# NAA Effects on Conifer Seedlings in British Columbia[1]

**David G. Simpson[2]**

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Abstract.- NAA (l-napthaleneacetic acid) soil drenches applied 20-40 days after sowing to container-grown Douglas-fir (20 $mgl^{-1}$), Ponderosa pine (10 $mgl^{-1}$), western larch (10 $mgl^{-1}$) or lodgepole pine (2 $mgl^{-1}$) increased lateral root formation and only slightly diminished seedling growth. After 2 field seasons, NAA treated container-grown Douglas-fir and western larch seedlings grew as well as un-treated seedlings. NAA treated (20 $mgl^{-1}$) bareroot-grown Douglas-fir and Ponderosa pine seedlings had greater numbers of lateral roots than untreated seedlings. Further study of application rates for bareroot nurseries is required.

## INTRODUCTION

Production of forest planting stock in containers in British Columbia has increased rapidly over the past 20 years (van Eerden and Gates 1990). In 1989, of the 300 million seedlings planned for production, 260 million were to be container grown. The principal species grown in British Columbia are spruces (white, Englemann, sitka), lodgepole pine, Douglas-fir, western red cedar, hemlock (western and mountain), true firs and miscellaneous other species including Ponderosa pine, white pine, western larch and yellow cedar.

In British Columbia, container grown plants are removed from their growing trays (usually styroblock 211, 313, 415) at the nursery, culled according to morphological standards that include the presence of a “plantable root system”, and packaged for cold storage, shipment and field planting. In some species, such as Douglas-fir (interior variety), Ponderosa pine, western larch and lodgepole pine the root plugs may be poorly formed, in the upper 20 mm of the plug. This lack of roots in the upper part of the plug can cause the root plug to fall apart on lifting thus making the seedling unplantable.

An earlier study (Simpson 1986) with the particularly problematic interior variety of Douglas-fir has shown that soil drenches of NAA (l-napthaleneacetic acid) applied to Douglas-fir seedlings at a rate of 18.6 $mgl^{-1}$ some 30 days after sowing were particularly effective in stimulating the production of first order lateral roots.

In spite of apparently conclusive results obtained at three different forest nurseries, B.C. Forest nurserymen have been hesitant to use NAA soil drenches on their stock. Questions raised by the nurserymen, and considered in this paper are:

a) Are the rates and timing suggested in Simpson (1986) generally applicable to Douglas-fir at other nurseries, and how are growth rates affected ?
b) Is NAA effective on other species including western larch, Ponderosa pine and lodgepole pine?
c) Is field performance of NAA treated stock affected?
d) Can NAA be used in bareroot nurseries?

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[2]Research Scientist, B.C. Ministry of Forests, Kalamalka Research Station, Vernon, B.C., Canada.

## METHODS

Data reported here were obtained from a number of trials, undertaken at various forest nurseries in B.C. (see acknowledgements). The cultural practices used in B.C. forest nurseries vary between nurseries; however, at a specific nursery the experiments were designed and undertaken such that the only aspect of nursery culture which varied was the rate and timing (days after sowing) of NAA soil drenches. In all experiments NAA treatments were applied as single applications either by hand watering or through overhead irrigation such that the blocks were saturated (2 l per styroblock) with NAA solution. The NAA solutions were prepared immediately before use from ethanolic stock solutions and the final ethanol concentration was 1%.

Sample sizes and replication varied between experiments; however, these values are indicated in figure and table captions. Statistical analyses were done using SAS-STAT™ (1985) programs for personal computers.

## RESULTS AND DISCUSSION

### NAA Effects on Douglas-fir

At the Hi-Gro Silva Forest Nursery in Quesnel, B.C. four Douglas-fir seedlots (2916; 2920; 8376; 8378) received drenches of NAA at 10, 20 and 50 $mgl^{-1}$ 30 and 45 days after sowing. Analysis of variance for the morphological variables (Table 1) suggests that although there are some significant seedlot x treatment interactions, growth of all four Douglas-fir seedlots was affected similarly by NAA treatment. There was a very clear

