Project No: New

Title: Viruses in Idaho wheat – prevalence and new rapid detection methods
Personnel: James Woodhall, University of Idaho, Parma Research and Extension Center (208-722-6701, jwoodhall@uidaho.edu)
Juliet Marshall, University of Idaho, Idaho Falls Research and Extension Center
Kurt Schroeder, University of Idaho, Moscow

Justification / Rationale:
Several viruses are present in Idaho wheat. Some of the important viruses include Barley Yellow Dwarf Virus (BYDV), wheat streak mosaic virus (WSMV) and the more recently discovered in Idaho, soilborne wheat mosaic virus (SBWMV). These viruses are capable of causing significant yield losses. For example, BYDV can cause a yield loss of between 11 and 33% (Wallis et al., 2019), wheat streak mosaic above 60% (Hadi et al., 2011) and soil-borne wheat mosaic virus up to 50% (Cadle-Davidson and Gray, 2006). There are concerns in viruses in Idaho wheat, particularly BYDV. Each year, the diagnostic lab at Parma Research and Extension Center screens 20-50 cereal samples for BYDV strains. Other viruses are screened on negative samples when required. However, around 50% of samples are negative for any virus. This is often attributed to other causes such as fungal pathogens or more frequently abiotic causes such as herbicide or weather-related damage. Nevertheless, there is concern that the current tests may be missing certain strains in Idaho or there are additional virus species present which have yet to be determined. In this project we will use a non-targeted diagnostic approach known as high throughput sequencing (HTS) to determine if there are new strain variants present in Idaho of existing viruses and this information can be used to validate the existing tests and to develop new rapid TaqMan PCR tests as required. A survey will be conducted to determine the prevalence of viruses in Idaho. This project is timely with the recent discovery of soil-borne wheat mosaic virus in Idaho and a soil test for the virus will be evaluated within the project.

Objectives:
1. To identify which are the most important viruses in Idaho.
2. Develop and validate rapid diagnostic methods for key wheat viruses.
3. Determine the suitability of a soil test for soil-borne wheat mosaic virus using a new bulk total nucleic acid extraction method and TaqMan PCR.
4. Communicate findings to the industry using a variety of methods (extension bulletins, oral presentations, electronic/digital means).

Methods / Plan of Work:
100 cereal fields will be sampled in Idaho over three years of the project. Initially soil will be sampled prior to planting and fields will be visited again twice for collection of plant material. Soil and plant material will be collected in a structured approach. Soil will be collected in a grid sample with at least 25 sub samples over 10 acres. Total nucleic acid will be extracted from 300 g samples of soil using a new method developed at Parma R&E Center which is currently successfully used for potato viruses in soil (PMTV and TRV). Plant material will be collected in a similar approach and both symptomatic and asymptomatic material will be collected. The number of samples will be augmented by samples received for diagnosis.

In the first instance, samples will be screened with PCR and real-time PCR assays for key viruses including BYDV (MAV and PAV strains), WSMV and SBWMV. In addition, TaqMan PCR assays for less common viruses in wheat will be utilized such as High Plains wheat mosaic emaravirus (WMoV) (note this virus is presently an issue in Idaho sweetcorn seed crops). In addition, a new assay for the BYDV-RPV strain will be developed during the course of the project. Symptomatic samples that are negative for key viruses as well as select asymptomatic samples, will be tested with HTS, this is a non-targeted approach which should detect any virus material in a sample. Presently, the costs are prohibitive and turnaround time too slow to offer HTS testing as a routine diagnostic service. However, when samples are collected and tested in bulk, HTS can be a useful approach to ensure more cost-effective testing methods are working.

The project leader will be James Woodhall based at Parma where the laboratory work will also take place. The Parma team will be responsible for sample collection in the Treasure Valley and Magic Valley. Staff from Juliet Marshall and Kurtis Schroder's teams will be responsible for sample collection in Northern Idaho and Southeast Idaho respectively. All PIs will contribute to delivering extension outputs such as bulletins and extension presentations.

Duration: 3 years

Cooperation / Complementation: The project builds upon existing diagnostic and extension work by all of the PIs involved in the project who undertake a proactive approach in surveillance for disease in Idaho wheat. Woodhall and Marshall receive funds from the National Plant Diagnostic Network (NPDN) which is a USDA project to support existing diagnostic activities but does not support new efforts or method development, which this project focuses on. As a number of viruses also occur on barley, Idaho Barley Commission funding will also be sought in proportion to the number of barley samples expected to be collected and tested within the project.

Anticipated Benefits / Expected Outcomes:
This project will directly help growers and consultants in understanding the problem of wheat viruses. It will also have additional benefits in clarifying the symptoms of various wheat diseases and disorders in the region.

Transfer of Information / Technology:
It is expected that at least one new assay (BYDV-RPV) will be available to growers at the end of the first ear of the project in time for early 2025 testing. A presentation on the project will be given in late 2025 at the Idaho Association of Plant Protection meeting in the Magic Valley. In addition, early in the project, a SBWMV bulletin will be produced as well as a sperate bulletin on diagnosing virus disease in wheat which will also give information on sampling and testing. At the end of the project a paper is expected to be written on the research as well as an overall extension bulletin on viruses present in Idaho wheat and barley.

