Developing Winter Wheat Varieties with Resistance to Pests and Pathogens
(Approved July 21012)

Principal Investigator: William Berzonsky Winter Wheat Breeding/Genetics, Plant Science Dept., SDSU
Collaborators: Buyung Hadi, Pesticide Ed and Urban Entomology, SDSU
  Jose Gonzalez, Applied Crop Genetics/Genomics, SDSU
  Marie Langham, Professor, Plant Virology, SDSU

Objectives:
To identify and incorporate into winter wheat varieties new sources of resistance to Barley Yellow Dwarf Virus (BYDV), Wheat Streak Mosaic Virus (WSMV), the wheat curl mite, and the wheat stem sawfly.

Importance to South Dakota:
Winter wheat is one of the most important cereal crops to the state of South Dakota, and especially to producers in the western portion of the state. Maintaining and increasing winter wheat yields and profitability will depend on SD growers being able to stay ahead of threats to production from emerging pests and pathogens. Some pathogens and pests, such as those represented by the viral diseases; BYDV, WSMV and its wheat curl mite vector were particularly devastating in their impact on SD winter wheat production in the recent 2011 growing season (**Fig. 1**).

Although the viral pathogens are often continuous threats to SD winter wheat production, earlier plantings of winter wheat and the presence of "green bridges" created by the survival of volunteer spring wheat have likely exacerbated the problem in recent production seasons. Similarly, the wheat stem sawfly is emerging as a significant threat to winter wheat production, perhaps due to the ready availability of straw in no-till systems or again, due to the "green bridge", i.e. the availability of green tissue at critical insect survival times.

In the case of the sawfly, a 2009 SD survey for sawfly reported some wheat fields close to the border of North Dakota exhibited up to 20 to 60 percent infestation rates (Blodgett, personal communication.). Because South Dakota is one of the few states with nearly the same acreage of winter and spring wheat and the sawfly has adapted its life cycle to infest both, it is critical that resistant varieties be developed to avoid the sawfly becoming a major problem to both wheat crops, as is already the case in Montana.

Several new sources of host plant resistance to these emerging pathogens and pests have recently been developed and released as germplasm (**Table 1**). We propose using molecular markers associated with the resistance genes for these traits to help pyramid or stack these genes into single genotypes and varieties. We will test our expectation that pyramiding these genes will produce winter wheat varieties with higher levels of resistance and/or more durable resistance to BYDV, WSMV, the wheat curl mite, and the wheat stem sawfly.

Outcomes/Deliverables:
- A better understanding of the extent and scope of emerging pathogen/pest problems facing South Dakota winter wheat producers.
- An overall enhancement of resistance for existing winter wheat breeding lines, which will hasten the development of resistant varieties.
- New winter wheat varieties with higher levels and more durable resistance to BYDV, WSMV, the wheat curl mite, and the wheat stem sawfly.

Justification:
Regardless of the impact of other bacterial and fungal diseases on the production of winter wheat, the viral diseases (BYDV, WSMV, etc.) are thought to have caused some of the heaviest of production losses in the 2011 production season.
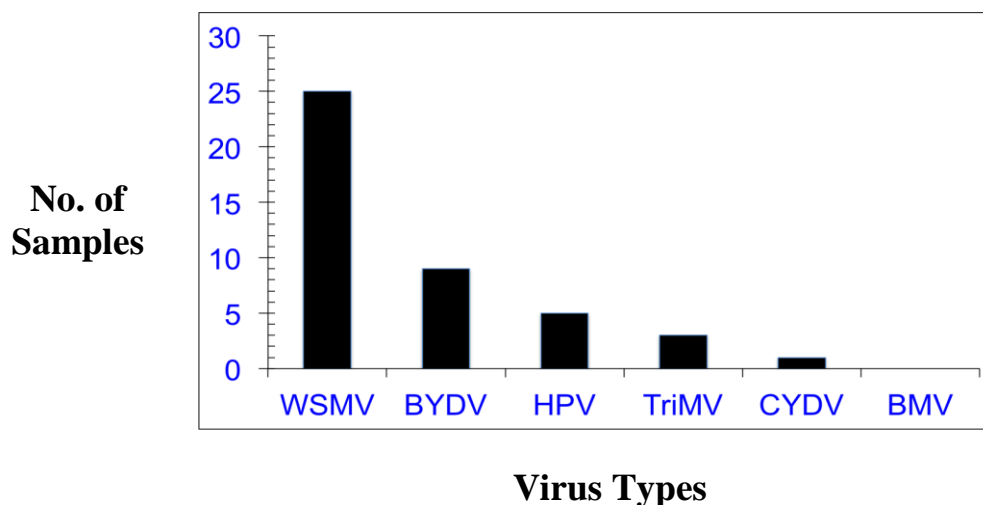
Virus Types

Fig. 1. Results of 2011 winter wheat samples processed by SDSU
Disease Diagnostics Lab (Data compliments of Connie Tande).

