NORWAY SPRUCE PROVENANCE AND PROGENY TESTING IN THE NETHERLANDS

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SUMMARY

Survival, early height growth and flushing behaviour of 72 provenances and 26 halfsib progenies of Norway spruce were studied in a nursery and in three provenance and three progeny trials.

Some of the provenances tested, especially those from Belgium and Czechoslovakia show good to fairly good promise and some of the Dutch halfsib progenies show great promise for use in Dutch forestry practice and breeding work.

I N T R O D U C T I O N

Norway spruce, Picea abies Karst., does not occur naturally in the Netherlands, but has been introduced repeatedly, probably over several centuries. The area planted with Norway spruce was very small at first, but increased during the afforestations in the last century and particularly during the afforestations of the heathlands in the northern part of the country in the 1930's. The total area under Norway spruce, however, is still not more than 20000 ha, which is about 10% of the area under conifer plantations.

Norway spruce is an attractive species for Dutch forestry because it can be established easily and produces high volumes. In the last decade or so, however, difficulties have occurred in many stands that were 30 to 40 years old. An increasing number of trees died from unknown causes. The symptoms were described as loss of old needles in spring, reduced growth in the subsequent summer, followed by more or less rapid die-back spreading from the top downwards in the same year or following years (Jansen en Schoenfeld 1973, Schoenfeld 1973). The disease is generally known as "Norway spruce mortality".

Little is known about the provenances used in early afforestations. Much of the seed was probably imported from Austria. Some of it undoubtedly came from high altitudes. Most of the stands were established with mixed material from different provenances, since in the 1930's it was general practice to mix different seed lots.

Norway spruce provenance research was initiated in the Netherlands in 1963 with a limited number of commercial seed lots from Austria, Czechoslovakia, Denmark, Germany, the Netherlands and Poland. A relatively small trial was established with this material in 1968.

A second more comprehensive series of commercial seed lots, including provenances from Belgium, was sown in 1967. A fairly large trial was established in Gortel from this material between 1969 and 1971. Using material of the same stock a very small trial was established in one of the new polders in 1970. The first results from the three trials of the first and second series were reported in 1975 (Kriek 1975).

The trial in Gortel had a bad start; it had to be planted twice. A number of provenance failed altogether in the starting phase and there was insufficient planting material left to replace all failed plots. It was therefore decided to sow the same provenances in a third series, to widen the scope of the investigations. The seed was sown in 1972. Two new trials were established with the plants of this third series; one in Smilde in the northern part of the country, the area of the afforestations of the 1930's, and one in the most recently reclaimed polder. The trial in Smilde was established in the autumn of 1974, the trial in Southern Flevoland in the spring of 1976.

A number of seed stands of Norway spruce were selected between 1970 and 1976. Selection was based on health, height growth in relation to site, trunk form, branching habit and crown characteristics. In one particularly good stand of 0,80 ha, some 25 trees were selected. The seed from these trees was collected in 1970 and sown in 1972 at the same time as seed from some trees in two other stands and seed from the third provenance series mentioned above. The halfsib progeny plant material was used to establish three trials: one in Smilde next to the provenance trial; one in Southern Flevoland, also next to the provenance trial; and one in Vaals in the extreme south of the Netherlands. The trials in Smilde and Southern Flevoland were established at the same time as the provenance trials, i.e. in the autumn of 1974 and the spring of 1976 respectively. The trial in Vaals was established in the spring of 1976.

The present report deals with the nursery performance of the third series provenances and of the halfsib progenies; the performance of the second and third series provenances in the large provenance trials in Gortel, Smilde and Southern Flevoland; and the performance of the halfsib progenies in the trials in Smilde, Southern Flevoland and Vaals.

DETAILS OF THE MATERIAL

All the seed lots of the provenances were provided by one Dutch seed dealer. Identification is in most cases to the level of provenance area. The seed for the trial in Gortel was sown in the nursery of De Dorschkamp in Wageningen in 1967. The plants were transplanted at the end of the second growing season and subsequently grown to three- and four-year old plants in the same nursery, before they were planted out in the trial.

