PROJECT NO: BJKT45, BJKT46, BJKT47, BJKT48

TITLE: Barley Yellow Dwarf Virus Effects on Wheat Water and Nitrogen Use Efficiency

PERSONNEL: Xi Liang, Juliet Marshall, Arash Rashed, Christopher Rogers

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JUSTIFICATION:

Barley yellow dwarf (BYDV) is one of the most common viral diseases of wheat and barley that results in significant yield losses. Barley yellow dwarf virus damage is characterized by yellowing and/or reddening of leaves, stunted growth, and reduced yield. The virus is transmitted by several species of cereal aphids, and the bird cherry-oat aphid is known to be one of the most efficient vector species. During the 2013 epidemic in Idaho, BYDV infection was widespread throughout the Magic Valley from Buhl to Murtaugh. The long, frost-free fall of 2012 is thought to be a contributing factor to this outbreak. As BYDV infections affect root and shoot growth it can not only impact photosynthesis but also reduce crop water and nitrogen (N) uptake. Impaired ability of plants to use water and N efficiently is of particular importance due to costs associated with irrigation and N fertilization, especially during drought periods. Investigations concerning reductions in water use and N uptake in BYDV-infected plants will provide data prerequisite for developing management strategies to maximize economic return. A field study was established in October 2015, and a greenhouse study was established in November 2016 at the Aberdeen R&E Center. In each study, multiple N rates were applied and incorporated at planting based on current UI recommendations. Mesh cages were installed, and viruliferous bird cherry-oat aphids were released to inoculate young seedlings with BYDV. Soil moisture is being continuously measured.

With recent increases in corn acreage in the region, BYDV is an increasing threat to Idaho cereal production as corn can act as a host from which aphids can acquire the virus. Little research has been conducted to evaluate the influence of BYDV on water use and nitrogen uptake of cereals, and this proposal is set to address this shortfall.

OBJECTIVES:

1) To determine the N uptake and yield responses to N rates in infected and uninfected plants;
2) To determine impacts of BYDV infection on water uptake and water use efficiency;
3) To evaluate BYDV infection on water uptake at different rates of N

PROCEDURES:

Winter wheat variety SY Ovation will be planted in 2016 at Aberdeen R&E Center. Nitrogen will be applied and incorporated at planting at 3 rates: 0, 100, and 200 lbs/acre. Mesh cages (3×3 ft) will be installed in plots prior to crop emergence. Viruliferous bird cherry-oat aphids will be released into the experimental cages 14 days after planting to inoculate young seedlings with BYDV. Experimental plots (5×14 ft) will be arranged in a randomized complete block design with 5 replicates for each treatment of N rate × BYDV infection. For each of the infected cage treatments, there will be one corresponding uninfected control.

During the season, rainfall will be measured in the field to quantify the exact water input. Soil moisture will be monitored at soil depths of 3, 6, 8, 11, 17, and 28 in. Plots will be irrigated according to reference ET and crop coefficients. Root samples will be collected using a soil auger at 0-6, 6-12, 12-18, 18-24, 24-30 in before the termination of irrigation. Root morphology (i.e., root length and surface area) will be analyzed using a WinRHIZO system. WinRHIZO system equipped with a specialized scanner is specifically designed for image analysis of root

morphology. The rooting depth, root biomass, and morphological traits will be used to evaluate the detrimental effects of BYDV on roots at different N rates; such effects are expected to correlate with water and N uptake. Nitrogen response curves will be developed for infected and unaffected wheat plants and an ANCOVA conducted where grain yield will be regressed against N rate. Determination of the N rate needed to achieve optimum grain yield will then be determined for both infected and unaffected plants and comparisons will be made between the two. Similar to grain yield, grain protein will be determined for each plot and regressed against N rate to determine the effect of infection on these parameters, and will be used to calculate nitrogen use efficiency. Water use efficiency will be calculated as grain yield divided by seasonal water use (rainfall plus irrigation). Variations in nitrogen rates are expected to affect virus-plant interactions, and subsequently, virus titer levels. Virus quantifications will be conducted with qPCR. This will allow us to evaluate whether nitrogen and irrigation managements could be utilized to improve plant ability to cope with BYDV. Greenhouse experiments are being conducted in conjunction to control for potential variability in field experiments.

No change has been made in our 2018 budget from 2017.

