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The Compost Connection

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Suppressing Plant Diseases with Compost

by David Granatstein

One of the benefits often ascribed to compost use is the fuzzy concept of reducing disease problems for plants. While this may have been based on casual observation in the past, researchers can now more clearly articulate the mechanisms and methods that indeed make some composts suppressive to plant diseases. Dr. H. Hoitink, a plant pathologist at Ohio State University and long-time compost researcher, summarizes much of the current knowledge in a recent book chapter (see References). The basic points are presented below, along with examples of other recent developments in the area of disease suppressive composts.

Mechanisms. In the past, compost users didn't worry much about any disease suppression. If it happened - great. But increasing numbers of growers are interested in alternatives to conventional pesticides. In order for compost to substitute for currently used fungicides, the disease suppressive character must be consistent and somewhat quantifiable to reduce risk for the growers. Research into the mechanisms of disease suppression in compost have led to the ability to produce consistently suppressive composts, especially for the nursery industry.

Pathologists describe two different types of disease suppression in compost and soil. General suppression is due to many different organisms that either compete with pathogens for nutrients and/or produce general antibiotics that reduce pathogen (go to page 3, *DISEASE*)

Improving the Nutrient Status of WSU Compost

by Kent Gephart, WSU Crops & Soils

The WSU compost facility has been generating compost with pH values up to 9 and higher. This is in larger part due to the high pH (8.6-8.8) of the primary feedstocks: separated dairy solids, bedding, and ash. Garden supply stores and nurseries that buy compost, as well as future buyers, have expressed concerns about the high pH levels and low levels of available nitrogen. A pilot study was initiated to examine what amendments could be added to the compost to lower pH and increase available nitrogen.

The pilot study was developed with different rates and combinations of urea, ammonium sulfate, gypsum, and elemental sulfur. The most promising treatment was a combination of ammonium sulfate and elemental sulfur, each applied at a rate of 1 lb. per cubic yard of compost, based on both reduction in pH and ease of handling. This was compared to untreated piles in a field scale study.

Two separate compost piles (150 cu. yd. each) were formed at the same time for the study. When the piles were 8 weeks old, ammonium sulfate and sulfur were added to one pile at a rate of 1 lb. each per cubic yard, while the other pile was used as a control. The pH, moisture, ammonium-N, nitrate-N, and sulfate status were measured weekly for 8 weeks. The percent moisture in both piles remained similar throughout the experiment. The pH value in the amended pile dropped 1 pH unit over the first two weeks, and remained 1 to 1.5 units lower than the control pile (Fig. 1). Ammonium-N levels were 50 to 130 mg/kg higher in the amended pile than in the control throughout the study (Fig. 2). Nitrate-N was also 11 to 195 mg/kg higher in the amended pile than in the control (Fig. 3). The amount of N added as

ammonium sulfate (about 200 mg/kg) was roughly equal to the increased N in the amended pile. The sulfate levels were generally higher in the amended pile, but did not demonstrate a consistent trend over the control.

By adding ammonium sulfate and sulfur at a rate of 1 lb. each per cubic yard, we were able to improve the pH and available nitrogen status of WSU compost.✷

Fig. 1. Compost pH measured on 1:5 wet compost to water slurry.

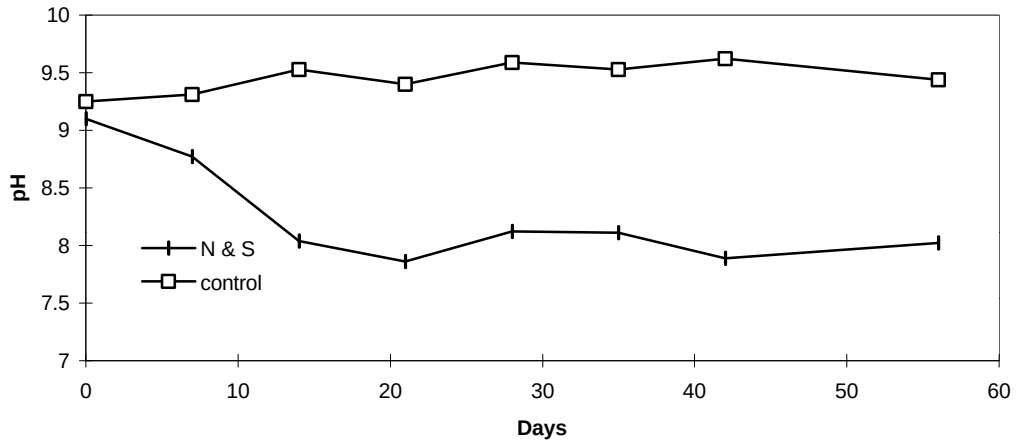


Fig. 2. Ammonium nitrogen content of the compost.

