

**Developing Winter Wheat
with High Yield, Disease Resistance, and Excellent End-use Quality
(Approved July 2012)**

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Objectives:

1. Rapidly develop South Dakota winter wheat varieties competitive and stable for grain yield compared with the top 5 percent yielding varieties in the state.
2. Rapidly develop South Dakota winter wheat varieties with resistance to the prevalent races and biotypes of bacterial, fungal, and viral disease pathogens.
3. Rapidly develop South Dakota winter wheat varieties with excellent quality for bread, wheat flour tortillas, and other emerging end-use markets.

Importance to South Dakota:

The recent South Dakota National Agricultural Statistics Survey of wheat varieties (SDNASS, 2011) demonstrated that over 50 percent of the most widely grown varieties in the state are publicly developed and the third most popular variety, 'Expedition,' was developed by the SDSU Winter Wheat Breeding Program and released by the South Dakota Agricultural Experiment Station (SDAES) in 2002. Additionally, 'Lyman', a 2008 SDAES winter wheat variety release, is gaining in popularity. The most recent 2011 SDAES variety release, 'Ideal,' is expected to compete very well with the most widely planted winter wheat varieties in the state. Clearly, the release of new winter wheat varieties from the SDSU Winter Wheat Program is important to the state and SDSU releases are favored by South Dakota wheat producers. Consequently, it is important to support the rapid development of high yielding winter wheat varieties with superior disease resistance and excellent end-use quality.

South Dakota is of special geographical significance because it is at the interface of the southern and northern areas of winter wheat production. This requires that winter wheat adapted to the state be able to resist new disease pathogen races that generally develop in the southern region and spread northward. It is well known that South Dakota winter wheat varieties represent some of the most disease resistant germplasm in the region, particularly resistance to Fusarium head blight (Bockus et al., 2011). Therefore, it's important to continue to focus variety development on maintaining and improving disease resistance.

A consensus of major U.S. milling and baking industry companies recently rated several of the most advanced South Dakota winter wheat breeding lines as having good to excellent milling and baking qualities (Wheat Quality Council, 2012). This is the result of extensive quality testing within the breeding program and a result of considerable collaboration the program enjoys with the Seed Technology Crop Quality Lab. It's important to South Dakota wheat producers to continue to release varieties with high quality in order for them to market their crop into an increasingly competitive domestic and global industry.

In 2010, Mission Foods, a leading US and worldwide producer of wheat flour tortillas announced the addition of a 100 percent whole-wheat flour tortilla to their product line, and as of 2008, wheat flour tortillas were deemed to be eligible for the national Women, Infant, and Children's (WIC) Program (Mission Foods Press Release, 2010). This eligibility is indicative of how popular wheat flour tortillas have become and the introduction of a whole-wheat tortilla is also indicative of an emerging flour end-use and healthy alternative to bread. It's important that the SDSU Winter Wheat Breeding Program be positioned to develop new varieties with the special starch and protein qualities to service this growing market, as well as other emerging end-use markets, for the benefit of South Dakota producers.

Outcomes/Deliverables:

- New and unique winter wheat segregating populations that combine superior yield, yield-stability, disease resistance, and improved end-use quality characteristics.
- Rapid production of winter wheat breeding lines exhibiting superior agronomic and quality performance compared with existing lines.
- Production of winter wheat varieties with new sources of host resistance to bacterial leaf blight, Fusarium head blight, leaf rust, and stem rust, and the dissemination of variety x environment information, the quality performance of varieties, and the response of varieties to disease and fungicides.

Justification:

Despite a decline in winter wheat production, there continues to be interest in new winter wheat varieties for South Dakota, and particularly the expansion of winter wheat production within the region. In 2011, the USDA estimated that approximately 1.6 million acres of winter wheat were seeded in South Dakota, which may represent one of the few times more winter than spring wheat was produced in the state. Coupled with high commodity prices, this is a good indication of the desire of South Dakota growers to produce winter wheat and maintain it in their crop rotations. As part of a continuing agreement with Ducks Unlimited and Bayer CropScience, the Winter Wheat Breeding Program at South Dakota State University is also developing varieties adapted to the broader portion of the region – The Prairie Pothole Region.

SDSU winter wheat breeding lines and varieties continue to rank among the very best in the region for resistance to Fusarium head blight (FHB), leaf rust, and stem rust. Although in FY12 USDA support has been reduced for all federal wheat disease resistance initiatives, the SDSU Breeding Program continues to receive funding from a federal stem rust initiative targeting the development of winter wheat varieties with resistance to the new race of stem rust in Africa, *Ug99*. This funding is recognition of the geographical significance of South Dakota as well as the historical losses in the Dakotas due to stem rust. Funding from the South Dakota Wheat Commission will help leverage federal funds to develop the necessary Fusarium and stem rust resistant varieties to safeguard winter wheat production in South Dakota.

The Seed Technology Crop Quality Lab continues to serve an important role in assuring that South Dakota winter wheat varieties meet end-use quality standards for the milling and baking industry. Commission support of this quality testing within the breeding program helps to maintain the domestic and global competitiveness of South Dakota winter wheat as well as address emerging end-use markets, as in the case of wheat flour tortillas.

South Dakota Wheat Commission funding will help support graduate student research, which is an important component of the breeding program and one which is justified because student projects provide crucial information on how to improve varietal development methodologies. Student projects are directly linked to specific production problems facing South Dakota winter wheat producers. Examples of these projects include; a student project to identify drought resistance traits in winter wheat, one to address how grain yield stability is maintained over environments, and one demonstrating how well the use of an automated sorter helps with selection for kernel color.

