GRANT CODE: New

TITLE: Predictive Modelling of Falling Number Risk Using Site-Specific Weather Data

PERSONNEL:

PI - Doug Finkelnburg, Area Extension Educator, Northern Extension District UI
Co-PI - Kurt Schroeder, Cropping Systems Agronomist, Plant Sciences Dept. UI
Consultant - Andrew Robinson, PhD Food Science/Computer Technologist

ADDRESS: U of I Extension, Nez Perce County, 1239 Idaho Street, Lewiston, ID, 83501

JUSTIFICATION:

Regional economic losses to the wheat industry due to low falling numbers have been calculated in the millions of dollars over the past decade. While federal dollars have been deployed to assist regional wheat breeding efforts to address the root causes of this problem, currently no genetic solution is available to eliminate the risk of low falling number discounts. Currently, falling numbers issues are unknown until grain is harvested and taken to the local elevator leaving little time for management decisions to mitigate the impacts of commingling sound and affected grain.

We have already developed a methodology for predicting weather conditions during various wheat developmental stages, with the original goal of forecasting Fusarium Head Blight risk under climate change. We utilized the "flowering" stage of the CERES-Wheat growth model and developed multiple indices of risk to report to growers. We propose applying a similar approach to historical weather data using the "grain fill" and "maturity" growth stages in order to provide predictive tools for identifying the risk of low falling numbers by location before harvest.

HYPOTHESIS & OBJECTIVES:

Our hypothesis is wheat growth is proportional to accumulated energy, which can be determined using data collected from university variety trials to predict the timing of various development stages in conjunction with site-specific weather data.
We will address our hypothesis with the following **objectives**:

1) Development of a wheat growth model to index historical climate data based on location.
2) Calibration of wheat model parameters based on the results of variety trials.
3) Creation of weather-based risk indices for late maturity alpha amylase (LMA) and pre-harvest sprout (PHS) caused low falling numbers.
4) Deployment of model results as a web application for grain growers, elevator operators, and other grain industry members.

PROCEDURES:

Development of a wheat growth model to index historical climate data based on location
We have already implemented the CERES-Wheat growth model (Hanks et al., 1991) to index daily climate data from the Climate Model Intercomparison Project (CMIP5), which encompasses both historical information (1950 – 2005), as well as future model based predictions (2006 – 2099) from 20 global climate models (Abatzoglou & Brown, 2012). This tool allows a user to specify a planting date and phyllochron value and receive a forecast for a given location within the continental United States (Livneh et al., 2015).

The CERES-Wheat model is used to segment daily weather data by different developmental stages and report summary statistics for the following intervals: emergence, tillering, booting, flowering, grain fill, and maturity. We will modify the proven codebase to query high-resolution historical data from corresponding pixels within the 4 km gridMET spatial dataset of the contiguous United States (Abatzoglou, 2013).

Calibration of wheat model parameters based on the results of variety trials
Initial model calibration to update phyllochron values for different locations was performed using 91 variety testing reports for both spring and winter wheat occurring from 2015 to 2018 from Washington State University. The 5729 total observations, 4793 from winter wheat and 936 from spring wheat, were used to model total GDD from planting date to heading date based on season, location, and year. The output was used to solve for the phyllochron value of the CERES-Wheat model, by aligning "end of preanthesis ear growth" to "heading date" from the variety testing reports.

The predictive model has been expanded to include 9,009 observations across Kentucky and 4,798 observations across Ohio from 2005 to 2019. Instead of using the default 95 GDD phyllochron, we now recommend users to use 150, 130, and 100 GDD for Washington, Kentucky, and Ohio, respectively. We will further update the predictive model as additional information from variety testing reports become available, with a focus on data collected from locations across Idaho.

Creation of weather-based risk indices for LMA / PHS
We have already developed risk indices for Fusarium Head Blight using formulas obtained from a literature search (Del Ponte et al., 2005; Dufault et al., 2006; Manstretta & Rossi, 2015; Trail et al., 2005). These indices use daily weather data as inputs and can also be indexed and summarized using the CERES-Wheat model. The result is a percentage in terms of relative risk.

We will perform data mining procedures on daily weather data to investigate if any weather anomalies can be detected in the historical record, with an emphasis on the growing seasons of 2011,2014, and 2016. We will also test various temperature-based metrics such as daily temperature range and compare how a specific year's result compares to the historical climate baseline.

