NORTHEAST AREA NURSERY SUPERVISORS CONFERENCE

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DEVELOPING ORGANIC MATTER

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After accepting to talk at this conference on developing organic matter in soils, I wondered why. There is a tremendous amount of literature on soil organic matter. The practical aspects of soil organic matter management are much less clear. The English refer to soil scientists working in the area of soil organic matter as "the muck and magic boys." The advantages and benefits of soil organic matter are well known and universally accepted. The documentation of specific practices aimed at organic matter maintenance and the results of these practices on yields and related production parameters is often somewhat difficult.

Before proceeding further, let's ask two questions: (1) can soil organic matter be increased, and (2) do we want to increase soil organic matter?

The answer to the first question is, within limits, yes. But above certain limits, organic matter increases are possible only at a high cost. The normal, or "equilibrium" organic matter in a soil depends on temperature, moisture and texture, among other factors. In the New England states, soils with 2% to 3% organic matter are not uncommon and such levels can be readily maintained. On the Delmarva peninsula, further south, with higher average temperatures and sandy soils, organic matter decomposes at a higher rate and organic matter levels over 1% to 1 1/2% are uncommon in well-drained soils. High organic matter levels are found only when poor drainage reduces soil aeration and hence the rate of organic matter decomposition.

The answer to the second question, "Do we want to increase organic matter?" is not clear-cut either. Organic matter in soils *per se* is of limited value. At very high rates, such as those used in the containerized production of ornamentals, organic matter certainly contributes to the porosity and generally desirable physical condition of the growth media. In field soils, the cost of such high levels of organic matter is prohibitive. At the more normal levels, it is the decomposition of the organic matter rather than the organic matter *per se* that produces the desired results. For example, some workers in Wisconsin measured the total organic matter, microbial gums and iron oxide content of soils with desirable, water-stable aggregation, a generally accepted criteria of good soil tilth. Total organic carbon made only a small contribution to aggregation and aggregate stability. The most important factor was microbial gums, which are complex polysaccharides resulting from organic matter decomposition. The objective of soil organic matter management should not be the increase of soil organic matter but the continuous return of organic materials to soil under conditions which will permit rapid decomposition of the organic matter. It is the decomposition and not the accumulation of organic matter that is of value.

WHY SOIL ORGANIC MATTER?

SOIL STRUCTURE

Let us now look briefly at some of the benefits to be obtained from the presence of decomposing organic matter. In most soils, soil structure improvement is a very important, if not the most important reason for concern about soil organic matter. It is difficult to measure "good" soil structure except by indirect measurements, such as increases in water-stable aggregation, increased rates of water infiltration, increased root penetration,reduced runoff and erosion. Even if soil structure is difficult to quantify, most of us have no difficulty in recognizing soil with desirable physical properties and desirable soil structure.

Organic matter promotes soil structure largely as a result of its decomposition. It promotes aggregation and stabilizes soil aggregates. This is largely the result of microbial byproducts of decomposition and the large amounts of fungal mycelium produced in actively decomposing organic matter. Stable soil aggregates result in larger pores and increased soil porosity, essential for infiltration, drainage and aeration. On erodable soils, decreased runoff results in decreased erosion. Also larger, water stable aggregates are not as susceptible to water transport.

WATER RETENTION

It is generally believed that water retention is increased by soil organic matter. This can be readily demonstrated when large amounts of peat are added to soils. In field soils, the increases in water retention are difficult to measure. Hillel, in his recent monograph on soil water, has only a few lines on the influence of organic matter on soil water retention: "Soil organic matter can help retain water, though the amount of organic matter normally present in field soils is too low to have much effect." Slatyer in his monograph of plant-water relationships makes no mention at all of the role of organic matter. The beneficial effects of soil organic matter on soil water relationships often observed in the field in a practical way are more likely due to increased infiltration, better porosity, etc., rather than any significant increase in the amount of water actually retained.

NUTRIENT AVAILABILITY

Some sources of soil organic matter are excellent suppliers of nutrients, for example, manures. Many sources of organic matter, such as crops grown as cover and green manure crops, do not add new nutrients to the soil but are valuable in preventing leaching of nutrients and in the recycling of nutrients. This is especially true for nitrogen. Soil organic matter can help convert soluble fertilizer sources of nutrients, especially nitrogen, into very good "slow release" fertilizers. Nitrogen losses through leaching are reduced. This is especially significant and important on sandy soils. Micronutrients such as copper, zinc and manganese are chelated, in which form they not only serve as good plant sources, but also tend to reduce the toxicity of excessive amounts of these nutrients.

