Evaluation of Wheat for Resistance and Response to Viral Diseases

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Objectives (Summarized for all parts of the proposal)
1. Evaluating winter wheat lines in the AYP-CPT nurseries for their performance when infected with wheat streak mosaic virus (WSMV).
2. Researching aspects of the viral disease relationship that will potentially enhance our ability to evaluate winter wheat for resistance or tolerance.
3. Completing data collection and evaluation for 2007-2008 WSMV Winter Wheat Nursery.
4. Planting and inoculating the 2008-2009 WSMV Winter Wheat Nursery.
5. Participating in the Great Plains Wheat Virus epidemiology proposal.

Wheat Streak Mosaic Virus Winter Wheat Evaluation Nursery

Justification:
Wheat streak mosaic virus (WSMV) (Family: Potyviridae; Genus: Tritimovirus) causes the most economically important viral disease affecting winter wheat in South Dakota. Studies have shown that winter wheat losses due to WSMV range from 2.5-5 million bushels annually with greater losses occurring in epidemic years. Transmitted by the wheat curl mite (Aceria tosichella Kiefer), WSMV has a complex disease cycle that includes winter wheat, spring wheat, corn, and a number of alternative hosts that also harbor the wheat curl mite. WSMV overwinters in winter wheat during its vernalization period. Early growth stages have shown a reduction of up to 40 percent in root and shoot weight. Thus, WSMV also functions as a contributing factor to winter kill in addition to its primary effects.

Wheat production is a significant component of the agricultural industry in South Dakota, and WSMV presents a significant challenge to wheat production. Control of viral diseases depends on the development of preventative disease management strategies. The most effective and economical of these strategies is the development and deployment of host plant resistance or tolerance. Efforts to develop winter wheat cultivars with higher levels of disease resistance and tolerance require the evaluation of plant materials to determine their susceptibility or resistance. Collaborative efforts of the plant virology and winter wheat breeding projects have resulted in recently released varieties and breeding lines with improved tolerance. However, the development of wheat cultivars requires annual evaluation. Without this process, susceptible materials will not be eliminated from the breeding program, and previous advances in resistance and tolerance will be lost.

Methods and Materials:
Evaluation of Resistance/Tolerance in Winter Wheat: The primary objective of this project is to provide evaluation of winter wheat (AYT-CPT) reactions to infection by WSMV. This evaluation provides information that is necessary for genetic selection. Without continuing

evaluation to remove susceptible material, WSMV resistance and tolerance will erode rather than improve.

Standard varieties and advanced winter wheat breeding lines will be evaluated by inoculation with high pressure spray. Winter wheat lines will be planted in four row plots in three replications, and half the plot will be inoculated using a high-pressure (80 psi) air compressor. Plants will be inoculated in the field during October at Feekes stage 2 with a mixture of 1:10 infected plant tissue and potassium phosphate buffer (KPB), pH 7.0, with 1 percent of silica carbide powder (600 mesh) added. Plants will be rated through the spring for symptom development and severity using the following scale:

Rating	Description of Symptoms
0	No visible symptoms
1	Very mild symptoms; Isolated small light green areas of mosaic; No stunting
2	Mild symptoms; Small areas of light green or yellow mosaic; Short streaks of less than 1 inch in length; Mild stunting
3	Moderate symptoms; Areas of predominately yellow mosaic; Coalescence of isolated areas into streaks extending most of the leaf length; Moderate stunting
4	Severe symptoms; Severe mosaic with yellowing covering the majority of the leaf; Some very small areas of necrosis; Severe stunting
5	Very severe symptoms; Extreme yellowing; Necrosis; Very severe stunting; Some plants exhibit death of leaves or the entire plant

Data will also be collected on the agronomic characters of winter wheat lines to determine the effects of WSMV. Each half plot will be evaluated for heading date, stunting, test weight, and grain yield. Enzyme-linked immunosorbent assay (ELISA) analysis will be utilized to provide additional information on virus concentration in wheat plants. The lines will also be evaluated to determine their levels of tolerance (the ability of plants to yield even though they are infected).

Great Plains Wheat Virus Epidemiology

Justification:
In addition to WSMV, South Dakota wheat can also be affected by barley yellow dwarf virus (BYDV) and cereal yellow dwarf virus (CYDV) (formerly known as BYDV-RPV). The predominant BYDV strain in South Dakota has been PAV. The bird cherry-oat aphid, Rhopalosiphum padi L., which is commonly found in South Dakota, transmits these viruses. Some years up to one third of the wheat samples tested for diagnosis of viral disease had BYDV. Often, mixed infections of WSMV and BYDV were present in these samples.

