

## Genetic Improvement of Hybrid Aspen – *Populus tremula* x *P. tremuloides*

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### *Material*

Aiming to produce superior hybrid aspen commercial material, a breeding project was initiated at the Forestry Research Institute of Sweden (Skogforsk) in 1985. A total of 280 plus trees of hybrid aspen, *Populus tremula* L. x *P. tremuloides* Michx., were phenotypically selected from 20-40 year old stands in southern Sweden. The *P. tremula* parents mainly originated from southern Sweden (latitudes 55.5° – 60.0°) and the *P. tremuloides* parents from the American states and Canadian provinces around the Great Lakes of North America. All clones were vegetatively propagated as herbaceous root sprout cuttings and planted on 14 test sites in southern Sweden during the period 1986-1991.

Genetic results from these clonal tests at age 8-16 years, each including 41 to 107 clones, replicated 8-20 times per site in randomised block design using single tree plots generally in a spacing of 3x3 m (1100 st/ha) is given below.

### *Survival*

Out of the 14 test sites four were excluded from the study due to poor establishment. In the remaining 10 sites (all on former agricultural land) survival was high (> 90 %) in seven and moderate (80 - 86 %) in three sites.

Dense vegetation increases competition for water, and makes environments more favourable for voles (*Arvicola terrestris*). This was the main reasons for mortality in the test sites. Survival seemed to be independent of genotype. There was no tendency for mortality increasing with age, at least not up to 16 years of age. On the contrary, mortality after the first years of establishment was very low (< 4 %). In this context it should be mentioned that all sites were fenced, reducing moose and roe deer damage to zero.

### *Canker*

Stem canker (*Entoleuca mammata* former *Hypoxylon mammatum*) and branch canker (*Leucostoma niveum*) present serious threats to hybrid aspen. The phenotypic selection of the 280 clones included in the tests was mainly carried out in 20 to 40 year-old trials and stands, where the trees had been potentially exposed to canker throughout their time in the field. Since only trees without any visible sign of canker damage, were selected it was assumed that the selected material would be less sensitive to canker than hybrid aspen in general.

Frequencies of medium to severe canker damage and stem crack damage (which is supposed to be correlated to canker) varied from 0 to 7 % among the different sites. So far, very few trees were killed by canker. This should for instance be compared to an estimated 2 % annual mortality for *P. tremuloides* in North America and a 30 % reduction in net growth on surviving trees.

The oldest test sites (14-16 years) had the largest frequencies of canker, implying that infections may increase with age.

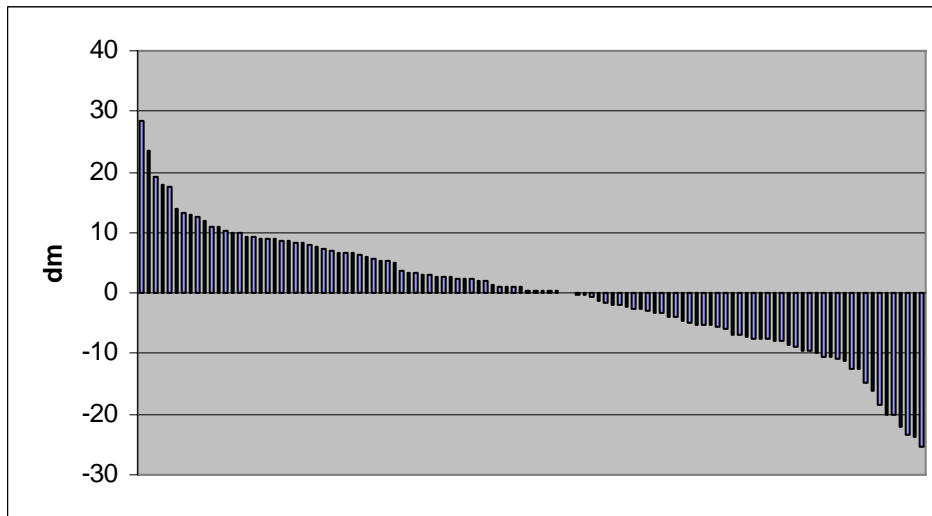
The clonal influence on canker damage was weak (heritability ( $H^2$ ) mostly < 0.10). However, it should be mentioned that genetic differences are difficult to identify for traits related to rare

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conditions (such as canker, since the proportion of damaged and dead trees was mostly low). There were no clear indications of any correlation between tree size and incidence of canker, neither any dependence between site parameters and canker damage.

### *Growth*

Annual mean height growth varied from 0.6 m to 1.3 m in the 10 test sites. The genetic variation among clones was high. The coefficients of variation was around 10% for height and 15 % for diameter. The high genetic variation is illustrated in Figure 1. The individual broad-sense heritability ( $H^2$ ) was in average 0.38 for both height and diameter, indicating a strong genetic control for growth traits.



*Figure 1. Example of genetic variation in height at age 13 years of totally 106 hybrid aspen clones. Each bar represents a single clone and illustrates the deviation from the mean. The mean for all 106 clones was 130 dm, represented by 0 dm on the y-axis.*

Successful early selection requires strong genetic correlations between the selection and the target age. In relation to the target age of 8 and 9 years, the mean genetic correlations at 4 years of age was 0.92 for diameter and 0.87 for height. These strong age x age correlations suggests that selection of superior clones for diameter at age 4 years (average height around 4-5 m) should lead to more or less the same selection of superior clones as a selection based on volume at age 9 years.

A significant genotype x environment (GxE) interaction indicates that clones grow differently in various environments. Such interactions make testing and selection more complex and reduce genetic gain. The GxE interactions were found to be weak, indicating that clonal rankings are quite stable across sites. This suggests that agricultural land in southern Sweden can be treated as a single test and utilization zone, which will simplify future possible hybrid aspen breeding programmes. The results also indicates that few sites are needed for genetic tests.

The genetic gain for individual trees was estimated to 14 % if the best 10 % of the genotypes in terms of height were selected from the 280 clones at the age around 9 years. This suggests that a

yield of up to 25 m<sup>3</sup> stemwood ha<sup>-1</sup> yr<sup>-1</sup> should be possible on fertile sites after selecting the best 10 % of the clones.

#### *Main conclusions*

Growth traits are strongly influenced by genetic factors and show substantial genetic variation. Genetic correlations among the same traits measured at different ages and sites are strong. Overall, the results after 8-12 years of growth in field demonstrated possibilities of powerful clone selection after early evaluation of clone tests at just one or a few sites.

If only growth is considered, early selection would be advisable. However, even though canker susceptibility seemed to be under weak genetic control generally, at some sites the genetic effects seemed to be more significant. Since it is essential to avoid clones that are sensitive to canker damage, and it might take 10 – 15 years for canker to develop fully, final selections of clones for commercial use should not be made until ages of 10 – 15 years, unless reliable, early artificial tests can be developed.

The yield of the 10 % best hybrid aspen clones was estimated to 20-25 m<sup>3</sup> stem wood ha<sup>-1</sup>, year<sup>-1</sup> during a 20-25 year rotation on better sites in southern Sweden (without fertilization). The high growth potential, the ability to regenerate from root suckers after final felling and excellent wood and fibre characters for producing high quality printing paper indicate a substantial commercial potential.

#### *References*

Stener & Karlsson 2004. Improvement of *Populus tremula* x *P. tremuloides* by phenotypic selection and clonal testing, *Forest Genetics*, 11(1): 13-27.