Von den im Alter von 9 Jahren zu den 20 größten Bäumen, zählten nur noch 2 (10%) im Alter von 50 Jahren zu den 20 größten; von denen im Alter von 15 Jahren sind es 3 Bäume (15%), von denen im Alter von 23 Jahren sind es 9 Bäume (45%), von denen im Alter von 35 Jahren sind es 12 Bäume (60%), aber von denen im Alter von 40 Jahren sind es 14 Bäume (70%), von denen im Alter von 42 Jahren sind es 15 Bäume (76%), die zu den 20 größten gehören und gut gewachsen sind. Alle anderen sind im Wettbewerb zurückgeblieben. Daraus erkennt man, daß wenn zwar die Bäume in jungem Alter unter den Wachstumsbesten sind, bleiben sie oft zurück je weiter das Baumalter fortschreitet.

III. Schlußfolgerungen

In Japan wird seit 1957 eine Elitebaumauslese durchgeführt, und ihre Klone werden in den Waldgebieten im ganzen Land ausgepflanzt. In jedem Gebiet ist ein Zuwachsprüfungswald angelegt und die Forschungen machen Fortschritte. In letzter Zeit wurde die Frage aufgeworfen, bis zu welchem Alter die Untersuchungen in den Zuwachsprüfungswäldern durchgeführt werden sollten. Ich denke, daß die oben beschriebenen Versuchsergebnisse hierauf eine Antwort geben können. In den Untersuchungen während 50 Jahren erkannte man, daß es im Wachstum der Zedern die 4 Typen (1) Wasetypus, (2) Okutetypus, (3) Dauerzuwachstypus und (4) Nicht-Dauerzuwachstypus gibt. Deshalb ist es gefährlich, vom Wachstum in den frühen Jahren auf das Wachstum in den späteren Jahren zu schließen. Man kann also die Schlußfolgerung ziehen, daß wenigstens 40 oder 42 Jahre lang, wenn möglich sogar 45 Jahre lang Untersuchungen in den Zuwachsprüfungswäldern durchgeführt werden sollten, wenn man 50 Jahre als Haubarkeitsalter betrachtet.

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The IUFRO *Abies grandis* Provenance Experiment in Germany

– Results at Age 18/19 –[1])[2])

By J. KLEINSCHMIT[3]), J. SVOLBA[3]), H.-M. RAU[4]) and H. WEISGERBER[4])

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Abstract

The results of the IUFRO Grand-fir provenance experiment in northern and central Germany at age 18/19 are presented for height, diameter, volume and losses. The experiment was planted on 13 sites, 12 of which are included here.

The provenances represent the coastal part of the natural range in British Columbia, Washington and Oregon quite well. From the continental part only 3 Idaho provenances are included.

In addition to 41 IUFRO provenances 22 other provenances are included, 5 from Vancouver Island and the rest from Oregon, where 11 represent elevational transsects.

In height growth low and mean elevation provenances from northern Washington, from Vancouver Island, Coastal Southern Washington, and North Oregon are performing best. The same is true for diameter growth and volume with a slightly better performance of Oregon sources in diameter due to the higher losses in the Oregon provenances.

Differences between test sites are considerable and explain roughly 2 thirds of total variation for quantitative characters. They are most drastic for losses, where also more rank change occur between provenances than for height and diameter. Volume differences of provenances range from 30% to 176% of standard provenances mean.

An overall ranking including height, diameter, and losses shows that 7 Washington provenances, 3 B. C. provenances and 1 Oregon provenance surpass the overall mean by at least 10%.

Correlations with earlier measurements of the same experiment demonstrate that early selection is not very precise and that indirect selection would not have been possible with the characters under consideration.

Key words: Abies grandis, provenance experiment, geographical variation, height, diameter, volume, losses.

FDC: 232.12; 165.52; 174.7 *Abies grandis;* (430).

Zusammenfassung

Der IUFRO Abies grandis-Herkunftsversuch in Deutschland. – Ergebnisse im Alter 18/19.

41 Herkünfte der IUFRO-Sammlung sowie 22 weitere Herkünfte der großen Küstentanne wurden in Nord- und Mitteldeutschland auf 13 Versuchsflächen angebaut. Für 12 Versuchsflächen werden die Ergebnisse im Alter 18/19 für die Merkmale Höhe, Durchmesser, Volumen und Ausfälle zusammengefaßt.

[1]) Revised version of a paper presented at the IUFRO Meeting in Limoges, France, 1995

[2]) Dedicated to Prof. Dr. LANGNER

[3]) Lower Saxony Forest Research Institute, Dept. Forest Tree Breeding, D-34355 Escherode, Germany

[4]) Hessian Forest Center for Management-Planning, Research and Ecology, Dept. Forest Genetic Resources, D-34346 Hann. Münden, Germany

Die Herkünfte repräsentieren den küstennahen Teil des natürlichen Verbreitungsgebietes in British Columbia, Washington und Oregon ziemlich gut. Aus dem kontinentalen Teil sind nur 3 Herkünfte aus Idaho vertreten.

