NURSERY SOIL MANAGEMENT

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Management of nursery soils can be divided into three general subject areas: physical, chemical and biological. There are problems associated with each of these areas which can be roughly divided into those which are relatively easily solved and those which are more difficult.

Let's take our soil management system apart and under each of the three major categories discuss those problems which occur and delineate those which are easy or tough to solve. Obviously the ounce of prevention idea should prevail for the tough ones, since it is usually much easier to avoid a problem than to correct it. Once we have delineated the problems, we can then proceed to discuss currently accepted standards and management methods to help us attain these standards.

PHYSICAL

Under the heading of physical problems we encounter such subjects as tillage, lifting, soil aeration, land shaping, and drainage. Drainage is divided into: (1) surface drainage, which is improved through land shaping, and (2) subsurface drainage, which can be accomplished through tilling. In most nurseries land shaping should result in a uniform slope of from 0.5 to 1.5 percent (depending on soil type) toward the bed ends. It is also important to keep bed ends open so that surface drainage can be complete. The need for subsurface drainage (tilling) is dependent upon soil conditions and precipitation patterns. No general recommendations can be given. Soil texture, structure and organic matter content affect all these attributes. They in turn affect root penetration, ease of root pruning or wrenching, cultivating, and lifting. Also, water penetration is affected by these soil physical properites, and this in turn can affect two other important areas; the development of certain root diseases and gaseous exchange in the soil (aeration). Soil physical conditions also affect the ease of shaping and the stability of the beds.

CHEMICAL

Chemical problems include such subjects as tree nutrition, soil fertility and acidity, the use of chemicals in pest control, the quality of irrigation water, and salt accumulation. What we need to know is what are the adequate amounts of nutrients which the

trees demand at various times and in what forms are these nutrients most available to the trees. Some of the newer fertilizers being developed by TVA such as sulfur-coasted urea, sulfur-coated KC1, and ammonium polyphosphate may assist the nursery manager by allowing him to make fewer applications of these slow-release and high analysis fertilizers. The use of high analysis fertilizers has reduced the amount of "other" nutrients which are applied in the fertilizers. For example, with the transition from normal super-phosphate to triple superphosphate, we have inadvertently omitted the addition of sulphur to the soil since normal superphosphate contains a fair amount of sulphur and triple superphosphate contains essentially none. Thus, we now have to be aware of the status of a wide range of nutrients in our soils and seedlings.

From the standpoint of soil testing, we are always attempting to improve our evaluation of the soil fertility status. At the present time, we are using certain nutrient levels as the desirable levels in the raising of various tree species. Based on analytical procedures such are used in most of the souther states, we currently recognize as minimum fertility standards for pine the following: phosphorus - 50 lbs/acre; calcium - 400 lbs/acre; magnesium - 50 lbs/acre; potassium - 150 lbs/acre; manganese - 10 lbs/acre; acidity - pH 5.5 to 6.2, and organic matter, the more the merrier, but at least 1 1/2 to 2%. If we change to the production of hardwoods, we know that these minimum standards must be raised, particularly calcium. Hardwoods feed very heavily on calcium and probably a minimum level of 1000 lbs/acre of calcium is required for the production of decent hardwood stock. These are nutrient levels determined prior to seeding. Recently we have followed nutrient uptake by the seedlings throughout the year and the concomitant nutrient depletion from the soil. As a result of this study, we now know that a late summer application of potassium is highly desirable in many pine nurseries. An application of 50 pounds of potassium per acre (contained in 100 pounds of either potassium chloride or potassium sulfate) will help finish the growth of the crop and, perhaps more importantly, hasten the hardening-off of the stock. This is especially important when it is desired to start the lifting season as early as possible. Finally, it is also highly desirable to sample the same areas of the nursery annually and accumulate "life history" data for soil properties as well as for the growth of seedlings. This will help us evaluate, over the years, the success of our fertility management program.

