

Some reasons for using gypsum on land in the Pacific Northwest

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Gypsum is usually thought of as the means for correcting sodicity of soils in arid lands. The use rate for this purpose is usually from one to several tons per acre and is determined by soil analyses. But gypsum has also much to offer for soils that are not sodic. Rates for these types of use are usually much lower.

Gypsum is one of the best sources of calcium, perhaps the most important of the secondary plant nutrients. But calcium is more than a nutrient. It is the major "balancing" element in plants and soils. It protects, within limits, from nutrient excess and deficiency, from problems caused by both high and low pH, and from heavy metal contamination. Along with organic matter, calcium improves soil structure.

Gypsum as fertilizer

Pure gypsum is 21% calcium and 19% sulfur ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). An essential nutrient itself, calcium also improves root uptake of other plant nutrients, especially ammonium nitrogen. Calcium does not move from old to new plant tissues, so a constant supply of soluble calcium in the soil solution is needed. The growing points of both roots and shoots are sensitive to insufficient calcium, but roots more so. The ratio of calcium to sodium is more critical than the actual concentration of calcium since balance is important. Calcium is also useful when there is an excess of magnesium.

Symptoms of calcium deficiency include...

- Water-soaked, discolored areas on fruits, such as blossom-end rot on tomatoes, peppers, melons and squash, or bitter pit or cork spot on apples and pears. Tip burn on young leaves of celery, lettuce and cabbage.
- Death of terminal buds and root tips.
- Abnormal dark green appearance of leaves
- Premature shedding of blossoms and buds.
- Weakened stems.

Calcium is more often deficient in high-rainfall, acid-soil areas, such as the Pacific Northwest, west of the Cascade Mountains, and east of the Mississippi River where soil may be acid. Deficiency symptoms, such as tomato blossom-end rot, often appear there after a period of heavy rainfall. Gardeners apply ground dolomite or limestone primarily to raise pH, but also to replace lost calcium (and magnesium when dolomite is used). Since the calcium in limestone is not water soluble, it must be incorporated into the soil and brought into contact with soil acids before calcium ions (Ca^{++}) are released.

Limestone does not migrate downward in the soil and is effective only to the depth incorporated. In contrast, gypsum dissolves sufficiently in the moisture of the soil to allow plant roots to absorb the calcium ions and the sulfate ions (SO_4^{2-}). Because it is dissolved in the soil solutions, gypsum readily migrates into the lower depths in the soil.

The other component of gypsum, sulfur as sulfate, is supplied to plants with gypsum is essential to protein synthesis. Sulfur is a constituent of the amino acids cystine, methionine and cysteine. It is also essential for nodule formation on legume roots and for the characteristic odors of plants such as garlic and onions. Sulfur deficiencies are less common than calcium deficiencies, but can occur throughout North America, particularly in high rainfall areas.

If sulfur is applied as elemental sulfur, it is not available until appropriate soil bacteria oxidize it to sulfuric acid. Surface-applied sulfur is oxidized faster than incorporated sulfur; but because the required bacteria are frequently not present in alkaline soils, the oxidation rate may be very slow. Gypsum supplies sulfur as sulfate, the form plant roots can absorb.

Symptoms of sulfur deficiency include...

- Light green to yellowish young leaves.
- Small and spindly plants.
- Retarded growth rate and delayed maturity.

Gypsum as soil conditioner

Compacted soils are potential problems anywhere, and organic matter, such as compost, is generally the best remedy, unless the soils are sodic. Gypsum helps get the most benefit from organic matter added to the soil. Soil crumbs and aggregates that give structure to soil are cemented together with glues that include ions, such as calcium. Leaching with rainwater decreases the salinity of soils. This can cause soil to lose its physical structure despite the present of adequate organic matter. Correcting acidity with limestone helps, but limestone does not contribute calcium ions to the soil solution. Gypsum also protects the soil from compaction and other types of degradation where irrigation water is reclaimed or of low quality.

Gypsum participates in flocculation of soil. The calcium serves as a binding agent which results in fine clay particles binding together to make larger and water-stable aggregates. Results include better soil aeration, less crusting, with improved seedling emergence, less dust, less clay adhering to root and tuber crops at harvest. But gypsum can do all these tasks better if combined with organic matter additions and even with water-soluble polymer soil conditioners (Wallace 1994, 1995; Wallace and Wallace 1995abc). Mycorrhizal fungi function best when a liberal supply of calcium is present (Lynd and Ansman, 1995).

Gypsum and soil pH

In most situations, gypsum has little effect on soil pH. Limestone is used to raise pH of acid soils and elemental sulfur to lower pH of alkaline soils. However, if soil is alkaline because of high bicarbonate ions, or if irrigation water contains bicarbonate, the soluble calcium in gypsum reacts with the bicarbonate to form insoluble calcium carbonate. The pH of the soil is

decreased to the range of 7.5 to 7.8 when bicarbonate is reduced. Also, limestone does not move through the soil to lower depths. Gypsum is the best way to supply calcium to soil and roots that are below cultivation depth where calcium and sulfate are needed to decrease the effects of subsoil acidity. A mixture of lime and gypsum is usually better than either alone to improve acid soil.

Water-soluble polyacrylamide (WSPAM) has been used in the Northwest, often with gypsum to enhance emergence of onion seedlings, to improve yields of potatoes (25 percent yield increase for only \$15 per acre was obtained), and for virtually eliminating erosion from furrows. The effects of combined gypsum with WSPAM and organic matter have been shown to be additive and synergistic. Combined responses are much greater than the sum of the individual ones. This means that gypsum and other conditioners can fit into best management practice systems to maximize the value of all.

Use Gypsum if...

- A soil test reveals any calcium or sulfur deficiencies.
- Soil pH is under 5.5 or over 8.2.
- The sodium absorption ratio (SAR) is greater than 4 or even less if rainfall is high.
- Water puddles on soil.
- Soil contains clay that is very dusty when dry.
- Soil particles disperse when wet.
- A crust forms on soil surface after rain or irrigation.
- Toxic amounts of heavy metals are present in the soil.
- Irrigation water contains high levels of sodium, bicarbonate, boron, or heavy metals like in reclaimed wastewater.
- Soil tends to erode like on slopes or with heavy rainfall.
- When irrigating with gray water that includes a variety of soaps.
- Soil boron levels are high around boron-sensitive plants.

Summary of major uses

Many benefits have been obtained for the use of gypsum on land. Those here are a few of the more important ones.

1. Providing calcium and sulfur as plant nutrients; the calcium also protects against imbalances of other elements.
2. Improve soils having high exchangeable sodium percentages.
3. Increase water infiltration of soils that take water poorly.
4. Decrease erosion from slopes and from soils having poor structure.
5. Increase soil flocculation where EC (conductivity) of soil is very low, like in high rainfall areas.
6. Improve acid soils, especially when co-used with lime.
7. Improve the effects of water-soluble soil conditioners and organics on land.