the gravitationally stable L1 point, about 1.5 million kilometres from Earth in the direction of the Sun. The spacecraft's instruments measure the speed, magnetic field and other properties of the charged particles streaming off the Sun. Those data translate into better forecasts of what could happen when a solar storm hits Earth, such as disruptions to satellite electronics or fluctuations in electrical power grids.

DSCOVR is NOAA's main tool for forecasting space weather, but it began life as Triana, a NASA Earth-observing spacecraft built in the late 1990s to gaze constantly at the planet. A pet project of Al Gore, then the US vice-president, Triana was shelved in 2001, then repurposed in 2008 for space-weather needs. "It was never designed from the beginning to be a space-weather satellite," says Steven Clarke, head of NASA's heliophysics division in Washington DC.

The satellite launched on 11 February 2015 and experienced its first outage four months later, when its onboard computer spontaneously rebooted. On average, the safe holds happen every 74 days, but two came just 8 days apart. They are not correlated with solar storms.

A NASA internal review board convened to study the problem could not definitively pinpoint the cause, but concluded that it was most likely to be Galactic cosmic rays randomly striking the spacecraft, causing high-energy ionization that reboots the computer. The computer, which was built by NASA in 2000, contains a processor card that is similar to those flying aboard many other missions and is meant to withstand the radiation hazards of deep space.

NOAA does have a back-up data stream, from the Advanced Composition Explorer (ACE) spacecraft that is also orbiting the L1 point. That was the primary source of solar-wind data until NOAA forecasters switched to DSCOVR in July. But ACE is 19 years old, and intense solar storms can swamp its forecasting instruments.

NOAA has requested an extra US$1.5 million from Congress to improve how it handles DSCOVR data, including its responses to the outages. The satellite is supposed to last until 2022, when a follow-up mission is slated for launch. Historically, NOAA has cobbled together its space-weather observations where and when it could, but the US government is starting to demand a more coherent approach. On 13 October, President Barack Obama signed an executive order that, among other things, requires NOAA to "ensure the continuous improvement of operational space weather services". ■

Crop yields and water efficiency could be improved with the use of better gene-editing techniques.

AFP/GETTY

BOTANY

A better way to hack plant DNA

As gene editing opens doors, crop researchers are hamstrung by the need for more-modern tools.

BY HEIDI LEDFORD

When crop engineers from around the world gathered in London in late October, their research goals were ambitious: to make rice that uses water more efficiently, cereals that need less fertilizer and uberproductive cassava powered by turbocharged photosynthesis.

The 150 attendees of the Crop Engineering Consortium Workshop were awash with ideas and brimming with molecular gadgets. Thanks to advances in synthetic biology and automation, several projects boasted more than 1,000 engineered genes and other molecular tools, ready to test in a researcher's crop of choice. But that is where they often hit a wall. Outdated methods for generating plants with customized genomes — a process called transformation — are cumbersome, unreliable and time-consuming.

Asked what hurdles remain for the field, plant developmental biologist Giles Oldroyd of the John Innes Centre in Norwich, UK, had a ready answer: "The big thing would be to improve plant transformation," he said.

"What we're all facing is this delivery problem," says Dan Voytas, a plant biologist at the University of Minnesota in Saint Paul. "We have powerful reagents, but how do you get them into the cells?"

At issue is the decades-old problem that it is difficult to modify plant genomes and then regenerate a whole plant from a few transformed cells. Genome-editing techniques such as CRISPR–Cas9 hold out the promise of sophisticated crop engineering that would once have been unthinkable — making it all the more frustrating when researchers run up against an old roadblock.

On 28 September, the US National Science Foundation (NSF) recognized this frustration by announcing that it would fund research into better transformation methods. That focus is one of four in a new plant-genome research programme that will receive a total of US$15 million.

"Everybody agrees that it really is the bottleneck for genome engineering," says Neal Stewart, a plant biologist at the University of

Tennessee, Knoxville, who co-organized an NSF workshop about plant transformation last November. “And I think there’s enough interest now in trying to come up with ways to fix the problem for major crops.”

OBSTINATE CROPS

Some plants, such as the diminutive thale cress (*Arabidopsis thaliana*), the ‘lab rat’ of plants, are easily transformed using a bacterium that can add genes to plant genomes. Researchers insert the genes they want to test into the bacterium (*Agrobacterium tumefaciens*), and then coax the microbe to infect the reproductive cells of the plant. When the plant then produces offspring, some of them express the new genes.

But this does not work for many crops, and use of *Agrobacterium* triggers extra scrutiny from government agencies such as the US Department of Agriculture because it is considered a plant pest. As an alternative, researchers can use ‘gene guns’ that fire DNA-coated gold beads into plant cells. Those cells are then bathed in growth hormones and coaxed to regenerate a full plant. Some plants, such as maize (corn), readily bend to this treatment. Others, such as wheat and sorghum, do not.

