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RUST ON IRON RODS INDICATES DEPTH OF SOIL WATER TABLES

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Abstract.--Preliminary findings indicate that average soil water levels during wet seasons can be measured by inserting clean iron rods (mild steel) in the soil and measuring the depth of rust on the rods after 8 to 16 weeks. Iron rods rust rapidly in aerated soil above the water table but remain free of rust below the soil water table where air is excluded. This technique appears to work well on imperfectly and poorly drained soils.

Additional keywords: Soil aeration, drainage, soil reduction.

Presently used methods of measuring soil water tables have limitations for field conditions where water wells require constant monitoring and results may be difficult to interpret because of fluctuations in the water levels. Electrical instruments such as oxygen meters and redox potentiometers are expensive and special training is needed to use them in the field. The appearance of mottling helps in indexing soil water tables but reflects the history of drainage properties rather than current conditions. In this paper I describe an inexpensive and simple technique for estimating depth to water tables on forest soils with shallow water tables.

METHODS AND MATERIALS

The theory behind the technique is that in poorly drained soil an iron rod will rust rapidly in the aerated zone but not in the saturated nonaerated or reduced zone. Thus, changes in the appearance of the metal indicate the depth of the aerated zone. Iron rods were chosen for this purpose based on the premise that the oxidation-reduction states of iron are similar to those of soils. The position on the iron rod where rust is no longer found should describe the average depth of the soil water table over a period of time.

To test the use of iron rods for determining soil water levels, we established two experiments. The first was in the hydroedaphytron at the Santee Experimental Forest in tanks which maintained soil water levels at 0, 8, and 24 inches below the soil surface. The subsoil in the tanks consisted of a sandy loam collected from the B2 horizon of a somewhat poorly drained soil obtained locally. The topsoil, the A1 horizon of a Coxville series (poorly drained soil), was placed to a depth of either 4 or 8 inches over the subsoil in the tanks. Four-year-old loblolly pine seedlings were growing on the soils. Welding rods (mild steel) 36 inches long and 3/32 inch in diameter

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were driven about 30 inches into the soil of each tank. Prior to placement in soil, the rods were cleaned of grease and wax. After 8 weeks the rods were removed and the depth of rust formation on them was observed.

In the second test, rods were driven into soil adjacent to 17 water wells on the Santee Experimental Forest where water tables are known to vary from a depth in excess of 3 feet to the surface. Soils were Caroline fine sandy loam (Typic Paleudult clayey mixed thermic), well drained; Craven fine sandy loam (Aquic Hapludult clayey mixed thermic), moderately well drained; Lenoir fine sandy loam (Aeric Paleaquult clayey mixed thermic), somewhat poorly drained; Coxville loam (Typic Paleaquult clayey kaolinitic thermic), poorly drained; and Bladen silt loam (Typic Albaquult clayey mixed thermic), poorly drained.

The Caroline, Lenoir, Coxville, and Bladen sites supported nearly mature natural stands of loblolly pine (*Pinus taeda* L.), age 50 to 70 years, with an understory of sweetgum (*Liquidambar styraciflua* L.), dogwood (*Cornus florida* L.), scattered oaks (*Quercus* sp.), and waxmyrtle (*Myrica cerifera* L.). The Craven site was vegetated with a 13-year-old loblolly pine plantation.

Water wells consisted of sections of 2-inch pipe 4 feet long. The pipes were perforated and inserted in holes dug to the diameter of the pipe. Six inches of the pipe were left above ground and a covering was provided to prevent entry of rain or litter. Water table depths were measured weekly.

