ADJUSTING SOIL COMPOSITION FOR TREE SEEDLING PRODUCTION AS INDICATED BY SOIL ANALYSES

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The chemical analysis of soils, commonly referred to as soil testing, to determine the fertility level and lime status of a particular soil, and to lend assistance in making fertilizer recommendations is now well accepted by most Agronomists and Horticulturists. Soil testing certainly has many limitations, but the information obtained from a good soil test is usually very helpful when properly interpreted, and recommendations are made by qualified personnel.

Routine soil testing procedures used by the many laboratories, both public and private, are quite different. There will, no doubt, always be variations because of the different chemical procedures used and of the great differences in soils. The fact that procedures differ adds to the value of soil testing, because states with widely different soils must often use different procedures--at least for some of the analyses. The procedures used in the southern states has now been published (1).

The L.S.U. Soil Testing Laboratory, operated by the Department of Agronomy, routinely makes determinations for soil reaction (pH), lime requirement, extractable calcium, magnesium and potassium; and easily soluble phosphorus. Other determinations are made when deemed necessary. The results obtained for the elements Ca, Mg, K, and P are reported as "available." It is well known that the total amounts of these elements extracted in the laboratory are not actually available to plants, but there is usually a good relationship between that extracted in the laboratory and what plants are able to obtain in the field.

ADJUSTING SOIL REACTION (pH)

The analysis of a soil for pH alone is often more than worth the entire cost of the soil test. When the pH of most soils drops below about 4.9, the acidity is strong enough to dissolve aluminum and/or manganese in sufficient amounts to become toxic to plants. The dissolved aluminum damages plant roots and also interferes with the uptake of phosphorus. The dissolved manganese affects the top portion of plants and, therefore, causes a more obvious damage than the damage from aluminum. The addition of liming materials in sufficient amounts to raise the pH to about 5.5 will prevent the excessive solution of these two elements under most, if not all, conditions. At this pH, the excessive aluminum and manganese that were in solution will be converted to much less soluble compounds and rendered harmless.

Another bad effect of pH below 5.5 is the fact that the aluminum, iron, and manganese that are dissolved will react with phosphorus and form insoluble compounds, thus causing a phosphorus deficiency. The phosphate fertilizer that is applied largely reacts with these elements and becomes unavailable. Once these compounds are formed, they are of little value in the future. However, if the pH is maintained at 5.5 or above, as plant growth will tolerate, the phosphorus applied will react more with calcium and form compounds that will remain in the soil and be much more available than Al, Mn. or iron compounds formed at a lower pH.

Soil tests can determine the approximate amount of limestone that is needed to raise the pH to the desired level. Samples to be analyzed for this purpose should be collected after any large addition of organic materials have been added because these materials will influence lime requirements. Limestone should be applied several months before planting because it reacts slowly with the soil acids.

The pH of some nursery soils may be higher than is desired. Soil tests can determine the amount of acidifying material needed to adjust the pH to the approximate level needed. Sulfur is usually added for the purpose of lowering pH, but a soil test should be made to determine how much is needed. Once the pH is lowered sufficiently, no additional acidifying material will be needed in the future.

ADJUSTING CALCIUM AND MAGNESIUM LEVELS

Since these are two essential elements, and many soils in Louisiana are deficient in one or both of them, the L.S.U. Soil Testing Laboratory determines the exchangeable (available) amounts of each. This permits the recommendation of materials that will supply only the element needed. Where the magnesium is medium to high in the soil, but calcium and pH are low, a source of limestone containing only calcium carbonate, or a high amount of calcium and low magnesium, is recommended. Under soil conditions where both calcium and magnesium are low, dolomitic limestone is recommended. The use of 2,000 pounds of ground agricultural limestone containing calcium carbonate will add approximately 200 parts per million of available calcium in about 7 inches of soil. The application of one ton of dolomitic limestone, containing about 55 percent calcium carbonate and 45 percent magnesium carbonate, will add about 110 parts per million calcium and about 65 parts per million magnesium to this 7-inch layer of soil. These quantities of lime will maintain these increased levels of calcium and magnesium for a few years.

In some instances, the soil pH and calcium content may be as high as is desired, yet the magnesium may be low. In these instances, magnesium may be applied as magnesium sulfate, or as sulphate of potash-magnesia.