Im Höhenwachstum haben Herkünfte aus Nord-Washington, von Vancouver Island, dem Küstenbereich in Süd-Washington und Nord-Oregon am besten abgeschnitten. Das gleiche gilt für Durchmesser und Volumenleistung mit etwas besserem Abschneiden der Herkünfte aus Nord-Oregon im Durchmesser, bedingt durch die höheren Ausfälle dieser Herkünfte.

Die Unterschiede zwischen den Anbaustandorten sind ganz beträchtlich und erklären für die quantitativen Merkmale etwa 2/3 der Gesamtvariation. Die auffälligsten Unterschiede zwischen den Standorten traten bei den Ausfällen auf, wo auch mehr Rangänderungen der Herkünfte zwischen den Standorten festgestellt wurden als bei Höhe und Durchmesser.

Die Unterschiede in der Volumenleistung der Herkünfte reichen von 30% des Gesamtmittels bis zu 176% des Gesamtmittelwertes.

Bildet man eine Gesamtrangfolge aus Höhe, Durchmesser und Ausfällen, dann übertreffen 7 Washington-Herkünfte, 3 British-Columbia-Herkünfte und eine Oregon-Herkunft den Mittelwert des Standards um mehr als 10%.

Korrelationen mit den früheren Aufnahmen der gleichen Versuchsflächen zeigen, daß eine Frühselektion keine zuverlässigen Ergebnisse geliefert hätte und daß eine indirekte Selektion mit den beobachteten phänologischen und quantitativen Merkmalen nicht möglich gewesen wäre.

1. Introduction

Grand-fir (*Abies grandis* LINDL.) is one of the important tree species introduced to Germany from western North America. It has by far not the importance of Douglas-fir but it is of interest due to the growth potential and its silvicultural characteristics.

First plantations have been established more than 100 years ago. On fertile sites Grand-fir surpasses all other exotics except *Sequoiadendron giganteum* and all indigenous species. Because of the higher nutrient requirements Grand-fir is of interest for better sites as compared to Douglas-fir (ALPERS, 1960; KRAMER, 1976).

Grand-fir shows less damages by deer and insects in Germany than *Abies alba* (BURCHARD, 1960).

The only older provenance experiment was planted in 1965 with 7 provenances from Oregon, Washington and British Columbia (all coastal) on 3 sites in northern Germany (KRAMER, 1976). The best provenances in this experiment were Denman Island (BC) followed by the Washington provenances Wind River, Snoqualmie and Randle. This experiment did not cover the interior part of the natural range and the provenances dot not represent the coastal part of the range very well either. The results of this experiment are in quite good agreement with the results reported by LACAZE (1976) with the same provenances for France and by LINES (1974) for Great Britain. A summarizing report about silvicultural behaviour and first results of the IUFRO Grand-fir provenance experiment were published in 1978 (RÖHRIG, 1978).

The IUFRO collection was planted on 13 field experiments in northern and central Germany one of which had to be omitted (*Fig. 1, Tab. 2*). In addition 3 field tests with a separate collection were established by RUETZ in Bavaria.

The nursery results and the early field performances were reported by KLEINSCHMIT (1978, 1986), KLEINSCHMIT and SVOLBA (1979) and RAU et al. (1990, 1991). The last publication summarized the results at age 12 and 13, respectively. Here the results at age 18/19 will be presented for 12 field experiments. The same material was tested on 4 test sites by the Federal Research Institute in northern Germany. The results up to the age of 15 years were reported by KÖNIG (1995).

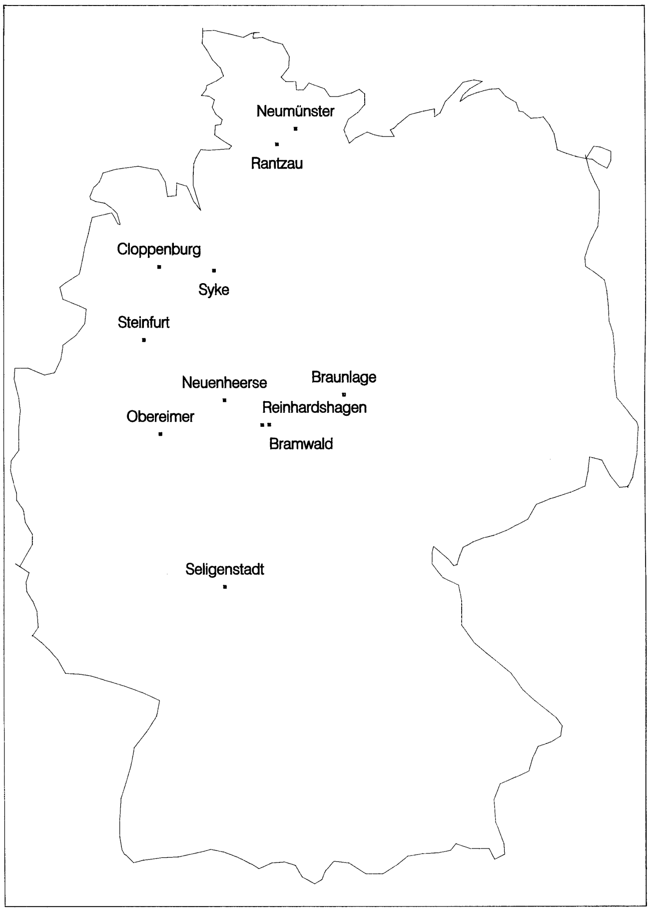

Figure 1. – Abies grandis – Provenance Test, location of sites.

