United States Department of Agriculture

Forest Service

Pacific Northwest Research Station

Research Note PNW-RN-465

Rooting Sitka Spruce From Southeast Alaska

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Abstract

Rooting and shoot growth characteristics of 10-, 15-, and 20-year-old Sitka spruce cuttings were studied. Twigs from three branch orders were tested with or without 5000 parts per million indole-3-butyric acid (IBA) hormone treatment. Rooting success averaged 64 percent. The effect of ortet age on rooting success was not significant. Cuttings from first-order branch positions rooted slightly better than cuttings from second- and third-order positions. Cuttings treated with the IBA hormone had slightly poorer root induction than control cuttings for all ortet age-branch order combinations, except first-order twigs from 15- and 20-year-old trees. Stecklings from 10-year-old ortets had greatest 1st-year shoot growth and lowest cull rate when they were transplanted and less plagiotropic growth than cuttings from 15- and 20-year-old ortets.

Keywords: Rooting ability, Sitka spruce, *Picea sitchensis,* southeast Alaska, Alaska (southeast), vegetative propagation.

Introduction

An opportunity exists for genetically improving new stands in southeast Alaska if positive selection pressure can be exerted during precommercial thinning. Unfortunately, little is known about genetic control of juvenile traits considered important to timber production or wildlife habitat. Ramets of clones of Sitka spruce *(Picea sitchensis* (Bong.) Carr.) are needed as test material from which broad sense heritability values for traits can be calculated. Such estimates can be obtained from measurements of rooted cuttings (Gill 1983) and would be of great help in establishing sound thinning guidelines.

If cloned trees are to be available for measurement, effective means of rooting stem cuttings of Sitka spruce must be found. Considerable information on rooting of *Picea* species has been published (for example, Roulund 1971, van den Driessche 1985). Evaluation of these published techniques and results will assist in selection of rooting methods and procedures most likely to promote favorable rooting.

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Many factors of ortet physiology, cutting treatment, and rooting medium can influence rooting success and steckling performance. Rooting percentage of conifer cuttings is usually affected by age of ortet and original position of the cutting in the crown. Cuttings from older spruce trees have poorer rooting percentage than cuttings from younger ortets (Roulund 1973). Rooting of Norway spruce *(Picea abies* (L) Karst) decreases from 65 percent for cuttings from 6-year-old ortets to 9 percent for cuttings from 40- to 60-year-old ortets (Kdhn 1976). Considerable variation among ortets is common. Sitka spruce cuttings from the lower crown root better than cuttings from the upper crown (van den Driessche 1983). Rooting of 13-year-old trees is 24 percent from the lower crown and only 10 percent from the upper crown. Norway spruce cuttings show a similar response (Girouard 1971).

Time of collection of cuttings from ortets also influences rooting success. Rooting of Sitka spruce is better when branch tips are collected in January and February than from October through December. They can also be collected in August and rooted in the fall (Roulund 1978). A study of Norway spruce indicates that cuttings may root better when gathered in July and August than from February to April (Bogdanov 1983).

Plagiotropic growth, which is related both to ortet age and cutting position in the crown, is an undesirable trait in stecklings. In Sitka spruce, plagiotropic growth is a greater problem in cuttings from old trees than from young trees (Gill 1983). Cuttings from 12-year-old Norway spruce ortets also exhibit more plagiotropic growth than do cuttings from 2-year-old ortets: Cuttings from the lower crown of Norway spruce are less plagiotropic than cuttings taken from the upper crowns of the same trees (Girouard 1971, Roulund 1979).

Results of hormone treatments of spruce cuttings vary. Two favorable indole-3-butyric acid (IBA) treatments for Sitka spruce are 25 mg/liter in a 24-hour soak and 3000 mg/liter in a 5-second dip. The average of the two treatments is 55-percent rooting for 8- to 11 -year-old trees vs. 38 percent for the untreated controls (van den Driessche 1985). When indole-3-acetic acid (IAA) is applied to Norway spruce cuttings in a dilute-soak treatment, rooting percentage improves slightly and the roots appear sooner.

