Grant Code: AP6300

Title: Screening for Resistance to Cereal Cyst Nematode in Current Wheat Varieties

Personnel: Dr. Juliet Marshall, Ext. Crop Mgmt. Specialist (SC and E Idaho)
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Justification/Rationale: Idaho, one of the largest cereal producers in the United States, is facing a significant pressure from cereal cysts nematodes (CCN) that can significantly reduce grain yield in susceptible and intolerant varieties. Widespread damage in spring cereal production occurs annually from Ashton to St. Anthony, and to the Rexburg and Idaho Falls areas. Due to weather conditions in the spring (e.g. a wet weather pattern in May) and early planting of cereal crops, large numbers of nematodes find homes on cereal roots, causing extensive damage while simultaneously building residual soil populations. Integrated pest and disease management and control strategies for this pathogen require accurate and extensive knowledge on genetics of the host and the pathogen. Studies in 2013 and 2014 revealed large differences in the degree of susceptibility to CCN among various wheat varieties. Since then, there has been a very large change in the varieties available to growers. As markets change, new wheat varieties have been introduced from European companies and newly released PNW lines have not been tested for resistance to CCN. These new lines have added to the number of choices available to area producers. The screening of the varieties and advanced breeding lines that are currently being tested in the extension variety trials will aid in determining variety adaptation to local conditions.

Objectives: The hypothesis is that screening of the varieties entered in the extension variety trials will reveal the degree of susceptibility of currently grown lines and perhaps reveal lines with unknown sources of genetic resistance. Utilizing aldicarb in the split plot design, we should also be able to estimate tolerance characteristics as well.

Methods/Plan of work: A field trial will be established near Idaho Falls in a field known to be heavily infested with high populations of CCN. Notification of project approval needs to be early enough for us to identify infested fields prior to grower planting. Preplant sampling will be performed to determine the level of CCN populations in the soil. All of the varieties in the extension variety trial will be planted in four replications in a split plot RCB design at the standard seeding rate (1,000,000 seeds per acre). Main plots will be variety, sub plots will be treatment with and without Aldicarb nematicide. Plots will be irrigated by the cooperating producer.

Plant samples will be dug near Feekes growth stage 10.5.1 (near anthesis or at head emergence), depending on the maximum visibility of white females attached to the roots. Five to six plants from each plot will be evaluated on morphology of root systems and scored for nematode damage according to the scale reported in Smiley and Marshall (2015). Agronomic parameters will be measured during the growing season, and plots will be harvested to determine grain yield and yield related characteristics. Comparison of yield between the aldicarb-treated plots (which reduce nematode pressure) and non-treated plots will provide an estimate of tolerance, ie. varieties that yield well with and without aldicarb are capable of providing economically viable yield when nematode pressure is high.

Duration: Year four of four.

Cooperation/Complementation: Area producers.

Anticipated Benefits/Expected Outcomes/ Transfer of Information/Technology:
Idaho wheat producers will receive the most recent wheat variety performance information in respect to CCN susceptibility to improve production efficiency, increase economic returns, and maintain their competitiveness. Information on variety performance is shared with growers and industry personnel through cereal schools, published materials, wheat nurseries, demonstrations, field tours and the Internet.

Literature Review:
Cereal cyst nematodes are one of the most destructive pathogens in small grain cereal production (Smiley et al., 2017), resulting in up to 50% reduction in yield in susceptible and intolerant barley varieties (Marshall and Smiley, 2016). CCN is widespread in southeast Idaho in high populations due to the combination of limited crop rotation and the planting of susceptible varieties of wheat and barley (Ensafi, 2018).
Jensen first reported *H. avenae* on oats in the USA in 1975. Initially, he stated the symptoms as possible aluminum toxicity before confirming the formation of cysts and identification of CCN through morphological traits (Jensen et al., 1975). Progression of the aerial symptoms was described as stunting, purple discoloration of first leaves, late flowering, unfilled heads and significant yield loss. Early in the season, pale green patches of weak plants with yellow lower leaves and few tillers are typical symptoms of CCN damage (Dababat et al., 2011). Similar symptoms regularly occur throughout the grain producing area of the Snake River Plain on barley and wheat. In the Ashton area a combination of iron and manganese toxicity and CCN damage occurs in low pH soils, complicating CCN diagnoses. However, CCN damage occurs throughout the Snake River Plain in soils ranging in pH up to 8.5.

