# INACTIVATION OF BIOCIDES IN TREE NURSERY SOILS

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A fable of Aesop tells about a man asking a. gardener a. pertinent question 'Why are wild plants strong an.d thriving, whereas cultivated plants are spindly and wilted? I n Aesop's day the reason. most likely was a. depletion of cultivated soils in fertility; in. our time similar results are often due to unskilled use of agricultural chemicals.

The contemporary demands of economics have "married" - for better and for worse - most nurserymen to 'the array of eradicants. The union with these toxic chemicals involves benefits as well as obligations; the most. important of the latter is to counteract the postoperative effects of the biocidic compounds.; some of which. possess a. very long-lasting destructive or deteriorating potential,. Unless the residual biocides are inactivated by physical, chemical, and biological amendments, the nursery is likely to produce inferior planting stock of either depressed or unduly stimulated unbalanced growth (Iyer, et , 1969),

Although. inactivation of eradicants is a recent development, experiences of the past decade have shown that: some amendments permit a. reasonably harmonious coexistence of biocides with essential soil components: roots., beneficial microbes, and available nutrients. The following descriptions outline the promising ameliorative measures.

Forest litter. Any remains of healthy trees and shrubs which undergo decomposition at. the soil surface, be they called leafmold, duff, or raw humus, are "a product and the source of life," With all our knowledge of chemistry and with our vast fertilizer industry, we do not possess compounds which. are equal to forest litter in. their capacity to biodegrade eradicants and to reclaim soil fertility (Mader, 1960). The biocide-inactivating effect of litter or leafmold is due to its multitude and diversity of microbes endowed with an enormous destructive as well as creative capacities,. The very fact that the world is not buried under the debris of tree litter testifies to the ability

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of these organisms to break down the raw organic remains with their decay-resistant lignin and benzene ring compounds. The latter, incidentally, are the essential constituents of many biocides.

No matter whether leafmold is applied broadcast, in the form of a suspension, or as an admixture to peat or fermented composts, it fulfills its highly beneficial function by injecting detoxifying organisms and growth promoting or growth regulating substances (Wilde, 1958, 1971), Leafmold is not readily procurable and its rate of application is limited by financial considerations. Nevertheless, an. addition of mere 5 cubic yards per acre of forest litter in either form of application constitutes a.n important amelioration of biocide-treated soils,

Peat, The relatively inert swamp deposits of plant exoskeletons ameliorate nursery soils via their physico-chemical attributes. A safe acidification, enrichment in nitrogen, stabilization of soluble nutrients, and even control of parasitic fungi and root-knot nematodes are among the benefits afforded by application of peat of a suitable composition. Most important, peat with its large external and intercellular adsorbing surfaces and high exchange capacity exerts a far-reaching effect on eradicants by adsorbing and corn piexing their toxic ingredients. In addition, peat is polymeric in structure and its large molecules may undergo esterification and form with carboxylic biocides the slowly-acting eradicant-polymer compounds (Allan, et al. , 1971) .

Sawdust. This is another inert material which upon activation acquires very high biodegrading and soil-ameliorating properties (Matsui, 1958) . The most economic use of sawdust is promised by its application as 1-inch topdressing on fallowed nursery soils and by treatment of the same with anhydrous ammonia at a rate of 200 pounds per acre. The ammonia is applied from a pressure tank with a knifelike distribution device. Shortly after application, the beds are sprayed with 200 to 300 gallons per acre of 4% by volume solution of phosphoric acid, if needed, the acid may be supplemented with potassium sulfate, micronutrient chelates, and other fertilizing ingredients. Spreading a small amount of inoculating materials, such as Coprinus-fermented sawdust, leafmold, a.nd horse manure, is likely to be beneficial. The treated sawdust then is rototilled into the soil to a depth of about 8 inches,

Animal manures. Horse, cow, sheep, and any other animal manures are an age-proven fertilizer for farm lands. Manures incorporate all essential nutrients and possess several other soil improving attributes, Yet animal manures cannot be unreservedly recommended for nursery soils, Their use is never free from the danger of soil and stock infestation with damping-off fungi, parasitic nematodes, and persistent weeds Moreover, when abundant rainfall or irrigation is followed by hot weather, a heavy application of manure may kill sprouting seedlings by excessive release of ammonia. Nevertheless, in cases of dire necessity imposed by accumulation of biocidic residues, application of animal manures may be a far lesser evil than a critical deficiency of biodegrading organic matter. Enrichment of manures with peat or leafmold, or spraying manure with a humate suspension, is likely to yield satisfactory results with regard to both soil fertility and inactivation of eradicants.

Herbaceous crops. A transitional culture of herbaceous plants serves as green manure, catch crop, or cover crop. As far as nursery soils are concerned, the term "green manure" is a misnomer, for the manuring or fertilizing effect of either leguminous or non-leguminous crops is utterly insignificant. On the other hand, herbaceous plants in their function as catch or cover crops provide a very valuable service by minimizing the leaching of nutrients and protecting soils from erosion.

The introduction of potent biocides has bestowed upon herbaceous plants an additional important role of decontamination crops. Herbaceous plants contribute to detoxification of biocide-treated soils by the uptake of certain compounds, particularly those containing nitrogen, and by supplying energy material for organisms employed in breakdown of eradicants. The suitability of different herbs to serve as extracting and biodegrading agents depends on their soil requirements and their tolerance of applied chemicals. In general, plants with abundant root systems offer best promise as inactivators of eradicants.

