Lime-Amended Growing Medium Causes Seedling Growth Distortions

R. Kasten Dumroese, Gale Thompson, and David L. Wenny

Research associate, University of Idaho, Department of Forest Resources, Moscow; greenhouse manager, Plum Creek Timber Company, Pablo, MT; and associate professor and manager, Forest Research Nursery, University of Idaho, Department of Forest Resources

Although a commercial growing medium with incorporated agricultural lime had been successfully used for years, it caused growth distortion of coniferous and deciduous seedlings during 1988. Seedlings grown in the amended medium were stunted and chlorotic, often with disfigured needles and multiple tops. Seedlings grown in the same medium without incorporated lime grew normally. These symptoms are attributed to a nutritional problem caused by dolomitic limestone in the medium. Tree Planters' Notes 41(3):12-17; 1990.

Dolomitic limestone is commonly added to commercial growing media, usually to raise pH and serve as a source of calcium (Ca) and magnesium (Mg). Four container nurseries in northern Idaho had been using the same peat-vermiculite (1:1) growing medium with incorporated limestone for several years, with good to excellent results. However, distorted Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco) seedlings were occasionally observed. Although the number of distorted seedlings was never widespread or serious, much speculation was given to the cause. In 1988, however, serious problems developed.

The Problem

Three weeks after germination was complete, portions of the crop were obviously chlorotic and stunted. The problem was unusual because it often affected every tree in a particular block (either pine cell tray or Styrofoam block), but not every block in a given seedlot. Affected blocks were randomly distributed throughout the seedlot. Eleven coniferous and 3 hardwood species appeared affected, although Douglas-fir and spruce (*Picea*) spp. were the most severely affected (table 1). The severity of the problem also varied with seedlot.

As the seedlings matured, the pine species recovered somewhat after being given additional nitrogen, although they were still shorter than normal seedlings. The symptoms of the Douglas-fir, western larch, grand fir, and spruce seedlings became more acute, often resembling herbicide damage. A club-like swelling also formed just beneath the terminal bud (fig. 1). These seedlings remained chlorotic and stunted, with

Table 1—*Species affected by lime-amended growing medium*

Common name	Scientific name
Conifers	
Rocky Mountain Douglas-fir	*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco
Engelmann spruce	*Picea engelmannii* Parry ex Engelm.
Blue spruce	*Picea pungens* Engelm.
Norway spruce	*Picea abies* (L.) Karst.
Western larch	*Larix occidentalis* Nutt.
Western redcedar	*Thuja plicata* Donn ex D.Don
Western white pine	*Pinus monticola* Dougl. ex D.Don
Ponderosa pine	*Pinus ponderosa* Dougl. ex Laws.
Scotch pine	*Pinus sylvestris* L.
Austrian pine	*Pinus nigra* Arnold
Grand fir	*Abies grandis* (Dougl. ex D.Don) Lindl.
Hardwoods	
Chokecherry	*Prunus virginiana* L.
Nanking cherry	*Prunus tomentosa* Thunb.
River birch	*Betula nigra* L.

Contribution 518 of the Idaho Forest, Wildlife, and Range Experiment Station.

Figure 1—*Douglas-fir seedling with tight curling of needles, resembling herbicide damage.* ***Arrow*** *points to swelling beneath the terminal bud.*

Figure 2—*A 6-month-old Douglas-fir with little internodal extension (circular object is camera lens cover).*

very short needles and deformed terminal buds. Some affected seedlings had extremely small internodes, and many 6-month-old seedlings were only 3 to 4 cm tall (fig. 2). The most severely stunted seedlings eventually developed tip necrosis (fig. 3). Some affected seedlings seemed to lose apical dominance as the lateral shoots continued to grow, often resulting in seedlings with multiple tops (fig. 4). The root systems were apparently unaffected, and most distorted seedlings had firm root plugs.

This problem was frustrating because an exact cause could not be identified. Assays for pathogenic fungi were negative. The pH of the medium was determined before sowing and ranged from 4.4 to 4.5. Three weeks after symptoms appeared, pH measurements of trays of normal looking seedlings and stunted seedlings were very similar, 6.7 and 6.8 respectively, although these values were higher than the target pH range (5.8 to 6.0).

Seedling tissue samples were analyzed at 12 weeks after germination to check for mineral nutrient deficiency or toxicity; the results were inconclusive (table 2). Even though irrigation water was acidified, further acidification of the water did not relieve the problem. Finally, late in the season, repeated applications of high rates of ammonium nitrate relieved the problem in some of the affected seedlings, but unfortunately allowed normal seedlings to grow too tall.

