"Blue" soils cause complex drainage problems

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Areas with high water tables sometimes have blue or blue-gray soils. In some cases, the blue soil is mottled with streaks of reddish-brown material. These conditions are caused by iron in soils that either are continuously saturated (blue or blue-gray soils) or are frequently saturated (mottled soils).

In an aerated soil, the iron is said to be oxidized. The iron, a ferric compound, is relatively insoluble in water, and under these conditions, helps promote good soil structure.

In saturated soil, however, a change in the state of iron can occur under certain conditions (which must be met simultaneously) in the soil environment: the presence of organic material; lack of oxygen; and

A shallow drainage system and careful irrigation management may be the only feasible solution when such soils underlie good top soil.

occurrence of anerobic microorganisms in an environment that promotes their growth (proper temperature and pH). If these conditions are present, then ferric iron is reduced to ferrous iron. The reduction process is accompanied by oxidation of the organic material by the microorganisms. The chemical reaction is described by:

$$CH_2O + 2\,Fe_2O_3 + 7CO_2 + 3H_2O \rightarrow 4Fe^{2+} + 8HCO_3^-$$

where CH_2O represents organic material. The result is a soil with a blue or blue-gray color or mottled appearance.

The reduced or ferrous iron compounds are much more soluble in water than ferric compounds. Experiments have shown that increasing the organic matter content of the soil hastens the reduction process, and increasing the time of saturation increases the amount of soluble iron.

For agricultural purposes, it may be necessary to drain these soils to provide a root zone environment conducive to plant growth. This is commonly done by installing subsurface drainage systems, which may consist of interceptor drains or of laterals spaced throughout a field, depending on the source of drainage water.

A key factor in the performance of a drainage system is the hydraulic conductivity of the soil. The hydraulic conductivity, a measure of the ability of water to flow through the soil, is described by:

$$K = \frac{Cd^2pg}{\mu}$$

where
K = hydraulic conductivity
d = some mean diameter of the pore space of the soil
p = density of water
g = gravity constant
μ = viscosity of water
C = dimensionless constant, which includes the effect of factors such as pore space shape and tortuosity.

Although the hydraulic conductivity is affected by several factors, it can be seen that the pore space diameter is particularly significant. Hydraulic conductivity is directly proportional to the square of the mean diameter of the pore space. Thus, changes in the pore space diameter can severely affect the hydraulic conductivity of a soil.

Some recent drainage investigations of fields where reduced soil conditions occurred revealed extremely low hydraulic conductivity in the reduced material. However, the soil texture indicated that water movement through the soil should be adequate for drainage.

The first site was a field in a river flood-plain. Throughout most of the problem area, the blue soil was overlain by a brown top soil, and both had a similar texture. In one part of the field, the blue soil extended up to the surface and was more sandy.

The second site was a field on a hillside. Near the bottom of the field was a seepage area, upslope from which sand underlay the

TABLE 1. Particle Size Analysis of Soils at Two Sites

Location	Clay	Silt	Sand
	%	%	%
River flood-plain site			
Top soil	15	71	14
Underlying blue soil	15	77	8
Sandy soil	11	36	53
Hillside site	18	12	70

TABLE 2. Iron Content and Organic Matter Content of Soils in Drainage Problem Areas

Location	pH	Organic matter content	Total iron*	Soluble iron†
		%	%	ppm
River flood-plain site				
Top soil	7.9	3.5	2.6	20
Underlying blue soil	5.7	6.4	2.3	248
Sandy soil	7.4	‡	1.4	140
Hillside site	5.3	1.3	2.6	210

*Approximation by perchloric acid digestion.
†Diethylenetriamine pentaacidic acid (DTPA) extraction.
‡Not measured.

top soil, and below which the underlying soil was a sandy loam. This texture change was the cause of the seepage area.

