News and Views
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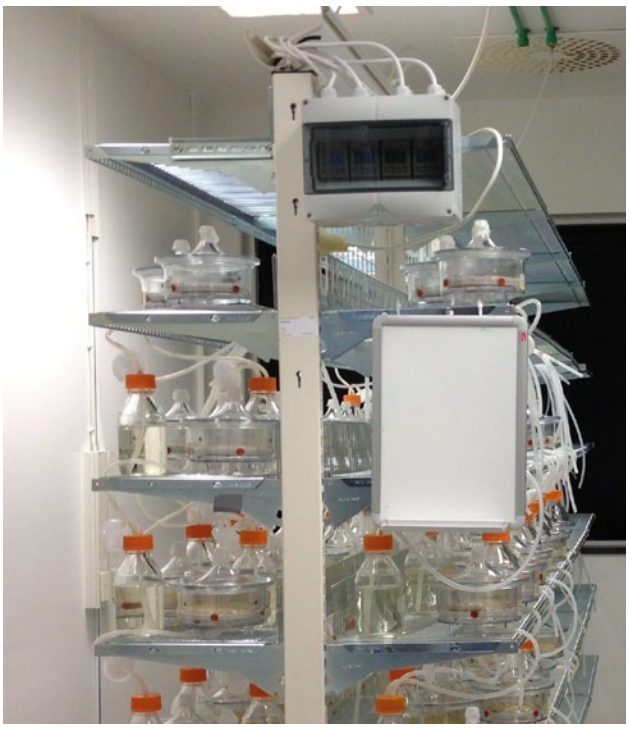

Key steps in the SE process are the multiplication and maturation of somatic embryos in bioreactors (left). The bioreactor docks directly on to the automated system for harvest of the mature embryos (right). The pilot facility at SweTree Technologies allows this process to be made without the costly manual moment of picking embryos. Photo STT.

Close to the application of somatic embryogenesis

It's been 30 years since the discovery that Norway spruce can be propagated with the aid of somatic embryogenesis. Researchers and industry believe that we are now close to scaling up the technology for commercial use. In 2015, a pilot system will be running in Sweden.

The SNS-supported network AdapCAR arranged a one-day workshop in Uppsala on the theme *Somatic embryogenesis for future forestry* in May 2014. **Tuija Aronen**, researcher at Metla, Finland, organised the workshop together with **Ulrika Egertsdotter**, SweTree Technologies (STT). Representatives from research organisations, industry and ministries in Sweden and Finland presented an overview of the state of somatic embryogenesis in the Nordic countries.

SE technology has unique potential for commercial plant production. The vision is an automated process where one seed embryo can be copied into thousands or millions more in a short time. Production can start at any time using embryos stored in liquid nitrogen (cryo preservation). During storage, the clones can be tested in the field, and the best can be selected for commercial use.

An automated process also has the potential to be economically viable, particularly when embryo duplication is made in bioreactors. Cost analysis for automated plant production using a 10 million a year production system of the same type as the current pilot system at SweTree Technologies suggests that an acceptable production cost can be reached. Even with more expensive production costs at lower production volumes, the higher cost can be justified by the higher genetic gains from selected clones.

Tuija Aronen.
Photo: Teijo Nikkanen.

Ulrika Egertsdotter.
Photo: Goizueta Business School

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Pilot equipment up and running

Sweden has got to grips with upscaling and automating the method. Four forest enterprises are supporting STT in the development.

Ulrika Egertsdotter explains that the company has now optimised and automated the steps for multiplication, maturation and harvest of the mature embryos.

– An automated method for planting of germinated embryos is also patented. The complete, integrated process for plant production will be implemented and tested at the pilot facility in Uppsala during 2015, she says.

Göran Örlander, chief forester at the company Södra, predicted that a decision on production facilities for SE plants will become a reality in 1–2 years. Södra is currently using some 1 million rooted cuttings of Norway spruce, and plans to increase it to 2 million.