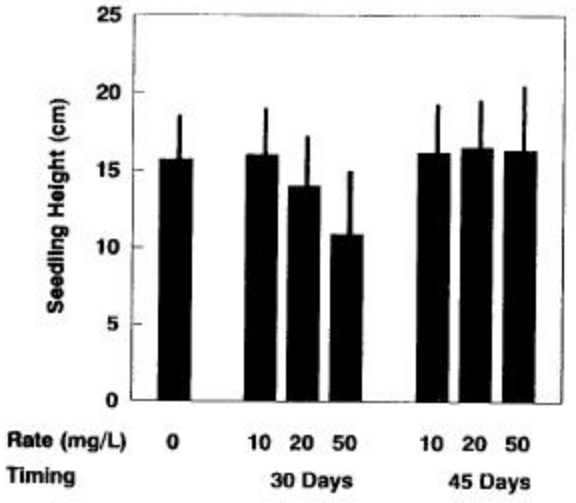


**Figure 1. Height of container-grown Douglas-fir seedlings treated with NAA. Each bar is the mean height of 300 seedlings. Standard deviation is indicated.**

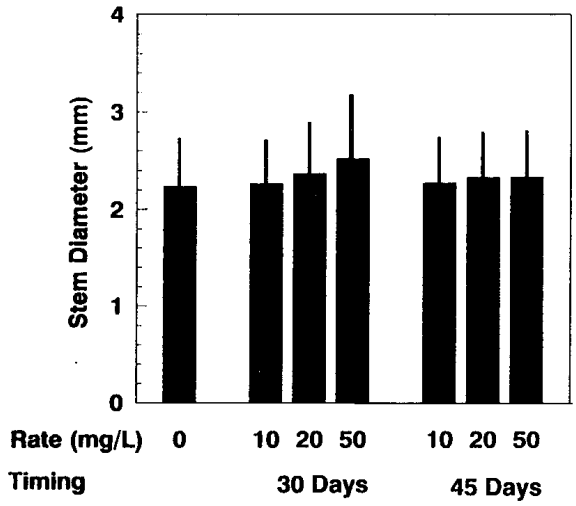


**Figure 2. Stem Diameter of container-grown Douglas-fir seedlings treated with NAA. Each bar is the mean diameter of 300 seedlings. Standard deviation is Indicated.**

Table 1. Analyses of Variance for Douglas-fir seedling morphology: Hi-Gro Silva experiment.

| | | Height | | Root Collar Dia. | | Shoot Weight | | Root Weight | | Lateral Roots | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Source of Variation | df | MS | F | MS | F | MS | F | MS | F | MS | F |
| Seedlot (S) | 3 | 236.5 | 3.83* (1) | 4.776 | 7.83*** | 205.6 | 1.97$^{NS}$ | 612.4 | 15.58*** | 2685.3 | 9.31*** |
| Treatments (T) | 6 | 1139.6 | 18.12*** | 2.628 | 2.58$^{NS}$ | 568.7 | 4.30* | 87.6 | 0.98$^{NS}$ | 44618.2 | 57.50*** |
| Contrasts | | | | | | | | | | | |
| Control (C) | 1 | 140.0 | 2.23$^{NS}$ | 2.973 | 2.92$^{NS}$ | 4.1 | 0.03$^{NS}$ | 275.9 | 3.08$^{NS}$ | 42587.9 | 54.88*** |
| Date (D) | 1 | 2805.8 | 44.61*** | 2.307 | 2.26$^{NS}$ | 748.9 | 5.66$^{NS}$ | 171.9 | 1.92$^{NS}$ | 184004.3 | 237.12*** |
| Rate (R) | 2 | 883.5 | 14.05*** | 3.663 | 3.59$^{NS}$ | 724.4 | 5.48* | 17.0 | 0.19$^{NS}$ | 17101.5 | 22.04*** |
| D*R | 2 | 1062.4 | 17.19*** | 1.581 | 2.59$^{NS}$ | 605.2 | 5.80** | 60.6 | 1.54$^{NS}$ | 3457.0 | 11.99*** |
| S*T = Error 1 | 18 | 62.9 | 1.02$^{NS}$ | 1.019 | 1.67$^{NS}$ | 132.2 | 1.27$^{NS}$ | 89.5 | 2.28* | 776.0 | 2.67** |
| REP (S * T) = Error 2 | 55 | 61.8 | 6.65*** | 0.610 | 2.62*** | 104.3 | 12.72*** | 39.3 | 11.23*** | 288.4 | 3.12*** |
| Error 3 | 2002 | 9.3 | --- | 0.233 | --- | 8.2 | --- | 3.5 | --- | 92.3 | --- |

(1) NS = p>.05; * = p≤0.05; ** = p≤0.01; * **= p≤0.001;

interaction between the rate and timing (date) of NAA treatment. For seedling height (Figure 1), stem diameter at root collar (Figure 2), dry weight components (Figure 3) and lateral root number (Figure 4) it can be seen that NAA applications made 30 days from sowing had greater effect than similar treatments made 45 days from sowing. At 30 days from sowing the greatest number of lateral roots were produced at the 50 $mg1^{-1}$ rate, however, seedling height and shoot weights were reduced at this level. Although there were effects on seedling morphology due to NAA, it is unlikely that these effects on growth were of a sufficient magnitude to increase culling losses. In fact, seedling root collar diameter (an important culling criteria in B.C.) was slightly increased by NAA treatment (Figure 2).