There are also instances when the pH is as high as is desired, yet more calcium is needed. On such soils where phosphorus is also needed, the use of ordinary superphosphate will supply calcium, which is present as calcium sulphate and monocalcium phosphate. This material contains about 20 percent calcium. Another source of calcium would be to use calcium nitrate as the source of nitrogen. The use of calcium sulfate, commonly called land plaster or gypsum, in addition to or in lieu of the use of superphosphate would also furnish additional calcium.

ADJUSTING PHOSPHORUS LEVELS

It is generally unwise to attempt to "change" the soil test level of phosphorus. Instead, the phosphorus should be added in sufficient amount for the crop to be grown. Work conducted by McGee and Ralston at Duke University, using sand culture, showed that slash pine seedlings made their best growth when phosphorus was added to the sand culture at the rate of about five parts per million. Although more would be needed under field conditions because it would not remain as available as in sand culture, these data do indicate that high levels of phosphorus are not essential. Their data also indicated that a plant composition of about 0.2 percent of phosphorus was desirable for good growth of pine seedlings.

The use of 60 to 100 pounds of available P_2O_5 (26 to 44 pounds P) per acre on soils with low to very low phosphorus levels is usually sufficient, except for plants with high phosphorus requirements. The amount needed on newly cleared land would be greater than on land where phosphate fertilizer had been applied for several years. The continued use of phosphate will help to saturate the phosphate "fixing" power of the soil, and thus more will remain available longer.

On soils containing medium to high levels of phosphorus, the use of small amounts of phosphate fertilizer as a starter is often helpful during the early growth of young plants. This is especially true when the soil is cold since temperature has a marked effect on phosphorus availability and utilization by the crop. A starter application of fertilizer phosphorus helps to develop the root system which can later obtain the needed phosphorus from the soil.

An all too common practice is the "over use" of phosphate fertilizer. When excessively large amounts are applied at one time, the phosphorus reacts with iron, and other micronutrient elements, forming insoluble compounds. This may create deficiences of essential micronutrient elements that would not have occurred with less phosphate use. Also, the continued use of "normal" amounts of phosphorus over a long period of time may have the same bad effect on the availability of these trace elements. Therefore, on soils where phosphorus is low and a relatively large amount is needed, the application should be gradually reduced after 2 or 3 years and, eventually, there may be a need for "starter" phosphate only.

As discussed earlier under the topic of pH, the higher the soil pH can be adjusted above 5, and up to about 6.2 - 6.5, the greater will be the availability of the residual phosphorus left in the soil after each annual application.

ADJUSTING SOIL POTASSIUM

On most nursery soils in the South, the soil potassium that is relatively available for plant use is that held as exchangeable potassium on the clay and organic soil colloids. Since most of these are sandy loams and contain low amounts of humus, they usually do not contain very much exchangeable potassium. Also, many of these soils do not contain large amounts of mineral potassium that is easily weathered, therefore, they tend to always be relatively low in "available" potassium.

The research by McGee and Ralston at Duke University showed that, in sand culture, about 125 parts per million of K was best for slash pine seedlings grown under greenhouse conditions. The fertilizer potassium supplied to the sand culture would be highly available. However, it would also be the only source of this element, since sand contains virtually no potassium.

Under field conditions on sandy loam soils, exchangeable potassium of about 60 to 80 parts per million is considered low for crops with moderate potassium needs, and very low for crops such as clover and alfalfa, which are crops that have higher potassium requirements.

On the sandy loam soils, the use of 50 to 75 pounds of potassium per acre (60-90 pounds K_2O), worked into the top 6 inches of soil would increase the exchangeable potassium by 25 to 37 parts per million in this layer of soil. These soils would then contain what is usually considered to be a medium level of exchangeable potassium. This amount of potassium in this layer of soil, plus that which plant roots may obtain from lower depths, should be sufficient for the season. The use of an additional 25 to 50 pounds of potassium on these soils may be beneficial under certain conditions and the cost would not be much and should assure that there would be enough. However. the use of excessively large amounts of fertilizer potassium was found by McGee and Ralston to be <u>detrimental</u> to pine seedling growth.

