Herkomsten
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Douglas fir IUFRO provenances in the Netherlands, 1968-69 Series. Nursery results.

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Introduction and objectives

In 1966-1969, the International Union of Forestry Research Organizations (IUFRO) organized the collection of seed of Douglas fir, Pseudotsuga menziesii (Mirb.) Franco from provenances throughout its natural range. The first series covering 104 provenances was collected in 1966 and 1967 in British Columbia, Canada and Washington and Oregon, United States.

In 1968 and 1969 seed from some 80 provenances and 90 individual trees (open pollinated) was collected in Oregon, California, Arizona, New Mexico, Colorado and Utah, United States.

Seed of both series was obtained for gene conservation and for provenance trials in the Netherlands. In the provenance trials, geographic variation in populations of Douglas fir are being studied and the suitability of provenances for plantation work in the Netherlands is being assessed.

Early results of 57 provenances of the first series have been reported (Kriek 1974). The present report deals with early results in the nurseries, of provenances and half-sib progenies of the second series.

Material

Seed of 46 provenances and 58 individual trees of the second IUFRO collection of 1968/1969 was received in the Netherlands. Origin of the seed and the number of trees from which the seed was collected are given in Table 1. The geographic distribution of the seed sources is shown in Figure 1.

The seed was sown in December 1970 in three replicates in a commercial nursery at Zundert in the south-west of the Netherlands under supervision of the Forest Research Station. The plots representing each provenance varied in area from 0.15 m2 tot 1.25 m2, depending on the amount of seed available and the expected number of plants.

Immediately after germination in April 1971 the plants of some provenances were injured by late frost. Some provenances suffered serious losses from damping-off, caused by Pythium spp. The extent of the frost damage and the losses were not recorded. At the end of the first season the number of seedlings in the plots varied from12 to 700 per square metre.

In spring 1972, the one-year-old seedlings were transferred to the nursery of the Dorschkamp Forest Research Station, at Wageningen. The same replicates were maintained. Each lot was planted in a plot of 4 rows, the length of the rows depended on the number of seedlings. The spacing between the rows was 35 cm and in the rows depending on mean height: 12 cm for provenances and progenies with a mean height less than 8 cm; 15 cm for provenances and progenies with a mean height 8-12 cm; and 20 cm for those with a mean height at least 12 cm.

During the winter of 1972/1973 the plants were protected by vertical screens of jute about one metre high, which were erected alongside the outer rows of the plots.

Weather

Temperature was the main factor in development in the nurseries.

For the period in which the plants were on the seedbed in Zundert, data from Oudenbosch, the nearest weather station, show that the months of April and September 1971 were colder and the month of May 1971 was warmer than normal (Table 2).

A late frost occurred late April 1971, after germination, damaging the plants slightly. An early frost occurred in Mid-September 1971 also causing damage.

While the plant were on the transplantbed in Wageningen in 1972-1973, the weather at the Wageningen station was as in Table 3.

Since the period of recording at this station is rather short not the deviations from normal for this station but the deviations from the longterm means of the central weather reporting station at de Bilt, westwards of Wageningen, are given instead.

The spring of 1972 was rather cold. Temperatures

Verschijnt tevens als Mededeling nr. 144 van „De Dorschkamp".

were lower in Wageningen than in de Bilt. In April the number of days with a minimum temperature below O°C was about normal in Wageningen and less than normal in de Bilt. There were no late frosts in May.

In September low temperatures were recorded between the 21st and 26th. No frosts were recorded at the weather stations, but in the nursery some frost damage was observed.

The winter of 1972/1973 was warm, although the number of days with a minimum temperature 0°C was normal.

The spring of 1973 was cold again. In April the number of days with a minimum temperature below 0°C was high. In May some late frosts occurred not harming the plants. September 1973 was warm.

Measurements and observations

Measurements and observations in the commercial and the research nursery are summarized in Table 4.

Heights

Heights were measured on the seedbed at the end of the first season and at the end of the nursery stage when the seedlings were 3 (1+2) years old.

Since the plot size and the seedling density varied between provenances and replicates, a mixed system of complete assessment and sampling was used on the seedbed. All plants were measured when the plot area was 0.25 m2 or less or when in a larger plot the seedling density was less than 400 per square metre. Larger plots with 400 per square metre or more were sampled systematically. In plots of 0.30 and 0.35 m2, two samples of 0.05 m2 were assessed, and in larger plots three samples of the same size (Table 4, Col. 5).

Figure 2 shows that after the first year in general the mean height decreased with altitude of the seed source.

At the end of the third season, 1973, the heights were measured of at most 60 trees in the two central rows of the plots. If less than 15 trees survived per row in a plot, all trees of all 4 rows of the plot were measured. (Table 4, Col. 10). The results show that several high-altitude provenances and progenies from southeastern Arizona and southwestern New Mexico grew rapidly and attained the same mean heights as the provenances from medium and low altitudes in North Oregon and California (Fig. 3). Poorest growth was in some provenances from very high altitudes in Utah and Colorado.

Frost

Frost damage occurred in mid-September both in 1971 in the seedbed and in 1972 in the transplant bed. In 1971 seedling damage was estimated for three replicates (Table 4, Col. 4). The provenances from Oregon and California, in particular, were damaged, some rather seriously.

In 1972 no detailed observations were made on damage by early frost, but the same pattern was observed. During the winter of 1972/1973, winter frost probably affected some provenances from California but could not be assessed because the early frost damage had not been recorded.

Late frosts hardly occurred during the nursery stage. Thus no information on susceptibility to this hazard is as yet available.

Losses of transplants

Losses of transplants for the period immediately after transplanting, March - June 1972, and June 1972 - August 1973, were recorded.

During the first period, losses were generally heavy, up to 41% for provenances from Oregon and California and light, up to 10% for provenances and progenies from the more southern states. These losses were due to plant shock and a light snow cover immediately after transplanting.

Losses in the second period ought to have reflected the influence of early and winter frost damage during the period and therefore should be higher for the Californian provenances than for those from the other states. But both heavy and light losses occur within the series of provenances and progenies of all regions. Some provenances and progenies suffered rather heavy losses of up to 27% (Table 4, Col. 6).

Spring flushing

Flushing of the top buds of a systematic sample of 10-15 trees per replicate (60-90 for each provenance) was recorded on 3 and 15 May 1973, at the beginning of the third growing season. (Table 4, Col. 7).

Seven stages of flushing were distinguished with photographs. The extreme values 0 and 6 were allocated when the final bud of the leading shoot was still resting and not swollen and when the emerging leading shoot was extending (Kriek 1974 p. 6-7).

A lower value suggests later flushing. Provenances and progenies with less than 60 plants have been omitted. On these data an analysis of variance was carried out and the test of Tukey was applied. The ranges of insignificance proved to be 0.60 at a confidence level of 99% and 0.55 at a confidence level of 95%.