We believe this is often the case, and furthermore, the sawfly is an emerging insect problem that has the potential to cause even more losses for both winter and spring wheat. The viral disease problem is ever-present and possibly worsening because of earlier winter wheat plantings and the existence of "green bridges" that facilitate survival of aphids and the curl mites -- vectors of the viruses. Excellent new sources of resistance and molecular markers associated with the genes for resistance to these pathogens and pests are now available (**Table 1**), and this favors a breeding approach that couples marker-assisted selection with pyramiding the genes into single genotypes and varieties. In addition, we hope to leverage support of this approach by applying doubled-haploid technology within the crossing scheme to hasten disease resistant variety development, a major focus of our existing Winter Cereals Sustainability in Action Initiative.

Materials and Methods:
Winter wheat materials are readily available to cross and combine sources of resistance to BYDV, WSMV, the wheat curl mite, and the wheat stem sawfly. To facilitate marker-assisted selection, closely linked molecular markers for these genes are also available (**Table 1**).

Table 1. Wheat genotypes available, their resistance genes, and associated markers.

Genotype	Resistance	R-Genes	Markers	Reference
PI 660987 (MT06X424-B6) PI 660988 (MT06X424-B20)	Wheat curl mite	*Cmc3 and Cmc4*	*Xgdm141, SCM09, XksuG8*	Hofer et al., 2011 Malik et al., 2003
PI 653716(Wesley)	WSMV	*Wsm1*	*STSJ15*	Mutti et al., 2011
PI 653714(Millennium)	WSMV	*Wsm1*	*STSJ15*	Mutti et al., 2011
Everest	BYDV	?	?	Fritz et al., 2011
Bearpaw and Mott	Sawfly	Solid Stem (*Qss.msub-3BL*)	*GWM247, GWM340, GWM547*	Cook et al. 2004

We plan to pyramid all resistance sources into single, adapted winter wheat genotypes by implementing the crossing and evaluation scheme represented in **Fig. 2.** With the exception of Mott, a regionally adapted sawfly resistant spring wheat, all parents are regionally adapted winter wheat genotypes, and the Montana genotypes also carry resistance genes for leaf rust, Septoria leaf blotch, and in the case of MT06X424-B20, low polyphenol oxidase activity.

Project Deliverables

- New winter wheat varieties with higher levels and more durable resistance to BYDV, WSMV, the wheat curl mite, and the wheat stem sawfly

- An overall enhancement of resistance for existing winter wheat breeding lines, which will hasten the development of resistant varieties

- A better understanding of the extent and scope of emerging pathogen/pest problems facing South Dakota winter wheat producer

Summary of Past SD Wheat Commission Funding:
This project represents an expansion of an award made by the commission to Dr. Sue Blodgett and her proposal to evaluate possible sources of resistance for wheat stem sawfly and Hessian fly. We anticipate this proposed research will be seamlessly integrated with a planned expansion of the SDSU doubled-haploid effort. Dr. Blodgett's past commission award included partial support of a M.S. graduate student and travel (total request of $15,389). After Dr. Blodgett left the employ of SDSU, a graduate student was identified and hired for the project. Initial crosses between solid stem genotypes have been made, and using a newly developed pheromone as an attractant, a small survey was completed to identify the presence and frequency of Hessian fly at several different South Dakota locations.

References:
Cook, J.P., D.M. Wichman, J.M. Martin, P.L. Bruckner, and L.E. Talbert. 2004. Identification of microsatellite markers associated with a stem solidness locus in wheat. Crop Sci. 44:1397-1402.

Fritz, A.K., T.J. Martin, and J.P. Shroyer. 2011. Everest hard red winter wheat. Kansas State University AES and Coop. Ext. Serv., Publ. L-930.

Hofer, P., J.E. Berg, L. Huang, R.J. Graf, and P.L. Bruckner. 2011. Registration of 'Yellowstone' winter wheat backcross-derived lines incorporating leaf rust and wheat curl might resistance. J. Plant Reg. 5:422-425.

Malik, R., G.L. Brown-Guedira, C.M. Smith, T.L. Harvey, and B.S. Gill. 2003. Genetic Mapping of wheat curl mite resistance genes *Cmc3* and *Cmc4* in common wheat. Crop Sci. 43:644-650.

Mutti, J.S., P.S. Baenziger, R.A. Graybosch, R. French, and K.S. Gill. 2011. Registration of seven winter wheat germplasm lines carrying the *Wsm1* gene for wheat streak mosaic virus resistance. J. Plant Reg. 5:414-417.