Breeding procedure speeds up winter wheat variety development

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Agricultural producers and waterfowl will benefit from a project at South Dakota State University that uses an innovative plant-breeding technique to shave perhaps two years off the time needed to produce winter wheat varieties for farmers in the Prairie Pothole Region of North America.

Using a technique that has been known since the 1980s but only more recently routinely implemented, breeders are pollinating wheat plants with corn to produce doubled-haploid wheat plants. The technique doesn't produce genetically modified plants or even combine the genes of the two crops because the corn chromosomes are transferred by pollination, a traditional crossing method, and the corn chromosomes, which are the carriers of the genes, are biologically eliminated during development of the wheat plants. In effect, the corn chromosomes act like placeholders that will be replaced by the wheat plant's own chromosomes during the production of the doubled-haploids.

The resulting doubled-haploids are homozygous lines with identical chromosome sets carrying genes originating only from the wheat parent. Consequently, instead of needing approximately six generations of conventional self-pollination, such homozygous lines are produced in only one. This procedure makes it easier and faster for breeders to select for desirable traits and produce finished varieties from those lines.

It's part of a push to produce winter wheat varieties specifically for the Prairie Pothole Region, or PPR, an area of nearly 300,000 square miles

that is home to millions of glacially formed wetlands.

South Dakota State University is one of three area universities involved in a Ducks Unlimited and Bayer CropScience initiative Winter Cereals: Sustainability in Action, or WCSIA. The WCSIA initiative seeks to increase agriculture productivity through research and agronomic assistance, while improving the habitat important to North America's waterfowl and other wildlife. North Dakota State University and the University of Minnesota are also involved in the project.

Winter wheat offers a big advantage to ducks in that it is seeded in the fall, so fields are not disturbed by spring planting operations coinciding with when ducks are nesting. Ducks Unlimited Canada's research shows that 24 times more nests are hatched in fall-seeded crops such as winter wheat and winter rye than in spring-seeded crops.

Bill Berzonsky, leader of SDSU's winter wheat breeding project, said postdoctoral researcher Melanie Caffe is working with him to speed up the process of developing winter wheat varieties by developing doubled-haploids.

"I would say in the traditional way, on average, we're probably talking 10 to 12 years from the initial cross to the final release of the variety. It could even be longer than that," Berzonsky said. "With this technique, my estimation is that it probably cuts off maybe one to two years from the process. You'd think it would cut off a lot more than that but we still need to test the doubled-haploid lines extensively in the field."

Berzonsky said using doubled-haploid lines has been done since about the 1980s — perhaps even longer, given the fact that wheat geneticists have long known about a technique that produces similar results but employs a different pollinator, a wild barley species.

“If you read the literature, there are many different types of pollen that can be used to more or less trick the wheat plant into thinking, at least initially, that it’s been self-pollinated. At a certain point, really during the development of the embryo itself, the dividing cells start to eliminate the chromosomes of the other species,” he said.

Caffe said the technique needs pollen of another plant species such as corn, and she, too, emphasized that it is not genetic modification in the same manner that produces transgenic or GM crops. The procedure doesn’t result in combining the genes of wheat and the other species — it only uses the pollen to induce the wheat to keep its own set of chromosomes, which are later chemically doubled in the last step of the procedure.

“This is not transformation. The aim is to arrive at a homozygous line,” Caffe said. “Instead of selfing many generations, in one step we can get to the homozygous stage. We cross the wheat with corn, and the chromosomes from the corn are eliminated from the cells during embryo development. In the dividing embryo cells you are going to have only the one set, the haploid set of chromosomes from the wheat.”

Berzonsky said that although one goal is to provide nesting cover and habitat for ducks in the PPR, farmers also benefit from adding winter wheat acres to their crop rotations.

“Increasing the acres of winter wheat is good for the growers for a number of reasons. Winter wheat fits into rotations very well. It’s a very nice crop because of the no-till aspects of its production, which should help conserve moisture in areas of drought or potential drought and conserve our soil and water resources.”

In addition, growing a fall-seeded crop such as winter wheat can lessen or spread the workload during the spring when most crops are being

seeded, and it allows producers to avoid dealing with wet conditions that are frequently present in the period leading up to and including spring planting. Finally, winter wheat often produces a higher grain yield than spring wheat because it is already at an advanced growth stage by the time spring wheat is just being planted. This allows the growing plants to take advantage of moisture deposited as snow in the winter and avoids warmer air temperatures during the flowering and grain-fill periods.

Blake Vander Vorst, Ducks Unlimited senior agronomist, said the implementation of the doubled-haploid plant breeding technique at SDSU is an exciting first step to increase the efficiencies of the winter wheat breeding programs in the PPR.

Alan Ayers, Bayer CropScience director of state affairs, agreed. “Improvement in traits such as cold tolerance, disease resistance and grain quality will pay big dividends for growers in the PPR and other regions in the future,” Ayers said.

Provided by South Dakota State University