DECOMPOSITION RATE OF VARIOUS ORGANIC MATERIALS IN SOIL

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INTRODUCTION

From an ecological viewpoint, it is important that organic materials decompose in soils. Elements such as nitrogen, phosphorus, and carbon are released in forms that can be used by new generations of living things (1,5). Also, some products of decomposition have value in improving structure of some soils by aggregation of fine particles into larger crumb-like units that facilitate water movement and exchange of oxygen, carbon dioxide, and other gases, between soil and the air above it (6,7).

From the viewpoint of growers of ornamentals, however, who rely on synthetic soils, or soil mixes, organic materials used in preparing these media should be relatively resistant to decomposition. If not, there can be several undesirable effects: shrinkage of mix volume, changes in soil porosity that affect aeration, rapid utilization of oxygen by microorganisms making anaerobic conditions possible especially after irrigation, and nutrient upsets by competition of microorganisms with plants. Thus, in soil mixes longevity of organic materials used in preparing them is important.

The usefulness of peat moss in mixes is due in large part to its resistance to decomposition. Other organic materials have been substituted for peat moss in mixes mainly because of economic factors. Redwood sawdust is a notable example. The cost of locally available organic waste products often makes them attractive as substitutes. In considering their suitability, one of the important factors, in addition to cost, is rate of decomposition.

Recently, the decomposition rates of a large number of organic materials have been measured in laboratory research at the University of California, Riverside. Some of these materials will be reported on here. Among these materials is a group of woods and barks from several types of trees grown in California. These forest byproducts were supplied by William Dost, Extension Forest Products Specialist, University of California, Berkeley.

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EXPERIMENTAL PROCEDURE

Decomposition rate was measured over a period of more than six months. A fertile top soil, Greenfield sandy loam, was used for the decomposition tests. It was obtained fresh from the field, air dried, sieved and placed in 100 g portions in 250 ml Erlenmeyer flasks. This soil had a pH of 7.0 to 7.2, an exchange capacity of 11 me/100 g, and an organic matter content of about 1.5 to 1.8 percent. The organic materials were mixed with the soil at concentrations of 0.1 to 0.5 per cent.

The soil was moistened to 60 percent of capacity (about 1/3 bar), connected to a closed system, and constantly aerated with CO_2-free, moist air at an incubation temperature of 22°C. The CO_2 evolved from the mixtures was collected in KOH solution and determined by titration after the addition of $BaCl_2$. The percentage of the applied carbon evolved as CO_2 was calculated after substracting the CO_2 from the unamended soil.

RESULTS AND DISCUSSIONS

The decomposition percentage of various organic materials during the 30-week incubation period are presented in the following table.

DECOMPOSITION OF ORGANIC MATERIALS IN GREENFIELD SANDY LOAM SOIL

Product	Percentage Decomposition After Weeks					
	1	6	12	18	25	30
German Peat Moss	< 1	3	6	13	18	18
Canadian Peat Moss	< 1	5	6	8	9	11
Redwood Sawdust	0	0	1	5	9	10
Redwood Shavings	< 1	< 2	4	10	17	19
Redwood Bark	< 1	2	8	22	35	38
White Fir Sawdust	< 1	4	8	16	24	28
White Fir Shavings	0	4	8	14	23	27
White Fir Bark	0	1	6	8	12	15
Douglas Fir Sawdust	< 1	3	8	21	31	35
Douglas Fir Shavings	< 1	3	9	14	20	25
Douglas Fir Bark	2	3	6	8	9	10
Ponderosa Pine Sawdust	< 1	4	16	23	27	29
Ponderosa Pine Shavings	2	7	14	24	33	37
Ponderosa Pine Bark	1	8	10	11	12	12
Sugar Pine Sawdust	< 1	4	7	12	14	15
Sugar Pine Shavings	1	5	10	13	16	17
Incense Cedar Shavings	< 1	< 1	1	2	3	4
Worm Manure (castings)	2	5	6	11	11	11
Rice Hulls	9	19	24	31	35	35
Oat Straw	21	55	73	75		

The slowest to decompose was incense cedar shavings (4 percent in 30 weeks); the fastest was oat straw (75 percent in 18 weeks). Organic materials that are high in polysaccharides and low in lignin decompose rapidly in soils. Those with higher lignin contents are degraded more slowly. It should be emphasized that the percentages listed in the preceding table are particle-size dependent; the smaller the particle size, the more rapid the decomposition. The sawdust and bark samples tested had particles 16-32 millimeters (1/16-1/8 inch). The other materials were ground to pass a 2-millimeter sieve.