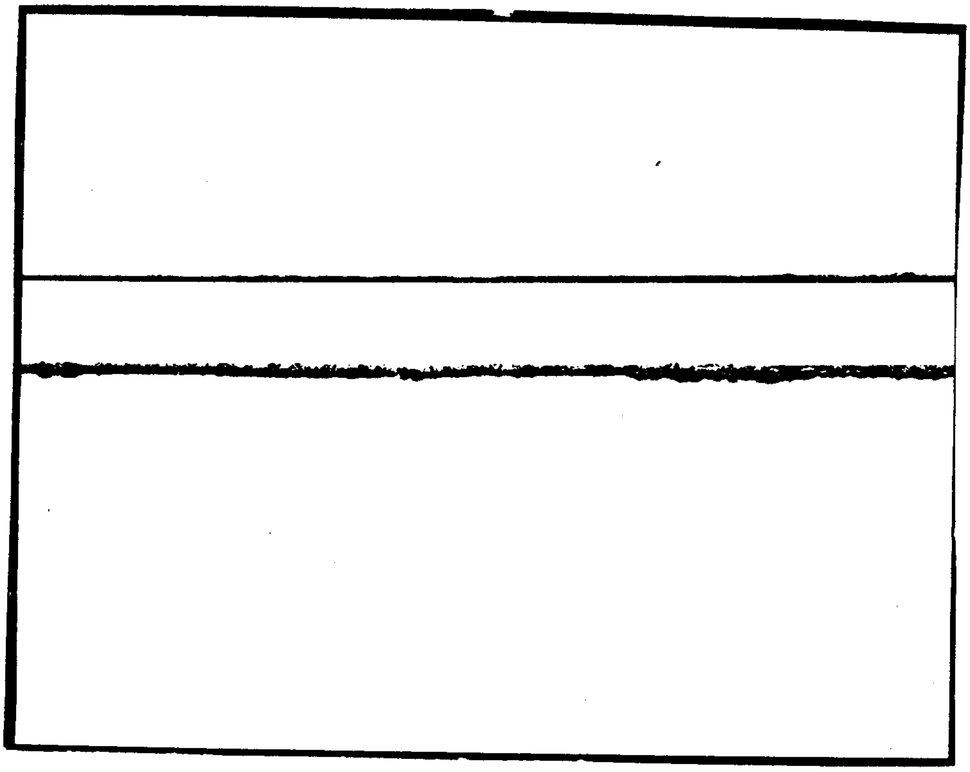
Iron rods of the type and size described above were inserted in the soil to depths of 20 to 30 inches. Three rods which had been cleaned of grease and varnish were inserted in the soil within 8 feet of each well. Rods were installed in the soil on November 12, 1976. One was removed from the soil on March 18, 1977 at each location; the second on May 2, 1977; and the third on October 18, 1977.

To determine the effectiveness of the rods, the depth of rust on the rods was compared with average measured depths of water tables.

RESULTS

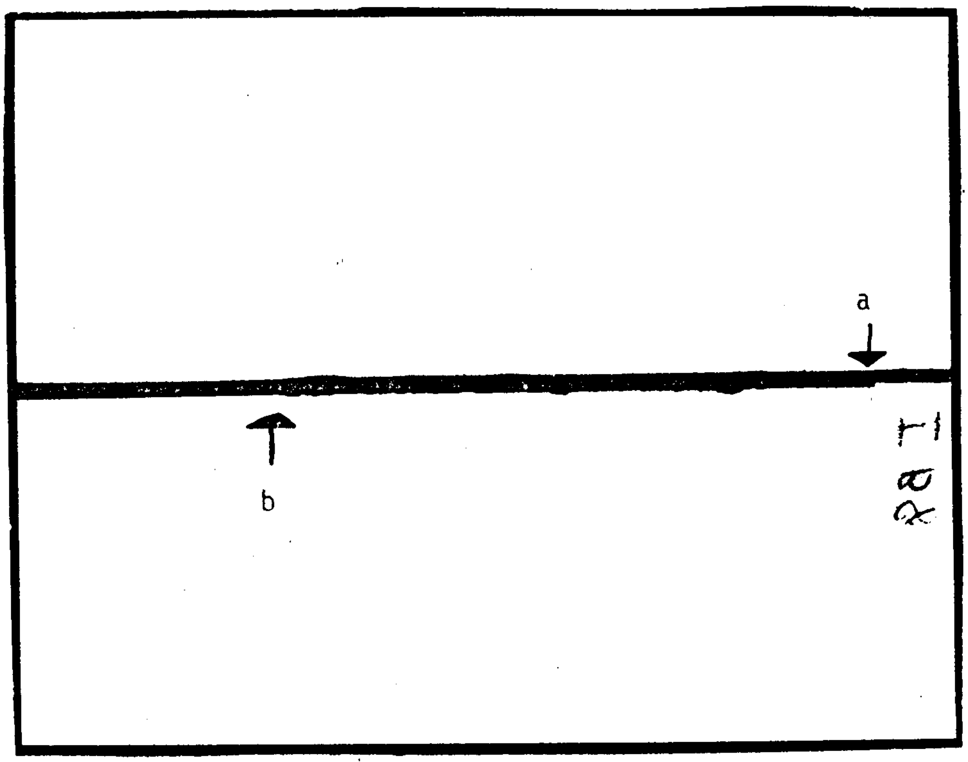
Rods were removed from soil tanks after 8 weeks and photographed (fig. 1). The degree of rusting was closely related to the upper limit of the water tables. No rust was found on those rods in soils saturated to the soil surface. Where water tables were 8 and 24 inches below the soil surface, rust accumulated to those depths but no farther. Separate measurement of soil redox potential with platinum electrodes substantiated the lack of oxygen below the water tables on these soils.

