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'Superdominant' mutant tomato gene could spark revolution

By JUDY SIEGEL
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Discovery by HU, New York researchers produces much higher yields and improved taste.

A single gene discovered by Hebrew University and US researchers promises to produce tomatoes – one of Israelis' favorite vegetables – in dramatically higher yields and with better taste.

The research, which was published this week in the online version of *Nature Genetics*, was carried out by researchers at the university's Robert H. Smith Faculty of Agriculture, Food and Environment and the Cold Spring Harbor Laboratory (CSHL) in New York.

The newly discovered gene controls when plants make flowers and works in different varieties of tomato. In addition, it can boost yield and taste when the plants are grown in a variety of environmental conditions.

The discovery was patented by Yissum, HU's technology transfer arm, which is seeking partners for further development and commercialization.

"This discovery has tremendous potential to transform both the billion-dollar tomato industry, as well as agricultural practices designed to get the [highest] yield from other flowering crops," says CSHL's Dr. Zach Lippman, one of the three authors of the study.

The study was co-authored by HU's Dr. Uri Krieger, who conducted his doctoral work on the gene, and Prof. Dani Zamir.

The team made the discovery while hunting for genes that boost hybrid vigor, a breeding principle that spurred the production of outstanding hybrid crops like corn and rice in the early 20th century. Hybrid vigor, also known as heterosis, is the phenomenon by which crossing two varieties of plants produces strong hybrid offspring with higher yields.

First observed by Charles Darwin in 1876, heterosis was rediscovered by CSHL corn geneticist George Shull three decades later, but how heterosis works has remained a mystery.

Plants carry two copies of each gene, and Shull's studies suggested that harmful, vigor-killing mutations that accumulate naturally in every generation are exposed by inbreeding but are hidden by crossbreeding.

Nonetheless, there is still no consensus on what causes heterosis.

A theory for heterosis, supported by this new Israeli-American discovery, postulates that improved vigor stems from a single gene – an effect called "superdominance" or "overdominance."

To find such overdominant genes, the team developed an innovative approach, turning to a vast tomato "mutant library" – a collection of 5,000 different plants, each of which has a single mutation in a single gene that causes defects in various aspects of tomato growth, such as fruit size and leaf shape.

Selecting 33 mutant plants, most of which produced a low yield, the team crossed each mutant with its normal counterpart and searched for hybrids with improved yield. Among several cases, the most dramatic example increased yield by a whopping 60 percent.

This hybrid was found to produce greater yields because there was one normal copy and one mutated copy of a single gene that produces a protein called florigen. This protein, described by *Science* magazine in 2004 as the year's "breakthrough discovery," instructs plants when to stop making leaves and start making flowers, which then become fruit.

In plants such as tomatoes, flowering (and therefore yield) is controlled by a delicate balance between the florigen protein, which promotes flowering, and a related protein that delays flowering. A mutation in only one copy of the florigen gene causes the hybrid to produce more flowers in less time – the key to improved yield.

What the researchers found was that to maximize yield, there couldn't be too much or too little florigen. A mutation in one copy of the gene results in the exact dose of florigen required to cause heterosis.

The scientists have observed the gene's heterosis effect in different varieties of tomatoes and in plants grown in different climate and soil conditions, both in Israel and New York (at CSHL and the Cornell Horticultural Experiment Station at Riverhead).

In addition to superior yield, the hybrids display another important quality: improved taste.

Tomato plants produce only a limited amount of sugar, which they distribute equally among their fruits. As such, higher yields usually result in each fruit having a lower sugar content. But remarkably, the florigen gene also boosted sugar content and sweetness of the individual fruits.

This study marks the first example of a single gene that consistently causes heterosis. The scientists are now looking to team up with agricultural companies to develop the hybrids for commercial use.

The concept that mutations in one copy of a single gene can improve yield has major implications for breeders. Mutant plants are usually thrown away, because mutations have been thought to stunt growth, but this study suggests that hybrid mutations might lead the next revolution of improved crops.

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