SOME BIONOMIC AND OTHER CHARACTERISTICS OF SLICK-SPOT SOILS IN OKLAHOMA

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The term "slick spot" is one commonly used to designate certain small barren spots which occur in the soil in many places in subhumid climates. In area these spots vary from only a few square yards to more than an acre. Their importance is considered in the negative sense since such soils are considered to be "nuisance" spots. When wet, they become "slick", literally, and that is doubtless how the term originated. When dry they become "caked" and extremely hard. They are very difficult to handle, for, if cultivated when wet, they become puddled easily and when they dry they become very cloddy; it is seldom that they can be transformed into good seedbeds. Thus, slick-spot soils seem to be liabilities on account of their more than ordinarily poor physical condition.

PHYSICAL NATURE OF SLICK-SPOT SOILS

Slick-spot soils can be distinguished in the field, even by a layman, by their size, general barrenness, and light grayish, or whitish, color as distinguished from the brown, red, or dark color of the normal soils which enclose them. As already mentioned, they become extraordinarily slick when wet, and hard and cloddy when dry. Texture, or size of soil particle, apparently has little correlation with the poor physical condition for, of the many soils herein studied, sandy soils have been encountered as often as clayey soils. This is generally not discernible by macroscopic inspection, only, but becomes apparent when mechanical analyses are made.

Although little difference exists between "normal" and "slick spot" soils in texture, large differences are noted between them in plasticity and permeability to water. Normal soils are less "greasy" when wet and much less inclined to "crust over" after rains than slick spots. Whereas it required from

one-half to two hours for 200 ml of distilled water to leach through 100 g of "normal" soils it required from 12 to 60 hours to go through the "abnormal" soils. This indicates the general "tightness" of the slick-spot soils and helps to explain why they are "droughty."

The reason for the poor physical condition of slick-spot soils is mostly ascribed to their high degree of dispersion. That is, the soil particles therein tend to become highly separated when the soil is wet. The mechanism of this phenomenon is not well understood but it is generally assumed that the presence of certain salts, particularly those containing sodium, is responsible. Thus, theoretically at least, anything which can be added to remove such salts should cause an improvement in the arability of the soils. Although slick spots occur "willy-nilly" in fields and thus interfere with cultivation their most damaging feature is that they erode easily. In many instances slick-spot areas have been converted into gullied lands in a short time by continual cultivation.

CHEMICAL NATURE OF SLICK-SPOT SOILS

Slick-spot soils are commonly classified as belonging to the white-alkali group of soils or to the saline soils. However, since many of them are not alkaline and contain very little or no soluble salts, they could be considered, more properly, to be *degraded* alkali or saline soils. There is such a heterogeneity in the nature of such soils, from place to place, that considerable difficulty arises in defining even wide distinctions among them. For example, some of them contain considerable water-soluble salts while a few contain only traces of salts. Great variations exist in the proportions of the various ions in these salts. As has been mentioned sodium—particularly exchangeable sodium—is generally considered to be the *sine qua non* of slick-spot soils. However, in more than a hundred different samples of soil in the present study, calcium, and even magnesium, far outrank sodium in quantity in most samples. Considerable difficulty has been encountered in obtaining sodium determinations that could be regarded as accurate and reliable. On numerous occasions, rather copious amounts of what was to be weighed as a sodium precipitate turned out to be mostly contamination material. A recent acquisition for the determination of sodium (as well as potassium) is proving that many previous sodium figures are too high. This instrument is the "flame photometer", in which the sodium is volatized and burned and thus determined by the intensity of its characteristic yellow flame.

As a result of the present findings it is here believed that slick-spot soils are not caused by the "present" presence of sodium therein but, instead, by the "past" presence of it. In other words, sodium *was* the actual cause of slick-spot soil formation, whether any of it still remains in the soil now or not. In fact, side experiments indicate very strongly that *most* of the sodium *must* leave the soil before the extremely bad physical condition can result. One soil plat, among others, was treated with sodium chloride at the rate of ten tons per acre and then was left subject to the weather. The original favorable physical soil condition was decreased detectably after the first subsequent rain. However, it was not until about two years later, when all of the sodium, except slightly more than a trace, had been leached downward to a depth of 10 to 12 inches and more, that the maximum deterioration was evident. Again it is mentioned that this mechanism is little understood.

Laboratory experiments show that when a normal soil is treated with salt water several things occur—immediately and subsequently. Ion-exchange reactions take place and an increased hydrogen-ion concentration (lowered pH) generally results. Leaching with distilled water removes the excess ions, including hydrogen, and the reaction of the soil moves toward, or even into, the alkaline range. In all instances it is seen that the leachates gradually

assume a straw-colored to dark-brown tinge. The coloring agent here is organic (humic) matter which was released by the action of the salts present. This humic material when precipitated, purified, dried, and analyzed is found to contain approximately 4 percent nitrogen.

Leaching experiments showed that the various slick-spot soils contained a maximum of about 10,000 ppm and a minimum of less than 100 ppm of soluble salts. The median was 600 ppm. The calcium and sulphate ions dominated the concentrations in more than half of the soils. Magnesium came next in amount. With the exception of several samples from the vicinity of the Salt Plains, in Alfalfa and Grant Counties, sodium seldom occurred in amounts greater than traces. Those particular soils were not considered as slick-spot soils, however, but as true saline soils. They contained more than 50,000 ppm of soluble salts and were practically saturated with calcium, sodium, sulphate, and chloride ions.