Flushing of all provenances was probably advanced by the shelter from the vertical jute screens. The provenances from Oregon and California flush rather early. Provenances from Washington in the 1966/1967 series flushed considerably later in a field trial. In view of the diffenrence in micro-climate, the provenances from Oregon and California most probably flush earlier than those from Washington. The provenances and progenies from the southern states flush very early.

The time lag in flushing within the 1968/1969 series between very early flushing progenies and provenances from the south and the later flushing provenances from the north was at least two weeks. The earliest-flushing progenies from Ponderosa Campground in Arizona, IUFRO no. 265, 267 and 268 reached 4.0 on 3 May, whereas the latest flushing provenance in this series, Ashland in Oregon, IUFRO no 1126, reached only 3.8 on 15 May.

No damaging late frosts occurred in 1973, thus the importance of the flushing pattern cannot be fully assessed, since it is not known how the early-flushing southern provenances and progenies would react to late frosts.

Lammas growth

Lammas growth may be of importance for damage caused by early frosts and winter frosts to these insufficiently lignified shoots. In August 1973, lammas shoot growth was recorded separately for the leading shoot and the lateral shoots of all plants. (Table 4, Col. 8 and 9).

All provenances and progenies had some lammas shoot growth. Lammas growth was frequent in some provenances from California and one from Oregon, IUFRO No 1138, 1140, 1148, 1149 and 1119, and the majority of the southern provenances and progenies (except some progenies from Colorado and Utah, IUFRO No 235-237 and 241-244) and especially in IUFRO No 271-297 from the southern parts of Arizona and New Mexico.

However no damaging early frost occurred in 1973. As the plants were lifted, packed in plastic bags and stored in January before any winter frost damage could be observed, we could not study the relation between lammas growth and frost damage. The frequent lammas growth of some of the provenances from California and the serious frost damage to the same provenances in 1971 indicates a possible correlation between the two features.

Grouping of seed sources

For most of the characteristics definite differences exist across the natural range of Douglas fir. An attempt was made to delineate geographic areas, using the continental divide, large gaps between origins and altitude as boundaries (Fig. 4).
The following altitudinal zones were distinguished: very low to low altitudes below 1200 m above sea-level, medium altitudes at 1200 to 1800 m, high altitudes at 1800 to 2400 m and very high altitudes at 2400 at 3000 m. The means per area are given in Table 5 for each of the characteristics mean height, flushing, lammas growth on top shoots or top and lateral shoots. Means and ranges are shown in Figures 5-8.

Analysis of variance shows that for each of the characteristics there were significant differences between areas and between progenies within stands at the 99% confidence level. For flushing there were significant differences at the 95% confidence level also between stands within areas. There were no significant differences between stands within areas for the three other characteristics.

For height and flushing significance of differences was tested for each pair of areas with Student's test, 95% conficence level (Tables 6 and 7). Provenances and progenies from low altitudes in Oregon, Area 1, and high altitudes in southeast Arizona and southwest New Mexico, Area 12 were clearly superior in height growth. Inferior in height growth were provenances and progenies from four areas at high and very high altitudes in Colorado, Utah and western Arizona, Areas 5, 6, 8 and 11. Provenances and progenies from medium altitudes in central Arizona, Area 9, flushed significantly earlier than those from most other areas. Between all other areas in the southern states the differences were generally insignificant. The differences between the areas in Oregon and California were in general small, but significant differences do exist between these areas on the one hand and those in the southern states on the other hand.

Lammas growth was particularly frequent on material from high and very high altitudes in west and southeast Arizona and southwest New Mexico, Areas 11 and 12 and only slightly less frequent on material from low altitudes in California, and medium altitudes in central Arizona, Area 2 and 9. Little lammas growth occurred on material from Areas 3 and 4 in California and from Areas 6 and 8 at very high altitudes in Colorado and Utah.

Conclusions

The early results suggest the following tentative conclusions.

1 Provenances from the northern Oregon area grow fast in the nursery.
They flush rather late, but still considerably, earlier than those from Washington.

2 Provenances from Areas 2, 3 and 4 in California grow fast. They flush simultaneously with those from north and south Oregon. The low-altitude provenances from the coast Area 2, frequently form lammas shoots and are probably prone to early

and winter frost.
They probably also suffer with late frosts.

3 The high-altitude provenances from Area 12 in southeast Arizona and southwest New Mexico grow fast and flush early. A very high percentage of plants formed lammas shoots.

4 Provenances and progenies from Areas 7, 9, 10, 13 and 14 at medium to very high altitudes in the southern states grow well, flush early and have fairly high percentages of plants with lammas growth.

5 Any consequences of lammas growth and early flushing of seedlings from Areas 7, 9, 10, 12, 13 and 14 for the incidence of frost damage remain to be seen. So far they seem hardier to autumn and winter frosts than coastal provenances.

6 Provenances and progenies from Areas 5, 6, 8 and 11 at high to very high altitudes in the southern states grow slowly, flush early and, apart from Area 11, have little lammas growth.

Literature

Kriek, W. 1974. Douglas fir IUFRO provenances in the Netherlands.
1966/1967 Series. Ned. Bosb. Tijdschr. 46(1):1-14; Meded. Bosbouwproefstation nr. 136.

Tables and Figures on p. 104-116.

