THE SOIL TESTING PROGRAM IN NORTH DAKOTA

W. C. Dahnke, L. J. Swenson and A. Johnson

By definition a soil test is a chemical, physical or microbiological operation that estimates a property of a soil related to the suitability of the soil to support plant growth. The relationship (correlation) between a soil test and crop growth is determined by conducting field trials on many fields over a period of years. When these field trials include several rates of a nutrient, a relationship can be established between the soil test and the amount of nutrient needed to obtain a certain yield (calibration). A fertilizer recommendation to a grower is basically made by assuming that a crop growing on his field will respond in the same manner as crops did in the field trials if they have a similar soil test.

Soil Testing in North Dakota

Soil testing was offered as a service to farmers by North Dakota State University for the first time in the fall of 1953. The tests offered from 1953 through 1967 were: 1) phosphorus by the sodium bicarbonate procedure; 2) soluble salts by electrical conductivity; and 3) pH measured with a pH meter. A. Bauer was the supervisor of the soil testing service from 1953 to 1960. In the early years of the program, significant contributions were made by E. B. Norum, R. A. Young and J. C. Zubriski. E. H. Vasey supervised the service from 1961 to 1967.

Since 1968 the soil testing program has been under the supervision of W. C. Dahnke and L. J. Swenson. Many changes have taken place in the soil testing program since 1967. In the fall of 1968, a test for nitrate-nitrogen in the top 2 feet of soil was introduced. Nitrogen is the nutrient most often lacking in North Dakota soils. This test accurately determines nitrogen deficiencies and is one of the main reasons for the rapid increase in the use of soil testing by North Dakota farmers (Fig. 1). For many years only 6,000 to 8,000 samples were tested each year, but within a few years after the introduction of the nitrate test, the number of samples increased to between 50,000 and 75,000 samples per year.

Dahnke is professor, Swenson is assistant professor and Johnson is agricultural research technician, Department of Soil Science.

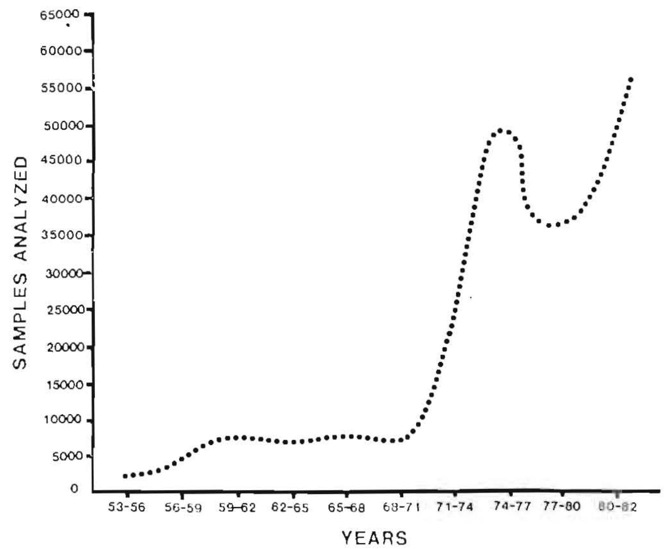

Figure 1. Average number of soil samples analyzed for three year periods from 1953 through 1982.

Another factor that may have increased the use of soil testing in North Dakota was a change in the interpretation of the phosphorus test. Previous to the 1969-70 soil testing year, the interpretation of the phosphorus test took into consideration soil pH. The interpretation was such that at a high pH, less extractable phosphorus was needed than at a low pH for a soil to fall in the same availability category. The result was that most fields in the western part of North Dakota ended up in the deficient categories due to their lower pH. The present interpretation does not use soil pH. With this change the samples falling into the very low and low categories decreased from about 70 percent of the samples to only about 20 percent, which more closely reflects the occurrence of responses to phosphorus fertilizer in western North Dakota.

Other changes and tests that have been introduced since 1968 are:

*A test for potassium was offered for the first time in 1968. Over 90 percent of the fields in North Dakota test very high in exchangeable potassium.

*Since 1970 fertilizer recommendations have been made by the use of a computer.