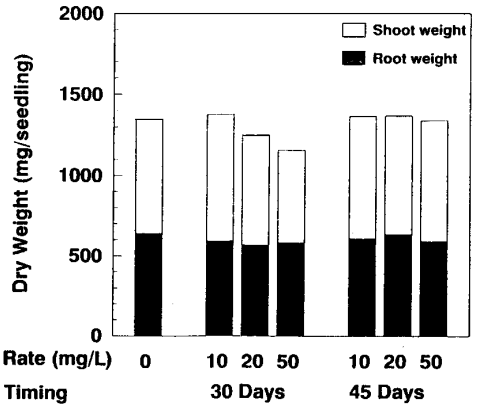


**Figure 3. Shoot and root dry weight of container-grown Douglas-fir seedlings Treated with NAA. Each bar is the mean weight of 300 seedlings. 5% LSD values are 84 and 51 mg for shoot and root weights, respectively**

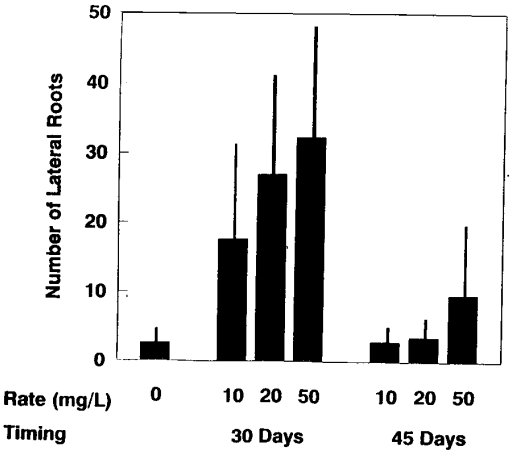


**Figure 4. First order lateral root initiation by container-grown Douglas-fir seedlings treated with NAA. Each bar represents the mean number of lateral roots from 300 seedlings. Standard deviations are indicated.**

It is clear that the recommended NAA application (Simpson 1986) of 18.6 $Mgl^{-1}$ (~20 $mgl^{-1}$) 30 days from sowing was an appropriate rate for Douglas-fir at this nursery.

At the Daveron Forest Nursery in Summerland, B.C. two Douglas-fir seedlots (8144; 26227) received drenches of NAA (20 $mgl^{-1}$ 30 days from sowing) . The height growth of these treated (as well as untreated) seedlings was measured periodically throughout the growing season (February - October). The results indicate that seedling height (Figure 5) was affected soon after treatment, and that subsequent growth occurred at similar rates in treated and untreated seedlings. Final heights were less in NAA treated seedlings as all seedlings ceased height growth around the same time, presumably in response to longer nights in late summer.

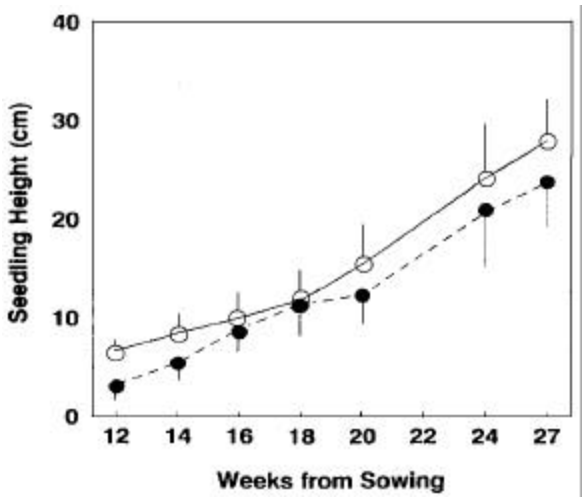


**Figure 5. Effect of NAA on height growth of Douglas-fir (8144) at Daveron Forest Nursery. Each point is the mean of 50 seedlings. Solid line = untreated broken line NAA treated. Standard deviation indicated**

The results from this trial suggest that depression of seedling height due to NAA application could be minimized by simply growing seedlings for 2-3 weeks longer. In B.C. forest nurseries, attaining sufficiently tall container grown Douglas-fir seedlings is rarely a problem; in fact, some nurseries resort to moisture and nutrient stresses in attempts to regulate height growth.