Additionally new viral threats to South Dakota wheat have developed in recent years. These include a new strain of High Plains Disease (HPD) and a new virus from Kansas, Triticum mosaic virus (TriMV). High Plains Disease is caused by a virus-like agent and can severely affect both wheat and corn. South Dakota was unaffected by some of the earlier HPD epidemics due to the original strain's need for high temperatures during early season growth and the poor HPD transmission by South Dakota wheat curl mite populations (T. L. Harvey, Kansas State University). However, a new strain has been identified that is actively

infectious at lower temperatures than the previous strain had been. Thus, HPD could now represent a significant threat to South Dakota. TriMV is a new virus affecting wheat that has been described by D. Seifers, Kansas State Univ. It was discovered because it infects the new RonL wheat lines. Its current range is unknown.

The Great Plains Diagnostic Network has proposed research to define the range of WSMV, BYDV-PAV, CYDV-RPV, HPD and TriMV and the threat that is posed by each virus to wheat production in the states of the GPDN. For this research, South Dakota has been allotted enough materials to test approximately 180 plant samples. However, South Dakota has wheat acreage ranging across the state and includes both winter and spring wheat. Thus, 180 samples would provide a poor representation in South Dakota wheat viruses and have only a limited ability to improve our knowledge of viral epidemiology. The purpose of this proposal is to provide additional materials for 700 additional samples against these five viruses to more adequately represent the wheat acreage in South Dakota.

Methods and Materials:
Plant samples will be collected from South Dakota winter wheat fields by producer submission, county educators, or other collections, and held on ice or frozen until extraction for testing. AgDia test kits purchased to match the kits used in the GPDN testing will be utilized for enzyme-linked immunosorbent assay (ELISA) testing. Samples will be extracted and diluted 1:10 with extraction buffer. ELISA will be accomplished by the standardized protocol for each virus. Absorbance of the developed plate wells at 405 nm will be obtained and utilized in the determination of positive and negative thresholds for sample evaluation.

Progress:

Evaluation for Resistance/Tolerance in Winter Wheat 2006-2007 WSMV Winter Wheat Evaluation Nursery—Sixty-seven entries in the AYT-CPT were planted into the WSMV Winter Wheat Evaluation Nursery and inoculated as described in the Methods and Materials. Table 1 summarizes the yield loss (%), test weight loss (%), the delay in heading, and the disease severity rating for these lines. The 2006-2007 Nursery had the appropriate environmental conditions to cause severe symptom expression and to provide rigorous evaluations. The lines with less than 30% yield loss included 98X0435-15 (4.6%), Buteo (26.1%), SD00151-6 (12%), SD05W140 (29.05%), Tandem (27.6%), and Wendy (28%). Other lines were severely infected with many ranging from 30-60% yield loss. The most severely affected lines had yield losses that exceeded 60%. These included: Expedition (64.9%), SD01W064 (62.8%), SD02224-1 (62.2%), SD02804-1 (70.9%), SD02804-1 (65%), SD03188 (64.4%), SD05104 (61.4%), SD05118 (67.8%), SD05133 (68.6%), SD05W066 (63%), SD96240-3-1 (65%), TAM107 (63.3%), Trego (64.5%), Wahoo (64.5%), and Wesley (68.8%).

The poor yields from 2006-2007 are emphasized by how many plots did not have a pint of grain for the test weight (test weights in red on Table 1). Most years, less than 12 plots have yields this low. In comparison, 51 of the lines test this year had infected plots with yields this low. Only Sage which had a poor stand had an uninfected lot with this type of yield. Heading delays ranged from 0.3 days for SD05W140 to 6.3 days for SD05118.

2007-2008 WSMV Winter Wheat Evaluation Nursery—Sixty-three lines were entered in the AYT-CPT trials were planted in the 2007-2008 WSMV winter wheat evaluation nursery.

These included: ALICE, ARAPAHOE, CO03W239, DARRELL, DAWN, EXPEDITION, FULLER, HARDING, HATCHER, HAWKEN, INFINITYCL, JAGALENE, JERRY, MILLENNIUM, NH03614, NUDAKOTA, OVERLAND, RONL, SAGE, SD00111-9, SD00151-6, SD01058, SD01273, SD02224-1, SD03164-1, SD03164-2, SD03184-3, SD03184-4, SD03188-2, SD03229-9, SD05118, SD05210, SD05267, SD05280, SD05W012, SD05W018, SD05W030, SD05W066, SD06035, SD06042, SD06053, SD06069, SD06111, SD06130, SD06138, SD06142, SD06158, SD06161, SD06163, SD06165, SD06173, SD06W117, SD06W158, SD07265, SD98W175-1, SD99W015-1, SMOKY HILLS, TAM 107, TANDEM, VISTA, WAHOO, WENDY, and WESLEY. These were inoculated last fall as described above and will be analyzed this summer.