DURATION: 2 years

COOPERATION:

Nilsa Bosque-Perez, Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID

Jianli Chen, Department of Plant, Soil and Entomological Sciences, University of Idaho, Aberdeen R&E Center, Aberdeen, ID

ANTICIPATED BENEFITS/EXPECTED OUTCOMES/INFORMATION TRANSFER:

The research will provide needed information on the impact of BYDV on water and N use efficiency, and grain yield. If differences are found, further research will be conducted to provide recommendations on irrigation/N fertilization rates to maximize economic return in BYDV-affected fields. Results of this research will be communicated to growers and researchers through cereal schools, newsletters, websites, progress reports, conferences, and refereed journal publications.

LITERATURE REVIEW:

Estimated damages associated with BYDV may range from 11 to 33% yield loss, in some cases exceeding 80% (Miller and Rasochova, 1997). Among different cereal aphid species (Bruehl 1961; Halbert and Voegtlin 1998), bird cherry-oat aphid, *Rhopalosiphum padi* (L.) is known to be an efficient vector of BYDV (Jimenez-Martinez and Basque-Perez 2004). Aphid feeding (i.e. *R. padi*) might trigger responses resulting in reductions in leaf photosynthesis and chlorophyll concentration (Franzen et al. 2008), which is similar to the changes in plant physical and biochemical composition in responses to pathogen invasion (Hammerschmidt 1999). More specifically, infection of BYDV reduced leaf area, transpiration, root biomass and length in cereal crops such as wheat, barley, and oat (Erion and Riedell, 2012; Riedell et al., 2003). The reduced root biomass and length resulted in reduced uptake of water, and correspondingly nitrogen, calcium, and magnesium (Erion and Riedell, 2012; Reidell et al., 2007). On the other hand, the grain yields and their components (i.e., seed number and kernel weight) were reduced due to the infection of BYDV (Riedell et al., 2003 and 2007). Therefore, the water and nitrogen use efficiency is expected to be impacted by the infection of BYDV. Similarly, it has been shown

that Wheat Streak Mosaic Virus reduces root biomass considerably and negatively impact plant efficiency in utilizing water resources (Price et al. 2010).

Citations

Bruehl G. W. 1961. Barley Yellow Dwarf. Pp 52. The American Phytopathological Society.

Erion, G G., Riedell, W. E. 2012. Barley yellow dwarf virus effects on cereal plant growth and transpiration. *Crop Science* 52: 2794-2799.

Franzen L. D., Gutsche A. R., Heng-Moss T. M., Higley, L. G., Macedo T. B. 2008. Physiological responses of wheat and barley to Russian wheat aphid, Diuraphis noxia and bird cherryoat aphid, *Rhopalosiphum padi* (L.) (Hemiptera: Aphididae). *Arthropod-Plant Interaction* 2: 227- 235.

Halbert S.E., Voegtlin D.J. 1998. *Evidence for the North American Origin of Rhopalosiphum and Barley Yellow Dwarf Virus*. Pp. 351-356. In: Aphids in natural and managed ecosystems, 5th international Symposium.

Hammerschmidt R. 1999. Phytoalexins: what have we learned after 60 years? *Annual Review of Phytopathology* 37:285-306.

Jimenez-Martinez and Basque-Perez 2004. Vriation in Barley Yellow Dwarf transmission efficiency By Rhopalosiphum padi (Homoptera: Aphididae_ after acquisition from transgenic and nontransformed wheat gentypes. *Journal of Economic Entomology*. 97: 1790-1796.

Miller W.A., Rasochova L. 1997. Barley Yellow Dwarf Viruses. *Annual Review of Phytopathology* 35: 167-190.

Price, J. A., Workneh, F., Evett, S.R., Jones, D. C., Arthur, J. Rush, C. M. 2010. Effects of Wheat Streak Mosaic Virus on root development and water use efficiency of hard red winter wheat. *Plant Disease* 94: 766-770.

Riedell, W.E.; Osborne, S.L.; Jaradat, A.A. 2007. Crop mineral nutrient and yield responses to aphids or barley yellow dwarf virus in spring wheat and oat. *Crop Science* 47: 1553-1560.

Riedell, W.E.; Kieckhefer, R.W.; Langham, M.A.C.; Hesler, L.S. 2003. Root and Shoot Responses to Bird Cherry-Oat Aphids and Barley yellow dwarf virus in Spring Wheat. *Crop Science* 43:1380-1386.