While primarily beneficial, the interactions of soil organic matter and nutrients may at times result in competition for nutrients between the plant and the soil decomposing microflora. This is again especially likely for nitrogen. This will occur when low-nitrogen, high-carbon materials, such as straw and bark, are added to soils. Competition for nitrogen may occur when the C/N ratio of the material is greater than 30/1, or the nitrogen content is lower than 1.2% to 2.8%. This is a factor which must always be carefully considered when organic materials are added to soils.

The carbon-nitrogen ratios of some common sources of organic matter are given in the table below:

Carbon-Nitrogen Ratios of Some Organic Materials

Material	C/N Ratio
Soil humus	10
Sweet clover (young)	12
Barnyard manure (rotted)	20
Clover residues	23
Green rye	36
Cane trash	50
Corn stover	60
Straw	80
Timothy	80
Sawdust	400

Data taken from several sources. Values are approximate only. Ratio in any particular material may vary considerably from the values given.

While the values in this table can serve as useful guides, it is important to remember that nitrogen fertilization can substantially change these values. This is especially true of grasses. Grasses such as timothy and rye grass, which may contain less than 1.0% nitrogen, may accumulate up to 2.5% to 3.0% nitrogen when fertilized with nitrogen or when grown following crops heavily fertilized with nitrogen.

NITROGEN REQUIREMENT CONSIDERATIONS

The approximate nitrogen factor or nitrogen requirement for the proper decomposition of organic materials added to soil can be calculated in the following manner, as given in many elementary soil fertility textbooks. The assumption is made that the soil C/N ratio is 10/1 and that 35% of the carbon will be assimilated by soil microorganisms for protoplasm formation.

1. Calculate CO_2 evolution

$100 - 35 = 65\%\ CO_2$ evolution

$\%C \times 0.65 = CO_2$ evolved

2. Calculate C assimilation

$\%C - CO_2$ evolution = C assimilated

3. N needed = $\frac{\text{C assimilated}}{10}$ - N content = N requirement

The following is an example for oat straw with C - 42%, N - 0.4%. The calculation is for 100 pounds of straw.

42 x 0.65 27.3 lbs. C evolved as CO_2

42 - 27.3 = 14.7 lbs. C available for assimilation

N needed = $\frac{14.7}{10}$ = 1.47 - 0.40 = 1.07 lbs. N needed per 100 lbs. straw

This method may overestimate nitrogen needed for slowly decomposed materials such as sawdust and bark.

SOME MATERIALS AND COMMENTS ON THEIR USE

PEAT

Excellent, but probably should be dismissed in most cases on the basis of cost. Caution: Some peats may contain excessive salts. There have been cases of nursery and landscape operators in Delaware, Maryland and Pennsylvania who have suffered damage from peat high in salts.

MANURES

Manures are an excellent source of both organic matter and nutrients. The nutrient content of manures is variable, depending on the source of the manure, how it is handled, how long and under what conditions it is stored. Typical concentrations of nutrients in broiler manure on the Delmarva Peninsula are given in the table below. Most manures are high in soluble salts which can cause damage in germinating seeds or to seedlings. As a general guide, applications of poultry manure under 10 tons per acre and of stable manure under 20 tons per acre can be safely made with no fear of salt damage. If higher applications are made, several months should elapse between application time and seeding or transplanting occurs. Assuming normal rainfall and well drained soil conditions, this should allow excess salts to leach. It is a good practice when large manure applications are made to determine the conductivity of the soil extract to insure that soluble salts are not excessive. The conductivity of a 2:1 water extract (one part soil, extracted with two parts of water, by volume) should not exceed 2.0 mmhos per cm. Some reduction in germination can occur between 1.0 and 2.0 mmhos/cm under dry soil conditions.

Manures are relatively high in nitrogen. In most cases, about half of the total nitrogen is readily available during the year of application. This will usually be substantially more than is needed or can be used by tree seedlings. It is therefore advantageous in many cases to use nanures in conjunction with grass cover crops or with high C/N ratio materials such as sawdust or barks. When used on a grass cover, the manure will result in luxurious growth of the grass, provide substantial organic matter over that contained in the manure, will reduce th C/N ratio of the grass, and provide improved soil tilth due to the roots of the grass.

