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GEOGRAPHICAL VARIABLITY OF THE NORWAY SPRUCE IN THE ESTONIAN SSR

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SELOSTE:

KUUSEN MAANTIETEELLINEN VAIHTELU EESTIN NEUVOSTOTASAVALLASSA

The regional variations in the Estonian vegetation have resulted in the division of the republic into geobotanic districts. The productivity of the Estonian spruce stands, as well as several morphological features of the spruces (e.g. weight of the seeds, cone dimensions, the shape of the cone-scale, crown dimensions, etc.) show geographical variation. For instance, the absolute weight of spruce seeds is higher in the areas to the south of the Kunda-Paide-Virtsu alignment, which runs from the north-east to the south-west of Estonia, compared to seeds from the areas to the north of it. As this alignment coincides well with the boundaries of the Western and Eastern Baltic geobotanic sub-provinces, defined by L. Laasimer, we might term this a sub-provincial variation of the spruce stands. The average absolute weight of the spruce seeds in the Western Baltic geobotanic sub-province (not including the islands) is 5.57 ± 0.03 g. and that in the Eastern Baltic sub-province is 6.10 ± 0.03 g. The difference is as much as 10 % (B < 0.999). In some individual Estonian territories, one can more often find different varieties, on the basis of the shape of the cone-scale. For instance, *Picea abies var. obovata*, in the surroundings of Tartu, occurs 8 times more frequently and *Picea abies var. acuminata* three times more frequently than around Rakvere (Northern Estonia). This is no doubt because of differences in the climatic and soil conditions, which in spite of the small area of Estonia (240 km North to South and 350 km East to West) are quite large. Similarly the air temperature in different regions in Estonia can vary by more than 20° C. It may be these differences in the conditions for growth that, over an extended period, have resulted in the geographical variability of the genetic constitution of the spruce stands in Estonia. The changes may be apparent in, for instance, the frequencies of the different varieties (derived on the basis of the shape of the cone-scale), the successors of which, in their turn, differ in the genetically controlled rapid growth factor. For example, in the favourable soil conditions of Southern Estonia, the successors of *var. acuminata* are at least 20 % taller at the age of 9 year those of *var. obovata.*

In order to check the possible geographical variability of the gene pool, preliminary experiments were carried out in the spring of 1969. Seeds of 93 spruce stands originating from 14 forest enterprises were sowed in a nursery in Tartu. After 2 years the seedlings originating from the south of Tartu (south-eastern Estonia) were the tallest followed by those originating from the same northern latitude but to the West of Tartu. Seedlings originating from the forest enterprises situated to the north of Tartu were smaller. In these experiments no association could be established between the absolute weight of the seeds used and the height of the seedlings (ETVERK 1974). Differences in the growth based on the provenance may also be observed in the later stage of growth. In the vicinity of Viljandi (south Estonia) the average height of the 9 years-old cultures of spruces (8 plus trees and 326 successors) originating from Pärnu and Rakwere forest enterprises situated to the north of Viljandi (a marine climate) was 100 ± 0.4 cm, and of those of the spruces (9 plus trees and 384 successors) originating from Võru and Kiling-Nõmme forest enterprises, situated a little to the south of Viljandi, was 122 ± 0.6 cm i.e. 22 % higher (B > 0.99). The differences in the growth became rather quickly evident in the vegetative successors of plus trees. At Sona seed-orchard, the height increment of the 140 grafts (4 clones) originating from Rakvere forest enterprise (north Estonia) did not differ from that of 207 grafts (5 clones) from Räpina forest enterprise (south east Estonia). By the third year, though, the height increment of Räpina grafts was 18 % greater than that of Rakvere grafts (19.9 ± 0.77 cm and 16.8 ± 0.91 cm B < 0.99 respectively).

