Good parents are predictable -- at least when it comes to corn

January 15 2012

In order to breed new varieties of corn with a higher yield faster than ever before, researchers at the University of Hohenheim in Stuttgart, Germany, and other institutions are relying on a trick: early selection of the most promising parent plants based on their chemical and genetic makeup, as well as on new statistical analysis procedures. The work has now been published in the authoritative journal *Nature Genetics* on Sunday evening, Jan. 15.

The problem is the sheer number: In the family tree of modern-day corn, there are two main groups with 10,000 pure-breed lines each. Each of these lines could potentially be used for producing a new variety by means of cross-breeding. In mathematical terms, that equates to 100 billion possibilities. In terms of corn, however, a parent's performance is no indicator of what potential lies hidden in their offspring. Even the feeblest of parents can produce mighty offspring when cross-bred.

But time is of essence: Currently it takes approximately 10 years for breeders to develop a new variety. Issues such as climate change, food shortages and the increasing demand for more energy, however, are making it essential to find solutions even faster.

Prof. Dr. Albrecht Melchinger, PhD student Christian Riedelsheimer and their research partners are experimenting with a new technique to solve both problems. The best parent plants are selected in two steps, beginning when they are not even planted yet or when they are just small plantlets. This saves time and guarantees the highest rate of success right

from the very start.

Trick Nr. 1: Use mathematics and experience when selecting

Riedelsheimer takes a tiny sample from a kernel of corn. Not enough to harm the kernel, but enough to get a full picture of its DNA structure. This analysis is conducted jointly by the University of Hohenheim and the IPK Gatersleben.

The rest is mathematics and experience. "We know today that there is no single gene which determines whether a stalk of corn will grow up strong or produce lots of kernels on the cob. Instead there are numerous sequences in its DNA which all contribute to the plant's development. We can now examine up to 56,000 of these sequences using the latest techniques in genome analysis", Riedelsheimer explains.

The analysis does not involve modifying the DNA, but rather creating a unique profile of each parent, a so-called "genome profile" or "genetic fingerprint".

To analyse the fingerprint, scientists have spent the past three years and more planting, cross-breeding, analysing chromosomes and recording yields. The observations in the field have been used to develop a mathematical-statistical model which can be used to predict a parent's genetic potency.

Trick Nr. 2: Early selection

The composition of the leaves is a second indicator of which plants make for especially good parents. More specifically, it is about the amounts of starch, sugar, amino acids, chlorophyll and other substances.

As with the genetic information, this data allows for a statistical prognosis of a plant's breeding capabilities.

Tests can be conducted to find out the levels shortly after the seeds have been sown, when the plantlets are roughly three weeks old and 20 cm tall. Compared with analysing the plant's genetic structure, taking samples in the field is rather an athletic activity. "The plant's metabolism varies constantly throughout the course of a day and that makes it necessary to collect the leaves quickly and shock freeze the samples immediately", says Riedelsheimer. "All in all we collected 6,000 samples- in just 69 minutes!"

For the technically-challenging task of analysing the substances, plant breeders work in collaboration with experts from the Max Planck Institute for Molecular Plant Physiology in Golm. The rest involves cutting-edge statistics. "Similar to the DNA profile, it is not the individual substances which are important for making predictions, but rather how these substances stand in relation to one another", Riedelsheimer explains.

New technology saves time, money and expensive acreage

"This new technique allows us to select the most promising parents with high accuracy and to focus all of our resources on these", says Prof. Dr. Melchinger.

This method also saves cultivatable land, which, in turn, saves money. "In order to test all possible crosses, we would have to plant corn on half of the earth's surface", a utopian, if not an expensive undertaking. "A single field plot costs us 50 euros. We test on two plots per genotype at ten different locations, making a total of 1,000 euros", Prof. Dr.

Melchinger explains. An analysis of the genome using a chip and a robot costs approximately 150 euros.

Impressive as well is the amount of time saved. DNA analysis of the kernels can be conducted during the winter months. Meanwhile, the plantlets to be analysed for their substance composition grow in the greenhouse. As a result, the best parent plants can be chosen and cultivated that same year.

Paradigm shift opens door to new research approaches

Nonetheless, it will take another few years until the new breed is ready. Breeders worldwide also know another trick, especially when it comes to corn. One that has been around for decades.

Prof. Dr. Melchinger describes a paradoxical phenomenon: "With corn, the offspring tend to be especially large when the parents stem from generations of in-breeding." Experts speak of "heterosis", hobby gardeners of "hybrids".

The most promising parent plants are sorted out and self-pollinated over many generations. Only then does cross-pollination take place in preparation for the sowing of the new hybrid variety.

Heterosis as a biological phenomenon has yet to be fully researched in detail, according to Prof. Dr. Melchinger. "We were able to determine in earlier research projects that the reasons for the phenomenon lie in the extremely complex interaction of many different genes."

For researchers, this has led to a paradigm shift. "We've moved away from the search for individual super genes." Instead we focus on the

interplay among the diverse elements in the genetic code. "This new perspective on plants will help the hybrid breeding programme immensely", Prof. Dr. Melchinger believes. "There is so much genetic diversity in corn. One must simply know how to combine it in the right way."

More information: *Nature Genetics*, Advance Online Publication doi: 10.1038/ng.1033

Provided by University of Hohenheim