– Rooted cuttings offer an opportunity to utilize genetically improved material, but the SE technique gives us access to the very best, he says.

Legal restrictions

The legislation differs between Finland and Sweden:

Sweden discusses SE-propagation of selected families (without tracking single clones). So called *family forestry*, involving planting of around 25 untested SE-clones from about six tested families, is an attractive option discussed by the forest companies.

Finland, on the other hand, demands that all clonal plants must be tested individually.

– Therefore, Finland is at a stage where lots of cell lines need to be planted in field tests. While the tests are running, we need to develop cost-effective mass propagation techniques, says Tuija Aronen.

The legislation in Sweden also puts restrictions on the use of clonal plants. A maximum of 5% and 20 hectares of a forest land unit can be used for clonal forestry. The restrictions in Finland and Sweden are due to potential risks and uncertainties.

Development continues

The technology involves many critical steps, which have presented a challenge for researchers over the years. The zygotic (somatic) embryos must be able to multiply and mature into new embryos, and the embryos have to germinate and develop into plantlets and plants. All steps need strict control of growth regulators, light, temperature, timing etc.

Several cell lines and even families are usually lost during the process. This is a problem, but it has been shown that, despite the losses, SE-trees in the field perform close to the average of the families they are derived from.

Still, there are amendments to be made by researchers and industrial developers. As **David Clapham**, researcher at SLU and STT, explains:

– We should not expect a major breakthrough of the technology. It is rather a matter of continuous small improvements and innovations over the whole range of activities. New problems arise and new solutions are needed when the procedure is scaled up. Innovations will continue even after we begin to produce a million plants or more. Suggestions for improvements will come from all levels, not least from the nursery staff.

A more comprehensive report can be found on AdapCAR website, see www.nordicforestresearch.org

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Somatic embryos. Photo Tuija Aronen.

What is somatic embyogenes?

Somatic embryogenesis (SE) is a process of non-sexual reproduction where embryos form and multiply from a single somatic cell or group of somatic cells in vitro. In conifers, the process usually starts with an embryo extracted from a seed. SE cultures develop from somatic cells of the embryos and can proliferate in the form of proembryogenic masses (PEM), with a doubling or tripling of fresh weight every two weeks. Mature somatic embryos develop from PEMs on media containing the growth regulator abscisic acid. After partial drying, the embryos will germinate on a suitable medium and develop into plantlets that can be grown on in a peat substrate. SE trees have been observed to behave normally, like trees from seeds of similar genotype, in field trials.

About AdapCAR

AdapCAR, The “Centre for Advanced Research in forest genetics, breeding and regeneration for adapting and mitigating climate change” is one of the SNS-supported CAR networks.

The overall aim of AdapCAR is to support development and implementation of good practices for use and management of forest genetic resources. The workshop on somatic embryogenesis is one example of networking activities.

Poplars will contribute to the delivery of wood energy in Iceland. The initial meeting visited one plantation trial. Photo Inga Bödeker

"WoodBio" will enhance the forests' role in the Nordic bioeconomy

Wood is so much more than pulp and timber. The 3-year Nordic project WoodBio will emphasise its role as a raw material in the developing Nordic bio-economy. The final result will include updated overviews of wood resources, options to increase supply and innovative ideas for the use of wood biomass. New research will also expand our knowledge of short rotation forestry.

Led by Iceland

The WoodBio project is led by Dr. Olafur Eggertsson, senior researcher at Iceland Forest Research.

Why is Iceland taking on this challenge?

– Iceland is a small country that has always been dependent on its natural resources – from the sea, the land and below the ground. We are also experiencing the effects of global warming, and realise how urgent it is to take actions to halt it, he says.

Forest is not the first thing a visitor thinks of when travelling to Iceland. Still, the current growing stock (trees above 10 cm diameter) amounts to 0.5 million cubic metres. The annual net increment is around 100,000 cubic metres, and will increase considerably in the coming decades, thanks to recent afforestation efforts.