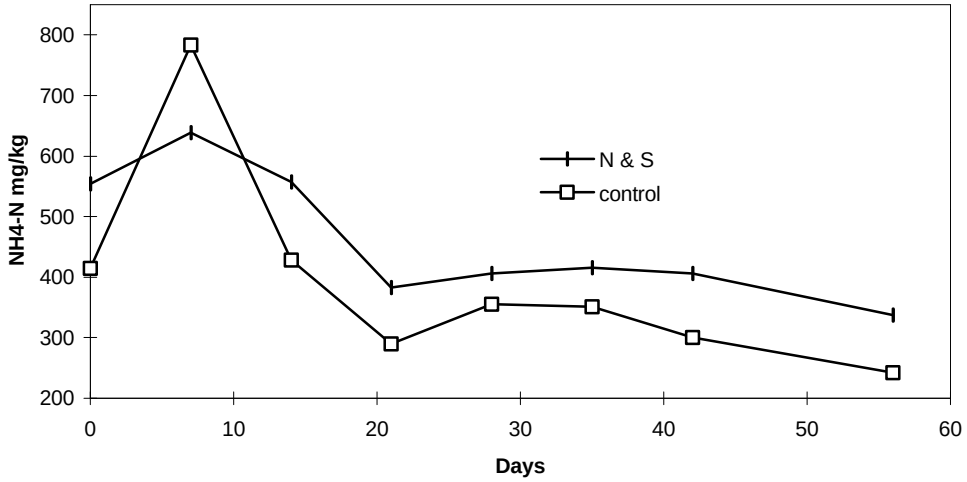
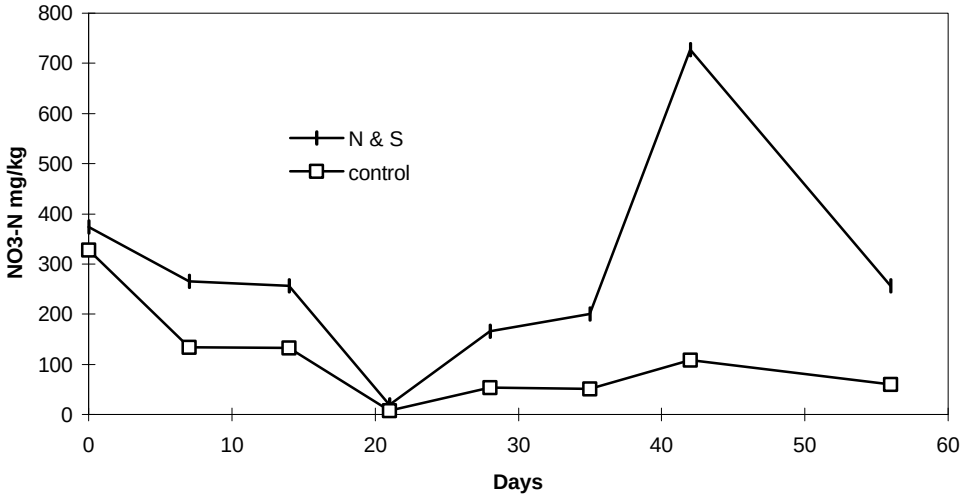


Fig. 3. Nitrate nitrogen content of the compost.



(*DISEASE*, from page 1)
survival and growth. This type of suppression is effective on those pathogens that have small propagule size, resulting in small nutrient reserves and the need to rely on external carbon sources. Thus an active microflora in the soil or compost will often prevent disease since the pathogens are outcompeted. Examples of this mechanism are suppression of damping off and root rot diseases caused by *Pythium* species and *Phytophthora* species.