Decomposition rates for Canadian and German peat moss were similar, between 10 and 20 percent. Redwood sawdust and worm castings fell into the same category. The barks, in general, also decomposed slowly. An exception was redwood bark. A greater surface area exposed by the unusual fibrous nature of the redwood bark may account for its more rapid breakdown (38 percent).

Sawdusts and shavings, as a group, (except for redwood sawdust) were intermediate, similar to the redwood bark. The range was 25-37 percent. Although rice hulls were also in this range, there was a notable difference during the first few weeks of decomposition. The rate for rice hulls during this early period was considerably higher, indicating that a fraction of the organic matter in rice hulls is readily decomposed. This suggests that composting of rice hulls prior to use in soil mixes would be a safety measure.

One should be aware that some fresh woods and barks contain resins, terpenes, tannins, and other substances which may be toxic to some plants. It may be, therefore, safer to compost these materials, too, for 30 days or longer before using them in potting media, especially if they are ground to small particle size, which accelerates their decomposition rate (2,3,4).

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HENRY ISHIDA, Moderator: We have some time now for questions for our panelists.

VOICE: Has perlite been used on a horizontal pad for evaporative cooling?

PAUL MOORE: I don't know of it being used specifically, but I know of some other aggregates that have. However, I think that aspen wool is one of the best materials for evaporative pads. It doesn't last as long as some of the mineral types but the water and film distribution and evaporation rates are among the tops of any materials that could be used. Aspen wool is cheap, and with a horizontal pad, you can use it for three years; the cost per year is really not great.

VOICE: If you use plastic to enclose greenhouses for heat conservation, does that interfere with air flow?

PAUL MOORE: It may if it is completely sealed. In our houses, we have tube doors at one end which we close up at night. Then I have exhaust fans, so during the daytime we do have air flow. There are shutters on the fans, which close it off, but the fan wall is completely enclosed otherwise with polyethylene film. There is an appreciable savings. In other words, you can conceive methods in which you can have your mechanical air flow, or if you use tube doors, for instance, conventional convection cooling will still work. The tubes in themselves are a dead air space when they are inflated. When they are collapsed, you have air flow during the day or any other time they are collapsed.

ESTHER LAWYER: We formerly used methyl bromide for fumigating our cold storage facilities. This year, on the recommendation of another nursery, we burned sulfur. Would Dr. McCain comment on this?

ART McCAIN: Sulfur burning couldn't approach what methyl bromide will do. I don't think that you can even compare them. Methyl bromide, as a fumigant, kills weed seeds, fungi, bacteria, and other things. It depends on what the problem is in your cold storage. It may be that methyl bromide was more than was really necessary. Another material you could use in lieu of methyl bromide is formaldehyde gas. All these are quite hazardous to use, however. It may be that you don't really need methyl bromide to fumigate your storage. This would be plant material for sale, or you may be concerned about *Botrytis*, and some other airborne types of spores. One of the things that is used to control *Botrytis* is thermal dusting with chlorophthalanil. This might suffice for airborne pathogens, although sulfur may also take care of some of these.

VOICE: Has there been any research done on microwave ovens for sterilizing?

ART McCAIN: Yes, there has. In fact, Ken Baker has done a lot of work on this; apparently it is primarily a heating phenomenon but it is an expensive way to heat soil. For a commercial venture you have to have quite a large machine. There is a publication describing this. I could probably get you a copy if you will let me have your name and address. It is perfectly feasible; primarily though you have to get the soil up to the required temperature for a certain length of time. The common practice now is to kill most plant pathogens at 140°F for 30 minutes. Microwaves can be used for heating soil but it is very expensive for heating large quantities.

VOICE: Has any work been done on sugar cane residue in soil mixes?

ROY BRANSON: *Sugar cane residue wasn't included in our* studies. I know of no work that has been done with it, but that *is no indication it hasn't been done. I expect it would decom*pose quite rapidly because of its high content of cellulose and other rapidly decomposable carbohydrates.

ART McCAIN: I can answer the sugar cane question. There is quite a bit in Hawaii. People like to use it but sugar cane bagasse is not a very satisfactory material; it breaks down rapidly and you get water drainage problems.

BRUCE BRIGGS: At the Eastern Plant Propagators' Meeting last winter, to conserve heat they took white poly and painted it with aluminum paint. They got quite a resistance. Do you have any data on the efficiency of this combination?

