



# Soil Wetting Agents:

## Their use in crop production

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Low water infiltration rate is often a characteristic of soil that is responsible for low irrigation and rainfall efficiencies. Excessive runoff causes the erosion hazard to increase and leaves less water on the field for crop production. Tillage, particularly deep chiseling, can increase water infiltration rate but this practice may have a high energy requirement and the benefits are often short-lived. The necessity to conserve fuel and reduce production costs has renewed interest in alternatives to tillage for increasing water infiltration rate. Soil wetting agents are being examined for their usefulness as such an alternative. There are those who extol their use as a cure for nearly every malady associated with crop production. Still others categorically condemn them as useless. Their true worth, as this paper explains, lies between those extremes. This paper suggests areas where soil wetting agents may be useful and where they're likely to be a waste of money.

### The infiltration process

In seeking a solution to the problem of low water infiltration rate, it is useful, if not essential, to understand both how the process works and how wetting agents affect it. Water infiltration rate is defined here as the speed at which rainfall or irrigation water moves into the soil. Essentially three forces act upon water to effect this movement. The first one, gravity, is a constant that can't be changed in a practical sense. The remaining two, adhesion and cohesion, are collectively and more commonly known as surface tension. Cohesion is the attraction of one water molecule to another while adhesion is the attraction of a water molecule to a solid. The effect of these two forces is demonstrated when one end of a capillary

(small diameter) tube is inserted into water and a column of water rises inside the tube against the force of gravity. The water molecules are attracted to and "climb" the tube's wall due to adhesive forces. An intact column of water is maintained by the attraction of one water molecule to another, cohesive force. A wetting agent (surfactant) added to the water reduces surface tension so the water won't rise as high in the tube.

In soils, pore space substitutes for the capillary tube and the forces of adhesion and cohesion work with gravity instead of against it to "pull" water into the soil. It follows that adding a wetting agent would slow water infiltration rate in the same manner that the rise was lessened in the capillary tube. In fact, research has shown that wetting agents have either no effect or an adverse effect on infiltration into wettable, hydrophilic, soils (12, 23, 26, 27).

### Wettable vs. water-repellent soils

Whether the soil is wettable or water-repellent is the dominant factor dictating whether a soil wetting agent will increase water infiltration rate or not. "Hydrophilic" describes a wettable soil; loosely interpreted, it refers to a soil with a strong affinity for water. The opposite, water-repellent, is hydrophobic, little or no affinity for water.

Varying degrees of water repellency have been observed in a number of soils. Coarse-textured soils seem to be affected more often than fine-textured soils (2, 7, 12). Water repellency has been found in soils after forest fires (6, 21), and in grasslands (4), turf (25), citrus groves (1), golf greens (13, 22), mine spoils (16, 17), and forest litter (12, 24). It should be noted that this listing should not be interpreted to

mean that all, or even a high proportion, of such conditions result in repellency. It is just that such conditions have been indentified as offering the potential for the problem.

## Soil problems associated with water repellency

Water repellency in soils can reduce productivity for several water-associated reasons. Most obvious is that water infiltration rate is slower so that there's more runoff compared to a similar, wettable, soil (5, 12). The increased runoff opens the way for problems associated with soil erosion.

Less water remains on the field for crop use, and the soil may not wet uniformly so localized dry spots will be present. This can adversely affect productivity, particularly that of shallow-rooted crops, and can lead to uneven germination, emergence, and survival of planted seeds (3, 20, 30). Likewise, plant nutrients in the dry zones would be less available than those in a moist soil. Without corrective measures, the soils that repel water are less productive and require more attention than similar but wettable soils. Research has shown that wetting agents are effective in such situations for increasing water infiltration rate and for more uniform wetting of the soil (12, 20, 30).

## Testing for water repellency

Several methods have been developed to characterize the degree a soil may be water repellent (11, 12, 29). Methods with the most precision and accuracy require laboratory facilities, but there are also several quick tests available for use in the field. Probably the one most useful for preliminary purposes is described by J. Letey and co-workers at the University of California, Riverside (12). In this test, a drop of water is placed on the soil surface and the length of time required for penetration noted. The drop will quickly flatten and move rapidly into a wettable soil. As the degree of water repellency increases, a drop of water will appear to stand more upright and move more and more slowly into the soil. If the repellency is only a surface feature, the drop will move rapidly into the soil once the surface repellency is broken. A drop of water on wax paper gives a good approximation of water repellency.

