WHY LABORATORY RESULTS DIFFER

THE NEED FOR LABORATORY STANDARDIZATION

Nat B. Dellavalle
Dellavalle Laboratory, Inc
Fresno, California

When the same or similar samples are sent to more than one laboratory, similar results are expected but rarely obtained. Different results lead to confusion and lack of confidence in laboratories and the client has no way of knowing which, if any, result is to be believed.

Variable results have occurred over time, and over large and small geographical areas. In 1972, Larry Whittsell reported variations between several California laboratories. Liebhardt and Cudick, in a 1982 series of articles in the "The New Farm" magazine reported variations in laboratory results as well as recommendations based on results, from private and public laboratories over a wide part of the United States. The Soil Fertility Staff of the Department of Agronomy at the University of Nebraska conducted a study over a 12-year period that showed the results of analyses and recommendations from five Nebraska laboratories varied during the entire time period. These are but a few examples of many known to the author. Most distressing is when clients spend far more money for fertilizer to prevent deficiencies than they would have spent for soil testing because they realize that the cost of overfertilization is much smaller than the loss that would result from a deficiency.

Several reasons for differences between laboratories are:

Different samples are sent to each laboratory.
Laboratories use different methods.
3. Some laboratories have modified the techniques.
4. Some laboratories have poor quality control and/or assurance methods.
5. Different methods of reporting are used.
6. Interpretation of results and recommendations, based on similar results, vary extremely.
7 Some differences are within the normal range of variation or accuracy of the test.

Splitting samples for submission to more than one laboratory requires understanding, skill and a lot of work in order to ensure that laboratories receive identical samples. Results cannot be expected to be similar if different samples are submitted to each laboratory. Sampling or sample splitting errors are more common than any other type of error. Clients, who do not understand field variation, may collect two or more samples from the same field or area and believe that they are all the same when, in fact, they are not. A single unmixed sample may be divided into more than one container. In order to eliminate variation between subsamples careful selection, preparation and splitting are required. A uniform fine or medium textured soil is preferred. Coarse soils or soils with a wide particle size distribution are more prone to particle separation during the mixing and splitting process. The bulk sample should be dried, ground to a uniform particle size and mixed thoroughly before splitting. A riffle, or other sample splitting device, should be used to divide the bulk sample into subsamples. Once split, the samples should be tested by one laboratory to determine uniformity. Then, and only then, can the samples be used to determine differences between laboratories.

Use of different methods is a leading cause of variation of results from different laboratories. During the 1940's and 50's, soil testing procedures were under development throughout United States and other countries. While each procedure developed was judged to be suitable for the individual locality, many different procedures were developed. A 1951 survey conducted by the Soil Test Work Group of the National Soil Fertilizer Research Committee found that 50 state soil-testing laboratories were using 28 different extractants for phosphorus and 19 for potassium. Only the Morgan method was in wide use (Soil Testing, 1980). Jones, in a 1973 survey of the same laboratories, found three extractants for phosphorus and three for potassium (Jones, 1973). Research and development continues and new procedures are being developed. Soltanpour in Colorado and Mehlich in North Carolina have developed so called universal extractants.

Even though there are fewer methods in use today, a great deal of variability remains. Although many laboratories utilize one of the methods in general use, they have made modifications without recalibrating the method. In the introduction to the Handbook on Reference Methods for Soil Testing, variations are reported that include:

1. Soil to extractant ratios ranging from 1:6.7 to 1:10 for Bray P1 instead of the orginal 1:7.
2. Bray P1 extraction times ranging from 40 seconds to 5 minutes instead of the original 40 seconds.
3. Soil to extractant ratios for normal ammonium acetate ranging from 1:3 to 1:10 with various shaking times.
4. Soil pH values measured in 1:1 or 1:2 water mixes, saturated pastes, or diluted salt mixtures.
5. Scooping a known volume instead of weighed subsamples and vice versa.
6. The amount of soil extracted.
7. Extraction vessel size and shape.
8. Shaking speed.

Other variables and POOR analytical techniques contribute to variation in results. A technician may be using the correct method but not proper technique. A few such poor techniques are:

1. Inappropriate purity of water, chemicals or reagents.
2. Volumetric & weight measurements without regard to required degree of accuracy.
3. Equipment or instruments poorly calibrated or uncalibrated.
4. Poor laboratory sanitation.
5. Improper preparation & storage of chemicals.
6. Failure to properly mix samples prior to subsampling
7 Contamination of one sample with another.

