


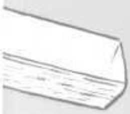


GYPSUM

and Sulfur-bearing AMENDMENTS for Arizona Soils

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Contents

	Page
When is a Soil Corrective Needed?	3
To Improve Soil Physical Condition	3
To Improve Quality of Irrigation Water	7
What is Gypsum? Where is it Found?	8
What Characteristics of Gypsum Affect Its Use?	8
How Much Gypsum is Needed?	9
How Can Gypsum be Applied?	9
What About Other Agricultural Chemicals Which Produce Gypsum?	9
Which Amendment?	11

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GYPSUM

and Sulfur-bearing AMENDMENTS

for Arizona Soils

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When Is A Soil Corrective Needed?

Gypsum is used to correct and reduce undesirable concentrations of sodium in soils. It is not used in Arizona as a plant nutrient to supply sulfur or calcium, since semiarid and arid soils are usually well supplied with these elements. Also, irrigation waters used in the state supply appreciable amounts of sulfur and calcium.

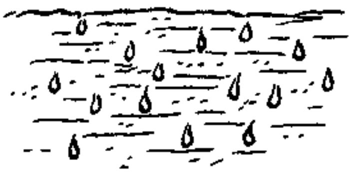
More than 10,000 tons of gypsum were sold in Arizona during 1960 according to the Annual Report of the Arizona State Chemist. This represented 67 percent of the total agricultural minerals sold in that year. During the same period more than one million tons of gypsum were sold in California.

To Improve Soil Physical Condition

On Arizona soils, gypsum and sulfur-bearing amendments are used primarily to improve soil physical condition. Since our arid and semiarid soils are well supplied with both calcium and sulfate, gypsum is seldom needed as a fertilizer.

Gypsum, sulfur, and various sulfur-bearing compounds have been used successfully for many years under certain conditions. Under other circumstances, their value is questionable. **What soil conditions can you expect to improve through the use of such materials?**

1. How permeable is your soil?



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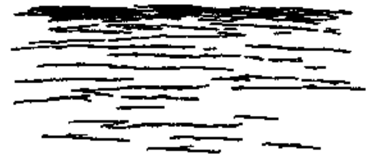


Or This?

In normal soils, the rate at which water penetrates the soil varies with texture. Water penetrates fine-textured (heavy) soils such as clay loams and clays very slowly. It will penetrate loams and sands much more rapidly.

Therefore, fairly slow penetration into a fine-textured soil does **not** mean it is impermeable. If, however, water stands on your soil for a long time and yet the soil is dry a foot or less below the surface, it **is** impermeable for all practical purposes.

If water penetrates your soil readily, gypsum or other soil conditioners probably will be of little value in improving soil physical condition.

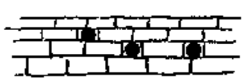
2. If your soil is impermeable, find out why.

When water does not penetrate your soil readily, take a careful look. If it has been plowed to the same depth for several years, a **plow sole** layer may have developed. If it has been cultivated while wet, it may have become **puddled.** If heavy equipment has been driven over it several times (particularly in furrows), it may be **compacted.** If an excessive number of tillage operations have been performed, it may be **pulverized.**

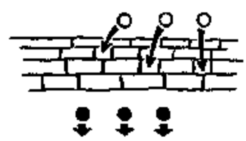
Any of these conditions can result in poor water penetration. Remedies such as varying the depth of plowing, reduced cultivation, manure applications, and turning under crop residues or cover crops will be of more value than gypsum.

If your soil is impermeable, but does not have any of the conditions noted above, obtain a laboratory test of your soil and irrigation water to find out if sodium is your problem.

3. Sodic (Alkali) soils can be improved by gypsum.



Too much adsorbed sodium. The particles are packed tightly and water cannot get through.



Soluble calcium replaces the excess adsorbed sodium which must then be leached out.

This replacement allows soil particles to group so that larger pore spaces are formed and water can pass through.

Soils containing too much sodium adsorbed on the clay usually have a poor physical condition. These are called "sodic" soils (formerly known as "black alkali"). They have poor structure and disperse readily upon wetting. When dry they are hard and compact, and form hard clods when worked. Unusual swelling and shrinking with accompanying formation of large cracks are also common features of a sodic soil. Characteristically the rate of water penetration is very low.