From the above facts, however, it cannot be maintained that the southern Estonia spruces are of a better genotype than those of the north since genotypes are evaluated on the basis of ecological conditions under which the experiments are carried out. On the basis of an analysis of the rapid growth the grafts from south Estonia fare better in south Estonia. Had the experiments been carried out in the ecological conditions of north or north-western Estonia, the results would presumably have been different. Such a conclusion is confirmed by the experiments carried out by H. Paves in Tartu. Spruce seeds from 32 different places (from the range of 54° 25′ to 67° 51′ N and 22° 19′ to 60° 00′ E) were sown simultaneously in open ground, and in a plastic-house. From amongst those in the open ground, five provenances, originating from the territory situated a little to the south and east of Estonia (average co-ordinates of the territory being 56° N and 37° E) grew equally well or better than Estonian spruces (Figure 1). This denotes an average shift of 7° to the East of the territory for spruces suitable for cultivating in Estonia. The results clearly indicate the dependability of the evalution of the genetic constitution on the ecological conditions prevailing at the place of experiment. The temperature of the plastic-house during primary stage of vegetation period resembled that of south Estonia and the continental climate of the areas to the east of Estonia.

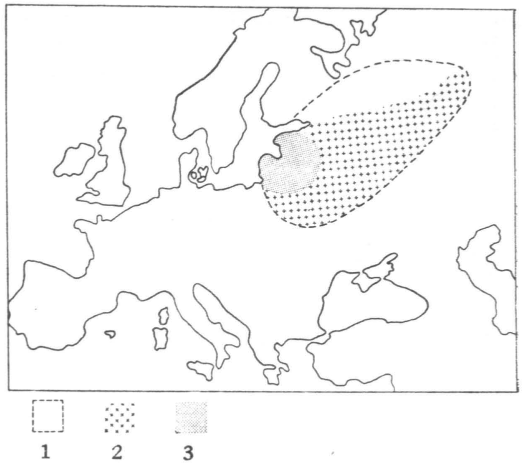

Figure 1.
1. The area of seed sources for experimental cultures.
2. The area suitable as a seed source for spruce cultures as determined by field experiments.
3. The area suitable as a seed source for spruce cultures in Estonia as determined by plastic greenhouse experiments.

Because of the genetically heterogeneous nature of all the seed lots actually used in our forest enterprises, those genotypes which grow favourably in the climatic conditions of the given area are eliminated while growing the seedlings in the plastic-houses, and the largest seedlings are obtained from the seeds which are geneticaly unsuited to the conditions of this given area. This became apparent during planting the plastic-house seedlings of the above-

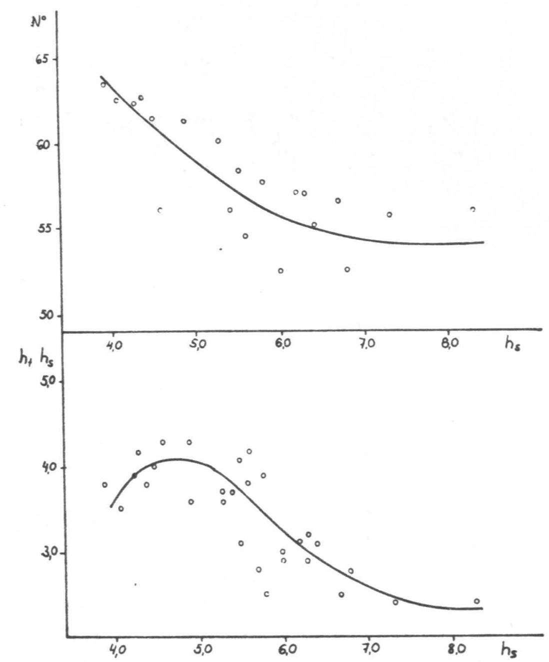

Figure 2.
Upper figure:
The relationship between seedling height before transplanting and latitude.
Lower figure:
The height growth development of seedlings grown in plastic greenhouses and transplanted in the field. The vertical axis indicates the relationship between the height of the seedlings before (h_s) and after (h_t) tranplanting; the horizontal axis indicates the height of the seedlings before transplanting (h_s).

