ARBORETUM KÓRNICKIE
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Provenance differentiation among Douglas fir seedlings

INTRODUCTION

Douglas fir has been cultivated in many parts of Polish forests for almost 90 years. According to survey data collected by the Institute of Dendrology and Kórnik Arboretum (Białobok 1959, Białobok and Chylarecki 1965) there are in Poland about 1170 stands of this tree. This figure fluctuates as a result of forest management practices.

However in spite of the fact that our interest in this species is of such long standing, no attempt has been made so far to establish the origin in North America of the seeds that have been used for the plantings. Schenck (1939) gives in his book a list of experimental plantations of Douglas fir yet as he underlines there is no information about the origin of the seeds used for these experiments. Most of the earlier studies on Douglas fir conducted in the XIX century and in the early part of the present one were aimed et evaluating the economic aspects of introducing the species into forest plantings, and as a result only older plantations were subject to observation. The study of the degree of adaptation of young seedlings from strictly defined origins to the climatic and pedological conditions in the sites of introduction has been undertaken much later.

The lack of information about the provenance of Douglas fir seeds used in plantations in Europe during the XIX century and in early XX century was common. The first provenance experiments were established in North America in 1912 (Wright 1962). For the purpose seeds were collected from 120 mother trees from 13 different regions between 44° and 48° latitude North, from the western parts of Washington and Oregon states. A similar experiment in Europe was, according to Ching and Bever (1960), established from seeds of 10 provenances in 1912 by Münch in southwestern Germany and by Schwappach in Chorin, in eastern Germany. Need for strict provenance experiments has existed for a long time, however only after the second world war did wider attempts to establish them begin.

In Poland the first provenance experiments on Douglas fir have been established by the Institute of Forest Research in 1963. They have had at their disposal seeds of Douglas fir from Washington, Idaho and New Mexico. For comparison in the experiment were included seedlings obtained from seeds collected in stands of the species growing in Wirty and Susz. Next a series of methodical studies on provenance differentiation in the species was begun by the Institute of Dendrology and Kórnik Arboretum, for which purpose seeds from 104 origins within the natural range of the species have been obtained. One of the most important factors associated with the cultivation of some Douglas fir provenances, not only in Poland but also in Central and Northern Europe, is the sensitivity, particularily of trees in the early part of their life, to low temperatures in the winter as well as to late frosts (S c h o b e r 1963. S c h ö n b a c h 1954, S c h ö n b a c h and B e l l m a n n 1967 and others).

Already S o k o ł o w s k i (1912) points out that green Douglas fir suffers from cold, while the gray Douglas fir has considerable resistance to low temperatures. S c h n e c k (1939) has noted cold damage in poor Douglas fir stands growing in the Mazury Lake District, which hals also been pointed out by T u m i ł o w i c z (1967). M a c i e j o w s k i (1951) recommends the use in plantings west of the Vistula of green Douglas fir from North America, from regions where it is at its optimum, that is from British Columbia and the state of Washington. East of the Vistula he suggests the use of *Pseudotsuga mensiesii* var. *mensiesii,* and *P. mensiesii* Franco var. *caesia* Aschers et Graebn. *Pseudotsuga mensiesii* var. *glauca* (Beissn) Franco is believed by this author to be unsuited for our conditions.

According to S c h e n c k (1939) seedlings of green Douglas fir are most readily damaged in the spring during sunny days following frosty nights. Interesting results about the resistance of Douglas fir seedlings to low temperatures are reported by I l m u r z y ń s k i, B e l l o n and others (1968), who have found cold injuries in the seedlings coming from the state of Washington.

Further studies on the subject have shown that Douglas fir provenances from the central part of British Columbia and those from higher elevations in Washington as well as the populations of *Pseudotsuga mensiesii* var. *glouca* from the southern parts of the Rockiers are charakterized by resistance to low winter temperatures, while those from the lower elevations in Washington are more susceptible to cold injury (S c h o b e r 1963, W r i g h t 1962 and others). Also dangerous for Douglas fir seedlings are late frosts (S c h o b e r 1963). Particularily the plants which begin spring growth early are damaged most. Numerous experiments on the subject, which have been described by S c h o b e r (1963) indicate, that provenances from a continental climate or from northern regions are more resistant to low winter temperatures, however seedlings from these regions are more readily damaged by spring frosts than those coming from the south or from a more oceanic climate. As S w e e t (1965)

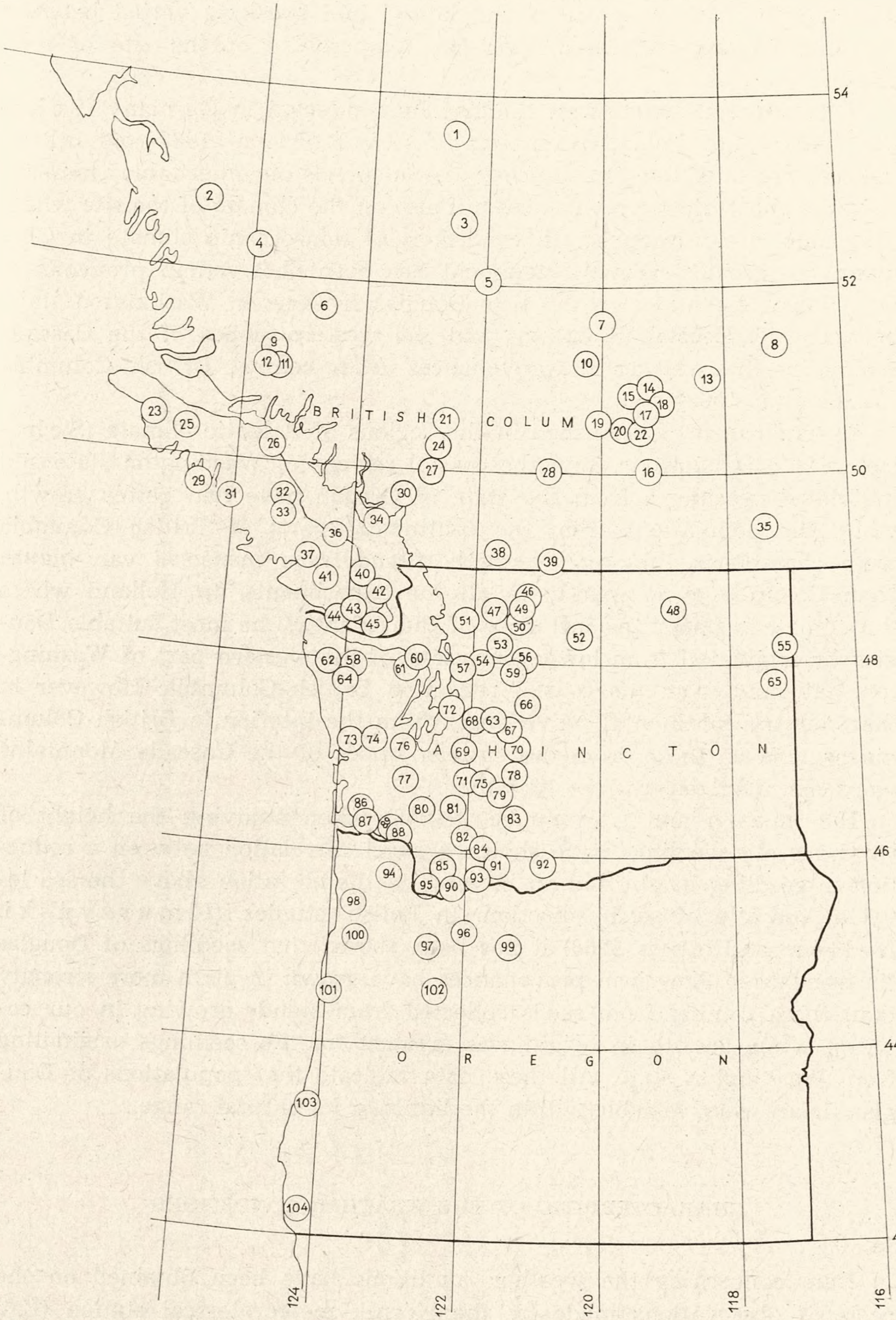

Fig. 1. Location of sites where seeds were collected

has shown the time of apical and lateral bud breaking varied between provenances and correlated with the temperature of the site of seed origin.

