PERENNIAL GRAIN RESEARCH

Winifred Bird asks Timothy Crews of the Land Institute if perennial grains can compete with annuals and what their future is in agriculture

Perennial crops are essential to permaculture. They free the farmer from the labor and ecological harm of clearing large stretches of land to replant yearly, build soil and provide year-round habitat for wild creatures. Fortunately, those looking to build a richly productive landscape have hundreds or even thousands of perennial fruits, nuts, herbs, vegetables, compost, fodder and oil crops to choose from.

Yet when it comes to cereals – the seed-bearing grasses that provide almost two-thirds of humanity's calories – the situation is drastically different. Farmers did not domesticate a single perennial grain over 10,000 years or more of agricultural history, and the handful of experimental varieties available today yield far less than their annual counterparts.

Researchers at the Land Institute, a plant science center in the heart of America's industrial farm country, want to change that. Using richly diverse native prairies as their model, the scientists here are attempting to breed perennial grains that build soil, yield abundantly, and require few external inputs. On 200 acres of experimental fields in Salina, Kansas, they are crossing wild and domestic varieties of sorghum, painstakingly selecting high-yielding individuals from fields of wheatgrass and testing out perennial polycultures.

The Land Institute is the world's leading perennial grain research institute. It was founded by the visionary biologist Wes Jackson in 1976 with the goal of fundamentally revolutionizing agriculture. Today, its staff numbers 30 and its assets total 14 million US dollars. The institute has yet to produce a grain good enough for public release, however.

"This is just something we all have to wait for," research director Timothy Crews said in a recent interview. "It is a deep permaculture project that, when we reach the point of having something workable, [permaculture farmers] will love, because it really will meet a lot of the criteria of a permanent agriculture."

Others are skeptical. Kenneth Cassman, a food security expert at the University of Nebraska, argues that perennial grains will never beat out annuals when it comes to yield, and that matters a lot given the world's growing population. The permaculture farmer, writer, and contributor to this magazine, Chris Smaje, has called the Land Institute's vision both "ecologically rather implausible" and overly reliant on a "magic bullet" solution to agriculture's woes. Researchers

photo © Fred McGolly

Previous page:
A field of Kernza (TM) producing intermediate wheat grass.

Left:
Erosion on a conventional Midwestern grain field after heavy rain in April 2013.

Below left:
Land Institute research assistants harvest the kernza/alfalfa plot.

should focus on creating "a sustainable food supply at the level of the food and farming system itself rather than in the genome of our crop plants," he wrote in a recent issue of the journal *Agroecology and Sustainable Food Systems*.

In other words, annual grains grown on a small scale using non-industrial methods can be sustainable too. Or can they? The question gets to the crux of the Land Institute's argument in favor of perennials, and Crews debates it vigorously.

"In terms of carbon loss and nutrient leakage, if you open up 3x3m (10x10ft), it is going to take place whether you are a postage stamp gardener or not," he said. "You can check erosion more easily at that scale in paddies or terraces, and if the land is fully exposed at certain times such as a dramatic precipitation event, you could lose a lot."

Lost Soil

A 2007 study, for instance, showed that soil disappears from plowed land at a median rate 95 times faster than it forms. (Northern Europe's gentle rains make it something of an exception to this rule, Crews acknowledged). Crews and his colleagues believe the best long-term solution to these problems lies in a transition to perennial grain polycultures.

"Every year [conventional] farmers start with a highly disturbed ecosystem that has no roots in the ground. It's cleared of all vegetation, it's almost like primary succession," he said. "So many problems that we just think of as being part of the package of agriculture – nutrient leakage, soil erosion, carbon loss, weed invasion – are actually attributes of this highly disturbed ecosystem. They're very predictable in ecology. And yet if you look at the mature native ecosystem in this region, the prairie, you do not have soil erosion, you do not have nutrient leakage, you do not have weed invasion into a mature standing community."

Thus the drive to create grain fields modeled on the prairie. The dilemma is that the annual cereals farmers grow today are much better at producing human food than their perennial prairie grass cousins. Annuals must pass on their genes in a single year, so they pour between one- and two-thirds of their energy into producing multitudes of nutrient-rich seeds. Perennials, on the other hand, invest a greater share of their energy in establishing the roots and vegetative structures they need for long-term survival.

