An Overview of the Role of Organic Amendments in Forest Nurseries[1]

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INTRODUCTION

Organic amendments in agriculture have been with us for thousands of years so there is a great deal of comfort in knowing that it is the right thing to do. Tilled soils definitely require periodic, if not yearly, additions of organic matter in order to maintain tilth, fertility, and favorable water holding characteristics. There is no getting around the fact that organic matter degrades and must be renewed if the soil is to perform effectively as a growing medium.

Forest nurseries have many things in common with agricultural operations. However, there is one very large difference. The forest nursery manager is as interested in the root system of the crop as s/he is the top of the plant. Unlike the typical agricultural crop, the organic matter from the root system of a forest seedling crop is not left in the ground. Maintaining organic matter levels in a forest nursery soil can be a bit of problem depending on the local environment.

This paper is an overview of organic matter amendments in nurseries. It covers some of the general principles of how organic matter affects the physical, chemical and biological properties of soils, how organic matter is decomposed in soils, and the various uses for organic amendments. This is by no means an exhaustive review of the topic. There is an excellent review of this topic by Blumenthal and Boyer (1982), which is soon to be updated. Much of this overview is drawn from that paper.

SOIL PROPERTIES

Physical Properties. Tilth is highly associated with the amount of decomposed organic matter in soil. Nursery soils where organic amendments are made on a regular basis are usually easier to till, prepare beds, and lift seedlings. These same soils can also be less likely to compact under common working conditions.

Sandy soils seem to benefit the most in terms of physical properties where organic amendments are concerned. Some sandy soils tend to compact naturally due to their particle size distribution i.e. the grains of sand, silt, and clay fit so well together there is less pore space. Humus tends to retard this natural phenomenon because it gives the soil a more granular structure. Clay soils also benefit from humus as well.

Here is a list of some of the physical benefits of organic matter in nursery soils:

1) lowering of soil bulk density
2) less mechanical impedance
3) better soil aeration
4) greater soil water penetra tion with increases in soil structure
5) less soil erosion
6) increased water holding capacity

CHEMICAL PROPERTIES

Organic matter is definitely a source of nutrients. Microbes - bacteria, fungi - decompose the organic matter into humus which eventually leads to a release of nutrients. There are several key

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concepts to understand about the release of nutrients from organic amendments. They are immobilization, mineralization, and the carbon to nitrogen (C/N) ratio. In the case of nitrogen immobilization microbes tie up nitrogen from the soil as they go about decomposing high carbon-low nitrogen organic sources. This phenomenon explains why seedlings turn yellow after fresh sawdust has been added to beds. The seedlings can not out compete the microbes for the N they need. Mineralization is where the microbes die after using up all of the available nitrogen and release the N tied up in their bodies. The C/N ratio is important because not all organic materials are the same and do not have the same C/N ratio. High C/N ratio materials require added fertilizer N if N immobilization by the microbes is to be avoided. Table 1 shows some C/N ratios for various plant materials.

Table 1. Carbon/nitrogen ratios of a few farm and forest products. (after Blumenthal and Boyer, 1982)

Organic Material	C/N Ratio, water-free basis
Alfalfa Hay	18:1
Meadow Hay	43:1
Wheat Straw	373:1
Oak Leaves, weathered	26:1
Douglas-fir bark (420 yrs old)	491:1
Peat Moss	58:1
Red Alder sawdust	134:1

The decomposition of organic matter depends on the following:

1) temperature
2) the level of oxygen in the soil
3) moisture
4) available minerals
5) the C/N ratio
6) the age of the organic matter
7) the physical composition of the organic matter i.e. lignin and cellulose contents.
8) the population dynamics of the microbial community i.e. species of microbes, population sizes.

These factors help explain why in wet cold soils the slow decomposition of organic amendments and why it is best to keep to already decomposed materials as additions in colder climates. In hotter climates where the growing season is longer and the microbial decomposition is rapid by comparison it is necessary to try to keep to large additions of organic matter. In the warmer climes it can be near impossible to increase the equilibrium level of organic matter with cover crops due to rapid decomposition.

Organic materials help the chemistry of the soil for one very important reason. Most materials have a very high cation exchange capacity (CEC), which means that they are able to bond with cations(NH_4,K,Ca,Mg). So, by adding organic amendments to a low CEC soil like a loamy sand (CEC-2) it is possible to raise the CEC by adding an organic with a CEC-300. In the same vein, organic matter also buffers the soil against changes in pH.

BIOLOGICAL PROPERTIES

Organic matter is the source from which microbes get their energy. This includes both the friendly microorganisms like the mycorrhizal fungi and the *Tricoderma* spp as well as the unfriendly microorganisms like the *Fusarium* spp. One point that is constantly made in the literature is to the fact that it takes a wide mixture of species in the soil to maintain a healthy environment. There definitely needs to be a large and diverse community of friendly organisms to balance out the detrimental effects of such pathogens as *Pythium* spp, *Phytophora* spp, and *Fusarium* spp - just to name the major ones.

