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RECOVERY OF GROWTH POTENTIAL OF NURSERY STOCK PRODUCED ON BIOCIDE-TREATED SOILS[1]

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SELOSTE:

BIOSIIDEILLÄ KÄSITELLYSSÄ TAIMITARHAMAASSA KASVANEIDEN TAIMIEN KASVUPOTENTIAALIN PALAUTTAMISESTA

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Certain biocides used in production of tree nursery stock exterminate undesirable organisms but cause an abnormal growth stimulation of plants. The reforestation material has decreased survival potential because of high degree of succulence, top:root and height:diameter ratios, and low specific gravity and root surface area. Some fumigants impede mycorrhizae development and arrest phosphorus uptake. Recovery of growth potential was achieved by aluminum sulfate and/or fermented compost inoculated with mycorrhiza-forming fungi.

Contemporary production of tree planting stock often depends upon the delicate balance between the death inflicting and life giving amendments.

In the middle of the 1940's, forest nursery practice accepted the use of highly potent organic eradicants to annihilate undesirable organisms (WILDE, 1958a). Some of these chemicals induce abnormal growth stimulation of the crowns of nursery plants, but depress the development of their root systems. In consequence, reforestation material acquires characteristics which decrease its survival potential: ability to withstand drought, frost, snow press, and attacks by parasites. The negative features imparted to plants by biocides are extreme degree of succulence, low specific gravity, abnormally high top:root ratio, greatly reduced adsorbing surface of roots, and impeded development of mycorrhizae (VOIGT, 1955; PERSIDSKY and WILDE, 1955; WILDE and PERSIDSKY, 1956). The latter effect in some instances precludes the uptake of phosphorus even from soils which are abundantly supplied with this element in available form (HENDERSON and STONE, 1967; LIPAS,[3] 1968).

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[3] Lipas, E. J. 1968. Dynamics of Nutrient Elements in Soils of Wisconsin Forest Nurseries. M. S. Thesis, Univ. of Wisconsin Library, Madison, Wis.

TABLE 1. Morpho-anatomical and physiological properties of 3-year-old seedlings of white spruce *(Picea glauca)* raised on untreated nursery beds and beds treated with Mylone at a rate of 580 lbs 50-D and 350 lbs 85-W per acre. Results per average seedling

Taulukko 1. Mylonilla käsitellyllä (660 kg 50-D ja 400 kg 85-W/ha) ja käsittelemättömällä alustalla kasvaneiden kolmivuotisten Picea glauca-taimien morfologis-anatomiset ja fysiologiset ominaisuudet. Keskimääräisen taimen arvoja.

Stock properties	Seedlings raised on control beds	Seedlings raised on Mylone treated beds
Height, cm.	21.3	36.0
Diameter, mm.	2.80	3.60
Height: diameter ratio	7.60	10.0
Oven-dry weight, g.	3.80	3.84
Oven-dry weight of crowns, g.	3.01	3.33
Oven-dry weight of roots, g.	0.79	0.51
Top: root ratio	3.80	6.50
Root titration, ml 0.3 N NaOH	0.23	0.17
Specific gravity of stems	0.47	0.39
Mycorrhizal short roots	abundant	sparse
Composition of Foliage, per plant		
Organo-solubles, %	35.5	30.6
N, mg.	29.8	42.6
P, mg.	3.3	4.3
K, mg.	10.8	12.9
Ca, mg.	14.4	23.9
Mg, mg.	2.1	4.7

TABLE 2. Morpho-anatomical properties of 3-year-old seedlings of red pine *(Pinus resinosa)* raised on untreated nursery beds and beds treated with Vapam at a rate of 60 lbs per acre. Results per average seedling

Taulukko 2. Vapamilla käsitellyllä (68 kg/ha) alustalla kasvaneiden kolmivuotisten Pinus resinosa-taimien morfologis-anatomiset ominaisuudet.

Stock properties	Seedlings raised on control beds	Seedlings raised on Vapam treated beds
Height, cm.	12.3	34.3
Diameter, mm.	4.10	6.20
Height: diameter ratio	3.00	5.50
Oven-dry weight, g.	7.69	9.57
Oven-dry weight of crowns, g.	5.77	8.61
Oven-dry weight of roots, g.	1.92	0.96
Top: root ratio	3.00	8.90
Root titration, ml 0.3 N NaOH	1.03	0.26
Specific gravity of stems	0.35	0.32