2. Material and Methods

63 Grand-fir provenances (*Table 1*) were sown 1976 and 1977 in Lower Saxony and Hesse. 41 originate from the IUFRO collection organized by ALAN FLETCHER (1986), 5 from a collection of Reid Collins (commercial collection) and 17 from a collection of RUETZ.

The provenances cover the coastal part of the natural range in Oregon (O), Washington (W) and British Columbia (BC) quite well, Idaho (ID) is represented by 3 provenances 2 of which were planted on 2 test sites and 1 only on 1 test site only.

11 provenances of the RUETZ collection represent elevational transsects in Oregon (Philomath 228 m, 380 m; Santiam River-Sweet Home 228 m, 380 m, 532 m, 684 m, 836 m; Santiam Pass-Sisters 684 m, 836 m, 988 m, 1140 m).

The results of these will be presented in the Figures separately (see *Fig. 2*). 46 provenances are common to 9 field tests and only 26 provenances are common to all field tests. These are used as standard provenances and all single values were expressed in relation to these standard provenances, the mean of which were put 100% for easier comparison.

The field tests were established in 1980 and 1981 (*Fig. 1*) in 2 m x 2 m spacing with 3 replications and between 16 to 42 plants/plot. Elevation ranges from 20 m to 580 m above sea level; annual mean temperature from 5.7 °C to 9.0 °C and average annual precipitation from 674 mm to 1179 mm

Table 1. – *Abies grandis* – IUFRO provenance experiment: variables in percentage of standard provenances 1994. Sowing 1976/1977.

