Soil Testing and Plant Analysis for Seedling Nutrition

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Introduction

Both soil testing and plant analysis can be used as valuable tools to evaluate plant nutrition. Laboratory analysis can provide the level of nutrients available in the soil as well as amounts taken up by the plants. It is the purpose of this paper to describe the concept of chemical analysis for plant nutrition and how you might evaluate the laboratory doing the work.

Soil Testing

The concept of soil testing is to analyze the soil for nutrients which are available for plant uptake, not the total amount in the soil. The resulting data should be related to response in plant growth. Nutrients which are bound in the mineral fraction and, to some extent, the organic fraction, are not readily available and will not affect plant growth.

Over the years, various extraction methods have been devised and correlated to plant growth. Although there are attempts to make these extractions reflect the concentration of nutrients that is exposed to the plant root, results are quite procedure dependent. The value of soil testing only becomes evident when combined with field calibration data.

Methodology has become quite regional. Analysis performed in a laboratory in one region may not be interpretable for a crop grown in a different region. Table 1 shows a comparison of four different methodologies for determining plant available phosphorus in several soils. It can be seen that phosphorus levels vary drastically using different procedures. Each procedure is correct as long as the correct field calibrations based on that procedure is used to make your conclusions. The key is to be consistent in the procedure that is used and to use a procedure consistent with your field calibration data.

Table 1. Soil Phosphorus

Extraction Procedure	95102	95107	95110	95111	95112
Bray P-1 (mg/kg)	15.5	243	7.3	17.1	63.8
Mehlich 3 (mg/kg)	16.2	351	60	130	125
Modified Morgan (mg/kg)	5.1	26.5	37.8	73.8	44.8
Bicarbonate (Olsen) (mg/kg)	30.2	123	21.1	50.5	56
AB-DTPA (mg/kg)		87	16	35.8	24.7

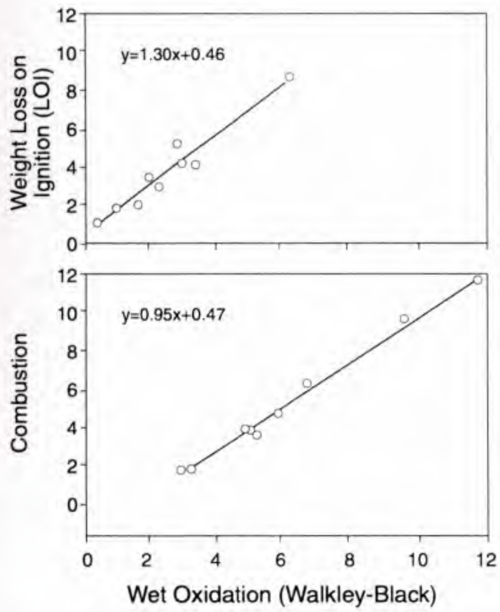

Figure 1. Comparison of methods for measuring organic matter.

Another example of analytical results being dependent upon method is the measure of organic matter in soil. In this case, it is necessary to measure the total amount. Figure 1 shows a comparison of three methods of measuring organic matter. It can be seen that, although there is a good correlation between the combustion and the wet oxidation (Walkley-Black), there is a poor correlation with loss on ignition (LOI). Loss on ignition, although used extensively by laboratories, gives poor results. It may be noted that there are potential errors in the wet and dry combustion methods also. A good laboratory should be aware of these potential problems.

In addition to being aware of the method that is used for the analysis, one should be knowledgeable of the form of the nutrient that is analyzed. In the case of nitrogen, laboratories will routinely analyze for nitrate-nitrogen, ammonium-nitrogen, or total nitrogen. The form that you analyze for is dependent upon the question that you are asking. Nitrate-nitrogen and ammonium-nitrogen are available for plant uptake and thus affect plant growth immediately. Tot nitrogen gives an indication of the nitrogen pool that eventually ma` be available. When comparing data, be sure that the form of the nutrient is the same.

Once the method is determined, laboratory procedures are normally quite precise. The largest source of error in soil testing is taking a sample which is representative of your site. The quality of soil testing data is therefore controlled, to a great extent, by the person taking the sample. There should be as much thought given to this step as to the selection and evaluation of a laboratory.