Seed from the same seed lots was sown in a commercial nursery in the south-west of the Netherlands in 1972. At the end of the second growing season the plants of this third provenance series were planted out in the nursery of De Dorschkamp in Wageningen. Some of this plant stock was used to establish the trial in Smilde in the autumn of 1974. The remaining plants were used to establish the trial in Southern Flevoland in the spring of 1976.

The seed from the individual trees in three stands was collected by De Dorschkamp and sown in the same nursery and at the same time as the seed of the provenances of the third series. Treatment of this plant material was the same as that of the provenances.

TRIAL DATA

Gortel

Date of establishment:	autumn 1969, but practically completely replanted in the spring of 1971.
Soil type:	coarse sandy holt podzol
Altitude:	± 35 m above sea level
Spacing :	1.50 x 1.50 m
Plant material:	Planted with three-year-old plants in 1969. Replanted with four-year-old plants from the same stock in 1971.
Plot size:	5 x 5 plants; 7.50 x 7.50 m
Design:	Inorthogonal block design with six blocks; 56 provenances are represented in one to six replications.

Smilde

Date of establishment:	Autumn 1974
Soil type:	Moer podzol
Altitude:	10 m above sea level
Site history:	35-year-old Norway spruce thrown by storm in 1972
Spacing:	2.50 x 1.50 m
Plant material:	Three (2 + 1)-year-old plants
Plot size:	4 x 4 plants; 10.00 x 6.00 m
Design:	Provenance trial: Orthogonal block design with six blocks; 66 provenances were planted in 6 replications. Halfsib progeny trial: Orthogonal block design with six blocks; 26 halfsib progenies and 13 provenances were planted in six replications.

Southern Flevoland

Date of establishment: Spring 1976
Soil type: Sandy lake bottom soil of 12 to 20 cm over clayey sea bottom soil
Altitude: 2,5 m below sea level
Site history: Lake bottom reclaimed in 1968
Spacing: 2.50 x 1.50 m
Plant material: Four (2 + 2)-year-old plants (same stock as Smilde)
Plot size: 4 x 4 plants; 10.00 x 6.00 m
Design: Provenance trial:
Orthogonal block design with six blocks; 71 provenances and 10 Dutch halfsib progenies were planted in six replications.
Halfsib progeny trial:
Orthogonal block design with six blocks; 26 halfsib progenies and 6 provenances were planted in 6 replications.

Vaals

Date of establishment: Spring 1976
Soil type: Loam, poor in lime
Altitude: 280 m above sea level
Site history: Coppice of oak and birch
Spacing: 2.00 x 2.00 m
Plant material: Four (2 + 2)-year-old plants (same stock as Smilde and Southern Flevoland)
Plot size: 4 x 4 plants; 8.00 x 8.00 m
Design: Orthogonal block design with four blocks; 24 halfsib progenies and 6 provenances were planted in 4 replications.
All trials were beaten up one year after planting.

C L I M A T E A N D W E A T H E R I N T H E P A S T P E R I O D

The Netherlands is a small and flat country. The trials and the nursery of De Dorschkamp are all situated between 50° 30' and 53° North and 5° 30' and 6° 30' East and are at low altitudes. The climate is influenced by the proximity of the North Sea and the Atlantic Ocean. Mean annual rainfall is between 750 and 850 mm, half of which falls during the vegetation period. Average summer temperature is about 9°C. The lowest winter temperature recorded so far is -22°C. The average number of frost days is 184.