The numerous studies on Douglas fir conducted in Germany (Schober 1963) and Poland (Ilmurzyński, Bellon 1968 and others) indicate not only that resistance to cold depends on inheritable characteristics of the various provenances but also on the climate of the site where the plants are introduced. In conditions of non-oceanic climate in Germany the greatest growth increment has been observed in provenances from lower elevations in the true Douglas fir zone in Washington state, between the Coastal Mountains and the western slopes of the Cascade Mountains, as well as in provenances from central British Columbia (Schober 1963).

In experiments established in the regions of Atlantic climate (Schober 1963) Douglas fir from the coastal regions of Washington state and individual specimens from the state of Oregon have had better growth, while the populations from the continental parts of British Columbia were characterized by poor growth. *Pseudotsuga mensiesii* var. *glauca* from Colorado grew weakly in all the experiments. In Holland where the climate is under the influence of the Atlantic, the most suitable Douglas fir originated from lower elevations of the western part of Washington state and from the coastal region in British Columbia. However in that country continental provenances from the interior fo British Columbia as well as those from the eastern slopes of the Cascade Mountains were characterized by poor growth.

Hermann and Lavander (1968) when studying the height of two year old seedlings have shown a strict correlation between a reduction in seedling height and an increase in the elevation above the sea level of the site of seed collection. In Polish studies (Ilmurzyński, Bellon and others 1968) it has been shown that seedlings of Douglas fir from three American provenances have grown in girth more strongly than those coming from seeds collected from stands growing in our country, while growth in height was greatest for the seedlings originating from Washington state. All these data indicate that populations of Douglas fir are very variable within the limits of its natural range.

CHARACTERISTIC OF THE WEATHER CONDITIONS

Data concerning the weather conditions have been obtained on the basis of observations made by the Kórnik meteorological station (Lat. 52°15′ N, Long. 17°06′ E) which is located in an open area about 1,3 km away from the Zwierzyniec forest nursery. The meteorological data only approximately characterize the actual situation in the forest nursery

Table 1

Climatic data for Kórnik in the period from III 1968 to IV 1969

			III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III
Extreme air temperature	2 m above the ground	max	23.5	29.0	25.9	31.9	31.8	28.4	26.6	19.0	19.0	4.1	6.9	6.7	8.2
		min	−9.7	−5.6	2.5	7.7	6.9	5.5	0.7	−1.6	−6.7	−19.1	−21.1	−19.5	−11.3
	5 cm above the groung	min	−13.2	−9.6	0.7	5.2	4.7	2.9	−1.9	−3.4	−7.0	−22.6	−23.5	−24.4	−11.8
Mean temperature of air 2 m above the ground			3.9	9.2	11.4	17.8	17.0	17.6	13.8	8.7	4.0	−3.3	−4.8	−3.3	−1.3
Days without frost 2 m above ground			18	22	31	30	31	31	30	29	22	2	3	4	1
Days with frosts 5 cm above ground			16	12	—	—	—	—	1	7	10	31	30	28	30
Days with snow cover			10	8	—	—	—	—	—	2	6	3	30	20	15
Relative humidity	∅		77	64	85	72	73	73	83	86	91	86	86	81	77
	min		26	19	33	33	28	35	41	52	58	46	60	38	35
	daily		29	22	9 i 15	18	1	8	11	22	3	14	1 i 27	15	22
Saturation deficit	∅		2.7	5.4	4.1	7.2	6.3	6.4	3.3	1.9	0.9	0.6	0.5	0.9	1.4
	max		18.5	29.2	16.1	31.1	28.1	23.6	18.0	7.9	8.9	3.0	2.1	2.8	4.9
	daily		30	23	11	18	6	24	7	31	3	14	27	2 i 7	22
Precipitation mm	1st to 10th		16.4	3.2	8.2	29.4	38.1	—	0.7	13.7	53.3	0.3	4.3	7.7	—
	11st to 20th		16.7	0.3	27.7	17.8	31.4	37.9	18.7	24.0	34.2	2.8	17.2	12.1	13.7
	21st to 30th		2.8	17.0	25.5	6.3	58.0	32.5	20.1	14.2	5.3	19.0	22.3	2.6	14.3
	total		35.9	20.5	61.4	53.5	127.5	70.4	39.5	51.9	92.8	22.1	43.8	22.4	28.0
	maximal		9.3	14.7	10.0	11.4	37.4	15.7	8.0	9.6	22.8	6.5	5.2	6.5	7.3
	daily		5	27	29	12	4	17	18	24	6	23	30	15	31

which is surrounded by a mixed and a pine forest. The data presented however are very characteristic for the weather pattern that existed in the period in question.

The weather in the 1968 vegetative period and in the winter of 1968/69 has had a profound influence on the first year results of the Douglas fir provenance experiment.

The spring of 1968 was generally warmer than is normal however May was cold and unfavourable for plant vegetation. In March and April there were still frequent frosts at soil level and in March there were 3 days with mean temperatures below zero. The minimal temperatures in March at 5 cm from the soil have reached — 13.2°C in the first 1/3 of the month and —12.0°C in the second. In April there were still 12 days with frosts in the first 2/3 of the month and the lowest soil surface temperature of —9.6°C has been noted on the 9th of April. Only in the last 10 days of the month no soil level frosts have been recorded.

The spring precipitation was sufficient for plant vegetation. However in April it was deficient, because only 20.5 mm fell while insolation was high, as a result the nursery had to be frequently watered, in the parts where Douglas fir seeds were sown.

In May there were cold days and the precipitation was plentiful and evenly distributed, it was 8.4 mm higher than the average over many years, thus the conditions were statisfactory for the emergence of Douglas fir seedlings, which was considerably extended in time.

June was a warm month (mean temperature for the month was 17.8°C and the mean maximal temperature was 23.1°C). However this month was characterized by insufficient moisture in the soil, even though the total precipitation was about 4.5 mm higher than the average over many years, however the distribution of the precipitation was bad. Abundant precipitation appeared only in July (127.5 mm) and August (70.4 mm) and these have improved the condition of the seedlings in the nursery.

Autumn was warm and in the month of September precipitation was low, in total 6.5 mm below the average for many years. October and November were characterized by abundant precipitation.

November was exceptionally warm, with an average temperature of 4.0°C while the mean over many years for nearly Poznań is only 2.6°C. In September already one frost was recorded. In October there were 7 and in November already 10. Abundant precipitation and high temperatures of the air in October and November have resulted in the prolongation of the vegetative period for the Douglas fir, particularily for the populations originating from the Pacific coastal regions.