Table 1 Location and number of trees from which seed was collected

IUFRO Sel. No.	BPS. Sel. No.	Provenance	Latitude N	Longitude W	Altitude (m)	Trees from which collected (N)
		Oregon				
1113	1776	Marion, Mill City	40°48'	122°42'	165	15
1115	1777	Benton, Corvallis	44°42'	123°13'	75	16
1119	1778	Lane, Eugene	44°01'	123°23'	210	16
1126	1779	Jackson, Ashland	42°05'	122°39'	1470	15
		California				
1127	1780	Siskiyou, Happy Camp	41°57'	123°30'	960	15
1129	1781	" , Seiad Valley	41°48'	123°00'	720-840	19
1130	1782	" , Hawkinsville	41°47'	123°40'	1050	14
1131	1783	" , Scott Bar	41°44'	123°06'	960-1020	17
1132	1784	" , Fort Jones	41°43'	122°50'	1140	15
1133	1785	" , Happy Camp	41°39'	123°31'	1230	16
1134	1786	" , Sawyers Bar	41°17'	123°08'	1110-1170	16
1135	1787	" , " "	41°17'	123°09'	1440	15
1136	1788	" , Dunsmuir	41°12'	122°18'	990	14
1137	1789	Shasta, Burney	41°05'	121°39'	1005	15
1138	1790	Humboldt, Arcata	40°55'	123°50'	450-510	16
1139	1791	Trinity, Weaversville	40°54'	122°44'	1080-1170	17
1140	1792	Humboldt, Arcata	40°54'	123°46'	870	18
1141	1793	Trinity, Big Bar	40°47'	123°12'	1230-1350	18
1142	1794	" , " "	40°43'	123°18'	975	15
1143	1795	Shasta, Wildwood	40°23'	123°00'	1170	16
1144	1796	Mendocino, Covelo	39°55'	123°18'	900	17
1145	1797	Glenn, Covelo	39°48'	122°56'	1530	15
1146	1798	" , Alder Springs	39°39'	122°45'	1350	16
1148	1799	Mendocino, Willits	39°23'	123°25'	540	17
1149	1800	Lake, Lower Lake	38°50'	122°42'	930	15
		Colorado				
1155	1801	El Paso, Monument Nursery	39°05'	104°55'	2190	10
1156	1802	" " , US.Air Force Academy	39°	104°	2250	8
1157	1803	Fremont, Coaldale - Hayden Cr.	38°20'	105°50'	2250	50 x
1158	1804	Custer, Wetmore, Newlin Cr.	38°15'	105°15'	2640-2700	100 x
1160	1805	Laplata, Pine River Bayfield	37°20'	107°34'	2220	25 x
1161	1806	Archuleta, Pagosa Springs	37°15'	106°52'	2400	50 x
		Arizona				
1162	1807	Coconino, Kiabab Plateau	36°30'	112°15'	2370	100
1163	1808	" , Government Hill	35°21'	111°57'	2460	10
1164	1809	" , San Francisco Peak	35°20'	111°40'	2700	50 x
1165	1810	" , " " "	35°20'	111°40'	2700	50 x
1166	1811	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

		New Mexico				
1167	1812	Taos, Dinner Canyon	36°04'	105°38'	2880	10
1168	1813	Sandoval, Clear Creek	36°03'	106°50'	2820	50 x
1169	1814	Otero, N. of James Canyon	32°55'	105°30'	2400	50 x
		Colorado				
206	1815	Fremont, Rainbow Creek	38°15'	105°42'	2670	8
210	1816	Pueblo, 2 mi W.of Rye Hwy 165	37°55'	104°57'	2220	1
221	1817	Rio Grande, S.of S. Fork	37°38'	106°42'	2520	1
222	1818	Archuleta, Devil's Creek	37°34'	107°18'	1980-2010	1
223	1819	" , " "	"	"	" - "	1
224	1820	" , " "	"	"	" - "	1
227	1821	Laplata, Hermosa Creek Rd	37°26'	107°53'	2160	1
228	1822	" , " " "	"	"	"	1
229	1823	" , " " "	"	"	"	1
230	1824	" , " " "	"	"	"	1
235	1825	Montezuma, Mesa Verde	37°19'	108°25'	2460	1
236	1826	" , " "	"	"	"	1
237	1827	" , " "	"	"	"	1
		Utah				
241	1828	San Juan, Blue Mountains	37°53'	109°26'	2580	1
242	1829	" " , " "	"	"	"	1
243	1830	" " , " "	"	"	"	1
244	1831	" " , " "	"	"	"	1
		Arizona				
248	1832	Cococino, Bill Williams Mtn	35°11'	112°11'	2400	4
250	1833	" , Govt. Hill	35°21'	111°57'	2460	1
253	1834	" , Newman Spring,Kendrick Mtn	35°25'	111°52'	2460	5
254	1835	" , San Fransisco Peak	35°19'	111°44'	2700	10
255	1836	Mohave, S.E.of Kingman	35°	114°	2340	1
256	1837	" , " " "	35°	114°	2340	1
258	1838	" , " " "	35°	114°	2340	1
259	1839	" , " " "	35°	114°	2340	1
260-3	1840	" , Oak Creek Canyon	35°03'	111°42'	1770	18
265	1841	Gila, Ponderosa Campground	34°18'	111°03'	1560	1
267	1842	" , " "	34°18'	111°03'	1560	1
268	1843	" , " "	34°18'	111°03'	1560	1
270	1844	" , Pinal Mt.Lookout Rd	33°17'	110°51'	2160-2430	1
271	1845	" , " " " "	33°17'	110°51'	2160-2430	1
273	1846	" , " " " "	33°17'	110°51'	2160-2430	1
274	1847	" , " " " "	33°17'	110°51'	2160-2430	1

N.B. x = squirrel caches

Table 1 (ctd).

IUFRO Sel. No.	BPS Sel. No.	Provenance	Latitude N	Longitude W	Altitude (m)	Trees from which collected (N)
		<u>Arizona</u> (ctd)				
275	1848	Pima, Mt Lemmon	32°23'	110°41'	2280	1
280	1849	" , " "	32°23'	110°41'	2280	1
282	1850	Cochisa, Chirachua Mnt	31°54'	109°14'	1830-1860	1
283	1851	" , " "	31°54'	109°14'	1830-1860	1
284	1852	" , " "	31°54'	109°14'	1830-1860	1
285	1853	" , " "	31°54'	109°14'	1830-1860	1
286	1854	" , " "	31°54'	109°14'	1830-1860	1
		<u>New Mexico</u>				
289	1855	Grant, Cherry Creek Campgr.	32°55'	108°12'	2040-2100	1
291	1856	" , " " "	32°55'	108°12'	2040-2100	1
294	1857	Catron, Mogollon Road	33°24'	108°46'	1980	1
295	1858	" , " "	33°24'	108°46'	1980	1
297	1859	" , " "	33°24'	108°46'	1980	1
293-7	1860	" , " "	33°24'	108°46'	1980	5
298	1861	Socarro, Magdalina Mnt, Hop Canyon	34°03'	107°12'	2400	1
299	1862	" , " " , " "	"	"	"	1
300	1863	" , " " , " "	"	"	"	1
301	1864	" , " " , " "	"	"	"	1
303	1865	Bernalillo, Sandia Mnt	35°12'	106°25'	-	1
306	1866	" , " "	35°12'	106°25'	-	1
309	1867	San Maguel, Pecos	35°46'	105°40'	2355	1
310	1868	" " , "	"	"	"	1
311	1869	" " , "	"	"	"	1
313	1870	" " , "	"	"	"	1
315	1871	Santa Fé, Borrego Mesa	35°58'	105°48'	2370-2520	1
316	1872	" " , " "	"	"	"	1
318	1873	" " , " "	"	"	"	1
320	1874	Taos, Dinner Canyon, Penasco Dist.	36°04'	105°38'	2820	1
322	1875	" , Goathill Campgr.	36°42	105°31'	2280	1
323	1876	" , " "	"	"	"	1
324	1877	" , " "	"	"	"	1
325	1878	" , " "	"	"	"	1
326	1879	" , " "	"	"	"	10