Differences in climate are small, although not without significance. They are caused by differences in distance from the sea and altitude. The trials in Southern Flevoland are the closest to the sea and are 2.5 m below sea level. The local climate is influenced by the presence of the lake from which the polder has been reclaimed. Winters are generally slightly warmer and summers slightly cooler than at the other sites. The trials in Smilde are about 10 m above sea level in an area with generally high relative humidity. The areas of Gortel and the nursery at Wageningen are slightly higher, 30 to 40 m above sea level, than Smilde. They lie to the south and south-west of Smilde and Southern Flevoland, and have a somewhat lower relatively humidity.
The trial in Vaals is at an altitude of 280 m. It is the most southern location in the Netherlands and one of the warmest spots in the country during the summer. It is generally also the coldest in winter because

of its highest and most continental situation. It has the highest rainfall but also the highest evaporation.

The initiation and progress of flushing of the plants depend on temperature in April and May. Both months were rather cold in 1975 and therefore flushing was rather late. No late frosts occurred in May, but sub-zero temperatures were recorded locally on the first two days of June of that year, resulting in serious late frost damage. No damaging late frost occurred either in the spring of 1976 or that of 1977.

Height growth and survival may have been influenced by rainfall and temperature during the summer months. The summers of 1975 and 1976 were dry to very dry with high temperatures. The summer of 1977 was fairly normal.

Table 1. Flushing means and mean heights in the nursery and the trials at different dates and ages

trial	year	1973	1974	1975	1977
Provenances 2e series					
Gortel	date	16/5	1/5		
	age	6 y	7 y		
flushing	mean	1.25	1.07		
Gortel	date		28/8		31/8
	age		8 y		11 y
	$\bar{h}$		1.11 m		2.28 m
Halfsib progenies and provenances 3e series					
Wageningen	date			20/5	
(nursery)	age			3 y	
flushing	mean			3,76	
Provenances 3e series					
Smilde	date				24/10
	age				6 y
	$\bar{h}$				0.50 m
Southern Flevoland	date				28/10
	age				6 y
	$\bar{h}$				0.53 m
Halfsib progenies					
Smilde	date				24/10
	age				6 y
	$\bar{h}$				0,57 m
Southern Flevoland	date				16/11
	age				6 y
	$\bar{h}$				0.56 m
Vaals	date				8/11
	age				6 y
	$\bar{h}$				0.67 m

A S S E S S M E N T S A N D R E S U L T S

Good survival, fast growth, late flushing and good health over the years are the characteristics sought after when selecting provenance areas, provenances and progenies for forestry practice and breeding. Late flushing material is of particular interest to the Netherlands, since late frosts occur frequently, especially during the first half of May.

Types of assessments, dates and resulting means for the whole trials are summarized in Table 1. Assessments carried out before 1975 have already been dealt with in an earlier report (Kriek 1975), but will be referred to below.

S U R V I V A L

At the time of planting 25% extra plants were always planted in each plot for beating up operations. All trials were beaten up one year after planting. Survival counts were made at the last assessment, at least one year after beating up.

G o r t e l

Survival was very poor after planting, as mentioned above. Therefore the trial had to be almost completely replanted. Survival was very good after the second planting and remained good up to age 11 years. All provenances except two had survival percentages of 90 to 100%. Overall survival was 98%.

S m i l d e

Both trials in Smilde were established with three-year-old plants. In general, plants at this age suffer more from rabbit damage and weed competition than older plants. The trials also suffered from droughts in 1975 and 1976. Survival was rather poor two years after planting, notwithstanding the beating up operation one year after planting.

Provenance trial: Survival varied from 51 to 90%. Overall survival was 73%. The two provenances from the Netherlands survived well (80% of the plants). The German provenances survived equally well (average: 78%). The provenances from Denmark and Belgium had average survivals of 75% and 74% respectively. Some 68 to 69% of the plants of the Czechoslovakian, Polish and Hungarian provenances managed to survive. Austrian provenances fared the worst, with an average of 64% of the plants remaining alive two years after planting. The plants of these latter provenances were the smallest in the nursery, whereas the Dutch provenances were among those with the tallest plants.

Halfsib progeny trial: Survival in this trial is much better than in the provenance trial; 85% of all plants of the progenies survived. The 12 foreign, mostly Czechoslovakian provenances included in this trial fared less well: only 78% of the plants survived. The progeny plant material was taller at the time of planting than the provenance plant material. It appears from these figures and the ones of the provenance trial that the taller the plants are at this age, the better their survival.

