The future of forest biotechnology: the potential of genetically modified trees

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Vantaa (Muhos)
* Genetic fingerprinting
* DNA markers; population genetics
* Recognition of genetic basis of important tree traits

Suonenjoki
* Gene expression profiles; climatic adaptation

Punkaharju
* Tree tissue culture
* Cryopreservation
* Genetic transformation techniques
Metla’s research on genetically modified trees /1

Development of genetic transformation techniques for birch, aspen, pine and spruce

- traditional methods using tissue-cultured target tissues
- pollen transformation followed by controlled crossings

Micropropagated transgenic birches

Transformed pine pollen germinates
Metla’s research on genetically modified trees /2

Transgenic trees as research tools, e.g. for studying

- C/N metabolism in birch
  (field trial destroyed in 2004)

- lignin biosynthesis in birch

Ecological interactions of genetically modified trees
- insect herbivory
- mycorrhizal symbiosis
- decomposition in soil

PtCOMTp-GUS activity in birch stem
Is there real potential for GM trees in Nordic countries?
Legal issues

We are committed to The Convention on Biological Diversity and The Precautionary Principle

Strict legislation covering field trials and marketing of GM cultivars
- openness: public hearing at application phase, public register
- careful risk assessment of planned genetic modification including potential long-term effects

Ownership of transgenes / GM cultivars
- responsibilities of the owner in the case of transgene spread?
Public acceptance

Sensitive issue

- forests as national property
- cultural & spiritual heritage
- leisure; everyman’s rights etc

Forest industries will use only raw materials their customers accept

- forest certificates (FSC, PEFC)
don’t allow GM trees
Economics – forest owner’s point of view

Will there be market for GM wood at the time of harvest?

Costs/ benefits; will there be profit?

- higher establishment costs
- better price for GM wood?
- income sooner?
- avoidance of losses due to pests or diseases

→ need for GM cultivars?

Spruce cuttings having +39% growth and better survival were too expensive for forest owners.
Long rotation times & transgene stability

Transgenic trees should be tested for their whole rotation time prior to applications?
→ OK for eucalypts; our species ??

Do we know enough about gene regulation / expression?
→ Uncertainty of proper transgene functioning over long rotation time

Specific leaf colour in birch is affected by tree ageing and environmental conditions.
Ecological issues

Transgenes spreading into natural populations & their significance
- simulation studies / neutral markers in natural conditions
- sterile trees as solution?

Potential effects on other species
- studied in confined experiments

Lignin-modified birches: Changed lignin quality (S/G) had no effect on insect herbivory, minor effect on the rate of mycorrhiza formation in vitro, and a clear effect on decomposition rate in soil.
Non-gm forest biotechnology

There is a great potential in natural / breeding populations

.. we’ll just have to able to detect the best trees and utilise them effectively in breeding and wood production
Understanding genetic control of important traits

YES to transgenic trees as research tools!
- to study and verify gene functions and their regulation

Effect of hormonal genes on plant architecture and phenology studied in transgenic birches.

Information on key factors behind the traits and how to modify them
- genetic modification OR
- selection of individuals carrying favourable forms of genes OR
- specific hormonal / nutritional treatments etc..
DNA / gene markers

→ Marker assisted (early) selection

→ Direct information on genes affecting the trait used as selection criteria
Vegetative propagation

Mass multiplication of selected trees
- uniform material
- rapid deployment

More research needed to develop cost-efficient propagation methods:
- somatic embryogenesis (artificial seed)
- cloning of mature conifers
Future of GM trees in Nordic countries

Transgenic trees are used as research tools

Careful follow-up of experiences obtained on short-rotation GM trees elsewhere in the world

No applications in operational forestry, but reconsideration if..
  - urgent / strong need for GM trees
e     due to environmental or economic reasons
  - change in public acceptance / forest certification

Transgenic birch in field trial.