A large part of the nitrogen in poultry manure is in the ammonium form which may be undesirable for some seedling species.

Typical Broiler Manure Composition
(Dry Weight Basis)

	Average	Low	High
Water	25%	18%	35%
Ash	20	15	30
Nitrogen	4	2	6
Phosphorous	1.5	1.0	2.0
Potassium	2.0	1.0	2.5
Calcium	2.0	1.0	2.5
Magnesium	0.5	0.3	0.8
Sulphur	0.4	0.2	0.6
Boron	30 ppm	1S ppm	60 ppm
Copper	200	30	500
Zinc	300	200	400
Manganese	300	200	400

Values in this table are from a large number of analysis reports in various sources for broiler manure from broiler houses in Maryland and Delaware.

SAWDUST AND BARK

These are often available and they are cheap and good sources of organic matter. These have high C/N ratios and will require nitrogen additions to promote decomposition and prevent nitrogen deficiency to plants. Allison et al with the USDA have published* values for the C and N content of sawdust and bark from different species. They report a carbon content for wood of 45% to

*Allison, F. E., USDA, Tech. Bull 1332, 1965

*Allison, F. E., R. M. Murphy and C. J. Klein, Soil Sci. 96, 187-91, 1963

50%. The overall average was 48%, with hardwoods averaging 47%. The nitrogen content of wood is reported as 0.093%, average, with a range of 0.045% to 0.277%. None of the hardwoods exceeded 0.1%. The nitrogen content of barks averaged 0.174% with a range of 0.038% to 0.41%. These values are based on 19 softwood and 9 hardwood species.

Their decomposition studies gave nitrogen requirements of 1 lb. nitrogen per 100 lbs. softwood sawdust and 0.6 lbs. nitrogen per 100 lbs. hardwood sawdust (compared to 1.7 lbs. nitrogen for 100 lbs. wheat straw). The lower nitrogen requirement than one would would expect from the high C/N ratio is probably due to the relatively slow rate of decomposition of these materials.

COVER CROPS AND GREEN MANURE CROPS

Any grass or legume adapted to the area can serve as a cover or green manure crop. The large amounts of fibrous roots produced by grasses is excellent in improving soil structure. Legumes contribute nitrogen, but in general, they do not produce as much organic matter and are not as effective in improving soil structure. In the Delmarva area, hairy vetch, either alone or with rye or barley and crimson clover, alone or with rye grass, are excellent choices, the legume providing 50 to 100 lbs. of nitrogen per acre per year and the grass contributing organic matter and the beneficial effects on structure of grass roots.

SEWAGE SLUDGE

Sewage sludge is an excellent source of organic matter at a low cost. The rate of decomposition is usually slow, hence nitrogen release is also slow, but nitrogen deficiency is not a problem. The rate at which sewage sludge decomposes varies with the treatment method used in the treatment plant. Heavy metals may be a problem in sewage sludge. State and Federal regulations concerning its use must be checked. Permits for its use are usually required. The rates that can be applied, that is, the "loading rate," will be determined by the nitrogen and heavy metal contents. Analysis should be obtained before making commitments to using sewage sludge and will very likely be required by regulatory agencies. Sewage plant operator analyses should be questioned unless the frequency of sampling is known. The composition of sludge can vary from day to day. In the northeastern states, the regulations for the use of sewage sludge are very conservative, and hence can be considered very safe.

CONSIDER NO-TILL

As an outsider to the forest tree nursery business I cannot judge the applicability of no-till practices to forest tree nurseries. Based on the degree of success of no-till practices in corn production, I would suggest that it be considered for these nurseries. No-till provides all the advantages of grass root growth in promoting soil structure. The killed residues provide an excellent mulch. The soil is protected at all times. Infiltration rates are increased and runoff and erosion are reduced. Experience with corn production indicates that no-till requires a high level of management. If management is poor, no-till can be a disaster. If no-till has a place in forest tree nurseries, I am certain that the same high level overall management will apply. Successful no-till requires that after the initial burn-down, remaining weeds are carefully identified and quickly controlled.

A FINAL CAUTION

It is important to remember that the decomposition of organic matter results in substantial production of soil acidity. Monitor soil ph and correct by liming if and as needed.