

Perennial Grain Agriculture: Recent Research Activities and Meetings

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Interest in perennial grain agriculture has continued to grow over the last couple of years. This is evident both in the number of scientists who are dedicating at least part of their research efforts to perennial crop development, as well as the number of international meetings on the topic. Below I have divided work on perennial grain agroecosystems into five categories, and have listed specific projects underway that pertain to each one.

1) Breeding Perennial Crops—two approaches

Achieve perenniality by crossing annual crops with perennial relatives

Multiple research groups are making wide hybrid crosses between annual crop species and perennial relatives to essentially capture perennialism in what otherwise looks and tastes like the annual grain. In collaboration with The Land Institute, Fengyi Hu's lab at the Yunnan Academy of Agricultural Sciences in China continues to make good progress developing perennial lines from crosses between annual rice and a wild perennial relative. Shuwen Wang at The Land Institute has gone further than any other researcher in working out the complexity of crossing annual wheat with several perennial relatives of wheat. Also at The Land Institute, Stan Cox has achieved promising results by crossing annual sorghum with a perennial relative. Jim Holland with USDA at North Carolina State has undertaken preliminary work crossing maize with a perennial version of its ancestor, teosinte.

Selective breeding of existing undomesticated perennials

Another strategy that is being pursued to create perennial grains is to use repeated cycles of selection and intra-species crossing to domesticate wild plant species. Lee DeHaan at The Land Institute continues to improve on yield and other traits in intermediate wheatgrass, or "kernza," a name given to the grain-producing domesticates of intermediate wheatgrass. Other groups that are breeding kernza include Jim Anderson's lab at the University of Minnesota, and Doug Cattani's group at the University of Manitoba. David Van Tassel at The Land Institute is making headway with domesticating populations of several perennial sunflower species, as well as hybridizing annual and perennial sunflower species.

2) Genomics

Technical advances in the field of genomics offer hope for accelerated breeding programs. Genetic maps for many important traits have already been developed for the major annual grain crops. However little attention has been given to their perennial relatives—especially for the genes that interact to confer perennialism itself. Several researchers are working on creating genetic maps for the perennial plants being used in the annual/perennial crosses. Andrew Patterson of the University of Georgia is working with Stan Cox on developing a genetic map that will further their work on perennial sorghum. Ed Buckler and Denise Costich (USDA/Cornell) are working with populations of eastern gamma grass, a relative of maize, to develop a genetic map for indentifying traits such as

winter hardiness. Shuwen Wang and Lee DeHaan of The Land Institute, Traci Viinanen, University of Chicago, Jessie Poland, USDA-ARS at Kansas State, and Steve Larson, USDA at Utah State University, are all working on some aspect of intermediate wheatgrass genomic analysis.

3) Trial perennial grains

Numerous research groups are making observations of how proto-perennial crops perform under diverse environmental conditions. A multi-disciplinary team at the University of Minnesota received ~750K from a state fund to evaluate a range of crops and cropping systems for biofuel production. Included in the mix are intermediate wheat grass grown in monocultures and bi-cultures with alfalfa. The research plots are established at six U.M. Experiment Stations: Waseca, Morris, Lamberton, Saint Paul, Crookston, Roseau. At Michigan State's Kellogg Biological Station Sieg Snapp, finished off the last year of a multi-year project growing out perennial wheat and intermediate wheat grass accessions. Her post-doc, Steve Culman, measured nitrogen uptake efficiencies across annual and perennial crop regimes. Other researchers who have evaluated Land Institute germplasm of one or more perennial crops include: Amir Ibrahim, Texas A&M (kernza), Seth Murray, Texas A&M (sorghum), Erik Sacks, University of Illinois (kernza, sorghum, sunflower, wheat). And numerous researchers have recently trialed, or are just starting to grow out Land Institute wheat germplasm, including Phil Larkin, Lindsay Bell and Richard Hayes, CSIRO, Australia; Dhruba Thapa, Nepal Agriculture Research Council; Stephen Jones and Kevin Murphy, Washington State University; Jude Maul, UDSA Beltsville; Mark Sorrells, Cornell University; Doug Cattani, University of Manitoba; Robbie Lindeque, Eastern Free State, South Africa; Mike Gooding, University of Reading, UK.

4) Developing perennial plant mixtures or polycultures.

With the goal of harnessing ecosystem functions to maintain soil fertility and control insect and disease pests, work is underway at The Land Institute to experiment with diversity in perennial crop mixtures. For example, Tim Crews is initiating several bi-culture plot experiments featuring Kernza and a variety of perennial legume species to evaluate competition and nitrogen transfer from the legume to grain crop.

5) Harvesting, milling, eating and drinking kernza

Kernza grown by The Land Institute has been combine-harvested from 30 acres and milled by Heartland Mill in Marienthal, Kansas. The flour was blended with wheat flour and used quite successfully for baking bread which was sold at The Land Institute's Prairie Festival. Free State Brewery in Lawrence, Kansas has made several experimental (and delicious) batches of beer from kenza grain, and there is a distillery in California that is in the process of producing a trial kernza whisky. Preliminary nutritional analyses have been conducted on kernza by the food science lab at University of Minnesota. The findings from this work will be published soon. Much more extensive food science analyses will be carried out at Minnesota as part of the multi-disciplinary biofuels project mentioned above.

Perennial agriculture meetings

Aside from a wide range of research activities being carried out by plant breeders and ecologists around the world, several meetings have been convened or are planned to evaluate the promise of perennial agriculture and progress to date. An annual meeting of primarily perennial grain breeders that also included growers, bakers, ecologists, agronomists and economists has taken place at the Kellogg Biological Station in Michigan (2011), University of Manitoba (2012), and is planned for the University of Minnesota (2014). Another annual meeting--this one focusing on perennial rice--has been hosted for the last five years by the Yunnan Academy of Agricultural Sciences in China, in cooperation with The Land Institute. The next meeting will be in November, 2012. At the end of October, 2012, The Gates Foundation will be hosting a small, intensive 2-day workshop in Seattle to explore whether perennial grains have the potential to address food security issues in parts of Africa. Finally, the Food and Agriculture Organization (FAO) of the United Nations is planning to convene an expert Consultation on research for "introduction of perennial habit in some basic food crops" next April (2013) in Rome.