

Bray R H & Kurtz L T. Determination of total, organic, and available forms of phosphorus in soils. *Soil Sci.* 59:39-45, 1945.  
[Illinois Agricultural Experiment Station, Urbana, IL]

This paper was the first refereed journal article to describe an acid-fluoride reagent for extracting "plant available" phosphorus from soils. That method (now known as Bray 1) is still, after more than 40 years, among the most widely used procedures in soil testing. [The *SCI*® indicates that this paper has been cited in over 445 publications since 1955.]

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A soil test has three parts: (1) a reagent to extract the "plant available" nutrient from the soil, (2) expeditious measurement of the amounts extracted, and (3) the interpretation of the measured amounts for their sufficiency for crop growth.

Soil testing methods proliferated during the 1930s. Plant scientists reported that roots excrete CO<sub>2</sub> and organic acids that were assumed to release nutrients from soil minerals. Numerous soil scientists proposed soil-test reagents designed to simulate the plant.

Roger H. Bray in the Department of Agronomy of the University of Illinois took the view that soil scientists should learn to identify the chemical forms of each plant nutrient in soils and to apply that knowledge to design soil tests. In 1938 under Bray's guidance, I began to study the forms of soil phosphorus and the reactions of phosphate fertilizers in soils. The organic fraction of soil phosphorus was being studied by S.R. Dickman, another graduate assistant, who originated the theory of fluoride as an extractant for phosphate adsorbed by soils. Bray combined our findings to develop

two rapid soil tests (P-1 and P-2) for two forms of soil phosphorus. Reference samples for calibrating the methods came from phosphate fertilizer trials on over 20 Illinois soil-experiment fields.

The editor of *Soil Science* requested an article on phosphorus for a special issue on chemical methods for soil analyses. Our resulting article "emerged as one of the most frequently cited works in its field" because it includes the Bray 1 soil test.

Acceptance of the Bray 1 was greatly enhanced by a comparative study published in 1956 by a national Soil Test Work Group.<sup>1</sup> Soil samples from 74 phosphate-fertilizer field experiments across the US and Canada were tested by 55 state and commercial laboratories by the method used by each at that time. Ten different methods were used in 41 of the laboratories with the remaining laboratories using a variety of other procedures. Three laboratories reported results with the Bray 1. The summary of the study reported that Bray 1 was the least affected by soil properties and that correlations between Bray 1 and cropping functions were consistently greater than with any other procedure.

Currently, only three phosphorus methods are used extensively in the US: Bray 1 in the north central, mid-south, and mid-east; Mehlich 1 in the southeast; and Olsen in the west. These distributions roughly follow soil regions. Publications containing modifications, for example, different soil-solution ratios or improved analytical methods for measuring phosphorus extracted by the solution, have appeared at intervals<sup>2-6</sup> and are often cited instead of the original article.

Bray was a distinguished soil scientist who made many important contributions to his field. His death in 1972 was commemorated by an *In Memoriam* published in *Soil Science*.<sup>7</sup>

1. Soil Test Work Group, National Soil Research Committee. Soil tests compared with field, greenhouse and laboratory results. (Whole issue.) *N. C. Agr. Exp. Sta. Tech. Bull.* (121), 1956. 19 p.
2. Council on Soil Testing and Plant Analysis. *Handbook on reference methods for soil testing*. Athens, GA: Council on Soil Testing and Plant Analysis, 1980. 46 p.
3. Knudsen D. Recommended phosphorus tests. *N. Dak. Agr. Exp. Sta. Bull.* (499):14-6, 1980.
4. Laverty J C. A modified procedure for the determination of phosphorus in soil extracts. *Soil Sci. Soc. Amer. Proc.* 27:360-1, 1963.
5. Olsen S R & Sommers L E. Phosphorus availability indices. (Page A L, ed.) *Methods of soil analysis. Part 2. Chemical and microbiological properties*. Madison, WI: American Society of Agronomy and Soil Science Society of America, 1982. p. 416-8.
6. Arnold C Y & Kurtz L T. *Photometer method for determining available phosphorus in soils*. (Mimeo.) Urbana, IL: Agricultural Experiment Station, University of Illinois College of Agriculture, 1946. AG 1306.
7. *In memoriam*: Roger Hammond Bray (1898-1972). *Soil Sci.* 115:3-4, 1973.