Tobacco plants may boost biofuel and biorefining industries

April 14 2015

Jihong Liu Clarke. Credit: Erling Fløistad

Researchers will genetically modify tobacco plants to produce enzymes that can break down biomass from forest raw materials. This may lead to a more effective, economic and sustainable production of biofuels.

Biorefining industries produce fuel, power, heat, and various chemicals. The products are made from biomass, such as food waste and forest-based materials. Today the forest-based biorefining industries face huge

challenges. The cell walls of wood biomass are very hard to break down and large quantities of enzymes are required in the industrial process. A Norwegian based research project now aims to develop low cost production of industrial enzymes using tobacco plants as a "green factory". Such enzymes may be used in the production of second generation biofuels, and to produce biochemicals that can replace various oil-based products. Second generation biofuels are made from non-food biomass.

It is cheap to produce industrial enzymes in plants

The first step to produce forest-based biofuels is to break down the biomass to sugar. To do this the industry needs a cocktail of enzymes. Currently the production cost of enzymes is high, which is a major impediment for a sustainable and cost effective biorefinery. This challenge is especially important for the Norwegian forest industry.

Usually chemical enzymes are produced in a fermenter-based system, which is a common industrial system to produce for instance food and alcohol. It is very expensive to build up a fermentation system. It has to be sterile, and it needs a lot of energy and water to control pressure and temperature. The Bioboost project will decrease the carbon footprint of biorefining by using genetically engineered tobacco, a non-food and non-feed crop, as a green enzyme factory. The goal is to replace energy demanding fermenter-based systems.

"Plants can use CO2 and energy from the sun for free. The whole production process of making the enzymes in plants is cheap, and environmentally friendly," explains Dr. Jihong Liu Clarke from Bioforsk - The Norwegian Institute for Agricultural and Environmental Research. She is the leader of the Bioboost research project.

The tobacco plant is according to Liu Clarke ideal for this purpose,

because it has a good biomass in the sense of many, and big, leaves. It also grows quickly, and can be harvested three or four times a year.

"The biotechnology used to recover enzymes is well known, and the tobacco plant is a good candidate because it has a lot of biomass that is easy to manipulate," says Liu Clarke.

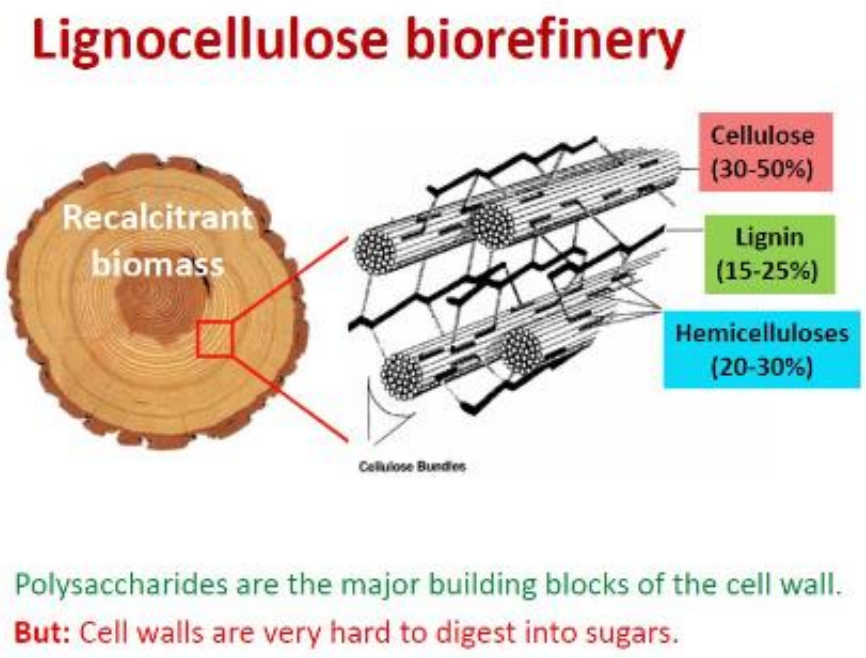
"Solutions that can contribute to lower the production costs of enzymes are urgently needed. I hope that this research project can contribute to at least one of the many solutions," says Liu Clarke. The project is financed by the Research Council of Norway, and the project period is four years.

Enzymes are the most expensive production cost

In the first phase of the project researchers from Bioforsk, NFLI (Norwegian Forest and Landscape Institute), and NMBU (Norwegian University of Life Sciences) will search for good enzyme candidates.

"Our project aims to produce key cell wall degrading enzymes in tobacco at low cost, in addition to identifying and characterizing valuable new enzymes during the project period," says Liu Clarke.

"We aim to carry out a pilot large-scale production of our selected enzymes in China, and our industrial partner Borregaard will test these enzymes once they are ready," says Liu Clarke. She emphasises that she is happy to lead a highly competent research team with both Norwegian and international partners.