Specific suppression, on the other hand, is usually explained by one or a few organisms. They exert hyperparasitism on the pathogen or induce systemic resistance in the plant to specific pathogens, much like a vaccination. With specific suppression, the causal agent can be clearly transferred from one soil to another. Pathogens such as *Rhizoctonia solani* and *Sclerotium rolfsii* are examples where specific suppression may work but general suppression does not work. This is because these organisms have large propagules that are less reliant on external energy and nutrients and thus less susceptible to microbial competition. Specific hyperparasites such as *Trichoderma* species will colonize the propagules and reduce disease potential.

The disease suppressive effect of composts can easily be eliminated by heat greater than 60°C (140°F). For example, studies of compost windrows heated to this level have shown loss of suppressiveness in the center but retention of suppressiveness in the cooler, outer layers. The suppressiveness returns during the cooler curing phase when the general microflora recolonize the compost if conditions (especially moisture) are conducive. A few beneficial species can survive the high temperatures, but the bulk of the desirable organisms are mesophiles, which means they need more moderate temperatures. The diversity of the mesophiles is greater than that of the thermophiles, or high temperature organisms, and this greater diversity contributes to suppressiveness by broadening the spectrum of potential biocontrol mechanisms.

The biological vacuum created after periods of high temperatures offers a chance to introduce a custom microflora, and researchers have successfully inoculated composts with microbial mixes to enhance biocontrol (see below). This should be done as soon as possible after heating so that the introduced organisms have minimal competition with the native microbes that will also be recolonizing the compost. A mix of both fungi and bacteria appear most desirable. The curing process generally takes about 20-30 days for microbial recolonization.

If the compost is too dry (<30% moisture by weight), fungi are more likely to recolonize. Such composts have been shown to be very conducive to *Pythium* related diseases. Nursery operators will prewet the potting mix and incubate it for 4-10 days to allow for the desired fungal and bacterial balance. Also, uncured compost may contain high levels of soluble nutrients that create favorable conditions for *Pythium* and *Fusarium* pathogens. These concerns are most crucial for composts used in potting soils. For composts applied to the field, recolonization from the soil will occur and minimize these problems. However, high temperature heating to destroy as many pathogens as possible is still important.

Recently, Ohio State University researchers demonstrated that the beneficial microbes in compost and other decomposing organic matter can activate certain disease-resistance systems in plants. When a pathogen infects a plant, the plant mobilizes certain biochemical defenses, but these are often too late to avoid the disease. Plants grown in compost appear to have these systems already running and this prevents the pathogen from causing disease. This mechanism, called systemic acquired resistance, is somewhat pathogen specific, but it opens the door for enhancing disease control through common farming practices.

Practical applications. The success of disease suppression with compost depends on a number of factors. The nature and fate of the pathogens need to be known. As described above, *Pythium* and *Rhizoctonia* are controlled by different mechanisms. Researchers have found that compost from most any source is suppressive to *Pythium* after proper heating and curing, but not so for *Rhizoctonia*. *R. solani* produces the enzyme cellulase and can thus proliferate in uncomposted materials such as fresh bark or straw. *Pythium* is just the opposite - it needs decomposed materials that contain soluble nutrients. Minimal composting and curing eliminates the ability for either pathogen to establish in the finished product.

Similarly, the compost must provide sufficient substrate for the general microflora if they are to be competitive. A very highly stabilized compost looses its ability to supply nutrients and energy to microbes, and as they decline, so does the level of general suppressiveness. The location of the composting operation can influence the recolonization process. An in-vessel system will usually have lower microbial diversity than an outdoor windrow.

The compost should have favorable chemical properties with regard to plant growth. High salt content has been related to increased disease susceptibility, apparently due to the chloride ion. Excess nitrogen can aggravate certain diseases, and some pathogens are favored by ammonium nitrogen versus nitrate nitrogen.

Perhaps the biggest challenge for consistent suppressiveness is producing a very consistent compost. Some facilities will be more able to do this than others, in part based on the stability of feedstock source and composition over time. A homogeneous material is needed for use as a potting amendment, since variation from pot to pot could lead to production problems.

Scientists are testing various methods to evaluate the level of suppressiveness in a compost. General suppressiveness is correlated with the overall level of microbial activity. Tests such as dehydrogenase and fluorescein diacetate hydrolysis both indicate microbial activity. The latter test has been correlated with the suppression of damping off of cucumber from *Pythium* and is being used as a quality control procedure.

