Grant Code:	New
Title:	Evaluating the impact of an Idaho invasive cereal aphid, *Metopolophium festucae cerealium* on wheat grain and flour quality
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Justification/Rationale: Some cereal aphids, such as the Russian wheat aphid *Diuraphis noxia* (Mordvilko) (herein, *RWA*), can cause significant yield and quality losses in their host plants. Feeding by *RWA* will result in chlorophyll loss, reduced leaf/plant development (Botha et al. 2005), and reduced protein content and wheat flour quality (Girma et al. 1993). *Metopolophium festucae cerealium* (herein, *Mfc*) is a newly invasive cereal aphid in the Pacific Northwest (Halbert et al. 2013), with damage levels comparable to *RWA*. *Mfc* is rapidly expanding its range across Idaho and into neighboring Montana and possibly Utah (SE and AR, unpublished data). *Mfc* is known to feed and reproduce on grassy weeds such as Idaho fescue and blue bunch wheatgrass (Davis et al. 2014) and damage cultivated grass crops through direct feeding. The damage is likely due to the injection of toxic saliva into the plant tissue; our preliminary data indicated that *Mfc* can significantly change the physiology of barley plants, including amino acid and sugar concentrations (RS, AR, SE, unpublished). We also found that *Mfc* infestation can change vegetation indices of winter wheat leaves (RS, AR, SE, unpublished).

Considering the *Mfc* presence in Idaho, its expansion, and its visual, physiological, and vegetation impacts on the host plants, it is crucial to understand how the quality and chemistry of wheat grain can change upon *Mfc* infestation. This proposal leverages funds from *Idaho Barley Commission* to study *Mfc* impact on malting quality and the *USDA-NIFA* to study range expansion, BYDV transmission potential, and develop damage thresholds. ***This proposal aims first to evaluate the extent of wheat grain quality losses, including falling number and pasting properties, in whole wheat flour following Mfc infestation. We will also quantify physicochemical properties of the starch in response to Mfc feeding. Finally, the impact of Mfc infestation on protein fractions in wheat flour will be examined as another crucial group of macromolecules in defining the functionalities of wheat flour and its products.***

Objectives:

I. Assess the direct effects of *Mfc* feeding on *wheat flour quality attributes*:
   a. Evaluate the impact of *Mfc* feeding on total protein content, falling number, and pasting properties of whole wheat flour,
   b. Evaluate the impact of *Mfc* feeding on pasting and thermal properties, swelling factor, and granule size and morphology of isolated starch,

II. Assess the direct effects of *Mfc* feeding on different *protein fractions* of wheat flour including gliadin and glutenin fractions and their subunits

Procedures/Plan of work: Three winter wheat cultivars, including Puma, SY Ovation and WB1529, will be used in this field study. Field plots (5 x 14-ft) will be planted in October. There will be a total of 9 treatments (three for each cultivar): 1) *Mfc*-infested, 2) bird cherry-oat aphid (*BCOA*)- infested, and 3) non-infested control. There would be 4 plot-replicates per treatment, per cultivar, arranged in a randomized complete block design. Before plant emergence, the center of each plot will be covered by 5(L)x2.5(W)x4(H)-ft field cages constructed from vinyl frames and mesh. To generate aphid-infested treatments, cages will be infested with a minimum of 200 *Mfc*, or BCOA, two weeks after emergence. Cages will be removed in the spring and plants will be sprayed to ensure no aphid is present. Plants in each treatment will be scored for visual symptoms in the spring. Grain will be harvested and prepared for quality and physiochemical analyses.

To address **Objective I-a,** wheat kernels will be milled using a lab grinder (Perten Lab Mill 3100). The falling number (FN) of wheat kernels will be measured using a falling number machine (Perten falling number 1700)

following the AACC Approved Method 56–81.03 (AACC International, 2010a). Total crude protein content will be determined using combustion method. Flour pasting properties will be measured with a Rapid Visco Analyzer (RVA; Newport Scientific Inc., Warriewood, Australia).

To address **Objective I-b,** starch will be isolated from the wheat flours according to (Shinde et al. 2003). Starch pasting properties will be measured with a Rapid Visco Analyzer (RVA; Newport Scientific Inc.) according to AACC International (2010b). The morphology of starch granules will be examined with a scanning electron microscope after coating with a thin layer of gold at 10 kV accelerating voltage under a high vacuum. The size and size distribution of starch granules will be examined. Starch thermal properties will be determined by a differential scanning calorimetry (Discovery DSC, TA Instrument). Swelling factor will be determined using blue dextran method (Tester and Morrison 1990).

To address **Objective II**, gliadin, albumin/globulin, and glutenin fractions will be extracted from the wheat flour using the method of (DuPont et al. 2004). All protein fractions will be freeze dried for RP-HPLC analysis. Proteins will be dissolved in 6 M guanidine HCl (pH=8.0) with 50 mM DTT, and will be alkylated with vinyl pyridine prior to injection (DuPont et al. 2004). An Agilent Technologies Series 1100 HPLC system equipped with a diode array UV/VIS detector and a Poroshell 300SB-C18 column (2.1×75mm, 5 µm particle size, Agilent Technologies, USA) will be used to elute the proteins with a gradient of acetonitrile: water (containing 0.1% TFA) from 10% to 90% acetonitrile over 60 minutes. The detection will be done at 210 nm and area under each peak will be applied to estimate amount of each protein fraction.

