Hybrid aspen (Populus tremula L. × P. tremuloides Michx.) complex study programme in hemiboreal Estonia

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Forestry in Estonia

- 52% of Estonian territory is covered by forests
- Area of forestland 2 200 000 ha
- 80 % natural stands
- 20 % semi-natural
- Annual increment 6 m³/ha
- Main tree species: Scots pine (*Pinus sylvestris*)
  - Norway spruce (*Picea abies*)
  - Birch (*Betula pendula, B. pubescens*)
- No practice in plantation forestry until 1990
- 1/3 of agricultural fields are abandoned since 1991
What is hybrid aspen?

*Populus x wettsteinii* Hämet-Ahti

- **Parental species:**
  - European aspen (*P. tremula* L.)
  - North American trembling aspen (*P. tremuloides* Michx.)

- First crosses in 1920s in Germany
- Since 1950s establishment of hybrid aspen plantations started in Sweden and Finland
- Its uniformly short fibres of a narrow diameter and thin walls are ideal for producing high-quality paper
- After clear cut a new generation arises from root suckers
- More damage and disease resistant than parental species
- More straight stemmed and better pruning than parental species
Introduction: biology of aspens

**Taxonomy (Eckenwalder 1996):**

Family *Salicaceae*, genus *Populus* (divided into 6 sections with ca 30 species), section *Populus* (aspens and white poplars, 10 species):

1) *P. adenopoda* (Chinese aspen)
2) *P. alba* (White poplar)
3) *P. gamblei* (Himalayan aspen)
4) *P. grandidentata* (Bigtooth aspen)
5) *P. guzmanantlensis* (Manantlan white poplar)
6) *P. monticola* (Baja white poplar)
7) *P. sieboldii* (Japanese aspen)
8) *P. simaroa* (Balsas white poplar)
9) *P. tremula* (European aspen)
10) *P. tremuloides* (Quaking (trembling) aspen)
Hybrid aspen in Estonia
(10-year experience with hybrid aspen plantations in Estonia)

Establishment of hybrid aspen plantations on abandoned agricultural lands started in 1999
Since then hybrid aspen has been cultivated on ca 700 ha
Micropropagated plants are used
Planting density 1000 – 1400 plants per ha
Usually site preparation (ploughing) is necessary
Biodegradable plastic tubes and net-like shelters are used to prevent damage by voles, hares and roe deer
In 2002 evaluation of environmental interactions of hybrid aspen planting was carried out
The 23rd Session of IPC
Hybrid aspen plantation after the fifth growing season in Estonia.

Mean height of the plantation 4.2 m (max height 8.0 m)
8 years old plantation
50 years old man
The 23rd Session of IPC

ROTATION

- Biomass
- 1st clear-cut
- thinning
- 2nd clear-cut
- thinning
- 3rd clear-cut

- Energy wood
- Pulpwood
- Aspen logs
Experimental areas, research, monitoring

- 58 experimental plots have been established in five-year-old hybrid aspen plantations.
- Dendrometric characteristics (height, diameter at breast height, current annual height increment and canopy dimensions) have been measured.
- Soil type according to WRB-FAO/UNESCO has been determined.
- Leaf samples have been taken for chemical analyses.
- A case study with 58 experimental plots has been established for long-term monitoring of biomass production and soil properties. On each plot a detailed soil survey has been made and the contents of main nutrients (N, P, K, Ca, Mg, B) have been determined.
Locations of 58 experimental plots established in hybrid aspen plantations in Estonia. All areas have been included to the NOLTFOX database (http://noltfox.metla.fi/)
Detailed aims

• Study of growth traits of hybrid aspen in Estonian conditions. Approximately 5000 trees within the experimental areas have been measured twice: at ages 5 and 7 years (next measurement at age 12 yrs)

• Growth-soil analysis: soil type according to WRB-FAO/UNESCO, chemical and mechanical soil properties → best former field soil conditions for hybrid aspen

• Leaf analyses (3000 leaves from 150 model trees): size, LWA, concentrations of NPK → nutrient demand on different soils, nutrient cycling

• Biomass production and wood properties (dry matter content, NPK, cellulose/lignin, calorific value) in young stands (50 model trees) → removal of DM and nutrients with harvest

• Comparison with alternative tree species on abandoned agricultural lands, e.g Silver birch, alders, triploid European aspen

• Natural biodiversity of forest plantations: vascular plants (vegetation succession), bryophytes, insects and fungi (phytopathological and entomological monitoring). → 232 long-term vegetation cover monitoring plots have been established.

• Evaluation of environmental impacts of forest plantations with half-exotic hybrid aspen towards natural aspen forests → gene flow, pests and diseases, plantations on landscape level
Growth = genotype x environment

All experimental areas were established in commercial plantations where 27 hybrid aspen clones had been randomly planted, on average 15 clones per one plantation.

We know, which clones have been used in one plantation but we do not know the clone of individual trees.

In some areas we have started backward determination of clones with DNA analysis, but it is expensive and there is a lack in experimental design for reliable clonal tests.

In the studied plantations the variation of growth traits within experimental areas was lower than that of all the studied trees. The growth speed of the trees was significantly different between the areas. Therefore we may presume that differences in the plot mean growth characteristics are influenced more strongly by the differences in site properties than by the choice of clones.
The average heights of 5-year-old hybrid aspen plantations on different field soils
Site conditions for hybrid aspen on abandoned agricultural lands

Mean height of 7-yr-old hybrid aspens growing on different soil moisture conditions
Regression between the average height of the trees and foliar content of nitrogen of 5-year-old hybrid aspens

\[ N = 1.62 + 0.18 \times \text{height} \]

\[ r = 0.74; \quad p < 0.001 \]
Diseases, biodiversity

Neofabrea populi
Floral diversity

Preliminary results and conclusions

- At the moment only general conclusions could be made on the subject
  - composition of the ground vegetation in 6- to 7-year-old hybrid aspen plantations is similar to the typical weed cover of an abandoned agricultural field
  - the influence of the shading by tree crowns is not significant, light conditions are quite similar in all horizontal layers of the stand
  - root competition does not seem to have a significant influence on the composition and cover of the field layer
  - apparently, the former land use (field vs grassland) and site preparation methods could be seen as important factors influencing the species composition of the ground vegetation
Conclusions about hybrid aspen

- On the basis of the evaluation of environmental interactions the potential risk of the influence of hybrid aspen plantations on the local environment is considered to be low.
- The dimensions of the best plantations and the best trees show the high growth potential of hybrid aspen in Estonian soil and climate conditions.
- More information is needed about interactions between soil conditions and growth rate of hybrid aspen.
- The establishment of a new pulp and paper mill in northern Estonia ensures the demand for hybrid aspen wood in the future.
Scientific output:

Three PhD students are involved in hybrid aspen studies

- ecology and management of hybrid aspen
- biodiversity of forest plantations
- comparison of alternative deciduous tree species for afforestation of abandoned agricultural land

List of papers in peer-reviewed ISI-Web journals:


- Tullus, Arvo; Soo, Tea; Tullus, Hardi; Vares, Aivo; Kanal, Arno; Roosaluste, Elle (2008). Early growth and floristic diversity of hybrid aspen (Populus x wettsteinii Hämet-Ahti) plantations on a reclaimed opencast oil shale quarry in North-East Estonia. Oil Shale, 25, 57–73.