Clay particles hold cations such as calcium, magnesium, sodium, and potassium attached to their surfaces. These cations, which can replace each other on the clay particle, are said to be adsorbed. If too large a proportion of the total adsorbed cations is sodium, the unfavorable physical condition described above will develop.

By definition, sodic soils contain enough adsorbed sodium to modify physical properties of the soil such that crop-producing value is reduced. The percentage of adsorbed sodium that could be classed as "too much" differs in different soils. On the basis of chemical equivalents, however, about 15 percent or more will cause difficulty.

When the sodium content of a soil becomes high enough to form soluble salts such as sodium carbonate in the soil solution, organic matter dissolves, coloring the solution black. Upon evaporation, the solution leaves a black residue. The observance of this deposit has led to the term "black alkali." Sodic soils may or may not exhibit such black deposits.

Sodic or "black alkali" soils respond to gypsum (and other amendments described later in this bulletin). The function of the gypsum is to supply soluble calcium which can replace sodium adsorbed on the clay. The gypsum application must be followed by a leaching irrigation to remove replaced sodium from the root zone of your soil.

Successful reclamation of a sodic soil depends upon:

(a) Adequate drainage through the soil (no restrictive layers which prevent the downward movement of water).

(b) Proper leveling (for surface irrigation methods).

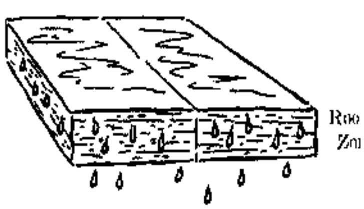
(c) Leaching.

(d) Establishment of a sodium-tolerant crop.

Water with a favorable (low) sodium to calcium plus magnesium ratio is also highly desirable.

4. You can reclaim many saline (salty) soils without gypsum or other conditioners.

A saline (salty) soil contains harmful amounts of soluble salts that may restrict plant growth depending on the amount of salts and the crop to be grown. Such soils usually have good permeability so long as the salts remain. Some are quite permeable at first, but become impermeable upon extensive leaching with good quality irrigation water.



If your soil contains harmful amounts of soluble salts, yet remains permeable when large amounts of irrigation water are applied, it can be reclaimed without using gypsum. Level your land properly, apply ample irrigation water to leach salts below the root zone, and grow your crop.

5. Some saline soils become impermeable when they are leached and may respond to gypsum.

Most saline or "white alkali" soils can be reclaimed by leaching alone as described above. However, in some instances such soils become quite impermeable if excessively leached with water low in soluble salts. When this happens, the soil usually contains adsorbed sodium, but the sodium effects have been masked by the saline condition.

Under these conditions, gypsum will be of the same benefit as on any other sodic soil. However, leaching with water fairly high in soluble salts may make it possible to maintain penetration rates to permit reclamation without the use of amendments.

Some saline soils become less permeable when leached even though sodium is not a problem. Gypsum applications may be of benefit in some such cases where flocculation is not maintained.

To Improve Quality Of Irrigation Water

Continuous use of water having an unfavorable (high) ratio of sodium to calcium plus magnesium will eventually result in development of a sodic soil with poor physical condition.

All natural waters contain some salts in solution. When the water is used for irrigation, these salts react with the soil. If calcium salts predominate, a water is classed as "hard" and the calcium will tend to maintain a favorable soil physical condition.

If sodium salts predominate, water is classed as "soft," and the adsorbed sodium will tend to accumulate in the soil resulting in an unfavorable physical condition. The often quoted phrase, "Hard water makes soft land and soft water makes hard land," holds true.

If your water is high in sodium but does not contain an excessive amount of total soluble salts, the addition of gypsum to the water may improve its quality for irrigation purposes.

What Is Gypsum? Where Is It Found?