Mycorrhizal fungi benefit from organic amendments as evidenced by the common presence of roots with mycorrhizae on them buried inside a small chunk of bark or wood chip. The fungus decomposes the bark, providing nutrients for itself and the nursery seedling plus gaining carbohydrates from the seedling. I have yet to dig up seedlings in soil well supplied with organic amendments and not found many roots intertwining their way through the larger pieces of organic material.

There is far too much that we do not know about the role of specific organisms in soil and how those organisms positively impact seedling quality. This is made even more critical with the

legal requirements to move away from methyl-bromide soil sterilization. There is also much to be learned about hove best to manage disease in soils without having to resort to sterilization.

MULCHES AND INCORPORATED AMENDMENTS

For the sake of simplicity both of these types of amendments will be discussed here because, in most cases, it is the same amendments being used in two different ways. Mulching amounts to putting a cover of a particular material over the newly sown seed bed in order to protect the seed from wind and water erosion, heat, and desiccation. On the other hand, incorporated amendments are usually disked into the soil in order to replenish the soil with organic matter. Incorporation is especially important in nursery soils to maintain or raise the organic matter equilibrium level.

There are a great many amendments that can be used. The common amendments for mulching are straw, sawdust, and bark. There are others like pine straw (needles), peat, hydromulch (paper sludge), paper mill and city waste sludges. Incorporated amendments tend to include sawdust, bark, and peat. Animal manures are also common, but acidic ("hot") manures like turkey and chicken need to be incorporated well enough in advance to avoid killing the seedlings. Sludges are also used, but they need to be thoroughly investigated prior to use. In fact, all organic amendments should be analyzed prior to use in a nursery since they may contain contaminants like pathogens or heavy metals. Green manures are often grown for incorporation, but it would seem that most green manure crops really do not alter the equilibrium level of organic matter. They can in some instances get the microbial populations so active that there is a net decrease in soil organic matter!

NITROGEN IMMOBILIZATION

It is an on-going issue as to how much nitrogen to add to the soil after adding an organic amendment to a soil. Usually, there is not much to be concerned about when mulching unless there is no other choice but to mulch with fresh wood chips or sawdust, then it may be necessary to add nitrogen. The more common problem is knowing how much nitrogen to add to a soil while incorporating any one of a number of organic amendments.

Table 2 shows a few examples of the amounts of nitrogen immobilized by microbes while decomposing some of the different sawdusts (Blumenthal and Boyer, 1982). If you were to take 1 ton of white pine sawdust and add it to an acre, the percent nitrogen immobilized after 160 days is .41 i.e. .41%. In order to prevent that potential immobilization from hurting the nitrogen uptake of the crop it is necessary to add 8.2 pounds of nitrogen per acre. The calculation is .0041 times 2000 pounds. Over 10 acres that is 82 pounds of nitrogen. That is not a lot of nitrogen and has the poten-

Table 2. Amount of nitrogen immobilized by micro-organisms decomposing sawdust of different softwoods and hardwoods. (modified from Blumenthal and Boyer, 1982)

Type of Sawdust	Percent Nitrogen immobilized after 160 days
Softwoods:	
Eastern Hemlock	.42
Douglas-fir	.30
White Pine	.41
Loblolly Pine	.60
Ponderosa Pine	.42
Hardwoods:	
White Oak	1.09
Yellow Popular	1.05
Black walnut	1.07

Source: Allison, 1965

tial to cause some problems in application trying to spread so small an amount over such a large area. However, given the amount of nitrogen put on nursery crops adding a little more fertilizer to the normal fertilizer schedule usually takes care of any problems. Of course, as the amounts of organic material increases where several tons may be going on per acre, it may be best to delay the sowing of any seedlings for a year and simply allow the soil and microbes to equilibrate.

Using low C /N ratio materials (<20), which has been known for years, is probably best. My preference is sawdust or bark that has been composted (left to sit in a pile somewhere on the nursery) for several years. This kind of material is ideal because it is not necessary to worry about immobilization and it can be used as a mulch and an incorporated amendment.

MEASURING ORGANIC MATTER

There are basically three different methods, which will not be gone into in any detail here. One of them uses perchloric acid, another uses potassium dichromate, and the other merely determines the loss on ignition in a muffle furnace. The first two have gone out of vogue due to safety hazards involved with them, even though they are considered the more accurate ways to measure organic matter by some. The latter method works very well, but can lead to errors with some soils. The suggestion here is to use the loss on ignition method and run enough samples over time to get a very good idea of where your soils are at in any give area. It is always advisable to send in two samples that you know are the same but identified as different samples in order to check the accuracy of the lab. Knowing the organic matter percent to the nearest 1 percent is all that is required or necessary.

POSTSCRIPT

At this writing Don Boyer is planning to rewrite his very lengthy paper on organic amendments in nursery soils. Hopefully, it will be in-press in 1994.

LITERATURE CITED

Blumenthal, S.G. and D.E. Boyer. 1982. Organic amendments in forest nursery management in the USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Administrative Report, October 1982, pp 73.