S o u t h e r n F l e v o l a n d

These trials were planted one growing season later, with plants of the same stock as in Smilde. Survival two years after planting, one year after beating up, 91% in bot trials.
Pronenance trial: The high survival in the trial does not leave much room for differences between groups of provenances. Some provenances from Czechoslovakian have relatively poor survival. In this group, 86% of the plants survived. The Dutch halfsib progenies included in this trial survived best (on average, 94% of the plants).
Halfsib progeny trial: All Dutch progenies survived very well. On the other hand, two out of the five foreign provenances included in this trial survived rather poorly for some reason or other.

V a a l s

In this trial 95% of the plants of the halfsib progenies survived up to two years after planting and one year after beating up. Of the five foreign provenances included in this trial 85% of the plants survived.

F L U S H I N G

The method of reading observations on flushing behaviour and the results obtained in Gortel in 1973 and 1974 were reported in 1975 (Kriek 1975). The same method was followed to assess flushing of the provenances of the third series and the Dutch halfsib progenies. We may recall that six stages of flushing are distinguished:

0 : bud in rest
1 : bud swollen
2 : bud bursting, new needles just visible
3 : shoot starts to elongate
4 : shoot elongating
5 : shoot very elongated

The observations were carried out in the nursery in Wageningen on 20 May 1975. Ninety plants per provenance or progeny (i.e. 30 in each replicate) were scored. At hte time of scoring the plants were at the beginning of their fourth growing season, their second after transplanting. The plants were later used to establish the trials in Southern Flevoland and Vaals.

P r o v e n a n c e s

The mean flushinh values were calculated from the observations. The mean for all provenances is 3.76. New means were calculated for the two groups with flushinh values lower than 3.76 and higher than 3,76 respectively. In this way four groups of provenances could be distinguished according to their mean flushing values:

group	mean flushing value
1. very early	mfv $\geqslant$ 4.00
2. early	3.76 $\leqslant$ mfv $<$ 4.00
3. late	3.50 $\leqslant$ mfv $<$ 3.76
4. very late	mfv $<$ 3.50

The results of the observations in the nursery led to the conclusion that in general, provenances from Austria flush very early and provenances from Czechoslovakian late to very late. The Belgian provenances are nearly equally divided between the two middle groups. Only two provenances have a mean flushing value higher than 4.00; none is very late. The German provenances are represented in all four groups. The Danish provenances have flushing values around the overall mean. The one Polish provenance is early and the Hungarian one is late. The two Dutch provenances are late and very late.

The third and second series have 55 provenances in common. The results of flushing observations on these provenances in 1973 and 1974 in Gortel and in 1975 in the nursery were compared. The correlation coefficient for ranking (Spearman) in the two subsequent years in Gortel is low ($r_{'73 - '74} = 0.63$), although highly significant. The correlation coefficients between the results of 1975 in the nursery and the ones of 1973 and 1974 in Gortel are even lower ($r_{'75 - '73} = 0.43$ and $r_{'75 - '74} = 0.55$) but still highly significant.

Flushing patterns are genetically determined but influenced by temperatures in April and May. The local microclimate is very important. The low correlation between the observations of 1973 and 1974 is most probably caused by differences in the course of the temperatures and change in micro-climate between the years. The variations in micro-climate are certainly much smaller within the nursery than within the trial in Gortel in which the canopy was not yet closed and in which differences in vegetation (grasses, heather, young regrowth of birch) may have caused relatively large variations in micro-climate. This aspect, together with the differences in the fluctuations of temperatures between the years, is responsible for the low correlation coefficients shown above. The more homogeneous micro-climate in the nursery make the observations of 1975 probably more reliable than the others, notwithstanding the youth of the plants.

