Breeding the future – how plant genetics will feed 10 billion people

MCT,1 a new macadamia variety, is known for its high consistent yield and high kernel recovery. These 8 year-old trees in Meadowlands, Australia have been cropping consistently since year 2.

Long before macadamias became known as the "queen of nuts" on gourmet shelves around the world, they grew wild in the subtropical rainforests of Australia: tall, untamed trees with small, tough nuts that few animals could crack. Today, through generations of selective breeding, macadamias have transformed from forest relics into a thriving global crop. But as climate change intensifies and environmental concerns grow, the next chapter in their story is being written in the world of genetics.

Breeding is no longer just about yield; it's about resilience, resource efficiency, and long-term sustainability. In this new era, science is taking a bold step back to nature, unlocking the wild genes of macadamia's ancestors to build a more sustainable future for both farmers and the planet.

The global population is projected to surge by 34%, reaching nearly 10 billion by 2050. To meet the rising demand for food, agricultural production must increase by a staggering 70%. In developing countries, around 80% of this growth will need to come from higher yields rather than expanding arable land. That makes one thing clear: we must grow more food with fewer resources. Plant breeding is at the heart of the mission – developing crops that yield more, use water and nutrients more efficiently, and that thrive in the face of climate change. These innovations aren't just about boosting productivity; they're essential for achieving long-term sustainability and ensuring global food security.

Modern plant breeding is transforming agriculture by producing high-yielding crop varieties that are resilient, resource-efficient, and rich in nutrition, all with minimal environmental impact. A key focus is on traits such as drought tolerance and nutrient-use efficiency, which help reduce reliance on fertilizers and conserve precious water.

In crops like macadamia, this approach has dual benefits: it boosts the economic viability for farmers while also promoting ecological sustainability. By blending traditional breeding techniques with cutting-edge tools like molecular markers, breeding programs are rising to meet global challenges, namely climate change, resource scarcity, and food insecurity. Crop modelling further enhances this effort, enabling breeders to predict how different varieties will perform under varied environmental conditions, guiding more strategic breeding decisions. Varieties such as MCT1, known for its high and consistent yield and superior kernel recovery, represent the future of the macadamia industry. However, as a product of traditional breeding, MCT1 took 30 years to reach commercial release. Integrating modern breeding technologies can significantly accelerate this process, enabling the development and release of improved varieties in a much shorter timeframe.

MCT1 nuts harvested from 10 year-old trees. Good crack-outs and a thin even shell are standout traits of this variety.

Cultivated macadamias have a relatively narrow genetic base compared to their wild relatives. This genetic limitation can reduce resilience to pests, diseases, and changing climates. However, modern breeding programs are turning to wild macadamia species as a vital source of new traits.

These wild species, found in natural ecosystems, are living gene banks, offering untapped potential for crop improvement. While domestication has given us the food crops we rely on today, it has also led to a significant reduction in genetic diversity, a phenomenon known as the "domestication bottleneck". By tapping into the germplasm of wild relatives, plant breeders can reintroduce lost traits and develop varieties better equipped for future challenges.

Introducing genetic diversity from wild species is no easy task. It involves a complex process of identifying, collecting, and evaluating wild plant material. Once beneficial genes are discovered, their functions need to be validated, and only then are they integrated into breeding programs. The process is slow and fraught with challenges. Wild species may carry undesirable traits alongside useful ones, and often lack detailed genetic and phenotypic data. Some may even have reproductive barriers that hinder cross-breeding.

The integration of traditional breeding with New Breeding Techniques (NBT) holds transformative potential. It can lead to a new generation of crop varieties better able to meet the needs of a changing world: more productive, more resilient, and more sustainable.

But breeding alone isn't enough. To truly revolutionise agriculture, improved crop varieties must be a part of a holistic strategy. This means aligning genetic advancements with sustainable farming practices that protect soil health, biodiversity, and water resources. For crops like macadamia, this integrated approach is key to reducing environmental impact while keeping pace with growing global demand.

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