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Soil Conditioners and Soil Water Infiltration

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Water movement through the soil is described by the Darcy Law $v = \frac{kdg}{u}(\frac{P}{L} + 1)$ where v is the quantity of water passing a unit cross section area of soil in a unit time, k is the permeability of the soil to water, d is the density of the water, g is the gravitational constant, u is the viscosity of the water, and P is the soil water pressure difference across a length of soil column L. Factor P is usually negative and is sometimes called suction.

The terms in the parenthesis describe the force causing water to move. The remaining factors on the right describe the ease with which water can move through the soil in response to this force. The $\frac{P}{L}$ component is the force due to the soil water pressure and the "1" allows for the force of gravity. On initial infiltration, the contribution of gravity force is almost negligible. Obviously, some of these factors cannot be changed (g, for example). However, anything which will make the right-hand side of the equation larger will mean faster infiltration.

The k factor will be highest for a soil with large pores (like a well aggregated mollisol or a wet, coarse sand). If we add a chemical to the soil which tends to disperse the soil, the aggregates will disperse and we will have a tight layer at the soil surface which will result in k getting smaller. Recall that a good detergent will disperse soil in the laundry and would be expected to disperse it in the field also.

Some "soil conditioners" are detergents or soaps. The d factor is the density of the solution. The equation says if we would double the density we would expect the infiltration to be twice as big. We are not likely to change the density of solution by adding a few milligrams of soil conditioner to a gallon of water. The u factor suggests (since it is in the denominator) that a larger viscosity will produce a smaller number on the right which means a lower infiltration. Thus, the thicker the solution the more viscous, and the slower the infiltration.

The P term can be thought of as the difference in soil water pressure across the infiltration profile. Before we consider this effect, let's examine some curves (Fig. 1) relating water content of soil to the soil water pressure. The pressure plate or pressure membrane equipment in soil physics laboratories can be used to establish these curves. The devices are commonly used to estimate field capacity and wilting point of soil. Typical relationships between clays, loams and sands are shown in the figure. Effects of adding wetting agents are also shown. Note that at a given water content the resultant soil water pressure is lesser with the wetting agent soil than with the normal soil.

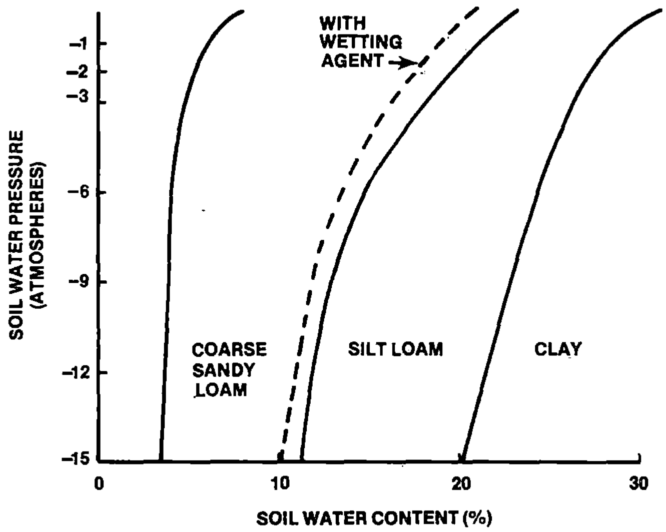

Fig. 1. Relationship between water content and imposed soil water pressure for three textures of siol. Effect of wetting agent on a silt loam soil is shown. Soil tends to hold less water.

The foregoing discussion assumes that the soil is completely wettable. If the soil is not readily wet by water, the presence of wetting agent can actually speed up the infiltration process. One can test the soil to determine wettability. A discussion of non-wettable soil is found in "Wetting-Agent Chemicals and Products to Improve Soil Physical Conditions," Fact Sheet #2230.