Exp. No.	IUFRO-No.	State	Name	Height	Diameter	Survival	Volume / ha	Vol/stem	Overall ranking
1	**12001**	**W**	**Buck Creek**	**114.7**	**111.5**	**134.9**	**138.2**	**130.7**	**120.3**
2	**12002**	**W**	**Tulalip Indian Res.**	**110.3**	**106.3**	**87.2**	**101.3**	**119.6**	**101.2**
3	**12003**	**W**	**Indian Creek**	**111.5**	**111.5**	**119.9**	**130.7**	**151.6**	**114.3**
4	12004	W	Gardiner	113.7	105.0	98.7	110.6	119.5	105.8
5	**12005**	**W**	**Bear Mountain**	**125.6**	**128.2**	**133.5**	**176.1**	**174.3**	**129.1**
6	**12006**	**W**	**Eagle Creek**	**100.1**	**97.0**	**93.1**	**87.4**	**96.2**	**96.7**
7	12007	W	Eagle Creek	100.9	99.9	133.6	98.3	96.7	111.4
8	**12008**	**W**	**Jack Creek**	**97.1**	**95.9**	**105.7**	**78.7**	**86.4**	**99.5**
9	12009	W	Cougar Flats	99.6	98.4	152.4	97.1	91.2	116.8
10	12010	W	Rattlesnake Creek	96.5	103.4	122.1	82.0	102.4	107.3
11	**12011**	**W**	**Clear Lake**	**100.1**	**101.6**	**136.7**	**100.4**	**97.0**	**112.8**
12	12012	W	Cascade Creek	86.9	88.5	88.8	66.8	73.3	88.0
13	12013	O	Cooper Spur	92.4	93.9	102.8	74.4	85.2	96.3
14	**12014**	**O**	**Beaver Creek**	**98.1**	**100.1**	**102.2**	**83.2**	**94.2**	**100.1**
15	12015	O	Sisi Butte	105.9	109.8	105.2	106.4	116.4	106.9
16	**12016**	**O**	**Santiam Summit**	**91.9**	**94.0**	**121.5**	**73.1**	**77.2**	**102.4**
17	12017	O	Tombstone Prairie	88.0	96.0	100.7	68.4	77.1	94.9
18	12018	O	Big Spring	84.9	88.1	84.1	55.7	77.2	85.7
19	12019	O	Roaring River Ridge	90.2	95.0	110.8	73.5	78.7	98.6
20	**12020**	**O**	**Crescent Creek**	**89.8**	**92.9**	**85.4**	**63.5**	**79.3**	**89.3**
21	12021	O	Whisky Creek	89.0	92.5	87.8	61.9	79.2	89.7
22	12046	BC	Mt. Prevost	95.8	94.3	82.6	87.4	86.7	90.9
23		BC	Courtenay	91.7	87.8	120.1	82.7	73.5	99.8
24		BC	Nanaimo Lakes	104.7	100.3	150.1	118.8	102.4	118.3
25		BC	Kuper Island	92.6	91.3	79.1	77.0	79.2	87.6
26		BC	Duncan	98.4	97.6	104.8	106.8	96.7	100.2
27		BC	Lake Cowichan	103.3	100.7	88.3	106.0	102.7	97.4
28	C-252-1.0	O	Philomath	85.1	86.2	74.3	73.9	75.8	81.8
29	C-252-1.5	O	Philomath	90.7	96.2	88.5	79.7	87.4	91.8
30	C-461-1.0	O	Santiam R. Sweet H.	96.8	99.7	97.8	100.3	104.8	98.1
31	**C-461-1.5**	**O**	**Santiam R. Sweet H.**	**92.2**	**95.0**	**86.0**	**90.6**	**90.6**	**91.0**
32	**C-461-2.0**	**O**	**Santiam R. Sweet H.**	**94.5**	**98.0**	**96.9**	**99.0**	**95.4**	**96.4**
33	C-461-2.5	O	Santiam R. Sweet H.	96.0	97.6	106.8	97.7	95.3	100.1
34	C-461-3.0	O	Santiam R. Sweet H.	90.6	95.9	98.0	98.6	88.9	94.8
35	675-2.5	O	Santiam Pass-Sisters	86.6	89.3	90.3	71.5	71.3	88.7
36	**675-3.0**	**O**	**Santiam Pass-Sisters**	**85.8**	**89.8**	**94.7**	**72.0**	**71.9**	**90.1**
37	675-3.5	O	Santiam Pass-Sisters	77.6	83.2	84.1	52.8	56.7	81.6
38	675-4.0	O	Santiam Pass-Sisters	88.6	88.2	93.1	72.4	71.2	89.9
42	12029	ID	St. Joe Porcup. Creek	92.2	87.1	98.1	69.9	73.7	92.4
43	**12040**	**BC**	**Salmon River**	**119.6**	**112.1**	**134.0**	**161.7**	**137.5**	**121.9**
44	**12041**	**BC**	**Oyster Bay**	**105.5**	**100.4**	**110.6**	**114.2**	**98.7**	**105.5**
45	**12042**	**BC**	**Buckley Bay**	**97.7**	**92.3**	**106.9**	**89.6**	**83.4**	**98.9**
46	**12043**	**BC**	**Sproat Lake**	**94.5**	**96.3**	**109.4**	**97.1**	**88.4**	**100.0**
47	**12044**	**BC**	**Kay Road**	**100.5**	**96.7**	**143.0**	**102.9**	**90.5**	**113.4**
48	**12045**	**BC**	**Yellow Point**	**95.8**	**90.6**	**100.5**	**85.0**	**79.8**	**95.6**
50	12047	BC	Sooke	112.4	108.9	97.2	129.5	124.3	106.1
51	**12048**	**W**	**Duckabush River**	**102.0**	**104.3**	**182.4**	**132.9**	**105.5**	**129.5**
52	**12049**	**W**	**Shelton**	**99.7**	**98.8**	**95.7**	**101.0**	**97.2**	**98.0**
54	**12051**	**W**	**Rainbow Falls Park**	**112.3**	**113.4**	**91.3**	**130.8**	**130.4**	**105.6**
55	12052	O	Pittsburg	109.0	108.3	156.0	156.9	123.9	124.4
56	**12053**	**O**	**Armstrong Road, Bluell**	**84.9**	**90.0**	**85.1**	**73.0**	**71.5**	**86.6**
57	**12054**	**O**	**Alsea Falls**	**90.6**	**93.1**	**110.4**	**89.5**	**84.1**	**98.0**
58	**12055**	**O**	**Salt Creek**	**96.9**	**101.4**	**84.2**	**90.4**	**97.4**	**94.1**
59	12056	O	Norway	84.7	85.0	33.8	29.7	68.9	67.8
60	**12057**	**O**	**Otter Point**	**91.4**	**94.3**	**43.5**	**49.3**	**84.2**	**76.4**
61	12026	ID	St. Joe Area	100.7	95.8	100.8	90.8	81.9	99.1
62	12038	ID	Clear Water	100.9	96.6	154.3	113.7	88.3	117.2
63	C-251-1.5	O	Falls City	102.3	97.5	166.1	131.8	105.6	121.9
64	C-262-2.0	O	Dexter/Bear Mt.	76.7	79.6	80.4	49.3	64.2	78.9
65	C-262-3.0	O	Dexter/Bear Mt.	97.9	98.8	97.2	94.5	96.0	97.9
66	C-471-2.0	O	Upper Mohawk River	89.6	81.4	86.2	52.5	61.9	85.7
67	072-0.5	O	Myrtle Point	97.9	106.6	64.3	70.2	109.1	89.6
68	481-1.0	O	Coast Fork Willamett	85.8	83.1	66.4	42.7	67.4	78.4
Overall mean				**96.8**	**97.0**	**103.8**	**91.4**	**93.0**	**99.2**
max.				125.6	128.2	182.4	176.1	174.3	129.6
min.				76.7	79.6	33.8	29.7	56.7	67.8

common provenances in bold letters

Table 2. – *Abies grandis* – IUFRO provenance experiment: description of plantation sites.