Olafur Eggertsson.
Photo: Heida Vernhardsdottir

– The forests are already in use today, despite the short history of new establishment. One example is a heating plant in Hallormstadur that uses wood from thinning operations. Wood is also used in small sawmills and for the important Icelandic ferrosilicate production.

A part of Nordbio

WoodBio is one of five projects under the Nordic bioeconomy initiative, NordBio, that was initiated under the Icelandic chairmanship of the Nordic Council of Ministers in 2014. Besides WoodBio, the projects cover topics such as sustainable use of marine resources, prevention of natural disasters, education and bioeconomy innovations.

All Nordic countries

Wood is the main renewable raw material in the Nordic countries. Finland and Sweden are among the leading producers of forest products in the world. Norway also has important forest resources, and Denmark and Iceland are increasing their resources with plans for more afforestation. Thus, forests play a crucial role in the transition to a biobased economy in the Nordic countries.

The project involves researchers from all of the Nordic countries. The overall aim is to highlight the role of forestry in the Nordic bio-economy with emphasis on wood biomass as a →

Kicking off the project in Reykjavik. Photo Helga Skuladottir.

raw material. The aim fits well into the strategy of Nordic Forest Research (SNS), which also collaborates with WoodBio.

WoodBio will be running for three years, 2014–2016. It is financed by the Nordic Council of Ministers to the tune of 600,000 DKK for the first year. The Icelandic Forest Service is also contributing.

Three work packages

The activities are divided into three work areas:

- **The first** will be an analysis and mapping of the use of wood biomass in the Nordic countries. The resulting reports will give overviews of the importance of wood biomass as an energy source, ongoing research projects, future demands for wood biomass and the economic impact of wood as an energy source. A specific study of import/export of wood biomass to the Nordic countries will also be undertaken.
- **The second** work package includes research on high productivity forest management and short rotation forestry, as well as biomass supply from conventional timber harvesting.
- **The third** package looks to the future. Studies will be conducted on the advance of new biomass-based technologies such as next generation biofuel, new bio chemicals and bio materials.

– One important question for the WoodBio project relates to the competition between different end users. Should wood resources be used for energy or for more high value products? The surveys will give an overview of new products that can be based on wood. There are a number of ongoing innovation projects, e.g. on ethanol production, biodegradable plastics, textiles, nanocellulose material (CNF), and sugars from wood to produce yeast, bacteria, and algae as fodder for fish farms, says Olafur Eggertsson.

– We will, however, not study the conventional wood industry chain and forestry logistics. These issues are covered by other projects, such as ENERWOODS.

Kick off, new research and planned meetings

The core group kicked the project off at a meeting in Reykjavik in March 2014 to set priorities and make plans. An open workshop on short rotation and high productivity forestry will be arranged in 2016.

– Currently, we are giving priority to mapping ongoing research projects in the Nordic countries relating to wood biomass in general, including a list of their outcomes and recommendations, says Olafur Eggertsson.

– We will also initiate new research and support ongoing projects. Since the budget is restricted, we will concentrate on wood biomass from short rotation forestry. This is one of the best ways to increase wood biomass production in the short run.

Examples of new research projects within WoodBio are:

- Effects of harvesting season on coppice regeneration of poplar, survival in Iceland.
- Sprouting and biomass production of hybrid aspen on agricultural soil in Finland.
- Harvesting methods for poplar to reduce moisture content – how should the trees be left to dry?

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Read more about WoodBio:
www.woodbio.com

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More info about SNS:

www.nordicforestresearch.org

News & Views is a newsletter from SNS containing short, popularized articles covering Nordic forest research and forestry. Articles presenting SNS-supported activities are prioritized. The newsletter is published eight times per year, and is available for download from the SNS and Scandinavian Journal of Forest Research websites.

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