Lettuce and Gene Editing:

Increasing Heat Resistance to Combat Changing Climate

As the climate changes and temperatures rise, growing lettuce gets harder. American lettuce farmers are having to grapple with, and farm through, challenging conditions.

A team of plant scientists at the University of California, Davis are employing CRISPR and other gene editing technologies to develop new heat-tolerant lettuce varieties.

Soaring Temperatures and Their Effect on Salad

Lettuce is grown during all four seasons and is harvested 364 days a year. It is then immediately shipped across North America and the rest of the world. Any threat to that supply chain — be it disease, weather or logistics — is taken quite seriously, not only by farmers, but also by plant breeders and scientists working to ensure the sustainability of the crop.

Rising temperatures due to climate change are one of the biggest threats to the supply chain and any unexpected heat makes it harder for farmers to grow quality lettuce. The crop's ideal growing conditions are between 60 to 65°F, and at 70 to 80°F, the plants flower and produce seed. Lettuce can tolerate a few days of temperatures from 80 to 85°F, provided that nights are cool. In 2019, the summer growing season was exceptionally hot, with daily average high temperatures at more than 90°F for the entire month of August.

Dr. Kent Bradford is a long-time California resident and Director of the Seed Biotechnology Center at the Plant Science Department at the University of California, Davis (UC Davis). He has a unique appreciation for the mission of maintaining both the viability and availability of this beloved vegetable.

"Most people think of lettuce as that consistently fresh, consistently delicious, consistently beautiful product in the produce section of every grocery store in America," Bradford explains. "But the reality is that we grow lettuce every day in all four seasons, in a variety of locations and in different soil conditions."

Delivering a consistent product to the consumer, day in and day out, requires between 30 and 60 different seed varieties for just one kind of lettuce. Multiply that by all the different lettuce products in the store and the magnitude of the important role of plant breeders becomes evident.

Advancing Gene Editing Technology

A collective of plant scientists at UC Davis embarked on a mission to improve the ability of multiple lettuce varieties to withstand rising temperatures. Their success suggests a promising future for the global lettuce industry; more profoundly, it showcases the enormous potential gene editing innovations represent as we work toward a more sustainable food supply.

At the UC Davis Genome Center, Director Dr. Richard Michelmore heads a group of scientists working in California's agricultural epicenter to advance the science of plant breeding via rapidly evolving analytic and computational technologies — specifically, the ability to sequence the genome faster and more affordably than ever imagined. Assisting Michelmore is Dr. Lien Bertier, a post-doctoral researcher who came to the United States from Belgium four years ago to focus on the development of gene editing tools for plant breeding applications—specifically CRISPR.

"Essentially CRISPR is a tool for scientists to modify or edit the DNA in living organisms with a high degree of precision," Dr. Bertier says. "It allows us to view DNA as an instruction manual, if you will, that codes for all the things that a living organism is. Sometimes that instruction manual can have mistakes. CRISPR allows us to go in and correct those mistakes and

giving us the ability to edit genes in any way we'd like."

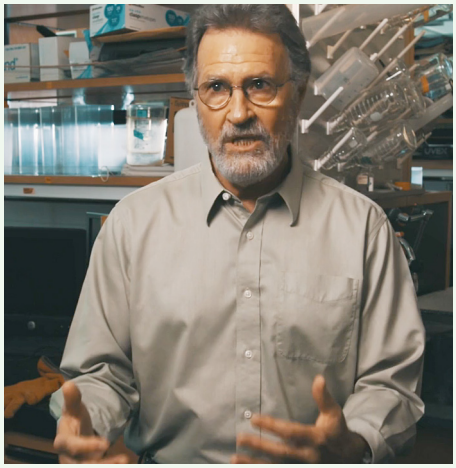
Building on Dr. Bradford's research identifying the gene responsible for heat sensitivity in lettuce, Drs. Michelmore and Bertier employed CRISPR/Cas 9 to go into the DNA, knock out the reactive gene and create a genetic mutation that produced lettuce plants that were almost 20°F degrees more heat resistant. Other than an improved ability to germinate at higher temperatures, the plants have identical characteristics of current lettuce varieties.

Since first being introduced to the public only a few years ago, CRISPR/Cas 9 has quickly proven itself to be a potent ally in the fight to protect crops from threats posed by disease, deteriorating soil conditions and climate change. In the span of just a few short years CRISPR/Cas 9 has risen from a theoretical area of biological research to a game-changing laboratory tool. Many believe that CRISPR/Cas 9 and other gene editing tools have the potential to provide new solutions to some of our greatest challenges around sustainable food production.

Gene Editing for Potential Economic Benefit

The lettuce market in California is worth almost US$3 billion and is the state's fifth-largest commodity. On average, Americans consume roughly 25 pounds of lettuce each year and the crop is also popular around the globe, with different varieties preferred by different regions. While China produces the most lettuce, more than 13.5 million tons per year, they retain the majority of it for consumption. The US and Spain are the two top lettuce exporters whose production totals 3.6 million and 900,000 tons per year, respectively.

While the new plant varieties developed with CRISPR/Cas9 are still in the experimental stage, the potential to soon provide lettuce farmers with heat-tolerant varieties is significant. Dr. Bradford points out that because



“To deliver a consistent product to the consumer, day in and day out, requires between 30 and 60 different seed varieties. And that’s just for one kind of lettuce.”

KENT BRADFORD
DIRECTOR OF THE SEED BIOTECHNOLOGY CENTER
PLANT SCIENCE DEPARTMENT
UNIVERSITY OF CALIFORNIA DAVIS

the edit works across a spectrum of lettuce varieties, like the specialty endive grown in Spain, plant breeders can eliminate the trait in hundreds of lettuce varieties in one stroke.

This gives farmers more tools to grow the hardiest, healthiest, and most nutritious crops they can in the conditions they are given.

As the world’s population projection expands to over nine billion people, the challenge to plant scientists, farmers and the agriculture industry is not only how to meet that demand, but how to do it in an increasingly sustainable manner under changing climatic conditions.

The development of crops with increased yield potential, better nutritional value, greater drought tolerance and an increased ability to withstand the dynamics of climate change, will need to utilize all plant breeding tools, including gene editing technology and other plant breeding innovations.

Key references:

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