Table 1. The mean yield loss (%), test weight loss (%), delay in heading date, and disease severity rating for the 2006-2007 *Wheat streak mosaic virus* Winter Wheat Nursery.

Line	Yield Loss (%)	TW Loss (%)	HD Delay	Rating
98X0435-15	4.55	-2.34	0.7	2.6
ALICE	51.68	17.40	2.3	3.1
ARAPAHOE	60.29	14.54	2.3	2.8
BUTEO	26.11	5.69	1.3	3.1
DANBY	46.12	2.02	1.0	2.7
DARRELL	48.25	9.75	2.3	2.7
DAWN	57.06	10.99	3.0	2.9
EXPEDITION	64.94	17.88	2.0	3.3
HARDING	49.80	9.18	3.7	2.5
HATCHER	41.28	3.16	2.0	2.7
JAGALENE	57.56	10.38	4.7	2.7
JERRY	36.91	0.95	0.7	2.9
MILLENNIUM	52.13	6.17	2.3	3.0
NH03614	30.90	1.07	0.3	2.7
NI04420	44.21	2.82	0.7	2.6
NI04421	31.00	0.55	1.7	2.9
NUDAKOTA	45.91	7.28	0.7	2.9
OVERLAND	44.18	6.96	2.0	2.4
OVERLEY	53.10	12.84	1.7	2.6
RIPPER	56.30	9.39	2.3	2.9
SAGE	-6.81	2.72	1.0	2.8
SANTA FE	57.48	23.70	1.7	3.1
SD00111-9	54.72	9.31	2.7	3.4
SD00151-6	12.01	4.49	2.0	2.8
SD01058	52.37	6.05	1.0	3.0
SD01122	59.42	12.69	4.3	3.2
SD01273	53.52	6.11	1.3	2.2
SD01W064	62.82	10.25	5.0	2.9
SD02224-1	62.21	13.69	4.0	2.8
SD02396-2	57.37	12.53	5.7	3.3
SD02480	42.11	3.11	2.3	2.1
SD02804-1	70.91	11.48	2.0	3.1
SD03171	65.02	13.76	3.3	3.2
SD03188	64.42	11.71	4.7	2.8
SD05004	53.21	6.57	3.0	2.4
SD05074	50.05	4.69	1.3	2.9

Table 1. The mean yield loss (%), test weight loss (%), delay in heading date, and disease severity rating for the 2006-2007 *Wheat streak mosaic virus* Winter Wheat Nursery (continued).

Line	Yield Loss (%)	TW Loss (%)	HD Delay	Rating
SD05104	61.38	5.69	3.0	3.2
SD05118	67.76	11.41	6.3	2.9
SD05133	68.57	12.94	3.7	2.9
SD05156	55.48	10.77	3.3	2.8
SD05160	51.37	3.45	1.0	2.6
SD05179	40.84	3.23	2.3	2.5
SD05182	46.43	8.81	3.3	3.2
SD05210	64.53	10.67	2.7	3.0
SD05250	33.08	3.98	1.7	2.9
SD05257	47.37	5.35	1.7	2.6
SD05267	54.73	2.77	2.0	3.3
SD05280	53.14	9.93	1.0	2.5
SD05W012	62.19	14.09	3.3	2.9
SD05W018	45.92	4.44	1.7	2.3
SD05W027	56.20	9.97	3.3	2.3
SD05W030	37.38	3.01	1.7	2.3
SD05W066	63.02	4.76	2.3	2.7
SD05W081	56.49	7.65	1.3	2.7
SD05W108	32.93	1.42	0.3	2.1
SD05W140	29.05	1.50	2.3	2.6
SD05W142	40.15	4.77	1.3	2.6
SD96240-3-1	64.99	5.59	2.0	3.1
SD98W175-1	45.18	7.36	4.0	2.6
SD98W175-1-14	39.04	3.28	0.3	2.6
SMOKY HILLS	48.34	9.43	2.7	2.6
TAM 107	63.34	11.39	0.7	2.8
TANDEM	27.60	-0.10	1.0	2.7
TREGO	64.46	8.36	3.0	3.1
VISTA	50.12	3.45	2.3	2.8
WAHOO	64.50	11.81	2.3	2.7
WENDY	27.99	-0.72	1.0	2.8
WESLEY	68.83	10.22	4.3	2.7

Note: Red test weights indicate that one or more plots had a total yield of less than a dry pint, and those test weights were calculated from less than a dry pint volume.