The field test also indicated a close relationship between the depth of rust and average water table depth. These values are compared with soil series drainage classes which reflect water table depths based on soil mottling (table 1). The average water table depths and depth of rust appear



1. Water table at soil surface.

2. Water table at 24 inches below surface.



3. Water table 8 inches below soil surface.

    a. Soil surface
    b. Water table

Figure 1.--Appearance of iron rods placed in soils with water tables 0, 24, and 8 inches below surface for 8 weeks. Note accumulation of rust on metal surface.

distinctly different for the well drained Caroline and poorly drained Bladen soils. The other three soils ranging in drainage classes from moderately well to poorly drained had values less well defined where average water tables ranged from 0.46 to 0.59 feet and depth of rust ranged from 0.35 to 0.65 feet after 16 weeks in midwinter.

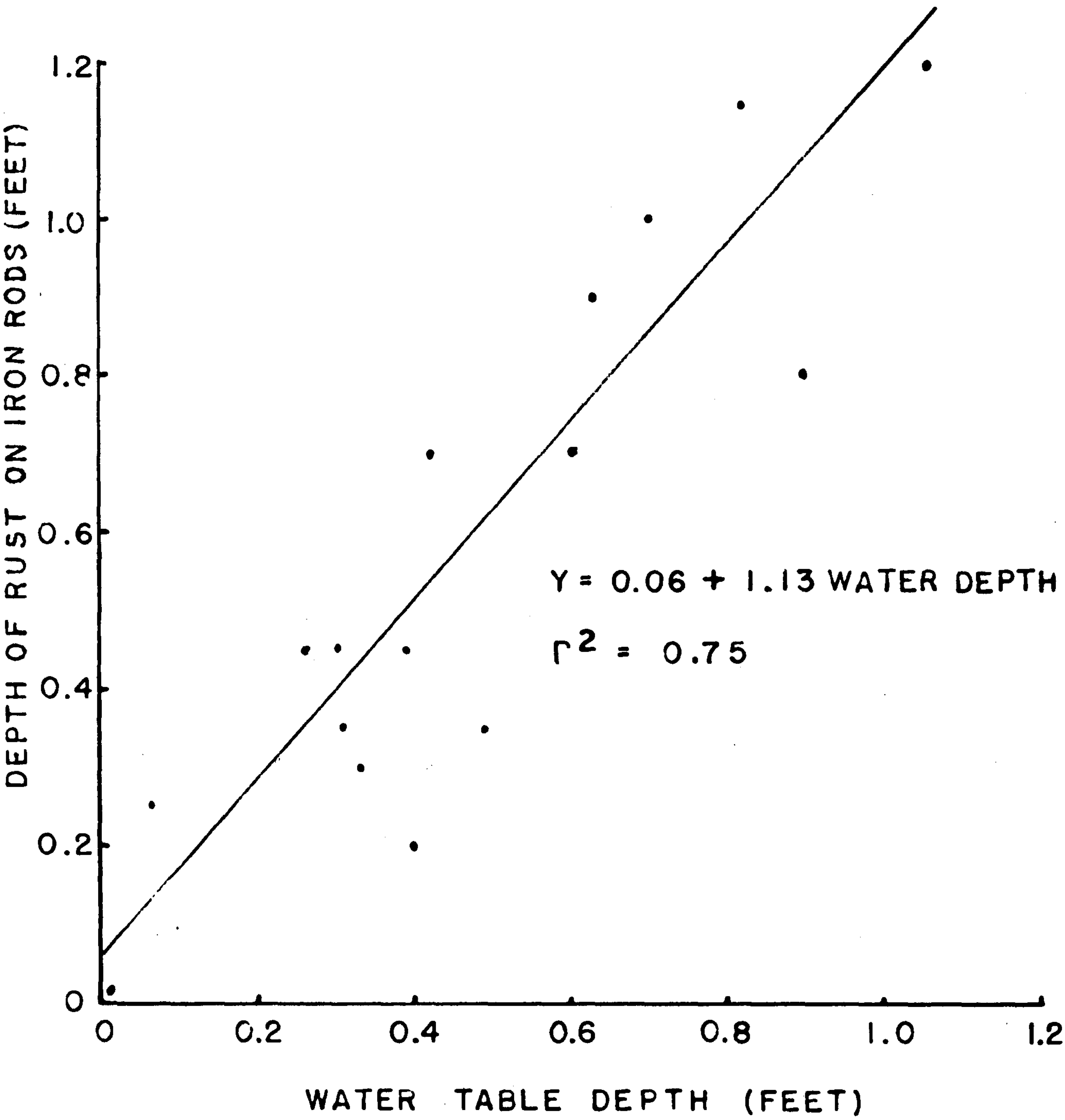
Table 1.--The depth of rusting on the rods and levels of water tables found on different soil series

