USING SOIL TEST RESULTS TO DETERMINE FERTILIZER APPLICATIONS

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Using soil test results is a very useful practice

IF the sample(s) of soil are good representations of the nursery soil. The lab results can be no more accurate than the samples submitted, and

IF you know the texture of the nursery soil, and

IF you know which soil extractant was used by the lab, and

IF you know what crop is to be grown, and

IF, for trees, which species is to be grown and whether it will be 1+Os, 2+0s, 3+0s, 2+1s, 2+2s, 3+2s, plug-1s, etc., and

IF, for a cover crop, whether summer or winter crop, turned under green, turned under mature, harvested and straw turned under, harvested and straw bailed, and whether peat, sawdust, compost, or other organic material will be applied (what that material is and its rate and time of application), and

IF you know those things and all but 1 of them is under the nursery managers control

THEN, using soil test results can be very helpful in determining needed fertilizer applications.

The first and foremost practical point to consider is the lab that actually runs the soil tests. In the South, it became imperative to select 1 common lab because there are more than 40 nurseries participating in a soil analysis interpretation project. Otherwise, the resulting collection of analyses would have been extremely confusing. Here are the reasons why:

1. Different labs use any of several extracting solutions. Some extract only a few nutrients and others extract a wider range. None of them get all nutrients needed by trees. Common extractants used include:

   Bray 1® or Bray 2® (developed in Illinois)

   Truce (developed in Wisconsin)
   Mehlich 1®, 2®, and 3®-(developed in North Carolina).
   Mehlich 1 is also referred to as the double acid extractant.

   Olsen®-(developed in Colorado)
   Others include, Morgan, 1 N ammonium acetate, buffered at some specific pH value or not buffered, and hot water.
2. Acidity (pH value) may be determined in water or in 1 N KCl.

   These values are always different by at least 1/2 pH unit.
3. Some labs do not run tests for boron (B) because B-deficient soils are mostly either of volcanic origin (not many nurseries in North America are in this category), are low in organic matter, or are sandy soils. Many nursery soils are B-deficient, but most agricultural soils are not. Thus, despite agricultural soils lack of need for this test, we really need to test the B level in many of our nursery soils.
4. There are 3 common methods for determining soil organic matter, and each will give very different results for the same

sample. Thus, in order to correctly interpret the results, you must know which method was used. These methods are loss-on-ignition, acid hydrolysis, and alkaline hydrolysis.

5. Numerous labs report available iron (Fe). Testing for this element is almost useless as far as nursery soils are concerned. Iron nutrition of seedlings is strongly affected by weather and species of tree being grown, and only slightly by soil availability. Most nursery soils contain ample Fe, yet Fe deficiency is very common.
6. Probably the most universally needed nutrient in tree nurseries is nitrogen (N) and yet there is no useful test for available N. Several labs do run extractable ammonium and nitrate tests. These results are only marginally useful, however, because those N sources are very dynamic in the soil and their test values vary from day-to-day. They represent a snapshot of soil N at one point in time and have very little value in terms of a whole growing season. As far as N supply and dynamics go, we rely more on tissue analysis and history than on soil testing.
7. Finally, and most confusing, labs vary greatly in how they present the results of their analyses. Acidity (pH value) and organic matter (%) are pretty standard. Beyond these 2, there is too much variability. We find results expressed as pounds per acre, kilograms per hectare, parts per million, milliequivalents per 100 grams, and as index values.

Each lab feels fully justified in using the methods and expressions of results employed. To get the maximum benefit from soil test data, a nursery manager almost needs an interpreter.

In medicine, it is said that diagnosis should precede prescription. The same is true in prescribing soil management operations in a nursery. Soil tests provide the diagnosis. We must prepare the prescription.

Before prescribing, we need to establish a set of levels for available nutrients, acidity, organic matter level, etc., for each crop that will be grown. This can only be done after we have decided on the laboratory that will run the soil analyses and we have learned the methods of analysis that they will use. In the South, despite the fact that we have not changed labs in over 15 years, the standards sheets have had to be rewritten twice. The lab changed the extracting solution both times. In both cases, the change was to an extracting solution that was better-suited to forest nursery soils than the preceding one. Currently, that lab is using Mehlich 3, which is excellent for nursery soils and determines the maximum number of nutrients.

