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Alkali and the Treatment of Alkali Lands

PART I

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BULLETINS.

The regular bulletins of the Station are sent free to all citizens of Idaho who request them. Late Bulletins are:

37. Some Conditions of Stock Poisoning in Idaho.
38. Grasses and Forage Plants in Idaho.
39. Some Experiments in Fungus Diseases in 1903.
40. Winter Spraying for the Apple Aphis.
41. Grasshopper and Cricket Outbreaks.
42. Experiments in Pig Feeding.
43. Planting the Apple Orchard.

ALKALI AND THE TREATMENT OF ALKALI LANDS

J. S. BURD

Observations made during recent trips through the arid section of Idaho have convinced the writer of the necessity for further investigations of the alkali question in this state. To this end measures have been taken to ascertain the conditions existing in certain of the more afflicted sections and the work is now progressing favorably. The results so obtained will be issued in succeeding bulletins. In the meanwhile, however, and pending the issuance of results concerning specific localities, it seems proper to issue a more general statement of wider applicability concerning the existing knowledge of the nature of alkali. Many of our cultivators are new arrivals unfamiliar with the methods of farming in the arid region and unused to irrigation practice. This latter alone has been the cause of much damage; the injudicious use of water having brought about accumulations of alkali so excessive as to make the raising of crops unprofitable, unless preceded by the application of the most thorough methods of reclamation.

Effects of Alkali.

The presence of large amounts of alkali in his soil is usually made plain to the farmer by the appearance at the surface of brownish stains or white crusts after a period of drought. This is particularly noticeable at the end of the dry season and the condition continues until water is again added to the soil or the surface is plowed under. But more convincing even than its actual appearance is the effect it produces on plant growth. In many cases this is marked by complete barrenness of the ground where the alkali has been strong enough to prevent the germination of seed or to kill the plant in its earlier growth. Or the crop may be merely retarded or stunted in its development. But in any case the full possibilities of the soil are not realized and the grower suffers loss.

Causes of the Trouble.

These effects are partially due to the plants absorbing quantities of alkali which can be neither assimilated nor gotten rid of. But undoubtedly the greatest damage is caused by its corrosive action on the outside at the base of the stem, in eating away the surface tissue where exposed to its action and interfering with the normal functions of the plant. In addition to this, one type of alkali by causing the decomposed vegetable matter or humus to collect on the surface of the ground, or by carrying it into the drainage, deprives the soil of one of the most important elements of fertility. It also by its action on clay renders the soil soggy and hard of tilth. And frequently, when collected a short distance below the surface, contributes to the formation of a hard pan which will neither allow roots to penetrate nor the soil to drain.

Composition of Alkali.

These effects are simply the result of the chemical nature of alkali and a knowledge of its composition is fundamental to an understanding of the subject. Chemically considered then, alkali is a variable mixture of salts which differ considerably in their effects on plant life. Some of these are quite corrosive, others are relatively inactive and small proportions of really beneficial salts are almost always present. It will be readily understood, then, that the harmfulness of a given type of alkali is dependent upon the amounts of the more corrosive salts it contains. Of these, Sodium Carbonate or sal soda, Sodium Sulfate or Glaubers salt and Sodium Cloride or common salt are the most important, and types of alkali are readily classified on a basis of these constituents.

Black Alkali.

If it consists in large part of sal soda it is usually known as black alkali. This is due to the fact that, dissolved in the soil water, it is able to take up the decayed vegetable matter or humus of the soil and when, as so frequently happens, the alkali comes to the surface, the humus also rises and is the cause of that blackening of the ground already mentioned.

White Alkali.

When, however, the alkali contains little or no sal soda it is usually known as white alkali, from the crust or deposit found at the surface under certain conditions. In general, the white alkali is largely make up of Glaubers salt. It should be understood, however, that black alkali will frequently produce a white deposit, owing to the fact that the soil is deficient in vegetable matter; or that the quantity of sal soda (which is white in its pure form) is so excessive as to cover up the telltale discoloration.

Sea Salts.

Besides these varieties other salty deposits, which have been caused by the evaporation of inland seas and arms of the ocean, are quite common. These latter consist largely of common salt. They are not, however the kind with which the farmers of Idaho have to deal.