Artificial irrigation. Water in contact. with soil can be either immensely beneficial or highly harmful. In addition to being "the life blood of crops," water with its dissolving, diluting, hydrolytic, and leaching effects is a powerful detoxifying agent. Some soils treated with biocides, including triazine, were freed of their harmful constituents in 2 months under conditions of high moisture as compared to 12 months in a dry environment.

The water-enforced detoxification, is most effective when a prolonged saturation of a fallow soil is followed by the gravitational discharge under the influence of heavy rain or artificial irrigation. Such a practice, however, should never be permitted on soils supporting nursery stock. In fact, an excessive use of water on fine textured soils or soils underlain by porous, gravelly substrata may be as injurious to nursery stock as any potent biocide, An excess of soil water may impart to the trees an extreme degree of succulence, promote incidence of fungal diseases, and depress the growth or even, kill the stock (Iyer, et al., 1972).

Activated charcoal. Steam heated charcoal with its high adsorbing capacity proved to be effective in moderating the harmful effects of eradicants , especially triazines, The rate of application of activated carbon, such as Carbol and Norte, varies from 50 to nearly 1,000 pounds per acre,

In the production of farm crops, the uniform distribution and incorporation of charcoal with the soil present considerable difficulties, in nursery practice, however, the inconvenient broadcast application of dust can be avoided by an addition of measured volumes of charcoal to peat or compost in the process of shredding organic remains, The use of charcoal can appreciably reduce the required amount of peat or other natural adsorbents , Reinforcement of charcoal or peat with ion-exchange resins or vermiculite has been suggested as another antidote to eliminate an excess of biocides from the soil.

Sugars. Several observations indicate that reinforcement of fertilizers or fertilizer solutions with crude sugars at rates of 100 to 200 pounds per acre moderates the toxicity of residual eradicants. Sugars provide readily assimilable energy material for a multitude of microorganisms and may play a significant part in biodegradation of biocidic residues, but thus far lime is the only "sweetening" additive that has found its way into forest nursery soils,

Allyl alcohol. This herbicide encourages multiplication of Trichoderma fungi which break down organic compounds and enrich the soil in available phosphorus (Yatazawa, et al,, 1960), Therefore, in nurseries using eradicants which immobilize the mycotrophic mechanism of trees and their ability to assimilate phosphorus, it is advisable to interpose allyl alcohol for the pre-emergence eradication of weeds. The common rate of application of allyl alcohol is 50 gallons per acre, Tree seed can be planted a week or ten days after the treatment,

Ally' alcohol prior to its volatilization is an extremely toxic compound and the maximum reasonably safe inter-row application to promote the availability of phosphorus is 5 gallons per acre in 1,200 gallons of water.

Aluminum sulfate, This comparatively harmless acidifying chemical inhibits the activity of nitrogen-oxidizing bacteria. and thus reduces the release of available nitrogen. In turn, it retards the foliar growth of tree seedlings and reduces their top-root ratio, thereby correcting the growth stimulating effect of some eradicants (Iyer, 1971), The application of aluminum sulfate should be made shortly after the pre-seeding eradication treatment. Depending on the texture and pH value of the **soil,** the desired depression of top growth of stock can be achieved by application of the chemical varying from 400 to 1,200 pounds per acre. The salt must be incorporated with the soil, preferably by rototilling , to a depth of about 8 inches . The most effective results , especially on coarse sandy **soils ,** are obtained by simultaneous application of 30 to 60 cubic yards of acid peat derived from Sphagnum bog moss (Borkenhagen and Iyer, 1972)

The major part in the immobilization of the foliar growth is played by aluminum rather than hydrogen ions . The aluminum , however, comprises only 8% of the compound and its tendency to enter the exchange colloids at the very surface of the soil greatly diminishes the effectiveness of liquid treatments

Organic growth retardants. Excessive development of tree crowns and high top-root ratio of the stock, inflicted by some biocides , may be controlled by several organic compounds which deserve trials under local conditions Maleic hydrazide and its potassium salt have a low order to toxicity but possess an ability to block cell division. These chemicals have been used successfully to protect citrus seedlings against frost damage Phosphon, a phosphonium chloride, is used to control the height growth of rhododendrons , azaleas , and other ornamentals Some organic compounds, such as Cycocel, chlormequat , and Alar or B-Nine , a hydrazide of succinic acid, induce the growth retarding effect when applied at certain concentrations . The nitrification inhibitors , such as potassium azide and N-serve or chloromethyl pyridine, may be of significance in reducin.g top growth of exacting deciduous trees requiring nitrogen in the form of nitrates.

Commercial fertilizers . Contrary to expectations , the distorted development of biocide-stimulated nursery stock can in some cases be corrected by the use of fertilizers . Their application induces additional growth stimulation, but adjusts the morphological and physiological balance of trees A significant improvement in the top-root ratio, specific gravity of stems , and adsorbing capacity of roots of DMTT-treated seedlings of red pine w as achieved by a heavy application of 2-6-15 fertilizer, composed of mono-ammonium phosphate and potassium sulfate (Iyer, 1970) .

The seeming paradox notwithstanding, the use of fertilizers often must comprise an. integral part of biocidic treatments .

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