SOILS AND CHRISTMAS TREE PRODUCTION
PART 1— FUNDAMENTALS

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Soils are essential for Christmas tree production. While the truth of this statement is obvious it has perhaps been less obvious that the charaaeristics of a particular soil will greatly influence the success of a Christmas tree production venture. For many, Christmas trees were a crop which was generally established on marginally productive agricultural land. Eroded, hilly, 'worn-out," poor, wasteland, wild land, cut-over or even worthless were terms used to describe sites and soils where Christmas trees could be produced.

In the past, successes of Christmas tree plantings were often surprising. Species like Scotch pine were able to not only survive but grow well on such sites. Although growth rates were not rapid and tree quality may not have been as high as that demanded by current -markets, successful operations were many.

However, because of many factors which now confront the Christmas tree producer including changes in consumer species preferences, market demand for higher quality trees, increasing production costs, reduced profit margins and increased competition among producers, it is essential that plantations be established only on sites where opportunities for success are the greatest.

While several factors influence site quality one of the most important is soil. Moisture relations (too much or too little), soil fertility levels, soil reaction (pH) and soil chemistry are a few of the several characteristics which should be understood about a panicular planting site. In the next several issues of the Michigan Christmas Tree ~ournal each of these and other attributes of soils as related to Christmas tree production will be considered. This information should assist growers in not only selecting sites which are compatible with the requirements of the species being produced, but should also help in understanding why trees in existing plantations are growing as they are.

SOIL FUNDAMENTALS

All soils are not alike. To most of us this is also obvious. However, many growers often attempt to treat individual sites and soils as though they can support any species. If there are limitations imposed by the soil, then the question often asked is what can I do to correct the problem. While amendments can sometimes be made, frequently the grower has to live with the problem. As an example in established plantations little corrective action can be done to alleviate excess water problems on soils with poor internal drainage. Understanding a few soil fundamentals can help avoid such problems by either treating the site before plantations (consider tile drainage in the situation just described) or planting a species which is more tolerant of wetter sites (e.g. white pine).

SOIL ORIGINS

Soils form from what are called parent materials. Parent materials are of different types and composition. They range from bedrock deposits such as limestone, sandstone or granite which weathers to form soil, to alluvial and glacial deposits which have also undergone weathering to develop into various soils. The nature of the parent material significantly influences the texture, structure, fertility and drainage characteristics of individual soils. In Michigan many soils which developed from glacial deposits are well-drained, coarse textured and somewhat low in fertility. Examples of these soil types are present in much of the western and northern sections of the state. Soils which developed from alluvial or water borne sediments, such as those present in the east central Saginaw valley region of the state commonly are poorly drained, although quite high in fertility due to their high content of fine textured clay particles. Use limitations between coarse and fine textured soils are many in that fertility, moisture relations and trafficability are impacted. Because Michigan has a varied glacial history, soils of the state are very heterogeneous with areas of coarse textured soils frequently interspersed with heavier, clay dominated soils. Areas of organic soils (mucks) are scattered resulting from shallow depressions which supported large amounts of woody and herbaceous vegetation. Decomposition of plant parts in such areas is slow, thus resulting in substantial accumulations of organic matter.

SOIL CLASSIFICATION

Over time a recognized soil classification system has been developed and accepted. This system attempts to classify soils based on similarities which resulted from reactions to common soil forming processes. Classifications commonly include references to texture which is used to identify a common characteristic based on particle size. Texture, often identified as coarse or fine refers to the relative proportions of sand, silt and clay which are present. These particles or soil separates as they are called influence the "feel" of a soil. The size limits of various sized soil separates(particles) are as follows:

Particle	Size range (millimeters)
Very coarse sand	1.00 to 2.00
Coarse sand	0.50 to 1.00
Medium sand	0.25 to 0.50
Fine sand	0.10 to 0.25
Very fine sand	0.05 to 0.10
Silt	0.002 to 0.05
Clay	0.002 and below