The Study

In 1988, four nurseries in northern Idaho and another in western Montana participated in a cooperative research project not originally intended to examine the effects of limestone-amended media. One batch of growing medium with incorporated dolomitic limestone was divided and samples were sent to participating nurseries. At the northern Idaho nurseries, Douglas-fir seedlings were grown in dolomite-amended media, but at the Montana nursery, two Douglas-fir seedlots were sown into cells containing growing medium with dolomitic limestone and growing medium without limestone.

Figure 3—*Apical necrosis of a distorted Douglas-fir seedling.*

At the Montana nursery, 90% of the trees grown under the nursery's usual regime in medium with dolomitic limestone were stunted (fig. 5). Normal seedlings were significantly taller, but the root collar diameters (calipers) of both normal and symptomatic seedlings were similar (table 3).

Of the five nurseries participating in the study, only the western Montana nursery and one northern Idaho nursery reported widespread stunting of Douglas-fir seedlings in medium with incorporated dolomite.

The Analysis

Although an exact reason for the growth problems may never be verified experimentally, we believe that the symptoms were caused, either directly or indirectly, by dolomitic limestone in the growing medium, probably by uneven incorporation of the dolomite. Problems with incorporated fertilizers are not unusual; Whitcomb concluded that variable growth of container nursery stock was mostly due to improper mixing of incorporated fertilizers *(13)*. This is even more of a problem in the small-volume containers used in forest nurseries, as it is difficult to evenly distribute a charge of fertilizer to each cell *(7)*. Even in a well-mixed medium, the amount of fertilizer can vary drastically because dry incorporated amendments easily separate out from dry growing medium during handling *(1)*.

Although the pH of the growing medium with incorporated dolomite was high, pH alone may not have been the root of the problem. Whitcomb concludes that nutrition of container-grown plants is unaffected by pH, and micronutrients are readily available between pH 4.0 and 7.0 *(12)*. However, when high concentrations of Ca, Mg, sodium (Na), or bicarbonates are present, micronutrient nutrition of container-grown plants is affected.

The symptoms were probably related to a mineral nutrient deficiency or toxicity. Affected seedlings had chlorotic terminal leaves, necrotic growing tips, short internodal distance and misshaped needles—these are common symptoms of boron (B), Ca, and copper (Cu) deficiency *(9)*. A Ca deficiency seems unlikely, because the pH of medium supporting affected seedlings was high and distortion was noted only in medium with incorporated calcium and magnesium, but a Ca "toxicity" is a possibility (Landis 1988). Also, the ratio of Ca and Mg must be balanced to prevent Mg or Ca deficiencies *(13)*.

Copper levels are inherently low in soils with high organic matter contents, and the dolomite may have further reduced Cu availability *(8)*. Maintaining the high organic growing medium in a saturated condition may also induce Cu deficiency. Because seedlings in both media were watered the same and foliar levels were similar, this seems unlikely as the source of the problem, although later irrigations to the less rapidly growing, stunted seedlings may have affected Cu availability.

Boron deficiency is commonly induced by liming acid soils. Soils with high levels of Ca and a pH greater than 6.5 can show B deficiency *(4)*. Even though tissue analysis did not show an apparent deficiency, the ratio of Ca to B may have been outside the range for normal plant growth *(11)*.

Stevenson *(11)* reports excessive plant uptake of Ca supplied by lime may cause a nutrient imbalance in the plant, and Brown *(2)* speculates iron (Fe) chlorosis is one such example. In fact, dolomitic limestone incorporated into a peat-vermiculite growing medium has been shown to induce lime chlorosis in Douglas-fir seedlings *(3)*. Landis' review *(5)* indictates that chlorotic plants with an iron deficiency are characterized by more total Fe and total Ca in their tissue than normal seedlings. Our tissue analysis data (table 2) shows distorted seedlings did indeed have higher amounts of Ca and Fe than normal seedlings.

Conclusions

Ruter and van de Werken *(10)* question the reasons for using dolomitic limestone with container-grown plants, concluding that nursery managers should question traditional nursery practices as the first step to improve stock quality. Growers who have used their trusty growing medium for years may want to inquire whether it contains incorporated limestone. Although media with incorporated dolomite