At both sites, holes were augered into the soil so that rate of water movement into the holes could be observed and soil hydraulic conductivity measured. After at least five hours of observation, no appreciable volume of water had flowed into the auger holes, even though the water table of the surrounding soil was at or near the surface. Hydraulic conductivity measurements were not possible because of the slow water movement.

It is believed that the low hydraulic conductivity of these soils is due to presence of reduced iron and high organic matter content. Under these conditions, ferrous hydroxide is formed and precipitates out of the water. The reaction is described by:

$$Fe^{2+} + 2HCO_3^- \rightarrow Fe(OH)_2 + 2CO_2$$

In laboratory experiments relating to reclamation of salt-affected soils conducted at U. C., Davis, by M. A. El-Nahal, the formation of gelatinous substances under reducing conditions similar to those at the sites was observed in many cases. The gelatinous substance in those experiments, accompanied by reduction of ferric iron to the ferrous state and presumed to be $Fe(OH)_2$, markedly reduced percolation through soil columns. The conditions at these sites indicate that this precipitate probably was forming and was a major contributing cause of the poor soil hydraulic conductivity.

A second factor also believed to be caused by the precipitate is compaction of the reduced soil. This compaction was evident while jetting observation wells into the soil. It is believed that the precipitate may have a lubrication effect, allowing soil particles to compact more readily than they would normally. This compaction would also reduce pore dimensions, thus lowering the hydraulic conductivity.

To correct this problem, it is necessary to drain the soil and oxidize the reduced iron. However, drainage is not possible because of the poor drainage characteristics and the periodic wetting by irrigation and rainfall. Thus, if a problem soil underlies a good top soil, a shallow drainage system installed only in the top soil, coupled with good irrigation management, may be the only feasible means of providing a suitable root environment.

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Insecticides enhance spider mite reproduction

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Organophosphorus insecticides stimulated egg laying of mites reared on the treated cotton plants.

Spider mites are perennial pests of cotton and many other crops in the San Joaquin Valley. They occur annually in most or all cotton fields, and severe infestations commonly follow application of an insecticide to control one or more insect pests. These outbreaks have been related by many scientists to population explosions after destruction of natural enemies of the mites. Most insecticides are broad spectrum, meaning they kill not only the pests, but also many spider mite predators. The most common predators in cotton that are so affected are thrips, bigeyed bugs, pirate bugs, and soft-winged flower beetles.

While conducting experiments on the effect of certain organophosphorus insecticides on growth and fruiting of cotton, we found that a miticide would hold spider mites in check on untreated plants but not on plants that had been sprayed with methyl parathion. Experiments indicated mites reared on plants treated with methyl parathion were no more resistant to the miticide dicofol (Kelthane) than spider mites from untreated plants. We began experiments to determine whether pesticide treatment influenced development rate, survival, or reproductive potential of the mites.

Methods

In greenhouse experiments cotton plants were treated three times at two-week intervals with normal dosage rates of either methyl parathion, toxaphene plus DDT, or dimethoate. Following the third application, twospotted mites (*Tetranychus urticae* Koch) were reared individually from the egg to the adult stage on plants so treated and on untreated plants. Females reared on these plants were mated and maintained on plants of the same treatment throughout either a 10-day period or the duration of their reproductive lives so that fecundity could be determined. Spider mites were monitored for developmental rate from the time eggs were laid until they reached the adult stage. In one experiment, reproduction by each of 16 females was ascertained as a gross value after 10 days of adult life. In the other experiments, daily egg-laying rates were followed throughout each mite's adult life.

Results

Treatment of plants with methyl parathion or dimethoate did not appear to affect egg hatch or the time required for mite development. However, the treatments significantly affected reproduction by spider mites.

In the first experiment, there were significantly more eggs and immature mites on plants treated with methyl parathion, so that the combined total of mite forms was greater on these than on untreated plants (table 1). Although significantly more spider mite eggs were produced on toxaphene-plus-DDT-treated plants, the total of all stages