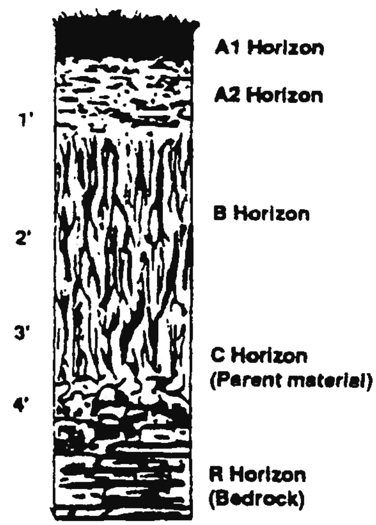
Each soil series present in the state has been given a specific name. This name is usually associated with the name of a nearby community where the specific soil type was first described, although the soil many be present in other parts of the state or even in adjacent states. As an example the Capac soil series identifies soils which consist of deep, somewhat poorly drained, moderately permeable soils which formed from a calcareous glacial outwash. This soil was initially described from information provided by a soil pit located in Sanilac county about two-and-a-half miles southeast of Sandusky. The town of Capac is located some 15 miles to the southwest.

Specific Capac soils may be further identified as Capac clay loam, Capac silt loam, Capac loam or Capac fine sandy loam, reflecting which soil particle size dominates. However, other structural drainage and fertility characteristics will be nearly the same for all soils within the Capac series regardless of texture.

SOIL PROFILES

Soils are best examined by observing a soil profile. This is accomplished by digging a pit to a depth of approximately four feet or to bedrock on shallower soils. The smoothed sidewalls of this pit represent a vertical profile of the specific layers or horizons of the particular soil. These horizons are quite distinct in mature soils and reveal important information about certain physical properties and characteristics of the soil. A typical soil profile is represented by the following figure:

The specific horizons are identified alphabetically and represent differences in chemical content, structure and color. The A horizon contains the most fertile soil as well as the majority of organic matter present. It usually is the darkest in color of all soil horizons and is also the most well drained. The B horizon is usually lighter colored than the A. It has a higher clay content and may contain more iron, silica and aluminum compounds. In many soils it contains materials and minerals which have been leached out of the A horizon. In contrast to the angular granular texture of particles in the A horizon, the B horizon aften has a larger aggregate or blocky structure. On wet or otherwise poorly drained soils, gray, yellowing or reddish colors (mottling) may be present in the B horizon. If present these indicate saturated moisture conditions occur at some time during the year. From a practical use perspective mottling generally means soil drainage must be improved through tiling if species like Fraser fir are to be successfully grown.



A Soil Profile

The C horizon represents the parent material from which the soil has formed. This horizon has been little influenced by any soil forming processes. It lacks any of the distinctive characteristics associated with the A or 8 horizon. Over geologic time upper regions of the C horizon can be modified somewhat to assume characteristics of the'B horizon as the soil forming processes continue. Composition of materials in the C horizon usually have had a significant impact on textural and fertility characteristics of the A and B horizons.

SOIL SURVEYS

In most Michigan counties detailed study of soils present in the county has been made. These results are published in an individual county soil survey. This survey contains abundant information on each soil series and type present, including a photographic soil map. Detailed descriptions of specific soils including their agricultural woodland productivity, engineering properties, physical and chemical properties as well as broad land use considerations are presented. Anyone desiring specific technical information about specific local soil series and types should consult the appropriate county survey.

SOILS AND CHRISTMAS TREE PRODUCTION
PART 2—SOIL TEXTURE AND STRUCTURE

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(Reprinted from Michigan Christmas Tree Journal, Summer 1994)

It is news to no one that Christmas tree production and marketing have become increasingly competitive in recent years. The market for low quality trees has shrunk; in many areas it is nonexistent. Successful Christmas tree growers must produce high-quality trees at the least cost.

Part 1 of this series on soils and fertility' emphasized the importance of soils and soils information to successfully producing quality Christmas trees at the least cost. An understanding of soils will enable growers to more effectively select sites with the greatest opportunity for success, match the appropriate tree species/variety to the site, understand the performance of existing plantations, and evaluate soil/site modifications such as drainage or fertilization to improve tree performance.

This article takes a brief look at two important soil physical properties, soil texture and soil structure. Future articles will examine other soil physical properties, soil chemical properties, soil fertility, tree nutrition, and fertilization.

THE SOIL

Although somewhat variable, a typical mineral soil for growing Christmas trees might consist of 50% solid material and 50% pore space. Approximately 90% of the solid material would be mineral, the remaining 10% organic matter. Approximately half of the pore space would be filled with water, the remaining half with soil air.

