Rooting of Douglas-fir Stem Cuttings: Relative Activity of IBA and NAA

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Abstract. The effects of naphthaleneacetic acid (NAA) and indolebutyric acid (IBA) on rooting, root quality, and budbreak of Douglas-fir [Pseudotsuga menziesii (Mirb.) Franco] stem cuttings were studied. Between 1 and 100 mg/liter, NAA was more effective than IBA in stimulating rooting. Regression analysis indicated that the highest rooting response to NAA was centered on 7.4 mg/liter, whereas 100 mg/liter IBA, the highest concentration tested, was the most effective. NAA concentration significantly affected budbreak percentage. Root quality was weak, but not significantly affected by auxin concentration.

Auxins are important agents for rooting cuttings of woody plants. Of the synthetic auxins tested, IBA and NAA stimulate rooting most effectively (8), but IBA is used more frequently than NAA because IBA was reported to have higher activity, a broader range of effective concentrations without toxicity, and to be effective in more species (4, 6, 7). Based on these observations, IBA usually is the central, if not the only, auxin used in woody plant propagation.

As part of a project to select and propagate superior Douglas-fir clones for the Pacific Northwest Christmas tree industry, a study of auxin treatments was initiated in order to improve utilization of the root-promoting properties of NAA and IBA, and to develop practical guidelines for commercial nursery production. The initial work evaluated the relative root-inducing activities of a wide range of IBA and NAA concentrations as well as the effects of IBA and NAA on root quality and bud growth.

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Fig. 1. Regression curves describing the rooting response of Douglas-fir cuttings to NAA and IBA. Data transformed by arcsin square root (proportion).

Table 2. Regression equations for rooting, root quality score, and bud burst of NAA- and IBA-treated Douglas-fir cuttings.

<table>
<thead>
<tr>
<th>Regression equation</th>
<th>NAA</th>
<th>IBA</th>
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<tbody>
<tr>
<td>sin⁻¹/rooting %</td>
<td>IBA = 4.8 + 9.24 ln mM</td>
<td>NAA = 24.7 + 30.19 ln mM − 7.55 (ln mM)²</td>
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<tr>
<td>sin⁻¹/bud burst %</td>
<td>IBA = 43.6</td>
<td>NAA = 37.4 ± 9.13 ln mM − 2.49 (ln mM)²</td>
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Because these Douglas-fir clones root poorly (0% to 5%) without auxin, untreated checks were not included. Following auxin treatment, the cuttings were stuck 5-6 cm deep in a medium of 4 coarse quartz sand: 1 peat (v:v) heated to 20°C ± 2°C with lead cables. Day/night air temperature was 15°C ± 4°C under natural light. Mist frequency was regulated by a Solutrol controller (General Scientific Equipment Corp., Hamden, Conn.) and time switch. The experimental design was a randomized complete block with 2 replications of 15 cuttings per treatment each year. Cuttings were evaluated the following August for root formation, root quality, and bud break. Bud break was rated by the percentage of cuttings with one or more buds that flushed and set a new bud. Data from 1982 and 1983 were fitted to quadratic functions by multiple regression analysis and then subjected to unbalanced analysis of variance. The IBA data were essentially linear, however, and are presented as such. Arcsin data can be converted to proportions by ŷ = (sin x)².

NAA was more active than IBA in stimulating rooting of the Douglas-fir clones tested in 1982–83. Analysis of variance indicated highly significant differences among clones and years, between NAA and IBA, and among concentrations applied (Table 1). The regression suggested that concentrations around 7.4 mM NAA should stimulate the highest rooting percentage, an average for all 5 clones of 67%, whereas with IBA treatment, the highest average rooting percentage, about 54%, was expected from 100 ppm IBA (Fig. 1, Table 2). Since 100 ppm IBA (20,300 ppm) was the highest concentration tested, it remains unclear what effects even higher concentrations of IBA would have on rooting. The auxin concentrations eliciting the best rooting percentage generally produced the best root systems as well, although the differences were small and not significant (data not shown).

Many buds, both terminal and lateral, on the cuttings, both rooted and unrooted, failed to grow. The regressions in Fig. 2 suggest a correlation of the NAA concentrations stimulating the highest rooting percentages with an increased percentage of bud burst. The interaction of NAA concentration and bud burst was significant at the 5% level (Table 1), whereas there was no effect of IBA on bud burst (Fig. 2). The ANOVA indicated that bud break was strongly correlated with the clone (Table 1).

