Aspen Breeding in Finland, New Challenges

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The Finnish pulp and paper industry has recently become interested in aspen as raw material for fine paper grades produced using lean technology. Especially the fibres characteristics of aspen makes its wood most suitable. During the 1950's and 60's there used to be breeding activities on hybrid aspen in Finland to provide raw material for the match industry. The material remained from that programme has been the basis for a new selection programme which was started in 1996. Studies have shown that there is large variation in fibre quality, which seems to be genetically based for at least a considerable part. This offers the way to improve fibre quality through further breeding and selection. A new breeding programme on (hybrid) aspen was started, which will specially emphasise on wood quality, but also on growth and resistance against pests and diseases.

Key words: aspen, hybrid aspen, paper production, wood quality, breeding.

Introduction

Since the beginning of the 1990's there is a renewed interest in aspen in Finland. Aspen has been found to be very suitable as raw material for new lean technologies in the paper production process. Lean technology means using less raw material, energy and capital per unit printing surface produced. As a result of developments in printing technology, there is an increasing demand for new grades of high quality fine printing paper. In order to be able to use more lean technologies, and to improve the quality of paper, the quality requirements for the raw material (fibres) become more and more important. In the future the paper industry will demand more homogenous raw material with special emphasis on the fibre morphology and dimensions (fibre length). The Finnish company Metsä-Serla uses wood from naturally grown aspen for its new machine in Kirkniemi which started to produce a new type of fine paper in 1996. The present capacity is about 300 000 m^3 aspen wood annually, obtained from Finland and the Baltic countries. For the near future it is expected that the demand for aspen wood by Metsä-Serla will increase. The quality of the fibres obtained from naturally grown aspen is, however, very variable. To ensure a sufficient supply of aspen wood also in the future, not only in quantity but especially also in quality, the aspen programme of Metsäliitto, of which Metsä-Serla is part, includes besides the technical aspects of paper production also aspects of breeding and cultivation of aspen.

During the 1950's and 60's, hybrid aspen used to be cultivated in Finland, with the purpose of growing raw material for the match industry. The crossing between the native European aspen (*Populus tremula*) and the North American aspen (*P. tremuloides*) had earlier shown faster growth in Sweden. For this reason a large breeding programme on hybrid aspen was set up during the 50's by the Foundation for Forest Tree Breeding and the Finnish Forest Research Institute. Within this programme a large series of field trials with hybrid aspen were established. During the 50's and 60's about half a million plants of hybrid aspen plants were grown by the Foundation from seed obtained from controlled crossings. These plants were planted out in 670 of commercial plantations, mainly in Southern Finland. In addition 17 field trials were established. During the beginning of the 1970's 300 of these stands, including 170 families, were intensively measured. From over 60 000 trees 19 different characteristics were assessed (Beuker, 1991). With the fall of the match industry also the interest in aspen decreased. Because aspen wood became nearly worthless, forest owners removed natural aspen from their forests to make space for more valuable species. Fortunately many of the trials and stands with hybrid aspen which were established during the 50's and 60's are still alive today. Because of their age

one might presume that the trees are well adapted to the southern Finnish climate. Each stand includes one or more full sib families. These stands have formed the basis for a new large selection and propagation programme which was started in 1995 for Metsäliitto by the Foundation for Forest Tree Breeding in co-operation with Metla.

Recent developments

Since 1995 nearly 1,000 individual hybrid aspen trees were selected on external phenotypic characteristics (growth and shape). Form each tree an increment core sample was taken. These samples were analysed at the University of Jyväskylä for wood and fibre characteristics (soluble lignin concentrations and fibre dimensions). The trees with superior values for these characteristics were selected for micro propagation testing. The success of micro propagation varies a lot between trees. In order to keep the costs of plant production reasonable, only trees with good propagation abilities were selected for mass propagation. From the 300 trees sampled in 1995-1996, 27 were taken into mass propagation of which 2 were native aspen. From these only the 12 clones with the very best propagation abilities are presently still in production. With this material about 750 ha of new plantations have been established for Metsäliitto since 1997, including 10 clonal trials and 3 management trials. About two third of this area was established in Estonia.

It is clear that the selections made so far have been rather desultory, especially because there is still very little known about the variation of the characteristics involved and about the causes of variation. Therefor, in the mean while, studies have started on the genetic variation of these various characteristics. First most of the data from the large hybrid aspen assessment during the early 1970's was written into the computer. This data will subsequently be analysed using modern statistical features. Preliminary results show that hybrid aspen has very good growth potential, especially on good soils, but that there are many threats which may destroy aspen plantations even nearly completely (Viherä-Aarnio, 1999). Especially mammalian herbivores (voles, hares and moose) had destroyed many of the stands (Henttonen et al., 1999). This means that new plantations with hybrid aspen should be protected against herbivores (Heikkilä, 1999), which leads to much higher costs for establishment. Pathogens have caused less dramatic damages, but should be certainly considered in the future as there are several pathogens threatening aspen (Kurkela, 1999). Early wood rot is a special problem with aspen (Hallaksela, 1999). Earlier studies with birch and poplars have shown that there is significant genetic variation in resistance against herbivores and pathogens respectively, which means that resistance may be improved through breeding.

The old data were also used to produce some first preliminary growth models for aspen and hybrid aspen in southern Finland (Hynynen, 1999). It was projected that hybrid aspen may grow up to 300 m^3/ha in 25 years on the best soils, whereas native aspen grows up to 200 m^3/ha. Within the Metsäliitto aspen programme there is the aim to grow at least two more rotations, growing from root suckers, after final harvesting of the first rotation. Because the root suckers are growing on an existing root system they are expected to grow even faster, especially in the beginning.

