A COMPARATIVE STUDY OF SOILS

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All soils may be compared in two very distinct ways, one with respect to the chemical composition and the other the physical condition of the soil, the first dealing mainly with the amount and quality of plant food, while the latter deals with the texture of the soil and its relation to plant development.

The physical condition of a soil is to a large extent due to the treatment it receives in the way of cultivation. And the fact that a soil is in good tilth can easily be recognized by the increased vigor of the plants grown upon that soil. A good physical condition of the soil is obtained largely by the work of the different implements of tillage and the various ways and times of the year these implements are used, and is therefore largely under the control of man. By changing the physical condition of the soil is the best and about the only way the agriculturist has of regulating and controling the movements of water and air in the soil, two of the most important factors which aid in the upbuilding and maintaining of a soil. It has been found that different soils act differently toward the movements of water and air and it is for this reason the following comparisons are made.

The amount of water a soil is able to hold depends upon several factors, namely: the size of the soil grains; the arrangement of the soil grains in the soil crumbs; the porosity of the soil; the amount of humus the soil contains.

Since the water is held in the soil primarily by a force known as surface tention, the object should be to have a given volume of soil contain as much of the soil grain surface as possible, and in view of the fact that the extent of this surface will vary inversely as the diameter of the soil grains it is evident why a soil with small grains should hold the most water. The total soil grain surface also varies with the amount of compacting the soil has received.

A compact soil contains more of the soil grains in a given volume, therefore containing more soil grain surface over which the water may act, and the result should be that the compact soil will hold more water in a given volume than the loose soil, if both were given free under-drainage.

In soils that contain humus there are porous particles introduced, which, also have a marked influence upon the water holding capacity of that soil. The effect the humus has upon the water may be compared to a piece of wood placed in water, absorbing water in the inner cellular spaces.

Five different soils were used in order to find a comparison between them with respect to their water holding capacity, namely: sand, sandy loam, loam, clay and humus. The sand was taken from a river bed and contained nothing except sand. The sandy loam was a mixture of fine sand and black surface soil, taken from bottom land. The loam was a black soil, taken from the first foot of upland, while the clay was taken from the sub-soil and was of reddish color, and the humus was nothing more than might be termed a good garden soil. All the soil was made as fine as possible by pounding it in a mortar, and all the particles that were larger than 5 m.m. in diameter were discarded and only the finer portions of the soils were used. The cylinders were one foot high and had a perforated bottom so as to allow the water to drain from the soil on the inside. After the soil was placed in the cylinders and weighed they were placed in water and left there until the soil was thoroughly saturated with water, after which they were taken out, and covered to prevent evaporation, then left to drain until all water ceases to flow from the tubes, after which they were again weighed and the difference between the wet weight and dry weight gave the amount of water held by the soil.

Power of loose soils to hold water.

Soil	Wt. of wet Soil	Wt. of dry Soil	Wt. of Water held	Water per cu.ft.	Water per ft. 6
	lbs.	lbs.	lbs.	lbs.	inches.
Sandy	2.88	2.59	.29	22.94	4.34
Sandy loam	2.68	2.12	.36	28.5	5.29
Loam	2.33	1.96	,37	29.17	5.52
Humus	2.54	2.06	.48	37.97	7.19
Clay	2.43	2.06	.37	29.17	5.52

The results show fairly well the difference in the water holding capacity of a coarse grain and a fine grain soil, the difference being equal to about 1.2 inches of water in the first foot. Also observe the large amount of water held by the humus compared with the water held by the other soils, the humus holding over a third more water than the sand, and about a fifth more than the loam.

In order to find the difference in the water holding capacity when these soils were campacted, the same soils were again used and prepared in the same way as in the previous experiment. And in place of pouring the soil loose in the cylinders, the soil was compacted after each measure full of soil was placed in the cylinders. The compacting was done by dropping a weight six times through a distance of one foot upon the soil after each measure full had been added. By this process all the soils could practically have the same amount of packing. The remainder of the experiment was conducted the same as the previous one had been.

Power of compact soils to hold water.

Soil	Wet Wt.	Dry Wt.	Water held.	Water per cu. ft.	Water per foot.
	lbs.	lbs.	lbs.	lbs.	inches.
Sandy	2.96	2.68	.28	22.15	4.4
Sandy loam	2.60	2.23	.37	29.27	5.54
Loam	2.52	2.13	.29	30.85	5.84
Humus	2.33	1.97	.36	___	___
Clay	2.68	2.30	.38	30.06	5.67

By comparing this table with the previous table, it will be observed that the compact soils retained on an average .2 inches of water more than the loose soils, and in no case did any of the soils hold less water when they were compacted than they did when loose. A surprising result was obtained with the humus which showed no increase, but on emptying the cylinders it was found that only about one-half of the soil was wet, the remainder being as dry as it was when placed in the cylinder. This was due to the fact that the soil expanded, making it impervious to water.