## NAA Effects on Other Species

At the Pacific Regeneration Technologies Forest Nursery in Vernon, B.C. a rate and timing study was undertaken with Ponderosa pine, western larch and lodgepole pine. Five rates of NAA (between 2 and 100 $mgl^{-1}$) and application dates which ranged from 17 to 67 days from sowing were considered.

For Ponderosa pine (Table 2), western larch (Table 3) and lodgepole pine (Table 4) there were significant treatment effects on seedling morphology. There were significant NAA rate and timing effects as well as significant interactions between application rate and application date. Data for the three species are presented in Tables 2 - 4; however, when considered together, these results suggest that NAA application resulted in increased numbers of lateral roots in all three species with the minimum application rate being 10 $mgl^{-1}$ for Ponderosa pine and western larch and 2 mgl1 for lodgepole pine. Application rates greater than these resulted in greater numbers of lateral roots being initiated; however, growth, particularly height and weight, was reduced at higher application rates. Timing of NAA applications was most effective between 20 and 40 days from sowing, later applications required greater application rates and often resulted in decreased growth without similarly greater numbers of lateral roots being produced.

## Field Performance of NAA Treated Seedlings

Western larch seedlings from the Pacific Regeneration Technologies Nursery in Vernon, B.C. and Douglas-fir from the Daveron Forest Nursery in Summerland, B.C. were treated with 20 $mgl^{-1}$ NAA 30 days from sowing. At the end of the growing season the seedlings were removed from their styroblock growing trays, packaged and cold (-2°C) stored overwinter as is the practice at many B.C. forest nurseries. Measurements of seedling morphology (Table 5) indicate that the NAA treatment increased lateral root numbers and had some effects on growth, particularly on height growth of western larch.

Overwinter stored seedlings were planted on forest sites at Hidden Lake (near Vernon, B.C.) and their heights measured at planting and again following the first and second growing seasons. The field results (Figure 6) indicate that height differences which existed at planting have become proportionately smaller (and less important) as the seedlings have grown larger. The annual height increment does not appear to have been affected by NAA treatment.

Table 3. MAA effects on 1+0 container-grown western larch morphology.

| Date | Rate ($mgl^{-1}$) | Height (cm) | Diameter (mm) | Shoot Wt. (mg) | Root Wt. (mg) | Lateral Roots (#) |
|---|---|---|---|---|---|---|
| May 27 | 2 | 16.4 | 3.05 | 864 | 642 | 14 |
| day 17 | 10 | 13.8 | 2.99 | 737 | 606 | 88 |
| | 20 | 11.9 | 2.85 | 652 | 623 | 96 |
| | 50 | 7.8 | 3.13 | 390 | 398 | 87 |
| | 100 | 6.5 | 3.45 | 354 | 347 | 91 |
| June 7 | 2 | 15.3 | 3.00 | 780 | 611 | 6 |
| day 28 | 10 | 316.2 | 2.91 | 793 | 632 | 59 |
| | 20 | 14.8 | 2.99 | 795 | 650 | 88 |
| | 50 | 7.5 | 3.33 | 358 | 312 | 84 |
| | 100 | 4.6 | 3.50 | 263 | 266 | 66 |
| June 21 | 2 | 19.7 | 2.99 | 464 | 712 | 7 |
| day 42 | 10 | 16.6 | 2.66 | 834 | 645 | 9 |
| | 20 | 10.4 | 2.38 | 494 | 654 | 11 |
| | 50 | 6.0 | 2.53 | 283 | 381 | 51 |
| | 100 | 4.6 | 3.42 | 245 | 296 | 39 |
| July 5 | 2 | 16.3 | 2.91 | 894 | 634 | 5 |
| day 56 | 10 | 14.5 | 2.73 | 770 | 742 | 7 |
| | 20 | 10.6 | 2.49 | 536 | 740 | 10 |
| | 50 | 9.0 | 2.67 | 441 | 674 | 33 |
| | 100 | 5.6 | 3.02 | 263 | 322 | 27 |
| control | | 13.8 | 3.34 | 920 | 710 | 6 |
| 5% LSD | | 2.1 | 0.36 | 222 | 82 | 19 |

