

Grant Code: AN5466

Title: An objective assessment of economic loss due to wireworm damage in Idaho wheat

Personnel: Arash Rashed, Associate Professor of Entomology; Jae Ryu, Associate Professor of Precision Agriculture; Patrick Hatzenbuehler, Assistant Professor and Extension Specialist – Crops Economics

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Justification/Rationale: Wireworms are the larval stage of all click beetle species (Coleoptera: Elateridae). In the recent decade, wireworms have been resurging as devastating pests of a wide range of crops in the Pacific Northwest (PNW), USA. Wireworms can stay in the soil for several years (up to 10 years) and infest crops in almost any rotation, threatening the livelihood of farmers. Wheat, one of the major crop commodities in Idaho, comprising about 17-percent of total crop cash receipts, is also challenged by this pest. The sugar beet wireworm (*Limonius californicus*) is currently the most commonly present, and damaging, species of wireworms in Idaho.

Until recently, neonicotinoid seed treatments were the only class of insecticides registered for application in wheat. But neonicotinoids failed to provide acceptable levels of control. Fipronil, however, is one of the main insecticides proven to be effective in controlling wireworms in other crops, e.g., potato. Use of fipronil in wheat requires special approval from the EPA. In 2017, Idaho wheat producers, represented by Idaho Wheat Commission (IWC), made progress toward submitting a Section 18 request, for fipronil, to the ISDA. Still, the application did not move forward to the EPA due to a missing estimate of economic loss to wireworms. This study aims to help address this issue to aid Idaho wheat farmers in their wireworm control efforts. It is important to note that broflanilide, a new class of insecticides that is highly effective against wireworms, entered the US market in 2021. While this is great news for Idaho producers, it posed some challenges in executing our proposed objectives for this proposal. This is because Idaho producers quickly adapted broflanilide seed treatments and we were limited in the number of fields that we could use for this study. In addition, 2021 draught limited dryland producers' ability to record yield on yield monitors. As such, we proceeded to use untreated field plots to address our objectives in this proposal.

Remote-sensing technologies can provide considerably more efficient analyses of crop stress and damage in large-scale farming than the traditional ground scouting and estimating methods. Here, we are proposing to identify field-scale spectral signatures associated with sugar beet wireworm damage on wheat crops. These measures combined with ground-sourced data on yield and wireworm count can be used to estimate yield and profit losses.

Objective: Quantify economic loss caused by the sugar beet wireworm in spring wheat in Idaho.

Sub-objective 1: Identify spectral signatures associated with wireworm damage early and late into the growing season; and,

Sub-objective 2: Assess yield and economic losses in relation to wireworm numbers and distributions within field.

Procedures/Plan of work: This study will be conducted in one commercial dryland wheat field (three experimental plots) in southern Idaho and two dryland fields in northern Idaho (two

experimental plots). The fields are known to be infested with wireworms. Each field (now 60 x 350-ft plot area) has been thoroughly surveyed for wireworm presence by placing bait traps. We initially intended to use 5-6 acres per field to assess wireworm damage. However, the widespread use of broflanilide by nearly all producers, combined with the impact of the 2021 drought, restricted us in detecting wireworm damage in the experimental sites. As such, for the 2022-23 season, we worked with our grower collaborators to secure and establish untreated plots to quantify wireworm damage; the marked plot areas have never been treated with broflanilide. Plots will be planted in the spring of 2022.

Later, a multispectral sensor mounted on an UAV will be used to capture ultra-high-spatial resolution images 3- and 12-weeks post-emergence. The captured images will be mosaicked, georeferenced and radiometrically calibrated. Digital surface models (DSM) will be generated and analyzed later to see if wireworm damage is influenced by various landscape variables (we are hoping to include hillsides in our study as they appear to be prone to wireworm infestation). The solar bait traps will be placed at the time of imaging, and then collected and counted for the number of wireworms.

The captured images will also be used to extract canopy spectral signatures and develop different vegetation indices (VIs). VIs are expected to be highly correlated with the evidence of wireworm presence (e.g., reduction in vegetation cover, failed germination, delayed crop maturation). Thus, they will be examined as variables for early detection of infestations. Estimations will later be evaluated based on ground and field visual observations. The ground data include wireworm counts from solar bait traps, visual scores of percent germination on a gridded map of the field, and grower-provided crop yields. We will then integrate artificial intelligence with a VI-based model to predict the final yield on a per acre basis. We will compare the predicted yield for healthy and infested areas to estimate the percentage of loss for each acre. At maturity, fields will be harvested, and yield maps will be generated using yield monitoring systems on grower combines. The predicted yield from VI-based model will be compared with the actual final yield, and in relation to the high-resolution per-acre wireworm count data, for validation. The VI-based data will be used in combination with wider range satellite data and the USDA-NASS Cropscape spatial area planted data for wheat to obtain estimates of aggregate yield losses due to wireworm. Since historical satellite and area planted data are available, we will calculate estimated statewide yield losses for the previous five years. These aggregate yield losses combined with planted area estimates will provide estimates of production losses. These annual production losses are then multiplied by the annual marketing year average prices to obtain statewide economic losses due to wireworm.