The winter begun in early December with a sudden appearance of low temperatures in the absence of snow cover which has resulted in the soil becoming frozen already arround the 13th of December to a depth below 20 cm. From the 18th of December the snow cover amounted to no more than 3 cm, and by the end of the month it increased to 9 cm. The minimal temperature was noted to be on the 30th of December –22.6°C at soil level and –19.1°C at 2 m above the ground.

The mean January temperature was noted to be –4.8°C. This is lower than the average over many years for Poznań by 2.8°C. The minimal temperature recorded in January on the soil surface was –23.5°C with a slight snow cover of only 12 cm. This has dwindled towards the end of January to 6 cm and finally to 3 cm. Precipitation for the month was 43.8 mm.

February was also cold, and the lowest air temperature reached –19.5°C and at soil level –24.4°C. The mean air temperature of –3,3°C was lower than the average over many years for Poznań which is –0.7°C. With such low temperatures and a thin or absent snow cover the effects of the cold have been very negative on the condition of the Douglas fir seedlings as will be shown further on in this paper.

March was still cold and the mean air temperature reached –1.3°C, while the average over many years for Poznań is 2.4°C. The minimal temperature at soil level was –11.8°C on the 5th of March when the snow cover was only 4 cm thick. In the later part of the month the temperature gradually increased so that towards its end there were no longer any days continually below zero and only small frost were recorded.

The weather pattern in the autumn and in the winter was unsatisfactory for seedlings of many of the provenances. This was primarly the result of long warm periods with high precipitation in the autumn followed by low temperatures of the air and soil with insignificant or no snow cover. These weather conditions were good selection agents for Douglas fir seedlings of many provenances, thus the results obtained are very informative for the future cultivation of the species in Poland. We have therefore decided to present these results already even though they are based only on observations collected in one year.

METHODS

In October 1967 the Institute of Dendrology and Kórnik Arboretum of the Polish Academy of Sciences have received 3.4 kg of Douglas fir seeds from the Coordinating Centre of the Working Group on Procurement of Seed for Provenance Research (International Union of Forest Research Organization) in Humlebaek, Denmark. The total 3.4 kg of seeds consisted of 104 seed lots originating from various North American seed collection sites. They are numbered 1001 to 1104. For each of the provenance exact geographic coordinates and elevation above the sea level have been provided together with information about seed weight in the sample (table 2). Also results of analyses on seed germination capacity have been provided for tests under the following conditions: a) seeds chilled for 14 days and then placed on a germinator at 25°C, b) non-chilled seeds placed in a thermostat at 25°C, c) non-chilled seeds placed on a Rhodewald germinator in conditions of alternating temperature. The results obtained are presented in table 3.

Until sowing time the seeds were stored for a period of 5 months in polyethylene bags at a temperature of +3°C. On the 25th of March 1968 the field experiment was established. Before sowing the seeds were soaked for 48 hours in distilled water, drained on a sieve and treated with red lead. Hand sowing was employed into pressed furrows 1 cm deep, after which the seeds were covered with soil. The distance between rows was 40 cm. and for each provenance 4 rows each 2 m long have been provided. The four rows were each in a different block and the sequence of provenances in each block was fully randomized. Between the blocks also 40 cm gaps were maintained.

From the 5th to the 2nd of May, every 4 days an estimate was made of the rate of seedling emergence. A three point scale was used:

0 — indicated that no seedlings have emerged,
1 — indicated that only a few seedlings emerged,
2 — indicated that the emergence was massive.

The scores were added for the 5 readings, and doubled when in the final reading the score was 1. This gave an estimate of seedling emergence rate independently of germination percentage. From sowing to the first emergence of seedlings the soil in the nursery was scarified and covered with garden peat to prevent excessive evaporation which could have been dangerous due to lack of moisture in April 1968.

Towards the end of June 1968 the percentage of germinated seeds was evaluated for each of the replicate in each provenance. For the purpose the number of seedlings obtained was divided by the estimated number of seeds sown.

During the summer no further observations were made. The soil was carefully cultivated and when first signs of damping off disease appeared a spray with chinozolium solution successfully checked the spread of the disease. On the 12th of November 1968 the termination of seedling growth was estimated for each replicate of each provenance using a five point scale:

1 — 100% of seedlings terminated growth,
2 — 75% of seedlings terminated growth,
3 — 50% of seedlings terminated growth,
4 — 25% of seedlings terminated growth,
5 — 100% of the seedlings were still growing.

A high value of this character indicates growth late into autumn.

The growing seedlings were bright green in the apical part of the shoot and did not have a terminal bud, while the leaves in the apical part

Table 2

Geographic coordinates of the provenances

Provenance no.	Lat N	Long W	Alt	Provenance no.	Lat N	Long W	Alt
1001	53°37′30″	122°40′30″	540 - 600	1053	48°16′	121°38′	150
1002	52°48′00″	126°57′30″	6	1054	48°13′	122°04′	90
1003	52°41′30″	122°26′00″	570 - 720	1055	48°12′	117°03′	720
1004	52°22′00″	126°00′00″	225	1056	48°05′	121°18′	600 - 690
1005	52°06′45″	122°00′00″	600	1057	48°05′	122°02′	90
1006	51°44′00″	124°44′24″	870	1058	48°04′	124°00′	300
1007	51°39′25″	120°00′00″	450	1059	48°03′	121°28′	570 - 630
1008	51°23′	117°00′	810 - 900	1060	48°02′	123°02′	30 - 90
1009	51°13′30″	125°34′50″	600	1061	48°00′	123°05′	450
1010	51°12′15″	120°09′45″	420	1062	47°59′	124°24′	90
1011	51°07′50″	125°35′30″	150	1063	47°51′	121°39′	120
1012	51°07′00″	125°35′45″	3	1064	47°48′	123°58′	240
1013	51°00′	118°12′	600	1065	47°47′	117°12′	540 - 660
1014	50°56′	119°13′	390 - 480	1066	47°43′	121°08′	870 - 990
1015	50°53′	119°24′	360 - 450	1067	47°42′	121°20′	300
1016	50°07′	119°15′	510	1068	47°41′	120°44′	540
1017	50°50′	119°34′	570	1069	47°28′	121°45′	150
1018	50°44′	119°13′	420 - 510	1070	47°24′	121°32′	480 - 600
1019	50°37′	119°54′	600 - 660	1071	47°23′	121°22′	780
1020	50°35′	119°38′	900	1072	47°22′	121°40′	540 - 660
1021	50°33′24″	122°30′00″	270	1073	47°19′	123°54′	135
1022	50°32′	119°24′	750	1074	47°18′	123°26′	450 - 540
1023	50°27′00″	127°27′00″	165	1075	47°16′	121°56′	240
1024	50°20′00″	122°43′30″	210	1076	47°15′	123°25′	120
1025	50°19′00″	126°53′00″	90	1077	47°15′	123°12′	90
1026	50°17′00″	125°28′00″	150	1078	47°13′	121°07′	630
1027	50°11′30″	122°52′30″	630	1079	47°02′	121°34′	720
1028	50°04′20″	120°51′00″	810 - 900	1080	47°01′	122°44′	60
1029	49°47′30″	126°38′20″	15	1081	46°48′	122°17′	420
1030	49°16′40″	123°09′00″	15	1082	46°40′	121°02′	750
1031	49°45′00″	126°04′00″	90	1083	46°34′	121°40′	570 - 720
1032	49°41′45″	125°03′30″	66	1084	46°34′	121°42′	300
1033	49°39′45″	125°09′20″	600	1085	46°33′	122°03′	330
1034	49°30′40″	123°52′55″	180	1086	46°22′	123°44′	3 - 6
1035	49°30′	117°16′	750 - 870	1087	46°21′	123°30′	180 - 240
1036	49°19′30″	124°51′00″	135	1088	46°19′	122°52′	150
1037	49°06′00″	124°46′00″	150	1089	46°18′	123°16′	150 - 240
1038	49°06′00″	121°42′00″	900	1090	46°05′	122°18′	450 - 540
1039	49°04′24″	121°48′00″	165	1091	46°00′	122°22′	120
1040	49°03′30″	123°57′00″	105	1092	46°00′	121°10′	480
1041	48°55′25″	124°26′00″	210	1093	45°48′	121°41′	450 - 540
1042	48°45′00″	123°45′00″	60	1094	45°46′	123°13′	210
1043	48°34′50″	124°04′48″	210	1095	45°37′	122°08′	450
1044	48°28′30″	124°14′00″	240	1096	45°23′	122°18′	270
1045	48°24′00″	123°44′00″	45	1097	45°19′	122°08′	600 - 720
1046	48°43′	121°07′	390 - 450	1098	45°13′	123°51′	120 - 180
1047	48°39′	121°43′	390 - 540	1099	45°06′	121°23′	720
1048	48°36′	118°44′	720	1100	45°06′	123°36′	150 - 210
1049	48°36′	121°23′	450 - 540	1101	44°24′	123°52′	30 - 90
1050	48°35′	121°24′	120	1102	46°23′	122°12′	900 - 1050
1051	48°32′	122°19′	60	1103	43°12′	124°10′	30 - 120
1052	48°23′	120°24′	720 - 840	1104	42°07′	124°12′	240 - 360

