Discovery of sorghum gene that controls bird feeding could help protect crops

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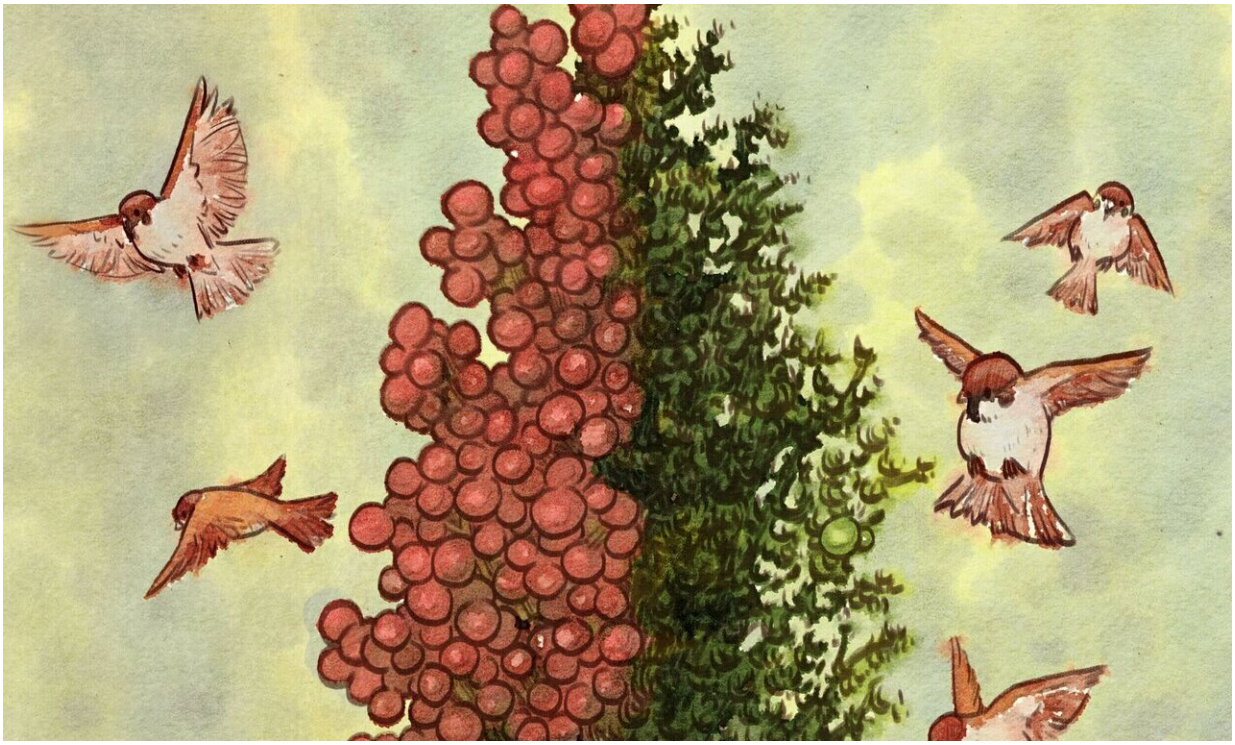

In this illustration, the left part shows the sorghum line avoided by bird contains the wild-type version of Tannin1. The right part shows the sorghum line preferred by bird has a mutanted version of the gene-tan1-a/b. Credit: Designed by Shijia Tang

A single gene in sorghum controls bird feeding behavior by simultaneously regulating the production of bad-tasting molecules and

attractive volatiles, according to a study publishing September 23 in the journal *Molecular Plant*. This gene, called Tannin1, controls the synthesis of bird-deterring astringent polyphenols called tannins, as well as bird-attracting fatty-acid-derived volatile organic compounds. The authors suggest that the findings could lead to novel control strategies to protect major cereal crops worldwide.