Formation of Alkali.

Our alkali, in common with that found generally in arid America, is the direct result of the action of those weathering and decomposition processes which break up rocks and form soils. And just as the entire character of the soil depends on the nature of the parent rock and the intensity of the natural decay, so does the quality and quantity of the alkali *originally formed* in any soil. But the amount and distribution of these substances *now present* in our soils depends very largely on rainfall and drainage. This is an immediate result ot the ease with which alkali is dissolved and carried about by the soil water. For where the rain is abundant, the soluble substances (largely alkali) are dissolved as rapidly as formed, washed into the depths of the soil, carried away by natural drainage to the rivers and finally to the sea. But in so-called arid regions, where the annual rainfall is less than 20 inches, practically all the water evaporates into the air; there is little or no draining away of excess water and the soluble salts are left in the soil. This alone is sufficient to account for the geographical distribution of alkali and explains why it is always found in regions where the rainfall alone is insufficient to water the crops.

Distribution as Affected by Surface Evaporation.

The distribution of the alkali in any given soil and its accumulation at the surface or at varying depths depends largely on the peculiar power possessed by all soils of lifting water or watery solutions. This action has frequently been compared to the rise of oil through the wick of a lamp and its influence may be exemplified as follows:—When rain falls upon the surface of the ground it saturates the soil to a depth depending on the amount of rainfall and the texture of the soil. At the same time it dissolves the soluble salts with which it comes in contact. Then when the clouds go away and the sun comes out, the water, in consequence of this capillary or lamp-wick-like power of the soil, rises to the surface, carrying the alkali with it. And as the water evaporates into the air the salts are left behind at the surface of the ground.

In this way the salts distributed throughout the soil may be collected and concentrated at the surface. The greater the evaporation during the summer, the more alkali will be brought up to the plants. It should be always borne in mind that even large quantities of alkali in the lower soil layers can have no effect on plant growth; as it is only when the salts come within reach of the plant that their deplorable effect is observed.

Irrigation Conditions.

The same principles which govern the rise of alkali with the natural water supply are equally true when the land is irrigated. We have seen that the amount of alkali brought up by the rain depends on the distance it penetrates into the ground. But not enough water falls in the arid regions to penetrate very far and the alkali brought up is the result of the leaching of only a few inches in depth. The large amounts of water annually used in irrigation, however, go deep down into the soil, dissolve out the alkali, which may be the result of thousands of years of dry weather, and in a single season of irrigation bring much of it to the surface. In fact it is only where water is artificially applied that trouble from alkali ever becomes acute. And as a consequence both the methods of prevention and cure of the alkali evil need be adapted only to irrigation conditions.

Prevention of Injury from Alkali.

The wisdom of forestalling the accumulations of alkali or nullifying the effects of its presence are only too obvious. The methods of accomplishing this, however, must be adapted to the source of danger. Besides the alkali in the surface soil reached by the plant roots, the alkali distributed throughout the sub-soil and that in neighboring lands; the salts dissolved in irrigation water may prove a constant menace. The influx of alkali from all these sources must be considered as possibilities.

Alkali in Irrigation Water.

The amount of salt permissable in irrigation water cannot be definitely stated, for the reason that the proportion of the salts thus carried which may be left in the soil will depend on the texture of the soil itself and the manner in which it is treated. For instance, in the case of a close, compact soil poorly cultivated, comparatively small amounts of salt in the irrigation water become a factor of importance. Since by surface evaporation they tend to increase the content of salt already present. But where a very coarse sandy soil is well cultivated and has good drainage, an almost incredible salt content for the water added may do no harm. It has been pointed out (Circular No. 10, Bureau of Soils, United States Department of Agriculture) that the amount of salts in irrigation water frequently assumed in this country to be the maximum allowable limit may be considerably increased if the Algerian method of irrigation be followed. The principle of that method consists in frequent and abundant irrigation of small plats, together with thorough cultivation and drainage. In point of fact our river and canal waters do not even approach this limit. And it is only when water is taken from drainage basins having no outlet that danger from this source need be apprehended. In such a case the irrigator will do well to have the water examined chemically before applying in the usual fashion.