The shallow root systems of seedlings are susceptible to penetration by the juvenile J2 stage at the root tip stopping the root growth. Many lateral branches of the root are produced in the area where nurse cells (syncytia) develop, resulting in bushy and highly branched roots. Following damage and development of the cysts, the root develops a knotted appearance (Dabbabat et al., 2011, Smiley et al., 2005). The knotted, stunted root systems result in reduced plant growth, nutrient uptake and water stress.

Research has been published on variety resistance and susceptibility (Smiley and Marshall, 2016, Marshall and Smiley, 2016 of wheat and barley varieties and the interaction of host varieties with nematode pathotypes. However, with the introduction of a wide variety of new European malt lines and new feed and food varieties, growers have no information on the susceptibility to the local pathotypes of CCN. With preplant testing of CCN populations, growers will know which fields to avoid planting susceptible varieties.

References:
Dababat, A. A., Pariyar, S., Nicol, J. M. and Duveiller, E. (2011) 'Cereal Cyst Nematodes: An unnoticed threat to global cereal production'. Technical Innovation Brief, CGIAR SP-IPM. 2011:11.
https://www.researchgate.net/publication/251372127_CGIAR_Systemwide_Program_on_Integrated_Pest_Management_Cereal_Cyst_Nematodes_An_unnoticed_threat_to_global_cereal_production
Ensafi, P. 2018. PhD Dissertation. Population Characterization of Two Important Nematodes in Southeastern Idaho Agroecosystems: *Heterodera avenae* and *Steinernaema feltiae*. University of Idaho, Department of Plant Sciences.

Jensen, H., Eshtiaghi, H., Koepsell, P. and Goetze, N. (1975) 'The oat cyst nematode, *Heterodera avenae*, occurs in oats in Oregon', *Plant Disease Reporter,* 59(1), pp. 1-3.

Marshall, J. M. and Smiley, R. W. (2016) 'Spring barley resistance and tolerance to the cereal cyst nematode *Heterodera avenae*', *Plant Disease,* 100(2), pp. 396-407.

Smiley, R., Dababat, A. A., Iqbal, S., Jones, M. G., Tanha Maafi, Z., Peng, D., Subbotin, S. A. and Waeyenberge, L. 2017. 'Cereal Cyst Nematodes: A Complex and Destructive Group of *Heterodera* Species', *Plant Disease,* 101:1692-1720.

Smiley, R. W., Whittaker, R. G., Gourlie, J. A., Easley, S. A. and Ingham, R. E. (2005) 'Plant-parasitic nematodes associated with reduced wheat yield in Oregon: *Heterodera avenae*', *Journal of Nematology,* 37(3), pp. 297-307.

FY2024

COMMODITY COMMISSION BUDGET

Principal Investigator: *Marshall*

Allocated by	**Idaho Wheat Commission** *(Commission/Organization)*	**during FY2022**	**$ 9,883**
Allocated by	**Idaho Wheat Commission** *(Commission/Organization)*	**during FY2023**	**$ 11,216**

REQUESTED SUPPORT:	*Awarded for FY2023*	*Requested for FY2024*
Budget Categories		
(10) Salary *(staff, post-docs, e* *NOTE: Faculty salary/fringe not allowed*	$ 4,059	$ 7,218
(12) Temporary Help/IH	$ 3,500	$ 3,500
(11) Fringe Benefits	$ 1,957	$ 4,502
(20) Travel	$ 950	$ 950
(30) Other Expenses	$ 750	$ 750
(40) Capital Outlay >$5k	$ -	$ -
(45) Capital Outlay <$5k	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -
TOTALS	$ 11,216	$ 16,920
TOTAL BUDGET REQUESTED FOR FY2024:		$ 16,920