Table 3

Test of Douglasfir samples, collected 1966/67

Lot no. -66/67	Name of Seed Source	Weight per 1000-seeds gram	Purity %	Germination (Munich)		
				Prechilled 14 days %	Not prechilled	
					Brutschrank 25°C %	Rodewald Atern. temp. %
1001	Stoner	6.12	89.2	41	36	23
1002	Dean	8.63	75.5	64	64	54
1003	Alexandria	8.30	94.6	77	71	62
1004	Stuie	9.60	85.6	80	88	80
1005	Williams Lake	7.88	84.6	53	50	43
1006	Tatla	8.96	90.7	59	57	63
1007	Clearwater	8.73	94.9	82	75	62
1008	Golden	7.19	89.4	51	61	46
1009	Klina Klini	7.45	74.5	72	56	62
1010	Barriere	7.97	93.5	67	54	50
1011	Klina Klini					
1012	Klina Klini	7.77	79.9	59	39	44
1013	Revelstoke	7.64	91.6	69	61	60
1014	Eagle Bay	8.46	84.0	71	73	67
1015	Blind Bay	8.42	92.4	69	70	68
1016	White Lake	8.10	87.9	75	84	66
1017	Squilax	8.40	93.1	57	68	45
1018	Salmon Arm	7.78	91.9	64	54	55
1019	Monte Creek	8.80	91.0	78	63	61
1020	Pillar Lake	9.19	93.0	78	81	63
1021	D'Arcy	9.34	94.1	81	65	65
1022	Fly Hill	9.01	86.8	66	72	69
1023	Jeune Landing	7.78	84.1	68	49	52
1024	Owl Creek	9.26	93.7	78	79	71
1025	Nimkish	5.76	89.2	67	46	52
1026	Stella Lake	6.66	82.5	54	60	50
1027	Alta	7.23	93.4	83	77	77
1028	Merritt	8.54	89.2	57	52	43
1029	Thasis	6.35	81.0	53	27	47
1030	Squamish	7.81	90.2	70	70	67
1031	Gold River	7.94	77.0	49	65	46
1032	Courtenay	8.68	93.7	66	70	43
1033	Forbidden Plateau	6.95	90.7	62	48	53
1034	Sechelt	7.65	90.1	72	66	64
1035	Nelson	8.19	95.7	81	66	67
1036	Alberni	8.95	91.8	84	73	62
1037	Franklin River	7.84	84.0	80	69	65
1038	Chilliwack	6.12	85.1	65	56	63
1039	Chilliwack	7.85	93.8	57	53	40
1040	Cassidy	8.21	90.6	79	74	63
1041	Caycuse	9.10	90.9	80	80	61
1042	Duncan	9.31	90.6	71	68	63
1043	San Juan	8.22	91.5	76	70	59
1044	Jordan River	6.42	46.4	39	32	40
1045	Sooke	7.66	91.1	62	60	72
1046	Diablo Dam	9.98	95.1	79	74	74
1047	Concrete	6.95	84.0	26	32	49
1048	Republic	9.82	96.0	66	60	69
1049	Bacon Point	7.89	91.6	60	38	61
1050	Marblemount	9.38	95.5	78	73	63
1051	Sedro Woolley	8.57	89.5	63	69	77
1052	Twisp	11.58	96.2	83	65	74
1053	Darrington	7.86	90.5	44	49	58
1054	Arlington	7.35	85.0	73	68	69
1055	Newport	9.78	95.3	43	67	58

(Table 3)

Lot no. -66/67	Name of Seed Source	Weight per 1000-seeds gram	Purity %	Germination (Munich) Prechilled 14 days %	Not prechilled Brutschrank 25°C %	Rodewald Atern. temp. %
1056	Sloan Creek	8.94	90.0	59	49	61
1057	Granite Falls	6.50	84.9	46	45	58
1058	Lake Crescent	8.29	91.2	78	68	79
1059	Perry Creek	7.86	83.8	54	42	52
1060	Sequim	7.96	85.5	66	76	82
1061	Louella Guard St.	7.99	86.5	68	74	80
1062	Forks	7.31	80.0	57	53	56
1063	Gold Bar	8.05	89.1	68	54	66
1064	Hoh River	8.41	87.4	61	70	69
1065	Spokane	9.70	90.1	58	47	53
1066	Scenic	6.88	76.7	49	65	63
1067	Skykomish	9.39	92.5	82	70	77
1068	Chiwaukum	12.11	96.0	83	70	69
1069	North Bend	6.64	79.9	40	33	44
1070	Denny Creek	7.91	89.6	50	62	59
1071	Keechelus Lake	9.21	93.2	74	83	79
1072	Chester Morse Lake	7.87	92.3	66	63	58
1073	Humptulips	8.64	90.2	80	65	75
1074	Matlock	7.75	79.2	65	64	67
1075	Enumclaw	9.07	91.5	73	53	63
1076	Matlock	8.83	91.5	66	70	69
1077	Shelton	8.67	86.8	63	51	47
1078	Cle Elum	9.27	95.0	79	70	79
1079	Parkway	8.72	86.4	66	58	59
1080	Yelm	8.56	83.4	64	46	50
1081	Alder Lake	8.01	89.8	63	62	63
1082	Rimrock	10.03	91.5	54	65	64
1083	Packwood	7.60	90.4	72	63	73
1084	Packwood	8.69	84.7	66	70	53
1085	Randle	9.02	81.5	59	58	63
1086	Naselle	9.43	84.3	69	75	77
1087	Skamokawa	8.25	80.2	52	55	48
1088	Castle Rock	8.71	90.8	65	67	59
1089	Cathlamet	8.97	73.6	58	60	47
1090	Cougar	8.90	87.8	65	71	69
1091	Yale	8.17	86.0	38	35	63
1092	Glenwood	9.38	86.1	66	54	56
1093	Willard	9.81	91.1	73	66	63
1094	Vernonia	9.66	90.9	69	65	69
1095	Prindle	8.55	89.4	58	47	54
1096	Sandy	8.54	86.7	54	53	47
1097	Cherryville	9.06	91.3	60	55	40
1098	Hebo	8.25	84.3	65	60	54
1099	Pine Grove	11.89	90.8	82	72	70
1100	Grand Ronde Agency	8.84	91.9	67	63	60
1101	Waldport	8.16	86.6	69	69	68
1102	Upper Soda	9.26	91.7	65	60	63
1103	Coquille	7.92	89.7	64	55	54
1104	Brookings	8.96	91.9	75	64	70

were slightly twisted. On the 30th of November 1968 the height of 50 seedlings in each replicate of each provenance was measured.