Table 2. Temperatures in 1971 and deviations from the 77-year means at Oudenbosch.

month in 1971	temperatures (°C) daily mean	dev.	mean daily min.	dev.	mean daily max.	dev.	lowest	date	number of days with minimum <0.0 °C 1971	normal
April	8.7	—0.7	3.4	—0.9	12.9	—0.8	—2.5	26	1	2
May	13.6	+1.2	7.7	+0.2	19.2	+1.3	1.0	1	0	0
Sept.	13.1	—1.4	7.7	—4.1	19.3	—0.3	—1.1	16	1	0

Table 3. Temperatures in 1972 and 1973 in Wageningen and deviations from the 75-years means at De Bilt

month		temperatures (°C) daily mean	dev.	mean daily min.	dev.	mean daily max.	dev.	lowest	date	number of days with min. <0.0°C '72-'73	norm.
April	'72 Wag.	7.5		3.2		11.6		—2.6	25	5	
	deB.		—0.8		—0.5		—1.8	—0.3	25	1	4
May	'72 Wag.	11.8		7.4		15.9		2.6	19	0	
	deB.		—0.7		+0.6		—1.8	3.4	19	0	1
Sept.	'72 Wag.	11.2		5.8		16.4		1.2	26	0	
	deB.		—2.5		—2.7		—2.6	2.8	21	0	0
Nov.	'72 Wag.	5.8		3.3		8.3		—4.7	25	5	
	deB.		+0.1		+0.1		—0.3	—0.1	25	5	6
Dec.	'72 Wag.	3.3		0.6		5.7		—9.6	31	15	
	deB.		+0.3		+0.1		+0.6	—9.2	31	16	13
Jan.	'73 Wag	2.8		0.8		4.7		—5.9	1	12	
	deB.		+1.2		+1.6		+0.5	—8.1	1	12	16
Febr.	'73 Wag.	2.7		0.2		5.2		—5.5	27	13	
	deB.		+0.9		+1.2		+0.3	—5.0	26	14	15
April	'73 Wag.	5.9		1.0		10.3		—4.4	10	9	
	deB.		—2.4		—2.2		—2.9	—3.1	4	9	4
May	'73 Wag.	12.1		6.9		16.8		—1.4	16	3	
	deB.		—0.4		0.0		—1.1	—0.5	16	2	1
Sept.	'73 Wag.	14.5		9.5		19.6		2.4	12	0	
	deB.		+0.5		+0.7		+0.5	4.3	12	0	0

Table 4 Measurements and observations in the nurseries at Zundert and Dorschkamp

1	2	3	4	5	6	7	8	9	10
			Zundert		Dorschkamp				
IUFRO Sel. No	BPS Sel. No	Provenance	plants with frost damage September 1971 (%)	height at 1 year (cm)	losses between June 1972 and August 1973 (%)	mean flushing value spring 1973	plants with lammas growth Aug. 1973 (%): on leading shoot	plants with lammas growth Aug. 1973 (%): on leading or lateral shoots	height at 3 years (cm)
		Oregon							
1113	1736	Marion, Mill City	55	14.4	4	3.2	18	32	75
1115	1777	Benton, Corvallis	40	13.0	4	4.0	18	28	73
1119	1778	Lane, Eugene	40	13.4	7	3.6	29	45	73
1126	1779	Jackson, Ashland	25	12.9	0	3.1	1	3	61
		California							
1127	1780	Siskiyou, Happy Camp	25	10.5	0	3.6	5	13	64
1129	1781	" , Seiad Valley	40	10.7	4	3.8	13	25	56
1130	1782	" , Hawkinsville	35	11.3	0	3.8	4	10	58
1131	1783	" , Scott Bar	50	9.8	7	3.7	6	11	56
1132	1784	" , Fort Jones	30	11.1	5	3.7	5	8	68
1133	1785	" , Happy Camp	25	10.5	1	3.5	11	16	57
1134	1786	" , Sawyers Bar	35	11.2	9	3.4	8	12	60
1135	1787	" , " "	20	10.2	16	3.5	9	21	53
1136	1788	" , Dunsmuir	25	10.4	8	3.5	11	16	55
1137	1789	Shasta, Burney	25	11.3	14	3.7	3	6	58
1138	1790	Humboldt, Arcata	80	13.9	12	3.5	61	80	55
1139	1791	Trinity, Weaversville	15	10.4	13	3.6	10	16	54
1140	1792	Humboldt, Arcata	35	13.6	11	3.4	36	43	58

1142	1794	" , " "	35	12.0	3	3.4	10	16	58
1143	1795	Shasta, Wildwood	65	11.0	16	3.5	8	13	53
1144	1796	Mendocino, Covelo	70	12.3	22	3.7	33	49	54
1145	1797	Glenn, Covelo	25	12.3	3	3.2	11	17	53
1146	1798	" , Alder Springs	45	12.6	3	3.2	6	11	58
1148	1799	Mendocino, Willits	95	13.4	15	3.7	72	82	51
1149	1800	Lake, Lower Lake	75	12.4	12	3.4	27	42	53
		<u>Colorado</u>							
1155	1801	El Paso, Monument Nursery	0	6.8	13	4.2	28	39	35
1156	1802	" " , U.S.A.F. Academy	0	5.0	14	4.1	17	30	41
1157	1803	Fremont, Coaldale-Haydn Cr	0	5.5	13	4.5	11	20	33
1158	1804	Custer, Wetmore,Newlin Cr	0	5.4	8	4.4	10	21	36
1160	1805	Laplata, Pine River, Bayfield	0	7.1	4	-	25	38	52
1161	1806	Archuleta, Pagosa Springs	0	6.5	7	4.4	16	32	43
		<u>Arizona</u>							
1162	1807	Coconino, Kiabab Plateau	0	5.7	5	4.3	14	23	41
1163	1808	" , Government Hill	0	7.4	4	4.5	11	37	54
1164	1809	" , San Fransisco Peak	0	6.7	3	4.5	31	62	48
1165	1810	" , " " "	5	6.6	7	4.5	23	48	42
1166	1811	Greenlee, Apache	5	7.6	1	4.3	23	44	60
		<u>New Mexico</u>							
1167	1812	Taos, Dinner Canyon	0	7.6	4	4.5	28	45	46
1168	1813	Sandoval, Clear Creek	5	6.8	5	4.3	17	28	46
1169	1814	Otero, N.of James Canyon	15	8.5	0	4.0	26	40	52
		<u>Colorado</u>							
206	1815	Fremont, Rainbow Creek	0	5.4	5	4.5	11	29	30
210	1816	Pueblo, 2 mi.of W.of Rye Hwy 165	0	6.2	12	4.4	21	31	36
221	1817	Rio Grande, S.of S. Fork	0	5.7	6	4.7	22	30	31
222	1818	Archuleta, Devil's Creek	0	7.6	0	4.4	11	37	51
223	1819	" , " "	0	8.7	2	4.7	6	14	53
224	1820	" , " "	0	7.3	18	-	3	50	40
227	1821	Laplata, Hermosa Creek Rd	0	7.0	7	4.5	17	35	45
228	1822	" , " " "	0	7.8	1	4.3	13	32	39
229	1823	" , " " "	0	5.8	0	4.6	36	57	45
230	1824	" , " " "	15	8.8	0	4.4	45	68	50

Table 4 (ctd).

