energy poplar

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Energy Poplar (Enhancing Poplar Traits for Energy Applications) is an EC Seventh Framework Programme project aimed at further improving poplar trees as an energy crop. The work is directed to understand and improve traits such as yield and wood properties coupled to Bioethanol production. The project also addresses environmental and economical sustainability questions.

The final goal of ENERGYPOPLAR is to develop poplar as a bioenergy short rotation coppice crop, suitable for large-scale deployment in Europe in areas unlikely to be used for food agricultural production. All will be placed in an environmental framework to ensure environmental sustainability with respect to land use, inputs and soil status.

Why are poplars particularly attractive 'second generation' bioethanol crops?

Many problems associated with first generation (1G) biofuels can be addressed through production of biofuels manufactured from agricultural and forest residues, and non-food crop feedstocks. Among these, poplar trees are well adapted to EU and other climates, we have several indigenous species with good biomass yields, and there is lengthy experience of their cultivation. Poplar biomass composition should be reasonable for conversion to biofuels, though this will benefit from optimisation - the major target of ENERGYPOPLAR. The poplar is also a 'model' tree, whose genome is sequenced and amenable to scientific advances and R&D: there is a strong network of European laboratories collaborating on poplar genetics.

Project Coordinator Dr. Francis Martin

What place do genetically enhanced poplars hold in biofuels, as an energy source in the longer term?

Genetically enhanced poplar trees with increased yield and cellulose accessibility are within reach. In greenhouse trials, very significant improvements have been made, but additional measurements and evaluations should be carried out. A 30 per cent increase in biomass yield or poplar wood that would require only half of the degrading enzymes currently needed to generate ethanol – both being feasible – would greatly increase economic benefit for the whole industry, from technology providers to farmers, and the liquid biofuel industry. More efficient land use could also increase acceptance of second generation (2G) biofuel crop by the public. It is a reasonable prediction that 2G and 3G biofuels, mainly from lignocellulosic feedstocks like SRC, SRF, agricultural residues and post-consumer waste, will provide between 20 and 30 per cent of world liquid transport fuel and after 2030. They will be significant for trucks, rail, sea transport and likely aviation. Light vehicles could progressively shift to plug-in technologies after 2030 based on a carbon free electricity supply.

Partner and Dissemination Workpackage Leader. Dr Magnus Hertzberg

Project progress

New Field trials

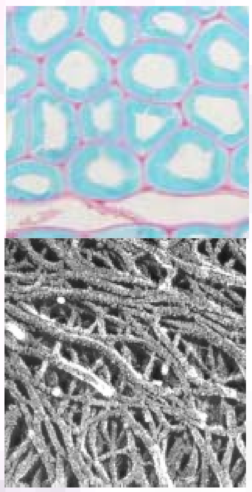
A central part of ENERGYPOPLAR is to develop SRC poplars that are capable of fast establishment, productive growth and improved lignocellulosic feedstock quality for the production of liquid biofuel through biological conversion to ethanol. In year two we have established several new field sites within Energypoplar in France, Belgium and the UK. There are also small, controlled semi outdoor trials in Germany. These include both trials of trees modified for lignin biosynthesis through single gene approaches and growth enhancing genes, and a wide natural population of black poplar, *P. nigra* that will be used to identify associations between yield and DNA polymorphisms in selected genes.

Identifying new genes for yield

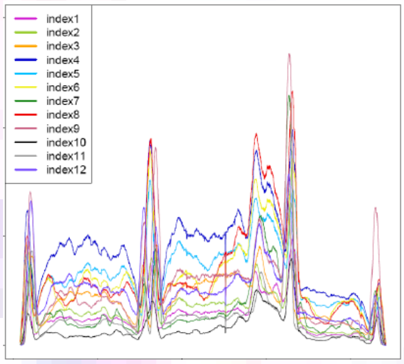
We have developed and used several approaches to unravel the complex molecular nature of optimized yield providing information that are used for the generation of novel genotypes. We have identified novel transcription factors potentially determining yield in poplar using bioinformatic approaches combining vast gene expression data series, gene specific information available within the consortium as well as information from QTL analysis. These transcription factors are now being analyzed *in planta* by genetic modification of their activity. In a third approach we investigate root & shoot architecture and function and their consequences for yield and root development. This study led to the identification of a key transcriptional factor controlling side root formation, and that rooting. Ectomycorrhizal fungi present in soil ecosystem are able to enhance tree root system through auxin signalling. Several novel poplar lines are under investigation for nitrogen acquisition, comparing the fate of nitrogen in fast- and slow-growing clones for the elucidation of useful phenotypes.

