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SPECIAL: PLANT INJURY CAUSED BY SAWDUSTS AND BARKS?

Reports of Bark Enhancing Plant Growth

Microorganisms antagonistic to plant pathogens and chemicals with properties similar to fungicides are produced in bark composts and contribute to the absence of root disease on plants grown in the composted bark. Controlled laboratory tests have shown that Phytophthora root rot is suppressed in composted hardwood bark. Another study showed that control of Fusarium in compost was equal to control in sterilized peat after two drenches with Benlate. (Hoitink and Poole, 1977).

Certain chemical compounds are released from fresh Douglas fir bark that when present in high concentrations may initially inhibit seed germination and delay early plant growth; however, low concentrations of the water extract of the bark material and/or adaptation of the plant material resulted in final growth far greater than that of the control. Also, damage from soil-borne pathogens was greatly reduced in the bark-amended plots. (Burgon, 1964).

Reports of Toxic Substances in Barks and Sawdusts

--Volatile Monoterpenes Identified as Toxic Substance in Douglas-fir Bark; Monoterpene Concentration Reduced to Stimulatory Levels by Composting. (Aaron, 1976)

Different species of fresh bark were assayed for possible phytotoxic effects. Rooted cuttings of two ornamentals (*Tradescantia* and *Coleus*) and tomato seedlings were transplanted into pots containing bark of each of the major coniferous species. Damage to the foliage of tomatoes growing in Norway spruce, Sitka spruce and Douglas-fir barks was soon observed (no symptoms of toxicity were exhibited by the two ornamentals). Similar toxicity of fresh spruce and Douglas-fir barks to development of mushrooms apparently resulted from high concentrations of monoterpenes emanating phytotoxic volatile oils (Table 5).

TABLE 5. VOLATILE OIL AND MONOTERPENE CONTENTS, WITH YIELDS OF MUSHROOMS.

Species	Volatile Oi (% dry wt.)	Monoterpene (% dry wt.)	Yield of Mushrooms kg/m^2 at Lee Valley EHS
Scots pine	0.1	0.02	3.36
Corsican pine	0.05	0.01	5.11
European larch	0.15	0.06	1.41
Japanese larch	0.06	0.03	1.51
Norway spruce	0.38	0.30	0.68
Sitka spruce	0.38	0.30	2.00
Douglas-fir	0.16	0.10	0.73

The effect of monoterpenes in the vapor phase on higher plants has not been studied in detail, but available information indicates that while high concentrations are generally toxic or inhibitory, lower concentrations of a number of the monoterpenes can stimulate seed germination. Alpha-pinene (the terpene most commonly occurring in bark) at concentrations lower than 220 ppm stimulates germination of radish seed, but concentrations of 220 ppm were found to reduce germination by 50 percent.

Additional experiments showed that the low terpene concentrations in heat-treated bark did not inhibit the development of the fungus mycelium (mushroom culture) and there were indications that they stimulated growth.

--Reducing the Monoterpene Content of Douglas-fir Bark: When bark is freshly pulverised and stacked in large heaps, activity by thermophylic bacteria causes the pie to heat up to temperatures exceeding 50° C; this in turn appears to cause harmful volatiles to be destroyed or driven off, or to be reduced to such a low level that they have a stimulatory effect on growth. Elevating the temperature to levels exceeding 50°C for a period of six weeks has three beneficial effects:

1. It reduces the monoterpene content by 75 percent to levels which are no longer phytotoxic.
2. It elevates the pH from the rather acidic level of about 4.5 to the more acceptable level of 5.5.
3. It virtually pasteurizes the bark in that most common pathogens are incapable of surviving exposure to temperatures above 50°C for weeks at a time and many of them are susceptible to terpene poisoning. (Aaron, 1976)

--Composting Bark Media Will Eliminate Toxicity and Control Pathogens (Hoitink and Poole, 1977)

Contrary to a commonly held opinion, some hardwood and softwood barks contain substances that are toxic to various plants. These chemicals in fresh bark are most toxic to germinating seeds and seedlings. Research at the Ohio Agricultural Research and Development Center, in Norway, and at the University of Illinois has shown that these inhibitors can be destroyed by composting.Composting (addition of nitrogen) and frequent turning of bark stacks (once every two weeks) eradicates both inhibitors and plant pathogens. Hardwood bark needs to be composted (addition of 2-3 lbs nitrogen per cubic yard fresh bark) for 10-12 weeks; softwood bark such as pine can be composted (addition of one lb nitrogen per cubic yard fresh bark) in stacks (15 ft. wide x 8 ft. high) for six weeks. During composting, microorganisms involved in breakdown of the particles generate heat: The temperature of the compost stacks reaches 120-

160°F for a period of 6-12 weeks, depending upon the type of bark being composted. It has been found that plant pathogens survive in bark stacks to which nitrogen has not been added and in stacks which have not been turned: Temperatures in large areas of such stacks seldom exceed 80° F; pathogens surviving in these low temperature areas may cause problems during the production period.