1	2	3	4	5	6	7	8	9	10
			Zundert		Dorschkamp				
							plants with lammas growth Aug.1973 (%)		
IUFRO Sel. No	BPS Sel. No	Provenance	plants with frost damage September 1971 (%)	height at 1 year (cm)	losses between June 1972 and August 1973 (%)	mean flushing value spring 1973	on leading shoot	on leading or lateral shoots	height at 3 years (cm)
		<u>Colorado</u> (ctd)							
235	1825	Montezuma, Mesa Verde	0	4.0	13	4.7	5	5	29
236	1826	" , " "	0	5.2	11	4.6	8	21	34
237	1827	" , " "	0	6.0	2	4.5	0	8	37
		<u>Utah</u>							
241	1828	San Juan, Blue Mountains	0	5.4	10	4.4	3	12	32
242	1829	" " , " "	0	6.5	10	4.3	1	5	29
243	1830	" " , " "	0	5.6	5	4.5	2	2	36
244	1831	" " , " "	0	5.3	4	-	0	4	30
		<u>Arizona</u>							
248	1832	Coconino, Bill Williams Mt	0	6.9	8	4.4	9	22	49
250	1833	" , Government Hill	0	8.1	5	4.2	20	47	48
253	1834	" , Newman Spring Kendr.Mt	5	6.7	9	4.2	19	48	48
254	1835	" , San Francisco Peak	5	7.1	6	4.3	36	67	50
255	1836	Mohave, S.E. of Kingman	0	7.2	27	-	18	41	41
256	1837	" , " " "	0	4.7	9	4.4	50	83	36
258	1838	" , " " "	0	5.1	18	4.2	33	58	35
259	1839	" , " " "	0	6.5	11	4.2	28	64	44
260	1840	" , Oak Creek Canyon	0	8.9	3	4.6	21	49	54
265	1841	Gila, Ponderosa Campground	5	7.8	2	4.8	34	61	46
267	1842	" , " "	0	10.5	4	4.8	17	40	59
26[illegible]	1843	" , " "	10	7.6	13	4.7	49	80	45

270	1844	" , Pinal Mt Lookout Rd	15	9.2	2	4.5	16	64	48
271	1845	" , " " " "	0	8.3	6	4.7	51	90	48
273	1846	" , " " " "	0	10.1	6	4.6	44	81	64
274	1847	" , " " " "	0	8.9	21	-	55	90	48
275	1848	Pima, Mt Lemmon	0	9.8	4	3.9	25	97	76
280	1849	" , " "	0	7.6	16	4.0	26	84	56
282	1850	Cochisa, Chirachua Mt	10	9.6	7	3.7	57	97	65
283	1851	" , " "	0	8.8	6	4.3	81	95	66
284	1852	" , " "	0	11.9	2	4.2	50	94	70
285	1853	" , " "	5	10.8	6	4.2	22	87	70
286	1854	" , " "	10	11.6	5	4.2	63	96	69
		New Mexico							
289	1855	Grant, Cherry Creek Campgr.	0	9.5	5	4.3	43	89	74
291	1856	" , " " "	0	9.4	0	4.4	37	80	67
294	1857	Catron, Mogollon Rd	0	8.9	3	-	67	87	65
295	1858	" , " "	0	8.4	5	4.4	60	96	60
297	1859	" , " "	0	8.9	4	4.5	22	87	67
293-7	1860	" , " "	5	8.6	1	4.4	29	74	63
298	1861	Socarro, Magdalina Mt,Hop Canyon	0	7.2	7	4.2	25	57	47
299	1862	" , " " " "	0	7.1	3	4.1	14	50	59
300	1863	" , " " " "	0	7.3	3	3.8	31	68	51
301	1864	" , " " " "	0	6.3	5	3.8	25	74	50
303	1865	Bernalillo, Sandia Mt	0	6.1	18	4.0	39	71	42
306	1866	" , " "	0	6.2	5	4.1	11	26	38
309	1867	San Maguel, Pecos	0	6.9	21	4.2	12	25	47
310	1868	" " , "	0	8.4	3	4.2	30	53	58
311	1869	" " , "	0	9.3	3	4.3	12	24	52
313	1870	" " , "	0	7.2	12	4.3	25	49	54
315	1871	Santa Fé, Borrego Mesa	0	7.9	2	4.4	11	37	51
316	1872	" " , " "	0	8.3	9	4.6	19	55	49
318	1873	" " , " "	0	8.1	6	4.2	11	21	54
320	1874	Taos, Dinner Canyon	0	5.9	9	4.3	29	51	45
322	1875	" , Goathill Campgr.	0	7.6	10	4.3	8	19	53
323	1876	" , " "	0	5.7	12	4.6	34	66	48
324	1877	" , " "	0	6.4	11	4.3	20	51	51
325	1878	" , " "	0	7.2	8	4.6	10	29	53
326	1879	" , " "	0	7.3	3	4.5	19	40	54
		Mean for all provenances				4.1			

Table 5. Grouping of seed sources by growth in height, flushing and lammas growth in the areas (Fig. 4).

Area No	Description	number of provenances	mean height (cm)	mean flushing value	mean perc. plants with lammas growth: on top shoots only	mean perc. plants with lammas growth: on top and/ or lateral shoots
1	North Oregon, alt.< 1200 m	3	73.8	3.57	21.6	35.2
2	California, West Coastal Range, alt.<1200 m	5	54.1	3.53	45.9	59.3
3	South Oregon and California, West Coastal Range, alt. 1200 - 1800 m	6	56.1	3.32	7.5	13.3
4	California, East Coastal Range and Sierra Nevada, alt.< 1200 m	11	58.0	3.60	7.5	12.9
5	Colorado, east of the Continental Divide, alt. 1800 - 2400 m	4	36.3	4.26	20.3	31.8
6	Colorado, east of the Continental Divide, alt. 2400 - 3000 m	3	32.4	4.50	13.1	26.0
7	Colorado, west of the Continental Divide, alt. 1800 - 2400 m	3	46.9	4.50	19.2	37.9
8	Colorado and Utah, west of the Cont.Divide, alt. 2400 - 3000 m	3	33.8	4.48	6.5	15.0
9	Central Arizona, alt. 1200 - 1800 m	2	51.2	4.71	30.1	57.5
10	Central and North Arizona, alt. 2400 - 3000 m	8	47.6	4.37	20.9	45.4
11	West Arizona, alt. 2400 m	1	38.4	4.25	41.5	73.8
12	Southeast Arizona and southwest New Mexico, west of the Continental Divide, alt. 1800 - 2400 m	6	63.8	4.27	41.4	83.9
13	New Mexico, east of the Cont.Divide, alt.1800-2400m	2	52.3	4.37	17.9	38.1
14	New Mexico, east of the Cont. Divide, alt. 2400 - 3000 m	6	50.0	4.19	22.4	46.8

Table 6. Significant differences between areas for height.