Deneedling the base of cuttings is often done before cuttings are placed in the rooting medium, but removing the needles may damage the stem tissues. In black spruce (*Picea mariana* (Mill.) B.S.P) (Phillion and others 1982) and Norway spruce (Roulund 1971), decreased rooting occurs when the basal 2 to 3 cm of cuttings are deneedled. Basal needles were removed from cuttings in the studies of Sitka spruce by van den Driessche (1983, 1985).

Rooting media can influence rooting percentage and root structure of conifer cuttings (Copes 1977). Successful rooting media for Sitka spruce are mixtures composed of equal parts (by volume) of peat, sand, and perlite (van den Driessche 1983) or of coarse grit and sphagnum peat moss in volume ratios ranging from 1:1 to 4:1 (Mason 1984). Other trials, however, of media with sand, sphagnum peat moss, and perlite indicate that the media do not Influence rooting success (Roulund 1971).

This report describes the rooting response and the 1st-year growth of cuttings gathered from 10-, 15-, and 20-year-old ortets in southeast Alaska. The purpose of the experiment was to determine the rooting capacities and growth characteristics of cuttings from trees of three precommercial thinning ages. Cuttings from three different branch orders were tested with and without the IBA rooting hormone.

Methods

In January 1985, cuttings were collected from Sitka spruce trees growing in three clearcuts near Petersburg, Alaska. The ortets were about 10,15, and 20 years old (±2 years). The trees were representative of trees growing on sites where precommercial thinning had been done or soon would be done. Five trees of each age class were sampled. Selection was solely for age uniformity within each age class. Cuttings were collected from the lower one-third of the crown; 7 first-order, 14 second-order, and 14 third-order branch tips were gathered from each tree and kept separate for each tree by branch order. The cuttings ranged from 50 to 150 mm in length and from 2 to 6 mm in diameter. The newly clipped twigs were placed on ice at collection and shipped by air to Corvallis, Oregon, where they were stored for about 2 weeks at 1° Celsius.

The base of each cutting was cut to expose fresh tissue shortly before it was placed in the rooting bed. The entire cutting was soaked for 1 minute in a saturated solution of Captan-50,[1/] and then the basal 2 cm of each cutting was soaked for 5 seconds in either 5000 mg IBA/liter (dissolved in 50 percent ethanol) for hormone treatment, or in just 50 percent ethanol for control treatment. Needles were not removed from the base of the cuttings. The cuttings were planted 1 to 2 cm deep at a 5- by 5-cm spacing.

Rooting was done in a plastic-covered greenhouse at Corvallis. The rooting medium consisted of equal volumes of peat moss and coarse vermiculite. Bottom heat was maintained at 21 °C (±2 °C). A conventional mist system maintained high humidity during daylight hours. Foliage of the cuttings was allowed to be dry at night to retard foliage diseases. A weekly spray program with one of four fungicide sprays (Captan-50, Benlate, Banrot, and Ferban) was used to prevent disease. Weekly application of 20:20:20 (NPK) water-soluble fertilizer was begun when new roots first became visible and was continued through August.

A total of 525 cuttings were placed in the rooting beds (15 trees x 35 cuttings per tree). Seven cuttings of the second-order and seven cuttings of the third-order branch tips from each tree were treated with IBA; an equal number of similar twigs that did not receive the IBA treatment served as controls. Only seven first-order twigs could be obtained from the lower third of each 10-year-old tree, so only seven were collected from each of the 15- and 20-year-old trees. First-order twigs from half of the trees received either the hormone or the control treatment, but there was no reciprocal control or hormone treatment for individual trees. Cuttings of each tree by branch order by hormone treatment combination were placed at random in the rooting beds in rows of seven twigs.

[1/] Use of trade names in this publication is for the information of the reader and does not constitute an endorsement by the U.S. Department of Agriculture of any product to the exclusion of others that may be suitable.

Three growth traits and rooting success were measured or calculated after growth ceased in October 1985. The trait defined as "cull rate" referred to the percentage of cuttings with weakly developed roots that were judged to be too poor to warrant transplanting. The degree of plagiotropism was visually quantified by classifying each rooted cutting that had new shoot growth in 1985 as orthotropic (0), slightly plagiotropic (1), or very plagiotropic (2). Cuttings that did not burst bud in the rooting bed could not be evaluated for plagiotropism. First-year shoot growth was measured from the base of the terminal bud scar to the tip of the 1985 terminal. Growth was measured to the closest millimeter.

