The Effect of Water-Soluble Potassium Silicate and Various Other Treatments on Soil Structure and Crop Growth

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The beneficial effects of organic matter and sod crops on soil structure and crop growth have long been studied (1, 2, 11, 13). A study has also been made on the aggregating influence of clay minerals (6, 8). The effect of cultivation on soil structure has been investigated by several workers (4, 10).

Silicon, until recently (5), was studied principally from the viewpoint of plant nutrition. Duchon (3), as early as in 1925, found a favorable action of colloidal silica on crop yields in sand culture fertilized with insufficient phosphoric acid, and he attributed this to the improvement of unfavorable physical properties of the sand by colloidal silica that permitted the better utilization of what little phosphoric acid was available.

Laws and Page (5) recently showed, even at very low concentration, high aggregating influence of sodium silicate solution for 1:1 type of clay minerals and also for certain soils other than those in which 2:1 type of clay minerals are predominant. In the light of their study it was considered worthwhile to explore the agronomic possibilities of water-soluble silicates in regard to their effect on soil structure and crop growth. In case the use of sodium silicate may supply sodium ions concentrated enough to be toxic to the growth of crops, consideration was given to the substitution of potassium silicate for silicate of soda. Bentonite, sand, and cinders were also included for comparison with potassium silicate.

METHOD AND MATERIALS

The investigation was conducted in the field in two parts. The soil was a Dunkirk silt loam which had been under almost continuous cultivation for 10 years. Prior to the layout of the experiment, aggregate analyses showed that the soil had a remarkably low state of aggregation, with about 18.1% clay (2) and 0.71 to 0.83% organic matter. All the treatments, to be described later, were randomized and had three replicates each. The dimensions of each plot were 6 feet by 4 feet.

In part I the entire land under experiment was disked, harrowed, limed (1 ton per acre), and fertilized at the rate of 25 pounds per acre within one week following the incorporation of these materials. The planting was done on July 29, 1946, and the crop was harvested September 12.

In part II the area under investigation was plowed and harrowed twice on July 22, 1945. Immediately after this, green alfalfa, alfalfa hay, wheat straw, fresh manure, and sawdust were incorporated with the immediate soil, as well as plowed under within the acre-furrow slice at the rate of 25% tons of dry matter per acre. Bentonite, sand, and cinders, sewage sludge were also plowed under at a later date at the rate of 25 and 25½ tons per acre, respectively. Treatments consisted of planting Sudan grass, soybean, and buckwheat on July 24, 1945, to study the effect of cultivation on soil structure and of soil desiccation by roots. The treatment was included for the proper evaluation of effects. Samples for aggregate analyses and moisture contents at the time of sampling were taken on four dates over a period of one year, and volume weight was determined only on one sample. The crops were left undisturbed in the field. In June, 1946, the entire area was disked, harrowed, limed, and fertilized. Liming, fertilization, seeding and harvesting of Sudan grass were done at the same time and at the same rate as mentioned before.

Aggregate analyses, moisture content, and volume weights were determined on the composite mixture of three samples taken at random from each plot. Aggregate size was determined by wet sieving in water, and the method was that of McHenry and Russell (6). The soil from the plot passed through a 4.7-mm sieve but was retained by a 1.08-mm sieve used for aggregate analysis. Five grams of soil were put on a 0.90-mm screen and soaked in water for one minute. The screen was then oscillated vertically by an electric motor at the rate of 40 ⅜-inch strokes per minute, and the material left on the screen was dried at 105°C and weighed. This weight minus the weight of the primary particles expressed, on a basis of the oven-dry weight of the sample, gives the percentage of water-stable aggregates. Each size class was run in duplicate. The aggregation data reported in this paper represent the water stability of aggregates of a particular size class rather than of all aggregates present in the soil.

RESULTS

PART I

Effects on soil structure and plant growth. Certain features of the soil and of the newly planted Sudan grass, as resulting from silicate treatment, were observed in the laboratory by treating the particular fertilizer mixture with potassium silicate solution. This was possible by the precipitation of silica by ammonium salts brought into solution with the subsequent liberation of ammonia gas (12). There were 16 treatments altogether, of which 8 were low and the remaining 8 seeded with Sudan grass at the rate of 25 pounds per acre within one week following the incorporation of these materials. The planting was done on July 29, 1946, and the crop was harvested September 12.