Developing Winter Wheat Varieties with Resistance to Pests and Pathogens Emerging as Significant Threats to SD Production

Report submitted by Dr. Melanie Caffee:
Viral diseases caused by the Wheat Streak Mosaic Virus (WSMV) and Barley Yellow Dwarf Virus (BYDV) can have a devastating impact on South Dakota winter wheat production. In addition, a new emerging pest, the wheat stem sawfly, which has caused significant losses on wheat production in Montana and other states in the region, is becoming a threat in South Dakota. Resistant or tolerant cultivars play an important role in managing those diseases and emerging pests. One of the objectives of this project was to develop winter wheat varieties with improved resistance to WSMV, BYDV and wheat stem sawfly by combining several sources of resistance into single winter wheat varieties.

The variety Mace, developed by the USDA-ARS and Nebraska Agricultural Experiment Station and released in 2007 (Graybosch et al., 2009), was used as source of resistance to WSMV. Its resistance to WSMV is conferred by the presence of *Wms-1* gene. The solid stem variety Bearpaw (MTS0721), developed by Montana State University and released in 2011 (Carlson et al., 2013), was used as source of resistance to wheat stem sawfly. Everest, a cultivar developed by Kansas State University and released in 2009 (Fritz et al., 2011), was used as source of tolerance to BYDV. Mace, Bearpaw and Everest are all regionally adapted cultivars. In addition to its tolerance to BYDV, Everest exhibits some level of resistance to Fusarium head blight, Hessian fly, leaf rust and stripe rust. Breeding materials issued from crosses with Mace, Bearpaw, or Everest are at the F_2, F_3, and $F_{3:4}$ stages. Additional lines will be derived from those populations and will be evaluated and selected based on agronomic characteristics, stem solidness and virus resistance. New crosses with additional sources of resistance will continue to be made in order to combine several sources of resistance into single winter wheat varieties.

By combining those different sources of resistance, we expect to develop breeding lines with improved resistance to WSMV, wheat stem sawfly, and BYDV, in addition to other diseases and pests commonly encountered in South Dakota. The future release of winter wheat varieties combining several sources of resistance will help wheat producers in controlling those emerging threats.

Carlson, G. R., J. E. Berg, R. N. Stougaard, J. L. Eckhoff, P. F. Lamb, K. D. Kephart, D. M. Wichman, J. H. Miller, N. R. Riveland, D. L. Nash, W. E. Grey, Y. Jin, J. A. Kolmer, X. Chen, G. Bai, and P. L. Bruckner. 2013. Journal of Plant Registrations 7:180-183.

Graybosch, R. A., C. J. Peterson, P. S. Baenziger, D. D. Baltensperger, L. A. Nelson, Y. Jin, J. Kolmer, B. Seabourn, R. French, G. Hein, T. J. Martin, B. Beecher, T. Schwarzacher, and P. Heslop-Harrison. 2009. Registration of 'Mace' Hard Red Winter Wheat. Journal of Plant Registations 3:51-56.

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.

Report submitted by Dr. Adrianna Szczepaniec:
In addition to these activities, **we tested the impact of five hollow and solid stem varieties of winter and spring wheat on the incidence and severity of wheat stem sawfly** (WSS) infestations in the field. This is an emerging pest of wheat, and has been especially devastating in Montana, Colorado, and Nebraska. There are reports of WSS damaging wheat in North Dakota as well. Damage by this insect causes severe lodging of wheat that affects harvest and contributes to significant loss in yield. Current management strategies are limited to the use of resistant wheat varieties, as chemical control of adults is not feasible, and no effective control methods of larvae inside the stems are available. Solid stem varieties have been shown to provide protection from WSS. They have not been tested in South Dakota prior to this work, however.

Methods: These trials took place in Bison and Ralph, where presence of WSS was noted in the previous year. Winter wheat varieties that were selected included Expedition, Ideal, Lyman, Overland, Wesley (hollow stem), and Bear Paw, Genou, Judee, MTS0808, and Rampart (solid stem). Spring wheat varieties included Advance, Brick, Forefront, Select, Traverse (hollow stem), and Choteau, Duclair, Fortuna, Mott, and Vida (solid stem). All varieties were replicated four times at each location. Samples of wheat stems were taken in late July and early August 2013. Three subsamples of five wheat plants were taken from each of the plot by walking in a diagonal pattern across each plot. Stems were brought back to the laboratory, dissected, and WSS were counted under the microscope.