Any field soil possesses some value of soil water pressure at all times. The force of gravity can cause water to move downward until the capillary pressure holding water to the soil pores balances the water draining force of gravity. The action of plant roots can lower this pressure further by further drying the soil. Thus, at a given depth of soil, the soil water possesses a given water pressure, depending upon gravitational drainage and action of plant roots. In the Darcy Law, the k factor (permeability) is dependent upon water content. The more water present, the greater the permeability. There is a relationship between presence of wetting agent in the soil water and the permeability. We can see from Fig. 1 that for a given soil water pressure, the presence of wetting agent will reduce the water content. The lower the water content, the lower the permeability, k. The lower the k, the lesser the flow of water. Thus, we would expect a wetting agent to reduce the infiltration rate of water into a soil.

Before the infiltration process can begin, the soil must be wetted. Some soils are not readily wetted. Wettability is influenced by presence of organic residues which are not readily wetted. These residues may be from live organisms like molds, partially decomposed plants or partially decomposed material from previous growing seasons. The Darcy equation can not describe movement of water until the soil becomes wetted. If rain water does not immediately wet the soil the infiltration process does not begin. If the soil is not wetted by the time the rainfall ceases, we get no infiltration. Wetting agents can aid in providing the immediate wetting of soil by rainfall. In cases where the soil is readily wet by rain, a wetting agent will be of no benefit. As seen above, it may in fact hinder the movement of water. It is best to test the soil in question before using wetting agents over a large area, since wetting agents are generally expensive.

Rapid Tests: A successful material to increase infiltration rate of a wettable soil must have one or more of the following characteristics:

a. The k must get larger.
b. The viscosity of the soil solution must become smaller.
c. The density of the soil solution must become greater.

We are not likely to affect the density of the material, so we concern ourselves with a and b. We may devise some tests to examine the characteristics of a solution:

1. Surface tension. If one shakes a container of solution and produces much foam which persists for a considerable time, one can be sure the surface tension has been reduced (not a desirable condition).
2. Viscosity. If one feels the solution between thumb and forefinger and it feels syrupy or oily or at least thicker than water, one can be confident that the viscosity has been increased (not a desirable condition).
3. If the material is believed to be a good detergent for laundry, it is then a good dispersing agent and will likely decrease the permeability of the soil (not a good condition).

Materials which possess one or more of these undesirable attributes can almost assuredly be believed to be detrimental to normal (wettable soil) infiltration.

RESULTS OF TESTS

Super Slurper

The soil with the highest natural crust strength was the one with the greatest reduction in strength, a desirable condition.

Water Infiltration Rate: The Super Slurper decreased infiltration rate at all concentrations tested for all the above soils.

Water Retention: The fine-textured soil was not affected. The coarse textured soils were found to have substantial increases in water retention. The effect was more dramatic at the higher water contents. A 0.4% Super Sluper treatment of the Cobb loamy sand nearly doubled the water retained at 1/3 bar suction. The amount of water held in the plant available range increased by a factor of 4. This result was supported by research conducted at Iowa State University. Plants in the laboratory and in the field were found to survive longer under the Super Slurper treated soil than under

Effect on Crust Strength of Soil

Soil	Decrease in Strength
1. Teller Sandy Loam	84%
2. Tillman-Hollister Clay Loam	75%
3. Cobb Loamy Sand	56%

Super Slurper was used at 0.4% concentration

SPECIFIC CONDITIONERS STUDIED

Material	Manufacturer	Reported Formulation
1. Wex	Conklin	alcohol ethoxylates, propylene glycol, dimethyl polysiloxane
2. Basic-H	Shaklee	linear alcohol alkoxylate
3. L.O.C. (liquid organic cleaner)	Amway	palm-oil soap
4. Super Slurper	(various) Developed at Northern Utilization Laboratory, U.S.D.A. Peoria, IL	hydrolized starch polyacrylonitrile graft copolymer
5. Adjuvant	Amway	"low sudsing surfactant which is both nonionic and biodegradable"

non treated soil. This was evidently due to water retained by the Super Slurper. These detailed tests were made by Nofziger and Hemyari, Agronomy Dept., OSU (Soil Sci. Soc. Am. J. 45:799-801. 1981).