Improved saccharification

One of the major bottlenecks in the saccharification process of wood to fermentable sugars is lignin. Five new transcription factors with a putative role in lignification have been identified and their expression levels are being altered in transgenic poplar. Calibration models have been established to be able to relate FTIR (Fourier Transform Infrared Spectroscopy) spectra to lignin concentration and to saccharification potential. Thus, FTIR can now be used on biological materials produced in the project to analyse lignin and saccharification potential. A saccharification protocol to process woody stems has been established and applied to the Poplar populations. A large variation exists in saccharification potential between different genotypes in the mapping poplar populations used in the consortium. Lignin and cell wall carbohydrates in the F2 POP1 population have been measured by wet chemical analyses. In the end, this information should provide the basis for optimizing saccharification potential by altering cell wall composition.



Improvements by using state-of-the-art genome analysis



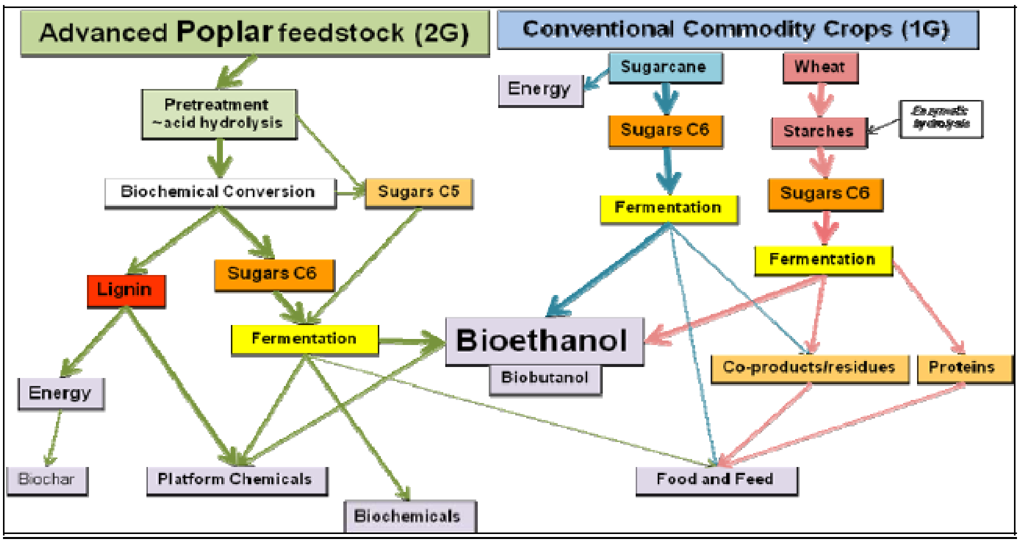
The main objective is the identification of novel genotypes and, in particular, genotypes carrying desirable characteristics for bio-ethanol production. This is pursued in two different ways. Exceptionally interesting results have been obtained by screening for natural variation in candidate genes by analysing a large number of poplar clones for the presence of naturally occurring polymorphisms in key genes involved in lignification. When mutants have been identified, experimental crosses can be performed. We have screened a large number of individuals identifying missense mutations in several genes and one mutation causing a stop codon in a gene related to lignin biosynthesis.

"A recent key achievement is the discovery of natural mutant alleles in genes related to lignin synthesis through state-of-the-art next generation sequencing. This major finding opens new possibilities of lower lignin-content plants without using genetically-modified poplars"

"This finding using the advancement of high throughput genome analysis will, coupled to advances in breeding technologies, greatly increase the possibility to use rare recessive alleles in breeding strategies"

Environment and economics

One main objective is to establish tools for environmental sustainability assessments of SRC poplar with respect to soil microbial diversity, greenhouse gas (GHG) mitigation, water and other inputs relevant to climate change. We are working with five 'base-cases' for the LCA scenario:
Poplars at **8** odt/ha/year (Business-as-Usual (BAU); **Advanced Poplars** at **12** or **16** odt/ha/yr; **Sugarcane 1G** bioethanol (imported from Brazil) and **EU Wheat 1G**.
Regional aspects of Poplar biofuel production in the EU North/South will also be accounted for in 'extension' of these base-cases using the assumption that 'Advanced Poplar feedstock is processed into and used as biofuel within 100 km of its cultivation site'.
The Life Cycle Analysis is being developed in the overall context of primary biofuel product(s) coupled to the important co-products shown below.



For further information please visit our Web site WWW.Energypoplar.eu