natural Resources Conservation Service

AMENDING SOIL PROPERTIES WITH GYPSUM PRODUCTS

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AGRONOMY TECHNICAL NOTE – Quality No-Till Series

The *Quality No-Till Series* provides management techniques for the successful adoption of Quality No-till Cropping Systems. This information is applicable to most Indiana soils and cropping conditions and covers broad application.

The soil chemistry in the surface zone may become stratified over time in some minimum and no-till cropping systems. In most studies, this has not been shown to be a significant yield limitation, however, chemical and physical soil properties that affect water infiltration and runoff can have negative consequences if not monitored and managed accordingly. Using gypsum products to change the physical or chemical properties of soil can be a useful tool to help mitigate some of these negative consequences when combined with a sound conservation cropping system. Refer also to additional AGRONOMY Technical Notes in the Quality No-till Series

Soil physical and chemical condition that are evaluated according to the information and tables below meet the NRCS ***approved process*** to determine need, timing, placement, and rate for gypsum products as stated in the Indiana (IN) Field Office Technical Guide (FOTG) Standard (801) Amending Soil Properties with Gypsiferous Products.

Primary purposes for Gypsum (calcium sulfate dehydrate – $CaSO_4$)-derived products

- Improve soil physical/chemical properties to reduce soil erosion and improve infiltration.
- Reduce dissolved phosphorus concentrations in surface runoff and subsurface drainage.
- Reduce the potential for pathogen transport from areas of manure and biosolids application.

How These Products Work:

- Calcium (Ca) is the only humus-associated cation that can flocculate clay particles. This aids in the process of building water stable aggregates.
    - In contrast, magnesium (Mg) at the soil surface tends to disperse clay particles, filling soil pores and creating crusts. The sulfate (SO_4) in gypsum reacts with the Mg to form $MgSO_4$ which is more soluble and can more readily leach into the soil profile than Mg alone.
- The combination of improved infiltration and gypsum's ability to react with phosphate (P_2O_5) also reduces soluble reactive phosphorus losses by 40 - 70% (Warren Dick, 2015).

Management Strategies

1. Reducing runoff decreases the primary transport mechanism for dissolved phosphorus (P). Runoff can best be decreased by implementing a Conservation Cropping System with continuous no-till, cover crops, and the treatment and prevention of compaction and surface crusting. Application of gypsum can complement any or all of these practices.
2. Evaluate the soil conditions. Look for surface crusting, poor aggregate stability, and lack of pore space.
3. Evaluate the field conditions. Look for signs of water saturation and ponding, yellowed crops, nutrient deficiencies, ruts, erosion etc.
4. Use normal soil testing procedures, and samples that are taken within the current or previous year, for use in evaluating need and application rate in Table 2. If recent tests are not available, schedule enough time to acquire new soil samples and lab results using the procedures in #5 below prior to planning gypsum application.
5. During subsequent normal soil sampling for nutrient management, take at least 1 surface (0 - 2") spot/reference sample from each area/management zone (12 acres or less) to represent the major soil types under consideration. This will be used to evaluate changes in the Calcium, Magnesium, Phosphorus, Potassium and pH levels in the soil surface and to prescribe adaptive management.

6. Prioritize gypsum application to fields with observed conditions from any of the following (alone or in combination):
    - 2 & 3 above
    - Clay content >30%
    - Cation Exchange Capacity (CEC) >12
    - Soil organic matter < 3%
    - Magnesium base saturation above 18%
    - Soil test phosphorus >80 ppm (0 – 8" soil sample)

7. If surface soil samples indicate pH of less than 5.8, and/or the full depth samples indicate a pH less than 6.0, the application of high calcium lime is a higher priority, and a better investment, than the application of gypsum. Plan gypsum application(s) for subsequent years if needed once adequate pH levels are attained.

8. **Application Rates** of gypsum will generally range from 1000 - 4000 lbs/ac/yr. Application rates will be determined from:
    - Product validation of the actual $CaSO_4$ content of the product
    - The screening and verification that product meets State and Federal contamination guidelines.
    - The guidelines in Table 2.

