BRIEF REVIEW

A new study on the North eastern continental Norway spruce provenances

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The present article is an introduction of a new study on the north eastern continental Norway spruce provenances. The presumptions, main objectives, material and basic methods are described. Knowledge on the variation patterns in growth rhythm of the natural populations in this region is limited. A number of existing national experiments are too specific to make a proper conclusion on large-scale trends. Present experiences are restricted to growth and external quality. The basic objective is to specify phenological variation patterns of the provenances. 113 origins are selected. The main assessments will be made in a short term nursery trial established in September 1996 and artificial freezing tests. Growth termination and initiation, dynamics of shoot elongation, frost hardiness and a number of juvenile growth traits will be assessed.

Key words: provenance, growth rhythm, frost damage, early testing.

Phenological patterns, such as initiation and cessation of active growth of the apical and subapical meristem together with rate of elongation, are important factors for the survival of Norway spruce seedlings under climatically harsh conditions. Seedlings with unsuitable growth rhythm could be seriously injured either by late spring frosts, if active growth is initiated too early, or by early autumn ones, if seedlings are not hardy enough. Optimal productivity, wood quality and a number of desirable morphological characters are important to consider. For instance, in southern Sweden spring frosts, which occur up to mid-summer, are the main threat to the healthy development of Norway spruce seedlings. It is not possible to avoid all frosts during the period of active growth, but by choosing the provenances with a relatively late bud flushing, the frosts in late May and early June may not be harmful. On the other hand, provenance transfer to the north and to the high altitudes is restricted by the injury of early autumn frosts if the seedlings are not hardy enough. To avoid these problems it is necessary to have proper knowledge of population variability in growth rhythm and associated patterns.

From the earliest Norway spruce provenance trials, the central and eastern European provenances were defined as late flushing, productive, possessing proper morphological characters (e.g. Langlet, 1960; Dietrichson, 1979). In the further study of over 1100 origins in the three Swedish sites of the IUFRO 1964/68 Norway spruce provenance experiment, more advanced groupings of the central and eastern European provenances have been made. The provenances from the north-eastern continental region (Belarus, the Baltic states, western Russia and north-eastern Poland) were outstanding from the rest (Persson & Persson, 1992). Provenances from the region possess higher heterozygosity than the central European ones (Lagercrantz & Ryman, 1990), what increases their adaptability to the new environments.

However, the area defined as north-eastern continental is large. The provenances from Lithuania, for example, were almost absent in all the international provenance trials. Similar, or even worse, is the situation is with the western Russian origins from the Pskov region (east to Estonia). It is worth to mentioning that some of the provenances in the previous studies were poorly described climatically and geographically (e.g. in the F. Prescher's report from 1982 three of five Lithuanian provenances were ascribed to the zone of the Russian Federation (east to Belarus)). Another shortcoming is the fact that the same seed lots from Baltic states used in the IUFRO 1964/68 series have been used in a number of the other trials (e.g. Hannerz, 1993). There are a number of national provenance tests in the Baltic states. The experiments, however, are too specific to compare the results. Having the "white spots" it is complicated to specify variation patterns of the provenances in the north-eastern continental region. The provenances in the region do have differences in phenology resulting in their further performance when transferring the provenances further north (e.g. Skrøppa, 1982; Skrøppa & Magnussen, 1993; Krutzsch, 1986; Prescher, 1982).

Though not much data is available, a preliminary comparison between the provenances from the Baltic states and Belarus could be made. According to B. Persson (unpublished) variation in phenological performance within the region of the Baltic states is much larger than the corresponding variation within Belarus. The Baltic provenances (taken as an average from Lithuania, Latvia and Estonia) had a tendency to set buds a bit earlier than the Belarussian ones. Similar patterns were reported by P. Krutzsch (1986). F. Prescher (1982) concluded that the Baltic provenances could be an alternative

in central and northern Sweden due to their relatively early growth cessation. He noted, however, that more research should be done in this case. Later on this provenance trial was assessed by M. Hannerz (1993). The results revealed, that the most promising provenances were found in the eastern parts of Latvia and Lithuania. According to J. Dietrichson (1980) and I. Dormling (1988) use of the Belarussian provenances in the localities with high incidence of autumn frosts should be avoided. Might the Baltic provenances be an alternative?

With more specific knowledge on the variation patterns in growth rhythm of the provenances within the north-eastern continental region, further selection on the family level is possible. I. Dormling (1982) stressed that Norway spruce populations moved to the north can never reach the same degree of hardiness as autochtonous ones. However, she noted, the resistance to the frosts can be improved by controlled crossings of the frost hardy and late flushing families. The long-distance crosses could result in the intermediate bud set in comparison with the parental families (Eriksson, 1978; Ståhl, 1980).

