Agricultural Chemistry.

The Chemistry of Clay Soils.

The term "clay soil" as applied in the following article, to a soil in which clay, or its basis, alumina, exists in excess of the proportion, mentioned in a former communication, required to constitute fertile ground. Much depends, of course, on the surface-features, whether the land be high or low; also, on the character of the subsoil, whether porous or close; for a soil containing say 85 to 95 per cent. of clay in the former case, might only be termed strong; while with the latter conditions present, it would be classed as very tough and heavy.

Clay soils are distinguished by the adhesiveness of their parts, a quality the very opposite of that possessed by *sandy* ones. Clay possesses the four following properties, by which it exerts a powerful influence on vegetation:—

1. It absorbs moisture and retains it strongly.

2 When thoroughly soaked, and afterwards dried, it cakes into a solid mass, and if quickly brought from a wet to a dry condition, it approaches the condition of unburnt bricks.

3. When exposed to heat it shrinks considerably.

4 It greatly retards putrefaction by excluding the action of the external air.

In the case of sandy soils, the importance of a due supply of water, and the best means of securing it, were discussed; now the ill-effects of excess are to be counteracted. From the second property the farmer learns the necessity of being cautious not to plough such land while wet. The third quality mentioned indicates the necessity of rendering the texture more open and friable by means of a mixture with less cohesive materials; and also by exposure to the crumbling and disintegrating effects of the atmosphere These measures also correct the evil mentioned under the fourth head.

Before treating of the means best adapted for correcting the defects of heavy clay land, it will be well to glance at some of the chemical properties of alumina, the basis of clay This earth is a compound of oxygen and a metal called *aluminum*; it is the principal ingredient of almost all rocks, except the purest kinds of limestone; it constitutes the great mass of ordinary clays, for these last are nothing but the product of the action of decomposing and disintegrating forces on the pre-existing rocks. In all these forms, the alumina as combined with silica, or silicic oxide, and sometimes with sulphuric or phosphoric acid. The ruby and sapphire are examples of almost pure alumina. It derives its name from the salt which it forms with sulphuric acid and potash, the alum of commerce It is of a white color, adheres strongly to the tongue, and has a remarkable tendency to unite with the organic matters. When dried at a moderate temperature, it dissolves freely in acids and solutions of the fixed caustic alkalies; but when strongly heated, it dissolves much more slowly. Carbonate of potash, soda and ammonia precipitate it when in solution, and this precipitate is again dissolved by the caustic *fixed* alkalies, but not by ammonia

It is evident from the above remarks that it is not so much a deficiency of ingredients as a peculiarly solid composition that is to be remedied in the case of clay lands For it has been shown that the alumina exists as a silicate, and therefore it is the mode in which the requisite materials are combined, that has to be dealt with; it is, in other words, an excessive existence of two properties, namely: the *attraction of cohesion* in the particles of the clay, and the *affinity* for water.

Again, it follows that where a subsoil is composed of heavy clay, the organic acids derived from the decomposition of plants at the surface exist in excess, on account of the absence of any *neutralizing* agent; such lands are often described as sour. Also from the excess of humidity it follows that the soil is *cold*; for the heat of the sun is spent in evaporating or dissipating the moisture. The principal means to be adopted in the treatment of such soil may be comprehended under the following heads:—

1. Supplying to the soil the deficient organic and earthy substances, (in this case principally calcareous matter).

2 Altering the depth, texture, and properties above mentioned, by mechanical means.

3. Changing its relation with respect to moisture.

4. Changing its relation with respect to temperature.

Under the first head is comprehended the application of manures, which may be either (1) animal and vegetable; (2) mineral; or (3) mixed.

1.—Vegetable and Animal Manures.

The main principles governing the application of these have been illustrated in the former article on sandy soil. Dr. Dana has given the term "geine" to all the decomposed organic matter of the soil of vegetable origin. It exists in two states—soluble, and insoluble; soluble in water, alkaline solutions, alcohol and acids. The latter variety becomes food by the action of air and moisture. Although the heavy soil requires a greater proportion of manure to fertilize them than freer soils; they retain the effects for a longer time.

2.—Mineral Manures.

Leached ashes. These, when applied in proper quantity, act beneficially on heavy soils. They should not be applied in too large quantities; and they should be intimately mixed with the soil. Chaptal says: "they possess the double property of amending a wet and clayey soil by dividing and drying it, and of promoting vegetation by the salts they contain." As a large portion of alkaline matter remains in the ashes, even after leaching, they benefit a wet, sour soil by neutralizing the acid, and assisting vegetable decomposition; while, at the same time, they loosen the soil and enable the roots of plants to reach full development.

Lime.

Common limestone, which is a carbonate of a metal called calcium, when burned, looses its carbonic acid, and becomes a caustic substance which absorbs water with production of heat, crumbling into powder at the same time, and beginning again to imbibe carbonic acid from the air. It thus becomes mild and less soluble in pure water.