	Geographic		Elevation	Temperature		Precipitation		Basic rock	Soil type	Water balance	Nutrient supply
	Longitude degree/° min	Latitude degree/° min	above sea level/m	year deg. C	growing season deg. C	year/ mm	growing season/ mm				
Bramwald	09 36	51 28	420	7.1	13.7	825	410	medium red sandstone	gley-like soil	fresh	oligotrophic
Bramwald	09 36	51 28	345	7.5	14.2	756	384	red sandstone	gley-like brown soil	varyingly moderately fresh	mesotrophic
Braunlage	10 40	51 43	580	5.7	12.1	1.179	546	shist	basepoor brown soil	moderately fresh	mesotrophic
Cloppenburg	07 49	52 57	15	8.6	14.5	760	360	diluvial sand	basepoor podsolic brown soil	markedly fresh	oligotrophic
Neuenheerse	09 03	51 38	355	6.5	12.8	1.040	500	gault sandstone	basepoor brown soil	fresh	oligotrophic
Neumünster	09 51	54 05	20	8.0	14.4	760	360	diluvial sand	podsol	varying fresh	mesotrophic
Obereimer	08 14	51 22	390	8.6	14.6	1.000	420	upper carbonic layers of shistclay and grauwacke	baspoor brown soil	moderately fresh	mesotrophic
Rantzau	09 45	53 47	30	8.4	14.6	750	364	glacial sand	iron-humus podsol	summerdry	mesotrophic
Reinhardshagen	09 29	51.31	240	8.0	14.3	725	352	red sand stone with loess	gley-like soil	varyingly fresh	mesotrophic
Seligenstadt	08 58	50 02	135	9.0	15.7	674	317	diluvial sand	brown soil	fresh	mesotrophic
Steinfurt	07 49	52 13	160	8.5	12.4	836	376	sandloess above moraine	podsolic parabrown soil	varyingly fresh	mesotrophic/ oligotrophic
Syke	08 40	52.50	25	8.4	14.5	741	346	moraine	podsolic parabrown soil	fresh	mesotrophic

(*Tab. 2*). Soil quality is partly mesotrophic, partly oligotrophic and with the exception of the Rantzau sites are reasonable fresh.

In autumn and winter 1994 the following measurements and records were taken:

Height in cm with a measuring pole;

Diameter in mm callipers in 1.3 m;

Losses.

Volume per tree and per hectare were calculated using basal area x height x shapefunction (BERGEL, 1972, developed for Douglas fir) and an overall ranking was done using the following procedure:

$$OR\ \% = \frac{\text{Height \%} + \text{Diameter \%} + (100\text{-Losses \%})}{3}$$

Analyses of variance, correlations and stability parameters were calculated using SAS and own programs of the Lower Saxony Forest Research Institute.

From the stability parameters calculated we will discuss here only the ecovalence (WRICKE, 1965) and the rank parameter (HUEHN, 1979).

3. Results

3.1 Height growth

Average height of the test sites at age 19 range from 2.9 m (Neumünster) to 7.4 m (Syke). Site differences are highly significant and account for 70% of total variation.

Provenance variation is highly significant too but only explains 13% of variation. Interaction accounts for 17%. Height of provenances ranges from 77% (O-Dexter, Bear Mt.) of standard provenances mean to 125% (W, Bear Mt.), which means in absolute values 3.55 m to 7.01 m.

The fastest growing provenances originate from low to mean elevations in the Pudget Sound area, from Vancouver Island, southern Washington west of the Cascades and northern Oregon. Nearly all central and southern Oregon provenances are growing slowly. There exists a significant positive correlation with latitude (r = 0.60***) and a negative with elevation above sea level (r = –0.31*) (*Table 3*).

The differences between the provenances of the elevational transsects are comparatively small and show up no trend. For Santiam Pass-Sisters the highest elevation source has the best growth. In Santiam River-Sweet Home the lowest elevation and the second highest elevation show best performance. Elevational differences are much smaller than the regional differences (*Table 1*).

Differences between provenances in stability are considerable. The 2 best growing provenances (W-Bear Mt. and BC-Salmon River) are very stable, number 3 in height growth (W-Rainbow Falls) is one of the most unstable provenances. Overall there exists no significant correlation between height growth and the different stability parameters.

If one compares test sites, there are obvious differences: Rantzau seems to be a good test site, since it shows highly significant correlations surpassing r = 0.6** with 5 other test sites. Steinfurt on the other side does not show high correlations with any of the other test sites, the highest is with Cloppenburg (r = 0.32 n.s.).

The test sites Syke, Obereimer and Reinhardshagen show high correlations (close to or above 0.6**). Neumünster test site correlates above r = 0.5** with Braunlage, Neuenheerse and Seligenstadt.

From a regional or ecological view it is quite difficult to find explanations for these correlations, since provenances on lowland sites are reacting similar to high elevation sites and different from other lowland sites.