Reporting methods are not consistent. Both nitrate nitrogen (NO_3-N) and nitrate (NO_3) are reported. Some laboratories have reported phosphate (PO_4) as P and others as P_2O_5. Result may be reported without defining the method used. Such differences may be subtle and can confuse the professional as well as the lay person. Examples are:

Methods of expressing results such as parts per million, a weight per weight measurement or pound per acre; or a weight per volume measurement, are not consistent.

2 Volume expression of results is used for weighed samples and vice versa.

Interpretation of results is another variable. The University of California estimates the gypsum requirement for sodic soils using weighed samples as meq/100 gm. Interpretation is included in the result when pounds per acre six inches is reported. That may not be clear to the client. Interpretation may be limited to a comparison with published "critical" or sufficiency levels, or it may include detailed recommendations of specific rates of specific materials.

Interpretation by some is based upon base saturation ratios while others use sufficiency levels. When more judgement and art, than science, are used to interpret results, wide variation is understandable. The farmers' management ability, production economics and other limiting factors, such as water or disease pressure are among considerations independent of the laboratory result.

The need for standardization is evident. Evaluation of results of analysis of individual samples or reports of extensive research without precise use of standard procedures and methods is not possible. Interpretive criteria developed with one method cannot be used to evaluate results produced with any other method or technique. Well-qualified persons who must work with laboratories using vastly different methods have much difficulty reconciling the differences. Those who do not understand or have time to cope with the differences simply do not use soil testing even though there is an economic need to do so.

Within the United States there are several efforts to standardize soil test procedures. Each makes use of sample exchange, and published methods. The NCR-13 Soil Testing Committee comprised of representatives from several states in the north central region of the

United States, Alaska and several Canadian provinces have published Recommended Chemical Soil Test Procedures for the North Central Region (Dahnke, 1980). Procedures with detail have been published in the Handbook on Reference Methods for Soil Testing (Council of Soil Testing and Plant Analysis, 1980). Procedures used in state-testing laboratories in the south eastern states of the United States resulted from cooperative effort in that area (Sabbe, 1974). The Northwest Plant Food Association has sponsored a sample exchange program for more than ten years and plans to publish recommended methods (personal correspondence, 1986). Most published methods are not applicable to arid and semi-arid regions. The Soil Improvement Committee of the California Fertilizer Association (CFA) sponsored and encourages involvement of California laboratories in the Northwest Plant Food Association program. A manual of California Soil Test Procedures has been published (California Fertilizer Association, 1980). An example of the complexity of standardization and certification is the recent hay testing program by the United States Alfalfa Hay Quality Committee (National Hay Association, 1984).

Involvement in the programs listed above is voluntary. There are no regulations or statutes requiring the use of particular methods for agricultural soil testing. The Council on Soil Testing and Plant Analysis, fertilizer associations, university personnel and others encourage standardization. Resistance from several areas delays standardization. Some resist regulation in any form; others feel that standard methods would discourage new research. There are also those who prefer methods that produce results to their liking; for example, unscrupulous fertilizer companies prefer methods that give low results. Some laboratory managers prefer procedures that are less costly despite inferior results.

Misuse of fertilizers in the United States is viewed as a source of pollution and regulation is expected. Regulation will require soil testing using specific methods set by statute or regulation as is now required for water, waste water and other samples.

Laboratory accreditation which requires that laboratories have appropriate personnel, equipment, instrumentation, methods and quality control and quality assurance programs is needed.

Soils and environments are diverse and there probably will never be a single perfect soil test. There will be a continued need for several standard methods. As we continue to learn about soil fertility and plant nutrition systems, there will be a need to improve existing methods and develop new ones.

Another major reason for lack of confidence in a test procedure is over expectation in the method. Users of the tests results need an understanding of the method, its basis and its limits.

Development of a "standard" soil test method requires several steps

1. Selection of a method that extracts or evaluates a soil property related to the crop response to be predicted.
2. Calibration of the test in greenhouse and field trials covering the entire range of responsiveness.
3. Evaluation of all parameters including the influence of testing method, sample size, sample measurement method, soil to extractant ratios, shaking time and speed, container size and shape and other variables on the test result.
4. Education of users of the method and users of results developed with the method with respect to critical parameters and limitations of the method.
5. Use of sample exchange programs and sound quality control and quality assurance methods to maintain good agreement between laboratories.