H a l f s i b p r o g e n i e s

In general, the Dutch halfsib progenies flush much later than the foreign provenances. Accepting the above limits between groups we may conclude that half of of the progenies belong to the "very late" group and two-thirds to the "late" and "very late" groups.

H E I G H T

P r o v e n a n c e s

Tree height was measured in all three trials in 1977. The plants in the Gortel trial are five years older than those in the other two trials. This is a disadvantage if we wish to compare the height growth of the 48 provenances which the trials have in common. The plants in Gortel are in a period of rapid height growth whereas the plants in Smilde and Southern Flevoland are just in the beginning of such a period. The figures of an earlier assessment of the trial in Gortel are available, but the correlation between the results of the two subsequent assessments at ages 8 and 11 years from seed is rather high ($r_{spearman} = 0.886$), so it makes little difference which results we use in the comparison with Smilde and Southern Flevoland. Comparison of the results from the 48 provenances in the three trials leads to the conclusion that

provenance x site and probably provenance x age and provenance x site x age interactions exist. Comparison of the results from the same provenances in Smilde and Southern Flevoland still shows a provenance x site interactions. Three provenances grow significantly better in Smilde than in Southern Flevoland; ten provenances grow significantly better in Southern Flevoland than in Smilde. However, the trials are still too young to allow definite conclusions to be drawn.

In order to come to some preliminary conclusions on the basis of the results available to date from the three trials, the following method of processing them was chosen.

The overall mean of each trial was set at 100%. The relative height in percentages was calculated for each provenance in each trial. Finally the mean relative height for each provenance over the three trials was determined as the arithmetical average of its percentage in each. This exercise was not limited to the 48 provenances the trials have in common, but was done for all provenances and progenies represented in the trials. It is clear that rather important inaccuracies may occur when provenances are not represented in all three trials.

The mean relative heights varied from 80% to 120%. The provenances were divided in four groups by establishing limits between groups the same way as was done for flushing. The four groups are:

group	mean relative height (m.r.h.)
1. very fast growing	m.r.h. $\geqslant$ 105%
2. fast growing	100% $\leqslant$ m.r.h. $<$ 105%
3. slow growing	93% $\leqslant$ m.r.h. $<$ 100%
4. very slow growing	m.r.h. $<$ 93%

The two Dutch provenances are very fast growing. Three-quarters of the Belgian and of the German provenances grow fast to very fast. The Czechoslovakian provenances generally grow more slowly; only one-third of the provenances are in groups 1 en 2. All three Danish provenances grow fast. All Austrian provenances but one grow slowly to very slowly and the Polish and Hungarian provenances grow very slowly (See also Figure 1.).

H a l f s i b p r o g e n i e s

The plants in the three trials are the same age. The trials have 26 progenies and 2 provenances in common. Progeny x site interaction exists here too.

The same method for processing the results of the height measurements was used, i.e. the overall mean of each trial was set at 100%. The relative height of each progeny and provenance in each of the trials was calculated and finally the mean relative height per progeny and provenance over the three trials was determined. Again, not all progenies and provenances are represented in each of the trials, and this may be the cause of important inaccuracies.

In order to compare the results in these trials with the results in the provenance trials, the mean relative height was corrected on the basis of the performance of 11 progenies and 2 provenances which the provenance trial in Southern Flevoland and the three progeny trials have in common.

After this exercise we can conclude that all the Dutch progenies but one grow fast to very fast. Four-fifths of the progenies grow very fast. (See also Table 3).

BASIS FOR CHOICE OF PROVENANCES AND OTHER BREEDING MATERIAL

The choice of provenances on the basis of growth and flushing behaviour can be indicated for forestry practice and breeding work by showing graphically the relative position of each provenance as far as these two characteristics are concerned (Figure 1).
It seems prudent to advise against further use of any provenances that grow very slowly and/or flush very early. Fast to very fast growing provenances that flush early may be useful if growth rate compensates the early flushing to some extent. Provenances that grow slowly and flush late to very late may improve their growth rate sufficiently to remain of interest to practice and research. Provenances above and left of the heavy line in Figure 1 are, in my opinion, acceptable for forestry practice for the time being. This group contains 64% of all provenances tested. The following percentages of provenances from the different countries, represented by more than one provenance, fall in this group:

Netherlands	100%
Denmark	100%
Belgium	76%
Czechoslovakian	71%
German Fed. Rep.	50%
Austria	7%

All provenances have been listed in Table 2 in which the same grouping has been followed as in Figure 1.