3.2. Diameter growth

The average diameter of test sites varies between 4.29 cm (Neumünster) and 11.46 cm (Braunlage). Site influences are highly significant and explain 74% of total variation.

Mean diameter of provenances ranges between 5.9 cm to 10.9 cm and is highly significant as well but provenances explain only 7% of total variation. 19 % are due to interaction.

Table 3. – Abies grandis – provenance experiment. Correlation matrix.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Flushing	1.00																		
2	Lammashoot	.09	1.00																	
3	Bud set	-.66**	-.24	1.00																
4	Height age 1	-.04	.30*	.51**	1.00															
5	Height age 3	.02	.77**	.02	.59**	1.00														
6	Root collar diameter	-.08	.63**	.17	.40**	.68**	1.00													
7	Height age 3 (test sites)	.31*	.78**	-.26	.48**	.91**	.56**	1.00												
8	Height age 5	.17	.76**	-.14	.52**	.94**	.56**	.96**	1.00											
9	Height age 8	.19	.69**	-.21	.36**	.84**	.47**	.83**	.92**	1.00										
10	Height age 18	-.22	.26**	.11	.20	.57**	.18	.43**	.56**	.71**	1.00									
11	Diameter age 18	-.19	.11	.18	.18	.40**	.15	.26	.39**	.59**	.92**	1.00								
12	Volume /ha	.03	.31*	-.20	.04	.54**	.25	.50**	.62**	.78**	.82**	.75**	100							
13	Volume/tree	-.09	.26	.07	.25	.57**	.25	.47**	.58**	.74**	.94**	.95**	.85**	1.00						
14	Losses age 5	.06	-.08	.00	.05	-.13	-.21	-.09	-.22	-.25	-.02	.05	-.38**	-.01	1.00					
15	Losses age 8	-.01	-.08	.21	.21	-.16	-.18	-.17	-.25	-.26	-.07	.05	-.49**	-.07	.89**	1.00				
16	Losses age 18	.18	-.01	.09	.25	-.16	-.13	-.07	-.22	-.34*	-.35**	-.25	-.67**	.30*	.78**	.85**	1.00			
17	Latitude	-.28*	.38**	-.10	-.09	.48**	.16	.39**	.49**	.56**	.61**	.36**	.59**	.45**	-.23	-.32*	-.56**	1.00		
18	Longitude	.41**	.51**	-.41**	.18	.47**	.23	.58**	.56**	.54**	.08	-.10	.34*	.09	-.38**	-.40**	-.26	.36**	1.00	
19	Elev. Above sea level	-.31*	-.79**	.51**	-.17	-.72**	-.39**	-.38**	-.78**	-.73**	-.34**	-.11	-.46**	-.32*	.10	.23	.14	.54**	-.70**	1.00

Table 4. – Top performing provenances.

State	Name of provenance	Overall ranking	Stability (ecovalence)	Representation on test sites
W	Duckabush River	130 %	5.68	11 test sites
W	Bear Mt.	129 %	4.47	11 test sites
O	Pittsburg	124 %	3.46	10 test sites
BC	Salmon River	122 %	5.23	11 test sites
W	Buck Creek	120 %	2.82	11 test sites
BC	Nanaimo Lake	118 %	0.27	9 test sites
W	Cougar Flats	117 %	1.30	9 test sites
W	Indian Creek	114 %	0.91	11 test sites
BC	Kay Road	113 %	1.94	11 test sites
W	Clear Lake	113 %	2.29	11 test sites
W	Eagle Creek (12007)	111 %	2.72	9 test sites

The fastest growing provenance (W-Bear Mt.) surpasses the average of the standard provenances by 128%, the slowest growing seed source only reaches 79% (0-Dexter, Bear Mt.) (*Table 1*).

The regional distribution of diameters is similar to that of height with the exception, that Vancouver Island sources have a slightly smaller diameter and some of the Oregon provenances are better in diameter.

This can be easily explained by the higher losses of the Oregon provenances which gave more space to the single tree.

Again the elevational transsects show only minor differences between the provenances from different elevation above sea level. Only in O-Philomath the higher elevation has 10% better diameter than the lower elevation.

Height and diameter are closely correlated (r = 0.92**). Diameter is correlated with height at age 3 too (r = 0.40**). The latitude only explains 14 % of variation in diameter (r = 0.36**), longitude and elevation have no significant influence on diameter (*Tab. 3*).

Stability parameters show similar trends as for height. The most stable provenance is W-Indian Creek, which is number 4 in diameter growth. Most stability parameters show a low negative correlation with height.

The interrelationship of the sites is similar to that in height.

3.3 Losses

Losses are an important indication for the adaptability of a provenance to the plantation site. They have at the same time influence on quantitative characters, especially on diameter, which increases with increasing spacing.

Average losses of the test sites range between 10% (Syke) and 56% (Neuenheerse) and have an overall mean of 35%. Site differences are highly significant, as are provenance differences and interaction. Losses between provenances across sites vary between 18% (W-Duckabush River) and 74% (O-Norway).