Trees were the units of replication for statistical analysis of rooting percentage success; no replication of individual hormone treatment by branch-type combinations was possible because individual trees had only seven first-order cuttings. Replication was increased for analysis of data for plagiotropism, cull rate, and shoot growth by combining data from the two hormone treatments because hormone treatment had little or no effect on growth traits. Growth traits were measured only on rooted cuttings. Percentage data were subjected to arcsin transformation before analysis of variance. Extremely conservative weighted analysis of variance was used to compensate for the unbalanced design of the study.

Results

Rooting success increased with ortet age, but the differences between ages were not significant (tables 1 and 2). Orthogonal comparisons were made for ortet ages—10 vs. (15 + 20) and 15 vs. 20—but results in the tables were combined because of lack of significance of the individual comparisons. None of the main treatments nor interactions for rooting success or growth traits were significant. Reasons for test insensitivity are presented under "Discussion." Lack of significance in rooting success for hormone vs. control treatments was surprising because the controls averaged 70-percent rooted cuttings and only 59-percent hormone-treated cuttings (table 2). The effect of hormone treatment on rooting success of second- and third-order branches from 15- and 20-year-old ortets was also large. The control cuttings rooted much better than the hormone-treated cuttings (67 and 72 percent vs. 55 and 56 percent, respectively).

Most cuttings from all three ages of ortets grew plagiotropically at the end of the 1st year. Cuttings of all 15 ortets exhibited similar degrees of plagiotropic growth, but cuttings from first-order branch tips were slightly more orthotropic than second and third order (tables 2 and 3).

Shoot growth the year of rooting was limited and averaged only 40 mm per tree. Growth of cuttings from 10-year-old ortets was greater than from the 15- and 20-year-old trees (table 3), but again the differences were not significant Cuttings taken from first-order branches grew slightly longer shoots than cuttings taken from second- and third-order twigs (table 2).

The cull rate at transplanting was directly related to ortet age: Fewer culls were found in rooted cuttings from 10-year-old ortets than from 15- and 20-year-old ortets (1 vs, 11 and 12 percent) (tablets 2 and 3). Four of foe five io-year-old ortets had no cull seedlings, even though there were 75 rooted cuttings from those four ortets. Branch order did not appear to influence the percentage of weakly rooted cuttings.

Table 1—Analysis of variance test of rooting success, plagiotropism, cull rate, and shoot growth of Sitka spruce cuttings

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F values	Significance of F values
Rooting success:					
Error 1	12	4.67858	0.38988		
Ortet age (A)	2	.11131	.05566	0.14275	0.87
Error 2	44	2.74123	.06092		
Branch order (B)	2	.03032	.01516	.24890	.78
Hormone treatment (H)	1	.04743	.04743	.77855	.38
A X B	4	.18575	.04644	.76231	.56
A X H	2	.08827	.04414	.72447	.49
B X H	2	.00687	.00343	.05636	.95
A X B X H	4	.07747	.01937	.31792	.86
Plagiotropism:					
Error 1	12	3.83645	.31970		
Ortet age (A)	2	.07531	.03766	.11780	.90
Error 2	20	3.65593	.18280		
Branch order (B)	2	.60160	.30080	1.64551	.22
B X A	2	.12584	.06292	.34420	.71
Cull rate:					
Error 1	12	.49320	.04110		
Ortet age (A)	2	.01445	.00723	.17591	.84
Error 2	22	.37143	.01688		
Branch order	2	.00655	.00328	.19431	.83
B X A	4	.10175	.02544	1.50696	.24
Shoot growth:					
Error 1	12	7738.18344	644.84862		
Ortet age (A)	2	353.41520	176.70760	.27403	.77
Error 2	21	1396.56682	66.50318		
Branch order (B)	2	78.76706	39.38353	.59221	.56
B X A	4	242.97906	60.74477	.91341	.47

Table 2—Rooting success, plagiotropic growth, cull rate, and shoot growth of 1st-, 2d-, and 3d-order branch tips from 10-, 15-, and 20-year-old Sitka spruce trees[1/]