Analyses of Variance

| | | Height | | Root Collar Dia. | | Shoot Weight | | Root Weight | | Lateral Roots | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Source of Variation | df | MS | F | MS | F | MS | F | MS | F | MS | F |
| Treatments (T) | 20 | 415.8 | 40.0***(1) | 2.037 | 6.8*** | 124886 | 7.4*** | 57851 | 25.1*** | 24827 | 30.8*** |
| Contrasts | | | | | | | | | | | |
| Control (C) | 1 | 112 | 10.8*** | 2.666 | 9.5* | 1008957 | 59.5*** | 620423 | 356.6*** | 27555 | 34.2*** |
| Date (D) | 3 | 5 | 0.5NS | 3.879 | 12.9*** | 113839 | 6.7** | 32409 | 14.1*** | 81289 | 100.9*** |
| Rate (R) | 4 | 1725.4 | 165.9*** | 4.95 | 16.4*** | 408680 | 24.1*** | 212815 | 92.5*** | 37314 | 46.3*** |
| D * R | 12 | 50.7 | 4.9** | 0.534 | 1.8NS | 22241 | 1.3NS | 9181 | 4.0** | 6322 | 7.8*** |
| Block (B) | 2 | 13 | 4.8NS | 0.278 | 1.2NS | 3774 | 0.2NS | 20103 | 8.7*** | 1214 | 2.72NS |
| Error 1 (T * B) | 40 | 10.4 | 3.9*** | 0.301 | 1.3NS | 16960 | | 2301 | | 806 | 1.8* |
| Error 2 | 567 | 2.7 | | 0.228 | | n/a | | n/a | | 445 | |

n/a = not available; dry weights were determined on a block rather than individual tree basis
* = $p \leq .05$; ** $p \leq 0.01$; *** = $p \leq .001$; NS = $p > .05$

Table 3. MAA effects on 1+0 container-grown western larch morphology.

| Date | Rate (mg * $l^{-1}$) | Height (cm) | Diameter (mm) | Shoot Wt. (mg) | Root Wt. (mg) | Lateral Roots (#) |
|---|---|---|---|---|---|---|
| May 27 | 2 | 14.6 | 2.79 | 639 | 846 | 13 |
| day 17 | 10 | 13.7 | 2.46 | 503 | 606 | 41 |
| | 20 | 16.4 | 2.71 | 412 | 587 | 63 |
| | 50 | 9.0 | 2.23 | 296 | 417 | 40 |
| | 100 | 7.0 | 2.31 | 258 | 395 | 43 |
| June 7 | 2 | 16.3 | 2.86 | 552 | 805 | 8 |
| day 28 | 10 | 13.9 | 2.80 | 623 | 756 | 32 |
| | 20 | 15.7 | 2.36 | 523 | 682 | 41 |
| | 50 | 13.5 | 2.93 | 465 | 618 | 43 |
| | 100 | 9.1 | 2.55 | 363 | 560 | 47 |
| June 21 | 2 | 14.2 | 2.50 | 693 | 836 | 10 |
| day 42 | 10 | 17.9 | 2.77 | 518 | 707 | 25 |
| | 20 | 4.0 | 12.66 | 447 | 562 | 38 |
| | 50 | 11.4 | 2.28 | 378 | 459 | 44 |
| | 100 | 7.5 | 2.26 | 251 | 344 | 42 |
| July 5 | 2 | 15.3 | 2.89 | 536 | 712 | 8 |
| day 56 | 10 | 15.4 | 2.80 | 486 | 757 | 4 |
| | 20 | 10.4 | 2.65 | 390 | 675 | 9 |
| | 50 | 5.8 | 2.34 | 220 | 397 | 25 |
| | 100 | 4.2 | 2.36 | 148 | 256 | 38 |
| control | | 21.8 | 2.46 | 685 | 667 | 2 |
| 5% LSD | | 3.7 | 0.37 | 114 | 158 | 10 |