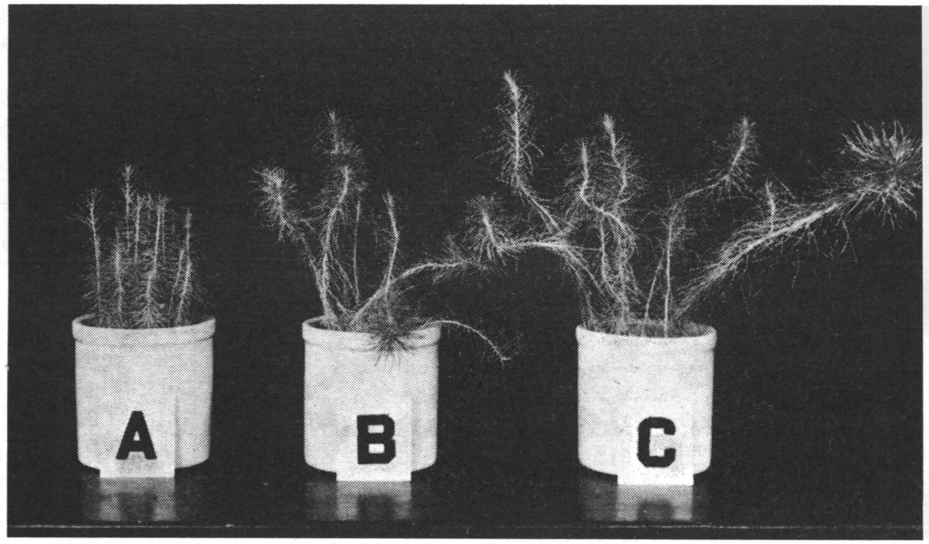

Fig. 1. Example of abnormal biocide-induced growth stimulation of seedlings of 1-year-old Monterey pine *(Pinus radiata)* raised in: (A) sandy nursery soil (Plainfield sand); (B) nursery soil treated with Vapam (60 lbs per acre); (C) nursery soil treated with Vapam (120 lbs per acre).

Kuva 1. Esimerkki epänormaalista biosiidilla aikaansaadusta kasvustimulaatiosta yksivuotisissa Pinus radiata-taimissa hiekkaisessa taimitarhamaassa (A) sekä pienemmällä (B=68 kg/ha) ja suuremmalla (C=136 kg/ha) Vapam-määrällä käsitellyssä taimitarhamaassa.

Examples of the adverse effects of eradicants on the external and internal makeup of white spruce, red pine, and Monterey pine are given in Tables 1 and 2, and Fig. 1 (Iyer, 1964; Iyer and Wilde, 1965). Fig. 2 illustrates the inhibition of root growth by volatile substances released from biocide-treated soil (Persidsky and Wilde, 1954; Iyer[1] 1968).

Improvement of nursery stock quality produced on some biocide-treated soils requires a reduction in the size and succulence of tree crowns, an increase in the adsorbing surface of root systems, and preservation or reintroduction of viable mycorrhiza-forming and extra-matrical fungal mycelia essential for the uptake of nutrients.

There are several approaches toward the solution of the complicated problem of amelioration of nursery stock quality, but one which gave most promising results in our trials was the use of aluminum sulfate, or aluminum sulfate in combination with fermented sawdust compost (Wilde, 1958b).

Aluminum sulfate $Al_2(SO_4)_3 \cdot 18H_2O$ causes acidification of the soil which retards the release of available nitrogen and decreases foliar growth of nursery stock. From the practical aspect, aluminum sulfate possesses two important

[1] Iyer, J. G. 1968. Biocides: Their Effects on the Growth of Nursery Stock under Different Methods of Soil Management. Ph.D. Thesis, Univ. of Wisconsin Library, Madison, Wis.

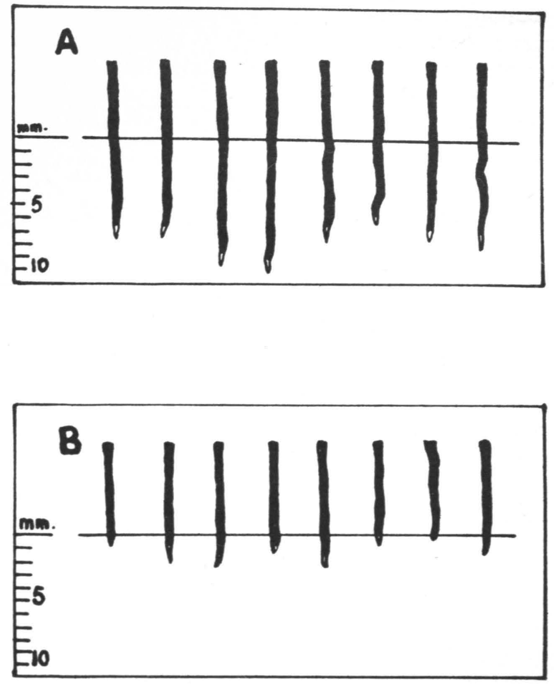

Fig 2. Effect of volatile organic substances (methyl-isothiocyanate) released from soils on the growth of excised roots of blue lupine *(Lupinus occidentalis)* after 96 hours of incubation at 23° C. (A) Untreated sandy nursery soil- -average root growth 8.*1* ± 0.*35* mm.; (B) Similar soil treated with Vapam at a rate of 60 lbs per acre- -average root growth 2.*0* ± 0.*70* mm. (After Iyer, 1968).