> (Douglas-fir and other softwoods have slower decomposition rates and therefore lower nitrogen demands than do hardwood barks. Also, barks decompose much more slowly than their respective wood sawdusts. With both barks and sawdusts, the finer the particle size, the greater the decomposition rate and nitrogen requirement. Fresh Douglas-fir sawdusts require about 3 lbs. of ammonium nitrate per cubic yard; this rate of ammonium nitrate addition is much too high to allow immediate use of the freshly treated sawdust. It is suggested that the nitrogen be mixed with the moist sawdust (or bark) and then the mixture be stored with frequent turning for a period of 30 days before it is used for potting or mulching. During this period the ammonium nitrate will have been converted into organic nitrogen, the salinity will have declined to a safe level, and any toxicity problems will have been eliminated. Bunt, 1976)

--Leaching and/or Composting to Eliminate Toxicity of Fresh Redwood and Cedar Sawdusts. Fresh, unleached redwood and cedar sawdusts have caused root damage and leaf discoloration of sensitive seedlings and rooted cuttings. Bedding plants have shown the greatest sensitivity to toxic components of raw sawdust. The toxic component in the wood by-products is readily reduced to harmless levels by heavy watering (leaching) and/or preliminary decomposition as occurs when mixed with soil or compost. Injury was increased when the fresh sawdust was steam sterilized. However, in most uses, such as landscape mulching, cut flower growing, pot plant and container growing, and field nursery growing, there appears to be no hazard if aged, leached and/or composted bark-sawdust is used. (Johnson, 1968)

--Leached Western redcedar tow is an excellent packing material for bare root trees and shrubs. It is inexpensive, retains moisture well, and retards fungus growth. Unleached cedar tow used for the same purpose is more questionable for there is some evidence that damage can occur to plant growth due to detrimental effects on several plant enzymes.

Fortunately, the harmful extractives in Western redcedar tow are easily removed by leaching with plenty of water. A normal winter's rainfall suffices to remove these extractives. But, be careful with the extractives that run out of the piled cedar tow for they are very toxic to fish. A fish kill attributable to Western redcedar extracts has recently been reported. The dead fish were of a species usually tolerant of mild amounts of pollution. It is reported that concentrations of 10 parts per million of these extractives will kill pollution tolerant fish in about 10 hours, while at concentrations of 100 parts per million, total fish kill is realized in less than 10 minutes.
If the leach water from piles of cedar tow is allowed to seep into the soil, the extractives are soon detoxified by combination of metal ions in the soil. But this same affinity for metals causes the extractives to be very corrosive to metals, especially iron, copper, and brass.

The moral of this story can be summarized in two don'ts and one do: 1. do use leached cedar tow for packing plants. It is inexpensive, easy to handle, and has some fungicidal properties. 2. don't let the runoff from your piles of leaching Western redcedar tow run directly into streams.
3. don't let expensive machinery come into contact with the leach water.

(Scroggins, 1971)

--Bark or Sawdust From Nonaerated Areas in the Stack will Cause Plant Injury (Bollen & Lu, 1966).
For mulching and other horticultural uses, dark colored, more-or-less-rotted sawdust is often preferable to the fresh product because of better appearance and somewhat lesser nitrogen demand. In such large piles as are frequent with commercial storage, moist sawdust becomes so compacted deep in the piles that aeration is excluded and anaerobic fermentation results. End products, including volatile organic acids, accumulate in this absence of free oxygen and excessive heating, often causing charring and even spontaneous combustion. Even if not charred, a dark brown sawdust resulting from the fermentation is strongly acidic and has a pungent odor. If used for mulching purposes, it will kill many plants, not only seedlings, but shrubs and young trees. Some of the fumes are volatile acids and these will cause at least a yellowing of leaves and defoliation even if below-ground parts are not injured. In some cases, the plants eventually recover. This is generally true of lawn grass. Severity of injury is dependent upon rate of application and weather conditions. Leaching by rain or irrigation accelerates root damage, while warm air temperature hastens evolution of fumes and results in rapid injury to leaves and tender plants.