For the 1968/69 winter the seedlings were left in the nursery without any special protective measures against low temperatures. When the snow has melted and the minimal daily temperatures reached positive values the percentage of seedlings damaged by frosts was recorded and the degree of the damage to individual seedlings estimated according to a three point scale:

1 — stems damaged to 25% of length,

2 — stems damaged to 50% of length,

3 — stems damaged to 100% of length.

The percentage of seedlings with score 1 plus twice the percentage of seedlings with score 2 and plus four times the percentage of seedlings with score 3 was the overall estimate of degree of frost damage.

In the spring of 1969 all the seedlings have been dug out and planted anew in rows with 20 cm spacing between the plants. The same sequence of provenances and replicates was maintained. Then the actual number of seedlings available for each provenance in each replicate after one year of cultivation was recorded.

All the observations obtained have been tabulated for the provenances and replicates and sent to the Laboratory of Numerical Methods of Wrocław University in order to obtain information about the degree of correlation between the various characters as well as with geographic latitude, longitude and elevation of the seed origign. Besides the correlation analyses also variance analyses were performed to estimate which of the studied characters significantly differentiates the provenances.

RESULTS

The total range of Douglas fir in North America extends considerably beyond the region from which seeds were collected for this experiment (fig. 1).

The information obtained on the performance of the plants in nursery conditions in Kórnik have been analysed with respect to several characters.

CHARACTERS 1. RATE OF SEEDLING EMERGENCE

The variance analysis has shown that provenances differ very significantly with respect to this character. The *F* value exceeds many times over the minimal values needed to claim with 99% certaintly that the differences are significant (table 4).

As can be seen from table 4 also the blocks have induced significant

Table 4

Analysis of variance for rate of seedling emergence

Source of variation	Degrees of freedom	Sum of Squares	Mean Square	F obtained	F 0.05	F 0.01
Provenances	103	719.46	6.98	7.22^{++}	1.28	1.42
Blocks	3	8.00	2.67	2.76^{+}	2.62	3.83
Residual	309	298.74	0.97	–	–	–
Total	415	1026.21	2.47	–	–	–

variation in the material with respect to this character which only stresses the need for replication in nurseries even though the conditions appear to be uniform.

Results of the correlation analyses presented jointly in table 5 indicate that the rate of seedling emergence is not correlated with the average height of the seedlings but is very significantly correlated with some of the other studied characters, positively with 1) number of seedlings obtained after 1 year of cultivation, ($r=0.71$), 2) percentage of emerged seedlings ($r=+0.74$), 3) latitute of the site of seed collection ($r=+0.53$), and 4) with altitute of the site of seed collection ($r=0.49$). With longitude the correlation was negative ($r=-0.45$). From these results it can be seen that seeds that are characterized by a fast rate of seedlings emergence and a high percentage of seedlings obtained from them have provided the greatest number of transplants one year after sowing. These seeds come from eastern and northern regions and generally from higher elevations within the region where the seeds were collected. The rate of seedling emergence is also correlated negatively with the percentage of

Table 5

Value of the correlation coefficient (r) between varions characters for 103 degrees of freedom

r significent at 0.05 level=0.195

r significent at 0.01 level=0.254

	Germination %	Rate of germination	Mean seedling height	Growth termination	No. of transplants obtained	% of seedlings damaged by frost	Degree of frost damage	Lat N	Long W
Rate of germination	0.736								
Mean seedling height	0.005	−0.088							
Growth termination	−0.535	−0.762	0.544						
No. of transplants obtained	0.749	0.711	−0.102	−0.550					
% of seedlings damaged by frost	−0.342	−0.415	0.733	0.745	−0.366				
Degree of frost damage	−0.356	−0.436	0.651	0.719	−0.433	0.924			
Lat N	0.351	0.530	−0.002	−0.455	0.307	−0.302	−0.324		
Long W	−0.461	−0.447	0.443	0.622	−0.514	0.560	0.548	−0.008	
Alt m.	0.392	0.486	−0.362	−0.654	0.393	−0.518	−0.468	0.107	−0.605

seedlings damaged by frosts ($r=-0.41$) which indicates that seedlings quick to emerge were less frequently and less intensly ($r=-0.44$) damaged by frost. A negative correlation coefficient of $r=-0.76$ between the rate of seedling emergence and the growth termination character indicates that seedlings of those provenances which were characterized by early seedling emergence were also early to complete growth.

CHARACTER 2. PERCENTAGE OF GERMINATED SEEDS

This character is correlated positively and negatively with the same characters as was the rate of seedling emergence, however the values of the correlation coefficient were somewhat different. It was somewhat better for the correlation with the number of seedlings after one year ($r=+0.75$) and for longitude ($r=-0.46$) while for latitude ($r=+0.35$) and altitude ($r=+0.39$) weaker. Also no correlation was found for seedling height (table 5). The provenance differentiation with respect to this character was very high as indicated by the variance analysis ($F=7.94$ see table 6).

Table 6

Analysis of variance for germination percentage

Source of variation	Degrees of freedom	Sum of Squares	Mean Square	F obtained	F 0.05	F 0.01
Brovenances	103	15698.87	152.42	7.94^{++}	1.28	1.42
Plocks	3	1668.93	556.31	28.98^{++}	2.62	3.83
Residual	309	5931.57	19.20	–	–	–
Total	415	23299.36	54.16	–	–	–

CHARACTER 3. MEAN SEEDLING HEIGHT

Provenances differed very significantly in seedling height which character was also under the influence of site conditions in different parts of the nursery as indicated by significant F value for the blocks (Table 7). Thus it can be said that the soil variation has a considerable effect on the growth of Douglas fir seedlings. The mean seedling height averaged over the four replicates is presented in table 8.

On the basis of the correlation analyses (table 5) it can be said that there is a very close relation between seedling height and the percentage of seedlings damaged by frost ($r=+0.73$) and the degree of that damage ($r=+0.65$). Somewhat lower values of the correlation coefficient have been obtained for the correlation with the growth termination character ($r=+0.54$) and for longitute of the site of seed collection ($r=+0.44$). Also a negative correlation has been observed between seedling height

Table 7

Analysis of variance for seedling height

Source of variation	Degrees of freedom	Sum of Squares	Mean Square	*F* obtained	*F* 0.05	*F* 0.01
Provenances	103	825.46	8.01	3.95^{++}	1.28	1.42
Blocks	3	35.83	11.94	5.89^{++}	2.62	3.83
Residual	309	626.20	2.02	–	–	–
Total	415	1487.49	3.59	–	–	–

and the elevation above the sea level for the studied provenance. Thus it can be said that seedlings coming from the coastal regions and from lower elevations of the studied area of Douglas fir distribution have a greater height, but they tend to suffer more from frost damage. No significant correlations have been observed between seedling height and latitude of seed origin, rate and percentage of emerged seedlings and the number of seedlings available after one year of cultivation.