At least one company's agents use the water-drop test to demonstrate how a drop of water beads up on wax-coated cardboard and how, with their product, the droplet spreads out and penetrates the cardboard. Apparently, the conclusion to be drawn from this demonstration is that all soils will respond the same as wax-coated cardboard. But a similar response

cannot be expected on all soils. Water does not bead up on wettable soils—soils that do not need wetting agents.

## Factors in choosing a soil wetting agent

Several materials classified as soil wetting agents or surfactants are on the market and they may be useful for treating water-repellent soils. Leachability and length of residual effectiveness apparently vary among them (14, 15, 18, 19, 25, 28). Most are either nonionic or a mixture of nonionic and anionic surfactant forms that are capable, in very low concentrations, of effectively reducing surface tension. More of the cationic surfactants are required to achieve the same effect and the cationic surfactants may adversely affect several important soil characteristics (10). Some surfactants are reported to remain effective for several wetting-drying cycles, whereas others do not (9). Characteristics of the materials reputedly to be soil wetting agents are not well documented, but such data should be available for a reliable, thoroughly tested, effective material.

## Soil texture structure vs. water repellency

Soil texture is probably the reason for low water infiltration rate in most cases. In fine-textured soils, the pore diameter is simply too small to permit rapid water movement. Cultural practices that conserve good tilth and aggregation help a great deal in maintaining good infiltration rates. Conversely, practices (like working a too-wet soil) which degrade tilth and aggregation magnify the problem. Unless the soil is also water repellent, wetting agents would not likely improve water infiltration into soils with traffic or tillage pans. Because water infiltration rate into a fine-textured, wettable soil is inherently lower than into a coarse-textured soil, there's less opportunity for improving rate into a fine-textured, water-repellent soil than into a similar coarse-textured soil.

A considerable body of accumulated knowledge from research indicates conditions under which wetting agents may be useful. There are clearly conditions under which they are useful, conditions under which that are not effective, and various degrees of effectiveness in between. Labels or other promotional materials that claim or imply universal effectiveness are, at best, misleading. Field studies conducted on wettable soils at the Colby Branch Experiment Station of Kansas State University (27) and elsewhere (8) have generally failed to substantiate

product claims for increasing water infiltration, plant population, nutrient uptake, or crop yield. However, using no-response data from wettable soils to condemn use on all soils is as invalid as using data obtained from water repellent soils to promote a product's use on all soils. Because water repellency occurs with considerably less frequency than the wettable condition, one would probably be wrong less often with a blanket condemnation than with a blanket endorsement.

## Recommendations

Good advice to those considering the use of soil wetting agents includes the following: First, use the water-drop test on the soil. Second, don't invest more in an unproved product than you can afford to lose. Either treat a strip in the field and leave the rest of the field for comparison or leave at least an untreated strip in a treated field. Due to year-to-year variability, it is virtually useless to compare yields obtained from an untreated field one year with those obtained on a treated field the next year. Field-to-field comparisons, even the same year, are similarly unsuitable.

Third, insist on data from an unbiased source to evaluate the performance of a product. Testimonials may be more indicative of the story teller's imagination than they are of the product's worth and the weight given such reports should be adjusted accordingly. Increased yield and/or quality weighed against cost of the treatment will generally be the deciding factor. Because yield can vary even within a small field, the yield data should represent an average of several areas where the same treatment was applied. Keep in mind that a difference of several bushels or several hundred pounds may be due to chance alone rather than the treatment increasing or decreasing yield relative to the check.

Fourth, be cautious when combining wetting agents and pesticides. Some sales people will claim that pesticide rates may be decreased (halved seems to be a common rule-of-thumb) when their product is used. Testimonials to this effect may only mean that either too high a rate was being used in the first place or residual pesticide has reduced the need for the higher rate. The pesticide label should indicate if a wetting agent will improve effectiveness. If a wetting agent does improve the effectiveness, it may already be included in the formulation. In such instances, additional wetting agents may only cause problems. The inclusion of a wetting agent, or any other material for that matter, not so stated on the label will likely void the warranty and transfer liability to the applicator.

Finally, although research has shown that soil wetting agents effectively increase water infiltration rate into water-repellent soils, it appears that such products are being promoted aggressively in areas where their use is questionable at best. In such areas, their use represents an additional production expense producers don't need.

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