The observation presented here, that root formation on Douglas-fir cuttings was more sensitive to NAA than to IBA, contrasts with earlier work on Douglas-fir (3). Griffith used IBA, IAA, and NAA 24 hr soaks and demonstrated that IBA and IAA were much more effective than NAA. Using equivalent concentrations and treatment in 1983, NAA was still found to be more effective than IBA (unpublished data). The discrepancy is clear; however, Griffith’s trials were conducted without mist or bottom heat, a radical change of environment.

Very few studies have compared rooting activities of IBA, NAA, or other auxins thoroughly in a species. Most previous work suggested that IBA was more active than NAA (4, 6, 7). Delargy and Wright (2) demonstrated that IBA stimulated slightly more rooting of apple cuttings than did NAA. A report of the relative rooting activities of several auxins of Pinus radiata indicated that β-naphthoxyacetic acid > IBA > NAA (1). Hinesley and Blazich (5) reported that 5000 ppm (24.6 and 49.3 ppm) IBA caused more rooting of Abies fraseri cuttings than 5000 ppm (26.9 ppm) NAA.

Hartmann and Kester (4) noted that IBA is most often recommended as a rooting agent because it is less phytotoxic over a broader range of concentrations and active in more species than other auxins. In Douglas-fir, NAA was supraoptimal and presumably phytotoxic above 7.4 mM, whereas IBA caused no apparent phytotoxicity at 100 ppm, the highest concentration tested. NAA was more effective than IBA up to at least 20 ppm in eliciting superior rooting, root quality and budbreak. Perhaps IBA concentrations greater than 100 ppm (20,300 ppm) would be more effective than 7.4 ppm (1376 ppm) NAA, but in these trials, NAA was clearly more effective in the range of concentrations traditionally encountered. The effective concentration range of about 3–10 ppm NAA should be broad enough to avoid phytotoxicity.

Due to disease and other poorly understood reasons, many buds on Douglas-fir cuttings failed to grow. One viable bud per cutting will suffice, but even this level was often not achieved. Reduced mist and regular fungicide applications improved bud budbreak, but problems remained. The data pre-
In summary, NAA was more active than IBA in eliciting rooting of Douglas-fir cuttings in response to the concentrations tested and under the conditions described. NAA concentrations stimulating the best rooting also tended to produce more budbreak. Rooting of Douglas-fir cuttings seemed to be very sensitive to auxin application. Therefore, attention to auxin relationships significantly improved the yield and quality of rooted cuttings and improved use of this important propagation tool. Furthermore, the contrast with Griffith’s report suggests that some environmental factors affect auxin activity. These are being studied.

Literature Cited

Evaluation of Some Indigenous Western Plants for Xeric Landscapes

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Abstract. Forty-five indigenous Western plants, mostly herbaceous perennials, were transplanted into a field plot and evaluated for water requirements and landscape value. The majority of species showed no significant differences in growth between irrigated and nonirrigated treatments. Several species are suggested for use as ornamentals in dryland or low-maintenance situations.

Climatic and soil factors limit the number of plant materials which can be effectively utilized for landscape purposes in the High Plains region (4, 6). Short growing seasons, low precipitation and humidity, desiccating winds, high solar intensity, fluctuating temperatures, and calcareous clay soils low in organic matter exclude many exotic ornamentals. Plants indigenous to the area have adapted to these adverse conditions (4, 5, 6). Some of these are being used as ornamentals, but many other attractive native plants generally are unavailable and represent potential introductions into the nursery trade (5, 6). Current availability of most dryland native plants is limited to collectors and specialized nurseries in the area. Demand is increasing, however, for attractive, low-maintenance, drought-enduring ornamentals (5, 6, 8). The catalysts for this demand include population influx, water shortages and concomitant rate increases, environmental concerns, and lifestyle demands (4, 5, 6).

Direct seeding of indigenous species may be useful for highway beautification (7, 8). In the home landscape, direct seeding may be initially more economical than buying containerized nursery plants, but necessary irrigation may favor the appearance of weed species. Confusion may arise as to which is the desirable plant. The increasing demand for low-maintenance ornamentals and the need for them as sizeable containerized plants gives the nurseryman a new area of opportunity. This research was initiated to evaluate several native species for use as low-maintenance ornamentals.

Seeds of 45 different species (most of which are native to one or more of the Four Corners states—Ariz., Colo., N.M., Utah) were obtained from collectors in the area (Tables 1 and 2). Following typical pregermination treatments, all species germinated in a greenhouse in sufficient numbers to provide an adequate supply of test plants. Seedlings were transplanted twice, from a germination flat to 5.7 cm pots and later to 11.4 cm pots. Growing medium consisted of 1 native clay