Soil series	Drainage class	Depth of Rust		Water Depth	
		Average	Range	Average	Range
		feet			
Caroline fine sandy loam	well drained	1.20	---	1.06	---
Craven sandy loam	moderately well drained	.59	.30-.80	.50	.26-.90
Lenoir fine sandy loam	somewhat poorly drained	.65	.20-1.15	.59	.40-.82
Coxville loam	poorly drained	.35	.35-1.15	.46	.30-.70
Bladen silt loam	poorly drained	.12	0-.25	.03	0.0-.06

The depth of rust on the rods was closely related to the average water depths after 16 weeks (fig. 2). The computed slope (near 1) suggests that the depth of rust conforms closely to the depth of the water tables. The relationship accounts for 75 percent of the variation in the water table depths.

Depth of rust on rods that remained in the soil for 24 or 45 weeks after installation accounted for no more than 50 percent of the variation in water depth during this time. Thus, leaving the rods in the soil only during the 3 to 4 months when water tables are highest appears to be best.

An attempt was made to relate the accumulation (thickness) of rust on the rods to water table depth. Oxidized iron was removed with sodium dithionate. The iron removed chemically accounted for only 35 percent of the variation in average water table depth. Increase in weight of rods due to rusting was estimated by cutting the rods into 4-inch segments and comparing the weight of rusted rods to rods not exposed to rusting. Weight difference of rods could not be related to water table depths.



RELATIONSHIP OF WATER TABLES TO DEPTH OF RUST ON IRON RODS

Figure 2.--Relationship of water tables to depth of rust on iron rods (n = 17).

In summary, rust accumulation on iron rods can be used to estimate depth to free water on somewhat poorly to poorly drained soils. The depth of oxide accumulation on the rods is a measure of soil aeration over time. It should be remembered, however, that the sites used in this test are representative only of the heavier soils of the lower Atlantic Coastal Plain. The iron rod method may fail on other soils and in other regions. Iron rods did not rust below the water table in the study soils because oxygen was lacking. In soil that has no organic matter and microorganism to deplete the oxygen, or where the water is constantly moving through the profile, the technique would probably fail because rust would tend to form below the water table.