Kuva 2. Maasta haihtuvien orgaanisten aineiden vaikutus lupiinin leikattuihin juuriin 96 tunnin inkubatioajan jälkeen 23° C:ssä. (A) Käsittelemätön hiekkainen taimitarhamaa — keskimääräinen juurenkasvu 8.1 ± 0.35 mm. (B) Samanlainen Vapamilla käsitelty maa (68 kg/ha) — keskimääräinen juurenkasvu 2.0 ± 0.70 mm (Iyerin (1968) mukaan).

advantages. It is readily soluble (87 g. per 100 ml.) and permits application in solution either by hand, by power sprayer, or by an overhead irrigation system. As a rule, an effective reduction of the foliar growth of plants is achieved at a soil reaction slightly below pH 4.8. In turn, the amount of salt needed to produce this effect on different soils can be determined by treatment of small soil samples and by measuring their pH values. In coarse textured soils, especially those low in organic matter, efficiency of aluminum sulfate treatments depends on an addition to the soil of raw peat of high exchange capacity, at a rate from 40 to 80 cubic yards per acre.

On some soils, application of aluminum sulfate alone can produce well-balanced planting stock of satisfactory growth potential. This is true particularly of soils not subjected to repeated application of fumigants and which did not suffer deterioration of their microbiotic mechanism. If the opposite is true, recovery of soil productive capacity can be achieved by application of fermented

TABLE 3. Morpho-anatomical properties of 1-year-old seedlings of Monterey pine *(Pinus radiata)* raised on nursery beds with combinations of Mylone (800 lbs of 50-D and 600 lbs of 85-W per acre), fermented sawdust compost (40 cu. yards per acre) and aluminum sulfate (800 lbs per acre). Results per average seedling

Taulukko 3. Mylonin (900 kg 50-D ja 680 kg 85-W/ha), käyteaineella käsitellyn sahajauhokompostin (48 m³/ha) ja aluminiumsulfaatin (900 kg/ha) erilaisilla sekoituksilla käsitellyllä taimitarhamaalla kasvatettujen yksivuotisten Pinus radiata-taimien morfologis-anatomiset ominaisuudet. Keskimääräisen taimen arvoja.

Stock properties	Seedlings raised on beds treated with,			
	Mylone	Mylone and $Al_2(SO_4)_3$	Mylone and compost	Mylone, $Al_2(SO_4)_3$ and compost
Height, cm.	22.0	11.9	27.3	19.0
Diameter, mm.	1.8	1.4	2.4	1.8
Height: diameter ratio	12.2	8.5	11.3	10.5
Oven-dry weight, g.	0.92	0.50	1.7	0.79
Top: root ratio	3.7	1.4	3.0	2.7
Root titration, ml 0.3 N NaOH	0.13	0.10	0.78	0.49

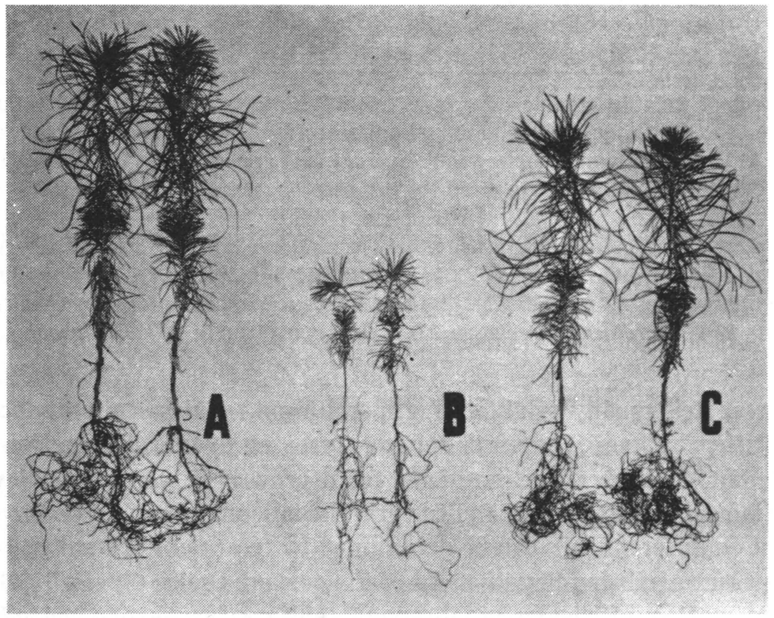

Fig. 3. Effect of aluminum sulfate and fermented sawdust compost on the morphological features of 1-year-old seedlings of Monterey pine *(Pinus radiata)*. Seedlings raised in sandy soil treated with: (A) Mylone (1,400 lbs per acre); (B) Mylone and aluminum sulfate (800 lbs per acre); (C) Mylone, aluminum sulfate and fermented sawdust compost (40 cu. yards per acre).