Area	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		-	-	-	-	-	-	-	-	-	-	-	-	-
2	+		o	o	-	-	o	-	o	o	-	+	o	o
3	+	o		o	-	-	-	-	o	-	-	+	o	o
4	+	o	o		-	-	-	-	o	-	-	+	o	-
5	+	+	+	+		o	+	o	+	+	o	+	+	+
6	+	+	+	+	o		+	o	+	+	o	+	+	+
7	+	o	+	+	-	-		-	o	o	o	+	o	o
8	+	+	+	+	o	o	+		+	+	o	+	+	+
9	+	o	o	o	-	-	o	-		o	-	+	o	o
10	+	o	+	+	-	-	o	-	o		-	+	o	o
11	+	+	+	+	o	o	o	o	+	+		+	+	+
12	+	-	-	-	-	-	-	-	-	-	-		-	-
13	+	o	o	o	-	-	o	-	o	o	-	+		o
14	+	o	o	+	-	-	o	-	o	o	-	+	o	
+	13	4	6	7			3		4	4		12	4	4
o		7	5	4	3	3	6	3	7	5	4		7	6
-		2	2	2	10	10	4	10	2	3	9	1	2	3

in vertical direction symbols mean:
+ significantly greater
o not significantly different
- significantly smaller

Table 7. Significant differences between areas for flushing.

Area	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		o	o	o	+	+	+	+	+	+	+	+	+	+
2	o		o	o	+	+	+	+	+	+	+	+	+	+
3	o	o		+	+	+	+	+	+	+	+	+	+	+
4	o	o	-		+	+	+	+	+	+	+	+	+	+
5	-	-	-	-		o	o	o	+	o	o	o	o	o
6	-	-	-	-	o		o	o	o	o	o	o	o	o
7	-	-	-	-	o	o		o	o	o	o	o	o	-
8	-	-	-	-	o	o	o		o	o	o	o	o	-
9	-	-	-	-	-	o	o	o		-	-	-	-	-
10	-	-	-	-	o	o	o	o	+		o	o	o	o
11	-	-	-	-	o	o	o	o	+	o		o	o	o
12	-	-	-	-	o	o	o	o	+	o	o		o	o
13	-	-	-	-	o	o	o	o	+	o	o	o		o
14	-	-	-	-	o	o	+	+	+	o	o	o	o	
+	0	0	0	1	4	4	5	5	10	4	4	4	4	4
o	3	3	2	2	8	9	8	8	3	8	8	8	8	6
-	10	10	11	10	1	0	0	0	0	1	1	1	1	3

in vertical direction symbols mean:
+ significantly earlier
o not significantly different
- significantly later

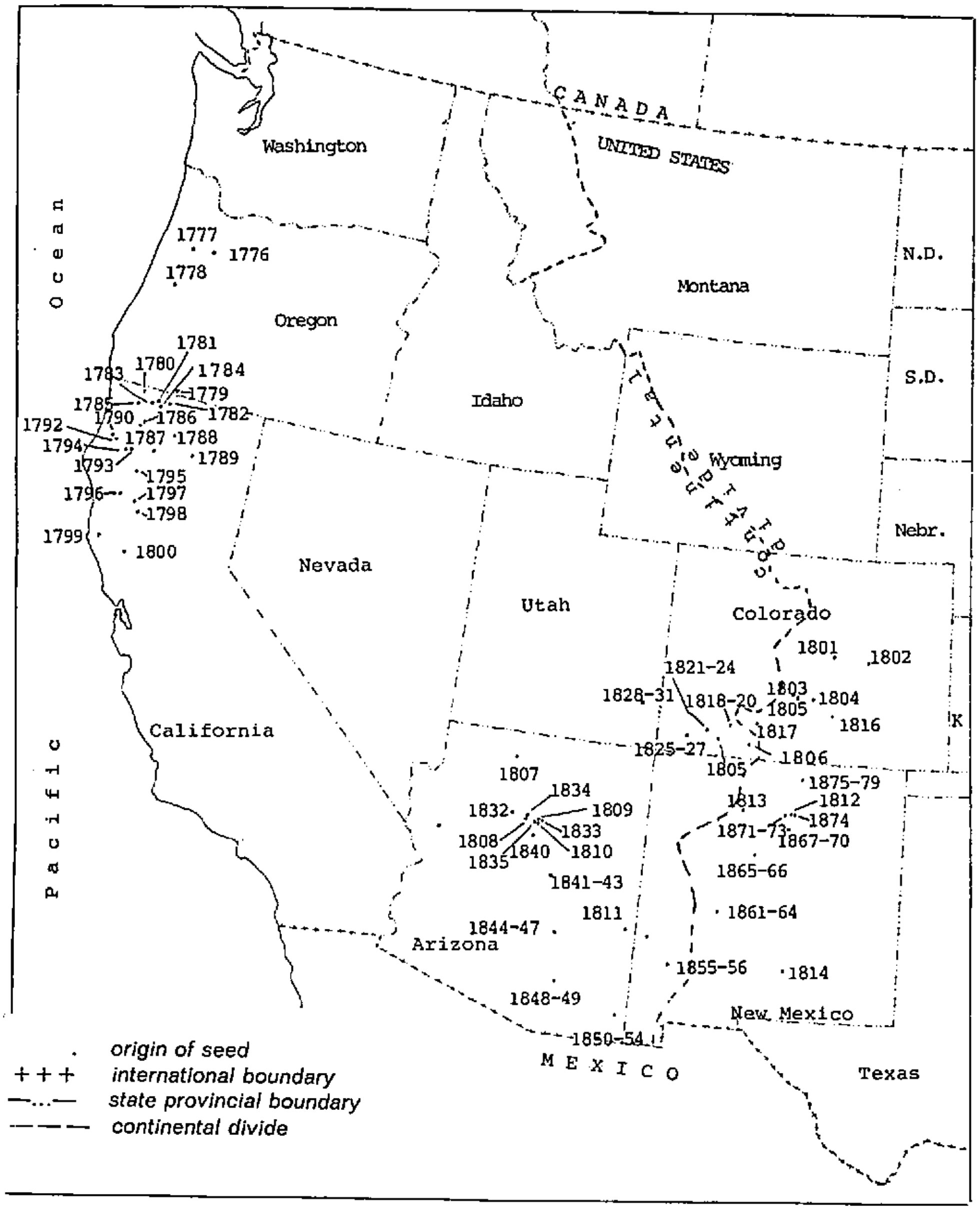

Fig. 1. Geographic distribution of seed sources 1968/1969 series.