The rate at which water will flow through a soil differs greatly with different soils, the rate depending primarily upon the degree of compactness of a soil and the size of its soil grains. The looser the soil and the larger its soil particles, the greater will be the amount of pore space through which the water may percolate. As a rule a soil of great water holding capacity is the one that will offer the greatest resistance to the percolating water. This rate of water flow is however largely influenced by the condition of a soil in the field, some soils have a sandy sub-soil while others are underlaid with a clay or gumbo, the one allowing the percolating water to pass away while the other holds the water in the surface soil. A soil in the field and especially after it has been dry for sometime, contains a large amount of air and if a soil is underlaid with a hard sub-soil the air cannot pass out as water passes in, unless it passes through the percolating water, and much air therefore remains in the soil and keeps the water from coming in. When water passes through clay it forms a kind of cement, which fills up the pre spaces and blocks the passage ways.

In an experiment used to determine the rate of flow of water through each of the five different soils, the same soils, namely: sand, sandyloam, loam, clay, and humus, were again used and prepared as they were in the previous experiments. The cylinders were eighteen inches high and had at the bottom a small tube that carried the percolating water into measuring vessels. These vessels were weighed when empty and after the water was allowed to percolate for 30 minutes they were weighed again with the water, and the difference in weight was the amount of water passed through in a given time. In order to have the same conditions throughout the experiment the water was kept continually on the surface of the soil in the cylinders.

Rate of flow of water through soil.

Soil	Wt. of empty vessel.	Wt. of vessel and water.	Water percolated in 30 min.	Rate of percolation per sq.ft.
	grams.	grams.	grams.	grams.
Sandy	30.54	547.04	516.5	232.42
Sandy loam	29.2	55.2	16.	7.20
Loam	28.56	31.06	2.5	1.12
Humus	28.9	28.91	.01	.45
Clay	31.1	33.64	2.54	1.15

By comparing the sand and humus one obtains somewhat of an idea of the marked difference in these two soils in this respect, the water running through the sand almost without resistance, while the humus soil was almost impervious to water because of the expanded condition of that soil.

The greatest and most important of all movements of water in the soil is that movement known as capillarity. It is by means of this action that water is supplied to the plant during the greater part of the year, also the drying of the soil is brought about by this same force bringing the soil water to the surface where it may evaporate. The capillary power of a soil depends upon several factors, that of surface tention being the main one. When the soil is compact and the soil grains small, capillarity will be strong. However, this does not always mean that because the capillarity is strong that the soil water will raise faster than in a soil where this force is weak, Take for an example two soils, a sandy and clayey soil, the water we find will rise much faster in the sand until it reaches a certain height, at which the upward movement ceases while the water in the clay will continue to raise and in the end will reach a much greater height, although it moves slower. The capillary movement is also largely effected by dry and wet soils, the effect of which can be best illustrated by pouring water on dry dust and on damp ground. In the first case the water will collect in drops, while in the second it will disappear almost as soon as it touches the damp ground. The dry dust mulch is largely used in conservation of soil moisture, the water which comes up from the lower depths by capillarity will stop as soon as it comes in contact with the dust of the mulch, and acts just the same as when water is poured upon the dust. But when the dust is dampened ,the connection is again made and the capillary action continues to the surface.

Even in cases where the surface is loose and damp we find that a considerable amount of moisture may be conserved by this lose surface.

The efficiency of a loose mulch was determined by using fine soil and placing it in cylinders so constructed that the water table was kept 18 inches below the surface, and all water might be added from below and allowed to enter the soil by capillarity. The surface soil in the cylinders was prepared in five different ways, one was left without a mulch, the four others having mulches one, two, three, and four inches respectively. The amount of water evaporated from each cylinder during a period of 18 days was as follows:

No mulch	8.71 c.c.
1 inch mulch	8.52 c.c.
2 " "	8.17 c.c.
3 " "	8.01 c.c.
4 " "	8.02 c.c.

A comparison of the results will show that the amount of the water evaporated decreased as the mulch became deeper, until the mulch reached three inches, after which there was practically no increase. If the mulch used had been dry and the particles of soil a little larger there would have been a greater saving of water.

When considering the movements of air in the soil we find different forces at work which produce these movements, such as the vacuum produced by percolating water and changes in temperature and barometric pressure. The rate at which the air will move in the soil if all forces are equal depends entirely upon the amount of pore space the soil contains.

An experiment was used to determine the rate of flow of air through the five different soils. The soils were made as fine as possible and by means of the packing machine were packed into a set of cylindrical tubes so constructed as to allow the air to pass through the soil and out of a tube at the bottom, then by means of an aspirator the air was forced through the soil. The aspirator was so constructed that by means of a weight hanging over a pulley a vacuum was produced which could only be filled with air that passed through the soil in the tubes. The pulley over which the cord that held the weight was acting was so graduated that the results could be read in the number of degrees through which the pulley turned in a given time. When the air was allowed to pass through the soil for ten minutes the results were as follows: sand 375°, sandy loam 295°, loam 165°, humus 105°, and clay 22°. The results show a wide difference in the amount of air that would pass through the soil in a given time, and the variation can be due to nothing else except to the fact that the sand contained a larger proportion of coarse grains of soil than did the clay or loam.

In conclusion then, it has been found that each of the soils differ widely in the way they act toward the movements of water and air in the soil. The humus had the greatest capacity for holding water and offered the greatest resistance to the percolating water, and flow of air through it. Sand has been found to hold very little water and, offering very little resistance to the flow of water, allows the greatest amount of air to pass through during a given time. The loam and clay graded somewhere between the sand and humus in every test.