The region of the Baltic states it self is a relatively large latitudinal gradient: from the 54 th latitude in the south of Lithuania, where the provenances are presumed to be similar to the north-eastern Polish ones, to the 59 th latitude in the north of Estonia, where similarities with western Russian and southern Finnish origins could be expected. Even in Lithuania there are 6 climatic zones (Karazija, 1988), reflecting a noticeable variation among the provenances in the country (Gabrilavicius, 1990). Therefore, grouping all Baltic provenances in one group should be avoided.

Geographical variation in juvenile growth traits of Norway spruce provenances have been observed in many studies (e.g. Griffin, 1978; Kaya, 1992; Skroppa, 1982; Popov & Zarikov, 1978). Considering the existing relationships between phenology and juvenile growth traits (e.g. Lieffers, 1987; Ekberg et al., 1994), a set of juvenile growth traits together with growth rhythm patterns can be used in describing variation between the provenances. A high correlation between morphological traits (seed size, seed weight, height at three years, time of bud burst) and allele frequency has been revealed by U. Lagercrantz & N. Ryman (1990) in the study on genetic structure of Norway spruce provenances used in the IUFRO 1964/68 experiment. That allows to definition of population structure in a region using the variation patterns in growth rhythm, seed and juvenile growth traits.

In addition to breeding for desirable phenological patterns and juvenile growth traits, wood quality can be improved by selecting provenances of optimal productivity. If a provenance flushes very late, it usually possesses a high potential to the height and diameter increment, especially at the beginning of a vegetation period. That negatively reflects in wood quality of the provenance, as it possesses low values of basic density. Studies on wood quality of the Lithuanian Norway spruce provenances are limited. Former Norway spruce breeding programs in the country were concentrated mainly on productivity and qualitative traits. Presently, with increased demands on timber quality, studies on wood properties are urgently needed.

Considering all the assumptions mentioned above, this new study of Norway spruce provenances from the north-eastern continental region have been started. There are a total of 113 origins as evenly as possible distributed in the north-eastern continental region. To have a comparable estimate of the patterns between the Baltic and the Nordic provenances to be tested, several southern Swedish and southern Finnish provenances are included. The provenances are documented climatically and geographically.

The basic objectives of the study are:

- To specify variation patterns in growth rhythm, frost hardiness and juvenile growth traits of the Norway spruce provenances within the north-eastern continental region.
- To assess age-to-age correlation in a number of the juvenile growth and seed traits important in early testing.
- To estimate relationships among juvenile growth traits; between the juvenile growth traits, growth rhythm and seed traits.
- To describe variation of the Lithuanian Norway spruce provenances in wood basic density and late wood content.

The following characters to be studied:

- Seed tests (germination, seed weight, embryo size).
- Growth rhythm (bud flushing, dynamics of shoot elongation during growth period, bud set and degree of lignification, occurrence of free growth).
- Juvenile growth traits (final height and root collar diameter, number of cotyledons, length of the whorl shoots, length of the leader shoot).
- Natural frost damage.
- Artificial freezing injury (sensitivity to frosts during bud flushing, variation in frost hardiness).
- Wood quality (basic density, late wood content) of the Lithuanian Norway spruce populations.

In order to have all the north-eastern continental region of the species distribution covered by the study, a pool of the autochtonous Norway spruce provenances from the Baltic states, Belarus, western Russia (the Pskov region, east to Estonia) and north-eastern Poland was selected. To have a comparable estimate of the patterns to be tested between the north-eastern continental and Nordic provenances, several southern Swedish and southern Finnish provenances are included. A total of 113 provenances will be studied. The

category of the seed lots is defined according the descriptions of seed source proposed by P. Krutzsch (1974): (1) mixed collections from 10 to 20 trees per stand and (2) collections from a number of adjacent stands within the borders of a forest district.

The Lithuanian, Estonian, Latvian, Russian, Belorussian seed lots are mixed collections from a number of stands within the borders of the regional forest management units- state forest enterprises (in addition, seven seed lots from Lithuanian seed reserves (phenotypically selected stands for seed production) are included). The Polish seed lots are mixed seed collections from a number of stands within the borders of a "seed region"(a sub-unit of a region of provenance). A "seed region" in size approximately corresponds to the area of a forest enterprise in, e.g., Lithuania. The stands are of the regular category. The Finnish seed lots are collected in so-called "standard stands" for forestry research described by M. Hagman (1971) as representative stands for the area in question, or at least as typical as they could be. It does not include a lot of plus trees, nor is a collection from inferior stands. The seed lots have been used in a series of experiments in Finland and could be described as "marker provenances". Provenances from the north-eastern continental region should have a potential to be used in the southern part of Finland. Since climatic conditions in the part of Sweden the trials will be established in are similar to the south Finnish ones, it is possible to make conclusions about performance of the provenances in that part of Finland. A seed lot from Sweden is a mixed collection from a seed collection area, which includes several adjacent stands. Some of the provenances have been used as markers in progeny trials. Thus, the categories of the seed lots are comparable with each other and the area a seed lot is collected from is large enough to represent natural populations in the region of origin.

