

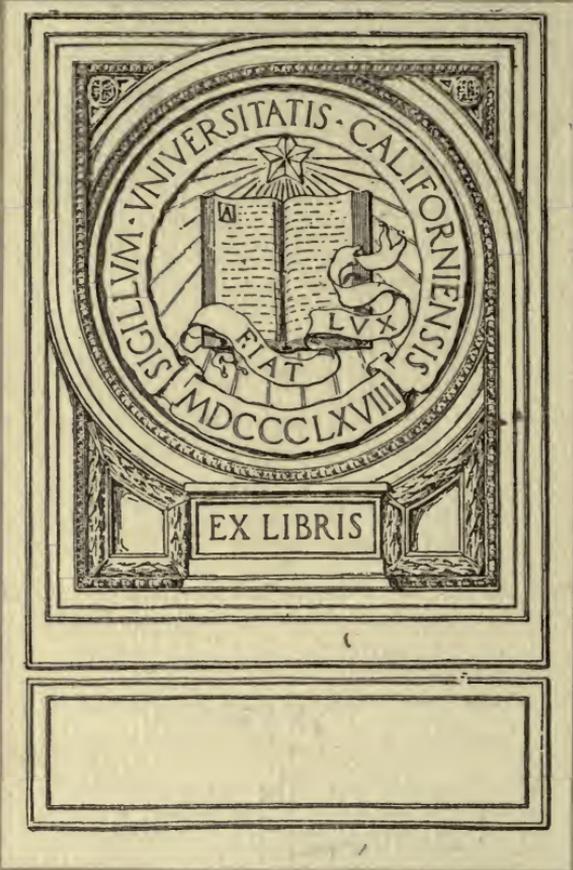
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THE USE OF LIME AND GYPSUM ON CALIFORNIA SOILS

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Much confusion exists in the popular mind with reference to the actual nature of lime and its use. The following brief statements are intended to clear up difficulties which exist and to reply to frequently recurring questions on the important subjects of lime and its use, and gypsum and its use.

THE NATURE AND FUNCTIONS OF LIME

The term "lime," as we may employ it in the agricultural sense, includes the following materials: Burnt lime or quicklime (oxide of calcium), hydrated or waterslaked lime (hydrate of calcium), ground limestone (carbonate of calcium). In addition a form of lime known as air-slaked lime is available, which may approach in chemical composition the ground limestone. Air-slaked lime results from the action of carbonic acid gas on water-slaked lime or from that of water and carbonic acid gas on burnt lime or quicklime. Either burnt lime, or hydrated or water-slaked lime will change to air-slaked lime if allowed to lie in the open air for a long enough period of time. The action is rather slow in the center of the pile of lime, however, and thus it may frequently happen that so-called air-slaked lime may consist of a considerable proportion of quicklime or of water-slaked lime, as the case may be, and found to be not as fully carbonated as one would expect. The total amount of air-slaked lime of the variety just described, which is available on the market is very small. A form of air-slaked lime is available on our markets, however, in considerable quantities today, which results from the processes of sugar refining, and which in chemical composition is very much more like

ground limestone than the ordinary forms of air-slaked lime just discussed. This so-called "sugar house" refuse lime will, in the dry state, contain from 70 to 80 per cent of calcium carbonate and is usually in a very fine state of division and for that reason is superior to ground limestone, even though the latter may contain a larger proportion of actual calcium carbonate.

Even in the agricultural sense, the term lime does not include gypsum. The latter is an entirely different substance from the three named above, as will be explained later. Speaking with the correctness of the chemist, the term "lime" is applied only to burnt lime (quicklime) or calcium oxide. Just how the three materials discussed agriculturally under the name lime are to be employed and where one is to be preferred to the other, if at all, are questions which are answered below.