Kuva 3. Aluminiumsulfaatin ja käyteaineita sisältävän sahajauhokompostin vaikutus yksivuotisten Pinus radiata-taimien morfologisiin piirteisiin. Taimet kasvatettiin hiekkaisessa maassa, jota käsiteltiin (A) Mylonilla (1600 kg/ha), (B) Mylonilla ja aluminiumsulfaatilla (900 kg/ha) ja (C) Mylonilla, aluminiumsulfaatilla ja käyteaineita sisältävällä sahajauhokompostilla (48 m³/ha).

sawdust compost sprayed with humus suspensions containing symbiotic fungi and by subsequent adjustment of soil reaction with aluminum sulfate solution.

It appears that mycorrhiza-forming fungi and extra-matrical symbionts incorporated into organic matter preserve their virulence and ability to re-establish the mycotrophic uptake of nutrients, particularly phosphorus. However, the anhydrous ammonia and phosphoric acid used in the preparation of sawdust compost produce ammonium phosphate which is likely to have greater availability than soil phosphorus extractible with sulfuric or hydrofluoric acid. This may also account for an increased uptake of phosphorus and, in turn, augmented root development, improvement of morphological balance, and consolidation of internal structures of trees.

Table 3 includes the results of analyses of 1-year-old Monterey pine seedlings produced on a sandy nursery soil treated with Mylone, fermented sawdust compost, and aluminum sulfate. Fig. 3 illustrates one of the most striking modifications in the morphology of plants achieved by these treatments.

Very similar results were obtained when aluminum sulfate was replaced by 60 cu. yards per acre of raw sawdust of hard maple, *Acer saccharum.*

DISCUSSION

Pitfalls in artificial propagation of plants are ever present today as they were in 600 B.C. In one of his fables, Aesop tells about a man asking a gardener the pertinent question: »Why are wild plants strong and thriving, while cultivated ones are spindly and wilted?» In Aesop's day the reason was most likely depletion of nutrients in cultivated soils; in our time similar results are often due to unskilled use of eradicants.

Today plant production is married by the benzene ring to an array of chemicals, married for better or for worse. Unfortunately, the matrimony between the biosphere and the new potent sources of energy was often accomplished without the help of an experienced matchmaker who possessed a knowledge of the compounds used, organisms to be destroyed and protected, and composition of soil. The soil is the medium which has to absorb chemical refuse left after every clash of life with ions and molecules; it has to digest the »fallout» or end products of chain reactions set in motion by different treatments.

As a fortunate exception, the use of eradicants in nursery practice does not generate the tragic consequences featured in Rachel Carson's »Silent Spring» (1962). Yet the zero hour has struck even for nurserymen to accept the self-evident truth that it is impossible to exterminate undersirable soil organisms by poisons, and yet to produce in the same soil without special amendments unharmed crops.

Experience in recent years has disclosed the existence of several roads which lead to a reasonably harmonious aggregation of biocides with other components of the soil: fertilizers, microorganisms, and root systems (MATSUI, 1961; MADER, 1959; YATAZAWA et al., 1960; DEVRIES,[1] 1962; IYER, 1965; IYER and TRAUTMANN, 1967; IYER et al., 1969). However, all of these roads invariably emanate from the same center delineated by analyses of soil and growing stock (WILDE et al., 1964). Establishment of this cardinal point is essential prior to any ameliorative measures because in work with eradicants, as in many other phases of plant production, there is only one general rule, namely, that there are no general rules.

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BIOSIIDEILLA KÄSITELLYSSÄ TAIMITARHAMAASSA KASVANEIDEN TAIMIEN KASVUPOTENTIAALIN PALAUTTAMISESTA

Tietyt taimitarhoissa käytetyt biosiidit aiheuttavat, samalla kun ne tuhoavat ei-toivottuja organismeja, myös epänormaalia taimien kasvua. Taimien elossapysymismahdollisuudet pienenevät suuresta mehevyydestä, korkeasta verso/juuri- ja pituus/läpimittasuhteesta sekä pienestä ominaispainosta ja juuripinnasta johtuen. Jotkut savusteet ehkäisevät mykoritsamuodostusta ja haittaavat taimien fosforinottoa. Taimien kasvupotentiaali palautettiin aluminiumsulfaatin avulla sekä/tai antamalla niille käyteaineita sisältävää kompostia, johon oli lisätty mykoritsoja muodostavien sienien rihmastoa.