*In 1972 a test for zinc was offered. A few years later iron, copper and manganese tests were also included. Micronutrient deficiencies are relatively uncommon in North Dakota and insufficient numbers of field deficiencies have been documented for extensive soil test calibration for micronutrients in North Dakota. Current interpretation categories have come largely from neighboring areas, where micronutrient deficiencies are more common.

*Since 1974, fertilizer recommendations have been based on yield goals established by the grower. Previously, recommendations were based on the average potential yield for four areas of the state. This did not take into consideration differences between fields or the management ability of individual growers.

*In 1976, a sulfur test was introduced using a calcium phosphate solution as the extractant. This test should be run on samples representing the 0-24 inch depth, as is done for the nitrate-nitrogen test.

The increased interest in soil testing has resulted in the establishment of 15 private soil testing laboratories in North Dakota since 1969. More are in the planning stage. The NDSU soil testing laboratory has assisted many of these laboratories in the areas of chemical analysis and interpretation.

Soil Testing Research

Research connected with the soil testing program has included work on when to sample soil, how to sample fields, nutrient reactions with soil, fertilizer placement, soil test correlation, soil test calibration, soil test interpretation, etc. Following are explanations and/or examples of some of these areas of research:

Soil sampling

A soil sample that truly represents the field from which it is taken is basic to any soil testing program. If the soil sample does not represent the field, the results are worthless. A truly representative soil sample must be accurate and precise. Accuracy refers to the correctness of a sample and precision measures the ability to resample a field and obtain the same results. Accuracy and precision are increased by taking a larger number of subsamples from the field and combining them to form the soil sample.

Many fields were intensively sampled in North Dakota during a sampling study to determine the amount of subsampling required for an accurate soil sample. Further objectives were to determine the effect that field size and sampling from nonrepresentative areas had on the accuracy of soil samples. This study shows that nitrate-nitrogen and phosphorus are much more variable than potassium and require a greater number of subsamples for an accurate soil sample.

Figure 2 shows that a large number of subsamples are necessary for extremely accurate samples. Extreme accuracy (within 5 percent of the true average) is difficult to achieve and not necessary for soil testing purposes. Likewise, it is very easy to obtain very inaccurate samples (within 25 percent of true average) which probably have little value for fertilizer recommendations.

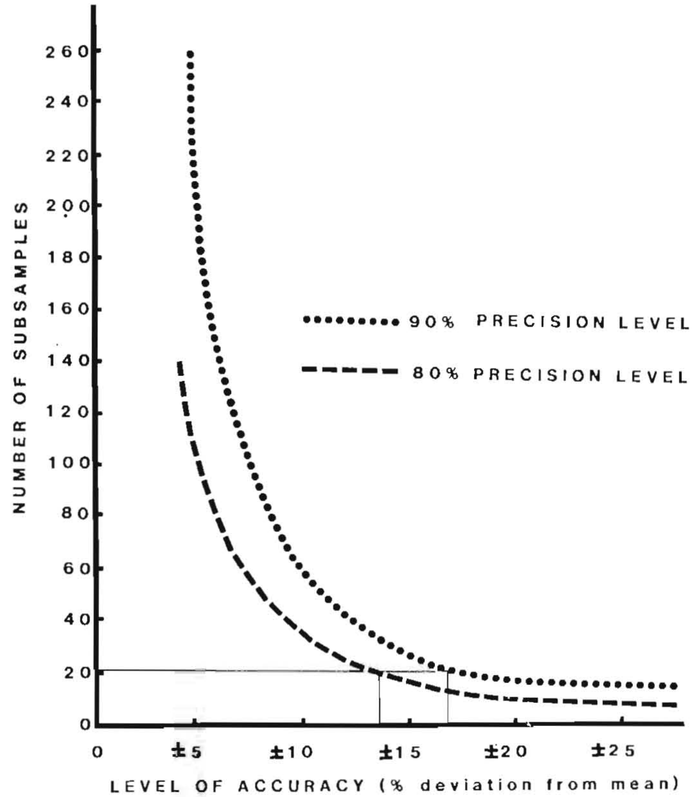

Figure 2. Number of subsamples required from a field for a soil sample that will be tested for nitrate-nitrogen at various levels of accuracy at the 80 percent and 90 percent precision levels.

The current instructions are to take a minimum of 20 subsamples within a field and combine them to form the soil sample. This will result in a soil sample that will very realistically tell the nutrient status of a field.