Before going into a detailed discussion of the mission or function of lime in soils, it is well to state clearly the relative values for practice of (1) the burnt, caustic or quicklime; (2) the hydrated or water-slaked lime, and (3) the carbonate or the air-slaked lime. These lime materials are largely valued for the amount of calcium oxide which they contain. Quicklime is nearly all calcium oxide. Hydrated or water-slaked lime contains less calcium oxide than quicklime, in about the following proportion: it takes 2643 pounds of hydrated lime to carry an equivalent quantity of calcium oxide to that carried by one ton of quicklime when both materials are pure. Nevertheless, for practical purposes, they are not to be considered as very greatly different, since the water-slaked lime contains certain advantages like that of fineness of division, which the quicklime does not have, and since they are rarely pure. Thoroughly air-slaked lime, like the sugar-house refuse lime and ground limestone, contains only a little more than half the amount of calcium oxide that the quicklime does and therefore two tons of either should be employed if it is to be used in place of the burnt lime. If the ground limestone is not very pure, that is if it contains less than 98 per cent of calcium carbonate, proportionately more, dependent upon the composition, as compared to the burnt lime should be used. The same applies to the sugar-house refuse lime. Just as the water-slaked lime has an advantage over the burnt lime, owing to the fineness of division of the former, so the sugar-house refuse lime possesses an advantage over the ground limestone for the same reason. It must be remembered, however, in all

of these cases, that the total amount of calcium oxide in every form of lime should be the first consideration when purchasing any of these materials. Other rules for making a choice depend upon conditions which are discussed below. Relative money values can be determined at any time from the foregoing explanation of relationship between the different lime materials. It must also be remembered in that connection, however, that the cost of handling larger quantities and the additional freight rates involved must always be taken into consideration in calculating the actual and relative cost of the different materials. The prices for lime vary in this state, in the knowledge of the writer, from \$2 per ton up to \$15 per ton, and there seems to have been no uniformity of price based on actual lime content or on fineness of division. Local circumstances of a variety of kinds have usually set the prices. Ground limestone and sugar-house refuse lime have been selling at rates varying from \$3.50 to \$6.50 per ton, and, in most cases, very little of the other forms of lime is available on the market for agricultural uses. A list of some of the principal firms which engage in selling lime in different forms may be obtained by addressing the Division of Soil Chemistry and Bacteriology.

The following is a consideration of the function of lime materials in soils:

1. Lime materials have the power of improving the crumb-structure of clay and making it more pervious to water and air, by making a large number of soil crumbs from large sticky masses. Therefore, lime makes clays and clay adobe soils looser, tends to prevent packing, baking, and cracking, makes plowing and cultivating easier, and, in general, makes the soil, physically, a healthier medium for plant growth.

2. Lime materials (as above described) serve as a source of the element calcium to plants. Calcium is one of the ten essential chemical elements in plant growth.

3. Lime materials tend to make "sour" soils "sweet." Speaking correctly, they tend to change an acid soil condition to a less acid one. Acidity of soils may be very detrimental to the growth of many agricultural crops.

4. Lime materials are necessary for useful and beneficial bacteria and other microorganisms of the soil. It furnishes these the element calcium, which is as essential to them as to the higher plants. It promotes a slightly alkaline condition, which is probably ideal for

their development. By its physical effect lime produces good air and moisture conditions for bacteria as above described.

5. Lime materials promote the normal decay of soil organic matter through their effects on the agencies of decay above described. The normal decay of organic matter in soil prevents accumulation of poisonous materials in soils which may be detrimental to plant growth.

6. Lime cannot be depended upon to neutralize the toxic effects of sodium carbonate or black alkali.

THE NATURE AND FUNCTION OF GYPSUM

Gypsum is the sulfate of calcium and therefore is not the same as "lime" nor the same as any of the three agricultural forms of the latter above described. The only thing which gypsum has in common with the three lime materials named, from the point of view of chemical composition, is that it, like the others, contains the element calcium. Let us study its functions in soils.

1. Gypsum exerts a similar physical effect to that of lime on the clay and adobe soils (see above).

2. Gypsum, like lime, serves as a source of the element calcium (see above).

3. Gypsum, like lime, stimulates the beneficial soil organisms in the nodules on roots of leguminous plants like the peas, beans, vetches, alfalfas, and clovers.

