Perennial cropping

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Newer roots for agriculture

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Annual grains, domesticated from wild species, have dominated agriculture since the Neolithic. A new study reports how turning to high-yield perennial rice crops could maintain key ecosystem functions while supporting livelihoods.

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In his 1980 book *New Roots for Agriculture*[1], the geneticist Wes Jackson envisioned a new way of farming. Key to his vision? High-yield perennial varieties of major grain crops, then almost entirely absent from global diets. Annual crops have long dominated agriculture: in fact, over 70% of food calories fuelling human civilizations come from a handful of them, domesticated over 8,000 years ago. Yet perennials have distinct advantages. They generally capture sunlight, nutrients and water for longer periods of the growing season and eliminate the need for annual soil tillage. By providing permanent cover, they encourage higher accumulations of soil carbon and reduce erosion and surface runoff, which can contaminate adjacent ecosystems. In *Nature Sustainability*, Zhang and colleagues[2] report the successful development of commercial perennial rice varieties in China with yields comparable to those of annual counterparts, along with benefits such as reductions in labour requirements and environmental impacts.

The past several decades have seen modest but growing investments in the development of perennial grain crops, including perennial counterparts of wheat, rice and sorghum suitable for the USA, China, Europe and Africa. One technique involves domesticating wild perennial species through continual selection of desirable traits over multiple generations[3]. A recently developed perennial grain currently grown for niche markets in the USA, Kernza, was domesticated from *Thinopyrum intermedium*, a wild relative of wheat. While yields of Kernza remain low compared with those of annual wheat, they are increasing. As with the development of perennial rice, plant breeders can also cross perennial species with domesticated annual relatives to produce perennial hybrids with desirable traits derived from the annual parent[3].

Both these approaches were painstakingly slow when reliant on traditional methods. But recent developments in genetic tools, such as mapping of quantitative trait loci and marker-assisted selection, while primarily harnessed to make incremental improvements to existing annual crops, herald speedier, more effective breeding of perennials. Thus, the success with perennial rice reported by Zhang and colleagues in southern China illustrates exciting new opportunities for genetic solutions to some of agriculture's most pressing challenges.

Particularly in low-income countries, those challenges include extreme weather events and soil degradation. Farmers are also feeling pressures to adopt practices that increase soil carbon levels to offset agriculture's significant contributions to climate change. Meanwhile, demands on food production are rising. Global undernourishment rates rose from 8% in 2019 to 9.8% in 2020 (ref. [4]). It is increasingly clear that farmers need more options to address a raft of issues – to improve livelihoods, adapt to extreme weather, increase soil health and carbon load, and reduce wasteful losses of water and nutrients, while meeting global food demands. Higher yields alone will not clear all the hurdles. A breakthrough in rice production such as that described by Zhang and colleagues is key because it addresses a range of these issues.

Rice is the primary food crop for four billion people, providing over 25% of the dietary calories in lower-income countries. Growing perennial rice instead of annual varieties does not just obviate important soil health issues[2]. As Zhang and colleagues found, a single planting of perennial rice supported two harvests each year over four years, with average yields of 6.8 Mg per hectare, similar to those of high-yield annuals. Perennial rice became commercially available in China in 2018. By 2021, some 48,000 Chinese farmers grew it – a fourfold increase from 2020 (ref. [2]). Because it is planted only once, perennial rice cropping reduced labour by nearly 60% and input costs by nearly half. Soil carbon and nitrogen levels increased, likely due to the reduction in tillage and perennials' more extensive root systems. The soil physical structure also improved, leading to better percolation and retention of water.

These findings affirm Zhang and colleagues' assertion that perennial rice represents a step change in food production, even as they illustrate the power of modern genetics[3] to speed novel and needed agricultural innovations. Their report will blaze new trails in genetic research rather than support the usual incremental improvements in dominant crops. It will also inspire a reconsideration of the criticism that investing in perennial grain development is too costly and long term[5]. The development of perennial rice cost less than US$20 million over 15 years (F. Hu, personal communication). That is an order of magnitude less than the annual investments to improve annual crops, indicating that research on perennials can be highly cost effective. As Wes Jackson pointed out some four decades ago, "the development of only one new high-producing perennial crop could pay dividends for both developed and developing nations forever"[1].

Given the magnitude and array of global challenges, including tensions between powerful nations, this study is also notable as a transformative collaboration between Chinese, Australian and US scientists working together to solve complex problems.

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Competing interests

The author declares no competing interests.