The higher losses are to be found in southern and central Oregon provenances. In British Columbia provenances the situation is very variable. Higher losses occur in provenances from southern Vancouver Island as compared to provenances from central and northern Vancouver Island.

The elevational transsects show up no drastic differences again. Losses at age 18 are not correlated with elevation above sea level (*Tab. 3*) but highly significant with latitude (r = 0.56**) and with quantitative characters, which means due to the transformation, that fast growing provenances had fewer losses.

The comparison of the losses on the different test sites show considerable differences. From 66 comparisons 19 correlations have a negative sign, and most correlations are quite low. The interaction variance component is as high as the location influence. Provenance differences in stability are considerable which means that ranking for losses is different from one experiment to another.

3.4 Volume per area unit

In volume production per hectare differences between provenances range between 30% (O-Norway) of standard provenances mean and 176% (W-Bear Mt.) Volume production is highest in Washington coastal provenances followed by

Vancouver Island. Only few Oregon provenances have above average volume production (O-Pittsburg, O-Sisi Butte). These differences are a combination of height, diameter and losses and therefore reflect the situation in these characters again (*Table 1*).

The drastic differences in volume production underline the importance of provenance choice. The slowest growing provenance only produces 17% of the volume produced by the fastest growing provenance at the same age.

3.5 Overall ranking

Overall ranking is closely correlated with volume production per hectare (r = 0.89***). It gives a somewhat higher weight to losses and excludes some of the provenances with good relative height but possibly still acceptable losses (12004, 12047, 12051).

The combination of growth characteristics and losses allows practical recommendations for provenance choice. The following provenances are well performing and can be recommended due to the present development of the IUFRO experiment (*Fig. 2*).

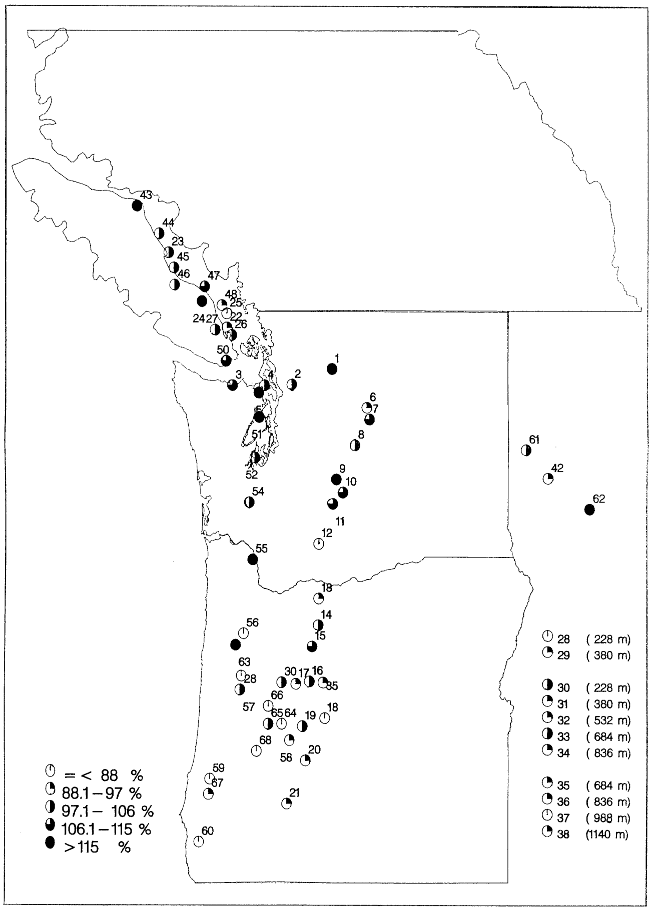

Figure 2. – *Abies grandis* provenance Test – Ranking in relation to standard provenances BC, Washington, Oregon, Idaho.

All these provenances surpass the average of the standard provenances by at least 10 % and are tested on at least 9 test sites. Seven of these originate from Washington, 3 from British Columbia and only 1 from Oregon. The most stable provenance of this subset is Nanaimo Lake followed by Indian Creek. No one of the provenances is extremely unstable.

3.6 Correlations with earlier measurements

It is of interest to compare the most recent measurements with earlier ones to judge the possibilities for early selection and with other characteristics for indirect selection. The characters included are listed in *table 3*. The most important target figure is volume production per hectare. This is significantly correlated with height at the end of the nursery phase (r = 0.54***) and in the field increasingly with the subsequent heights until age 18 (r = 0.82***). Volume production shows significant negative correlations with losses (better provenances have fewer losses; data not transformed), and with elevation above sea level (decreasing production with increasing elevation), correlations with latitude and longitude are positive and significant.

The phenological characters taken in the nursery have very little influence on volume production. Only lammashoot-formation is significant by correlated with volume production age 18 (r = 0.31*). Influence of lammashoots on height decreases with increasing age. Phenological characters are however significantly correlated with the geographical variables. The same is true for the height measurements in the different ages (*Tab. 3*).