We will also develop predictive models of FN using the results from existing data sets available from regional university variety testing programs and USDA wheat quality research combined with the historical weather data indexed by the CERES-Wheat growth model. After assessing model performance, further indices of LMA / PHS risk will be created which carry a validation from our case study.

Deployment of model results as a web application for grain elevator operators
We will develop a web application using R Shiny to translate the model scripts into an interactive dashboard wherein a user only needs to input a location of interest. The output will be visualized as a plot with different planting dates across the x-axis and indices of risk along the y-axis. Users will be able to view either the ensemble of multiple risk indices or select individual metrics of interest. Given a location and planting date, a user could determine the risk of grain harvested from that area having a low FN and potentially make decisions to investigate further or even segregate grain prior to storage.

DURATION: 1 year (2020-2021)

ANTICIPATED BENEFITS/EXPECTED OUTCOMES/INFORMATION TRANSFER:
We anticipate the creation of several risk metrics derived from the analysis of weather data in conjunction with FN. Model predictions will be made readily available to grain operators to forecast where and when FN might be a problem, and use that information to make managerial decision concerning the segregation of grains prior to storage.

LITERATURE REVIEW:
While the rate of biomass accumulation is principally influenced by the amount of light intercepted by plants, the duration of growth is almost directly proportional to temperature. The concept of thermal time, often measured in growing degree days (GDD), has been widely used to describe the process of summation of temperatures to predict plant growth duration. The time interval between the emergence of successive leaves in cereals varies with temperature (Gallagher et al., 1979). The amount of GDD required to produce a leaf, also known as a phyllochron, is an important parameter in many dynamic crop growth simulation models (Ahmed & Fayyaz-Ul-Hassana, 2011; Hunt & Pararajasingham, 1995). Leaf appearance and leaf expansion influences leaf area development, which in turn affects photosynthesis and evapotranspiration.

Crop growth models, such as CERES-Wheat, can utilize the maximum and minimum daily temperatures provided by the downscaled GCMs to forecast the timing of different development stages of wheat for a given location under climate change. However, the phyllochron parameter is poorly understood and identified by the original modelers as a major unknown (Jones et al., 1984). The CERES-Wheat model has been validated using 113 datasets collected worldwide (Otter-Nacke et al., 1987), and default phyllochron parameters are recommended to researchers. The default values for the CERES-Wheat model have been used to evaluate climate-yield relationships for the Pacific Northwest (Feng et al., 2017). However, the phyllochron is known to vary by planting date, latitude, and genotype (Baker et al., 1980; Bauer et al., 1984; Kirby et al., 1982, 1985; Wiegand et al., 1981).We have already demonstrated that the results from past wheat variety trials already contain enough information to estimate phyllochron values, which can be used to provide ground-truth references to use with the CERES-Wheat model.

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FY2021

IDAHO WHEAT COMMISSION - BUDGET FORM

Principal Investigator: (insert name)

If applicable,	Allocated by	Idaho Wheat Commission	during FY 2019	$ -
If applicable,	Allocated by	Idaho Wheat Commission	during FY 2020	$ -

REQUESTED FY2021 SUPPORT:

Budget Categories	(10) Salaries (*staff, post-docs, etc.*)	(12) Temp Help	(11) Fringe	(20) Travel	(30) OE	(70) Graduate Tuition/ Fees	TOTALS
Idaho Wheat Commission	$ -	$ -	$ -	$ 500	$ 25,000	$ -	$ 25,500

TOTAL BUDGET REQUEST FOR FY 2021: $ 25,500

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

Budget Categories	*(Insert PI Name)*	*(Insert CO-PI Name)*	*(Insert CO-PI Name)*	*(Insert CO-PI Name)*
(10) Salaries	$ -	$ -	$ -	$ -
(12) Temp Help	$ -	$ -	$ -	$ -
(11) Fringe Benefits	$ -	$ -	$ -	$ -
(20) Travel	$ -	$ -	$ -	$ -
(30) Other Expenses	$ -	$ -	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -	$ -	$ -
TOTALS	$ -	$ -	$ -	$ -

Total Sub-budgets $ -

Brief Explanatory Comments: (see FY2021 RFP for guidance)

Consulting Fee - $21000

Computer Hardware (Server System & Processor) - $4000

Fall 2019 Version