Sampling from nonrepresentative areas of a field, such as headlands or small areas of distinctly different soil types, salt spots, eroded knobs, etc., greatly decrease the accuracy of the sample. If these are avoided the amount of subsampling required for the soil sample is greatly reduced.

Field size doesn't appear to have much influence on the amount of subsampling required to obtain an accurate soil sample as long as the entire field has had the same fertilizer and management history. If a large field is a result of combining two smaller fields, it should be sampled as separate fields until the two areas become similar.

Soil test correlation

Many soil tests have been proposed and/or used to determine whether or not nutrients need to be added to soils. Because soils throughout the world are different, all soil tests do not work on all soils. The objective of soil test correlation is to choose the soil test that best predicts the probability of a nutrient response for the soils in your area.

For example, the Bray P_1 test for phosphorus is probably the most commonly used test for phosphorus in the U.S. Work by Zubriski indicated that although this test worked fairly well in North Dakota, the sodium bicarbonate, also known as the Olsen test, did better in predicting a response to phosphorus. This is mainly because on certain high lime soils the acidic extractant used in the Bray test is apparently neutralized before much phosphorus is extracted. The result is that little phosphorus is extracted even though the soil may be very high in phosphorus. For this reason the Bray P_1 test is not used as a test for phosphorus in North Dakota.

Soil test calibration

Most of the research that is presently being done in connection with the soil testing program involves soil test calibration. Soil test calibration is simply the process of determining how much of a nutrient needs to be applied to get a desired crop response at various soil test levels. This work has to be done under field conditions. Due to the large influence of weather on crop growth, trials have to be conducted over a period of years to obtain accurate data on crop response. A large amount of soil test calibration data has been collected in North Dakota for small grains, potatoes, sugarbeets, corn, grass and sunflowers. There are relatively little data, however, for the other crops grown in North Dakota. An effort is being made to get more soil test calibration data for these crops.

The Practical Value of Soil Testing

Soil testing consists of sampling soils, testing the samples and then making a nutrient recommendation based on the soil test and the crop to be grown. Fertilizer recommendations based on soil tests are not exact and cannot be exact due to the influence of weather on crop growth and the difficulty of sampling and fertilizing a medium as variable as soil. For these reasons, soil test results are normally reported in categories, such as **low, medium, high** and **very high.** These relative terms can best be defined in terms of the probability of getting a response to an application of fertilizer. For example, the term **low** means that 80 percent or more of the time a crop growth response will occur if nutrients are applied. On a **medium** testing field there is about 50 percent chance of getting a response to applied nutrients. A **high** testing field has a fairly good reserve supply of nutrients and crops will respond to applied nutrients only about 20 percent of the time. Responses generally occur in years of exceptionally good growing conditions. **Very high** testing soils are so well supplied with nutrients that it is highly unlikely a response to added nutrients will occur.

In the soil testing program at NDSU, fields that test **medium** in phosphorus and/or potassium receive a recommendation that is approximately equal to the amount of nutrient removed in the harvested portion of the crop. This amount of nutrient will maintain the soil in the **medium** category over the long term and it is also enough to obtain the expected yield in responsive years. **Low** testing fields receive recommendations that are approximately 50 percent greater than **medium** testing fields. Soil reserves are less on **low** testing fields; therefore, the crop is more dependent on applied nutrients. The recommendations for **high** testing fields are about 50 percent less than **medium** testing fields. Fields testing **very high** get a recommendation of zero.

The points we would like to make about soil testing are:

*Soil testing is the best available method of determining the relative nutrient status of soil.

*The actual response to fertilizer and the optimum amount needed will vary greatly from year to year in ways that cannot be forecast. This results from weather having a large influence on the growth of crops.

*Soil testing should, therefore, be used to determine the relative levels of nutrients in each field. Test fields for residual nitrogen each year. Test for the other nutrients once every three to five years. Enough nutrients are then supplied so that nutrients do not become limiting in reaching near **maximum** yields for your local conditions and your management ability. This will result in a higher **average** yield per acre and, therefore, a higher profit per acre than fertilizing for average yields or fertilizing for a different yield goal each year based on present or predicted growing conditions.