Natural tech for 'dimming' genes brings transformative potential to agriculture

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Keerti Rathore stands in his lab with ultra-low gossypol cotton plants that were created using RNA interference, a gene-silencing technique. Credit: Texas A&M AgriLife photo by Beth Luedeker

Until the 1992 advent of a tomato that could delay softening, the fruit was picked green to withstand shipping. The delayed-softening trait was an example of the gene-silencing technique RNA interference, RNAi, before the underlying mechanism was understood and the term was created.

Through the years, scientists across the globe have developed a greater understanding of RNAi. One team has published a thought piece on RNAi's transformative potential in modern agriculture. Its title is "RNA Interference in Agriculture: Methods, Applications and Governance," and it is published by the Council for Agricultural Science and Technology.

Keerti Rathore, Ph.D., Texas A&M AgriLife Research plant biotechnologist in the Texas A&M Department of Soil and Crop Sciences, was one of six scientists who joined lead authors Ana María Vélez Arango, assistant professor, University of Nebraska-Lincoln, and Kenneth Narva, head of entomology, GreenLight Biosciences Inc. on the paper.

RNAi is a gene-silencing mechanism commonly found in plants, animals and fungi. It's believed to serve as a natural defense against viruses and other cellular invaders. However, researchers have discovered many applications of RNAi for health and agriculture.

The authors of the paper say RNAi has become a powerful crop protection and enhancement tool. The technique targets specific messenger RNA, or mRNA, in organisms and offers an environmentally friendly alternative to traditional pesticides. Its high specificity minimizes unintended effects on nontarget organisms, improving safety and efficacy.

RNAi technology explained

Rathore said RNAi technology has been used to benefit agricultural products for years. But the mechanisms underlying desirable traits produced by the previously unnamed technology needed to be better understood.

Papaya was the first crop showing virus resistance due to RNAi technology. As the papaya ringspot virus ravaged Hawaii's papaya production in the late 90s, researchers at Cornell University sought to develop a resistant variety. Rathore said these researchers might not have known how it worked at the time, but they used RNAi to save Hawaii's papaya industry. Additional RNAi research has been conducted using some commercially available virus-resistant squashes.

"People didn't know about the underlying mechanism (RNAi), but they were already using it," he said.

Rathore explained that RNAi silences a targeted gene in a plant or animal in a unique way. It differs from the better-known CRISPR, which completely targets and knocks out genes.

"CRISPR is like the on/off switch," Rathore said. "The entire function of the gene is gone upon its knockout. In contrast, RNAi is like a dimmer switch used to adjust the lighting in the room, but, in this case, it dims the level of gene expression."

Genes and their products have useful roles in the life of the plant or animal, he said. If that gene is totally knocked out, there might be unexpected or unwanted effects. "If you use RNAi to reduce gene expression level by 50%–90%, you can avoid the detrimental effects of a total knockout. Also, you can target a gene for silencing with RNAi in a highly tissue-specific manner."

RNAi use at Texas A&M AgriLife Research

Texas A&M and researchers like Rathore are among those doing research to improve the quality of food products. Rathore's gossypol work is a prime example. Ultra-low gossypol cottonseed is the first product using RNAi that has come out of a university and gone through deregulation—approved by the U.S. Department of Agriculture, USDA, and the U.S. Food and Drug Administration.

Gossypol, which is a toxic compound, is present throughout the cotton plant and is valued for the protection it provides the plant from insects and some diseases, Rathore said. But because gossypol is also present in the seeds, they can't be used as food or feed for nonruminant animals despite their high protein and oil content. Rathore said this is especially important because many cotton-producing countries, particularly in Asia and Africa, suffer from hunger and malnutrition.

But, in 2019, the U.S. Food and Drug Administration gave the green light for ultra-low gossypol cottonseed to be used as human food and in animal feed based on Rathore's work to remove the toxicity in the seed, something he had been working on for nearly 25 years.

"RNAi allows us to silence that gossypol gene in the seed, but when the seed grows into a plant, everything goes back to normal in the plant except for the next generation of seeds," he said. "With CRISPR, you cannot achieve tissue specificity like you can with RNAi. The tissue-specific gene silencing allowed us to create this ultra-low gossypol cottonseed. If we totally eliminated it, insects would target that plant much more."

Tissue-specific targeting of another gene using the RNAi has also allowed Australian scientists to increase the oleic level in cottonseed oil, making it almost as good as olive oil, Rathore said.

RNAi acceptance worldwide

The authors of the paper, supported by the U.S. Department of Agriculture's Agricultural Research Service, the Animal and Plant Health Inspection Service, and the National Institute of Food and Agriculture, believe it can serve as a vital resource for regulatory agencies, policymakers and the public.

Rathore said interest continues to grow in RNAi technology to control pests and diseases. The paper outlines the current applications of RNAi in agriculture, provides regulatory perspectives on RNAi-based pesticides, and discusses the challenges and prospects of the technology in commercial agriculture.

"As people become more familiar with the technology, I'm optimistic that it will become more widely accepted," he said. "There are more products already coming through. RNAi silencing has been used to reduce the level of caffeine in the coffee plant, where it is possible now to have coffee with a low level of caffeine without the need for chemical extraction. We want to educate people about this technology and the benefits it can deliver."

Another area where RNAi technology is taking off and has hit markets is in the control of corn rootworms. Instead of creating the trait within the plant, researchers are testing a spray to control specific insect pests by inhibiting their growth and development.

"This technology is one tool that can help us maintain our productivity by lowering the cost of growing a crop and providing safety for humans and the environment by reducing the need for toxic chemicals," Rathore said.

More information: Ana María Vélez Arango et al, RNA Interference in Agriculture: Methods, Applications, and Governance (2024). DOI: 10.62300/IRNE9191

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