Alkali in Neighboring Lands.

Danger from this source is owing to the backing up of partially saturated drainage water from adjacent lands; or to a rise of the ground water of a region. The avoidance of such conditions can only be accomplished by increasing artificially the natural drainage. Or by inducing those responsible for the influx to provide better outlets for their waste and drainage water. The drainage method will remove the cause and the evil at the same time and by lowering the ground water below the depth through which the capillary power of the soil can raise it to the surface, removes the possibility of further annoyance from this source.

Alkali Ready Formed in the Soil and Subsoil.

Even where there is no danger from outside sources the farmer may still have to reckon with the alkali ready formed in the depths of his own soil. We have seen that the constant tendency under irrigation conditions is for the alkali to accumulate at the surface, where it will do the most harm. A number of methods have been suggested to keep it down, at least during the growing season. Some of these have been used with success under all all sorts of conditions. Others can only be used under certain circumstances.

Economy and Flooding.

Two practices in common use for this purpose are the economical and the copious application of water. The one would fail where the other succeeds. The first is adaptable to close heavy soils which drain poorly. In such soils this practice is the only favorable one, for larger quantities of water would merely cause an increase of evaporation and consequent rise of the alkali. On the other hand, a light porous soil with excellent drainage could be flooded to advantage, the rapidly escaping water dissolving and taking the alkali with it.

Character of Crops.

In this connection the character of the crop is quite important. A deep rooted crop with large leaf surface has the power of keeping the alkali down in a marked degree, the reason being that such a crop absorbs a large proportion of the water before capillarity can bring it to the surface. In addition its large expanse of foliage shades the ground and hinders evaporation. These are characteristics of alfalfa in a marked degree and account in part for the phenomenal success of this crop in the arid region.

Thorough Cultivation.

The practice of thorough cultivation during the season when evaporation is most active is essential to the successful cultivation of arid lands. Such cultivation by forming a loose tilth at the surface has the same effect as mulching. It retards surface evaporation and the consequent rise of alkali, and conserves the soil moisture. Its importance cannot be too much insisted upon.

Reclamation Methods.

Although the over-running of arid lands by alkali frequently arises through lack of knowledge on the part of the farmer, yet there are numerous instances where the most careful methods have availed nothing against the adverse conditions met with. In all such cases as well as where virgin soils originally contain quantities of alkali, intolerable to even the most resistant plants, it becomes necessary to reclaim the land by more heroic methods. A number of procedures have been suggested for this purpose which either diminish the bad effects of alkali or actually remove it from the soil.

Scraping.

The rise of alkali, so frequently mentioned, may result in the formation of an alkali crust which contains quite a considerable proportion of the salts of the soil. And it sometimes happens that simply scraping off and carrying away this crust will diminish the salt content so much that the soil will bear a crop the following year. The scraping should be done at the end of the dry season when the greatest surface accumulation has occurred and before the winter rains have again carried any of it down into the soil.

Use of Salt Absorbing Crops.

It is of course true that all crops absorb various salts from the soil and indeed these latter are to a certain extent necessary to the life of the plants. But certain plants have this power in a marked degree and have frequently been used to take the alkali out of the soil. These are the root crops in general and the beet in particular. If such crops be planted and the entire plants bemoved from the field the improvement is frequently quite marked. Such crops are not usually of very good quality and sugar beets from alkali lands are frequently useless to the manufacturer of sugar.

Use of Chemicals.

A method of reclamation which depends on the character of the alkali is the use of chemicals. Gypsum or land plaster is the substance available for this purpose and is frequently efficacious where the alkali is of the black variety. White alkali will not respond to this treatment, for the simple reason that all gypsum does is to convert the black alkali into the white. The advantage in doing this is entirely due to the fact that most plants will stand considerably more of the white alkali than of the black. But when the black alkali is very excessive it may not pay to use gypsum, since the correspondingly large quantity of white alkali formed may still be enough to kill the crop.

Flooding and Underdrainage.