Nitrogen has not been mentioned under the heading of soil testing since there is no adequate test for available soil nitrogen. Our best current assessment of nitrogen needs can be made by determining the amount of nitrogen in the lifted seedlings and then making sure that there is sufficient nitrogen added to the soil to provide about one and one-half times that much nitrogen. For example, loblolly seedlings, when lifted, contain approximately 100 pounds of nitrogen per acre. Thus we will apply about 150 pounds of nitrogen per acre during the growth of the crop. This can be supplied, for example, in 450 pounds of ammonium nitrate. Half of this (75 pounds of nitrogen) is plowed down during bed preparation and the remainder is applied as several light side-dressings at two to three week intervals during the summer.

We have already indicated that nutrients are needed in adequate amounts at proper times. Another subject which is beginning to become recognized as quite important is nutrient balance. In other words, not only are the amounts of nitrogen or phosphorus available in the soil important, but their ratio is important. This subject is currently being studies most intensively in Scandinavia. Through the information obtained, we hope to be able to effect some economies in our fertilization program in the furture. Also under chemical properties, we should note again organic matter. Since organic matter is the seat of most of the cation exchange sites in many nursery soils, it is needed to hold nutrients against leaching. A sandy soil that is low in organic matter leaches easily. However, if that same soil can be enriched in organic matter, then irrigation water or rain are not likely to remove the nutrients.

It is important not only to have enough water for irrigation but one must be aware of the quality of the water as well. We may tolerate a reasonable salt content in irrigation water provided that we know which elements are responsible for the salt content. For instance, calcium is needed by all trees and water which contains a reasonable amount of calcium is fine. Sodium, on the other hand, is not a needed nutrient, adversely affects soil structure, and causes an osmotic stress in the seedlings. Thus, just knowing the amount of salt in the irrigation water is not enough. We must also know which elements constitute the salt. Obviously, if the salt content is naturally very low, then we probably won't have to worry about it.

BIOLOGICAL

Under the biological heading we find both small organisms and large organisms of importance in the soil, and we find bad guys and good guys. The next two speakers on the program will cover the most outstanding bad guys and good guys. Consequently, we will only mention some general terms and ideas at this point. We may find the microbes in the soil invading the roots of the trees, closely associated with the surface of the roots, or ignoring the roots and living in the soil proper. In any of these cases, the organisms may be either beneficial or detrimental. Among the large organisms that inhabit the soil, we would have to include the weed seeds. We will discuss them shortly. As in the case of both physical and chemical problems in the soil, the biological problems are also related to the level and form of organic matter. The organic matter, which is important in the biological problems, is that which is fairly easily decomposed. This organic matter provides the food source for the beneficial organisms and we suspect now that it also results in the liberation of some carbon dioxide close to the surface of the soil, which may then be taken up by the seedlings for growth through photosynthesis. This can be rather significant; for example, an acre inch of sawdust or other organic matter can contain almost ten times as much carbon as goes into the tree crop in any given year, assuming loblolly or slash pines to be the crop of concern. Only a portion (perhaps 10%) of this will be decomposed and liberated as carbon dioxide in any one year, but even if a portion of this is used in photosynthesis, it can serve to significantly enhance the growth of our trees or cover crops.

The use of cover crops is included in the soil management plan by most nurserymen and experience has indicated the soundness of this practice. The value of cover cropping, however, is sometimes misunderstood. Most cover crops, when turned under, do not increase the soil organic matter content, except temporarily, because they are easily decomposed. It is this ease of decomposition, however, that is one of their chief benefits. They provide the food source for many of the beneficial soil organisms, ranging from those which are antagonists of root pathogens to those which produce the polysaccharide gums which stabilize and improve soil structure. The real values of a cover crop are: (1) they protect the soil from wind and water erosion; (2) they take up and hold nutrients in the crop which will be turned under and thus conserved against leaching; (3) they provide the energy source for the beneficial micro-organisms, and (4) they replace tree roots in the soil with roots of plants which are not hosts to tree root pests. This enhances the biological control of a number of soil-borne pests.