Duration: Spring 2020 through Spring 2023. This is the first year of a two-year proposal.

Cooperation/Collaboration: This is a cooperative project between Drs. Rashed, Ryu, and Hatzenbuehler programs.

Anticipated Benefits, Expected Outcomes and Impacts, and Transfer of Information: A main goal is to provide needed information to the IWC in their application to the ISDA to submit a Section 18 waiver request to the EPA. We also expect to produce at least 1 professional research publication focused on the use of UAV in estimating yield loss to wireworms in wheat. Other publications on the use of UAV in monitoring for pest conditions in cereals would be possible. The results will be shared at the professional meetings of national, regional, and local levels. We also expect to train our newly recruited M.S. student in agricultural research methodologies, UAV

utilization for in-field assessment of wheat crop status. We will include this project in our regular updates during field days, cereal schools, and other events.

Literature Review: Spectral data collected by remote sensing technologies are used in a broad range of environmental studies such as vegetation analyses and plant community structure (1, 2, 3, 4). Despite the technological and analytical advances, remotely sensed data are underutilized in the study and management of pests in agricultural ecosystems. Efforts on this subject have primarily been limited to laboratory and field experiments evaluating reflectance spectra of pest-infested plants collected by sensors located within a few meters of the plant canopy.

Remotely sensed data that have shown promising results in assessing plant chemistry and functional traits in complex ecosystems (4,5,6,7) and may also provide critical information on the status and severity of pest infestations in crop fields. Pest infested plants such as wheat, soybean, and cotton, consistently showed lower VIs than the non-infested plants (8,9,10). Recently, data collected from UAVs have been used to map the distribution of cryptic pest species such as grape *Phylloxera* in vineyards (11). Spectral data from distant platforms, including UAVs and satellites, have the potential to provide frequent, efficient, and cost-effective tools to map pest infestations and yield loss in agricultural areas, including wheat fields.

References:

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5. Asner, G. P., Martin, R. E., Anderson, C. B. & Knapp, D. E. Quantifying forest canopy traits: imaging spectroscopy versus field survey. *Remote Sens. Environ.* 158, 15–27 (2015).
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11. Vanegas, F., Bratanov, D., Powell, K., Weiss, J. & Gonzalez, F. A novel methodology for improving plant pest surveillance in vineyards and crops using UAV-based hyperspectral and spatial data. *Sensors* 18, 260 (2018).

**FY2023
COMMODITY COMMISSION BUDGET**

Principal Investigator: Rashed

Allocated by <u>Idaho Wheat Commission</u>	during FY2021	\$	9,991
<i>(Commission/Organization)</i>			
Allocated by <u>Idaho Wheat Commission</u>	during FY2022	\$	9,998
<i>(Commission/Organization)</i>			

REQUESTED SUPPORT:	<u>Awarded for FY2022</u>	<u>Requested for FY2023</u>
Budget Categories		
(10) Salary <i>(staff, post-docs, et NOTE: Faculty salary/fringe not allowed)</i>	\$ -	\$ -
(12) Temporary Help	\$ 3,180	\$ 3,250
(11) Fringe Benefits	\$ 651	\$ 570
(20) Travel	\$ 6,167	\$ 6,167
(30) Other Expenses	\$ -	\$ -
(40) Capital Outlay >\$5k	\$ -	\$ -
(45) Capital Outlay <\$5k	\$ -	\$ -
(70) Graduate Student		
Tuition/Fees	\$ -	\$ -
TOTALS	\$ 9,998	\$ 9,987

TOTAL BUDGET REQUESTED FOR FY2023:

\$ 9,987

BREAKDOWN FOR MULTIPLE INDEXES:

Budget Categories	<i>Rashed</i>	<i>Ryu</i>	<i>Hatzenbuehler</i>	<i>(Insert Co-PI Name)</i>
(10) Salary <i>(staff, post-docs, et</i>	\$ -	\$ -	\$ -	\$ -
(12) Temporary Help	\$ 1,250	\$ 2,000		\$ -
(11) Fringe Benefits	\$ 510	\$ 60		\$ -
(20) Travel	\$ 1,850	\$ 3,272	\$ 1,045	
(30) Other Expenses	\$ -	\$ -	\$ -	\$ -
(40) Capital Outlay >\$5k	\$ -	\$ -	\$ -	\$ -
(45) Capital Outlay <\$5k	\$ -	\$ -	\$ -	\$ -
(70) Graduate Student				
Tuition/Fees	\$ -	\$ -	\$ -	\$ -
TOTALS	\$ 3,610	\$ 5,332	\$ 1,045	\$ -
Total Sub-budgets				\$ 9,987