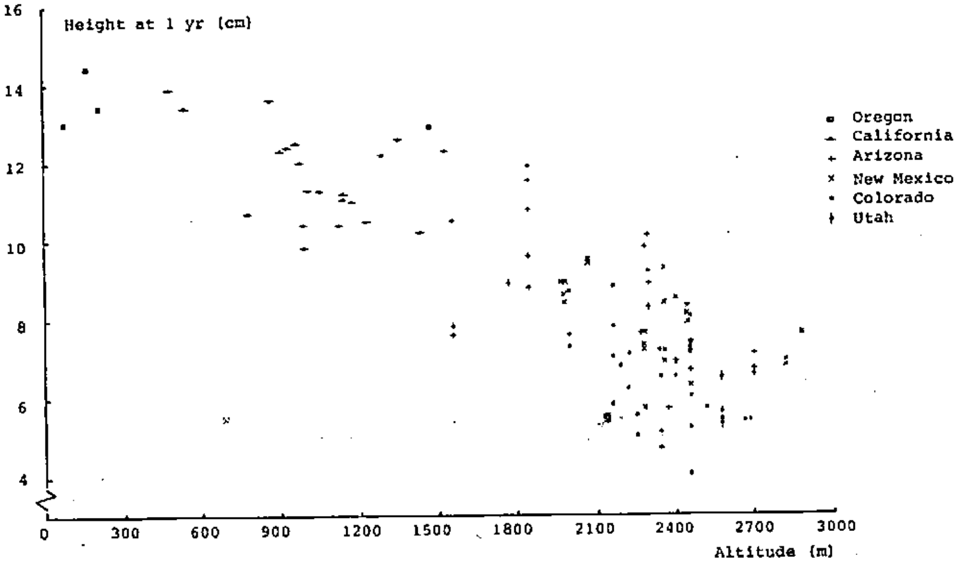

Fig. 2. Height at age 1 year in relation to altitude of seed source.

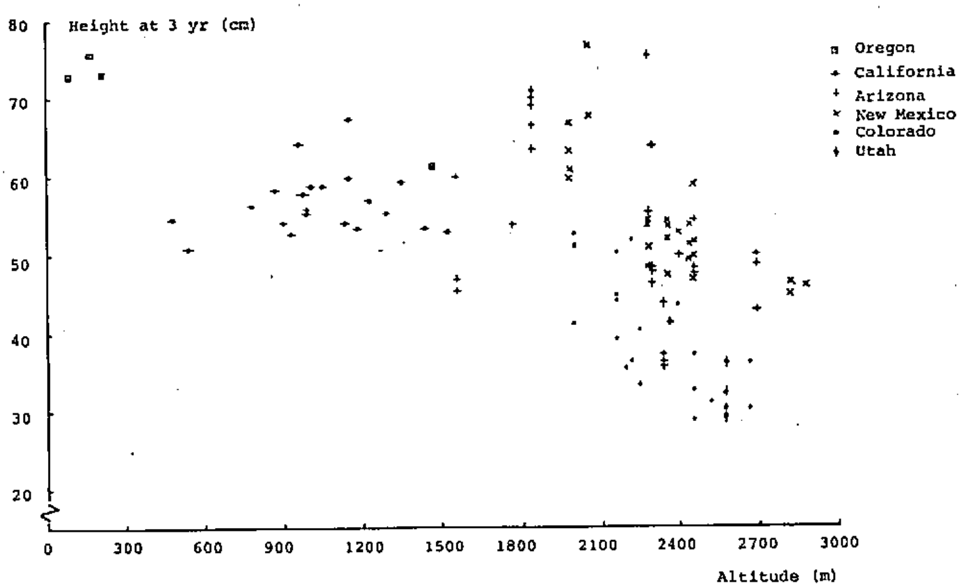

Fig. 3. Height at age 3 years in relation to altitude of seed source.