From the above it may be concluded that Dutch forestry should be especially interested in provenances from Belgium and Czechoslovakia and also in some specific provenances from Germany, as some very promising provenances come from that country.

Very good material is present in the Netherlands itself. This is emphasized by the results from the progeny trials. For these trials the relative position of each progeny and provenance represented in the trials in respect of height and flushing behaviour is shown schematically in Table 3 in the same way as is done for the provenance trials in Table 2.

It will be clear that in view of the difficulties with Norway spruce mentioned in the introduction, and the fact that excellent material still seems to be present in Dutch forests, the potential for selection and breeding in the Netherlands should be exploited. At this moment testing of some other 120 halfsib progenies from 12 selected seed stands is under way.

CONCLUSIONS

As provenance areas, especially in such a widely planted species as Norway spruce, may form a week basis for identification of genetic quality of a certain seedlot, the present study should be regarded as a reconnaissance in the geographic variation of the species rather as an effort to identify the best seed sources for Dutch forestry practice. However, the results I have obtained so far enable the following conclusions to be made:

The provenances we tested from Belgium and Czechoslovakia and some provenances from the German Federal Republic show good to relatively good promise for use in Dutch forestry practice and possibly for breeding purposes.

The provenances we tested from Austria in general grow slowly to very slowly and they flush early to very early. They should not be used in Dutch forestry practice and breeding work.

Dutch provenances and halfsib progenies of trees from some selected

healthy seed stands, show great promise for selection and breeding work in the Netherlands.

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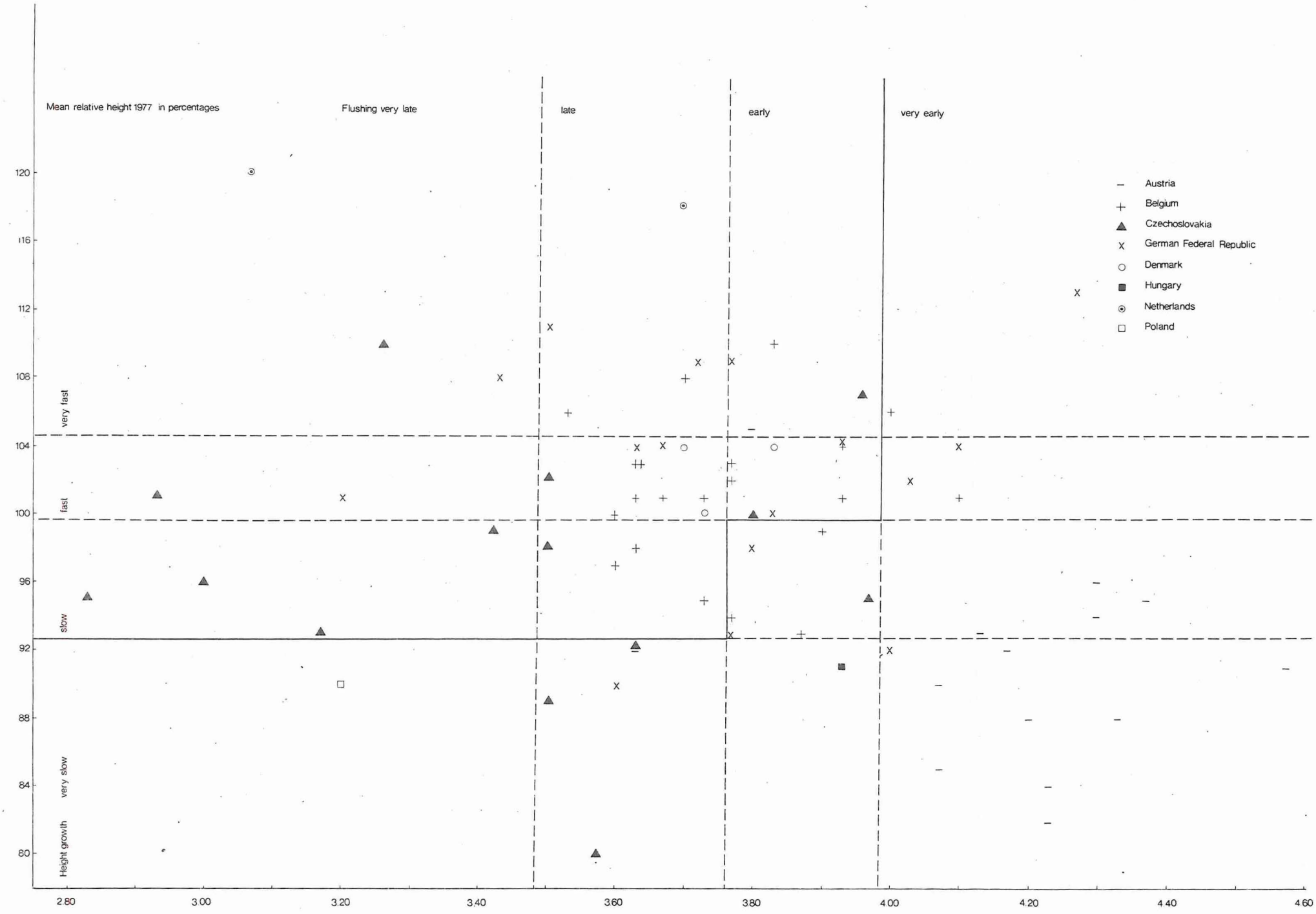