However, as pointed out in Part 1, soils are not uniform with depth but can be viewed in vertical profile as consisting of a series of layers or horizons, each with its own physical and chemical characteristics. Although tree roots are concentrated near the soil surface, the characteristics of all the horizons throughout the entire soil profile must be examined when evaluating a soil for Christmas tree production. Characteristics of deeper horizons often markedly influence Christmas tree performance.

SOIL TEXTURE

The soil particles which make up the mineral portion of a soil horizon are classified by size into sand, silt, and clay. The proportion of sand, silt, and clay in a soil horizon determines its texture.

SOIL PARTICLE	PARTICLE SIZE
Very coarse sand	1.0 mm to 2.0 mm
Coarse sand	0.5 mm to 1.0 mm
Medium sand	0.25 mm to 0.50 mm
Fine sand	0.1 mm to 0.25 mm
Very fine sand	0.05 mm to 0.1 mm
Silt	0.002 mm to 0.05 mm
Clay	<0.002 mm

Sand is an irregularly shaped particle, rarely smooth or flat, composed predominately of the mineral silicon dioxide (SiO_2). Of the three soil separates, sand particles have the smallest surface area per volume and the largest pore size. Soils containing large amounts of sand exhibit relatively rapid soil air and water movement (drainage) and retain relatively little water available for tree use. Sands contribute little to the soils chemical properties except by providing a physical framework on which the chemically active soil colloids (clay and organic matter) may adhere. Soils in which sand is the dominant particle are often referred to as "coarse" or "light" soils.

Silt is also an irregularly shaped particle, rarely smooth or flat, composed predominately of silicon dioxide. Silt has smaller pores than sand, but larger than clay. As a result, silt drains more slowly than sand and retains more water available for tree use. Like sand, silt has little chemical activity but provides a physical framework on which the chemically active colloids (clay and organic matter) may adhere.

Clay, the smallest recognized soil particle, has both a fixed shape, flat and plate-like, and a fixed chemical make-up, layers of silicon and aluminum bound together by oxygen. Of the three particles, clay has the largest surface area per volume and the smallest pore size, resulting in relatively slow soil air and water movement (drainage) and the retention of a relatively large amount of soil water against the draining force of gravity. Because of its chemical and physical structure, clay particles are very active chemically, with many important plant nutrients adhering to their surfaces. This capacity to adsorb nutrients, termed cation exchange capacity, is extremely important as a source of soil nutrients for plant growth and will be discussed in a future article. Soils in which clay is the dominant particle are often referred to as "fine" or "heavy" soils.

Each soil horizon is assigned a textural name based on the relative proportion of sand, silt, and clay particles it contains. The textural names, along with their composition are presented in the accompanying textural triangle. To use the textural triangle, the percentage of clay and silt are located on the clay and silt sides of the triangle. These percentages are then projected inward to their point of intersection. The percent clay is projected inward along a line parallel to the sand side of the triangle; the percent silt is projected inward along a line parallel to the percent clay side of the triangle. The name of the compartment in which the two lines intersect is the textural class of the horizon. A soil horizon that consists of 60% sand, 30% silt, and 10% clay, for example, would be a sandy loam.

In general, loams are considered the most desirable textural I class for Christmas tree growth. They provide the best blend of the three soil separates to produce optimum soil moisture and aeration, soil drainage, and soil nutrient exchange capacity. As one moves in any direction away from the loam textural class one or more soil properties usually become less suitable for growth. For example, if one moves in the direction of more sand (toward a sandy loam, a loamy sand, or a sand) soil drainage may become excessive (resulting in droughtiness) and the nutrient holding capacity of the soil (cation exchange capacity) will be lower (less clay).

There are essentially no cultural practices available to Christmas tree growers that directly modify soil texture. Sand cannot be converted to clay; silt cannot be converted to sand; etc. However, some of the undesirable soil water characteristics of soils with excessively sandy or clayey textures can be modified by improving the soil structure (discussed below) through the addition of organic matter. The relatively low nutrient capacity of sandy soils can also often be improved by increasing the amount of organic matter or by frequent light fertilization.

