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Scientists Find Common Genes Defending Coffee Plants Against Devastating Disease

Arabica coffee, the most economically important coffee globally, accounts for 60% of coffee products worldwide. However, the plants it hails from are vulnerable to a fungal disease called coffee leaf rust, which devastated Sri Lanka's coffee empire in the 1800s. An international team of researchers co-led by Nanyang Technological University, Singapore (NTU Singapore) has made a breakthrough that helps protect Arabica plants against this disease. The study, published in Nature Genetics, involved a large consortium of researchers and coffee breeders from Australia, Belgium, Brazil, Canada, China, Colombia, Finland, France, Germany, Indonesia, Italy, the Netherlands, South Africa, Spain, Switzerland, Uganda, and the United States.

The high-quality genome sequences of the three plant species, together with the candidate genetic sequences for coffee leaf rust resistance, form the cornerstone for breeding new varieties of Arabica plants that are more adaptable to change and more resistant to diseases caused by pathogens like fungi. The project involved a large consortium of researchers and coffee breeders from Australia, Belgium, Brazil, Canada, China, Colombia, Finland, France, Germany, Indonesia, Italy, the Netherlands, South Africa, Spain, Switzerland, Uganda, and the United States.

Arabica plants have low genetic diversity, making them susceptible to pests and diseases. The cultivated plants typically do not have the genetic trait that confers resistance to coffee leaf rust, which is caused by the Hemileia vastatrix fungi. The loss of leaves lowers the quality and quantity of the plants' berries harvested for brewing coffee. To prevent a potentially disastrous wipeout of Arabica plants worldwide by coffee leaf rust, the scientists studied the genomic origins and breeding history of the plant. They did so by mapping out the highly detailed genomic sequences of Arabica and two related coffee-producing plants, Robusta (C. canephora) and C. eugenioides, which are the modern-day ancestors of Arabica.

The scientists' analysis suggested that the resistance to coffee leaf rust in Arabica may have been lost when Arabica plants became widely cultivated, as all cultivated Arabica coffee plants are derived from the same stock with very little genetic variability. However, a hybrid of Arabica and Robusta resistant to the disease was found on Timor island in 1927, but the descendants of the Timor hybrid plant still form the basis of all coffee leaf rust resistant variants.

Researchers have discovered genes that could confer resistance against leaf rust in different coffee plants, but the identification process was slow. New research mapping out the genomes of different coffee plants in great detail has made it faster and more accurate to identify resistance genes. The researchers analyzed the most common cultivated coffee varieties, representing about 95% of the world's coffee production, and compared them with descendants of the Timor hybrid. They found a region of DNA sequences common among different leaf rust resistant coffee plants, with a new combination of Robusta-based genes that may convey resistance in Arabica plants in general.

The researchers postulated that Arabica stemmed from a chance event 350,000 to 610,000 years ago when the Robusta and C. eugenioides plants were naturally cross-pollinated to create the first Arabica plants in the wild. This dating comes in between previous estimates, which could be due to historical changes in population sizes in the wild and cultivated plants, as well as the different sources and limited amount of data used.

By comparing the high-quality genomic sequences of Arabica with those of Robusta and C. eugenioides, the research team found that the three species are still highly similar genetically. This suggests that for future breeding programs to ensure that Arabica plants have disease resistance, breeders can consider using other related coffee species, such as Robusta and C. eugenioides.

However, using Arabica plants alone to breed for the resistance trait is problematic because even the wild varieties of Arabica have very low genetic diversity, making it harder to breed for disease resistance. The highly detailed genomic sequences mapped for all three coffee plants mean that other useful traits could be identified in the future, such as resilience to drought, better crop yield, and more aromatic coffee beans.

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