Analyses of Variance

| | | Height | | Root Collar Dia. | | Shoot Weight | | Root Weight | | Lateral Roots | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Source of Variation | df | MS | F | MS | F | MS | F | MS | F | MS | F |
| Treatments (T) | 20 | 569.2 | 18.1***(1) | 1.6212 | 5.8*** | 71050 | 15.8*** | 85212 | 9.9*** | 9125 | 26.9*** |
| Contrasts | | | | | | | | | | | |
| Control (C) | 1 | 2618.2 | 83.1*** | 0.3632 | 1.2$^{NS}$ | 179024 | 29.9*** | 18741 | 1.6$^{NS}$ | 23118 | 93.6*** |
| Date (D) | 3 | 332.7 | 10.6*** | 1.6779 | 5.4** | 58896 | 13.1*** | 44862 | 5.2** | 14417 | 58.4*** |
| Rate (R) | 4 | 1430.8 | 45.4*** | 3.314 | 10.7*** | 239770 | 53.4*** | 336989 | 39.1*** | 21168 | 85.7*** |
| D * R | 12 | 111.2 | 3.5** | 1.1476 | 3.7** | 8851 | 2.0$^{NS}$ | 17229 | 2.0$^{NS}$ | 2622 | 10.6*** |
| Block (B) | 2 | 6.1 | 0.8$^{NS}$ | 0.3442 | 1.4$^{NS}$ | 107 | 0.02$^{NS}$ | 5452 | 0.6$^{NS}$ | 405 | 3.5$^{NS}$ |
| Error 1 (T * B) | 40 | 31.5 | 4.2*** | 0.3084 | 1.3$^{NS}$ | 4491 | | 8608 | | 247 | 2.1*** |
| Error 2 | 567 | 7.5 | | 0.2379 | | n/a | | n/a | | 11 | |

n/a = not available; dry weights were determined on a block rather than individual tree basis
* = $p \leq .05$; ** $p \leq 0.01$; *** = $p \leq .001$; NS = $p > .05$

Table 4. NAA effects on 1+0 container-grown Lodgepole pine morphology.

| Date | Rate (mg * $l^{-1}$) | Height (cm) | Diameter (mm) | Shoot Wt. (mg) | Root Wt. (mg) | Lateral Roots (#) |
|---|---|---|---|---|---|---|
| May 27 | 2 | 11.0 | 2.39 | 568 | 521 | 25 |
| day 23 | 10 | 5.2 | 2.07 | 298 | 424 | 31 |
| | 20 | 3.3 | 1.50 | 158 | 262 | 30 |
| | 50 | 2.3 | 1.72 | 152 | 257 | 32 |
| | 100 | 2.0 | 1.80 | 130 | 212 | 30 |
| June 7 | 2 | 12.2 | 2.24 | 595 | 520 | 27 |
| day 34 | 10 | 10.4 | 2.01 | 422 | 446 | 34 |
| | 20 | 7.4 | 2.18 | 428 | 447 | 40 |
| | 50 | 3.3 | 2.62 | 214 | 374 | 34 |
| | 100 | 2.3 | 2.03 | 155 | 271 | 23 |
| June 21 | 2 | 12.0 | 2.35 | 550 | 547 | 12 |
| day 47 | 10 | 8.7 | 2.01 | 390 | 534 | 29 |
| | 20 | 4.7 | 2.20 | 269 | 251 | 26 |
| | 50 | 3.7 | 2.62 | 180 | 247 | 12 |
| | 100 | 2.9 | 2.98 | 177 | 255 | 31 |
| July 5 | 2 | 13.0 | 2.18 | 563 | 514 | 4 |
| day 61 | 10 | 11.0 | 2.32 | 456 | 577 | 5 |
| | 20 | 7.8 | 2.14 | 343 | 532 | S |
| | 50 | 3.0 | 1.82 | 220 | 427 | 25 |
| | 100 | 3.8 | 3.20 | 218 | 264 | 24 |
| control | | 18.8 | 2.05 | 630 | 495 | 3 |
| 5% LSD | | 1.7 | 0.34 | 65 | 86 | 9 |