9. Gypsum derived products must have a particle size less than 1/8 inch. Fluid application is acceptable.

10. This additional guidance is used for the more critical scenarios with the following chemical and physical soil properties:
    - Mg % base saturation >18% should receive the upper rate for the CEC range in table 2a.
    - Clay content >50% - consider planning 2 applications in alternating years (e.g. years 1 and 3)
    - Phosphorus concentration >80 ppm from a 0-8" sample – consider planning 2 applications in alternating years
    - Soil test phosphorus (STP) is greater than two times the "adequate level" for crop production, or when the P Index rating for the field is HIGH or VERY HIGH - broadcast no less than 1 ton/acre on the soil surface (not incorporated).
    - Manure application – broadcast no less than 1 ton/acre of gypsum within 5 days after manure application or prior to the next runoff event, whichever occurs first.

11. Application timing:
    - Summer or fall, immediately after crop harvest and when dryer soil conditions reduce risk of soil compaction, is always the preferred timing.
    - Gypsum is a moderately soluble product - avoid applying to snow-covered or frozen ground to prevent loss to wind and water.
    - Most Gypsum products have enough moisture to freeze up when temperatures are significantly below freezing. This makes proper application not possible for most equipment.
    - There are some instances in the late winter and early spring when daily freeze thaw cycles occur, and the surface freezes at night and thaws enough in the afternoon to dampen the surface where the gypsum could begin reacting with surface soil. Application on this slightly frozen ground would be okay, However this is a narrow window and caution is needed to assure no rutting or compaction occurs which could counteract the benefits of the gypsum.
    - Avoid applying gypsum ahead of a significant water runoff event such as a forecast prediction of greater than .5 inches of rain in a 12 hour period, or significant snow melt.
    - Manure/gypsum application timing – Broadcast gypsum on the soil surface (not incorporated) prior to or within 5 days after manure application or prior to the next precipitation event after manure application, whichever occurs first. ***Under no circumstances will manure and gypsum be blended due to the likelihood of toxic gas emissions.***

12. An increase in soil bio-diversity improves soil health and nutrient cycling. Regular soil testing, scouting for crop nutrient deficiencies, monitoring of soil compaction, tissue sampling and monitoring soil health indicators should be part of a strategy for conservation cropping systems.

13. For best results, gypsiferous products should be part of a conservation cropping system that includes: quality no-till or strip-till; adapted nutrient management; strategic cover crop integration; diverse conservation crop rotations; precision farming technology; prescriptive conservation buffers and other support practices such as drainage water management. These practices are integrated into a profitable and sustainable system where each practice complements the rest.

14. Gypsum may be applied to pastures anytime livestock are not present. Do not allow livestock re-entry until the gypsum products have been removed from the vegetation by rainfall/irrigation.

Table 2: Gypsum derived product application rate determination to improve soil physical/chemical properties and increase infiltration. The prescribed minimum application rates are based on a calcium sulfate dihydrate equivalency of 100%.Composition of pure gypsum ($CaSO_4 \cdot 2H_2O$) is 79% calcium sulfate ($CaSO_4$) and 21% water (H_2O). Pure gypsum contains 23.3% calcium (Ca) and 18.6% sulfur (S). Application rates for products that are less than 100% calcium sulfate dihydrate equivalence should be adjusted accordingly

Cation exchange capacity (CEC) is an indirect indicator of clay and organic matter content of soil and is related to how adjustment is needed when certain cations are excessive or deficient. The saturation ranges in Table 2a represent optimal cation availability for good soil structure as well as plant and biological use.

Table 2a: Target ranges for base saturation of cations to improve soil chemical and physical properties.

Base Saturation	Balanced
Calcium	70 – 80%
Magnesium	10 – 13%*

*Mg soil test level should not fall below 200 lb/acre

Calcium and magnesium have the greatest impact on soil structure. Lower CEC soils that tend to be droughty would prefer calcium at the lower end of the range and magnesium to be at the higher end. Higher CEC soils tend to perform best with calcium at mid-to-hi range and magnesium at the lower end of the range. (NOTE: Amendment tables based on electrical conductivity for addressing saline and sodic soils are not addressed in this standard.)

Table 2b lists recommended annual application rates based on CEC. Multiple applications at the recommended rates will improve soil chemical and physical properties in a reasonable time without creating soil nutrient imbalances. Once the ratios shown in Table 2a are achieved, application rates can be reduced or stopped until soil test values indicate otherwise.

Table 2b: Gypsum application rates to improve soil chemical and physical properties.

CEC	Rate (ton/acre)*
<5	N/A
5 – 9	0.25 - 0.5
10 – 15	0.5 - 1
>15	1 - 2

Goal: Base saturation of Ca = 70% to 80%

* Annual application rate in ton gypsum/acre