4. *Gypsum does not make "sour" soil "sweet." It will not change an acid into a slightly alkaline soil as do the lime materials. Gypsum possesses no alkalinity, and therefore will not be of assistance, or act as a corrective to "sourness" or acidity in soils.*

5. Gypsum will neutralize the toxic effects of sodium carbonate or "black alkali."

LIME VERSUS GYPSUM

The question comes to us frequently as to whether "lime or gypsum" will correct a certain difficulty in soils. This confusion of two distinct types of substances has done much harm, and the reader is asked to read carefully the statements made above with respect to each in order that errors may be obviated. As above noted there is at least one very important function which lime performs in the soil which gypsum cannot perform. If soils need correction for acidity, the lime materials will do but not the gypsum. Too much emphasis cannot be placed on this distinction. In fact, to be on the safe side the use of lime is advised even in cases in which people with

exact information might, perhaps, give the preference to gypsum. The distinct and limited uses for gypsum are below described, however, to serve as a guide.

LIME ON HEAVY SOILS

No determination needs to be made to inform the owner of heavy land if lime is necessary to improve the soil's texture as above described. The decision both as to the amount to apply and as to the feasibility of applying it must be made on the basis of the cost of lime and the degree of "running together" or baking and cracking, which is characteristic of the soil. From one to two tons of the burnt lime or of the hydrated lime, or from two to four tons of the ground limestone, may be safely applied to improve the working qualities of heavy soils. Application may be made by means of one of the several types of lime spreading machines or the lime may be deposited in piles and spread with a shovel. It should be well plowed in and covered up at a time when there is sufficient moisture in the soil for the lime to act well.

The burnt lime and the hydrated lime are to be preferred to the carbonate of lime for making heavy soils lighter if the cost will allow. The first two forms act more vigorously and more quickly. Applications of lime are best made prior to fall or winter plowing or one or more months prior to planting. This must particularly be borne in mind if either burnt lime or hydrated lime are employed.

LIME ON "SOUR" OR ACID SOILS

If "sour" soils are also heavy clays or clay adobes, the recommendations for the use of lime above made for heavy soils are to be followed. If sour soils are loams, silts or sands, the ground limestone is to be preferred to the other forms of lime where it is obtainable.

To test your soil for sourness or acidity proceed as follows: Mix some of the surface soil to be tested and moisten thoroughly. Mold it into a ball of wet earth about three or four inches in diameter. Break the ball in two and on one of the broken surfaces place two strips of red litmus paper previously moistened with clean boiled water. (Litmus paper, both red and blue, may be obtained in drug stores.) Do not touch the moistened litmus paper with the fingers if possible. Set the broken surfaces of earth together again and press tightly. Perform the same test with another ball of earth, but

use blue instead of red litmus paper. Allow the balls of earth to lie undisturbed for half an hour; then open, and if the red litmus paper has turned blue no lime is needed. If it remains red, and the blue litmus paper turns red, lime is needed and should be applied as above directed. If neither the red nor the blue litmus paper should change color during half an hour or more, then the reaction of the soil is neutral and small applications of ground limestone, not to exceed one ton per acre, will be sufficient.

WHEN AND HOW GYPSUM MAY BE USED

Gypsum may be used to good advantage on alfalfa fields to stimulate the growth of the plants. This is especially to be remembered in connection with alfalfa fields of several years' standing in which "bald" spots or bare patches are found. An application of gypsum in such cases, not to exceed 300 or 400 pounds to the acre, along with fall disking will give striking stimulation to the plants and rejuvenate the field. The reason for this is believed to be that gypsum is a stimulant to the alfalfa plant itself and to the nitrogen-gathering bacteria which grow in the nodules on its roots.

If lime is very expensive, as it may be in some districts of this state, gypsum, if much cheaper, may also be used as indicated above, to lighten heavy soils. Applications varying from one-half ton to one ton per acre may be used in such cases.

Another use for gypsum, which is more limited, consists in applying it to "black alkali" land to neutralize or make harmless the black alkali. *In this respect gypsum cannot be replaced by lime.* The amounts to be used in such cases will depend on the amount of black alkali present in the soil. This must be determined for those interested by the California Agricultural Experiment Station, which should be communicated with under such circumstances. Address Division of Soil Chemistry and Bacteriology, Budd Hall, Berkeley, California.



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