SOIL STRUCTURE

Soil structure is the term used to describe how soil particles (sand, silt, clay) are bound together (aggregated). Nine soil structural units or types are commonly recognized.
Soil structure may modify soil textural characteristics affecting such soil properties as the amount and size of pore space, soil water drainage and content, soil air movement and content, and root growth.

In the surface horizon the presence of a granular soil structure can substantially improve the soil water drainage, soil aeration, and the amount of water available to plants. When soil structure is weak or absent, it can often be improved by adding organic matter. Granulation of a coarse-textured surface horizon by adding organic matter can improve its ability to adsorb and hold moisture and increases the water available to plants. Granulation of a fine-textured surface horizon by adding organic matter can improve soil water drainage and soil aeration, and increase the water available to plants. In both situations the organic matter is acting as a binding agent for the soil particles, modifying the amount and size of the pore space. In both situations the increased organic matter provides additional water holding capacity, and may also provide nutritional benefits by increasing the soils cation exchange capacity and providing nutrients through decomposition.

The amount of organic material that should be added to a particular soil depends on several factors including the type of organic material being used, the soil type, and the soil nutrient content. Growers contemplating adding organic material to Christmas tree plantations should work closely with an Extension Agricultural Agent or someone experienced in the use of organic matter soil amendments. Improper use of organic matter as a soil amendment can create major problems with soil structure and/or fertility.

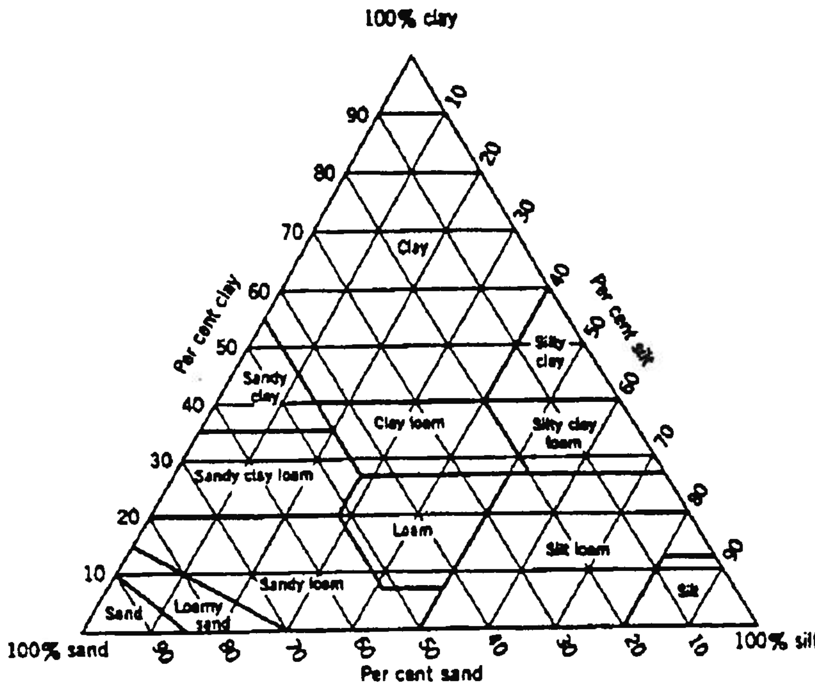
STRUCTURAL TYPE	DESCRIPTION	LOCATION/COMMENTS
Single grained	single, solid particle	visualize loose sand
Granular	porous round aggregate	plow depth
Crumb	very porous round aggregate	plow depth, less common than granular
Blocky	squarish blocks with sharp edges	subsoils
Nut-like (nuciform)	squarish blocks with rounded edges	subsoils
Columnar	pillars with rounded tops	subsoils
Prismatic	pillars with flat tops	subsoils
Platy	thin horizontal plates	any part of profile
Massive	large, irregular, featureless mass	uncommon

The texture of soil horizons below the surface can also be extremely important to Christmas tree growers. Some soils, for example, contain a lower horizon with a texture and structure that impedes soil water drainage. The presence of such an horizon, sometimes referred to as a "fragipan" or "pan," can affect species suitable for planting on the site or substantially reduce the growth and quality of the trees planted. Such an horizon could, for example, reduce the drainage enough that the site would be unsuited for growing Fraser fir or Douglas-fir, or would require uneconomically long rotation lengths. Such structural features need to be identified before trees are planted and their impact minimize or the site not planted. Depending on the situation, minimizing the impact might involve cultural practices such as subsoiling or tiling, or the planting of species tolerant of the existing drainage conditions.