Results: There were significantly greater populations of WSS in Bison than in Ralph. Moreover, numbers of WSS in Ralph were too small to make inferences about the impact of the different varieties on likelihood of WSS infestations. We identified several varieties that tended to have fewer WSS in Bison, such as Genou (winter wheat solid stem variety), Advance and Brick (spring wheat, hollow stem varieties). WSS levels in general were still relatively low in Bison, however, and we noted a large variability in likelihood of infestations. This variability precluded any definitive conclusions about the effectiveness of the varieties we tested against WSS. This research will be repeated next year, and we will pull data from both years in order to identify patterns of WSS infestations based on variety type to identify varieties that have exhibit adequate resistance to WSS.

There were location-dependent differences in test weight (spring wheat) and percent protein (winter and spring wheat) that were not related to whether the varieties were hollow or solid stem. Solid stem varieties of winter and spring wheat did have slightly slower yields than hollow stem varieties at both locations, however.

Relevance to Producers: The challenge that we face with this new emerging pest is lack of effective chemical control options, and lack of data on feasibility and effectiveness of using resistant varieties of wheat in South Dakota. The goal of this work is to identify varieties of winter and spring wheat that provide sufficient protection against WSS while suffering little yield penalty and producing grain of desirable quality. Data we collected in the first year of this research is preliminary, however, and limited by the small populations of WSS noted in the study locations. This was probably caused by the fact that the pest is only beginning to colonize South Dakota. Moreover, cool and wet spring contributed to generally lower insect pressure this season. We will continue this research in locations that will likely see increasing pressure from WSS in order to gather relevant data that will allow us to make informed recommendations for producer in South Dakota when this pest becomes a more prominent threat.

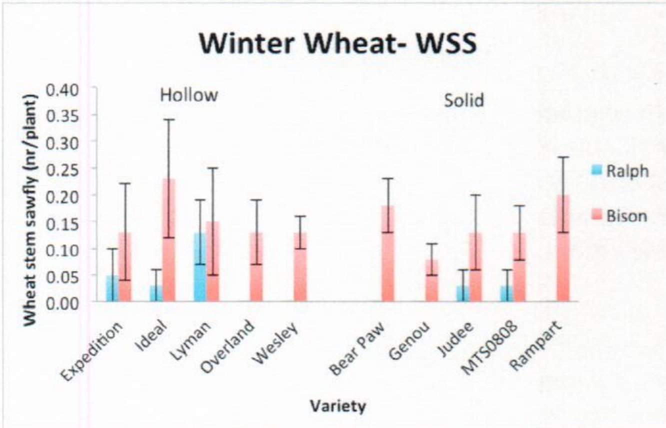

Fig. 1. Effect of hollow and solid winter wheat varieties on wheat stem sawfly (WSS) numbers. There was a significantly greater number of WSS in Bison than in Ralph. Population levels were relatively low and highly variable, however, which affected our results ($F_{9,30}$=0.39; P=0.93). While not statistically different from hollow varieties, solid variety Genou tended to have the lowest number of stems infested with WSS among all solid varieties we tested.

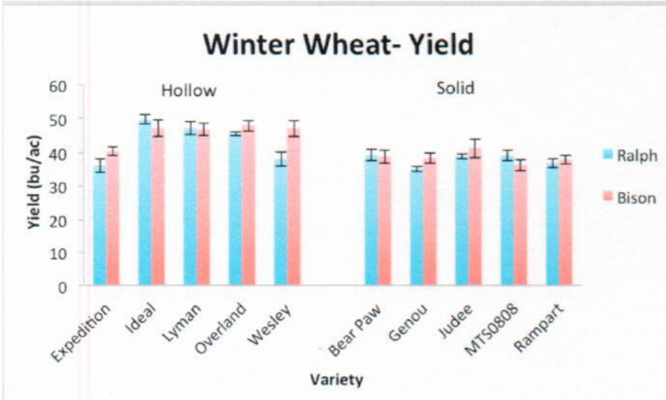

Fig. 2. Yield of hollow and solid stem varieties with WSS resistance. There was a significant difference in yield between the hollow and solid stem varieties in Ralph ($F_{9,30}$=10.39; P<0.01) and Bison ($F_{9,30}$=5.57; P<0.01). With the exception of Expedition at both locations and Wesley in Ralph, the hollow varieties tended to have higher yields than the solid stem varieties.