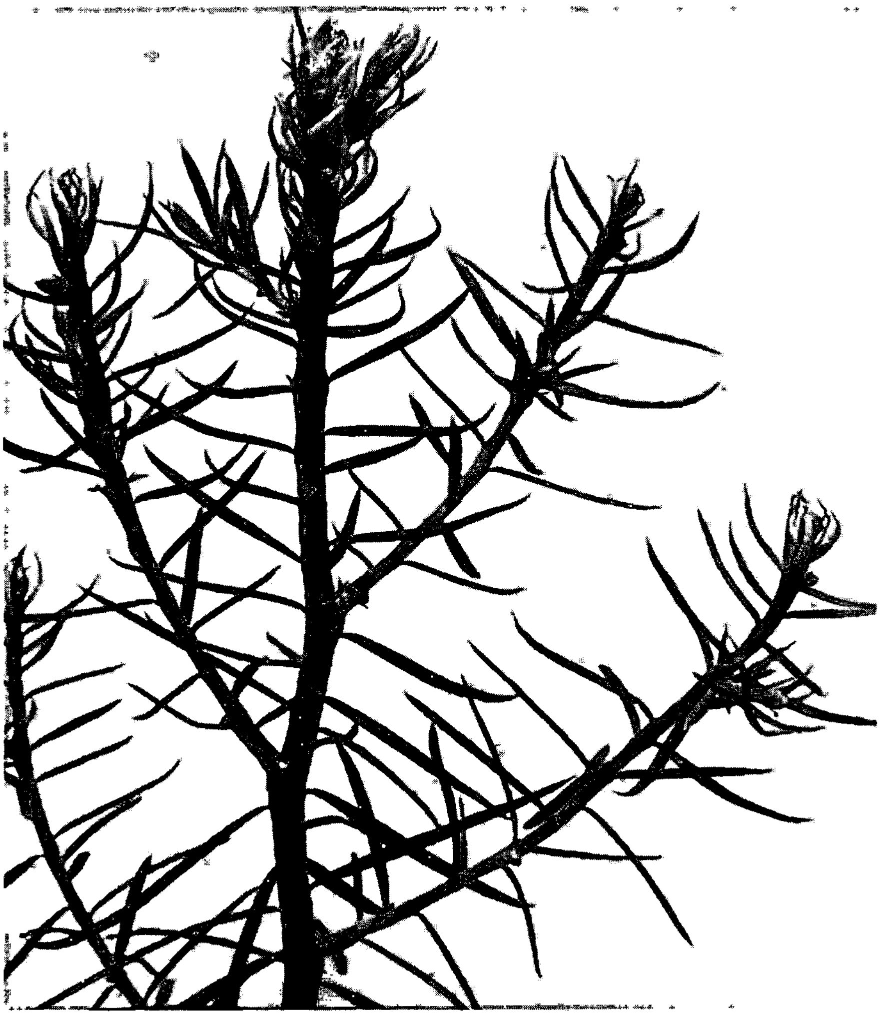

Figure 4—*Douglas-fir seedling exhibiting a lack of apical dominance but continued growth of lateral branches.*

Table 2—*Tissue analysis of distorted and healthy appearing Douglas-fir seedlings during budset in the growth cycle*

	Healthy	Distorted	Standard*
Macronutrients (%)			
N	0.93	2.31	1.40–2.20
P	0.31	0.40	0.20–0.40
K	1.03	0.84	0.40–1.50
Ca	0.32	0.48	0.20–0.40
Mg	0.15	0.20	0.10–0.30
S	0.13	0.22	0.20–0.30
Micronutrients (ppm)			
Cu	6	6	4–20
Zn	32	29	30–150
Mn	161	229	100–250
Fe	239	416	60–200
B	29	37	20–100

*From Landis and others *(6)*.