Basic-H

This is a highly biodegradable compound. It is evidently designed to be a good cleaning compound. The manufacturer suggests one not put the fingers in the container for fear of introducing bacterial activity which can degrade the performance of the material. Our tests were performed with a fresh mix of Basic-H solution each day to hopefully avoid problems of biodegradation during the course of the study. One proponent of Basic-H has suggested that a Basic-H solution in a post hole in clay soil would drain far faster than a similar hole filled with water. Our test was made in a set of holes each 2 ft. deep and 2 1/2 in. in diameter in a clay loam soil. Four replications of the test were conducted on pairs of holes, one with Basic-H solution at 5% and one with water. The tests showed Basic-H solution to move into the soil at a slower rate than the water.

In one hole the level of the solution decreased rapidly. It was discovered that the sides of the hole had sloughed off into the bottom of the hole creating a more spherical cavity which lowered the level of the solution quite rapidly. Obviously such a test should be done on several pairs of holes to insure that effects of gopher holes, cracks and the like do not distort the results of the test.

Surface tension and viscosity of the solution were measured in the laboratory. Surface tension was indistinguishable from water and the viscosity was greater than water.

Infiltration of water and Basic-H solution into uniform columns of soil was measured in the laboratory. For this test the concentration of Basic-H was .05%. The Basic-H solution infiltrated the soil slower than the water.

L.O.C.

This product appears to be a very good cleaning solution and easily produces much foam. It infiltrated post holes in the field at a much slower rate than water. No further tests were made.

WEX

This material was studied at several concentrations in the laboratory and at the 5% concentration in the field in post holes in a manner as described under Basic-H. This material moved into the soil from a post hole much slower than did water. In the laboratory, tests of infiltration into uniform columns of soil were replicated and conducted in two manners. In one set of measurements, the WEX was put in the water (1% solution) and that was allowed to infiltrate. In another set, the WEX was first put into the soil, the soil was dried and then water infiltrated into that material in a column. WEX, in this manner, was studied in two concentrations. In all cases, the infiltration of solution was less than the pure water.

OTHER MATERIALS REPORTED IN THE LITERATURE

Trade Name	Manufacturer	Reported Formulation
1. Krilium	Monsanto	HPAN. Hydrolized polyacrylonitrile
2. Unknown	Monsanto	VAMA. Copolymer of vinyl acetate and malic acid
3. Unknown	Monsanto	IBMA. Copolymer of isobutylene and the half ammonium salt, half amide of malic acid
4. Water-In	Unknown	Alkyl polyethyleneglycol ether, non ionic
5. WA-100	Unknown	Ethoxolated alcohol, non ionic
6. Soil Pen	Unknown	Linear sulfonate, anionic

Conditioners 1, 2, and 3 were tested for effect on cation exchange capacity (CEC) of several western soils at concentrations of .05 to 0.4%. They behaved similarly and increased CEC about 2% for the lower concentration. The increase was realized only when there was thorough and intimate contact between the soil and the conditioner at the time of application.

Materials 4, 5, and 6 have been tested for enhancement of water infiltration on water repellent coal mine spoils in Texas. Number 6 was found to be effective in this regard. The effect of the non ionic agents were not effective at the concentrations tested. Some people have found that the sulfonate compounds suffer from interaction with any dissolved salts and in such conditions, it is common to use non ionic compounds. Some workers (Calif. Agric. Mar. 1969, P. 608) found No. 4 to be effective in improving water infiltration into peat media and for increasing water infiltration into lawns with significant thatch.

Ability of fertilizer compounds to effect the action of Krilium showed that if Krilium was first added to the soil and the aggregates were stabilized, the inorganic salts had little effect upon the conditioner. Where the fertilizer is added first, the cations reduced aggregation and anions had little effect. Calcium and magnesium had greatest effect in rendering Krilium ineffective (Soil Sci. 83, P. 475. 1957).

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