All biochemical analyses will be performed at the University of Idaho, Department of Entomology, Plant Pathology and Nematology (and Animal, Veterinary, and Food Sciences), Moscow, ID, except total crude protein analysis which will be sent to Waters Agricultural Laboratories Inc. in Georgia.

Duration: The proposal is intended to provide preliminary date for pursuing federal funds. It would be the 1st year of a 3-year funding request.

Cooperation: Proposed research is being carried out collaboratively among Dr. Sadeghi, Dr. Rashed and Dr. Eigenbrode.

Anticipated Benefits, Expected Outcomes and Impacts, and Transfer of Information: Currently, University of Idaho is the only institution studying this invasive cereal aphid, which makes this and all future study findings original and highly valuable to small grain industry. Studies on different aspects of *Mfc* ecology and damage threshold is supported by NIFA. Studies on the impact of *Mfc* feeding on malting quality is supported by IBC. Finding through these studies led us to also consider the effect of this aphid on wheat grain quality. Acknowledging support from Idaho Wheat Producers, our findings will be communicated to growers and the scientific community through cereal schools, conferences, and scientific publications. A minimum of one refereed journal publication and one extension Bulletin is expected form this work.

Literature Review: *Metopolophium festucae cerealium* is a new aphid species to the USA insect fauna, that is quickly expanding its range across several states (Halbert et al. 2013). Surveys from some sampling sites suggested that *Mfc* population can outgrow those of other cereal species (SE, unpublished). Unlike most other cereal aphids, considerable feeding damage has been reported in association with *Mfc*. Damaged plants are distinguished by the presence of red spots at the point of feeding, which later develops into necrotic tissue, resulting in reduced above- and below-ground biomass (Davis et al. 2014; Dent 1986). *Although the level of damage from Mfc feeding is significantly high, no study was conducted on the impact of Mfc feeding on wheat quality and chemistry*. Feeding by a damaging aphid such as *RWA* has been associated with reduced photochemical efficiency in photosystem II (Burd and Elliott 1996), as well as reductions in protein content and mixing time of wheat kernels (Girma et al. 1993). In addition to physiological defense mechanisms triggered by aphid feeding (Botha et al. 2005), changes in photosynthetic capacity are expected to result in variations in plant biochemical contents, consequently the quality of harvested wheat grains.

Falling number is an essential factor in the quality of wheat flour, which determines the quickness of liquefaction of wheat flour caused by α-amylolysis of starch (Hagberg 1960), and it is used to price the wheat

grain and even defines its application. Although the main cause of low falling number is related to high α-amylase activity by pre-harvest sprouting or late-maturityα-amylase (LMA), starch chemistry and properties will significantly contribute to the low falling number. For instance, an increase in small starch granules (Type B) with lower viscosity was reported to contribute in low falling number issue (Shao et al. 2019). Other than starch, wheat proteins are another important group of macromolecules, which define the quality and functionality of wheat flour. There are many different types of proteins in wheat, including albumins, globulins, gliadin, and glutenin based on their solubility. Gliadin, glutenin, their ratio and sub-units are very important in defining wheat flour and dough functionality. Gliadin/glutenin ratio was reported to have a significant negative correlation with specific loaf volume, dough development time, and dough stability (Dhaka and Khatkar 2015).

References

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FY2023

COMMODITY COMMISSION BUDGET

Principal Investigator: ***Rashed***

Allocated by _____ *(Commission/Organization)*	during FY2021	$ -
Allocated by _____ *(Commission/Organization)*	during FY2022	$ -

REQUESTED SUPPORT: Budget Categories	*Awarded for FY2022*	*Requested for FY2023*
(10) Salary *(staff, post-docs, et NOTE: Faculty salary/fringe not allowed*	$ -	$ 10,200
(12) Temporary Help	$ -	$ 1,500
(11) Fringe Benefits	$ -	$ 4,207
(20) Travel	$ -	$ -
(30) Other Expenses	$ -	$ 10,500
(40) Capital Outlay >$5k	$ -	$ -
(45) Capital Outlay <$5k	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -
TOTALS	$ -	$ 26,407

TOTAL BUDGET REQUESTED FOR FY2023:	$ 26,407

BREAKDOWN FOR MULTIPLE INDEXES:

Budget Categories	*Rashed*	*Eigenbrode*		
(10) Salary *(staff, post-docs, et*	$ 10,200	$ -	$ -	$ -
(12) Temporary Help	$	$ 1,500	$ -	$ -
(11) Fringe Benefits	$ 4,162	$ 45	$ -	$ -
(20) Travel	$ -	$ -	$ -	$ -
(30) Other Expenses	$ 6,500	$ 4,000	$ -	$ -
(40) Capital Outlay >$5k	$ -	$ -	$ -	$ -
(45) Capital Outlay <$5k	$ -	$ -	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -	$ -	$ -
TOTALS	$ 20,862	$ 5,545	$ -	$ -
			Total Sub-budgets	$ 26,407