Ortet age and branch order	Rooting success of hormone treatment 2/											
	0 p/m IBA		5000 p/m IBA		Average rooting		Average plagiotropism 3/		Cull rate		Shoot growth	
	Percent		Percent		Percent				Percent		mm	
10 years:												
1	93	(2)	67	(3)	77	(5)	1.3	(4)	0	(4)	51	(4)
2	57	(5)	57	(5)	57	(10)	1.4	(7)	0	(7)	57	(7)
3	63	(5)	51	(5)	57	(10)	1.5	(8)	2	(8)	45	(8)
Mean	66	(12)	57	(13)	61	(25)	1.4	(19)	1	(19)	51	(19)
15 years:												
1	52	(3)	71	(2)	60	(5)	1.2	(4)	7	(5)	33	(4)
2	74	(5)	57	(5)	66	(10)	1.4	(9)	14	(9)	25	(9)
3	77	(5)	54	(5)	66	(10)	1.3	(9)	10	(9)	31	(9)
Mean	70	(13)	58	(12)	65	(25)	1.3	(22)	11	(23)	29	(22)
20 years:												
1	71	(2)	76	(3)	74	(5)	1.6	(4)	12	(5)	44	(5)
2	71	(5)	51	(5)	61	(10)	1.6	(9)	13	(10)	40	(9)
3	77	(5)	63	(5)	70	(10)	1.3	(10)	11	(10)	39	(10)
Mean	74	(12)	61	(13)	67	(25)	1.5	(23)	12	(25)	40	(24)
All ages:												
1	69	(7)	71	(8)	70	(15)	1.3	(12)	7	(14)	43	(13)
2	67	(15)	55	(15)	61	(30)	1.5	(25)	10	(26)	39	(25)
3	72	(15)	56	(15)	64	(30)	1.4	(27)	8	(27)	38	(27)
Mean	70	(37)	59	(38)	64	(75)	1.4	(64)	8	(67)	40	(65)

1/ Numbers in parentheses are the number of rows of 7 cuttings (replications) on which each weighted mean is based.

2/ IBA = indole-3-butyric acid.

3/ 0 = orthotropic, 1 = slightly plagiotropic, 2 = very plagiotropic.

Table 3—Average rooting success, plagiotropism, cull rate, and shoot growth of cuttings from individual trees in the 10-, 15-, and 20-year-old classes[1/]

Ortet age and tree number	Rooting success 2/		Plagiotropism 3/		Cull		Shoot growth	
	Percent				Percent		mm	
10 years:								
1	91	(5)	1.4	(5)	3	(5)	50	(5)
2	23	(5)	1.2	(2)	0	(2)	22	(2)
3	83	(5)	1.4	(5)	0	(5)	35	(5)
4	100	(5)	1.5	(5)	0	(5)	83	(5)
5	9	(5)	1.3	(2)	0	(2)	54	(2)
Mean	61	(25)	1.4	(19)	1	(19)	51	(19)
15 years:								
1	69	(5)	1.6	(5)	19	(5)	29	(5)
2	97	(5)	1.3	(5)	0	(5)	32	(5)
3	23	(5)	1.4	(3)	0	(4)	21	(3)
4	43	(5)	1.1	(4)	13	(4)	39	(4)
5	91	(5)	1.3	(5)	19	(5)	24	(5)
Mean	65	(25)	1.3	(22)	11	(23)	29	(22)
20 years:								
1	49	(5)	1.3	(5)	12	(5)	46	(5)
2	81	(5)	1.9	(5)	3	(5)	44	(5)
3	89	(5)	1.5	(5)	13	(5)	41	(5)
4	40	(5)	.9	(40)	21	(5)	24	(4)
5	79	(5)	1.8	(4)	0	(5)	44	(5)
Mean	67	(25)	1.5	(23)	12	(25)	40	(24)
Mean of all ages	64	(75)	1.4	(64)	8	(67)	40	(65)

[1/] Numbers in parentheses are the numbers of rows of 7 cuttings (replications) on which each mean is based.

[2/] Rooting success for each ortet was based on 5 replications of 7 cuttings, whereas growth trait data were based soley on measurements within replications where rooting had occurred.

[3/] 0 = orthotropic, 1 = slightly plagiotropic, 2 = very plagiotropic.