SOURCES OF INFORMATION

How do growers find out about the textural and structural characteristics of their soils? Serious Christmas tree growers should have a soil map of their plantations. As discussed in Part 1, this can be developed and detailed information on the characteristics of the soils present can be obtained from a county soil survey. The soil survey contains location maps and a detailed description of each soil in the county. County soil surveys can be obtained from the local (field) office of the Soil Conservation Service.

Soil mapping in the county soil survey is often, however, not detailed enough for Christmas tree growers. Variations in soils too small to be included in the survey can be critical to Christmas tree production. This is particular true in areas with mild topographic relief where subtle changes in soil texture, structure, or internal drainage occur. For this reason growers should discuss the soils in their plantations with the Soil Conservation Service District Conservationist responsible for their county. In some instances it may be desirable to request the Soil Conservation Service map the individual Christmas tree farm. Such a request would be made through the local Soil Conservation Service office. Also, growers should get their hands dirty and dig some soil pits or use a soil probe or auger to evaluate the characteristics and uniformity of the soils mapped in their plantations.



TEXTURAL TRIANGLE

1 Koelling, M. R. 1994. Soils and Christmas Tree Production - Part I Fundamentals. Michigan Christmas Tree Journal 38(2): 25-28.

SOILS AND CHRISTMAS TREE PRODUCTION
PART 6 - ORGANIC MATTER

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Organic matter is a component of soil which contributes to both soil physical and soil chemical properties. Common characteristics and properties of soils including color, water holding capacity, nutrient exchange ability, aeration and/or porosity, texture and microbial content and activity are related to the presence of organic matter in soils. Organic matter can be considered an essential component necessary for the establishment and maintenance of soil fertility. While the importance of adequate organic matter levels for agricultural crops has been established, the contribution of organic matter to the productivity of soils used for Christmas trees is not as well appreciated.

What is organic matter?

Several organisms comprise the organic fraction of soils. Soil organic matter originates with the incorporation into the soil of the remains of both plants and animals. Residues from formerly living organisms undergo extensive change once they come in contact with the soil. Many different types of microorganisms use organic debris as a food-energy source. In the process those readily decomposed components disappear, however, more resistant products remain and eventually are converted to humus. Humus is identified as un-recognizable organic residues which influence both physical and chemical properties of the soil. Although the amount of humus in the soil is subject to change over time, it can persist at relatively stable levels for long periods.

Organic matter contents in soils are variable. Normal amounts range from I to 6 percent. However, organic matter may exceed 6 percent in some soils. Organic soils such as peats or mucks may contain percentages of 12 to 15 percent or more. Organic contents in these soils are high due to predominantly wet conditions and accompanying poor aeration. Additionally, most highly organic soils are found in cooler regions where normal decomposition processes are slower.

Why is organic matter important?

Organic matter is an important soil constituent because its presence influences several different properties and characteristics. Some of these are obvious; others are less apparent. The effects of organic matter can be grouped as follows:

1. Effect on color - Soils with significant organic matter accumulations are usually dark in color, ranging from various tones of brown to black. In contrast soils with low organic matter accumulations are commonly beige to reddish in color.

2. Influence on soil physical properties - The presence of organic matter promotes the development of texture in soils by contributing to the formation of soil granules. Soils with a granular texture are less plastic in nature. Accordingly, both water holding capacity and air exchange is increased. The amount of granulation in most soils can be increased by improving the organic matter content.

3. Increases cation exchange capacity - The nutrient adsorption potential of a particular soil can be increased by the presence of organic mater. These increases are substantial and can be highly important in improving the fertility of some soils such as those with a texture varying from loams to different amounts of sand. Increasing the cation exchange capacity results in the soil being able to "hold" more nutrients thus providing better opportunity for enhanced plant growth.

4. Improves nutrient suDDlv and availability - Since the cation exchange capacity is increased by organic matter present in the soil, the nutrient supply is likewise increased. Exchangeable nutrients such as the cations of calcium, potassium, magnesium, etc. are easily replaced with hydrogen ions from the plant. Other nutrients such as nitrogen, phosphorus and sulfur may be present in organic forms which are less resistant to loss from the soil profile by leaching.