BREAKDOWN FOR MULTIPLE INDEXES:

Budget Categories	*Marshall*	*(Insert Co-PI Name)*	*(Insert Co-PI Name)*	*(Insert Co-PI Name)*
(10) Salary *(staff, post-docs, et*	$ 7,218	$ -	$ -	$ -
(12) Temporary Help	$ 3,500	$ -	$ -	$ -
(11) Fringe Benefits	$ 4,502	$ -	$ -	$ -
(20) Travel	$ 950	$ -	$ -	$ -
(30) Other Expenses	$ 750	$ -	$ -	$ -
(40) Capital Outlay >$5k	$ -	$ -	$ -	$ -
(45) Capital Outlay <$5k	$ -	$ -	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -	$ -	$ -
TOTALS	$ 16,920	$ -	$ -	$ -
			Total Sub-budgets	$ 16,920

Budget Justification

$	7,218	Post doc, at $24.06 per hour for 300 hours, to conduct field trial, sampling and nematode isolation and quantification
$	3,500	Hourly help at $15/hr for field maintenance, lab help including counting nematodes isolated from soil samples for approximately 233 hours
$	4,502	Fringe rates based on staff and IH PERSI at 42%
$	950	Travel to infested field for planting, based on motor pool rates
$	750	Field stakes, coin envelopes, harvest bags, lab supplies, equipment rental, combine hours (4 hours at $85/hr)

ANNUAL REPORT

Grant Code: AP6300

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Personnel: Juliet M. Marshall, Ext. Crop Mgmt. Specialist (SC and E Idaho)
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Tod Shelman, Scientific Aide II
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Abstract
Crop rotations in eastern Idaho are frequently limited to one to three crops, with most of the production time dedicated to cereals – wheat and barley. Understandably, without rotation soil-borne diseases and crop-specific nematodes build up to damaging levels. In fields where rotations are restricted, soil-sampling to test for nematode species and population levels is useful to determine what wheat variety could be planted to reduce yield losses. All varieties and advanced breeding lines in our Extension Variety Trials were tested in a field with high levels of cereal cyst nematode (CCN). Resistance levels were characterized. In addition to the known resistance in WB Rockland, the advanced breeding line from Dr. Jianli Chen's breeding program IDO1804S was identified as having resistance to CCN. Additional lines were identified as moderately resistant, including IDO2004S, Expresso, IDO2002, WA 8342, UI Platinum, UI Cookie, WB7328, Dayn, IDO1902S, Dagmar, and IDO2105S. Lines identified as susceptible are not recommended for planting in areas of limited crop rotation or in fields that have tested with high soil populations of CCN. Worthy of note is the reduced nematode damage on WB936 with the seed treatment of Ilevo (BASF product) when compared to the untreated seed of WB936.

Background / Objectives:
Ongoing annual monitoring of cereal production field in Southeast Idaho including Ashton, St. Anthony, Rexburg and Idaho Falls show an increased population density of cereal cyst nematode (CCN) which is causing significant pressure on wheat and barley productions. The damage on spring cereal varieties is now considered significant on susceptible, moderately susceptible and intolerant ones, specifically for spring wheat cultivars with early planting at wet weather in heavily infested field. Lack of management options including biological control, availability of effective and affordable nematicides, and lack of interest and affordability for including rotation makes the genetic resistance to CCN crucial and important approach for increasing the yield in the region. The introducing new European cereal lines, and PNW lines to Idaho with high population of CCN requires continues testing against CCN. So far, only few resistant cultivars including WB Rockland carrying *Cre5* resistant gene could maintain the resistance response to CCN pathotype in PNW. Although low in yield and therefore not preferred by growers, WB Rockland can be used in breeding programs. European variety LCS Odyssey malting barley is another great example where we found a good resistant response against CCN in eastern Idaho.