For recalcitrant crops, it can take months of painstaking cell-culture work — optimizing growth conditions and hormone concentrations — to regenerate the full plant. The conditions needed for success vary not only from crop to crop, but also between plants of the same species.

Plant-transformation experts are a rare breed, says Joyce van Eck, one such specialist at Cornell University in Ithaca, New York. “There’s a lot of art in what we do,” she said at the London workshop. “It’s difficult to find people with that training.”

Add to that a dearth of funding for new methods, and researchers are left having to rely on decades-old techniques.

A BETTER WAY

But that could change as the hunt for alternatives heats up. Stewart and his collaborators have developed a robot that performs an established technique called protoplast transformation faster and more accurately than is possible by hand. The method uses enzymes to digest the cell wall, making it easier for researchers to introduce new genes. The problem of regenerating the whole plant, however, remains. Researchers used a similar approach, without robots, to perform CRISPR–Cas9 gene editing in a variety of plants, including lettuce and rice.

The cell-culture steps are still difficult. Stewart says that one person in his lab laboured unsuccessfully for two years to transform a tall grass that he uses for biofuel research. But the declining cost of enzymes allows researchers to perform more experiments, and the robotics improve throughput. Stewart is so enamoured with his creation that he has composed a song for it. “It’s our baby right now,” he says.

Others, such as Fredy Altpeter of the University of Florida in Gainesville, are hunting for a suite of genes that, when switched on or off, would make plant cells more amenable to transformation and regeneration from culture. “I think it will lead to much broader application of this technology, and will enable people who are not experts in cell culture to make those improvements,” he says.

But researchers can’t afford to wait for those developments, says Oldroyd. His project, which aims to develop cereals that use nitrogen from the soil more efficiently, will plough through tests of hundreds of transgenes using the old, cumbersome methods. “We just have to be patient,” he says. ■

INFECTIOUS DISEASE

Infected mosquitoes fight Zika

South America hosts largest trials yet of Wolbachia*-infected insects to combat viruses.*

BY EWEN CALLAWAY

Two South American metropolises are enlisting bacterium-infected mosquitoes to fight Zika. The effort is the world’s biggest test yet of an unconventional but promising approach to quell mosquito-borne diseases.

Mosquitoes that carry *Wolbachia* bacteria — which hinder the insects’ ability to transmit Zika, dengue and other viruses — will be widely released in Rio de Janeiro, Brazil, and Medellín, Colombia, over the next two years, scientists announced on 26 October. The deployments will reach around 2.5 million people in each city. “This really has the potential to be a game changer in terms of vector control — the biggest thing since DDT,” says Philip McCall, a medical entomologist who studies mosquito control at the Liverpool School of Tropical Medicine, UK.

Small numbers of *Wolbachia*-infected mosquitoes have already been released in both Rio de Janeiro and Medellín. But large biomedical funders have now announced US$18 million to scale up the efforts. “We really want to deploy quite quickly in large sections of these cities,” says Scott O’Neill, a microbiologist at Monash University in Melbourne, Australia, and head of the Eliminate Dengue Program, which is leading the mosquito releases. Footing the bill are the Bill & Melinda Gates Foundation in Seattle, Washington, the London-based Wellcome Trust and the US and UK governments. Brazil’s government is chipping in with an extra $3.7 million, O’Neill says.

VIRUS BLOCKERS

Wolbachia pipientis plagues some 60% of insect species worldwide — but doesn’t naturally infect *Aedes aegypti* mosquitoes, the species that transmits Zika, dengue and numerous other viruses. The bacteria can hinder their hosts’ fertility and influence the sex of offspring. They can also block viruses from reproducing in infected fruit flies and mosquitoes, as O’Neill and his colleagues discovered in the late 1990s. The team later developed laboratory populations of infected *A. aegypti*.

ISTOCK/GETTY

***Aedes aegypti* mosquitoes spread Zika, dengue and other viruses.**

When tens of thousands of these mosquitoes were released near the small city of Cairns in northern Australia in 2011, the bacteria spread rapidly among local *A. aegypti* mosquitoes; 90% of mosquitoes in a targeted area were infected within weeks. Tests in Indonesia and Vietnam found similar success. It’s not yet clear whether the strategy also reduces rates of dengue infections in humans, but O’Neill’s team has begun a trial in Yogyakarta, Indonesia, to find out.

The Eliminate Dengue team started releasing *Wolbachia*-infected mosquitoes in two Rio de Janeiro neighbourhoods in 2014, and in a suburb of Medellín in 2015. The bacteria block the replication of Zika and chikungunya virus (which caused widespread outbreaks in Latin America and the Caribbean in 2013–14). O’Neill’s team hopes that the scaled-up deployments can combat those diseases, as well as dengue, which infected ▶