Probably the most significant thing we do biologically to our soil is to eradicate many organisms and alter the balance of the rest through fumigation. Fumigation has become almost a universal operation in nursery soil management. We have worried for some time whether the adverse effects on the soil microbes might actually exceed the beneficial effects in terms of disease and weed control. However, experience has shown ratherly clearly that when fumigation is done properly, we have much more to gain than to lose from it. Many nurserymen would fumigate their soil if weed control was its only beneficial result.

We said at the outset that we would attempt to divide the subjects into areas in which the problems are difficult to solve and areas in shich the problems are moderate or more easily solved. I believe we can say that soil texture is probably the most difficult soil property to change. The removal of excess salts from the soil is also quite difficult and soil structure is somewhat difficult to change. Therefore, these are the problems we try to avoid rather than to correct. Soil texture can be controlled primarily through proper nursery site selection in the first place. Fine sands to loamy sands make ideal nursery soils. Sandy loam [y] are also satisfactory but heavier soils or coarse sands have increasingly difficult problems and we should try to avoid such soils.

The use of proper irrigation water in reasonable amounts coupled with proper drainage will avoid the accumulation of excess salts in the soil. Proper irrigation varies during the growing season but once emergence is complete, it can best be regulated through the use of tensiometers. These instruments not only tell when irrigation is needed, but more importantly, they indicate when adequate irrigation has been completed.

Soil structure is not difficult to maintain if soil of proper texture has been initially selected and if an adequate amount of organic matter is maintained in the soil. Otherwise, poor soil structure may result and be a very severe problem, especially in heavy soils. This is reflected in difficulties being encountered during tillage and lifting operations. Also, the soil surface may seal and irrigation water will run off rather than into the soil.

Under the moderate or easy-to-change category, we would list organic matter maintenance, fertility maintenance, pH regulation, and control of most soil organisms. There can be situations where any of these is difficult to alter, but in most instances, problems with them are reasonably easy to detect, and fortunately, reasonably easy to correct. We have already discussed the value of soil testing in soil fertility and acidity management and soil fumigation in the control of soil organisms.

Now I would like to speak specifically about organic matter maintenance. As we have seen, organic matter is important in all three problem areas - physical, chemical and biological. The growing of nursery stock involves operations such as tillage and lifting of stock which continually result in the loss of organic matter from the soil. Thus, we must constantly be replenishing this organic matter to the soil. The type and amount of organic matter to use may vary from place to place, and fortunately, we have a fairly wide range of materials which can be used satisfactorily. In a number of nurseries, material such as sawdust is being used as an organic matter source. Sawdust is a good source of organic matter except that it is woefully short of nutrients, especially nitrogen. It is possible to add supplemental nutrients to sawdust directly in the soil, particularly if the sawdust is applied ahead of a cover crop rather than ahead of a seedling crop. However, it is probably better to supplement the sawdust with nutrients and compost it prior to its application to the soil. There are different alternatives to sawdust enrichment. One is to enrich it with fertilizer nutrients, and the other is to enrich it with materials such as poultry manure or other animal waste. Either is quite satisfactory if done properly. Composting is relatively rapid and involves the evolution of much heat. This results in the destruction of weed seeds, pathogens, etc. Decomposition in the soil does not offer these advantages.

The management of forest nursery soil is a complex business. Of this, there can be little doubt. Fortunately, we now have a big enough reservoir of experience and research to materially assist us in developing a successful soil management plan for any nursery which is located on a decent site. An active research program is still a profitable venture, however, from the stand-points of improving our efficiency of operation and the quality of the stock we produce. We are still short on good information on the production of some hardwood species, but even this subject is being investigated. In conclusion, I think we can be optomistic about the future. We will have problems but most of them will be identifiable and solvable. No real catastrophes loom on the horizon except possibly the vagaries of the weather.