Caustic, or quick-lime, as before remarked, dissolves vegetable fibre and renders it soluble, but forms compounds with the soluble portions of vegetable and animal substances which are soluble with difficulty, and only after the lapse of considerable time Lime, when spread on a sod surface, is prevented in some measure by the grass and fibres of the roots from descending into the soil; while the rains from time to time dissolve it, and carry down an alkaline solution which neutralizes the sourness of the soil. Again, in every particle subjected to the action of the atmosphere, the carbonic acid gas of the latter converts the alkaline solution into a carbonate, and this being much less adhesive than clay when the land is ploughed, the soil pulverizes readily. But in order that the land may receive the benefit of a lime application, it should in all cases be *freed from excessive moisture*. The mode of doing this will be mentioned hereafter.

It has been recommended to employ a mixture of unslacked lime and earthy material, containing a certain proportion of decomposing organic matter (river and marsh-muck, &c). The lime is used in the proportion of two bushels to the cubic yard, and about 50 yards of the mixture are applied to each acre. Lime acts beneficially in three ways: 1. As a *neutralizer*. 2. As a *decomposer*. 3. As a *converter*.

1. The first mode of action takes place in all soils where free acids exist.

2. The second mode takes place where metallic and earthy geates exist, long-formed and sun-baked, and scarcely acted on by rain or dew. Lime decomposes these, forming a soluble combination.

3. It acts in the last manner on the solid and insoluble *geine*, and vegetable fibre, converting it into soluble vegetable food.

Marl.

This valuable substance, consisting largely of silicates of potash and iron, has been used with highly beneficial effect in the State of New Jersey. It exists along the Gulf and Atlantic borders, forming a portion of the Cretaceous formation. As this formation is not present in Western Canada, our farmers are unable to obtain marl, or more properly, green sand; for the term is also used to denote a clay containing a large proportion of carbonate of lime, and this substance prevails in Canada.

3.—Mixed Manures.

This class consists of those derived partly from organic and partly from mineral substances.

Coal Ashes.

Where tenacious clayey soils adjoin cities and large towns, these may be profitably used.

Composts.

These consist of decomposing vegetable and animal substances mixed with earth. Lime acts beneficially on these mixtures by assisting the fermentation of vegetable and animal fibre. They should be thoroughly turned over several times, so as to mix the materials together. This is a method of increasing the amount of manure on a farm, which should not be neglected.

Under the second head are included all the various operations of cultivation, or tillage.

Fallowing.

The necessity for summer fallowing in these days, when the proper rotation of crops is pretty well understood, can hardly be said to prevail, except in cases where land has been thoroughly exhausted by repeated grain crops. But the farmer will find a most valuable means of pulverizing heavy clay soil in fall ploughing and cultivating, leaving the fresh surface in a position to receive the beneficial effects of the air during the winter. Of course there are some rainy seasons when this would be impracticable. In dry weather he must spare neither the plough nor the cultivator.

Burning.

Although this process is hurtful to calcareous and light lands, to perfect soils, and to lands rich in decomposed vegetable and animal substances; it has been proved to do good on poor, cold clays when broken up for the first time. It has also been recommended in the case of deep peaty soils where there is an excess of undecomposed vegetable fibre.

Ploughing, Harrowing, &c.

The extra amount of these operations demanded by a heavy soil, constitutes one great objection to such land. The land must not be worked when too wet, it cannot be worked when very dry; a medium, therefore, has to be chosen, and this, in some seasons, is with difficulty obtainable. It has of late been a matter of much dispute as to the respective advantages of *deep* and *shallow* ploughing. While it cannot be denied that the former kind of cultivation is calculated to work to the best advantage in soils where there is a good depth of fertile mould, it cannot be pursued in cases where the subsoil is tenacious, until the land has undergone a thorough course of underdraining and manuring.

Under the third head the operation of draining must be classed. As it is impossible to treat in detail such an important subject in a short article; it will only be remarked that a few ditches dug through the lowest parts of the farm, will be of little value in the kind of soils here described. The land must be thoroughly drained by an underground system of main and branch pipes, so that a sufficient outlet is provided for the excessive moisture. By this downward tendency of the water, a reservoir is provided, which, in seasons of drought, yields its moisture again to the soil above. At the same time that the excessive amount of water retained in clay subsoils is removed by draining, the temperature of the soil is improved; for as the heat of the sun is not exhausted in drying, the compact mass as before, it becomes diffused through the particles of soil, while the surplus water trickles slowly towards the drains.

Other more general means of improving the temperature of soils are discussed in works treating the wider subject of rural economy These comprise the preservation of our forests, and the rearing of groves on bare hill-sides, as well as other kindred subjects. C. M. S.

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