Borregaard is a Norwegian company that produces advanced and environmentally friendly biochemicals, biomaterials and bioethanol that can replace oil-based products.

The company has developed its own process to convert biomass to chemicals and biofuels. A demonstration plant has been up and running for the last two and a half years.

"Enzymes are the single most expensive production cost in this process, except for the raw material itself," says Technology Director in Borregaard, Guldbrand Rødsrud.

He explains that a few producers maintain a high price level for enzymes. Today Borregaard depends on buying enzymes from these

producers.

"We intend to search for other options, and a more effective production process. If the research team fulfils its goals, it can be the beginning of a new and cheaper way to produce enzymes. It may give us the possibility to become more competitive to oil-based products," says Rødsrud.

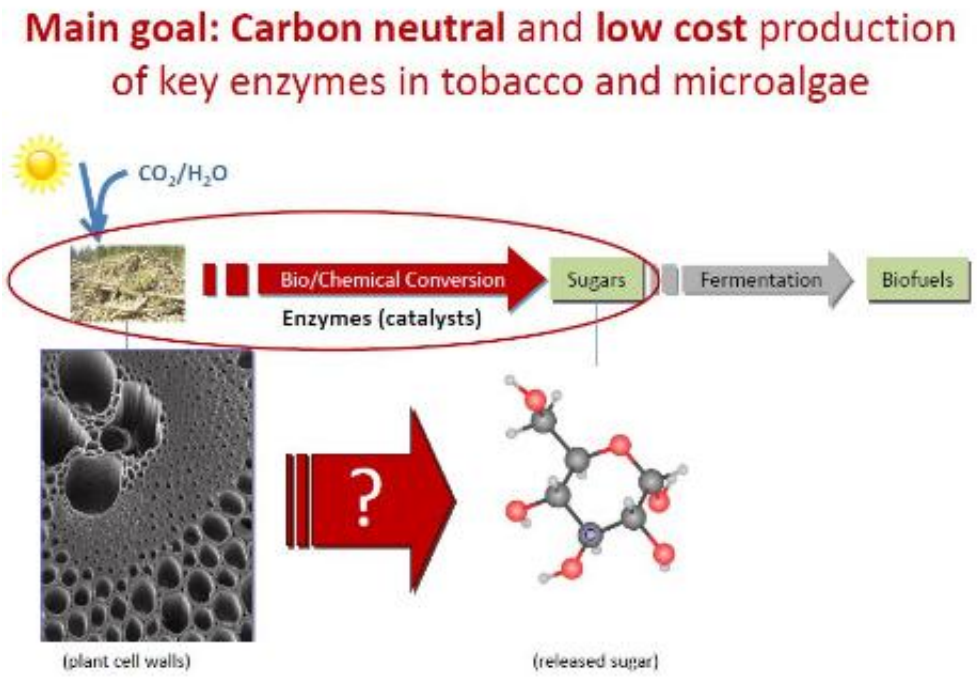
Tobacco plants and GMO is like a cell phone

The researchers will search for a gene to put into the tobacco plant that will make the plant produce many enzymes, which again will break down biomass effectively.

Liu Clarke explains that they add gene codes for proteins, and the proteins produce a change.

"The genes are only genetic information. The functions lies in the product. We add genes that manipulate the tobacco plant to create the products we want."

She compares the tobacco plant with a cell phone.



"Many years ago, my cell phone was just a phone and its weight was almost half a kilo. Today the phone has everything, like a camera, internet and a speech recorder. However, the core is still a phone. It is the same thing with the plants. The core is there, and the more we get to know the plants the better we get to know the technology."