Analyses of Variance

| | | Height | | Root Collar Dia. | | Shoot Weight | | Root Weight | | Lateral Roots | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Source of Variation | df | MS | F | MS | F | MS | F | MS | F | MS | F |
| Treatments (T) | 20 | 650.7 | 103.3*** (1) | 4.7467 | 18.3*** | 86403 | 58.9*** | 45409 | 17.6*** | 3816 | 19.5*** |
| Contrasts | | | | | | | | | | | |
| Control (C) | 1 | 4340.2 | 688.9*** | 0.7231 | 2.8$^{NS}$ | 267037 | 181.9*** | 137048 | 53.2*** | 12007 | 61.3*** |
| Date (D) | 3 | 247.2 | 39.2*** | 7.9966 | 30.9*** | 34382 | 23.4*** | 42167 | 16.4*** | 32905 | 167.9*** |
| Rate (R) | 4 | 1609.2 | 255.4*** | 4.4047 | 17.0*** | 319273 | 217.5*** | 158233 | 61.4*** | 7715 | 39.4*** |
| D*R | 12 | 36.3 | 5.8*** | 4.3836 | 16.9*** | 6733 | 4.6*** | 10192 | 4.0*** | 1975 | 10.1*** |
| Block (B) | 2 | 35.4 | 11.8*** | 0.2761 | 1.4$^{NS}$ | 392 | 0.03$^{NS}$ | 5045 | 2.0$^{NS}$ | 433 | 4.5* |
| Error 1 (T * B) | 40 | 6.3 | 2.1*** | 0.259 | 1.3$^{NS}$ | 1468 | | 2577 | | 196 | 2.0*** |
| Error 2 | 567 | 3 | | 0.1953 | | n/a | | n/a | | | |

n/a = not available; dry weights were determined on a block rather than individual tree basis.
* = $p \leq .05$; ** $p \leq 0.01$; *** = $p \leq .001$; NS = $p > .05$

Table 5. Effect of NAA on seedling morphology at Daveron (Douglas-fir) and Vernon (western larch) nurseries.

| Species-Seedlot | Treatment | Height | Root Collar Diameter (mm) | Shoot Weight (mg) | Root Weight (mg) | # Lateral Roots(2) 0-20 mm | # Lateral Roots(2) 20-50 mm |
|---|---|---|---|---|---|---|---|
| D-fir 8144 | Control | 28.2 ± 3.8(1) | 2.8 ± 0.4 | 1625 ± 405 | 880 ± 250 | 3 ± 1 | 7 ± 3 |
| D-fir 8144 | NAA | 25.0 ± 3.6 | 2.6 ± 0.4 | 1331 ± 328 | 880 ± 250 | 17 ± 15 | 19 ± 17 |
| D-fir 26227 | Control | 27.7 ± 4.2 | 2.6 ± 0.4 | 1542 ± 390 | 950 ± 320 | 3 ± 2 | 7 ± 4 |
| D-fir 26227 | NAA | 24.1 ± 5.9 | 2.6 ± 0.4 | 1440 ± 687 | 867 ± 360 | 40 ± 19 | 33 ± 20 |
| W. larch 5235 | Control | 27.6 ± 3.3 | 3.1 ± 0.5 | 1082 ± 247 | 739 ± 180 | 4 ± 4 | 7 ± 2 |
| W. larch 5235 | NAA | 14.0 ± 2.2 | 3.0 ± 0.4 | 582 ± 159 | 762 ± 207 | 61 ± 25 | 67 ± 36 |

(1) mean m standard deviation (n = 25)
(2) number of first order lateral roots originating from primary root between 0-20 mm and between 20-50 mm below soil surface.

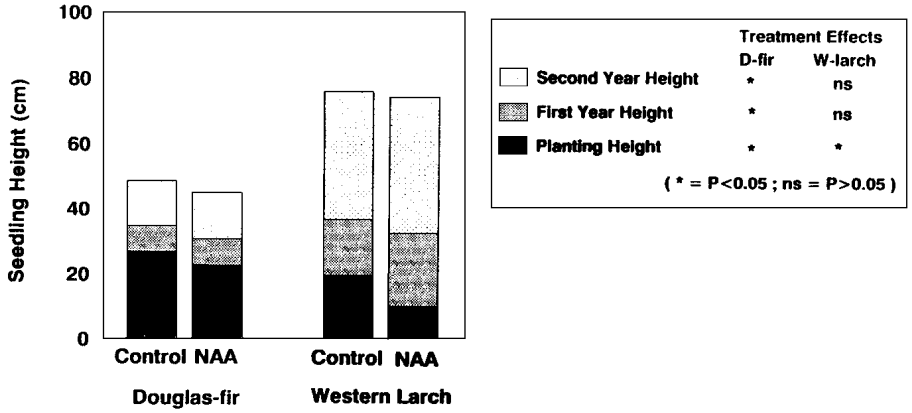


**Figure 6. Mean total height at planting and after the first and second growing season for Douglas-fir and western larch container-grown seedlings treated or not with NAA. Each bar Is the mean of 75 or 150 western larch or Douglas-fir seedlings, reepectlvely.**

Root form of forest planted seedlings has not been examined at the Hidden Lake plantation, however, the growth of treated seedlings in clear plastic root observation boxes has been examined. Roots of NAA treated Ponderosa pine, western larch and lodgepole pine seedlings appear to be more vigorous and more evenly distributed around the root plug compared to roots of untreated seedlings (Figure 7). If this change in seedling root form also occurred in forest planted seedlings is not known, however further study of forest planted NAA treated seedlings will indicate if this is the case.