Figure 1 Graphic of the position of flushing behaviour and height growth of provenances in the Gortel, Smilde and Southern Flevoland trials

Table 2. Grouping of provenances according to flushing behaviour and height growth rate.

Flushing

Height growth	very late					late					early					very early				
	Sel.nr.	provenance	country	alt	tr*	Sel.nr.	provenance	country	alt	tr	Sel.nr.	provenance	country	alt	tr	Sel.nr.	provenance	country	alt	tr
very fast	2260	Starej Vode	CS	-	2	2234	Izel	B	m	3	2227	Allentsteig	A	m	2	2238	La Flêche Bertrix	B	m	3
	2201	Niederd.Tiefland-W.	D	1	3	2243	Forêt d'Anlier	B	m	3	2250	Berismenil	B	m	3	2203	Harzvorland Westerh.	D	-	2
	2231	Austerlitz	NL	1	2	2208	Jura	D	m	3	2210	Frankenwald	D	m	3					
						2216	Ubriges Süddeutsch.	D	m	3	2264	Pribram pol.Hlubos	CS	-	1					
						2264	Maartensdijk	NL	1	2										
fast	2267	Muráň	CS	-	2	2237	Roche auxCorbeaux	B	m	3	2233	Centre Belge du Bois	B	m	3	2242	Gilsaumont	B	m	3
	2212	Bodensee u. Oberschwaben	D	m	3	2240	Huqueny	B	m	3						2204	Oberharz	D	m	2
						2244	Penitentier	B	m	3	2239	Vecmont	B	m	3	2207	Oberes Neckerland	D	m	3
						2248	Transinne	B	m	3	2241	Bois de Hêtre	B	m	3					
						2232	Mestures Straimont	B	m	3	2245	Bièvre	B	m	3					
						2235	Fange du Sauvet	B	m	3	2262	Čadci	CS	-	3					
						2269	Slovensko, Beňuš	CS	-	2	2213	Bodensee u. Oberschwaben	D	m	3					
						2202	Harzvorland Westerh.	D	-	3										
						2205	Schwarzwald m.Baar	D	m	3	2214	Vorallgäuer Fichte	D	m/h	2					
						2254	Sostrup Hemmed	DK	1	3	2255	Kongsø Plantage	DK	1	3					
						2253	Nødebo	DK	1	3										
slow	2256	Strážovske pohorie	CS	-	3	2236	Grapfontaine	B	m	3	2247	Arlon	B	m	3	2222	Schneegattern	A	m/h	3
	2257	Slovenské Rudohorie	CS	-	1	2246	Rafronceau	B	m	3	2249	Bois du Seigneur	B	m	3	2224	Weyer	A	m/h	1
	2265	Podolinec	CS	-	2	2251	Bos St. Jean	B	m	3	2252	Nassogne	B	m	3	2226	Lochenhaus	A	m	2
	2268	Slovenská Lupča	CS	-	2	2263	Rozmital	CS	-	2	2266	Přibram, pol. Bohutin	CS	-	2	2228	Windischgarsten	A	m	2
											2206	Schwarzwald m.Baar	D	h	3					
											2215	Bayer Moränen u. Mol.	D	h	3					