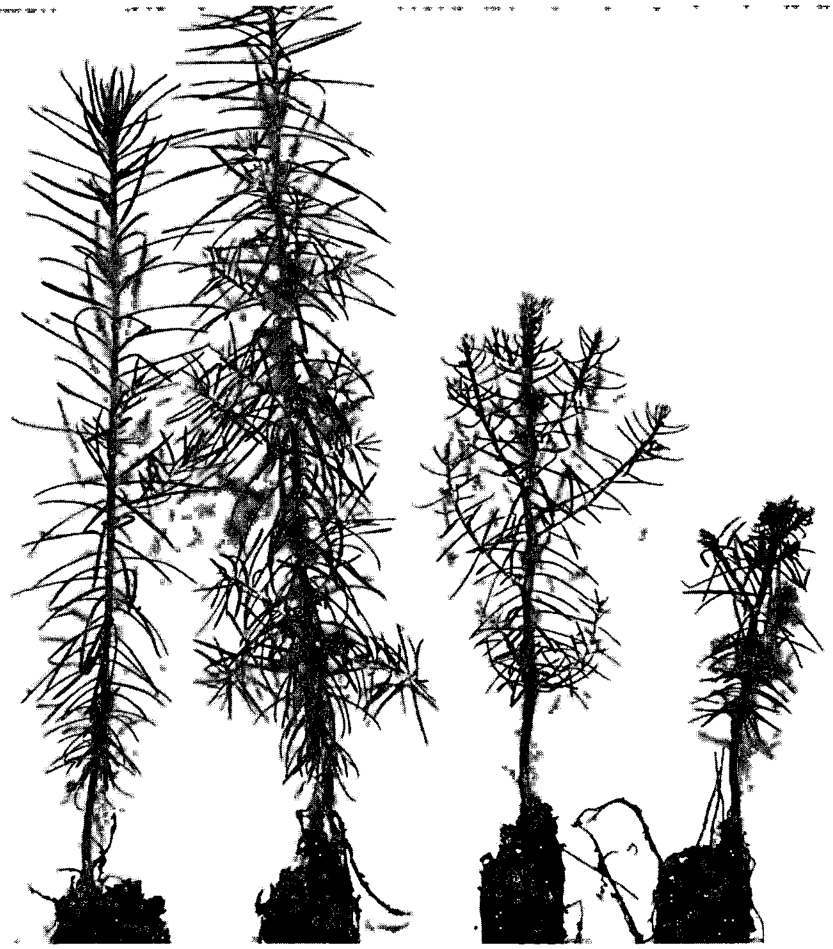

Figure 5—*Two normal Douglas-fir seedlings* (**left**) *grown in dolomite-free growing medium and two distorted seedlings* (**right**) *grown in medium with incorporated limestone.*

Table 3—*Growth of Douglas-fir seedlings in growing medium with dolomitic limestone and limestone-free growing medium*

Seedlot/ treatment	Height (cm)	Root collar diameter (mm)
DF 25-1428		
Medium with limestone	15.7*	2.86*
Medium without limestone	23.9*	2.64*
DF 25-2508		
Medium with limestone	13.1*	2.58
Medium without limestone	23.3*	2.54

*Different at the $P < 0.05$ level of significance using Tukey's LSD.

had traditionally been used for years in northern Idaho, the circumstantial evidence reported here indicates this may have caused a serious problem.

Our observations indicate that incorporated lime induced iron deficiency in Douglas-fir seedlings, although other micronutrient deficiencies may have been involved. Dangerfield *(3)* found that the formulation of the fertilizer applied during the growing season had a significant effect on the seriousness of lime-induced chlorosis. This phenomenon could explain why seedling growth was unaffected at three of the five nurseries participating in this study. Landis and others recommend no liming materials be incorporated into the growing medium for three reasons *(9)*:

1. It is difficult to obtain good distribution of limestone during mixing.
2. The pH of most peat-vermiculite growing mixes is usually adequate and routine irrigations and fertilizations will raise pH.
3. Calcium and magnesium nutrition can be adjusted more quickly and accurately using water-soluble fertilizers than by using dolomitic limestone.

The solution to the potential dolomite problem is as easy as requesting medium without limestone. In the following year, three nurseries in northern Idaho sowed part or all of their crops in dolomite-free medium with little or no adjustment to growing regimes, and their seedlings were of good to excellent quality.

Literature Cited

1. Bartok, J.W., Jr. 1985. Media mixing systems offer efficiency, variety. Greenhouse Manager 4(8):108–110, 112–113.
2. Brown, J.C. 1961. Iron chlorosis in plants. Advances in Agronomy 13:329–369.
3. Dangerfield, J.A. 1978. Influence of lime incorporated in soil mix on growth of Douglas-fir. Fisheries and Environment Canada Bi-monthly Research Notes 34(1):1–2.
4. Laffe, S.R.; Styer, R.C. 1989. Too B or not too B: learn to recognize boron deficiency. GrowerTalks 53(8):66.

5. Landis, T.D. 1988. Management of forest nursery soils dominated by calcium salts. New Forests 2:173–193.
6. Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1989. Seedling nutrition and irrigation, Vol. 4, the container tree nursery manual. Agri. Hdbk. 674. Washington, DC: USDA Forest Service. 119 p.
7. Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1990. Containers and growing media, Vol. 2, the container tree nursery manual. Agriculture Handbook 674. Washington, DC: USDA Forest Service. (Manuscript in preparation.)
8. Lucas, R.E.; Knezek, B.D. 1972. Climatic and soil conditions promoting micronutrient deficiencies in plants. In: Mortvedt, J.J.; Giordano, P.M.; Lindsay, W.L. eds. Micronutrients in agriculture. Madison, WI: Soil Science Society of America, Inc. pp. 265–288.
9. Marschner, H. 1986. Mineral nutrition of higher plants. New York: Academic Press. 674 p.
10. Ruter, J.M.; van de Werken, H. 1986. Is dolomitic limestone overused in container media? American Nurseryman 163(12):49–51, 54–57.
11. Stevenson, F.J. 1986. Cycles of soil: carbon, nitrogen, phosphorus, sulfur, micronutrients. New York: John Wiley & Sons. 380 p.
12. Whitcomb, C.E. 1983. Does pH really have an effect on nutrition of container-grown plants? American Nurseryman 158(9):33–35.
13. Whitcomb, C.E. 1988. Plant production in containers. Stillwater, OK: Lacebark Publications. 633 p.