WATER

Very few nurseries are irrigated with distilled water. Thus, we need to be able to adjust our calculations to account for nutrients that are applied in the irrigation water. The most common problem encountered is that a calcitic limestone aquifer is tapped for water. This is almost guaranteed to apply an imbalanced amount of calcium (Ca) and magnesium (Mg). The ideal is to have about 4 parts of Ca for each 1 part of Mg in the soil. This is recorded as a Ca/Mg ratio of 4. Mother Nature gives us a bit of a break by tolerating a range of Ca/Mg ratios from about 1 (equal amounts of Ca and Mg) to 10 (ten times as much Ca as Mg). Once you get outside that spread, however, you have a problem that demands attention. Most commonly, the irrigation water provides Ca at much more than 10 times the amount of Mg. Since we cannot subtract Ca from the soil, we frequently must add Mg, even though on an absolute basis there is already an adequate supply of Mg. In this case, the ratio is at least as important as the absolute values. If the Ca/Mg ratio exceeds 10, there is a real likelihood of a lack of chlorophyll formation. This results in poor growth and a general chlorosis. Often, people will see these symptoms and respond by adding more N. They are then bewildered because addition of N does not eliminate the chlorosis, not realizing that a shortage of N is not the problem.

There are other problems that may be related to the irrigation water. Some aquifers contain considerable Na. This tends to do 2 things. First, it raises the pH value of the water and sometimes that of the soil as well. Second, Na will antagonize the uptake of potassium (K). Sodium also tends to enhance crust formation at the soil surface. This is caused by the defloculation of clays in the soil. In addition, many of the internal pores in the soil become blocked, and internal drainage is seriously impaired. Irrigation water quality is only one aspect of soil fertility management. Other items critical in the management of soil fertility are acidity, Ca, Mg, phosphorus (P), potassium (K), N, trace elements, and organic matter.

ACIDITY (PH VALUE)

When you receive soil test results from a lab, the first item to look at is the pH value of the soil. Soil acidity affects many things in the soil and in the seedlings, but it mainly affects the availability of several nutrients. Thus, we want to keep the soil within a range that, for most species we grow, is not too far from pH 5.5. If we need to reduce acidity (raise the pH value) lime is added. The amount of lime needed is strongly affected by soil texture and organic matter content. For example, to raise the pH value from 5.0 to 5.5 in a medium sand with low organic matter may require no more than 0.5 ton of lime per acre. The same pH change in a silt loam with ample organic matter may easily require up to 2 tons of lime per acre. Also, we need to look at the Ca/Mg ratio to see whether we should do the pH adjustment with dolomitic or calcitic lime. Dolomitic lime provides plenty of Mg whereas calcitic lime does not. If the pH value is too high, we usually lower it with elemental sulfur (S). The amount of S needed is, again, affected by the pH change needed and the soil texture. One ratio that does stay pretty well fixed is that about 800 pounds per acre of S will provide the opposite effect on the soil pH value of 1 ton of lime (either calcite or dolomite).

CALCIUM

When Ca is needed but the pH value is correct, we apply gypsum (calcium sulfate). This will also provide some S. Whereas both forms of lime and S need to be applied prior to planting, gypsum is useful because of its higher solubility. It can be applied either preplant or postplant (as a topdressing).

MAGNESIUM

Sources of Mg include Epsom salts (magnesium sulfate), magnesium nitrate, magnesium carbonate, and a product called Sul-Po-Ma-', which is a mixture of potassium and magnesium sulfates. These are all sufficiently soluble to be applied either preplant or postplant. One thing to note here is that although magnesium nitrate is a fine source of Mg, it is a poor source of N for most tree species. Douglas-fir does seem to use that N fairly well, but nearly all other species do not use it very efficiently.

PHOSPHORUS

For many years, when phosphorus (P) was needed, it was provided prior to planting as ordinary superphosphate (OSP). Its problem was a low analysis (0-20-0). It has been mostly replaced by triple superphosphate (TSP) because of its higher analysis (0-46-0). However, there is one hidden trap in making the change from OSP to TSP. Most people were unaware that when they applied OSP, they were also applying S to the soil. In fact, OSP contains more S than P, and a need for S as a nutrient was rare. Today, we find frequent need for S. The TSP does not contain any sulfur. That is because phosphoric acid is used in its manufacture, rather than the sulfuric acid that was used in the manufacture of OSP. Finally, we must note that neither OSP nor TSP are very soluble. Thus, they must be applied preplant and disked in. Sometimes, we discover a need for P after the crop is growing. This is supplied as diammonium phosphate (DAP) because it is considerably more soluble than either OSP or TSP. The DAP has one other effect that can be very useful. Mycorrhiza development can be slow, and DAP, for some reason that is not fully understood, will provide a stimulation of mycorrhizae development. This is true regardless of the P and N supply in the soil.

POTASSIUM

Potassium is easily provided and is about the least expensive nutrient we need. The most common source is potassium chloride (muriate of potash). A second source, which is quite useful because of the S it contains, is potassium sulfate (sulfate of potash). As mentioned earlier in our discussion of Mg, Sul-Po-Ma-" supplies K, S, and Mg should there be a need for these nutrients. All of these sources are quite soluble. Thus, they can be applied either preplant or postplant. Usually, because they are so soluble, it is not wise to apply all the potassium prior to planting. One or 2 topdressings during the growing season is usually a good idea. In soils that are low in K, a late growing season topdressing is often suggested. Physiologists have told us that a good supply of potassium in late summer and early fall will help harden off the seedlings before cold weather arrives. In soils that are already well-supplied with K, the benefit of this application is understandably less pronounced.

