A green heart

How can we boost the yields of wheat plants? Dr. Claus Frohberg from Bayer's Crop Science Division in Ghent, Belgium, is looking for answers to this question. The biologist is a keen gardener and plant enthusiast who applies the same passion to his research work. His goal is to direct more biomass into the wheat grains and less into other parts of the plant in order to achieve higher harvest yields.

Beads of perspiration pearl on the scientist's forehead; it's hot in the greenhouse. But Dr. Claus Frohberg hardly seems to notice the temperature as he walks along the rows of pots and inspects the wheat plants in them. The progress he sees is clearly much too exciting for him to feel the heat. Although he usually works at the computer in his office, he likes to check up on "his" plants at regular intervals. "They're growing well under the artificial light," he notes with satisfaction.

Frohberg is conducting research into how the yields of wheat plants can be increased. Wheat flour is found in bread, pasta and pizza. About 20 percent of the world's calorie requirements are met by wheat. "But the demand could soon outstrip the supply," says Frohberg. To help prevent this, scientists at Bayer's Crop Science Division are searching for ways to increase the yield of this cereal crop. Frohberg, a Scientific Expert for Crop Efficiency Trait Research in Ghent, explains the approach they are taking. "In the long term, we want to optimize the ratio between a plant's yield and its total biomass – in other words, increase the useful portion, what is known as the harvest index."

A scientist with green fingers: Dr. Claus Frohberg is a real fan of plants, and not just because it's his job. He also spends much of his free time on his hobby, bonsais. The miniature trees need a lot of care.

Frohberg's area of research is carbon partitioning, which is based on photosynthesis, or the plant's energy metabolism. Light and carbon dioxide (CO_2) from the atmosphere are converted into biomass and sugar (sucrose). This sucrose in turn forms the starch that makes up 70 percent of wheat grains. "To increase the yield, we attempt to influence the plant's systems for transporting substances in such a way that they increase their photosynthesis and send more mass to the grains," explains Frohberg. The cereal will then transport more sucrose to its flowers and grains and less to other parts of the plant. What sounds so feasible and easy to plan is actually extremely complicated to implement. In order to intervene in the central metabolic pathways, researchers

735

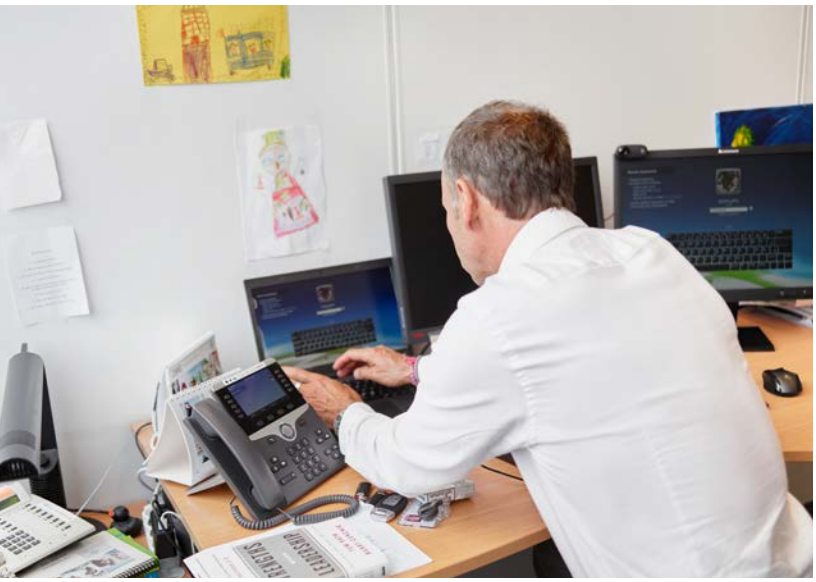
million tons

of wheat were harvested in the 2015/2016 season.

Source: U.S. Department of Agriculture

Photos: Gaby Gerster/Bayer AG (5), private (2)

A regular visitor to the greenhouse: although he works mainly in an office, Dr. Claus Frohberg takes every opportunity to monitor the growth of young wheat plants in person. His team is working to identify the best ways of boosting yields of the cereal.



25 years of research: nowadays Frohberg works mostly at a computer in the office or in the greenhouse (top photos). His career started literally in the field. He (sitting in the minibus, photo bottom left) and his colleagues at the time (Christophe D'Hulst, Volker Büttcher, Corinna von Almsick, back row, from left) worked on transgenic potatoes at the Max Planck Institute in Golm in 1996. As a doctoral candidate Frohberg (photo right) worked with Ivar Virgin (left) at the Institute for Gene Biology Research in Berlin in 1992.

need extremely precise knowledge of the conversion processes in the plants they are working with. It's immediately clear that Frohberg is intimately familiar with wheat. He talks about the plants as if they were good friends. "They're all individuals, no two plants look the same," explains the 51-year-old, surveying the long rows of plant pots in the greenhouse. "That's what I find so appealing about these plants."

Frohberg has been working in the field of carbohydrate metabolism for many years. In 1996, he co-founded PlantTec Biotechnology GmbH R&D in Potsdam, Germany. Back then, he and his colleagues were conducting research into "improving quality traits of crop plants by means of genetic modifications to starch biosynthesis." In 2002, PlantTec was acquired by Bayer, which freed Frohberg from time-consuming paperwork. "Working in such a big company helps me concentrate on what is really important in research," he says today. In addition to plant optimization, his main duties at Bayer involve patenting research findings. Some 70 patents have been filed by Frohberg, in some cases together with colleagues. They describe innovations ranging from individual, newly discovered genes to ways of establishing new metabolic pathways in plants. Frohberg is fascinated by details about the inner workings of plants. "The more you know about them, the better you can work with them."