CHARACTER 4. TERMINATION OF SEEDLING GROWTH

Date of growth termination in a vegetative season is a very important characteristic in the choice of provenances resistant to early autumn frosts. The seedlings which were late in terminating growth in height were the ones which suffered most from low temperatures. Seedlings from the coastal regions were characterized by intensive growth in height but this growth was terminated late in the season and it was from these provenances that fewest transplants were obtained after one year. (See table of correlations, table 5). Also a very significant correlation was obtained between this character and the elevation above the sea level of the site where the seeds were collected, ($r = -0.65$) which indicates that seedlings originating from seeds collected at higher altitudes were quicker to terminate growth in height in the autumn.

The termination of seedling growth character was not affected by variation in site conditions within the nursery because there were no significant differences between the blocks, while the variance for the provenances was very high as can be seen from table 9.

CHARACTER 5. NUMBER OF DOUGLAS FIR SEEDLINGS AFTER ONE YEAR OF CULTIVATION

This character very significantly differentiated the provenances and the high value of *F* obtained in the analysis of variance for the blocks

Table 8

Average values for each provenance of the seven studied characters

Prov. no.	Germination %	Rate of seedl. emergence	Seedling ht.	Growth termination	No. of 1 yr. plants	% plants frost domaged	Degree of frost damage
1	2	3	4	5	6	7	8
1001	13.75	8.50	3.74	1.25	381	0.00	0.00
1002	2.75	6.75	6.86	4.25	89	17.72	21.67
1003	22.27	9.00	3.12	1.00	842	0.00	0.00
1004	21.75	8.00	7.29	4.25	334	27.03	46.07
1005	15.97	10.00	4.16	1.00	511	0.56	1.55
1006	21.20	10.00	3.92	1.00	726	0.60	1.50
1007	25.45	10.00	5.45	1.50	632	0.55	0.60
1008	18.07	9.50	3.58	1.25	409	0.00	0.00
1009	15.75	7.50	7.28	4.50	197	24.29	93.60
1010	21.07	9.50	4.86	1.50	581	1.51	5.40
1011	7.07	6.25	5.38	3.50	79	16.48	39.47
1012	8.52	7.25	6.10	3.75	242	8.85	22.45
1013	18.97	9.50	4.27	1.50	343	0.16	0.17
1014	23.12	10.00	7.48	3.00	1254	21.72	26.00
1015	27.30	9.75	6.23	2.25	703	2.09	2.50
1016	30.10	10.00	5.21	1.50	627	5.24	7.12
1017	24.80	9.75	5.28	1.50	611	1.08	1.32
1018	24.12	9.50	4.94	1.00	630	0.26	0.22
1019	25.67	10.00	3.99	1.00	643	0.55	0.80
1020	22.00	9.50	3.70	1.25	433	0.16	0.15
1021	19.55	8.25	7.48	3.25	322	13.89	30.37
1022	20.25	9.75	5.00	1.25	692	0.00	0.00
1023	16.55	8.50	8.89	5.00	375	26.93	44.42
1024	27.00	9.25	7.89	4.75	735	28.81	47.52
1025	15.70	8.50	9.86	4.50	366	36.51	64.10
1026	12.15	6.50	6.80	4.75	330	3.08	9.60
1027	19.15	9.25	5.55	2.75	440	7.56	26.25
1028	17.02	10.00	4.20	1.25	577	0.00	0.00
1029	11.95	7.25	7.10	4.75	310	17.41	26.35
1030	15.37	8.00	6.57	4.25	351	10.55	15.62
1031	13.55	7.75	7.66	5.00	371	34.51	63.67
1032	13.37	7.25	5.98	4.00	214	15.06	20.77
1033	16.82	9.00	7.93	4.00	511	25.95	48.57
1034	16.27	7.25	8.72	4.50	354	23.91	39.65
1035	30.27	9.75	4.74	1.50	626	1.36	2.55
1036	20.47	8.25	8.32	4.75	399	34.85	64.65
1037	21.50	8.75	7.52	4.00	499	22.08	36.92
1038	16.17	8.00	7.52	4.00	318	17.73	27.97
1039	13.80	7.25	6.57	4.75	623	16.45	28.60
1040	18.10	8.00	6.87	4.25	396	17.67	28.70
1041	20.95	8.50	7.66	4.50	487	18.40	31.32
1042	15.15	7.50	8.64	4.50	438	36.49	69.75
1043	15.72	7.50	6.92	4.25	379	25.79	38.15
1044	1.60	6.75	6.14	4.50	51	31.75	60.82
1045	15.80	7.50	8.74	4.50	346	35.66	47.47

(table 8)

1	2	3	4	5	6	7	8
1046	23.80	8.00	6.57	4.50	472	12.75	24.17
1047	12.62	7.25	8.02	5.00	538	28.08	50.97
1048	22.70	10.00	3.59	1.50	817	0.00	0.00
1049	14.95	7.00	7.97	4.50	308	24.77	64.95
1050	21.80	7.75	7.27	5.00	348	21.55	40.12
1051	18.72	7.00	5.91	4.75	387	28.94	47.02
1052	30.50	10.00	5.40	1.00	959	0.65	0.70
1053	14.22	7.25	5.05	4.25	793	16.40	30.25
1054	8.52	7.25	5.70	4.00	219	32.41	42.92
1055	23.72	9.50	4.95	1.25	814	0.00	0.00
1056	17.70	7.50	6.88	4.50	591	15.87	30.92
1057	4.50	5.75	4.92	4.25	219	4.65	12.57
1058	13.27	6.50	4.39	4.75	227	8.75	18.90
1059	15.22	8.50	7.73	4.25	646	25.81	45.92
1060	11.30	6.25	8.17	4.75	204	32.77	84.57
1061	11.87	7.00	7.19	4.50	286	30.18	54.85
1062	5.82	6.25	4.63	4.25	152	6.45	23.27
1063	12.12	7.00	5.93	4.50	284	12.53	28.35
1064	14.50	6.50	5.89	4.75	292	23.72	33.92
1065	13.95	9.00	4.15	1.25	659	1.26	1.42
1066	2.20	6.00	5.87	3.00	70	13.75	19.65
1067	22.90	6.75	6.51	4.75	477	24.51	46.35
1068	32.10	9.75	5.90	1.50	941	1.19	1.57
1069	8.35	5.50	4.94	5.00	298	11.37	16.12
1070	13.10	6.25	5.66	5.00	355	14.83	26.25
1071	17.75	7.25	5.82	2.50	218	6.03	9.32
1072	16.82	5.72	6.37	4.50	296	9.74	21.52
1073	16.40	7.00	4.79	4.25	246	5.26	9.05
1074	13.42	7.75	5.47	4.75	439	19.14	31.07
1075	16.52	6.75	6.62	5.00	241	16.92	50.87
1076	11.95	7.25	5.84	3.75	260	20.41	36.77
1077	14.35	5.75	6.03	4.75	527	16.90	24.22
1078	24.00	8.50	7.60	2.75	520	10.97	15.05
1079	14.42	8.00	6.50	3.50	480	17.76	29.50
1080	11.32	6.25	6.13	4.75	275	20.30	47.55
1081	12.15	5.50	3.63	3.00	286	7.31	5.75
1082	17.77	9.50	6.30	1.50	618	6.30	6.70
1083	14.90	7.25	7.17	4.50	307	22.90	44.32
1084	13.52	7.25	6.64	5.00	362	11.88	21.75
1085	13.15	6.75	5.83	4.00	263	24.02	37.27
1086	15.20	7.50	7.34	4.50	454	26.37	45.95
1087	10.30	6.00	4.02	4.75	332	15.22	39.85
1088	15.17	5.00	5.05	4.75	414	15.25	23.80
1089	10.82	6.75	6.28	5.00	395	19.73	34.17
1090	15.02	7.50	6.57	4.75	418	19.49	34.62
1091	9.47	6.75	5.15	4.50	272	11.36	26.42
1092	12.27	7.75	6.13	3.50	387	17.15	24.25
1093	10.80	6.50	5.26	4.25	271	19.17	36.15
1094	14.80	8.00	6.07	4.50	391	14.39	31.90