Laboratories wi agree when and only when they

1. receive properly split samples
2. use the same methods
3. have and use proper quality control and quality assurance programs
4. use standard methods of reporting
5. interpretations and recommendations are expressed separately from results.

An accreditation program that requires standard methods and good laboratory practices is needed.

REFERENCES

California Fertilizer Association. 1985. Western Fertilizer Handbook 7th ed. The Soil Improvement Committee. CFA. Sacramento, California.

California Fertilizer Association. 1980. California Soil Testing Procedures. The Soil Improvement Committee. CFA. Sacramento, California.

The Council on Soil Testing and Plant Analysis. 1980. Handbook on Reference Methods for Soil Testing. CSTPA. University of Georgia Athens, Georgia.

Dahnke, W.C. (ed). 1975. Recommended Chemical Soil Test Procedures for the North Central Region. North Central Regional Pub. 221. North Dakota Agr. Exp. Sta. Bull. 499. 23p.

Hills, Jack F., Albert Ulrich, Robert Sailsbery. 1978. Sugarbeet Fertilization. Division of Agricultural Sciences. University of California. Berkeley, California. Bulletin 1891.

Homer, Chapman D., Parker F. Pratt. 1961. Methods of Analysis for Soils, Plants, and Waters. Division of Agricultural Sciences. University of California. Riverside California.

Jones, J.B. 1973. Soil Testing in the United States. Comm. Soi Sci Plant Anal 4:307-322.

Laboratory Certification Subcommittee of the U.S. Alfalfa Hay Quality Comm. 1984. Hay Testing Laboratory Certification Manual. National Hay Association and the American Forage and Grassland Council. Pub. No. 2.

Liebhardt, W.C. & Cudick, M. 1982. The Never Never Land of N The New Farm. Also see other articles in the series.

Page, A.L., R.H. Miller, D.R. Keeney, (Ed). 1982. Methods of Soil Analysis. Chemical and Microbiological Properties. 2nd ed. American Society of Agronomy, Inc. Soil Science Society of America, Inc. Madison, Wisconsin.

Peck, T.R., J.T. Cope, Jr., and D.A. Whitney (ed). 1977. Soil Testing: Correlating and Interpreting the Analytical Results. ASA Special Publ. No. 29. Madison, Wis. 117p.

Reiseover, H.M. (ed). 1983. Soil and Plant Tissue Testing in California. University of California. Division of Agricultural Sciences. Berkeley, California. Bulletin 1979.

Sabbe, W.E. and H.L. Breland. 1974. Procedures Used by State Soil Testing Laboratories in the Southern Region of the United States. Southern Cooperative Series Bull. No. 190 23p.

Sallee, William R., W. Martin. 1962. Phosphorus for Alfalfa Production in Tulare County. Agricultural Extension Service. University of California. Visalia, California.

Soi. Fertility Staff. 1978. A comparison of Suggested Fertilizer Programs Obtained from Several Soil Test Laboratory Services. Agronomy Department, University of Nebraska, Lincoln, Nebraska. Agron. Dept. Report No. 26.

Soil Fertility Staff. 1980. A Comparison of Suggested Fertilizer Programs Obtained from Several Soil Test Laboratory Services. Agronomy Department, University of Nebraska, Lincoln, Nebraska. Agron. Dept. Report No. 36.

Soil Fertility Staff. 1985. A Comparison of Suggested Fertilizer Programs Obtained from Several Soil Test Laboratory Services. Agronomy Department, University of Nebraska, Lincoln, Nebraska. Agron. Dept. Report No. 49.

Soltanpour, P.N. and A.P. Schwab. 1977. A New Soil Test for Simultaneous Extraction of Macro- and Micro- Nutrients in Alkaline Soils. Comm. Soil Sci. Plant Anal. 8 (3):195-207.

United States Salinity Laboratory Staff. 1954. Diagnosis and Improvement or Saline and Alkali Soils. U.S. Dept. Agr. Handbook 60. 160p. U.S. Government Printing Office, Washington, D.C.

Walsh, L.M. and J.D. Beaton (ed). 1973. Soil Testing and Plant Analysis (Revised Edition). Soil Science Society of America, Madison, Wis. 491p.

Whittsell, L.E. 1972. Comparison of Soil Sample Analysis by Five Agricultural Laboratories. Proceedings of the California Soil and Plant Conference, California Chapter of A.S.A. p 75, 76.