Breeding Corn for Sustainable Agriculture

Sustainable farmers are often more concerned about corn's nutritional quality for their livestock or their consumers than in, say, the crop's characteristics as a feedstock for ethanol fermentation or how many transgenic traits are stacked into its DNA. In fact, some producers are more than a little concerned about trends in the seed industry that include consolidation, the loss of public sector breeding programs, and rising technology fees.

Walter Goldstein leads a tour of experimental corn varieties

PFI is working with scientists who are partnering with farmers to develop corn that better suits their needs. This corn takes a variety of forms, from hybrids, to "synthetics," to open-pollinated varieties. Things came together in 2001, with Walter Goldstein of the Michael Fields Ag Institute distributing seeds of his open-pollinated variety Nokomis Gold and ISU corn breeder Kendall Lamkey realizing that his work might be useful to the sustainable agriculture community. PFI assisted these two agronomists on an initial USDA SARE project, and in 2003 the partnership expanded to include USDA corn breeder Linda Pollak.

Since then much work has been done on farms and experiment stations, and field days and meetings have drawn growers and small seed houses. Field days, research plots, or variety selection has been carried out by PFI members **Don Adams and Nan Bonfils** (Madrid), **Francis Blake** (Waukon), **Ron and Ladonna Brunk** and **Steve and Tara Beck-Brunk** (Eldora), **Linda and Ron Grice** (South English), **Earl, Ronda, and Jeff Hafner** (Panora), **Laura Krouse** (Mt. Vernon), **Gary Laydon and Pat Mennenga** (Plainfield), **Mike Natvig** (Protivin), **Bob Burcham at the Neely-Kinyon Research Farm** (Greenfield), and **Dan Specht** (McGregor). Wisconsin farmers have hosted plots and field days through the Michael Fields Ag Institute.

The meetings have brought out the diverse needs among those interested in sustainable corn breeding. For example, there are some producers who are more interested in palatability than yield. They may be happy with an open-pollinated variety or a "synthetic" variety that they can adapt to their needs with some selection. Other producers want nutritional quality, but they also need high yields. Included in this group are small seed companies. The project is providing something for both these groups.

How can a breeding program that is tiny in comparison with the rest of the seed industry expect to come up with something new? By returning to the "roots" of corn, which lie in Mexico and Central and South America. USDA breeder Linda Pollak has spent most of her career working with these types of corn, which were selected for several thousand years by farmers who ate the corn themselves. These "exotic" varieties can contain high protein, oil, vitamins, or antioxidants. The trouble is, they are adapted to environments other than the Midwest. They need a growing season with shorter days than we have. In the Midwest these corns only tassel when the geese are flying south!

That is where the breeding comes in. The process started with another project called GEM (Germplasm Enhancement of Maize) that involves cooperative breeding from private and public breeders. GEM produced a series of "breeding crosses" that contain some genes for adaptation to the U.S. and some exotic genes for enhanced nutrient content. Linda and Walter were familiar with these crosses from their involvement in GEM, Linda by evaluating the exotic varieties and then coordinating the startup of GEM, and Walter by being a breeder cooperator. Linda and Walter are taking different but complementary approaches to improving the breeding crosses.

Walter is taking a "population improvement" approach similar to his improvement of Nokomis Gold. This fits in well with his resources, his need to work with earlier-maturing germplasm, and the Michael Fields philosophy.

Linda is using the inbreeding/testcross evaluation approach (Figure 4), which fits with her resources and her past GEM experience developing lines from the exotic breeding crosses. Starting from those breeding crosses, a couple of cycles of self-pollination and selection ("S1" and "S2") increase the uniformity and weed out undesirable traits.

Then it's time to see which of the S2 lines might eventually go into the makeup of a good hybrid or

Exotic variety X commercial inbred (GEM)

Select "breeding crosses""

Selfing" breeding crosses to develop S, lines

Select

"Selfing" S_1 crosses to develop S_2 lines

Select

S2lines X tester inbred line

Yield tests of experimental hybrids

(S_2 X tester)

Select 10 best combining S_2 lines

Combine 10 best S_2 lines together to make
a "synthetic" variety

Figure 4. The inbreeding and testcross evaluation approach.

synthetic variety. Their "combining ability" is evaluated by crossing them with established inbred "testers" and growing out the seed of the "experimental hybrids" resulting from these crosses.

There are many of these crosses, and they are planted at a number of farms. Table 7. shows results from yield trials of experimental selected, Midwest-adapted inbred lines in a single-cross test with a commercial inbred tester over eight locations in 2006. The BARBGP2:N08a12 experimental lines were originally derived from a population made by crossing a high-yielding population from the Caribbean island of Barbados with two adapted Corn Belt inbred lines. Note that the test cross that yielded best overall was not necessarily the same cross that gave the top yield at a particular site.

Table 7. Results from yield trials of experimental selected, adapted inbred lines in a single-cross test with a commercial inbred tester over eight locations in 2006. The BARBGP2:N08a12 experimental lines originally derived from a population made by crossing a high-yielding population from the Caribbean island of Barbados with two adapted Corn Belt inbred lines.

	Entry	Yield Bu/Ac	Test Wt. Lb/Bu	Moisture %
Highest-Yielding Site	BARBGP2:N08a12-249)--01-03/tester	181.5	59.8	15.4
	NC+ 52N17 (Check)	167.8	62.2	13.2
	BSSS(R)C15/BSCB1(R)-C15 (Check)	153.4	57.7	21.8
Over All Sites	BARBGP2:N08a12-20)--01-01/tester	143.8	59.4	14.2
	BSSS(R)C15/BSCB1(R)-C15 (Check)	132.0	58.2	20.2

The breeders ultimately go back to the S2 lines that made good experimental hybrids and use them in their breeding projects. Linda Pollak typically takes ten of the best S2 lines and crosses them in all directions to make a "synthetic" variety that should display a degree of hybrid vigor. These synthetics can then go through another selection cycle to make new S2 lines, but they may be reasonably good varieties in their own right. **Ron and LaDonna Brunk** (Eldora) grew a synthetic in 2004 that yielded 200 bushels in a small plot. The Brunks are now using selection to adapt that corn to the farm and are increasing the seed for planting a larger area. Until they have enough seed for a field trial, they won't know if this synthetic is reliable.

Grain quality is another aspect of the breeding program, and its importance is quickly coming into focus with changes in the organic poultry industry. Methionine is the amino acid most limiting in typical poultry feed, so organic producers have added synthetic methionine to feed to make up for the deficiency. This may be prohibited after October 2008. However, our breeding program has varieties with about one-third more methionine than typical corn, and in a recent trial by Organic Valley Co-op the corn successfully replaced added synthetic methionine. The challenge now is to increase seed of this variety so that it can go into production in time.

The corn breeding project needs farmers! If you have a small, isolated field, you could grow out a variety for seed increase. Or you might want to try one of these varieties in production, or even improve it for your farm with Linda or Walter's help. Your farm can be a site for yield evaluations managed by Linda's staff, or you can make an experimental variety cross hybrid in a small, isolated spot. Contact PFI if you'd like to be in the loop for future corn breeding workshop and field day announcements.