NITROGEN

As mentioned earlier, N is always needed. Nitrogen is used by plants in either of 2 forms. When the N atom is associated with hydrogen, as in ammonium or urea, it is called "reduced." When the N atom is associated with oxygen, as in nitrate, it is called "oxidized." Most tree seedlings will use either reduced or oxidized N. But, most species are much more efficient at using reduced N. We commonly apply ammonium nitrate, which includes both and is satisfactory and reasonably economical to apply. Also, it has essentially no effect on the soil acidity. The alternative source, ammonium sulfate, is very efficiently used, and it provides some S. However, it does lower the pH value of the soil. Sometimes that is desirable and sometimes it is not. In many parts of the world outside the United States and Canada, ammonium nitrate is not available. Formulations where all N is supplied in the nitrate form, such as magnesium nitrate, potassium nitrate, or sodium nitrate (sody), should not be used as N sources for tree seedlings. It is a waste of both time and money.

Urea is a good source of N, as long as it is promptly watered-in. When urea lies on the soil surface for only a few hours, it is likely to be broken down by enzymes that are produced by many soil microbes. The result is that ammonia gas is produced and lost into the atmosphere. That wastes both N and money. If urea is used correctly, it is fine. However, the potential for significant N loss is always present.

Beyond these 3 common sources, there is a plethora of other materials that are called "slow release" sources of N. In the right circumstances, they can be useful. Usually, their biggest problem is cost. Also, many of them do not release their N at a rate that matches the seedling needs. Basically, their convenience is frequently out-weighed by their cost and/or lack of synchronization with the seedlings' requirements.

MINOR (TRACE) ELEMENTS

These come in various forms. However, most of them are quite soluble and are principally applied to the foliage. These include sodium borate, copper sulfate (blue vitriol), manganese sulfate, and zinc sulfate. Iron (Fe) is available in sources of all sorts, but chelated forms are usually the most effective (although not always the cheapest to use). Ignoring Fe, the other trace elements provide a fairly easy-to-remember rule of thumb, as far as their needs on nursery stock. Alphabetically, they are B, Cu, Mn, and Zn, and typical rates of application are 2, 3, 4, and 5 pounds per acre, respectively. They are only applied when a soil test indicates a low supply.

Iron deficiency occurs in hot weather, regardless of soil test level. Iron availability is strongly affected by a group of soil bacteria that are called "iron-oxidizing bacteria." When active, they convert Fe into a non-available form. They become very active in warm soil and die down again in cool soil. The rate of foliar application of Fe varies with species of tree and the severity of the deficiency. Many species will respond to 1 or 2 applications of Fe at 2 pounds per acre. Some require as much as 4 applications at 4 pounds per acre. Nearly all nursery soils contain adequate Fe. The problem is availability, not quantity.

ORGANIC MATTER

Cover crops or "woody" material (peat moss, to wood chips, to bark) all provide organic matter. Which do we need and why? They are all beneficial, but do different things. Woody materials provide some physical benefit, but mostly we want the lignin that the wood contains. Lignin provides cation exchange sites that hold nutrients against leaching and help hold the pH value where we want it. Cover crops (also called green manure or catch crops) help reduce wind and water erosion, catch and hold nutrients, and provide food for beneficial soil organisms. They also serve as a slow-release fertilizer. They release nutrients as they decompose. Woody materials last in the soil from 2 to several years. Cover crops do not increase the soil organic matter content significantly, except for a few weeks or months. Their rate of decomposition is rapid.

How much organic matter do we need in the nursery soil? First, we need to note that the soil organic matter "equilibrium level" depends principally on climate and soil texture. In Pacific Northwest nurseries, it is common to find 5% to 8% organic matter. In the deep South, 1% to 2% is about all that can be maintained with the same effort. The microbes hardly slow down in the continuously warm soils of the South. In the North Central region, because of cold winters, soils come closer to a 3% to 5% equilibrium level.

OTHER SOIL PROPERTIES

Physical and biological properties of soil are also important in the growth of quality stock. However, they are not included in soil testing. Consequently, we will merely mention that they can have significant effects that are either positive or negative on the seedlings response to nutrient additions.

SUMMARY

When used correctly, soil testing will provide the diagnostic information needed for efficient management of soil fertility, acidity, and organic matter content. It will increase the efficiency of fertilization and produce a high percentage of grade one seedlings. The most important need at this time is to determine the appropriate levels for nutrients, acidity, and organic matter for each tree species we plan to grow.