Chemically, gypsum is hydrated calcium sulfate ($CaSO_4 \cdot 2H_2O$). The pure salt contains 23.2 percent calcium, 18.6 percent sulfur, and 20.9 percent water. It occurs as a mineral in two forms, gypsite and gypsum, both of which are found in Arizona. **Gypsite** occurs naturally as a powder or as small grains disseminated throughout the earth mass. **Gypsum** is the crystalline or rock form occurring in mineral deposits.

In some soils, gypsum is derived from deposits present in the sedimentary material from which the soils were formed. In other soils, it results from precipitation of calcium and sulfate during salinization.

Depth and concentration of gypsum in the soil layers were originally controlled by the extent of leaching during soil formation. Recent accumulations of gypsum in the surface and upper layers of soil are controlled largely by man-imposed soil and water management practices.

What Characteristics of Gypsum Affect Its Use?

Solubility

Gypsum is sufficiently soluble in water for effective use on soils, although much less so than some other common soluble salts. At ordinary temperatures, a saturated solution contains about 0.25 percent, or 2500 parts per million, gypsum.

Under field conditions, the practical solubility of gypsum is influenced by presence of other salts, temperature, time, and fineness. However, it usually will be somewhat less than the maximum quoted above. Its solubility may be increased several fold by the presence of other salts such as sodium chloride in the water. (This is important as sodium salts cause the most serious physical problems in soils.)

Fineness

When purchasing gypsum for use as a soil corrective, insist upon finely ground material. Finely ground gypsum will dissolve more rapidly than coarsely ground material of the same quality. The amount of gypsum in a solution obtained by shaking ground gypsum with water may vary 20 percent or more depending on the fineness of grinding.

Quality

Know the purity of the product you are buying and buy on the basis of guaranteed analysis of calcium sulfate.

Gypsum can be obtained in mill-run or refined grades. Refined grades are rarely lower than 90 percent calcium sulfate. Mill run is available in a variety of grades ranging to as low as 20 percent calcium sulfate. The Arizona Fertilizer Materials Act requires that, "the percentage of calcium sulfate contained therein be indicated clearly on each source of gypsum or agricultural mineral, the principal constituent of which is calcium sulfate."

How Much Gypsum Is Needed?

The amount of gypsum to use will depend upon the gypsum requirement of the soil, the quality of irrigation water to be used, and economics of the situation.

There is no unfavorable effect on a crop from using fairly large quantities of gypsum. As much as 22 tons per acre have been used on Arizona soils with no ill effect on plants.

Economics usually prohibit the use of high grade (95 percent) gypsum at rates much in excess of 3 or 4 tons per acre unless a high-value crop is to be grown. Application rates less than 2 tons per acre are probably cf little value unless made at very frequent and uneconomic intervals. In case the area to be treated is not uniformly poor, spot applications at heavy rates may prove most effective and economical.

If you are considering the use of gypsum, obtain an estimate of the gypsum rquirement for your soil. Consult your County Agricultural Agent for information on taking soil samples and obtaining a gypsum requirement test.

How Can Gypsum Be Applied?

Direct application of gypsum to the soil is preferred. The usual method of application is to broadcast and disk into the surface. This insures intimate contact between gypsum and soil particles. Deeper penetration of the chemical can be obtained by broadcasting, plowing under, and disking.

Gypsum also may be applied in irrigation water on a continuous basis. Automatic dispensers have been manufactured to provide continuous feeding of finely ground gypsum into a central source of irrigation water.

What About Other Agricultural Chemicals Which Produce Gypsum?

Certain agricultural chemicals when added to calcareous soils will react with calcium carbonate in the soil to produce gypsum. Some of these chemicals are: **sulfur, sulfuric acid, sulfur dioxide gas, calcium polysulfide,** and **iron sulfate.**

Sulfur (S)

Sulfur has long been recommended for use in calcareous soils for various reasons. It has been used for reclamation of sodic soils, to aid in preventing surface crusting, and to improve the availability of certain plant nutrients.

Sulfur is oxidized to sulfuric acid by soil bacteria. The oxidation proceeds most rapidly in well aerated, warm, and moist soil. Conditions favoring oxidative microbial activity also favor oxidation of sulfur.