(table 8)

1	2	3	4	5	6	7	8
1095	6.82	7.75	6.19	3.50	181	17.86	36.52
1096	7.57	6.00	4.41	4.75	207	11.94	18.42
1097	11.70	6.25	4.27	4.50	293	8.81	17.70
1098	9.55	7.75	4.65	4.50	262	17.99	31.52
1099	21.15	9.00	7.45	3.00	467	14.60	22.80
1100	10.42	7.00	4.61	3.75	262	8.72	20.10
1101	8.77	7.50	6.68	5.00	150	36.91	86.22
1102	14.85	6.50	4.54	3.75	382	14.77	29.47
1103	9.72	6.50	6.71	5.00	199	43.32	96.60
1104	14.40	6.00	5.56	4.75	201	25.62	71.92

(table 10) indicates that location of the seedlings within the nursery plot has a very significant effect on the number of transplants obtained.

The average number of seedlings per provenance in block I was 137.08 in block II 111.79 in block III 85.85 and least in block IV 81.29. This gives a deviation from the mean for all the replicates for block I 33.08 for block II 7.79 for block III —18.15 and for block IV —22.71.

The number of seedlings after one year of cultivation for the individual provenances was correlated with the percentage of germination ($r = +0.75$) with the rate of seedling emergence ($r = +0.71$) and also, but to a lesser degree with the latitude ($r = +0.31$) and the elevation above the sea level ($r = +0.39$) of the site of seed collection. Negative correlations were obtained with the termination of growth character ($r = -0.55$),

Table 9

Analysis of variance for the termination of seedling growth

Source of variation	Degrees of freedom	Sum of Squares	Mean Square	F obtained	F 0.05	F 0.01
Provenances	103	764.76	7.42	11.73^{++}	1.28	1.42
Blocks	3	0.57	0.19	0.30	2.62	—
Residual	309	195.43	0.63	—	—	—
Total	415	960.76	2.31	—	—	—

Table 10

Analysis of variance for the number of seedlings after one year

Source of variation	Degrees of freedom	Sum of Squares	Mean Square	F obtained	F 0.05	F 0.01
Provenances	103	1 108 562.0	10 762.74	6.16^{++}	1.28	1.42
Blocks	3	208 012.38	69 337.46	39.67^{++}	2.62	3.83
Residual	309	549 103.61	1 747.91	—	—	—
Total	415	1 856 678.0	4 473.92	—	—	—

the degree of damage by frosts ($r=0.43$) and the percentage of seedlings damaged by frost ($r=-0.51$). The correlation between the number of seedlings after a year and their height is not significant (table 5).

CHARACTER 6. PERCENTAGE OF SEEDLINGS DAMAGED BY FROST

Economically this is one of the most important characters when differentiating provenances. This differentiation is highly significant as well as that induced by site conditions in the nursery (blocks).

Table 11

Analysis of variance for the percentage of seedlings damaged by frost

Source of variation	Degrees of freedom	Snm of Squares	Mean Square	F obtained	F 0.05	F 0.01
Provenances	103	50085.92	486.27	3.93++	1.28	1.42
Blocks	3	2173.50	724.61	5.88++	2.62	3.83
Residual	309	38167.50	123.52	—	—	—
Total	415	90427.25	217.90	—	—	—

The mean percentage of seedlings damaged by frost for the whole experiment was 15.78% while in the individual blocks it was as follows:

Table 12

Block no.	Mean percentage of seedlings damaged by frost	Deviation from the mean $\bar{x} = 15.78$
I	17.203	1.418
II	16.745	0.960
III	17.347	1.562
IV	11.844	—3.940

Most resistant to frost were the provenance from Stoner (1001), Alexandria (1003), Fly Hill (1022), Merritt (1028) and Republic (1048). In these seed lots not a single seedling was frost damaged. There was no provenance in which all the seedlings were frost killed. One of most damaged 41.37% provenance was from the river Klina-Klini (1009), while another provenance from this river, located only 70 km to the north east and named Tatla (1006) belongs to the more resistant provenances since only 0.62% of the seedlings were frost damaged. This phenomenon of considerable provenance differences between populations located relatively close to each other was observed also for other characters.

Besides the provenance no. 1009 from Klina Klini a very high percentage of seedlings damaged by frost was observed in the following provenances: Alberni (1036) – 35.02%, Duncan (1042) – 35.67%, Sequim (1060) – 40.20%, Waldport (1106) – 41.85% and Coquille (1103) – 43.65%.

The number of seedlings damaged by frost was positively correlated with seedling height ($r=+0.73$). Provenances whose seedlings were tall were most damaged by the frost. Also it is obvious that there was a correlation with the termination of seedling growth ($r=+0.74$), that is those seedlings which grew longer in the autumn have been more seriously damaged by frost. With the degree of frost damage the correlation was very close indeed ($r=+0.92$). The provenances in which the largest proportion of seedlings was frost damaged also had the most seriously frost damaged seedlings. The percentage of frost damaged seedlings was also correlated with the longitude ($r=+0.56$), that is the eastern provenances were more resistant. Also the provenances with more frequently damaged seedlings were characterized by low germination percentage and slow rate of seedling emergence (table 5). This character was correlated negatively with the elevation above the sea level of the site of seed collection ($r=-0.52$). Seedlings originating from greater altitudes were less frequently damaged by frost.

CHARACTER 7. DEGREE OF SEEDLING DAMAGE BY FROST

This character was very closely correlated with the percentage of seedlings damaged by frost and with all the other characters with which this percentage was correlated. Results of these correlation analyses are presented in table 5.

Analysis of variance of this character has also shown that provenances differ very significantly in the degree to which seedlings were damaged. There were also significant differences between blocks. The F values are presented in table 12.

Table 13

Analysis of variance for the degree of seedling damage by winter colds

Source of variation	Degrees of freedom	Sum of Squares	Mean Square	F obtained	0.05	0.01
Provenances	103	207120.81	2010.88	3.30^{++}	1.20	1.42
Blocks	3	9081.27	3027.09	4.97^{++}	2.62	3.83
Residual	309	188214.73	609.11	–	–	–
Total	415	404416.81	974.49	–	–	–

DISCUSSION AND SUMMARY

So far it has not been possible to conduct such extensive studies on Douglas fir in Poland as this experiment, covering 104 provenances from a major part of the species range permits. Several characters have been studied in seedlings from these provenances and in particulr note was taken of their resistance to low winter temperatures.