ANNUAL REPORT

Grant Code: AN5466

Title: An objective assessment of economic loss due to wireworm damage in Idaho wheat

Personnel: Arash Rashed, Associate Professor of Entomology
Atoosa Nikoukar, Graduate Student
Jae Ryu, Associate Professor of Precision Agriculture
Patrick Hatzenbuehler, Assistant Professor and Extension Specialist – Crop Economics

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Accomplishment: To evaluate yield loss to wireworms in wheat fields, four wireworm-infested fields were selected in southern (2) and northern Idaho (2). In each chosen field, 5-6 acres were marked and scouted for wireworm presence using one solar bait trap per acre. One field had to be eliminated since only two wireworms were collected from the marked area. We proceeded with the remaining three fields. However, during the unusual 2020-2021 growing season drought, producers' ability to record yield data on their yield monitor was limited; in some locations, record lows of 5-8 bushel/acre were estimated. Perhaps, the severe drought during the last growing season also affected wireworm activity. However, distinguishing damage by wireworms from losses due to drought could not be obtained accurately. Figure 1 provides an illustration based on two satellite images of a rainfed spring wheat field (a hillside) affected by both wireworms and drought.

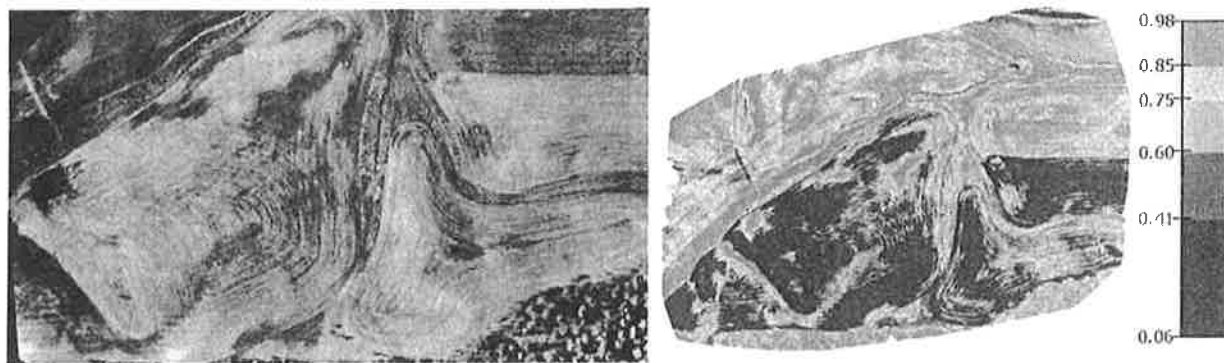


Figure 1. RGB aerial photograph (left) and a NDVI (right) image taken by a Red Edge MX sensor; green indicates low-stress areas whereas red marks high stress canopy possibly driven by drought and/or wireworm infestation.

In addition to drought, the widespread use of broflanilide seed treatment, with high efficacy against wireworms, limited our ability to find wireworms throughout the 2020-2021 crop year. The project Co-PIs are currently working to use our county-level wireworm data, precipitation and temperature data, USDA CropScape spatial area planted data, and satellite images to develop an estimate of yield loss based on our 2015-2018 wireworms survey data. Since this period precedes that of substantial broflanilide usage, wireworm damage on wheat in Idaho was likely substantially greater then.

To overcome the challenges, for the 2021-2022 crop year we have established field plots in areas that were not treated with broflanilide (three plot areas in southeast Idaho, one near Moscow, Idaho, and one in eastern Washington). Those areas included plot areas that will be planted with untreated spring wheat and will be used to estimate yield loss. The plot areas were continuously monitored and are known to be heavily infested with wireworms. The same plots and aerial (drone and satellite) will be used to correlate wireworm damage and wheat yields with various indices, such as the normalized difference vegetation index (NDVI) and the visible atmospherically resistant index (VARI).

Projections: Our marked plots will be planted with untreated spring wheat in April 2022. We will obtain satellite images at three different stages of crop development to estimate damage surface and correlate that with wireworm numbers and yield data. Broflanilide-treated plots will be used as wireworm free controls. For estimation of yield losses due to wireworm, we intend to develop a general system in which we match crops damaged by pestes with specific drone and satellite image information. For example, as shown in Figure 1, wireworm damage is associated with non-emergence of wheat crops, which correlates with brown rather than green colored ground and lower NDVI values. Thus, if the existence of drought can be ruled out based on precipitation data, then the brown areas can be attributed to wireworm. The challenge will be to identify the specific satellite data needed to make these demarcations, and then to combine them with other data to estimate yield losses at a more aggregate scale (e.g., county). These issues will be investigated as the estimation system is developed through mid-2022.

Publication: N/A