Genetic diversity in *Malus* × *domestica* (Rosaceae) through time in response to domestication

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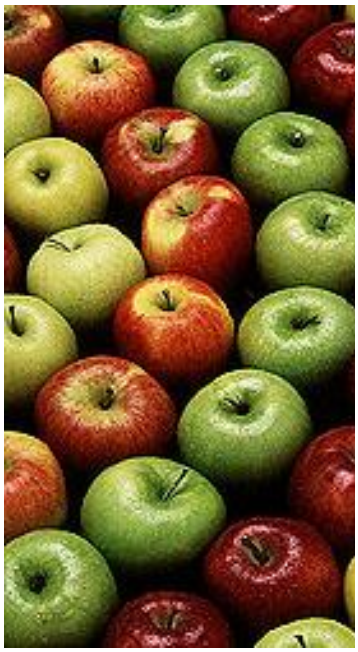
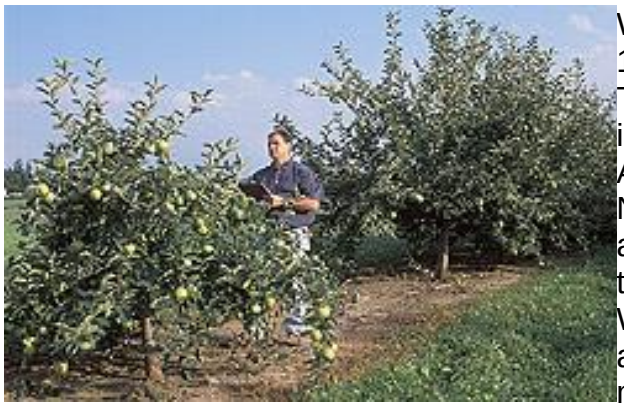
SUMMARY:
This study was inspired by recurring questions about whether genetic diversity of commonly grown crops has been lost over the years. The loss of genetic diversity, called genetic erosion, is reflected in rising consumer interest in heirloom cultivars and their conservation. The issue has also sparked interest in how well the USDA conserves diversity of these older cultivars in gene banks. We investigate this question in apple. Apple cultivars are propagated clonally and so the genetic identity can be maintained indefinitely over centuries. We "fingerprinted" apple cultivars using a set of DNA markers called variable simple sequence repeat (SSR). We then compared the amount of diversity in SSR markers in cultivars commonly grown through the centuries with more modern varieties. The experiment used 1228 cultivars of apple conserved in the National Plant Germplasm System collection at Geneva, NY that includes both modern and ancient cultivars. By comparing the age of the cultivars with their measured SSR diversity one can assess the magnitude and direction of genetic erosion over the course of apple breeding in the last few centuries. Results indicate that SSR diversity did not statistically vary among cultivars that dated in the 1200-1600s, 1700s, 1800s, 1900-1950, and 1951-2000. Overall, domesticated apple has retained high genetic diversity throughout the domestication and improvement process. While apple diversity is effectively preserved in germplasm collections, it is not used in apple cultivation. Just 15 cultivars account for 90% of worldwide apple production, and 11 of these show lower diversity than is readily available. Careful management of germplasm collections is needed to ensure that collections remain intact and can be accessed for future breeding efforts.

WHY THIS PAPER IS COOL:



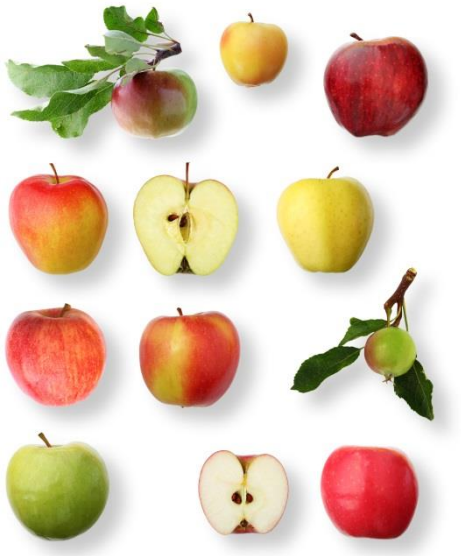
Apples have been a favourite food in Asia and Europe for thousands of years and are a staple in the US. There are 7500 known apple cultivars, suggesting that there is a lot of genetic diversity. We wanted to know how much diversity and whether there was a trend towards decreasing diversity in the crop over the last 50 years, as rumoured for other crops.

Apple cultivars are unique compared to many other crop cultivars because they are maintained by cuttings that give an identical genetic replica of the original tree. Growing out the seeds from an apple you enjoyed won't get you more of the same apples! Clonal propagation of apples suggested to us that apple domestication may have occurred differently than other crops like wheat and tomatoes. Moreover, long-lived trees and widespread enjoyment of specific apples may have helped to maintain the genetic diversity throughout its cultivation history. This paper is cool because it asks genetic questions in a historical perspective of a beloved food.



We harvested leaves from 1228 different cultivars. These cultivars are included in the USDA-ARS collection in Geneva, NY (left) and represent apples that were grown in the Middle Ages until now. We extracted the DNA, and characterized genetic markers (right).

WHAT WE LEARNED:



The popular apple cultivars have changed over the last 800 years, the genetic diversity hasn't. Most likely this means that important genes that control traits like apple color, sweetness and harvest date have not been lost.

Apple varieties

Even though genetic diversity is available among apple cultivars, we tend not to use it. A small subset of apple cultivars is used in cultivation.

Pictured here is the cultivar 'Golden Delicious' wich is the second most popular apple in the US after Red Delicious. Golden Delicious was discovered in 1905 by Andrew Mullins.