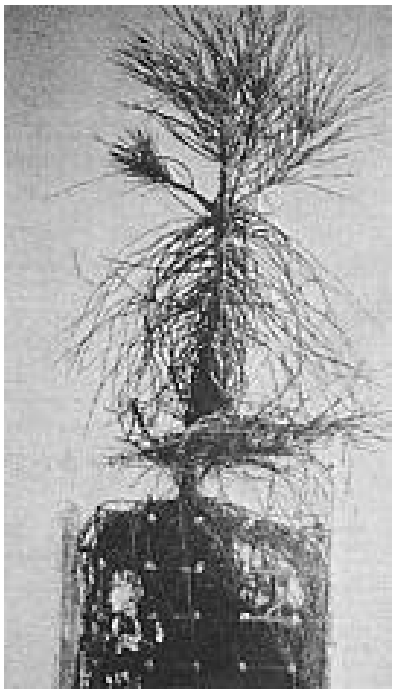

**Figure 7. NAA treated lodgepole pine seedling grown for one season in root observation box. Notice the lateral roota originating from the upper part of the root plug.**

Table 6. Effect of NAA on 1+0 bareroot Douglas-fir and western larch seedling morphology at Weyerhaeuser Canada Nursery.

| Species-Seedlot | Treatment | Height | Root Collar Diameter (mm) | Shoot Weight (mg) | Root Weight (mg) | # Lateral Roots(2) 0-20 mm | # Lateral Roots(2) 20-50 mm |
|---|---|---|---|---|---|---|---|
| Douglas-fir (1377) | Control | 6.5 | 1.67 | 332 | 237 | 0.3 | 3.4 |
| | NAA(1) | 6.8 | 1.80 | 353 | 244 | 1.5 | 6.1 |
| Ponderosa pine (8260) | Control | 5.5 | 2.28 | 682 | 407 | 0 | 1.8 |
| | NAA | 5.6 | 2.42 | 705 | 440 | 1.9 | 8.2 |

(1) 20 mg L-1 NAA applied 30 days from sowing.

(2) Number of first order lateral roots originating from the primary root between 0 - 20 mm and between 20 - 50 mm below soil surface.

NAA Effects on Bareroot Nursery Stock

At the Weyerhaeuser Canada Grandview Forest Nursery near Armstrong, B.C. sections of nurserybed sown 30-days previously with Douglas-fir and Ponderosa pine were treated with NAA. The NAA was applied at mid-day such that 2.5 $1m^{-2}$ of 20 $mgl^{-1}$ NAA drench was applied to nurserybeds which had just been irrigated.

At the end of the first growing season, seedling morphological assessment indicated (Table 6) that the number of lateral roots in both Douglas-fir and Ponderosa pine had been increased by NAA treatment. There were slight, but not significant, effects on seedling height, root collar diameter and dry weight in both species.

Results at the end of the second growing season are not available as the experiment had to be abandoned due to an infestation of strawberry root weevil larvae *(Otiorhynchus oratus).*

## CONCLUSIONS

The results from the experiments undertaken in several B.C. forest nurseries with the plant growth regulator NAA suggest the following:

- NAA will affect the number of first order lateral roots initiated by conifer seedlings such that for container grown stock better formed root plugs are produced.

- The timing of application for all species seems to be similar with applications between 20 and 40 (30 best) days from sowing most effective.

- The rate (concentration) of NAA applied as a soil drench to container grown conifers varies between species. Recommended rates which minimize negative effects on shoot growth yet promote substantial root initiation are 20 $mgl^{-1}$ for Douglas-fir; 10 $mgl^{-1}$ for Ponderosa pine and western larch, and 2 $mgl^{-1}$ for lodgepole pine.

- Although the root form and vigour of container grown seedlings after outplanting may be enhanced by NAA treatment, early field performance results from Douglas-fir and western larch outplantings do not indicate enhanced field growth. Negative effects of NAA treatment on field growth have not been observed.

- NAA treatment of bareroot Douglas-fir and Ponderosa pine nursery stock may result in increased numbers of first order lateral roots. Further investigation of the rate of NAA application at 30 days from sowing in required.

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