PAUL MOORE: No, but the aluminizing of the material gives reflective insulation against radiant heat loss. Much of the heat loss through polyethylene is through radiation. Our data on aluminized mylar should be applicable to aluminized polyethylene as well.

VOICE: In your soil mix, when you use peat moss, is there any difference between using real fine grades and the greenhouse grade?

ROY BRANSON: There is a difference. I didn't show you the data, but we used fine, medium, and coarse peat moss. Decomposition was somewhat more rapid with the finer material. This is true of any organic material. The data you saw were for coarse grade peat mosses.

ART McCAIN: Most peat that you buy has some plant pathogens in it. Despite the fact that the label states that it is disease-free and all that, it may contain plant pathogens. This work was done by some Pennsylvania plant pathologists; they found *Pythium* species and other fungi in it. If you have no problems, don't worry about it. But it is a source of infection and, with particularly valuable propagating material, you should consider treating the peat that you buy. It is scraped up off the ground, put in bales, and handled in various ways. There are several commercial potting mixes but I don't know if these have been tested. It is not easy to test; you just can't run it through the usual tests because the population of organisms is very low — but peat moss can be a source of contamination.

VOICE: Can you comment on the introduction of beneficial bacteria or other microorganisms in soil that has been sterilized?

ART McCAIN: This is a very interesting area and there is something to it. However, there are fraudulent products on the market that claim they contain beneficial organisms. You probably know the term mycorrhiza. This means "fungus root". Pines, for example, have mycorrhizal associations with higher fungi. Many plants have a beneficial association between certain fungi and their roots which increases the efficiency of nutrient uptake. In fact, citrus is quite dependent on a group of mycorrhizal fungi. When we treat soil, heat it, we kill the mycorrhizal fungi. If you plant clean stock, like I am preaching to you, you may have to add more fertilizer. The important thing is that mycorrhizae reduce the consumption of fertilizers and nutrients by effectively increasing the root surface. The mycorrhizal fungi grow out from the roots. It is the rule to have mycorrhizal infection in nature. Almost any plant you pull up will have it but you can't see it because they are microorganisms. They invade the roots but without any particular disruption.

How can we introduce mycorrhizal fungi into soil? There are interested companies. Abbott Laboratories is one; they are producing these fungi, but they are not commercialized yet. What they are going to cost, we don't know. There are publications in the literature; one I am familiar with is on poinsettias. You can usually demonstrate the value of this beneficial fungus, but it has to be done with a nutrient-deficient soil. From a practical standpoint today, it is much cheaper just to add more fertilizer. Fumigation kills the mycorrhizal fungi. There are beneficial bacteria also. We all know about nitrogen-fixing bacteria in nodules in legumes but there are some others; exactly what is going on we don't know. There are bacteria you can treat potatoes with — increasing growth and yields, possibly an antagonistic situation. There is definitely a microorganism antagonist of the crown gall bacteria. This thing works as a prevention. During propagation you may have a lot of trouble with crown gall, for instance, on euonymus. But if you treat the cuttings to introduce the antagonist, it will prevent crown gall development. The antagonistic bacteria is being commercialized and tested. If you read *California Agriculture*,[1] you saw an article in there about prevention of crown gall. We have tried this procedure on a number of ornamental plants; it doesn't always work. It seems there are certain strains of the crown gall bacterium and certain strains of the antagonistic bacterium.

But what I would like to caution you about is the phony products. Many are fraudulent, but there are good ones coming along. Look at the data. Have the data published been criticized, or are the claims based just on testimonials? If the promoters can't supply you with confirming literature from some reputable scientific journal, beware. Even in your own organization, someone may present a talk and show you the data; it is open to criticism, and that is good. But most of the promotion we see is supported only by testimonials. Some of the people are very sincere in promoting their products. They believe it, but they are ignorant.

VOICE: In large greenhouses, where you may have several hundred feet span, you may have cooling pads, fans, etc. You may get a heat buildup with 30°F difference from one end to the other. Have you ever heard of installing another set of pads in the center of the house?

PAUL MOORE: Usually the length from pad to fan should not exceed 120 feet; some do, but heat rise is a function of the distance between pad and fan. It may not work on larger greenhouses but the pressurized system, where you are introducing cool air through tubes, eliminates this high differential. We can keep the differential in our house to within two degrees.

[1] University of California, Division of Agricultural Sciences monthly publication, Berkeley, Calif.