Literature review:
The APS compendia on wheat diseases and pests lists at least 23 key viruses that can impact wheat. This is likely to be an underestimation since some of the pathogens involved exists as species complexes such as BYDV which occurs as at least seven strains. In addition, many viruses may

be involved in a synergistic relationship to cause symptoms and yield losses. For example, Triticum mosaic virus (TriMV), identified in WSMV-resistant winter wheat in Kansas in 2006 requires co-infections of two or more of these viruses to cause much more severe symptoms and yield loss than infection by a single virus (Stenger et al., 2007).

Soil borne wheat mosaic virus (SBWMV), has been found in northern Idaho for the first time in 2023 (U of I, 2023). SBWMV is transmitted by a fungus-like parasite called *Polymyxa graminis* in the soil and causes green and yellow patches on the leaves of winter wheat and barley, especially in cool and wet conditions. SBWMV can reduce yield by 50% to 80% in susceptible varieties and can persist in the soil for several years.

Barley yellow dwarf virus (BYDV) is a serious and widely occurring viral disease of cereal crops and other grasses (Marshall and Rashed, 2014). Important economic hosts include wheat, barley, oats, and occasionally rice and corn. Although the virus may affect both winter and spring cereals, it is often a greater concern in winter crops. BYDV is spread by aphids that colonize and reproduce on grassy host plants. BYDV strains are efficiently transmitted by different species of cereal aphids persistently. Due to their great variability, the symptoms of BYDV might be mistaken for those of nutritional deficiencies, root and crown illnesses, environmental stress, and wheat streak mosaic. Approximately 14 days following infection, symptoms start to show. Among the signs of barley's disease are interveinal chlorosis and a vivid yellowing of the leaves that begins at the tip and spreads toward the base. Early, severe infections can cause shriveled grain, delayed maturity, abortion of florets, and stunting.

Wheat streak mosaic virus (WSMV) is a common disease in many wheat-growing regions in the US and the world. The wheat curl mite, *Aceria tosichella*, vectors the virus in the field. It is also easily transmissible through sap by mechanical inoculation. Symptoms of WSMV include the yellowed mosaic pattern of parallel discontinuous streaks on the leaves of infected plants. As symptoms progress, the leaves become mottled yellow. Plants infected before early tillering are stunted, discolored, and rosette. The extent of stunting and rosetting in a field gives some indication as to the severity of the disease and ultimate yield loss.

References:

- Cadle-Davidson, L. and S. M. Gray. 2006. Soil-borne wheat mosaic virus. *The Plant Health Instructor*. DOI: 10.1094/PHI-I-2006-0424-01
- Hadi BAR, Langham MAC, Osborne L, Tilmon KJ. 2011, *Wheat Streak Mosaic Virus* on Wheat: Biology and Management, *Journal of Integrated Pest Management* 2, J1–J5, https://doi.org/10.1603/IPM10017
- Marshall, J and Rashed, A. 2014 Barley Yellow Dwarf Virus in Idaho Cereal Crops. University of Idaho Extension Bulletin CIS 1210.
- Stenger D, Young B, Qu F, Morris T, French R. 2007. Wheat streak mosaic virus P1, not HC-Pro, facilitates disease synergism and suppression of post-transcriptional gene silencing. Phytopathology 97:S111.
- U of I, 2023. New Viral Threat. https://www.uidaho.edu/news/news-articles/colleges/cals/2023/071023-viral-threat
- Wallis J III, Rajotte E, Rosa C. The Past, Present, and Future of Barley Yellow Dwarf Management. *Agriculture*. 2019; 9(1):23. https://doi.org/10.3390/agriculture9010023

FY2025
COMMODITY COMMISSION BUDGET
Principal Investigator: *James Woodhall*

Allocated by _____ *(Commission/Organization)*	during FY2023	$	-
Allocated by _____ *(Commission/Organization)*	during FY2024	$	-

REQUESTED SUPPORT Budget Categories	*Awarded for FY2024*	*Requested for FY2025*
(10) Salary *(staff, post-docs, et NOTE: Faculty salary/fringe NOT allowed*		$ 10,000
(12) Temporary Help/IH		$ 6,000
(11) Fringe Benefits		$ 4,628
(20) Travel		$ 900
(30) Other Expenses		$ 8,450
(40) Capital Outlay >$5k	$ -	$ -
(45) Capital Outlay <$5k	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -
TOTALS	$ -	$ 29,978

TOTAL BUDGET REQUESTED FOR FY2025:	$ 29,978

BREAKDOWN FOR MULTIPLE INDEXES: Budget Categories	*Woodhall*	*Marshall*	*Schroeder*	*(Insert Co-PI Name)*
(10) Salary *(staff, post-docs, et*	$ 10,000	$ -	$ -	$ -
(12) Temporary Help		$ 3,000	$ 3,000	$ -
(11) Fringe Benefits	$ 4,130	$ 249	$ 249	$ -
(20) Travel	$ 300	$ 300	$ 300	$ -
(30) Other Expenses	$ 7,548	$ 451	$ 451	$ -
(40) Capital Outlay >$5k	$ -	$ -	$ -	$ -
(45) Capital Outlay <$5k	$ -	$ -	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -	$ -	$ -
TOTALS	$ 21,978	$ 4,000	$ 4,000	$ -
			Total Sub-budgets	$ 29,978