mentioned 32 lots of different provenances in the open ground. The seedlings that grew slowly in the plastic-houses grew considerably more rapidly in the open ground; the contrary was also true — the seedlings that had rapid growth in the plastic-house, grew slowly in the open ground. This is well evident from figure 2, where the ratio of the height of the transplant to the seedling is in inverse proportion to the height achieved by the seedlings in the plastic-house. On the basis of the above facts, it is feared that the stands established using the seedlings grown in plastic-houses would be less valuable than those planted with seedlings grown in the open ground, as some of the genotypes favourable to the open ground get eliminated (they have either perished in the unfavourable conditions existing in the plastic-house or having remained shorter than the others, they have been remodev at the time of grading). Hence only genetically homogenous seed lots, the genetic constitution of which corresponds to the ecological conditions obtaining on the open ground, should be sowed in the plastic houses.

The speedier growth, under Estonian conditions, of the spruces originating from the south is confirmed by the successors of the Lithuanian plus trees (a total of 432 nine year-old trees); these, in the same experimental area were, on the average, 14 % taller than the successors (882 trees) of the Estonian plus spruce trees. This has confirmed the opinion that in order to grow Norway spruces in the northern region of the area, seeds obtained from the territories 400—600 km southwards ought to be suitable (Heikinheimo 1949, Gunzl 1969). Presumably this has some connection with the climate of the Northern Hemisphere becoming gradually warmer as well as the slow adaptability of the gene pool of the spruce-stands.

The variance component of the provenance has been evaluated by variance analysis (Plohinski 1967). Taking a forest enterprise as a unit of provenance (trees originating from the same forest enterprise bear the same geographical provenance), the variance component of provenance, based on 14 provenances of the 2-years-old spruce seedlings, is 6 ± 0.4 % ($B > 0.999$) and based on 5 provenances of the 9-years-old trees, it is 7 ± 0.5 % ($B > 0.999$). Of course this is considerably less than 67 ± 0.01 % ($B > 0.999$), the variance component of provenance in the entire Norway spruce area in the Soviet Union, based on 32 provenances. The variance component decreases as the geographical areas covered by the experiment is narrowed. If we take into account only the territory where, on the basis of 2-year-old seedlings, import of seeds in Estonia (Estonia, Latvia, Lithuania, Pihkva district, and North of Byelorussia) are also considered, then the variance component of the provenance is $40 \pm 0{,}02$ % ($B > 0.999$). This indicates that the import of seeds from other parts of the area might be more effective than obtaining them from some selected but narrow territories of Estonia. On the other hand, it may be presumed that by the creation of an artificial population in the form of a seed-orchard, which may be obtained from the progenies of plus trees, we may be able to have seeds the genetic quality of which may not be any worse than the best quality imported seed lots. In experiments with the 9 year old successors, the influence of the parent trees (plus trees of Estonian origin) on the height of the successors was as much as 21 %, where the average height of the fastest growing successors exeeded the average height of the trees over the entire experimental area by 30—35 %.

M. Giertych (1977) has divided the area of Norway spruce in Europe into 13 regions according to which Estonia belongs to the 8th (Eastern Baltic) region. It appears as if the boundaries of the 7th and 8th regions in Estonia should be included in the 7th (North East) region.

It seems, therefore that attention has to be paid to the geographical origin of spruce seeds in relatively smaller territories in order to avoid the possible degradation of the genetic constitution of culture stands. Until it has been ascertained that the lower growth of spruces of north Estonian origin in south Estonia is not a consequence of the spruces growing in different site-types or that the same site-type spruces differ genetically in north and south Estonia, spruce cultures from the seeds of south Estonia should not be established in north Estonia and vice-vers. If the entire problem is reduced to different forest site-types (fertile and deep soil site-types are to be found more frequently in southern Estonia compared with northern Estonia), spruce-seeds would have to be obtained according to their site-type or their group. It is essential to carry out experiments over an extended period in order to determine the influence of growing seedlings in the plastic-houses on the genetic quality and growth of culture stands.