Discussion

Ten- to twenty-year-old Sitka spruce can be cloned easily with rooted cuttings. Trees of precommercial thinning age can be rooted and, in later years, broad sense heritability values for selected phenotypic traits can be determined from the rooted cuttings. Only small differences in rooting success were found between trees of the three age classes. No ortet failed to root, but 3 of 15 ortets averaged less than 25-percent rooting. Thus, about 20 percent of ortets selected for cloning programs might not be suitable if many ramets per clone are needed. Selecting 25 percent more ortets than are actually needed will compensate for the trees that root poorly.

Rooting success was better than; published reports suggest Better rooting probably resulted from a more favorable rooting environment Rooting success of the/ control treatment—70- and 74-percent for 15- and 20-year-old ortets, respectively—was higher than the reported 54-percent .rooting obtained with optimum IBA treatment on cuttings of 17-year-old Sitka spruce ortets or the 38 percent for control cuttings (van den Driessche 1985). Rooting results similar to those from the 15-year-old ortets were reported for Sitka spruce cuttings gathered from hedges of 14 to 16-year-old ramets

(69-percent rooting) (van den Driessche 1983). Eighty-three percent rooting was obtained with cuttings from 8-year-old ramets (Roulund 1971); cuttings from younger ortets and serially propagated hedges usually root more successfully than do cuttings from older ortets. For the cuttings from the oldest ortets to root best is unusual. Such an occurrence may simply be the result of sampling only five ortets in each age class.

Study of hormone and branch-order effects on rooting success indicated that, under the environmental conditions of this study, considerably better rooting occurred without hormone treatment. The difference of 11 percent between 70- and 59-percent rooting for 0 and 5000 p/m IBA, respectively, was large but not statistically significant. Lack of significance resulted because of the insensitivity of the analysis. An extremely conservative analysis of variance test was used to compensate for irregularities caused by the small sample size and the unbalanced design of the study. The sensitivity problem was compounded even more in the analysis of the three growth traits because measurements could be taken only on cuttings that had rooted; thus they had fewer datum points than for rooting success, where all cuttings were evaluated. An experiment with greater replication and an equal number of cuttings of each branch order would have been more sensitive, and significance might have been detected for several variables—especially for the difference in rooting between second- and third-order shoots of 15- and 20-year-old ortets.

Insensitivity in detecting significant treatment differences was even more pronounced for the cull-rate analysis because the only cuttings evaluated were those that both had rooted and had new shoot growth in 1985. Far fewer culls were found with cuttings from 10-year-old ortets than from 15- and 20-year-old ortets, yet the analysis of variance indicated no significance. The difference in cull rate may relate to cuttings of younger ortets rooting more rapidly or to having the inherent ability to induce the formation of more abundant adventitious root primordia. Greater vigor of cuttings from younger ortets was also suggested by longer shoot growth of cuttings from 10-year-old ortets.

The 5000 p/m IBA treatment, the same treatment that is very good for Douglas-fir cuttings (Copes 1983), may be too concentrated for promoting rooting of Sitka spruce. It appeared to decrease rooting of second- and third-order branch tips of 15- and 20-year-old ortets. Similar reduction in rooting success was not seen with cuttings from 10-year-old ortets. One researcher found that a 3000 p/m IBA treatment applied as a quick dip stimulated rooting in Sitka spruce cuttings, but the treatment was less successful than a 25 p/m treatment applied as a dilute soak (van den Driessche 1985). Both the dilute soak and the quick dip IBA treatments gave better rooting results than the control. In Douglas-fir cuttings, noticeable differences in rooting were noted when IBA treatment was applied to twigs of different branch orders (Roberts and Fuchigami 1973). A direct comparison of the present study's 5000 p/m IBA treatment with published reports in which different concentrations of IBA were used is difficult because the control cuttings of the present study rooted better than the best hormone treatments reported in the literature.

The high incidence of plagiotropic growth the year of grafting is not unexpected with conifer cuttings from 10- to 20-year-old ortets (Wuhlisch 1984). Observations must be taken in a few years on the transplanted cuttings to determine the extent and duration of the condition. If cuttings from younger ortets are less likely to be plagiotropic, they would be better for clonal tests. The same condition is true of branch-order effects on leader growth and tree form.

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June 1987