Beyond a doubt the most effective manner of reclaiming alkali lands consists in flooding and underdrainage. By this process the water added at the surface percolates into the soil, dissolves the salts and the alkali charged water is drawn off by means of drains. This results in gradually diminishing the salt content of the soil and it is only a question of time when the land will become sweet encugh to grow crops.

The value of underdrainage has long been insisted upon by those interested in the study of alkali conditions. But it has only been in the past few years that its unqualified success has been demonstrated publicly on a large scale. This has been done by the Department of Agriculture, whose practical success with the method near Salt Lake City and at Fresno, Calif., cannot fail to convince the must skeptical.

The method itself consists in the placing of parallel drains (whose distance apart will depend upon the nature of the soil) and constant flooding of the land till reclamation is complete.

Choice of Methods.

The choice of reclamation methods will always depend on the conditions met with. And particularly upon the following: Nature of the surface and subsoil. The ease with which water rises through and drains out of both. Distance of the ground water below the surface of the land. Lay of the land and efficiency of the natural drainage. Kind, amount and distribution of the alkali in the soil. Cost of the various methods.

It therefore behooves the farmer to familiarize himself with the conditions existing in his land and the causes which influence the extent and distribution of the alkali. For it is only the possibility of modifying such conditions which gives the farmer of the arid region control over the alkali and permits of the successful cultivation of some of our richest agricultural land.

Publications of the University of Idaho Agricultural Experiment Station.

Those marked * are exhausted; all others will be sent to residents of Idaho upon application, and to residents of other states when supply is sufficient to warrant it.

BULLETINS.

1. Preliminary Statement.
2. Proposed Plans of Work.
3. The Application of Chemistry to the Agricultural Development of Idaho.
4. (1) Methods of Preventing Smut in Wheat and Oats. (2) Carbon Bisulfid as a Squirrel Exterminator. (3) A New Squirrel Exterminator.

*5. The Relation of Meteorology to the Agricultural Interests of Idaho.
*6. Annual Report for 1893.
7. Insecticides and Spraying.
*8. Water and Water Analyses.
9. (1) Idaho Soils: Their Origin and Composition. (2) Miscellaneous Analyses.
*10. Idaho Agriculture, Descriptive and Experimental.
11. Smuts and Rusts of Grain and Approved Methods of Dealing With Them.
*12. Sugar Beets in Idaho.
13. Meteorology.
14. Twelve of Idaho's Worst Weeds.
15. Annual Reports, 1897-1898, and Miscellaneous Information.
16. The San Jose Scale in Idaho.
17. Construction and Management of Hotbeds.
18. Sugar Beet Investigations in 1898.
19. Miscellaneous Analysis.
*20. Apple Scab in the Potlatch.
21. The Codlin Moth.
22. Onion Growing.
23. Meteorological Records and Prediction of Frosts.

*24. Cattle Feeding and Crop Tests.
25. The Composition of Arsenical Insecticides.
26. (1) Crude Petroleum, (2) The Elm Louse, (3) The Pear Leaf Blister Mite.
*27. Mushrooms or Toadstools.
*28. Some Idaho Soils.
*29. (1) Annual Reports, 1899-1900, (2) Meteorological Records.
30. The Service of Soils.
31. Some Spraying Experiments for 1901.
32. Feeding Steers and Lambs and Analysis of Stock Foods.
33. Some Grasses and Clovers and How to Grow Them in Idaho.
34. Tomato Culture.
35. Meteorological Records and Soil Temperatures.
36. The Codling Moth.
37. Some Conditions of Stock Poisoning in Idaho.
38. Grasses and Forage Plants in Idaho.
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43. Planting the Apple Orchard.
44. Alkali and the Treatment of Alkali Lands.

PRESS BULLETINS-New Series.

1. Information Concerning Chemical Analyses.
2. The Forest Tree Tent Caterpillar.
3. Fire Blight: A Bacterial Disease of the Pear and the Apple.
4. Two Important Cabbage Insects.

REPORTS.

*1. 1893—Bulletin 6.
2. 1894
3. 1895
*4. 1896
5. 1897—Bulletin 15.
6. 1898—Bulletin 15.
*7. 1899—Bulletin 29.
*8. 1900—Bulletin 29.
9. 1901
10. 1902
11. 1903