Hard White Winter Wheat Breeding

Principal Investigators:

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Progress:

We doubled the number of hard white winter wheat (HWWW) lines tested for quality between 1998 and 2007. Tests included protein, mixographs, sedimentation, polyphenoloxidase (PPO) enzyme activity, pre-harvest sprouting tolerance and coleoptile length, in addition to stem rust, wheat streak mosaic virus (WSMV) and Fusarium head blight (FHB) screening. We incorporated resistance to prevalent races of stem rust and increased the winter survival ability of HWWW. We also increased coleoptile length and decreased PPO activity without sacrificing bread-making qualities. Pre-harvest sprouting (PHS) tolerance receives great attention in our program. Our latest HWWW "Alice" has PHS tolerance level that is similar to the red genotypes.

The Headrow nursery at the Dakota Lakes Research Farm consisted of 3933 white progenies in 1998, 5340 in 1999, 1635 in 2000, 7502 in 2001, 1954 in 2002, 11707 in 2003, 4915 in 2004, 8837 in 2005, and 5980 in 2007. The Early Yield Trial (EYT) nursery had 125 white entries in 1998, 182 in 1999, 174 in 2000, 117 in 2001, 99 in 2002, 141 in 2003, 270 in 2004, 255 in 2005, 235 in 2006, and 163 in 2007. The PYT nursery had 44 white entries in 1999 and 2000, 40 in 2001, 26 in 2002, 29 in 2003, 39 in 2004, 40 in 2005, 23 in 2006, and 16 in 2007. The Advanced Yield Trial (AYT) nursery had 3 experimental white entries in 1998, 26 in 1999, 22 in 2000, 10 in 2001, 11 in 2002, 14 in 2003, 8 in 2004, 11 in each 2005 and 2006, and 12 in 2007. The Crop Performance Testing (CPT) Variety Trials nursery had 3 experimental white entries in 2000 and 2001, 5 in 2002, 4 in 2003, 5 in 2004, and 3 in each 2005, 2006, and 2007.

Before 2004, only a few HWWW lines tested low for PPO activity. From among the large number of low PPO stem rust resistant lines in our 2004 EYT, several lines had strong gluten characteristics that were not linked to high protein levels. The best performers were included in the 2006 AYT, and three lines were tested in the 2007 CPT. In the past the availability of such germplasm was limited. The combination of low PPO, strong gluten, and moderate protein will maximize the probability of selecting lines that possess both good noodle color stability and breadmaking characteristics. We are placing more emphasis on rust, WSMV, and tan spot resistance, in addition to quality and PHS tolerance in our HWWW germplasm. Collaborative effort in research with Dr. Gu is ongoing to identify PHS resistant germplasm to incorporate into the breeding program.

Project Objectives:

1. Accelerate and strengthen early generation population development through expansion of single-seed descent (SSD) greenhouse procedures to involve disease and PPO screening.
2. Develop and utilize improved germ plasm for specific HWWW traits such as pre-harvest dormancy,
3. Expand field testing for populations already under development, and
4. Develop improved HWWW cultivars and germ plasm that will increase yield and stability, end-use quality both for bread and noodle, and consequently increase marketability of South Dakota winter wheat.

Rational and Justification:
Our continued effort to develop adapted HWWW varieties is driven by enhanced milling performance, increased domestic interest in white, increase consumption of whole-wheat bread (tastes less bitter, requires less sugar during processing, looks nicer than red, whole-wheat bread) and other HWWW products, the promise of increased export opportunities to the oriental and Middle Eastern markets which prefer HWWW for making noodles and steamed bread, and the potential of expanding the acreage of HWWW in the Great Plains once adequate pre-harvest sprouting levels become available. We are watching the western Kansas and eastern Colorado experience with HWWW marketing. A great effort is being lead by the private industry and wheat producers' boards to overcome such obstacles. This experience should also be transferable to South Dakota growers.

Our primary justifications for increased HWWW breeding efforts include the following:
1) Availability of flexible handling and marketing avenues (e.g., elevators in the state are accustomed to handling multiple crops and have multiple small storage bins for multiple smaller crops),
2) speculation that if HWWW predominates in the Great Plains, many hard red winter wheat producers in South Dakota might be discounted at least by the reported milling advantage (3 – 5 percent) of HWWW (assuming $10 wheat and a 50 million bushel crop, these discounts could total $25 million annually for South Dakota winter wheat),
3) the availability of only very few public or private sector broadly adapted HWWW cultivars suitable for planting in South Dakota requires increasing the local breeding efforts to meet the needs of the South Dakota producers.

Project Proposal:
The majority of white/white populations will be handled through a modified bulk hybrid method starting with the F1 increase and ending with lines entrance into the AYT which is planted in eight locations in South Dakota, and one location each in North Dakota, Nebraska, and Colorado. Based on field performance and various cooperative screening tests, roughly two to five lines will be advanced each year for further testing in the CPT Variety Trial, and the Northern Regional Performance Nursery (NRPN). The USDA-ARS Regional Quality Lab will perform comprehensive milling and baking tests on all lines advanced to the CPT or retained for a second year of AYT testing. An emerging crop quality lab at SDSU is also expected to enhance progress from selection with regard to HWWW quality. Promising elite lines from the program will be entered for comprehensive bread quality testing by the Wheat Quality Council (WQC) and for noodle and steamed buns quality testing by the US Wheat Associates. Based on performance and various cooperative evaluations, promising elite lines at this stage will be advanced for further testing and subjected to preliminary seed increase to prepare for possible release.

We will handle the red/white populations separately from other crosses in a new procedure with two headrow generations prior to entry in the EYT nursery. The F2 nursery will be space-planted to enable sampling of heads from each plant in the F2 populations. Heads with white seeds will be retained and planted as F3 headrows. A head will be harvested from each plant in selected headrows. A few seeds of each head will be evaluated for PPO and heads with very high PPO will be discarded. The remainder of heads will be planted as F4 headrows the following season. Selected F4–derived lines will undergo extensive yield testing in the EYT, PYT, AYT, and CPT

nurseries similar to red/red and white/white populations. The Arizona nursery will still be used for purification of Breeder Seed prior to Foundation Seed increase.

We have made crosses with HWWW experimental lines that demonstrated superior level of pre-harvest sprouting resistance and excellent quality. This level of sprouting protection will eliminate the risk of sprouting in the Southwestern parts of the state, and will make it possible for future production of HWWW further east and north. We will continue development of reliable and repeatable screening procedures for preharvest sprouting tolerance. We also practiced a backcrossing program that involved adapted white lines, as recurrent parents, and elite red germplasms that have excellent disease resistance in addition to tolerance to cold and drought stresses as donor parents to improve the adaptation of our white wheat germplasm.

We are now testing for actual noodle color of promising advanced HWWW lines in our lab. Only lines that we include in the NRPN were tested for this trait in the past.