IDAHO WHEAT COMMISSION - BUDGET FORM

Allocated by	Idaho Wheat Commission	during FY 2016	$	9,006
Allocated by	Idaho Wheat Commission	during FY 2017	$	12,224

REQUESTED FY2018 SUPPORT:

	Salary	Temporary Help	Fringe	Travel	OE	Graduate Tuition/Fees	TOTALS
Idaho Wheat Commission	$ -	$ 6,225	$ 2,545	$ -	$ 3,450	$ -	$ 12,220

TOTAL BUDGET REQUEST FOR FY 2018: $ -

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

	Liang	*Rashed*	*Marshall*	*Rogers*
Salary	$ -	$ -	$ -	$ -
Temporary Help	$ 3,459	$ 1,581	$ -	$ 1,185
Fringe Benefits	$ 1,414	$ 646	$ -	$ 485
Travel	$ -	$ -	$ -	$ -
Operating Expenses	$ 600	$ 1,850	$ 500	$ 500
Graduate Student Tuition/Fees	$ -	$ -	$ -	$ -
TOTALS	$ 5,473	$ 4,077	$ 500	$ 2,170

Total Sub-budgets $ 12,220

Explanatory Comments: (see FY2018 Guidelines for definition)

11.21.2016 - Version

ANNUAL REPORT

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ACCOMPLISHMENTS:

A greenhouse study was established with N applications and barley yellow dwarf virus (BYDV) infection. Seeds of winter wheat variety SY Ovation were planted and kept in a growth chamber at 10 °F for 6 weeks for vernalization. Vernalized seedlings were transferred to experimental pots (6 in × 2 ft) in the greenhouse. Pots were fill with soil collected from a small field area of a Declo sandy loam (Coarse-loamy, mixed, superactive, mesic Xeric Haplocalcids) at Aberdeen, where soil texture was confirmed via particle size analysis. The collected soil is expected to be responsive to N applications as only 50 lb N/acre was measured as inorganic nitrogen (N) in the soil. Nitrogen was applied at 4 rates: 0, 120, 240, and 360 lbs N/acre. Mesh cages (6 in × 24 in) were installed on each pot. Bird cherry-oat aphids were released into the experimental cages to feed on the plants and/or inoculate young seedlings with BYDV. The three BYDV infection treatments included control (with no aphids released in the cages), viruliferous aphids (killed 10 days after release by insecticide spray), and viruliferous aphid (maintained until harvest). Experimental pots were arranged in a randomized complete block design with 6 replicates for each treatment of N rate × BYDV infection in the greenhouse.

Our results indicated that compared with the control, WUE and NUE were significantly reduced in response to BYDV infection. The decrease could result from the decrease in shoot and root growth (Figs. 1-3). N uptake was reduced by BYDV infection, but increasing N fertilization could compensate some N uptake in infected plants (Fig. 1).

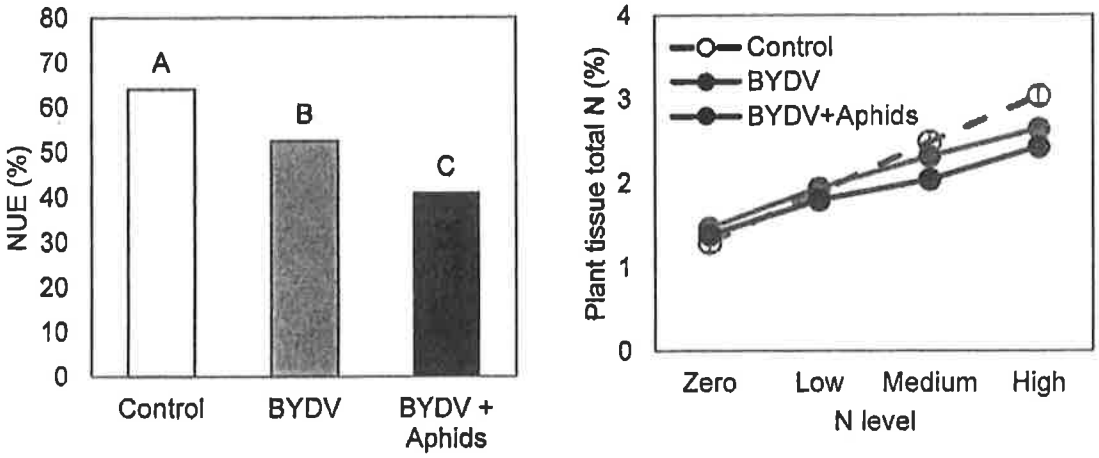

Fig. 1 Nitrogen use efficiency (NUE) (left) and plant tissue total N (right) in response to BYDV infection and N levels