Sour sawdust should never be used for mulches, potting mixes, or soil conditioners. The pungent, penetrating odor of any dark sawdust should provide sufficient warning against its use. To counteract the acidity, whether the sawdust is black or brown, requires from 250 to 300 lbs of limestone per ton. On the other hand, fresh sawdust requires less than 10 lbs per ton; well-rotted sawdust, in which the rotting took place in the presence of air, may require 50 to 70 lbs limestone to neutralize some acidity that develops even with more or less free oxygen.

--Salt From Bark of Salt-Water-Floated Douglas fir Logs May Injure Plants (Bollen, 1971).
Percent of NaCl found in bark from saltwater-floated Douglas-fir logs ranged from 0.75 to 1.94. This salt is readily leached by rainfall or irrigation. Use of such bark for mulching or soil conditioning at usual rates of about 40 tons per acre could result in injury to salt-sensitive plants if leaching was sufficient only to concentrate the salt in the upper root zone. Salty bark ground to nominal ¼ to ½ inch size commonly used for horticultural purposes offers less hazard as a mulch than as an incorporation. Chunk sizes used for walkways and decorative purposes would probably have no toxic effects. Salt leached from salty bark mulches or incorporations would have no appreciable effect on soil microbes and their essential activities

Conclusions?
Barks and sawdusts can be safely used as mulching materials and components of potting media provided that they are first composted with nitrogen to eliminate toxic substances, control plant pathogens that might have been present in the bark, and supply the nitrogen requirement of microorganisms involved in decomposition of the material. Once the bark or sawdust has gone through the composting process, the principles that apply to the use of sand, peat, soil or other materials as mulches or media components are equally applicable to the use of the composted bark. The physical characteristics should be evaluated and adjusted to meet your requirements, i.e. the particle size will affect water movement and the supply of air to the plant root system. Chemical characteristics (i.e. salinity, presence of toxic substances, pH, nitrogen demands, etc.,) should be evaluated prior to use and if factors that would cause plant injury cannot be corrected, the medium should not be used.

There is no ONE right potting medium that will be satisfactory to all growers for growing all plants in all containers. Designing a plant production system (selecting type of plant material to be grown, selecting the potting medium, selecting the container, selecting the irrigation system and deciding upon the frequency and duration of each irrigation, selecting the type of fertilizer and the method, time and rate of application, and adjusting for stage of plant growth and seasonal affects) is similar to designing clocks--not all clocks will have the same size or number of gears, but if the proper selection and installation of gears in each individual clock (system) is made, then each of the diverse clocks will keep accurate time. The same is true of the plant production systems--though diverse in choice, if individual components are properly integrated into a whole system, good quality plants should be produced. For example, a container filled with only Douglas-fir bark particles will drain quickly after irrigation and will not retain as much available water as will some other media: It would be an excellent medium to use for epiphytic plants or in certain cases where very good drainage is required (i.e. outdoor container production during the winter in areas having high rainfall) or where automated irrigation would allow frequent application and replenishment of the limited water supply in the medium. It would be a poor choice of media for production of plants having a high water requirement growing in a dry, high-light environment, and irrigated manually with a hand-held hose.

A medium composed entirely of Douglas fir bark has been successfully used by Dr. Dave Adams (Multnomah County Extension Agent-Ornamental Horticulture) and Dr. Bob Ticknor (North Willamette Experiment Station, OSU): To one cubic yard of finely ground, aged Douglas fir bark (particle size less than ¼ ") add:
1 lb ammonium nitrate (if using slow release form of nitrogen, may use up to 2.5 lbs actual nitrogen). Supplemental nitrogen feedings will be required during the crop production period.
1 lb potassium sulfate.
2-3 lbs single superphosphate.
2-3 lbs agricultural grade lime (coarse ground).*
2-3 lbs dolomite* (#10 or #7 grind).
2-3 lbs gypsum.
0.5 lb iron sulfate.
*NOTE: If growing rhododendrons or similar crop with acidic pH preference, the above rates of lime and dolomite would be cut in half.

Although both aged and composted bark are used successfully by some nurserymen, specific guidelines are lacking. Physical properties of the composted bark, fertilizer amendments (particularly nitrogen), and the overall economics of bark as compared to peat need further investigation.

To assist you in making choices compatible with your entire plant production system, the following references are suggested: Bunt, 1976; Green and Adams, 1977; Green, Spomer, and Gessert, 1976; Johnson, 1968.

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