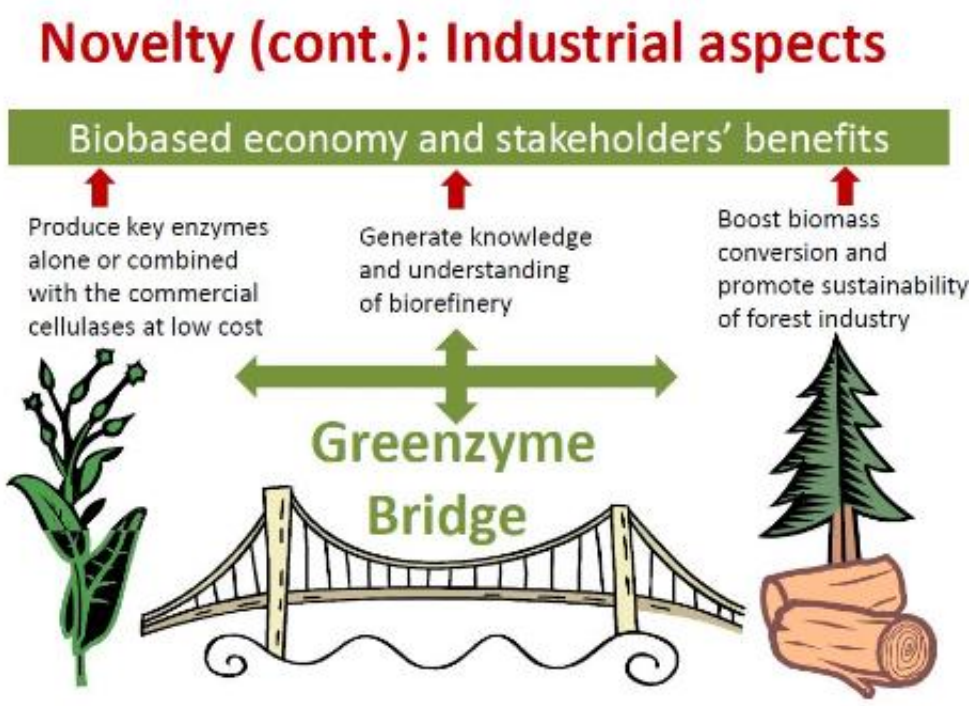
No major ethical dilemmas

Liu Clarke does not see any major ethical dilemmas regarding the application of GM (genetically modification) technology on tobacco plants.

"First of all, we do not eat the tobacco plant, and it does not grow naturally in Norway because the climate is too cold. The plants are

cultivated in a confined greenhouse, with the permission of the Norwegian Directorate of Health. "

"Many people are sceptical to GMOs, but in this case, we use tobacco plants with the help of biotechnology to produce valuable enzymes for industrial biorefinery. I believe there are mainly benefits, because we produce cheap enzymes and use the tobacco plant in a health-friendly way," says Liu Clarke.

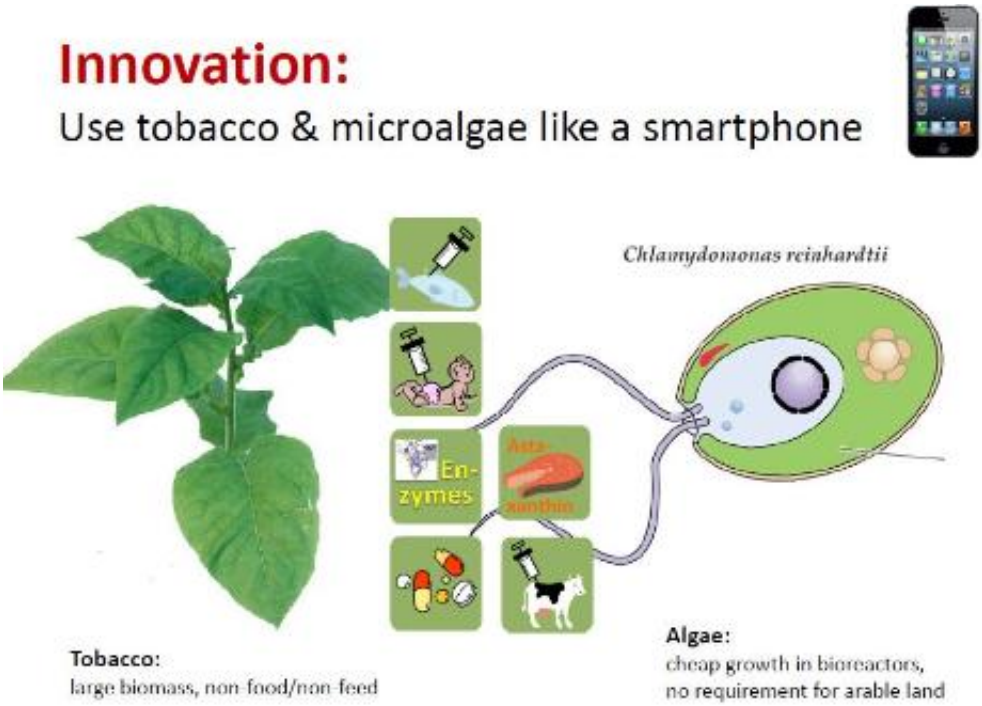


Biofuels and lack of political will

The five Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) have announced ambitious goals towards decarbonizing their

energy systems by 2050. This means biofuels are expected to account for at least 50% of total energy use in transport by 2050. In Norway, a number of national strategies and policies have been launched to promote the production and use of energy from renewable sources, while at the same time revitalizing the forest sector.

Borregaard produces twenty million litres of ethanol every year, of which about five millions are used to produce biofuels. Still, very little of Borregaard's produced biofuels are sold in Norway. Rødsrud explains that the general market for biofuels in Europe is at a standstill due to a lack of consistent and predictable policies.



"In Norway, a political decision is the only missing link to create a

market. The production of second generation biofuels is already running in Sarpsborg. There is a critical need for long-term and predictable policies," says Rødsrud.

He points out Switzerland as a successful example of a created biofuel market. The country is one of Borregaard's major customers because it has implemented a law compulsorily blending second generation biofuels into fossil fuels.

Provided by Bioforsk