A problem in Finland is that all old hybrid aspen trials and stands are based on families. There are no clonal trials yet with trees having a sufficient diameter to take wood samples. Such trials are needed to study the causes for variation in yield and wood quality characteristics (genetic vs. environmental). Also the possible correlation between the different characteristics have to be studied. Fortunately a number of such trials exist in Sweden, and we are very thankful to SkogForsk in Ekebo, and to Lars Göran Stener in particular, for their willingness to let us use their clonal trials for collecting wood samples. Those trials were 7 to 13 years of age, and are consisting 18 clones. The estimates for clonal heritability for fibre and yield traits based on these trials ranged from 0.42 to 0.86 and from 0.38 to 0.77, respectively. These results indicate that there are possibilities to improve wood quality through tree breeding, but as they are based on a limited amount of material further studies will be necessary. Between some of the fibre and growth traits a strong correlation was found.

In co-operation with Prof. Ülo Tamm of the Estonian Agricultural University, native aspen stands were selected in Estonia, and increment core samples were taken. This includes trees from the famous triploid aspen stand at the field station of the university in Järvselja.

Classification of aspen clones and recommendations for plantation establishment

In order to guarantee a sufficient quality of the aspen regeneration material on the marked, The Finnish Ministry of Agriculture and Forestry has in 1999 im-

Table 1. Summary of the classification system for hybrid aspen clones.

Category	Requirements	Max. number of plants produced per clone
C3, selected clones	• the values for the selection criteria should be better than the average of the population selected from	600 000
C2, qualified clones	• the values for the selection criteria should be better than the average (20% error risk) in field trials which require: • **2 locations per utilisation area** • 4 comparison entries • 5 growing seasons	1 200 000 (incl. C3)
C1, tested clones	• the values for the selection criteria should be better than the average (5% error risk) in field trials which require: • **2 locations per utilisation area** • 4 replicates per trial • **25 trees per clone per plot** • 4 comparison entries • 12 growing seasons	2 000 000 (incl. C2)

posed a classification system for merchandised (hybrid) aspen clones, based on international schemes. This system is summarised in Table 1. In addition the Finnish Forest Research Institute has prepared guidelines for the establishment of clonal plantations with (hybrid) aspen (Table 2). In order to avoid competition between clones with different growth characteristics and in order to enable the industry to make use of specific qualities of single clones these guidelines support the establishment of single clone stands. However, in order to avoid at the same time large plantations with only one clone, with the possible risk for failure due to e.g. a pest or disease, the maximum size of a single clone plot is recommended to be about half a hectare. For larger sites it is recommended to use different clones in single clone blocks up to about half a hectare in a kind of chessboard design. The recommended spacing between trees is 3 x 3 m, which means nearly 1000 trees per ha.

Table 2. Recommendations concerning the number of clones and block sizes for the establishment of clonal plantations with (hybrid) aspen.

Area, ha	No. of trees	No. of blocks	No. of clones
0,2 – 0,4	200 – 400	1	1
0,4 – 0,5	400 – 500	1 – 2	1 – 2
0,5 – 0,8	500 – 800	2 – 3	2 – 3
0,8 – 1,0	800 – 1000	2 – 4	2 – 4
1,0 – 1,5	1000 – 1500	3 – 7	3 – 7
1,5 – 2,0	1500 – 2000	4 – 10	at least 4
2,0 – 2,5	2000 – 2500	5 – 12	at least 5
over 2,5	over 2500	at least no. of trees / 500	at least 6

Perspectives

So far nearly 1,000 trees have been selected from the old trials, and wood samples were taken. Of these 27 have already been in mass propagation and by 2001 propagation material from about 60 new clones should be available for the establishment of field experiments. The aim of Metsäliitto is to establish 1,000 ha of aspen plantations in Finland annually. For this alone 1 000 000 plants per year are needed, but the total need for aspen plantation may be expected to increase.

It is hardly to believe that the best possible clones have already been found among the 1000 trees selected so far. There is also a need to select clones with different characteristics for different uses, e.g. different grades of paper. In addition the limited size for single clone blocks and the limited number of plants (2 000 000) to be produced per clone will require continuous development of new clones. The search for super clones with faster growth, wood quality and propagation ability, and preferably also some resistance against herbivory and diseases, will continue. However, the resources of the old hybrid aspen stands will become exhausted soon, as the best performing trees have been selected already. Therefore a new breeding programme with aspen and hybrid aspen was set up and a part of it was started this year. Along with selection and testing, this programme includes the making of new crossings, both within *P. tremula* as between *P. tremula* and *P. tremuloides*. For the hybrid crossings there will be more emphasis on the selection of suitable parental clones in both species. Besides for the desired characteristics this will include concerning the *P. tremuloides* especially selection for clones with sufficient hardiness against the climate of Southern Finland. Within the programme breeding populations will be established for different utilisation areas. These will be established in close cooperation with the gene conservation programme for broad-leaved species in Finland, because both programmes have the intention to preserve a large genetic variation. There is an increasing affection against the use of exotic material in Finnish forestry. Although concerning this the situation for hybrid aspen is not fully clear, there will be more emphasis on breeding within the *P. tremula* in the programme. There will be special attention for the production of so called long distance hybrids. It has been found earlier that also when crossing origins which are separated by long distance, heterosis may occur for growth. However, when using Central European origins a lack of hardiness may

become a problem. In order to obtain clones which are better adapted also the back crossings of hybrid aspen with P. tremula will be tested. Traditional breeding with aspen is still long term work. Because of this studies have started to see how gene technology (gene transfer) can be used in aspen breeding, especially to improve fibre quality and resistance against pests and diseases.

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