Materials and Methods:

The development of high-yielding winter wheat varieties will follow an established and successful procedure that involves; a) Making approximately 500 to 750 inter-matings per year, b) Selecting for plant type and disease resistance among hundreds of segregating early generation F₂ and F₃ populations and thousands of segregating headrows, and c) Evaluating and advancing breeding lines from a replicated Early Yield Trial Nursery (EYT), a replicated Preliminary Yield Trial Nursery (PYT), and a replicated Advanced Yield Trial Nursery (AYT). The very highest performing breeding lines will be advanced and tested statewide in a Crop Performance Trial (CPT) and region-wide in the Northern Regional Performance Nursery (NRPN). Lines exhibiting the highest disease resistance, grain yield, and end-use quality characteristics will be considered for release, and those with potential to be released, will also be tested for end-use quality on a commercial scale in Wheat Quality Council (WQC) Trials.

The crossing strategy is to make adapted/adapted (two-way crosses) and adapted/un-adapted//adapted crosses (three-way crosses), between SDSU winter wheat parents and those derived from regional winter wheat programs

that represent adapted and un-adapted types (e.g. spring wheat or other exotic germplasm). Selected parental germplasm will have superior resistance to the disease pathogens and insects threatening South Dakota producers. Unique germplasm with resistance to FHB, WSMV, tan spot, Septoria, stem and leaf rusts, and hard white grain characteristics continue to be advanced within the breeding program. We have initiated crosses with spring parents that have new sources of resistance to Septoria and stem rust, which were obtained from the USDA-ARS (in Fargo, ND), and we continue developing germplasm from Kansas that carries new sources of resistance to the *Ug99*. Single and three-way crosses involving solid-stemmed spring wheat parents and parents from Montana State University have been made and lines are being developed from these crosses. These lines are expected to exhibit resistance to the wheat stem sawfly.

Variety development will benefit from an accelerated breeding approach that is part of an existing agreement with Ducks Unlimited and Bayer CropScience. Portions of the breeding activities relating to disease evaluations of the winter wheat breeding trials and the accelerated breeding approach will be performed in collaboration with Ms. Connie Tande and the SDSU Plant Diagnostics Lab, as well as with the recently hired faculty Cereal Research Pathologist, Dr. Shaukat Ali. Disease evaluations will be conducted using replicated field nurseries in which the PYT, AYT, and CPT breeding lines are exposed to natural and artificial disease pathogen pressures. Breeding line entries will be inoculated and evaluated for leaf, stem rust, and tan spot in annual greenhouse screenings, and the same lines will be evaluated under heavy natural rust infection conditions in nurseries planted at Castroville, TX.

To assess yield stability over South Dakota environments and the contributions of disease resistance to genotypes, we will continue to compare CPT nursery results from those treated with a fungicide to those from CPT nurseries that do not receive fungicide treatments. In addition, a conditional statistical model developed by SDSU faculty member Dr. Jixiang Wu will be applied to the CPT fungicide and non-fungicide treated yield trials. Use of these data in such a model will help us determine the yield components that contribute to yield-stability and understand how to effectively select for this always important characteristic. Additional data collected on disease response and stay-green response to the fungicide treatment will be included in the model.

The expansion of end-use quality testing at the Seed Technology Crop Quality Lab has improved the ability of the Winter Wheat Breeding Program to assess end-use quality of breeding lines and to test for unique qualities necessary for emerging markets. Specifically, in collaboration with Dr. Padmanaban Krishnan, the breeding program expects to routinely conduct quality tests for the starch and protein qualities necessary for the production of superior bread types, noodles, and wheat flour tortillas. A newly developed dough expansion evaluation system, a recently acquired Chopin SDmatic, and a specially modified wheat flour tortilla maker will be utilized to determine breeding line end-use qualities and predict the quality of new varieties. Dr. Krishnan's cereal chemistry expertise and help in interpreting data generated is vitally important to the success of advancing the very best breeding lines for possible release.

Project Deliverables:

- Annual Winter Wheat Variety Description Guide and Field Tour Information on Winter Wheat Varieties
- Annual Reports of Breeding Program Status
- Thorough Assessments of Winter Wheat Bacterial Leaf Streak, Lr, Sr, and Tan Spot Disease Resistance
- Completion of Graduate Student Research Projects, Publication of Results, and Matriculation of Graduate Students
- Thorough Assessments of Winter Wheat Milling & Baking Quality
- Winter Wheat Variety Releases

Summary of Past SD Wheat Commission Funding: This represents a continuation of the FY11 project funded

Computer programs for evaluating yield stability were developed and along with the collection of additional data, the programs will be implemented to assess yield stability of genotypes in comparisons between fungicide and non-fungicide treated nurseries. In FY11, the SDSU Diagnostics Lab processed winter wheat samples submitted by growers for virus identification. In FY 12, we expect the Diagnostics Lab will help guide selection by

processing more samples from within breeding nurseries throughout South Dakota locations. Marker genotyping for host plant resistance genes to Fusarium, leaf rust, and stem rust helped with the selection and advancement of breeding lines with excellent disease resistance. Extensive testing for protein quantity along with mixograph and other tests of functional quality helped with the selection of high end-use quality breeding lines, a group of which are being considered as possible varietal releases.

References:

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- SDNASS, 2011. Wheat varieties-2011. USDA South Dakota National Agricultural Statistics Service, Aug. 2011.
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