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SELOSTE:

KUUSEN MAANTIETEELLINEN VAIHTELU EESTIN NEUVOSTOTASAVALLASSA

Kuusimetsiköiden tuotossa ja monissa kuusen morfologisissa ominaisuuksissa esiintyy huomattavaa maantieteellistä vaihtelua Eestin alueella. Esimerkiksi siemenen paino on maan eteläosissa suurempi kuin pohjoisosissa. Samoin käpysuomun muodon perusteella erotettavien kuusen eri muotojen yleisyys vaihtelee maan eri osissa. Näiden vaihteluiden täytyy olla seurausta ilmaston ja maaperän alueellisista eroista, jotka Eestissä ovat huomattavat, maan pienestä koosta huolimatta. Tartossa suoritetussa taimitarhakokeessa etelämpää tuodut eestiläisestä simenestä kasvatetut taimet olivat 2-vuotiaina suurempia kuin länempää peräisin olevat, ja pienimpiä olivat pohjoisesta siirretyt alkuperät. Viljannissa on 9-vuotiaissa eestiläisten pluspuiden jälkeläiskokeissa nähtävissä 22 % pituuskasvuero eteläisempien ja pohjoisempien alkuperien välillä. Alkuperien kasvunopeuserot ovat ilmenneet samanlaisina myös eestiläisten pluspuiden vegetatiivisissa jälkeläisissä siemenviljelyksissä.

Eri alkuperillä saatavat tulokset voivat kuitenkin muodostua erilaisiksi sen mukaan, millä paikkakunnalla ja missä ympäristössä niitä vertaillaan. Muovihuonekasvatus antaa siirretystä materiaalista helposti paremman kuvan kuin avomaakasvatus. Myös taimiyksilöiden välisten suhteellisten kasvunopeuserojen on todettu muuttuvan, kun materiaali on muovihuonevaiheen jälkeen siirretty jatkokasvatukseen avomaalle. Onkin pelättävissä, että muovihuonekasvatuksessa tuotetaan tietyn alueen metsänviljelyyn heikosti soveltuvaa materiaalia. Muovihuoneissa kunkin alkuperän suurimmiksi taimiksi kehittyvät yksilöt, joiden geneettiset ominaisuudet parhaiten soveltuvat kasvuun näissä olosuhteissa. Vastaavasti paikalliseen ilmastoon ja avomaaolosuhteisiin paremmin soveltuvat taimet jäävät pienemmiksi ja saattavat eliminoitua taimien lajittelussa.

Liettualaisten pluspuiden jälkeläisillä saadut tulokset tukevat yleistä kokemusta etelämpää siirretyn kuusen paikallista nopeammasta kasvusta Eestissä: 9-vuotiaissa kokeissa niiden pituusetumatka eestiläisiin pluspuujälkeläisiin nähden oli keskimäärin 19 %. 400—600 km:n siirtoja etelästä pohjoiseen pidetään sopivina (Latviasta, Liettuasta, Valkovenäjän pohjoisosista). Siirtojen edullisuus perustunee siihen, että ilmasto on vähitellen lämpenemässä ja eestiläiset kuusen luonnonpopulaatiot eivät ole ehtineet sopeutua tähän muutokseen. Toisaalta näyttää siltä, että tuottamalla siemen eestiläisistä pluspuista perustetuilla siemenviljelyksillä voidaan saavuttaa yhtä suuria kasvunlisäyksiä kuin parhailla tuontialkuperillä. Siemensiirtoihin ja taimien muovihuonekasvatukseen liittyy vielä riskejä viljelymetsien geneettistä laatua ajatellen. Alkuperäkysymyksiin olisikin kiinnitettävä huomiota entistä suppeampien alueiden puitteissa; esimerkiksi kasvupaikkarotujen esiintyminen ja merkitys on vielä selvittämättä.