Factors Affecting Soil Organic Matter Levels

It has been indicated that organic matter levels are not the same for all soils. Several factors influence the content and maintenance of organic levels. Some of these relate to natural conditions which cannot be controlled while others can be influenced by management. The most significant factors include:

1. Climatic conditions - Two components of climate, namely temperature and precipitation, have a marked influence on organic matter content and stability. In general organic matter contents are less for comparable soils located in warmer as opposed to cooler regions. Likewise, organic matter levels generally decrease as precipitation levels increase. This results from the more rapid decemposition of organic matter in warmer, dryer regions than under cooler and more moist conditions. In part this explains why organic soils are most often located in northern as opposed to southern latitudes.

Within a localized region soil moisture levels are probably more significant in explaining variations than is temperature. Low lying areas or soils which are superficially drained will usually have higher organic matter content than well drained, upland sites. Since such areas are common in many farm fields throughout Michigan and other upper midwest states, this helps explain why crop growth rates, fertilizer needs and herbicide effectiveness frequently vary, even within the same field.

2. Natural vegetation - In uncultivated soils those which developed under grassland vegetation will usually have higher organic matter contents than those formed under forests. The high fertility of prairie soils in the central midwest is a reflection of high organic matter contents which developed under native vegetation dominated by grasses. Annual biomass productivity

expressed in volume per unit area is usually greater for grasslands in humid areas than for forests. Additionally, there is some evidence which suggests that organic residues from grasslands decompose in such a way that higher organic levels results.

3. Texture and drainage - These two characteristics have been identified as significant factors affecting soil organic matter contents. While the presence of organic matter plays a role in improving texture by promoting particle aggregation, coarser textured soils such as sands usually contain less organic matter than do fine textured soils such as clays. It is believed this results from improved aeration which promotes more rapid decomposition of organic residues. Likewise, well drained soils have better air exchange and thus more rapid oxidation of organic materials. Aeration and water relations are both less favorable for decomposition in fine textured, poorly drained soils, therefore organic matter contents are higher. However, if organic soils such as mucks are drained and cultivation follows, rapid oxidation of surface organic matter occurs.

Sources of Organic Matter

The primary source of most original soil organic matter was plant material. In agricultural soils organic matter accumulated from the vegetation growing on the site before the particular soil was cultivated. This may have been either forest vegetation or grasses and other herbaceous vegetation, depending on location and related site and climatic factors. Organic matter and humus formed from the non-consumed portions of annual plants and from the leaves, twigs, stems and roots of perennial plants, either annually or when the plant died.

Once a particular site has been cultivated additions to organic matter levels occur from annual biomass residues remaining after harvest of the crop being grown, or from other specific practices designed to add organic matter. The addition of animal manures or the planting and incorporating into the soil of green manure crops such as rye or buckwheat will increase organic matter levels. Substantial levels of organic matter also result from the decomposing roots of harvested plants as well.

Carbon-Nitrogen Ratios and Concerns

It has been indicated that soil organic matter is an essential component of a productive soil which contributes to both physical and chemical soil properties. A principal component of organic matter which serves as an energy source for many soil microorganisms is carbon. In fact, the population of soil microbes in most soils is related to the amount of organic matter present. In addition to carbon, microorganisms also require nitrogen for both reproduction and growth.

As a result of several research investigations it has been determined that a predictable ratio exists between carbon and nitrogen (C/N ratio) in soil organic matter. For most upland soils this ratio varies between 8:1 and 15:1. For many soils the ratio is narrower, between 10:1 and 12:1 with little variation among similarly managed soils within the same climatic region. The constancy of these ratios reflects the combined influences of climatic factors, primarily temperature and precipitation.

While the C/N ratio for soil organic matter is in the 10:1 to 12:1 range, the C/N ratio for plant residues may vary from 20:1 for manure and certain leguminous residues to values approaching 100:1 for straw and similar residues. For most soil microorganisms the C/N ratio in their bodies varies from 4:1 to 9:1.

