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In focus
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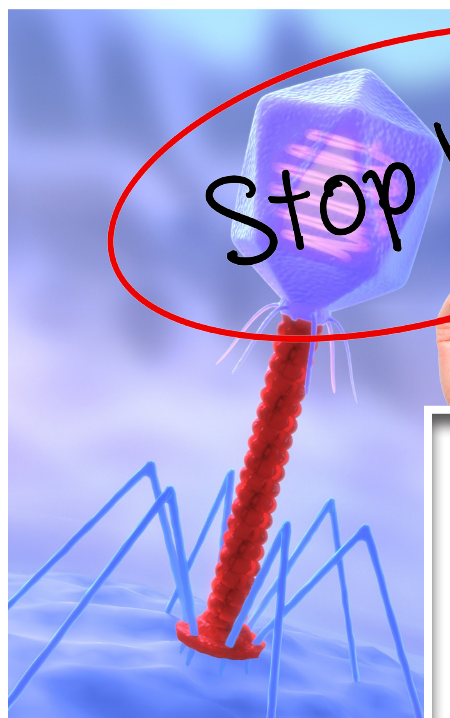
RNAi and Crop Plants: A New Twist on Agricultural Biotechnology

Last month, we introduced RNA interference, or RNAi, a molecular mechanism that defends plants, fungi, and animals against viruses made of RNA, a chemical relative of DNA. When a RNA virus takes over a host cell it needs to copy itself and the copying process creates double strands of RNA. The RNAi defense mechanism recognizes these as foreign and degrades these double-stranded RNAs plus any single-stranded RNAs that it "recognizes".

Proteins are made on single-stranded RNA templates, so a gene targeted by RNAi can't produce the protein that it usually makes. The gene has not been changed, but it no longer can be used to make proteins or duplicate the viral RNAs. We speak of a RNAi-targeted gene as being "knocked down" or "silenced." This natural gene silencing mechanism is why genetically modified (GM) papaya that contains a coat protein gene from Papaya Ringspot Virus is able to resist the virus.



It's been almost two decades since farmers began growing the virus-resistant papaya; today, the GM 'Rainbow' papaya makes up roughly 75% of Hawaii's papaya crop. Virus-resistant GM squash, another RNAi crop, represents a small fraction of the U.S. zucchini and yellow squash markets. But GM papaya and GM squash were developed before crop breeders knew how RNAi works. Now that the RNAi mechanism is better understood, how has it been used in agriculture?

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Two recent RNAi products, Innate potatoes and Arctic apples, have been deregulated by the U.S. Department of Agriculture (USDA) and found safe and nutritious by the Food and Drug Administration (FDA). The subject of a previous bulletin, Simplot's Innate potato contains engineered genes from wild and cultivated potatoes. Innate potatoes are less prone to bruising and, when cooked at high temperatures, produce less acrylamide, a very toxic and proven animal carcinogen which is produced by potatoes.

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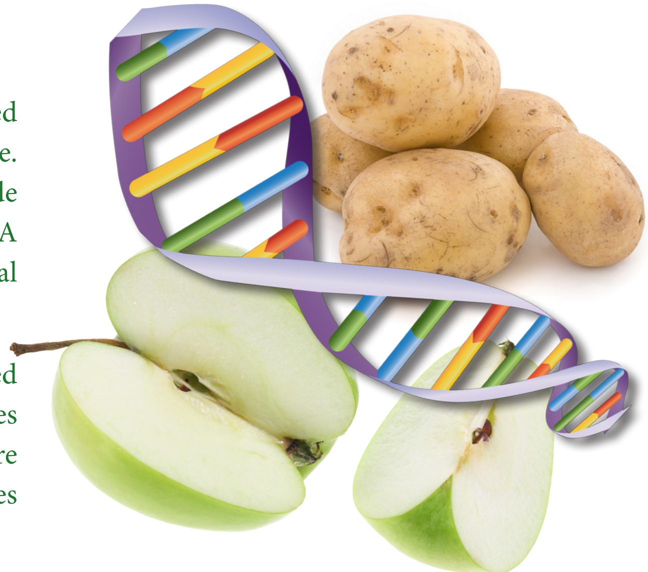
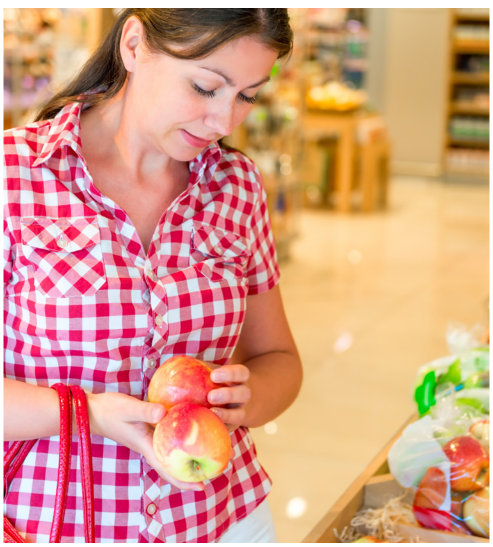
More Variety

Second-generation Innate potatoes have an additional potato-derived trait: resistance to the blight fungus that caused the Irish potato famine. These new varieties can greatly reduce the amount of chemical fungicide applied to potatoes in the field, and have already received USDA and FDA approval. The new varieties are now being evaluated by the Environmental Protection Agency.

Arctic apples, developed by Okanagan Specialty Fruits, contain an added apple gene that knocks down production of the enzyme that causes browning. As a result, Arctic apples remain white-fleshed when cut and are not discolored by bruising. Granny Smith and Golden Delicious varieties of the Arctic apple are currently being grown in commercial orchards.



Consumers Benefit



How will food shoppers react to these new RNAi crops? While most GM crops have traits that appeal to farmers, such as pest or disease resistance and herbicide tolerance, Innate potatoes and Arctic apples offer improved food quality traits to consumers to benefit from.

Preferred Mods

Some members of the buying public may prefer potatoes modified with potato genes or apples modified with apple genes to crops modified with genes from bacteria or viruses. (It's worth noting that during the process of evolution, bacterial and viral genes have been added to the genomes – the DNA - of all plants and animal, including humans.)

Determining Future

For now, however, major potato consumers such as McDonald's and Frito-Lay have not adopted the first generation of Innate potatoes. Consumer reaction to Arctic apples won't be apparent until the trees start yielding fruit, but as with Innate potatoes, fast-food chains are reluctant to sell this new GM product. The fate of these crops may determine the future of plants that have already been engineered using RNAi for improved nutrition, reduced allergenicity, removal of contaminants from polluted soils, and other useful traits.

Finally, RNAi may revolutionize biological pest control. Plants could be modified to produce double-stranded RNAs with sequences that match important insect genes, or crops could be sprayed with transgenic bacteria that express double-stranded insect RNA. Insects would then eat a small amount of the transgenic plant tissue or bacteria, and the double-stranded RNAs would enter through the insect gut. Many questions must be answered in developing this technology, such as which required pest genes would be best to silence, how to ensure that gene-silencing RNAs reach gene targets in the pest, and how to protect non-target species. These challenges do not reduce the great promise that RNAi holds for reducing the amount of chemical pesticide applied to crop plants and for limiting crop damage by resistant insect pests.

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