At the beginning of March 1996 the provenance seed lots were sown in a greenhouse of the Department of Forest Yield Research (Swedish University of Agricultural Sciences). In May 1996 the same set of the provenances were seeded in a greenhouse (with temporary cover) of the Lithuanian Forest Research Institute. At the beginning of September 1996 the seedlings grown in Sweden were transplanted to a nursery trial. In Lithuania the bare-root seedlings will be grown for 2 years in the greenhouse and will be transplanted to a number of field trials afterwards.

Sampling for the study on wood quality (basic density and late wood content) of the Lithuanian Norway spruce provenances have been made in a provenance experiment in Lithuania.

Below the basic assessments and their objectives are presented. Concerning assessment on embryo size the following hypotheses are tested: (1) are the relationships between seed weight and embryo size significant enough in Norway spruce on the provenance level to use seed weight value as an estimate of embryo size, (2) does the influence of the embryo size on seedling development remain significant in the futher growth of Norway spruce, and (3) is there any remarkable geographical variation in embryo size among the provenances. Embryo size will be assessed using *x*-ray images. Mean provenance value of the ratio embryo length/ seed length will be calculated.

Phenological assessments have the following the objectives: (1) to assess sensitivity of the provenances to late spring and early autumn frosts, (2) using the phenological patterns to describe geographical variation in the north-eastern continental area of the species distribution (latitude: from 53°30'N to 59°30'N and longitude from 21°00'E to 30°00'E.), (3) to assess variation between the provenances in dynamics of shoot elongation during growth period and (4) to estimate differences in dynamics of shoot elongation between late and early flushing provenances, (5) to describe relation between the phenological patterns and juvenile growth, seed traits. Variation in the degree of growth termination and sensitivity to the early autumn frosts between the provenances will be assessed by studying the terminal bud set and the degree of lignification of the leader. A scale, which includes different bud set stages, will be employed. The bark colour will be used to estimate the degree of lignification. Variation in growth initiation between the provenances and the probability of injury from late spring frosts will be assessed according to the time of bud flushing. Terminal bud flushing on the leader will be estimated according to the scale proposed by Krutzsch (1973). Observations on the elongation of the terminal shoot will be made 4-5 times during the period from the beginning of May to the middle of August. Occurrence of the free growth will be recorded.

Concerning juvenile growth traits the objectives are to assess: (1) provenance variation in the early growth traits, (2) relationship between the early growth traits and (a) phenology, (b) seed traits, (3) relationships among the early growth traits, (4) to have an initial estimate of the early growth traits to follow age-to-age relationships, (5) to answer the questions: (a) are the seedlings with higher value of the ratio leader shoot/whorl shoots prior to the ones with lower value of the ratio in respect of height, basal diameter and growth rate? (b) can the ratio leader/whorl shoots be used as a trait in assessing differences between provenances?

In addition to the phenological and juvenile growth traits, damage levels after overwintering (in early May) and after the period of possible injury of spring frosts (late June) will be estimated.

The objectives for the freezing tests are the following: (1) to define at which of the bud flushing stages (Krutzsch 1973) seedlings are most sensitive to the spring frosts, (2) to assess geographical variation in frost hardiness of the north-eastern continental provenances.

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НОВЫЕ ИССЛЕДОВАНИЯ СЕВЕРО-ВОСТОЧНЫХ КОНТИНЕНТАЛЬНЫХ ПРОИСХОЖДЕНИЙ ЕЛИ ОБЫКНОВЕННОЙ (*PICEA ABIES (L.)* KARST.)

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Резюме

В статье описаны обусловленность и главные цели исследования Северо-восточных континентальных происхождений ели обыкновенной, а также материал и основные методы такого исследования. Ряд национальных исследований является слишком специфичны, чтобы сделать подходящие выводы на масштабе региона. Настоящий опыт ограничен испытаниями роста и продуктивности. Основная цель данного исследования – уточнить закономерности межпопуляционной фенодогической изменчивости. В дальнейшем будет исследовано начало и конец активного роста, динамика роста, морозоустойчивость и ряд признаков ранней диагностики.

Ключевые слова: происхождение, фенология, морозоустойчивость, ранняя диагностика.