The nature of the carbon compounds in the compost will influence energy availability for microbes and thus the longevity of general suppressiveness. A high tech method called nuclear magnetic resonance (NMR) holds promise in evaluating this aspect. It could aid in identifying promising complementary feedstocks and in determining optimum maturity. For example, the nursery industry has found that composted pine bark at 20% volume of the potting mix provides excellent control of *Pythium* and *Phytophthora* related diseases, eliminating the need for fungicide drenches. NMR might help identify other suitable materials that could produce a similar effect.

Field experience. As implied above, the nursery industry is using disease-suppressive compost widely

and routinely. Based on the successes there, researchers are testing compost on a number of field crops for potential disease suppression. Disease-suppressive soils are a well-known phenomenon and are related to shifts in the microbial population. Researchers in California showed that soils on organic farms were more suppressive to two tomato diseases than soils from conventionally managed farms, due to differences in soil organic matter, microbial biomass, and nitrate level. So composts can clearly contribute to long- term changes such as this through carbon additions. But there appears to be short-term enhanced suppressiveness as well.

Reports from the field are starting to come in. A Florida researcher found that compost all but eliminated macrophomina, a fungal disease on beans, compared to the severe disease on the untreated plots. Composted solid waste (MSW) was applied at rates ranging from 36-72 tons per acre. Bean yields in the composted plots were nearly double that of the untreated. A crop of black-eyed peas followed the beans, and again yields doubled with compost. *Rhizoctonia* related disease was reduced by 80 percent with the high compost rates and 40 percent with the medium rates.

In another Florida experiment, composted sewage sludge (MSS) was applied to a tomato field initially to look at water conservation. However, the researcher noticed that early blight disease was significantly less with compost than without, as was bacterial leaf spot. He also observed a dramatic difference in rootknot nematode damage, with severe damage on the no compost plots versus no damage in the adjacent rows where compost had been applied. In another test, MSW compost was spread in bands across a tomato field that had large circular patches infected with *Rhizoctonia*. Where compost had been applied, plants were healthy even in the disease patches, compared to sick plants without compost right next to them.

Other applications include use of compost to combat alfalfa decline in Pennsylvania, *Phytophthora* root rot on soybeans and peppers in Ohio, and nematodes on potatoes in Idaho. In addition, several investigators are testing the use of compost teas as a foliar spray to combat leaf diseases.

In Ohio, Dr. Hoitink has patented a process to inoculate compost with beneficial microbes for biocontrol. A similar effort was conducted in Washington State under a grant from the Clean Washington Center, the former state agency dedicated to use of recycled products. Peninsulab, a private lab in Poulsbo, WA, conducted a comprehensive study (see References) of microbial inoculation of yard waste compost from Tacoma, WA.

Various inoculants and points of inoculation were tried. Bioassays were conducted for suppressiveness to *Rhizoctonia solani*, *Pythium ultimum*, and *Fusarium solani*. Many of the batches of compost were suppressive prior to inoculation, but inoculation did increase suppressiveness up to 80 percent more. Combinations of beneficial organisms gave better results. And the use of beneficial microbes isolated from the uninoculated compost gave as good or better results compared with the organisms from the lab. In one trial, the inoculated compost was suppressive to all three pathogens.

Due to logistical problems, the inoculation was not done at the ideal time and still the introduced organisms were able to establish and become effective. The study demonstrated the variability of suppressiveness with the uninoculated compost. Inoculation appeared to reduce this and provide a more consistent suppressive effect. The lab estimated the cost of inoculating the compost at about $1 per cubic meter.

Conclusion. The use of compost for enhancing biocontrol of plant diseases is established in the nursery industry and on the threshold of entry into field crop production. The greatest hurdle appears to be consistency of the suppressive effect, so risk to the grower can be reduced and the expenditures for current fungicidal control can be diverted into compost purchase. More needs to be known about the suppressive potential of composts for particular pathogens on specific crops and soils. The potential for inoculation of compost with selected microbes is great, given the various biotechnology tools available for selection of desirable organisms. Disease suppression can add significant value to compost and

open badly needed agricultural markets to the benefit of the growers, compost producers, and the environment.

References

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