To be able to conduct research effectively, the scientists first have to make the link between a specific gene and a plant trait, such as large grains or long heads. "Phenotyping, as this process is termed, is an important part of our work," says Frohberg. It also helps Bayer's researchers to determine what happens inside plants when they react to environmental stimuli such as drought, strong sunlight, cold or the salt content of the soil. "A plant is the result of the interplay between its genome and the environment in which it grows." This is what makes plant research so difficult. "But also so incredibly exciting," enthuses Frohberg.

His enthusiasm for bonsais is infectious

With his corduroy pants and running shoes, laughter lines on his face and typical Berlin patter, Frohberg does not conform to the standard scientist cliché. But anybody talking to him quickly picks up on his expertise and his passion for plants, which is also a major feature of his private life. He has about 40 bonsai trees at home. "I love trees," he admits. "And these miniature versions of mighty trees let me enjoy the majesty of these organisms right in my own home." He gushes with enthusiasm when he talks about his bonsais. "Plants are tied to their location, they can't run away, so they have to accommodate all the good but also all the less favorable environmental conditions. They're much better at doing that than we are."

These circumstances apply to bonsai trees just as much as they do to the object of Frohberg's research – wheat. "Nobody can exactly predict how wheat will react to external manipulation. It's too flexible for that." So anybody wanting to make targeted modifications and optimization changes to plant growth will need to be patient.

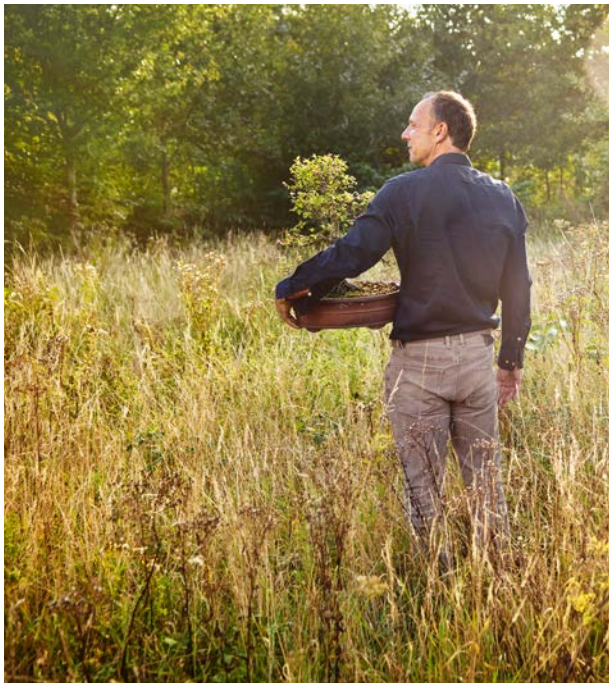
First of all, the researchers have to identify the genes that have an influence on the plant's yield and robustness. They elucidate how plants regulate the processes involved in the formation of their fruit and what factors have an impact on them. It is precisely these processes that Bayer's scientists want to optimize. "A specific section on a gene is however generally responsible for only a small part of its variance," explains Frohberg. The yield can only be enhanced by targeting the right interplay between several gene sequences. In their search for this complex recipe, researchers have one major advantage over conventional plant breeders, who can see the final result in their harvest yields but not how it came about. Researchers, by contrast, can look inside a plant – at least to a certain extent.

At present, Bayer's scientists in Ghent are using more than 70 technologies to test ways of increasing wheat yields. Some of these plants are currently growing under glass – each in its own pot, and labeled with a number and barcode. They regularly lure Frohberg away from his desk. "A good researcher has to be able to do practical work as well," he says. Lots of theories can be constructed, "but at the end of the day, we need robust results from tests into trait enhancements and yield increases conducted in the greenhouse and in field trials." One thing that researchers must never lose sight of, however, is that the location is always a determining factor in yield optimization.

International cooperation is important for Frohberg

Bayer is collaborating with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia in this area; in this country, scientists are likewise conducting field trials with particularly well-suited wheat mapping populations which they are investigating using cutting-edge phenotyping methods. The yield researchers in Ghent are also involved in publicly funded projects like the International Wheat Yield Partnership (IWYP), in which Frohberg is a member of the Scientific Advisory Board. The scientists' common goal is to discover procedures to make wheat more productive. One of Frohberg's strategies is the breeding of particularly high-yielding hybrid varieties. These crops are formed as the daughter generations of two pure-bred lines, but only if self-pollination by the parent lines is suppressed, otherwise the plants pollinate themselves.

"It would be fantastic if a product that I was actively involved in actually made it to the market," says Frohberg. But before that happens, there is a lot of work to be done by him and his colleagues. Nonetheless, it is important to him that everybody in his team understands what they are working for and what they are aiming at. It is this scientific curiosity that turns a job into a vocation. "We always have our eyes on the target," he says. He's looking forward to the research ahead of him – regardless of whether it's done at the computer, in the greenhouse or outside in the field.



Nature helps him to switch off. Dr. Claus Frohberg has around 40 bonsai trees at home. He also grows vegetables with his son and enjoys fishing.

"My heart is green," is how he describes himself. Nature helps him to switch off. Every weekend, he exchanges the nature in Ghent ("where incidentally there are too few trees") for Berlin, where his family lives. If he has the time, he likes to do some gardening. He and his son are growing bell peppers and other crop plants in a raised vegetable bed. "But not wheat," he grins. ■