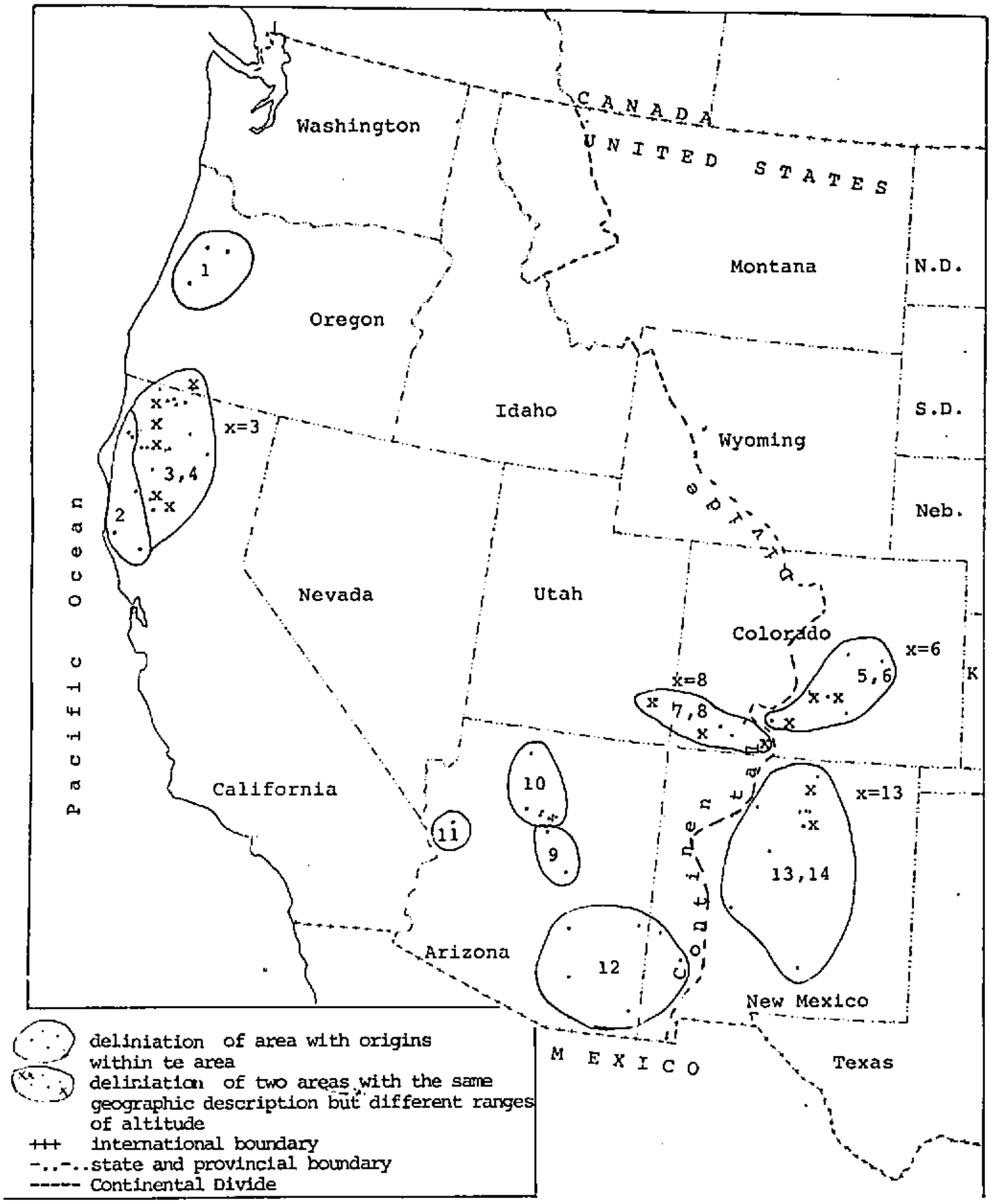

Fig. 4. Grouping of provenances and progenies.

Means and extremes per area

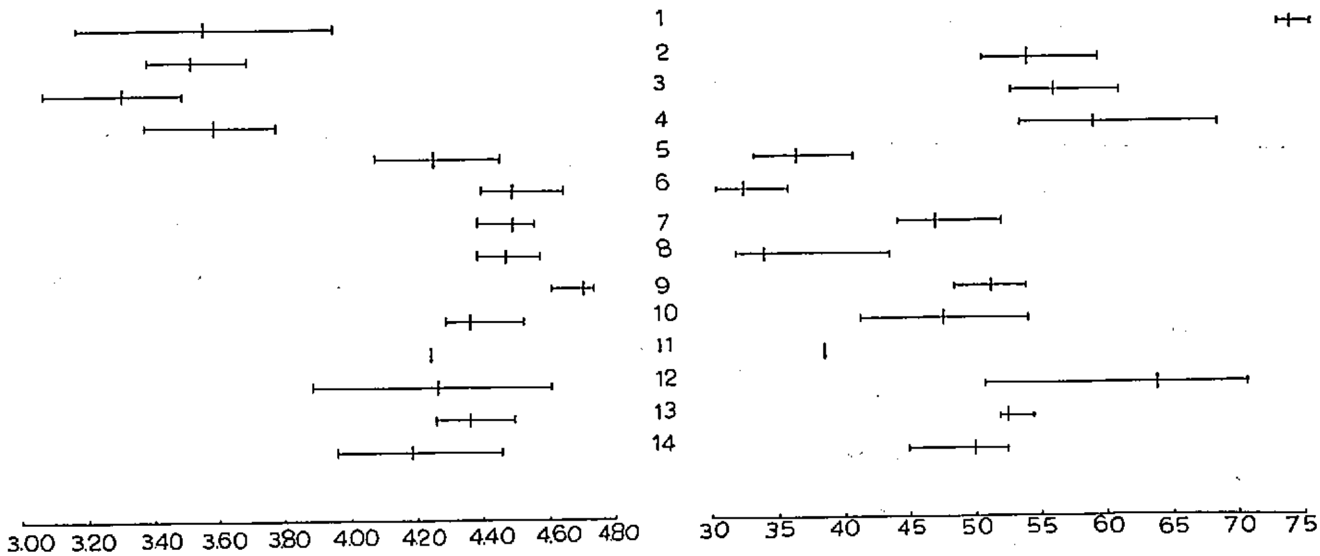

Fig. 5. Flushing.

Fig. 6. Heights at 3 years.

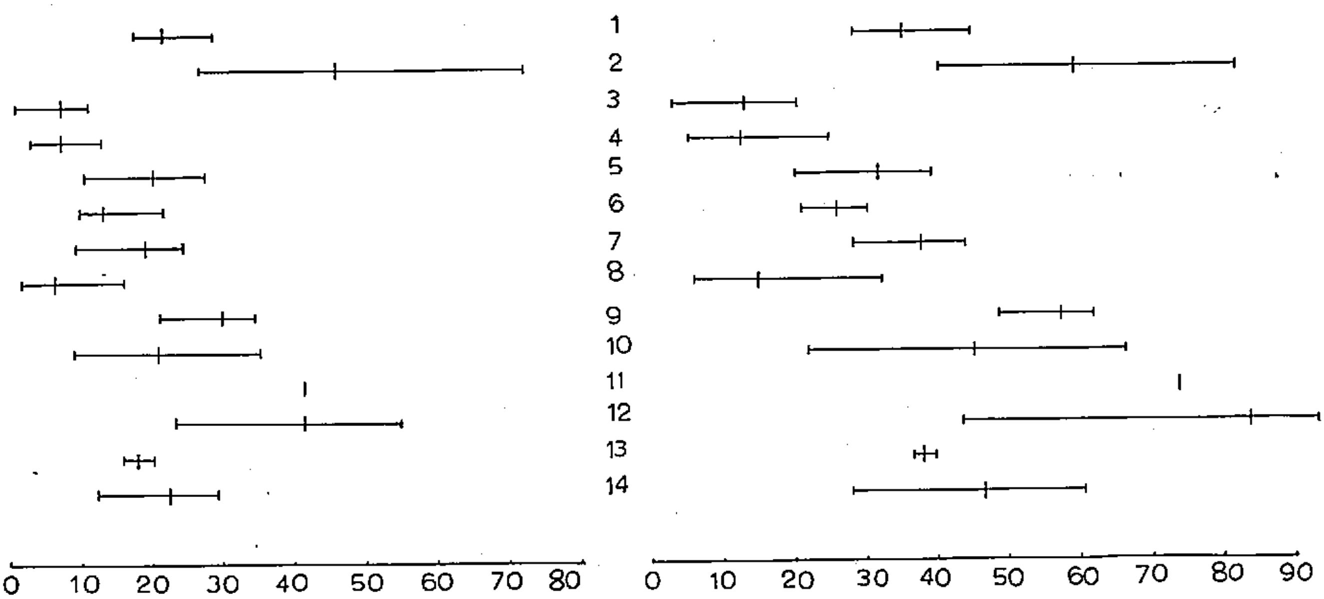

Fig. 7. Plants with lammas growth on top shoots only (%).

Fig. 8. Plants with lammas growth on top or lateral shoots (%).