Plant Analysis

The best method for extracting a soil for nutrients available to a plant would seem to be the plant itself. Indeed, plant tissue analysis can give valuable information on nutrient status of the soil as long as one understands the limitations of the method. In many cases, plant tissue analysis is a more valuable tool than soil testing.

In addition to the concentration of available nutrient in the soil, two factors which influence concentration of nutrients in plants are stage of development and the part of the plant analyzed. In general, nutrients will decrease over the growing season. Usually the best time for sampling is during a period in which the change in concentration versus time is small. The part of the plant that is analyzed is that which shows the greatest change in response to differing available soil nutrients. For conifer seedlings, the plant part that is analyzed is the current year's needles and the optimum time of sampling is in the late fall when nutrient levels are stable.

Laboratory procedures for plant analysis are a little more straightforward than soil testing in that one is looking for total concentrations. The method usually consists of a digestion step to dissolve the sample and an analysis step. Generally the analysis of the sample is well defined once it has been digested. Table 2 shows a comparison of three different digestion procedures for an NIST (National Institute of Standards and Technology) standard reference material (Pine Needles SRM 1575). It can be seen that different procedures can give different results. Although dry ashing the sample gave results comparable to wet ashing and microwave digests for phosphorus, potassium, calcium and magnesium, the results are poor for manganese, iron, copper, zinc and sulfur. In contrast to soil testing methodology, there is a correct number which should not be method dependent. Incomplete recoveries using a dry ash procedure will lead to incorrect results.

Table 2. Comparison of digestion procedures for SRM 1575 pine needle reference (NIST)

Digestion procedure	P %	K %	Ca %	Mg %	Zn mg/g	Mn mg/g	Fe mg/g	Cu mg/g	S %
Dry ash	.12	.37	.46	.11	57	139	109	2.4	.050
Microwave	.13	.39	.48	.12	75	806	192	3.4	.121
Wet ash (nitric/perchloric)	.12	.37	.46	.12	79	758	183	3.6	.117

Insuring Good Data

Although the laboratory activities may seem out of your control, being informed can help insure the best data for your program. The quality of the information that you receive from a laboratory begins with your ability to keep accurate records and to take a representative sample. The best laboratory analysis available is of no value if these two criteria are not met.

A good laboratory should have some type of quality assurance/quality control program in place. Quality assurance consists of all the protocol which will insure that the data is of the best possible quality. This includes:

- proper identification of the sample
- maintenance and calibration of instruments and equipment
- record keeping
- training of personnel
- proper methodology
- sample exchanges with other laboratories
- proofreading of data output

Everyone in the laboratory should be part of the quality assurance program. Laboratories should be willing and able to discuss their program with you. The last part of quality assurance is your judgment. If the results do not make sense, question the laboratory. All laboratories make mistakes. Laboratories should be willing to rerun samples if requested to do so with a good reason.

Quality control is the process of standardization and making measurements of known samples to establish the validity of the procedure. It is a specific part of the quality assurance which is run concurrently with unknown samples. Judgments are made by the analyst as to the validity of the numbers based upon quality control results. Typical quality controls might include a series of known standards for calibration for the instrument, an independent known standard to verify the concentration of the calibration standards, and the analysis of a known sample. The known sample is processed through all the steps of the procedure to check sample preparation as well as analysis. Plant samples are available from the National Institute of Standards and Technology, however no soil references are available. Good laboratories that do soil testing will be involved in sample exchanges with other laboratories to give an independent evaluation of their procedures.

Conclusions

Soil testing and plant analysis can be used as an effective tool for optimizing plant growth. Some knowledge of laboratory protocol can be helpful in evaluating the data. The validity of laboratory information is dependent upon:

- Proper sampling
- Appropriate and consistent laboratory methodology
- Good laboratory quality assurance program
- Use of correct field calibration information

Laboratories should be forthcoming in the methods that they use to determine the quality of the data that they produce. A discussion with the laboratory to determine the methods that are used and its quality control/ quality assurance program will help insure the most meaningful data.