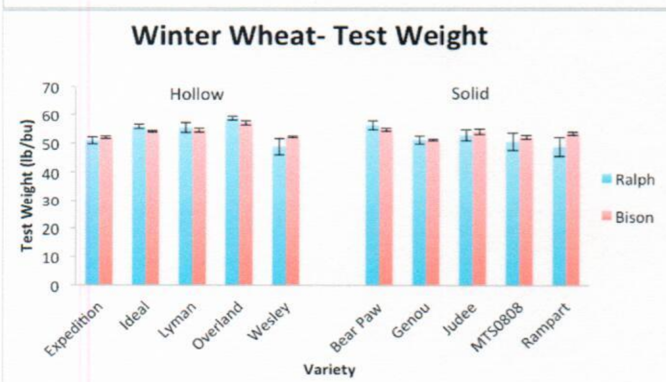

Fig. 3. Test weight of hollow and solid stem varieties with WSS resistance. There was a significant difference in test weight among the varieties in Ralph ($F_{9,30}$=2.79; P=0.02) and Bison ($F_{9,30}$=8.87; P<0.01). The hollow varieties tended to have higher test weight than the solid stem varieties.

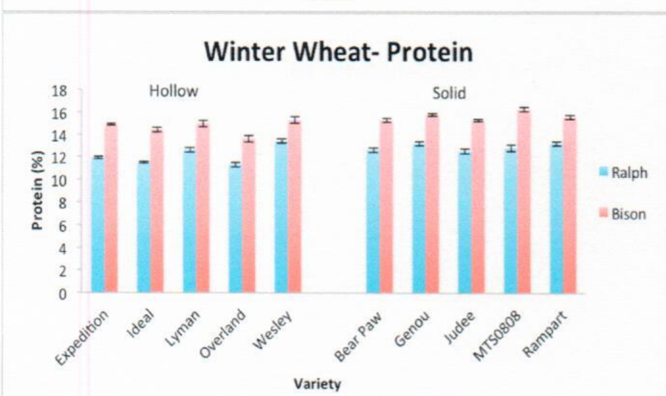

Fig. 4. Percent protein in hollow and solid stem varieties with WSS resistance. All varieties in Bison had greater protein content than varieties planted in Ralph. There were also significant differences in protein among varieties in Bison ($F_{9,30}$=13.31; P<0.01), and the solid stem Montana variety MTS0808 had the greatest protein content, while the hollow variety Overland had the lowest protein content. Significant difference in Ralph ($F_{9,30}$=12.49; P<0.01) where primarily driven by hollow stem varieties Expedition, Ideal, and Overland, which had the lowest protein content

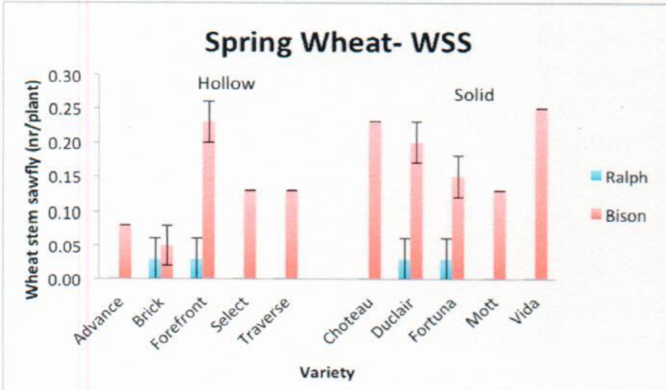

Fig. 5. Effect of hollow and solid spring wheat varieties on wheat stem sawfly (WSS) numbers. There was a significantly greater number of WSS in Bison than in Ralph. Population levels were relatively low and highly variable, however, which affected our results ($F_{9,30}$=0.78; P=0.64). We found that two hollow-stem varieties, Advance and Brick, had the lowest rates of WSS infestation.