The differences in these various ratios can have a significant influence on the maintenance of soil fertility levels, primarily as it affects nitrogen. When large amounts of organic residue are added to the soil natural microbial decomposition processes begin. Large additions of high C/N ratio material actually result in an initial decrease in available soil nitrogen as microbes reproduce, utilizing available soil nitrogen in the process. Therefore, the amount of nitrogen available for plant growth decreases, particularly in an available form which can be readily absorbed by the plant. This condition may persist for several weeks or even months as soil organisms continue to break down and decompose the added plant residues. Eventually decomposition will be completed and a stable C/N ratio re-established. The length of time necessary for decomposition, and the time in which available nitrogen will be reduced, depends on the C/N ratio of the added organic residues. Legumes will decompose more rapidly; straw will decompose much more slowly and will exert a more pronounced adverse effect on available soil nitrogen levels.

Improving Soil Organic Matter Levels

It is possible to increase the organic matter content of most mineral soils. This involves additions of plant and/or animal residues as surface applications, or by establishing stands of so-called green manure crops such as rye, buckwheat, oats, soybeans and vetch among others. These plants are plowed under before they reach maturity, thereby substantially increasing the amount of organic residues added to the soil. Leguminous plants characteristically have a higher nitrogen content, ie. lower C/N ratio, and are preferred over other plant types. Green manure crops should be established and incorporated into the soil in the year before other crops are planted in order to allow carbon-nitrogen levels to stabilize.

Applications of animal manure can also increase soil organic matter contents. Annual applications of 2 to 2 1/2 tons per acre can result in the addition of 1000 pounds or more of dry organic matter to the soil, thus contributing substantially to the maintenance or improvement of organic matter levels.

Other organic residues such as wood chips, sawdust, lawn clippings, leaves and compost of various types can also be added to the soil. Some of these such as wood chips and sawdust have a very high C/N ratio. When these or similar materials are used it is recommended that additional nitrogen applications be provided when the residues are added. They will hasten decomposition as well as reduce the utilization of available soil nitrogen by decay organisms. Nitrogen applications are usually not as necessary when leaves or well decomposed compost is used.

Organic Matter and Christmas Tree Production

While applicable to both traditional agricultural as well as tree crops, much of what has been considered is more commonly viewed as being related to the production of agricultural crops. However, management of soils to maintain and enhance organic matter levels where tree crops are produced is also important.

Although it is not as easy to manipulate organic matter levels once trees are established, there are a few recommendations which can be offered.

The planting of green manure crops on sites where trees will be established offers significant benefits in improving organic matter levels. Establishment and plowing under a green manure crop 1 and preferably 2 years before planting will improve organic matter contents as well as provide significant control of many weeds and grasses. Additionally, the tilth of the soil is improved; a factor which contributes to increased survival following planting. Buckwheat, red clover and rye are excellent species from which to select a green manure crop.

Animal manures and/or litter manure mixtures can also be used to increase organic matter levels. Application amounts of 5 tons and more per acre have been used. At these relatively high levels some additional nitrogen applications are suggested, especially where large amounts of straw, wood chips or sawdust are present. This is particularly important if the application is made within a year or less of planting.

Cover crops are recognized as an effective means of maintaining organic matter as well as providing soil protection and some assistance in weed control. Cover crops can be established either before trees are planted or following planting when the trees are small. Legumes such as Dutch white clover will develop into a thick stand, thereby crowding out other vegetation. This leguminous species will contribute nitrogen to the soil, thus promoting tree growth. Where cover crops are present chemical weed control must be restricted to band applications or involve the use of wick applications to control vegetation which is taller than the desired cover crop. Occasional mowing of the areas between the rows of trees will also assist in vegetation control. Where cover crops are established before planting conventional drilling or similar seeding methods are used. In established tree plantings frost seedings in late winter-early spring have proven successful.

Applications of organic residues such as mulches of wood chips, needles, leaves, shredded bark, etc. is not widely practiced in Christmas tree plantations. Although theoretically such materials would result in organic matter increases, applications should be balanced with nitrogen applications to minimize nitrogen deficiency concerns related to tree growth.

In conclusion, organic matter is an important soil component which influences both physical and chemical properties. Christmas tree producers like their counterparts in traditional agricultural operations will benefit by managing soils to maintain or augment existing organic matter levels. This is particularly significant for tree species which require higher quality sites. The production of trees of the highest quality results from application of the best management techniques to trees growing on the most favorable sites. Managing soil organic matter levels can assist in maintaining high quality sites.