very slow	2273	Puszcva Augusttowska	P	1	2	2220	Trattenbach	A	h	3	2270	Eperjes-Tokaj	H	m	2	2217	Rauris	A	h	3
						2258	Banskej Bystrica	CS	-	3						2218	Klaus	A	m/h	3
						2259	Mošovce	CS	-	3						2219	Raitis	A	h	2
						2261	Ziline	CS	-	3						2221	Eisenhappel	A	h	3
						2211	BayerischerWald	D	m/h	3						2223	Mittenberg	A	m/h	3
																2225	Trieben	A	h	2
																2229	Feldkirchen	A	m/h	2
																2230	Mittenberg	A	m/h	2
																2209	Jura	D	h	3

NB. * number of trials in which the provenance is represented

+ altitude 1 = low (below 300 m) m = middle (300-700 m) h = high (above 700 m) m/h = middle to high - = unknown

Table 3. Grouping of progenies and rome provenances according to flushing behaviour and height growth rate

Flushing

Height growth	very late				late				early				very early			
	Sel. nr.	progeny/provenance	country	tr*	Sel.nr.	progeny/provenance	country	tr	Sel.nr.	progeny/provenance	country	tr	Sel.nr.	progeny/provenance	country	tr
very fast	2389			3	2386			3	2398			3	2397	Maartensdijk	NL	3
	2391			3	2399	Maartensdijk	NL	3	2402	Maartensdijk	NL	3				
	2394			2	2410			3	2408			3				
	2395	Maartensdijk	NL	3	2464	Maartensdijk(prov.)	NL	3	2416	Hoge Veluwe	NL	3				
	2400			3					2264	Pribram pol.Bohutin	CS	1				
	2401			3												
	2407			3												
	2412	Hoge Veluwe	NL	3												
	2414			3												
	2417	Staverden	NL	3												
	2421			3												
fast	2392	Maartensdijk	NL	2	2403	Maartensdijk	NL	3	2420	Staverden	NL	3	2387	Maartensdijk	NL	3
	2260	Starej Vode .	CS	3	2404			3	2213	Bodensee u. Oberschwaben	D	2				
					2419	Staverden	NL	3								
					2243	Forêt d'Anlier	B	2								
slow	2267	Muráň	CS	3	2269	Behuš	CS	1	2253	Centre Belge du Bois	B	1	2393	Maartensdijk	NL	
	2268	Slovenska Lupčá	CS	1					2245	Bièvre	B	1				
	2231	Austerlitz	NL	1					2249	Bois du Seigneur	B	1				
									2266	Pribram, pol.Bohutin	CS	1				
very slow	2257	Slovenské Rudohorie	CS	1	2240	Huqueny	B	2	2250	Berismenil	B	1				
	2265	Podolinec	CS	1												

NB. * Number of trials in which the progeny or provenance is represented.