Conversion of sulfur to sulfuric acid does not proceed to any appreciable extent in cold or dry soils. Winter applications, for example, oxidize very slowly. During the summer months, it usually will be converted to sulfuric acid in 4 to 6 weeks if moisture is available.

Sulfuric acid formed from elemental sulfur reacts with insoluble calcium carbonate in soil to produce gypsum. In addition, carbonic acid and calcium bicarbonate are formed. In this manner, insoluble soil calcium is thus made available to react with the soil to displace harmful sodium.

Sulfur is applied by broadcasting directly to the soil followed by disking and irrigating. Since sulfur is insoluble in water, it cannot be applied effectively by adding to irrigation water.

Sulfuric Acid (H_2SO_4)

Sulfuric acid reacts with the soil in the same way it does when formed from sulfur. It reacts immediately to form gypsum. Because it is soluble in water, sulfuric acid can be applied either in irrigation water or directly to the soil. Commercial sulfuric acid is about 93 percent pure.

Sulfuric acid is highly corrosive to concrete and steel. It is **not** advisable to add it to irrigation water if the water must pass through concrete pipes, culverts, or concrete-lined canals. Because of the danger involved in handling, experienced operators are brought into the program to make the application.

Sulfur Dioxide (SO_2)

Sulfur dioxide is a colorless, noninflammable gas with a very irritating odor. It usually is added to irrigation water where it forms sul**furous** acid. This reacts rapidly in the soil to form sulfu**ric** acid, then to form gypsum.

Since sulfur dioxide has a limited solubility in water, application must be made over a long period of time and during two or three irrigations to be as effective as sulfuric acid.

Calcium Polysulfide

Calcium polysulfide is a highly alkaline, brown liquid. Upon reacting with water the sulfur is precipitated as finely divided elemental sulfur. Thus it must go through the same process as powdered sulfur before it can react with calcium in the soil to make gypsum.

Calcium polysulfide which contains about 23 percent sulfur and 6 percent calcium, usually is applied in irrigation water. It is not corrosive to concrete or steel.

Iron Sulfate ($FeSO_4 \cdot 7H_2O$)

Iron sulfate contains about 12 percent sulfur and usually is known as copperas or cake. It often is obtained as a by-product of the mining industry.

Iron sulfate reacts rapidly in moist soil. The end products of this reaction are gypsum and iron oxides. The gypsum can be used to replace sodium, and the iron salts act as cementing agents holding soil particles together.

Applications of iron sulfate are made by broadcast methods.

Which Amendment?

The amendment you choose will depend upon (1) your soils, (2) the time required for the amendment to react in the soil, (3) the availability of materials, and (4) the cost of the amendment per unit of calcium it supplies either directly, or indirectly by reaction with calcium carbonate in the soil.

Gypsum supplies calcium directly, while other materials supply calcium indirectly by reaction with calcium carbonate in the soil. In the few soils not containing calcium carbonate, it is necessary to use gypsum or to supply lime in addition to the amendment.

The rate at which various correctives become effective varies widely. Sulfur is slow acting, because of the intermediate biological reactions which are necessary. Gypsum is effective as soon as it goes into solution. Sulfuric acid is very quick acting.

The Amounts of Various Amendments Required to Supply 1000 Pounds of Soluble Calcium When Applied Under the Proper Soil Conditions.

Amendment	Purity	Pounds required to supply 1000 pounds of soluble calcium
Gypsum ($CaSO_4 \cdot 2H_2O$)	100	4300
Sulfur (S)	100	800
Sulfuric acid (H_2SO_4)	95	2600
Iron sulfate ($FeSO_4 \cdot 7H_2O$)	100	6950
Lime-sulfur solution (calcium polysulfide)	24 (% sulfur*)	3350

*Because such solutions have indefinite chemical compositions, their purity is expressed in terms of sulfur content.

The application of a soil corrective is not a substitute for good soil and water management. Used properly and when needed, such materials can be beneficial; used improperly, they will be ineffective and the problem will still remain.

For more detailed information on the use of gypsum pertaining to a specific situation on your own farm, see your local County Agricultural Agent. Also, at the County Agent's Office in your county you may obtain other publications with agricultural and home economics information. Ask for a list of these publications—Folder 68.