Results / Accomplishments: A total of 68 spring wheat cultivars were planted in 4 replicates in RCB design. We collected five plant root systems at Feekes 10.5.1 (flowering stage near anthesis). Roots were transferred to Aberdeen R&E Center. All roots were washed, stained, and evaluated under a stereo microscope. Attached white cysts and swollen J4 inside the root were counted and reported per root system. To increase the accuracy of the evaluations, white cysts that were washed off during the extraction were also collected and counted. CCN morphological identification confirmed *Heterodera avenae* species. Roots were also checked for presence of *Pratylenchus sp.* root lesion nematode (RLN). The yield was evaluated for all cultivars, and plots with high incidence of RLN inside root were eliminated from the yield calculations.

Resistance assessment was based on the following category:
VR (Very Resistant with ≤ 1 White Female per plant), R (Resistant with 1.1 to 3), MR (Moderately Resistant: 3.1 to 6), MS (Moderately Susceptible: 6.1 to 12), S (Susceptible: 12.1 to 25), and VS (Very Susceptible >25).

Initial (preplanting) population of CCN was higher than minimum damaging population threshold. Results from average new cysts per root system indicates that only IDO1804S is **resistant**. 11 varieties (IDO2004S, Expresso, IDO2002, WA 8342, UI Platinum, UI Cookie, WB7328, Dayn, IDO1902S, Dagmar, IDO2105S) are **moderately resistant**.
35 varieties (WB6430, Duclair, WB7313, Net CL+, IDO2101FHB, IDO2104HF, UI Stone, IDO1904S, Tekoa, WA 8372, Jefferson HF, WB9724CLP, AP Renegade, BZ919-059, WB7696, YSC-603, WB6211CLP, WB9668, WB9707, AP Coachman, Ryan, MT1939, WA 8357, Glee, TMC 2021, WB936 (with seed treatment Ilevo and Stamina from BASF), IDO2202CL2, IDO1404S, WB7202CLP, Choteau, MT2063, SY-Teton, Sy Gunsight, WA 8374, Melba) were rated as **moderately susceptible**.

Sixteen varieties (WA 8359, Rocker, WB936 (untreated), WA 8388CL+, Alum, BZ919-101, WA 8330, Hedge CL+, WA 8327, Seahawk, IDO2103FHB, WA 8356, WA 8354CL+, IDO1702S, WB9879CLP, BZ917-221) are **susceptible**.

Four varieties (WB7589, Louise, WA 8351, and Alturas) are **very susceptible**.

Outreach / Applications / Adoption: The current approach includes staining technique which provides accuracy in evaluations and better estimation of resistance level. Previous studies clearly indicate that cereal varieties need to be evaluated over the time to make sure that resistant or moderately resistant varieties can maintain the level of genetic response. Resistant lines can be used in infested fields to reduce disease loss and increasing the soil CCN populations. Lines identified as susceptible are not recommended for planting in areas of limited crop rotation or in fields that have tested with high soil populations of CCN. Worthy of note is the **reduced nematode damage** on WB936 with the seed treatment of Ilevo (BASF product) when compared to the untreated seed of WB936.

Projections: The staining technique incorporated in this study is well established and has been successfully utilized in our previous study trials (Ensafi, 2018). This study should be repeated including new spring wheat advanced lines. We would like to continue the research to statistically confirm the results of this experiment, including the new varieties from the extension variety trial. Further testing of Ilevo to quantify protection from losses is warranted.

Publications: the results are at preparation for publication developed from the PhD Dissertation:

Ensafi, P. (2018). *Population Characterization of Two Important Nematodes in Southeastern Idaho Agroecosystems: Heterodera avenae and Steinernema feltiae*. PhD thesis University of Idaho.