

Letter to the Editor

Use and Abuse of the Soil pH Measurement

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This communication is for the benefit of plant pathologists and other biologists who make measurements of soil pH. There is an apparent misconception that only a beaker, a spatula, some water, soil, and a modern pH meter are required to determine soil pH. Numbers are easily obtained in this manner, but accurate measurement of soil pH (readings; as opposed to numbers per se) is critically dependent on how the soil sample is handled prior to, and during, the actual pH measurement. Dilution with varying amounts of water can cause pH variations of greater than one pH unit (i.e., 10-fold) (6). Other factors which influence apparent pH values include the concentration of CO₂ and of soluble salts in the soil; procedures used in preparing the sample; temperature of the sample relative to that of the buffer used as a standard; the depth of placement of the two electrodes in the sample; and whether the electrodes are stirred or not stirred through the sample during the actual measurement (4, 6).

Volume 60 and the first nine issues of Volume 61 of PHYTOPATHOLOGY contain 91 papers on soils and soil-borne plant pathogens. Although pH is an important variable in such studies, it was reported in only 24 of the papers, and only three (3, 5, 9) reported how the value was obtained. To state simply that a pH meter or a glass electrode was used is not meaningful. As a minimum, papers should report the soil to solution ratio, and whether a salt solution or water was used for the suspension liquid.

Soil pH values presented in Table 1 were obtained for a Puyallup fine sandy loam and a Ritzville silt loam to illustrate the magnitude of variation that can occur with different preparatory or measurement procedures. Field-moist samples were prepared by different procedures (Table 1), using various dilutions of water, 1 N KCl, or 0.01 M CaCl₂, and the pH was subsequently measured.

As the dilution of soil with water was increased, the observed pH of the soil increased. This effect relates to the colloidal properties of the soil. With increasing dilution, the concentration of calcium plus magnesium in the equilibrium solution increases relative to that of hydrogen, which results in a decreased hydrogen ion activity, and an increase in soil pH. Of the values reported in Table 1, the saturated paste most closely approximates a field-water content, but by inference we would suspect that the pH would be even lower in the field, where the soil water content is less than saturation. The pH values for unstirred water suspensions were higher than for stirred suspensions, and varied with

the depth to which the calomel electrode was inserted. This is related to junction potentials existing in the measuring systems, and is particularly pronounced in low-salt samples. Values obtained from the supernatant solution are preferred to those obtained from the soil suspension (7). Air-drying the sample for storage usually causes the pH to rise. Measurements made immediately in the field are more accurate than those made on samples transported to the laboratory and air-dried.

Schofield & Taylor (8) proposed that soil pH measurements obtained from 1:2 suspensions of soil in 0.01 M CaCl₂ are more accurate than those obtained from soil suspended in water alone. For nonsaline soils, their method provides pH values that are virtually independent of the degree of dilution and the initial salt concentration. This medium also represses most liquid junction potentials. In short, it provides a more accurate estimate of the soil solution pH in situ (6). As stated by Black (2), "The method proposed by Schofield and Taylor (1955) appears to be the best now available for measuring soil pH on a practical basis if the objective is to obtain an estimate of the pH of the soil solution where the water content of the soil corresponds to field conditions". Pathologists and other biologists would do well to adopt this method as a standard whenever possible. Results could be reported as "pH in 1:2 soil:0.01 M CaCl₂ suspensions". As shown in Table 1, such values are typically about 0.5 of a pH unit lower than those obtained where water alone is used. Some European workers prefer to measure soil pH in 1 N KCl. Values so obtained can be as much as two units lower than those measured in water, due to displacement of large quantities of surface acidity from soil colloids by the KCl. Such an approach might be adopted where a measure of total soil acidity, rather than acidity of the soil solution was sought by the worker.

The concentrations of carbon dioxide and soluble salts have a great influence on soil pH. Moreover, they vary within a given sample, depending on whether the sample is in situ near a plant root, or exposed to the atmosphere on a laboratory bench. The pH of an alkaline soil (e.g., the Ritzville silt loam), in an atmosphere of 10% CO₂, may be as much as two units lower than that of the same sample in equilibrium with air containing 0.03% CO₂. Because of high CO₂ concentrations in many soils, organisms or plant roots may be exposed to pH values considerably lower than those measured in the laboratory. Whitney & Gardner (10) reported that soil pH is a linear function of the log of the partial

TABLE 1. The effect of preparatory and measurement procedures on soil pH values

Suspending fluid, method of preparation, and handling of soil and suspension ^a	pH							
	Puyallup fine sandy loam				Ritzville silt loam			
	Saturated paste	1:1 ^b	1:2	1:5	Saturated paste	1:1	1:2	1:5
Water	5.1	5.3	5.4	5.5	7.7	7.8	8.0	8.2
Unstirred supernatant		5.7	5.7	5.8		8.1	8.2	8.5
Unstirred suspension		5.7	5.6	5.9		8.2	8.4	8.4
In equilibrium with air containing 10% CO ₂			5.2				6.1	
Sample air-dried overnight prior to preparation of suspension			5.5				7.3	
1 N KCl	4.4	4.4	4.4	4.5	6.4	6.4	6.4	6.4
0.01 M CaCl ₂	4.9	5.0	5.0	5.0	7.3	7.3	7.3	7.3

^a Except where noted, all measurements were made on samples in equilibrium with atmospheric CO₂ at 25 C, and were stirred intermittently for 1 hr prior to measurement and during measurement.

^b Soil:solution ratio (w/w) in soil suspensions.

pressure of CO₂ in calcareous soils. A mathematical adjustment can thus be used to improve the accuracy of the soil pH value, but such adjustment is contingent upon a knowledge of the CO₂ concentration in the system, and upon the relationship between CO₂ concentration and pH for the soil in question. Likewise, salts which may accumulate at root surfaces (1, 7) can cause differences in pH between microsites on the root and locations in bulk soil. The Schofield-Taylor method reduces the magnitude of errors caused by variations in soluble salt concentration, and bathes the electrode in a medium not too dissimilar from that encountered by organisms and roots in many agricultural soils.

In spite of the above difficulties, soil pH is a very useful index, and remains as the most commonly measured soil property. The facts mentioned herein, hopefully, will help familiarize workers with some of the considerations involved in measuring and interpreting such values. Values reported in past publications are always meaningful on a relative basis within a given paper, provided that the worker standardized his method and did not have water content, CO₂ partial pressure, or salt concentration as additional variables while conducting his experiments. The greatest problems arise when attempts are made to compare the values of one worker with those of another. It is particularly important for such comparisons, and for the development of a reliable body of information on the effects of soil pH on plant pathogens, that whatever methods used be described as accurately as possible, and that standardized methods be used whenever possible.

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