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Reviving Ancient Crops with Modern Genetics

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Modern genetics is crucial for reviving ancient crops, enhancing traits like drought tolerance and nutritional content. Techniques such as genome sequencing provide insights into the genetic basis of these crops' unique adaptations, while marker-assisted selection (MAS) speeds up the breeding of improved varieties. CRISPR-Cas9 gene editing allows precise modifications to enhance resilience and other desirable traits. Additionally, preserving genetic diversity through modern genetics ensures these crops can adapt to future challenges, supporting sustainable agriculture. Overall, integrating genetic tools with ancient crops helps reintroduce their benefits to contemporary agriculture, fostering a more resilient and nutritious food system.

Value of Ancient crops

Ancient crops, sometimes referred to as heritage or forgotten crops, hold immense value in today's agricultural landscape. These crops, often cultivated for thousands of years in diverse environments, have evolved traits that make them particularly valuable for modern agriculture, especially in the face of global challenges like climate change, food insecurity, and loss of biodiversity. One of the most significant advantages of ancient crops is their resilience to environmental stressors. Many of these crops were domesticated in regions with harsh climates, such as extreme temperatures, poor soil quality, and low water availability. Over centuries, they developed natural adaptations that allow them to thrive where modern crops might fail. Ancient crops are often nutritionally superior to many modern staples. The cultivation of ancient crops contributes to agricultural biodiversity, which is essential for ecosystem health and resilience. Modern agriculture has become increasingly dependent on a limited number of crop species primarily rice, wheat, and maize which makes food systems more vulnerable to pests, diseases, and climate change. Ancient crops are deeply intertwined with the cultural heritage and traditional practices of the regions where they originated. Reviving and cultivating these crops supports food sovereignty by empowering local communities to maintain control over their food systems, preserve traditional knowledge, and sustain cultural practices. As consumer awareness of the benefits of ancient crops grows, so too does their market potential.

Challenges faced by ancient crops in the era of modern agriculture

- Low Yield and Productivity
- Lack of Market Infrastructure
- Limited Research and Development
- Processing and Harvesting Difficulties
- Cultural and Consumer Acceptance
- Genetic Erosion and Loss of Diversity

Role of Modern Genetics in Reviving Ancient Crops

Modern genetics has become a powerful tool in the effort to revive ancient crops, allowing scientists and plant breeders to unlock their full potential for today's agricultural challenges. These advanced genetic techniques enable us to enhance the desirable traits of ancient crops, making them more suitable for modern farming practices, increasing their nutritional value, and ensuring their resilience in the face of climate change.

1. Genome Sequencing and Genetic Mapping: Genome sequencing is the foundation of modern genetics, providing detailed blueprints of the genetic makeup of ancient crops. By sequencing the genomes of these crops, scientists can identify key genes responsible for desirable traits such as drought tolerance, disease resistance, and nutritional content. For example, researchers have mapped the genome of **quinoa**, identifying genes that contribute to its high nutritional content and ability to thrive in saline soils. This information allows breeders to select and enhance these traits in new varieties, making quinoa more adaptable to different environments (Jarvis *et al.*, 2017)

2. Marker-Assisted Selection (MAS): Marker-assisted selection (MAS) is a technique that uses genetic markers specific sequences in the DNA associated with particular traits to assist in the selection process during breeding. This method accelerates the breeding process by allowing breeders to identify plants with the desired traits at the seedling stage, long before those traits become physically apparent. In the case of teff, a staple grain in Ethiopia, MAS has been used to identify and select for traits like early maturation and increased yield. By focusing on these markers, breeders can develop new teff varieties that are more productive and better suited to diverse growing conditions (Gebremariam *et al.*, 2020)

3. CRISPR and Genome Editing: CRISPR-Cas9 and other genome-editing technologies have revolutionized plant breeding by enabling precise modifications to the DNA of crops. Unlike traditional breeding, which can be time-consuming and imprecise, genome editing allows scientists to directly alter specific genes responsible for undesirable traits or to introduce beneficial traits from other species. Sorghum, an ancient cereal grain, is naturally drought-resistant but can contain high levels of tannins, which reduce its nutritional value. Using CRISPR, scientists have edited the genes responsible for tannin production, creating low-tannin varieties that retain their drought tolerance while being more nutritious and palatable (Gao, 2018)

4. Genomic Selection: Genomic selection is a method that uses genome-wide data to predict the breeding value of a plant. This approach allows breeders to evaluate the potential success of breeding different plants without having to wait for them to grow and produce seeds. By combining genomic data with phenotypic information (observable traits), breeders can make more informed decisions about which plants to crossbreed. In reviving ancient barley varieties, genomic selection has been used to improve traits like yield, disease resistance, and adaptability to different climates. By leveraging the genetic diversity of ancient barley, breeders can create new varieties that are both high-yielding and resilient to climate change (Sallam *et al.*, 2015)

5. Resurrecting Lost Traits: Many ancient crops have lost certain traits due to centuries of neglect or selective breeding focused on other attributes. Modern genetics allows scientists to reintroduce these lost traits by identifying and reactivating dormant genes.

Amaranth, an ancient grain with high nutritional value, was once widely cultivated in the Americas. Through genetic analysis, scientists have identified traits that were lost during its decline in cultivation, such as certain resistance factors to pests. By reintroducing these traits through selective breeding and genetic modification, amaranth is being brought back as a resilient and nutritious crop.

6. Hybridization and Cross-Breeding: Hybridization, the process of crossing different varieties or species to produce offspring with combined traits, is another way modern

genetics is reviving ancient crops. By understanding the genetic makeup of both parent plants, breeders can create hybrids that combine the best characteristics of each. In the case of spelta, an ancient wheat variety, cross-breeding with modern wheat has allowed breeders to combine spelta's nutritional benefits and hardiness with the higher yields and disease resistance of modern wheat. The result is a crop that is both commercially viable and nutritionally superior.

7. Climate Adaptation: As the climate changes, the ability of crops to adapt to new environmental conditions becomes increasingly important. Modern genetics allows for the rapid development of crop varieties that can withstand extreme conditions such as drought, heat, and salinity. A perennial grain with a deep root system, Kernza is being developed as a climate-resilient crop that can sequester carbon and reduce soil erosion. By using genomic tools to enhance its traits, researchers are making Kernza a viable alternative to annual grains like wheat, particularly in regions affected by climate change (Knüpffer, 2009)

Conclusion

The integration of modern genetics in reviving ancient crops offers significant benefits, enhancing their resilience, nutritional value, and adaptability. By leveraging techniques such as genome sequencing, marker-assisted selection, and CRISPR-Cas9, scientists are reintroducing these valuable crops into contemporary agriculture, addressing global challenges like climate change and food security. Looking ahead, ongoing advancements in genetic technologies will continue to improve crop traits and support sustainable farming practices. Future research will likely focus on expanding the use of ancient crops globally, optimizing their integration into diverse agricultural systems, and further exploring their potential to contribute to a more resilient food supply.

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