"We discovered the molecular mechanism controlling bird feeding behavior on sorghum seeds," says co-senior study author Qi Xie of the Chinese Academy of Sciences. "Beyond illustrating an example of how a field observation led to characterization of an ecologically impactful molecular mechanism, our study reveals new insights about the chemistry of bird-plant ecological interactions and suggests multiple strategies for developing new chemical- and genetic-based control measures to prevent the catastrophic yield losses caused by birds each year."

Damage by birds causes great loss to agricultural production worldwide. With cereal crops, birds cause damage by pecking seeds and sucking the juice of immature seeds, preventing full development of many grains and frequently encouraging mildews and other plant diseases. Currently, there are few efficient control measures to protect field crops from bird damage. For example, anti-bird nets can require immense manpower and material investments, and they can harm birds.

On the left: the sorghum line avoided by bird, on the right: the sorghum line preferred by bird, Credit: Qi Xie

Some cereal crops most vulnerable to bird damage include wheat, barley, rice, sorghum, and millet. Sorghum is a major global cereal crop that is a steady source of calories for more than 500 million people worldwide and is also an important source of biofuels. Sorghum yield losses caused by birds have been reported to reach as high as 52%. Some evidence suggests that bird taste preferences depend on various properties of sorghum, but the underlying molecular or chemical basis has not been clear.

By conducting a genome-wide association study, Xie and co-senior study author Yaorong Wu of the Chinese Academy of Sciences discovered that Tannin1 regulates bird feeding behavior. The sorghum lines avoided

by birds contain the wild-type version of Tannin1, while the bird-preferred sorghum lines have a mutated version of the gene. "Plants benefit from the wild-type Tannin1 gene, and birds benefit from the mutated form of Tannin1," Wu says.

Using mass spectrometry, they found that seeds harvested from the sorghum lines preferred by birds had reduced accumulation of metabolites of the biosynthesis pathway for flavonoids called anthocyanins and proanthocyanidins, also known as condensed tannins. These findings are consistent with past research showing that Tannin1 regulates the expression of genes involved in anthocyanin and proanthocyanidin biosynthesis.

Sorghum lines for seed production. Credit: Shaojie Jiao

At the same time, seeds harvested from the sorghum lines preferred by birds had higher levels of 9 out of the 23 detected volatile organic compounds, with some fatty-acid-derived volatiles reaching 30-fold increases. Aromatic volatile organic compounds from plants are known to attract pollinators and seed dispersers. In addition, the bird-preferred sorghum lines showed a higher expression of genes involved in the fatty-acid biosynthesis pathway compared to bird-repelling sorghum lines.

In feeding experiments, the researchers found that sparrows preferred to eat untreated seeds compared to seeds soaked in solutions containing anthocyanins, proanthocyanidins, or tannic acid. Both condensed tannins and tannic acid are polyphenols whose astringency may impair the taste or digestibility of the seeds. On the other hand, birds were more attracted to seeds soaked in volatiles called 1-Octen-3-ol or hexanal compared to untreated seeds.

According to the authors, the findings suggest that genetic polymorphisms at a single locus, Tannin1, can confer major metabolic regulatory impacts on multiple pathways of plant polyphenol and fatty-acid metabolism, ultimately determining whether a given sorghum line will be deemed an attractive food source by birds.

"Our discovery that Tannin1 has an enormous impact on the feeding preferences of birds will almost certainly guide molecular marker-assisted selection efforts in crop-improvement programs seeking to limit or prevent bird damage to agricultural production systems," Xie says. "Moreover, our insights about which compounds attract birds and which compounds are distasteful to birds suggest a variety of novel control

measures that could be undertaken to prevent yield losses. For example, we could chemically or genetically block the activities of enzymes in attractant volatile biosynthesis or program the condensed tannin content or use tannic acid or condensed tannins as safe, green pesticides to protect crop seeds in the field."

More information: Molecular Plant, Xie, Shi, and Tang et al.: "Control of Bird Feeding Behavior by Tannin1 through Modulating the Biosynthesis of Polyphenols and Fatty Acid-Derived Volatiles in Sorghum" www.cell.com/molecular-plant/f … 1674-2052(19)30287-4 , DOI: 10.1016/j.molp.2019.08.004

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