To breed high-yielding perennial grains, scientists must shift the energy balance back towards seed production without tipping it so far that the plant is no longer producing the strong roots it needs to survive multiple seasons. They can also take advantage of the fact that perennials tend to have a larger energy pie to start with: they generally start growing earlier than annuals each spring and photosynthesize sunlight for more days each year.

There are two basic strategies for this breeding work. In the first, researchers grow wild perennials like wheatgrass and gradually domesticate them by saving seed from plants with large, plentiful, evenly-maturing grain (or as Crews

Below and right:
Kernza breeding plots. The white bags are used to bag seed heads which will be cut off, taken back to the lab, and assessed for many traits such as seed size, weight and shape.

Far right:
Roots of the Silphium oilseed crop.

puts it, "plant out 14,000 and find 200" of the best). In the second, they cross distantly related annual and perennial varieties, such as wheat and wheatgrass, in an attempt to bring perennial characteristics into the annual.

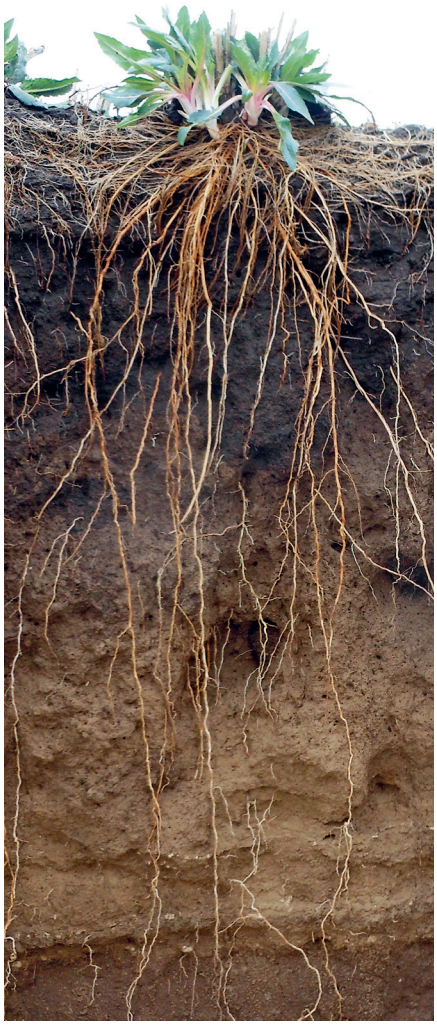
These are difficult tasks, long relegated to a thin scattering of idealistic agronomists. Recently though, interest has grown. The U.S. Agency for International Development and the Bill and Melinda Gates Foundation are both investing in perennial grain research, and in 2013, a workshop organized by the Food and Agriculture Organization of the United Nations on the topic attracted experts from around the world. Chinese plant breeders are perhaps closest to success, with a perennial rice suited to erosion-prone upland fields nearly

ready for release.

At the Land Institute, breeding work currently focuses on four crops: wheat, a domesticated wheatgrass they call kernza, sorghum, and silphium (an oil crop in the sunflower family). Staff are also experimenting with polycultures that combine these crops with legumes or other plants. Although yields remain well below those for annuals (kernza produces one-third to one-sixth the grain of conventional wheat, for instance), Crews is confident of improvements to come.

"We're not even close to leveling off on yield increase in any of the breeding programs that we're pursuing right now," he said. As for the practical details of cultivation, Crews said much work remains to be done. "Weeds are not nearly as big of an issue in perennial systems, but there will be more weeding than one encounters in the prairie," he wrote in an email. "The unique management challenges will be more in managing competitive balances between species. One might need to manually cut back legumes at certain times to force the release of nitrogen during grain fill, or burn the whole plot in the winter to shift the competitive balance between species. We are just beginning to consider these management approaches."

Whatever they discover, it is sure to be of interest to permaculture gardeners and farmers all around the world



Winifred Bird is a freelance journalist who writes about the environment, architecture, and culture for publications in the United States and Japan. Currently based in Illinois, she spent ten years in rural Japan, learning about foraging and food preservation and trying out local farming methods.

Timothy Crews is Director of Research at the Land Insitute. His own research focuses on carbon, nitrogen, and phosphorous economies of perennial grain intercrops, especially grain-legume biocultures. He holds a PhD in Ecology and Evolutionary Biology from Cornell University.

For more information on the Land Institute visit: **https://landinstitute.org**

1 http://tiny.cc/fao-staples
2 http://tiny.cc/perennial-vision
3 http://tiny.cc/soil-erosion