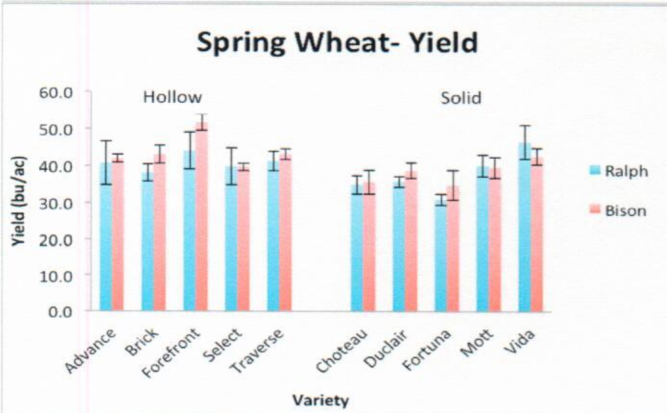

Fig. 6. Yield of hollow and solid stem varieties with WSS resistance. There was a significant difference in yield among the varieties in Bison ($F_{9,30}$=3.72; P=0.004) but not in ralph ($F_{9,30}$=1.44; P=0.22). Forefront and Vida were the highest yielding hollow and solid stem varieties, respectively.

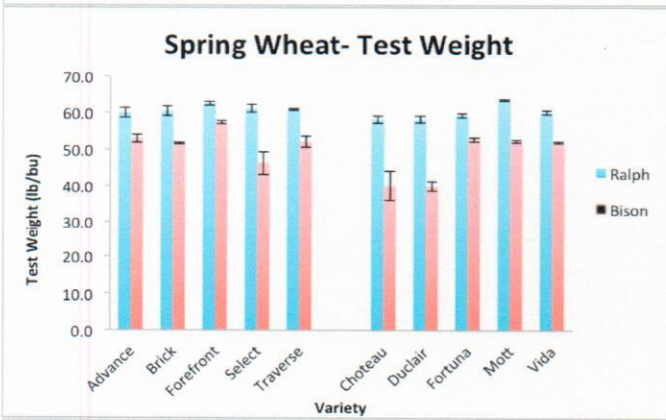

Fig. 7. Test weight of hollow and solid stem varieties with WSS resistance. All varieties planted in Ralph had greater test weight than varieties planted in Bison. There was also a significant difference in test weight among the varieties in Ralph ($F_{9,30}$=3.45; P<0.01) and Bison ($F_{9,30}$=11.09; P<0.01). Hollow stem varieties in general did not have greater test weight than solid stem, with the exception of Choteau and Duclair in Bison, which had the lowest test weight.

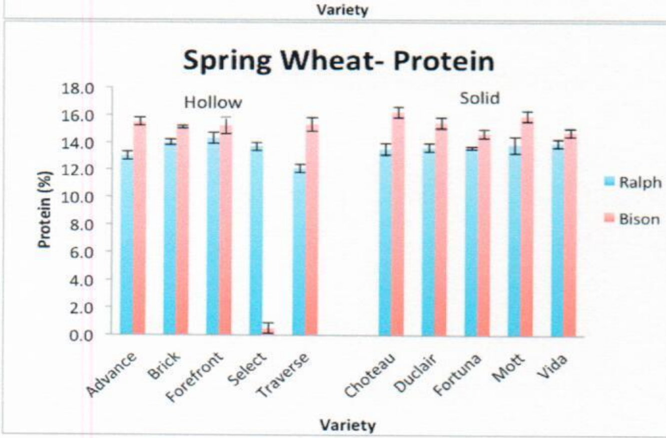

Fig. 8. Percent protein in hollow and solid stem varieties with WSS resistance. With the exception of Select, all varieties in Bison had greater protein content than varieties planted in Ralph. There were also significant differences in protein among varieties in Ralph ($F_{9,30}$=3.36; P<0.01), but not in Bison ($F_{9,30}$=1.58; P=0.17). There was no apparent difference between hollow and solid stem varieties on protein content in either location.