Losses show no significant correlation with most of the other characters except the last 2 height measurements and volume per hectare. Influence of latitude on losses increases with increasing age (–0.23 (age 5), –0.32* (age 8), –0.56** (age 18) influence of longitude decreases (–0.38**(age 5), –0.40** (age 8), –0.26 n.s. (age 18)).

4. Discussion

The general trends of the IUFRO provenance experiment are about the same as were found in the earlier experiments and in the experiment reported by König (1995). It is however obvious, that the Washington provenances have a better ranking in this experiment than in the experiment reported by Kramer (1976). Under more tough climatic conditions in Bavaria the provenances Elwha Wash. 140 m (= W-Indian Creek 12003) and W-Buck Creek, 400 m (= 12001) were performing best (Ruetz, person. communication).

If one compares the average performance of states it is obvious that the provenances from Idaho improve their position in height. Of course the limited experimental base for these provenances does not allow generalizations. In volume production Idaho is however on last position. Washington is improving the position for height too., B.C. is slightly decreasing and Oregon definitely decreasing. In volume production B.C. is on top position slightly above Washington. Oregon provenances only produce on average 72% of the volume as compared to B.C. and Washington.

The possibilities for early or indirect selection seem to be quite restricted when testing an exotic tree species like *Abies grandis* in Germany. Height at age 8 allows prediction of volume production (at age 18) with a certainty of 61%, at age 5 with 38% and at age 3 with 29%.

Even at age 18/19 a final conclusion cannot be drawn, however result should be quite reliable by now.

There seems to be a contradiction between the fact, that the elevational transsects do not show significant influences and on the other hand volume and heights show highly significant correlations with altitude. This can be explained however by the fact, that in the overall material regional influences overlap with elevation. Some of the highest elevation sources originate from Oregon, some of the lowest elevation sources from British Columbia.

The suitability of the sites is quite different. There are however no clear regional trends which would allow an *a priori* site selection for testing.

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Populationsgenetische Betrachtung eines Pilotprojektes zur intraspezifischen Kreuzung der Weißtanne (*Abies alba* MILL.) in Sachsen

Von L. LLAMAS-GÓMEZ

Institut für Waldbau, Technische Universität Dresden, Pienner Straße 8, D-01737 Tharandt

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Zusammenfassung

Die Erhaltung der Weißtanne in Sachsen erfordert Maßnahmen zur künstlichen Überwindung der Isolation der Restvorkommen. Dazu zählen u. a. auch gelenkte Kreuzungen. 1994 wurde an der Sächsischen Landesanstalt für Forsten Graupa ein Pilotprojekt zur intraspezifischen Kreuzung der Weißtanne gestartet. Die gelenkten Kreuzungen wurden an einem isoliert stehenden weiblichen Partner durchgeführt. Neben der erzwungenen Selbstung wurde Pollen von 6 Tannen und ein Gemisch mit Pollen von 4 Tannen verwendet. Ferner wurde Saatgut aus freier Abblüte sowie von nicht isolierten, mit dem Pollengemisch bestäubten Makrostrobili gewonnen. Der Anteil voller Samen bei der Selbstung war im allgemeinen niedriger als bei der erzwungenen Fremdung. Dennoch machen die erzielten Vollkornanteile bei der freien Abblüte sowie bei der erzwungenen Selbstung die hohe Selbstfertilität der Tanne deutlich.

Mittels Isoenzymanalysen wurde der Genotyp der Kreuzungspartner bzw. ihrer Nachkommen an 10 Genloci festgestellt. Hinweise auf Segregationdistortionen bei den Einzelkombinationen wurden nicht gefunden. Über 35% der Nachkommen aus der Selbstung bzw. aus der freien Abblüte waren an keinem und 65% an lediglich einem Genort heterozygot. Von den Nachkommen aus der Bestäubung mit dem Pollengemisch waren dagegen 85% heterozygot an 2 und mehr Genorten. Die Parentalanalyse an Saatgut aus dem freien Abblühen zeigte keine Unterschiede zwischen den Genotypen der erzwungenen Selbstung und der freien Abblüte. Die Anteile der Nachkommen aus dem Pollengemisch weichen signifikant von den Erwartungswerten ab. Es wurde festgestellt, daß Gameten, die in Einzelkombination einen relativ niedrigen Vollkornanteil haben, im Pollengemisch durchaus Selektionsvorteile aufweisen können. Die Zusatzbestäubung von frei abgeblühten Makrostrobili trug beim untersuchten Mutterbaum zu mindestens 85% der Nachkommen bei.

Schlagwörter: Abies alba (MILL.), Züchtung, kontrollierte Kreuzung, Isoenzyme, genetische Strukturen, Parentalanalyse.

FDC: 165.41; 165.3; 165.5; 174.7 *Abies alba*; (430).

Abstract

The conservation of the residual populations of Silver fir (*Abies alba* MILL.) in Saxony requires activities to get over the isolation e.g. controlled crossings. In 1994, the Saxon State Institute for Forestry began first experiments to pollinate isolated Silver fir trees by controlled crossing. Isolated macrostrobili were pollinated with pollen from 6 single trees and a pollen mixture from 4 of them simultaniously with controlled