The results obtained from this experiment are generally in agreement with those obtained in other parts of Europe where the climate is as continental as ours. The 1968/69 winter was in our conditions characterized by weather typical for a continental climate.

When studying the rate of seedling emergence it has been found that the provenances whose rate was high also ended up with high germination percentage and a large number of transplants after one year of cultivation. These provenances came from the eastern and northern parts of the studied range and generally from considerable elevations above the sea level. Mean seedling height was a character differentiating the provenances considerably.

There is a strict correlation of seedling height with the percentage of seedlings damaged by frost as well as with the degree of that damage. From these studies it can be concluded that seedlings coming from coastal regions or those from low elevations within the studied area of Douglas fir distribution attain greater heights but at the same time are more seriously damaged by low winter temperatures. These results are in agreement with those reviewed by Schober (1963) for western Europe as well as with those obtained by Ilmurzyński, Bellon and others (1968) and Hermann and Levandera (1968). It was not possible to establish a significant correlation between seedling height and the latitude of the site of Douglas fir seed collection.

Such a character as the time of termination of seasonal growth is important for the selection of provenances resistant to damage by early autumn frosts. Seedlings of coastal provenances from North America are characterized by intensive growth, extended long into late autumn and as a result it is these that have suffered most from frost damage. Seedlings from provenances of higher elevations have terminated seasonal growth much earlier than those from lower elevations. Similar results concerning correlations between date of growth termination and seedling resistance to low temperatures have been obtained also by Schönbach (1967) and Schober (1968).

The determination of the percentage of seedlings with frost damage for individual provenances is the most important result of this investigation. Most resistant to low temperatures in our conditions were the seedlings from provenances from the Rocky Mountains in British Columbia, namely Stoner (1001), Alexandria (1003), Fly Hill (1022), Merritt (1028) and from the western part of the Rockies in Washington state, provenance Republic (1048). Among the most seriously damaged by low temperatures were seedlings of provenances from Washington state Duncan (1042), Sequim (1060), Coquille (1103), and from Canada from the plains between the Rockies and Coastal range as well as from the coastal range itself, Alberni (1036) and Klina-Klini (1009). However seedlings from provenance Tatla (1006) located only 70 km north east from the Klina-Klini provenance were among the more resistant ones. These results indicate that the differentiation of seedlings with respect to frost resistance can at times be considerable even for provenances located close to each other. This has been pointed out by other authors also. The susceptibility to frost was found to be strongly correlated with seedling height and with the duration of the growing period in the autumn. Seedlings of eastern provenances were generally more resistant than those from the western part of the range under investigation.

From the introductory results presented here it can be concluded that in our climatic conditions most satisfactory Douglas fir provenances would be those characterized not only by intensive growth but also by high resistance to low temperatures. Generally these two characters do not go together in our seedling material. There were however some provenances which were exceptional in that they were characterized by both intensive growth and low temperatures (tables 8). These were Caycuse (1041), Chilliwack (1038) and D'Arcy (1021) from British Columbia, Cle Elum (1078) from Washington and Pine Grove (1099) from Oregon. Detailed studies would be required on the Douglas fir stands long under cultivation in Poland, which have been subjected to our climatic conditions for a long time. Even though origin of these populations is not known, their productive value is often high and therefore comparative studies with those on Douglas fir of known origin from indiginous stands within the natural range of the species are very much in demand.

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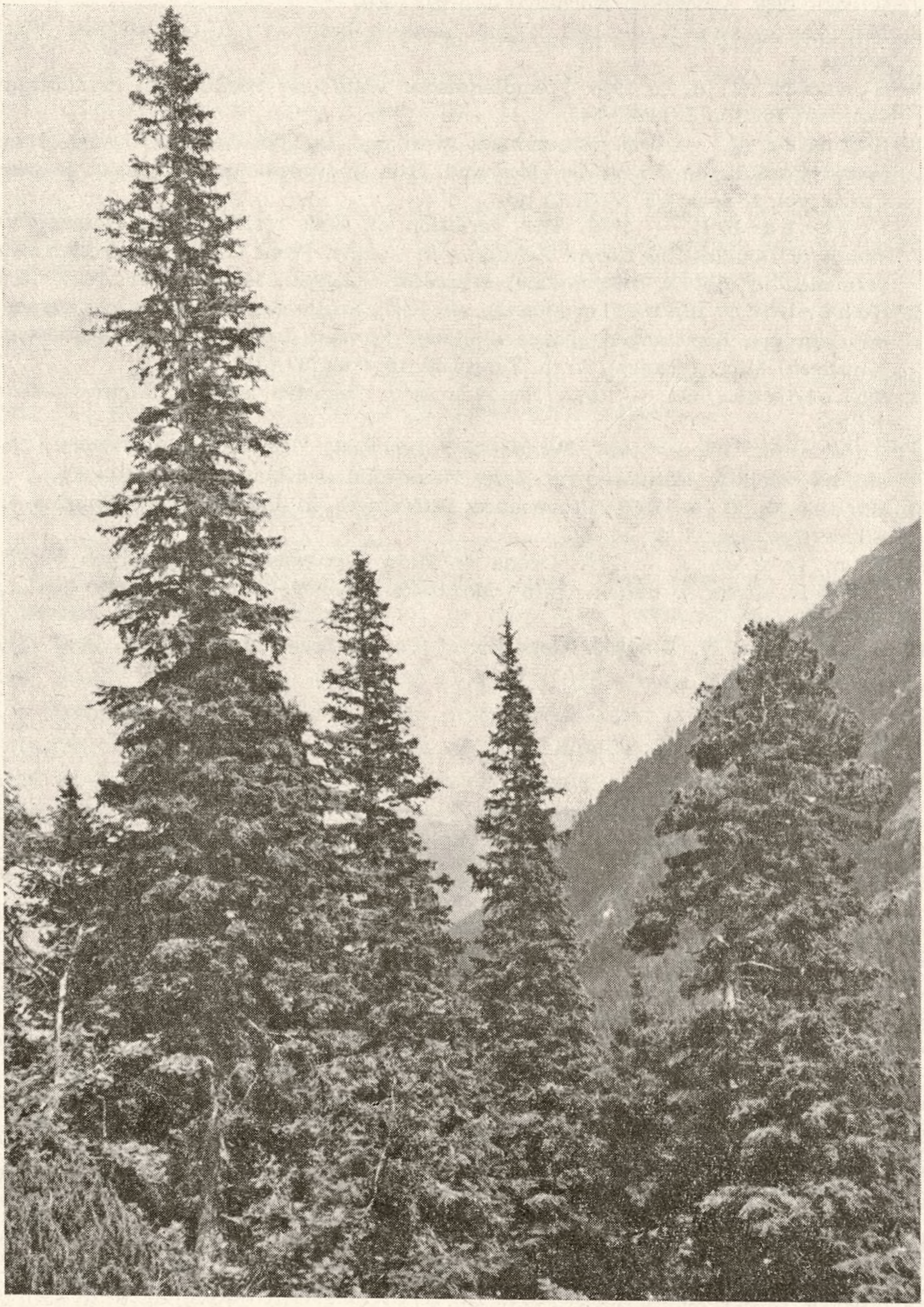

Fot. K. Jakusz

Świerki (*Picea excelsa* Lk.) z lewej i limba (*Pinus cembra* L.) z prawej w pobliżu Morskiego Oka w Tatrach