Potassium is readily leached from sandy surface soils, and may accumulate in clay subsoils. However, the accumulation of potassium in the subsoil may be largely out of the reach of pine seedlings. Because of this, plus the fact that most plants absorb more potassium than needed, <u>if available,</u> it is recommended that potassium be applied annually. Potassium does not usually accumulate in unlimed sandy surface soils to any extent. Reasons for avoiding the use of excessive amounts of potassium are: (1) that KC1, muriate of potash, is a salt and can damage plants; and (2) excess use of potassium on soils low in exchangeable Mg or Ca may accentuate the deficiences of one or both of these elements in the plant.

THE USE OF NITROGEN FERTILIZERS

Many chemical laboratories do not determine nitrogen in soils. Most southern soils generally contain low contents of nitrogen. The addition of large amounts of raw organic material, such as sawdust, further complicates the problem of supplying nitrogen to tree seedlings since the sawdust contains a high amount of carbon and only a small amount of nitrogen. Turning under legumes will add about 60 pounds of total nitrogen per ton of dry weight material. About one-half of this nitrogen would be available for plant use during the following crop season.

The amount of nitrogen that should be applied will depend largely upon how much raw organic material has been added to the soil--and to a limited extent, on how much leaching takes place. Sandy soils are more subject to leaching losses than are clays. In the work at Duke University by McGee and Ralston, it was shown that about 125 parts per million of nitrogen, in sand culture, was sufficient. In sand culture, a great majority of the nitrogen applied should be available to plants.

Under nursery conditions, and especially where large amounts of sawdust or other similar organic materials are used, considerably more nitrogen would be required in order to have the "available" nitrogen that was found to be needed in the work conducted at Duke University. There have been attempts to add enough nitrogen to give a 10:1 ratio of carbon:nitrogen in soils containing large amounts of sawdust. This certainly is not necessary--nor desirable. In fact, such large amounts of nitrogen would be excessive and may actually reduce growth. Excessive nitrogen fertilization may result in such a high salt content in the soil that plants may be damaged or killed.

Because of the "unknown" facts concerning raw organic materials used, and the tie-up of nitrogen by micro-organisms decomposing these materials, it will probably remain necessary for nurserymen to continue periodic nitrogen applications, based on previous experiences, and also on visual observations of the seedling to determine their color and general growth vigor.

The source of nirogen used may be quite important. All of the nitrogen sources will have some effect on soil reaction (pH). The use of sodium nitrate will tend to raise pH, and probably have little or no benefit other than the nitrogen it supplies. Calcium nitrate will also have a slight effect on raising the soil pH, and the calcium will also serve as a necessary plant nutrient.

The other commonly used nitrogen materials are acidic, but they vary in their effects. When ammonia nitrate or Urea are used, about 1.8 pounds of lime ($CaCO3$) will be needed to neutralize the acidity produced by each pound of nitrogen applied. When ammonia sulfate or ammonium phosphate are used, about 5.5 pounds of lime will be needed to neutralize the acidity produced by each pound of nitrogen applied.

Most of the high analysis fertilizers contain ammonium phosphates and some contain ammonium sulfate. A water soluble 13-13-13 would be an example of such a fertilizer. The acid effects of such a fertilizer would be about 2 to 3 times as great per pound of nitrogen applied, as would be when 8-8-8 was used because the 8-8-8 would contain less, if any, of the more acid producing materials.

Therefore, on soils that are already strongly acid, the use of large amounts of fertilizers containing the more strongly acid forming materials may produce enough acidity to create growth problems because of toxic amounts of aluminum and manganese that would be brought into the soil solution.

SUMMARY

Soil testing is a valuable aid when used correctly. The following are suggestions for adjusting soils:

1. Adjust the pH to the level desired for the plant to be grown.

2. Keep the pH above 5, and preferably to a minimum of 5.5 to avoid toxic aluminum and manganese.

3. If the pH is too high, add sulfur to increase acidity.

4. Add lime or other sources of calcium and magnesium to keep fairly good amounts of these elements available.

5. When phosphorus is low, add moderate amounts (60 - 100 pounds P205) annually.

6. As phosphorus availability increases after several years, reduce the amount applied.

7. When available phosphorus is medium to high, use only a small amount of "starter" phosphorus, if any.

8. When potassium is low, add 60 - 120 pounds of K20 annually. Where the amount is medium, add only 30 - 60 pounds annually.

9. Apply nitrogen "as needed" for the color and growth that is desired.

10. Do not over fertilize and create problems with excessive phosphorus, potassium, nitrogen, or acidity.

LITERATURE CITED

1. Southern Cooperative Series. 1965. Bulletin No. 102 (June).