From medicinal plant of the American Indians to reproducible raw material

Botanists in Düsseldorf launch research project on the cup plant

The Plains Indians of North America smoked it, took extracts from it and chewed it like chewing gum: Silphium perfoliatum L., the "cup plant", as it is known by amateur gardeners. Barely acknowledged in its native country, German researchers are now discovering this plant anew as a real all-rounder.

Illustration: Alessio Capponi from The Noun Project

BY ARNE CLAUSSEN

They not only want to use it as an energy crop for biogas production, but also as insulating material and a substitute for peat. And the cup plant is also a supplier of flavonoids, an important raw material for pharmaceuticals. Pioneering work is being performed in this area by researchers in Düsseldorf together with their colleagues in Aachen and Bonn.

"When I heard for the first time how useful the cup plant can be I was completely overwhelmed", enthuses Dr. Elena Pestsova, plant researcher in Düsseldorf. The biologist and Christian Wever, her colleague at the Chair of Developmental and Molecular Biology of Plants led by Professor Peter Westhoff, were fascinated by the cup plant, a flowering plant related to the sunflower. Together with colleagues from Aachen and Bonn, they applied to the Bioeconomy Science Center (in short BioSC; see box) for a three-year research project in the framework of which they want to examine the cup plant in depth. Topics range from characterization of ecotypes of various origins to cultivation and material use to extraction of flavonoids. SPREAD (Evaluation and development of energy plant Silphium perfoliatum L. as a source of renewable raw materials) is a cooperative project funded by BioSC to the sum of about € 660.000.

Popular with beekeepers in the GDR

"In the former GDR", recounts Christian Wever, "the cup plant was very popular with beekeepers, since it is very hardy and has a long flowering season".

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Photos: Christian Wever

1: Cup plant in full bloom. The plants can also be admired in the "Energy Crops" area of the Botanical Garden of Heinrich Heine University Düsseldorf.

2: In the course of several years, the already known ecotypes of Silphium perfoliatum produce remarkable quantities of biomass. Bushes can reach as high as three metres.

3: Silphium perfoliatum is familiarly known as the cup plant. It owes its name to the way it collects rainwater with the help of opposite leaves which grow very closely together.

4: In the first year, Silphium perfoliatum develops just one not particularly competitive leaf rosette near the ground.

Other than that, a few farms grow it as fodder and silage. The fact that bees like it and that it makes excellent fodder are, however, just two of its many positive features.

In the first year, the cup plant is rather inconspicuous: it forms just a leaf rosette near the ground and therefore competes with wild herbs which threaten to overgrow it. These have to be removed by hand, which is very costly. Nor does the cup plant deliver any yield in the first year. But from the second year onwards, it shoots up and then produces large quantities of biomass for over ten years, from which methane can be extracted by means of fermentation: First trials have already taken place in Thuringia. But in fact the biomass recovered from the cup plant is too valuable for this. The objective of the SPREAD project is to develop new varieties of cup plant and application scenarios.

Application scenarios in the planning

The square-shaped stem is interesting as a building material: If you cut it open, you find spongy, non-lignified tissue. When dried, the stem provides a very light, airy and fine-pored material, which as a result displays a high thermal insulation value and is also interesting as a fibrous additive for use in construction materials. The Plains Indians use the cup plant as a medicinal plant, amongst others to dress and heal wounds. A particular ingredient is held partly responsible for its medical effect: Flavonoids. Amongst these flavonoids are a large part of the flower pigments of plants. They are attributed, amongst others, with antioxidant characteristics. In addition, anti-allergenic, anti-inflammatory, anti-bacterial and cancer-inhibiting effects have been proven.

The cup plant is a very undemanding plant. It is at home in temperate climes,

capable of growing in poor soil too and comparatively resistant to aridity due to its long roots which reach several metres deep into the ground. It can also survive harsh winters with temperatures as low as -30 °C. As it is a perennial plant it requires – in comparison to annual plants – only small quantities of fertilizer and is better able to bind nutrients in the soil. For this reason, the cup plant can also be used to regenerate leached soil.

Despite its large range of positive characteristics, no great notice was paid by researchers to the cup plant, not even in the USA, its native country. Now the plant biologists in Düsseldorf together with their colleagues in Aachen and Bonn want to change this. Whilst the researchers in Bonn will take care above all of field trials as well as material use, the biotechnologists in Aachen will concentrate on a biorefinery in a cascade process: First of all the flavonoids will be extracted and then the remaining biomass will be fed into the biorefinery and then, for example, fermented to methane.

At Heinrich Heine University Düsseldorf, the focus lies on the plant itself and its different ecotypes. "In fact, in Europe we only know just a few cultivated sources of the cup plant", says Dr. Petsova, explaining the very limited possibilities for hybridization as a result. Christian Wever wants to increase diversity and will therefore set off in the autumn of 2016 for the prairies of North America. Following in the footsteps of the indigenous Indians, he wants to find new wild varieties of the cup plant in its native country and collect its seeds: "Back in Düsseldorf we will sow these seeds and perform microbiological trials to examine the different types with regard to their characteristics." Apart from growth behaviour and gene expression analysis, the researchers will investigate, amongst others, the distribution of the flavonoids in various parts of the plant as well as gene activity in the flavonoid metabolism. And the aim is to find ecotypes which already grow faster in the first year and thus require less care and make cultivation cheaper. This collection of various wild varieties will form the basis for new cultivation approaches on the basis of different plant characteristics.

On the trail of the Plains Indians

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BioSC – Bioeconomy Science Center

Photo: private

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In 2010, the universities of Aachen, Bonn and Düsseldorf together with Jülich Research Centre (Forschungszentrum Jülich) founded the Bioeconomy Science Center (BioSC), a centre of excellence for sustainable bioeconomy. In the framework of the BioSC research alliance, numerous interdisciplinary partnerships between scientists at the four facilities have already evolved which were devoted to bioeconomic topics. In order to implement innovative and interdisciplinary research approaches generated in the BioSC by these partnerships, project funding can be obtained from North Rhine-Westphalia's BioSC Strategy Project. Since 2013, the Ministry of Innovation, Science and Research of North Rhine-Westphalia is supporting the BioSC with € 5.8 million each year for a period of at least ten years. In addition, the aim is to attract bioeconomic research projects from other third-party sources on the basis of first results from this collaboration.

Over 30 projects at the BioSC are currently being funded. BioSC projects are conditional – apart from scientific quality and relevance – on cooperation between at least two of the facilities and a focus on at least two of the BioSC's four research priorities:

- Sustainable plant bioproduction and resource stewardship
- Microbial and molecular transformation of resources into materials
- Process engineering technologies for renewable resources
- Economy and social implications of bioeconomy

The 14 HHU chairs currently involved in the BioSC are very successful in the acquisition of projects. HHU is involved in nine of the eleven BioSC projects approved so far in 2015.

Central coordination of the BioSC is the responsibility of the BioSC Office which is located at Jülich Research Centre. Additionally, offices were installed in 2014 at the three partner universities as a contact point for researchers. The Scientific and Administrative Coordinator at the BioSC Office in Düsseldorf is Dr. Sira Groscurth.