REACTION OF SLICK-SPOT SOILS

Most of the soils under present consideration were truly alkaline soils—their pH being higher than 7. The maximum pH encountered was 8.9 and the minimum 6.1. In most instances, but not all, leaching the soils with distilled water caused an increase in pH, the maximum increase being 1 pH unit. Statistically there was little correlation between the amount and kind of salts present and the degree of rise in pH. The mechanism of this increase in alkalinity due to leaching is not understood. Theoretically, at least, if the bases were present as carbonates, leaching could result in their hydrolysis and thus cause the increase in alkalinity. However, no carbonates were present in any of the soils and bicarbonates occurred at a maximum of only four ppm.

ORGANIC MATTER AND NITROGEN IN SLICK-SPOT SOILS

As previously observed, when the soils were leached with solutions of basic salts, or when the basic soils were leached with distilled water, organic matter was lost and this organic matter contained considerable nitrogen. Of all of the basic soils studied, the highest organic-matter content found was 1.61 percent, and the highest nitrogen content was 0.08 percent. The minimum concentrations of organic matter and nitrogen found were 0.37 and 0.01 percent, respectively. The organic matter and nitrogen contents of normal soils taken from the vicinity of the slick-spot soils averaged nearly double the above maximum figures. Since organic matter improves the physical conditions of soils by its "lubricating" action and supplies nitrogen as a nutrient, it is quite possible that much of the poor physical condition and general sterility of slick-spot soils is due to the loss of organic matter from these soils caused by the action of excess-salt concentrations. Evidence is being accumulated that if plants growing in these soils can be supplied with sufficient moisture and air they can withstand the comparatively large amounts of salts usually present and make satisfactory growth. The addition of extra nitrogen is quite beneficial in this connection.

BACTERIAL POPULATION IN SLICK-SPOT SOILS

It is generally believed that fungi do not flourish in soils which are alkaline in reaction. For this reason no fungous counts were here made. In order to get an idea of the bacterial numbers in the various slick-spot soils, and the normal soils that enclose them, counts were made in each case in soils from fifteen different places, widely separated. The technique used was as follows.

All soil samples were air dried and finely pulverized with mortar and pestle. Ten grams of each soil were added to 90 ml of distilled water and

shaken vigorously for 15 minutes. Ten ml of this suspension were added to 90 ml of distilled water and thoroughly shaken. Serial dilutions were made in this manner until dilutions were obtained that ranged from 1:10 to 1:1,000,000. The following dilutions were plated: 1:1000, 1:10,000, 1:100,000, 1:1,000,000. Three platings for each dilution were made. The medium used was Difco yeast-dextrose-agar buffered at pH 7.0. The plates were incubated for one week at room temperature and colony counts were then made. The maximum number of bacteria per gram of normal soil was 8,700,000, the minimum being 2,500,000. For the slick-spot soils the maximum number per gram of soil was 7,600,000 and the minimum 1,735,000. Here again, no correlation existed between the numbers of organisms and the amounts or kinds of soluble salts present. In either case these numbers are extremely below those normally considered as common for "fertile" soils such as garden soils.

Many things in connection with the present study are quite puzzling in their revelations. Not the least of these is the fact that of all the slick-spot soils sampled the one which was considered to be the "worst" had the highest bacterial count. The small area from which it was taken has been entirely barren for years and when the samples were taken the soil was nearly as hard as concrete. Bad as this soil is, it has recuperative powers. When a sample of it was treated with a little complete fertilizer and organic matter and then incubated for a week its number of bacteria increased almost tenfold. Another instance of amelioration occurred in the above-mentioned soil that was treated with ten tons of salt per acre. A sample of it was subsequently treated with ground gypsum at the rate of two tons per acre. About six months after this treatment it was found to contain approximately 65 million bacteria per gram. This is more than ten times the number of bacteria present before treatment.

RECLAMATION OF SLICK-SPOT SOILS

Although the total area of slick-spot soils in the State is not great, and their intrinsic value is accordingly small, they are important from the nuisance standpoint and because they are foci of erosion. For this reason an attempt has been made to study these soils to find practicable means of improving them. Thirty sites were chosen and the areas divided into plots which were given various treatments. The following counties are represented: Grant, Major, Blaine, Kingfisher, Noble, and Payne.

Each plot was two-rods square and eight plots were laid out at each site. Materials used in the treatments were as follows: Limestone, ground gypsum, calcium-silicate slag, manure, straw, sulphur, iron sulphate, and a phosphate-and-nitrogen-combination fertilizer. The first five materials were used at the rate of two tons per acre and the last three at 500 lbs. per acre.

Although only two seasons have elapsed since the first plot was laid out, various degrees of amelioration are already apparent. And, although the results are not entirely in agreement in all instances, treatment with gypsum has produced more improvement than any other single procedure. Use of the combination of gypsum and manure was second in effecting improvement. It is somewhat too early to foresee what the other materials will do.

As yet, improvement is being estimated mainly according to increase in ease of handling. That is, the extent to which difficulty in plowing, cultivating, etc., is lessened by improvement in the physical condition of the soil. One very noticeable soil change has occurred in Blaine County as a result of the gypsum treatment. This is especially the case where gypsite was used. Gypsite is a finely divided form of gypsum due to the natural weathering of ordinary gypsum. It is believed that the advantage of weathered gypsum over ground gypsum lies in its much finer state of division. Where this material

was used, crusting over of the soil after rains and subsequent drying out has diminished markedly. Such improvement should soon enhance the natural fertility of slick-spot soils and modify them in the direction of the normal soils which enclose them.