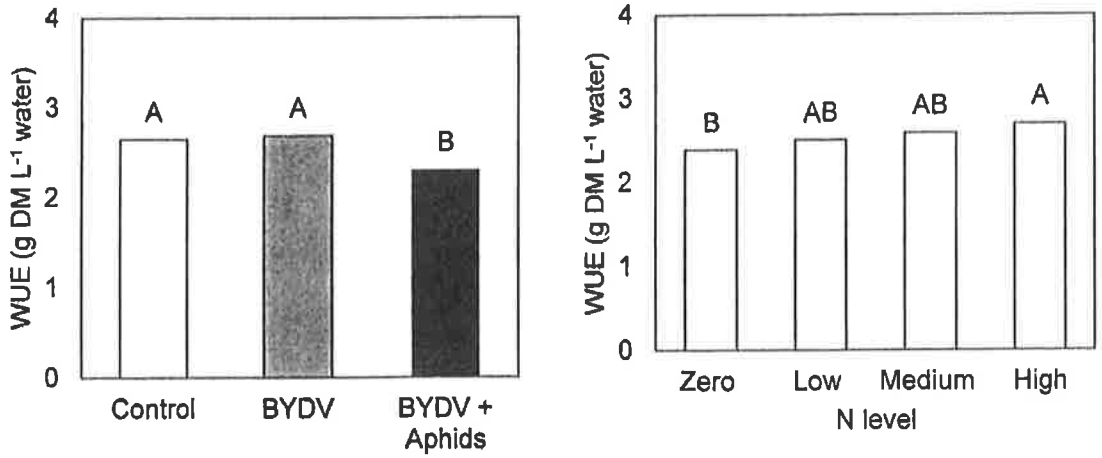

Fig. 2 Water use efficiency (WUE) in response to BYDV infection (left) and N levels (right).

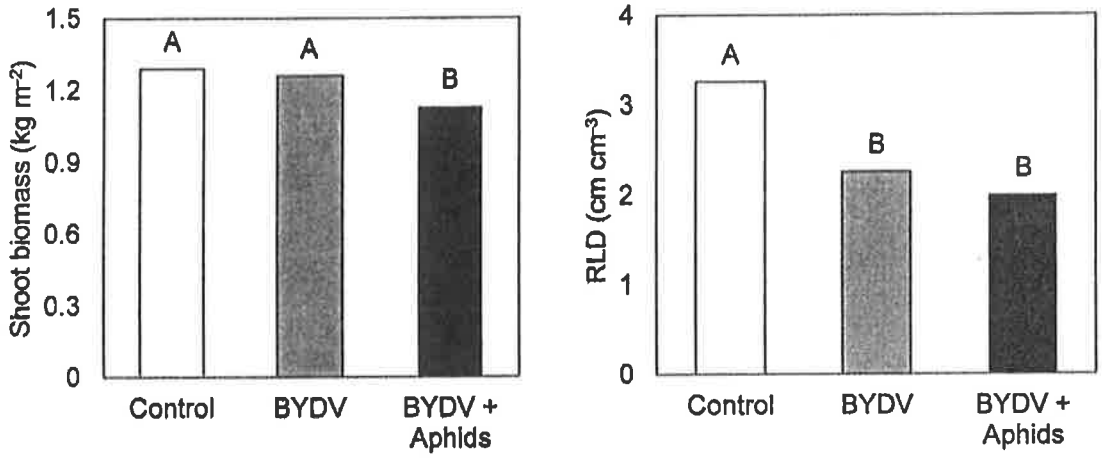

Fig. 3 Shoot biomass (left) and root length density (RLD) (right) in response to BYDV infection

PROJECTIONS:

The study will provide needed information on the impact of BYDV on water and N use efficiency, and grain yield. If differences are found, further research will be conducted to provide recommendations on irrigation/N fertilization rates to maximize economic return in BYDV-affected fields. Results of this study will be communicated to growers and researchers through cereal schools, newsletters, websites, progress reports, conferences, and refereed journal publications.

PUBLICATIONS:

Part of the results of the current study was presented:

X Liang, JM Marshall, A Rashed, CW Rogers. Barley yellow dwarf virus effects on wheat water and nitrogen use efficiency. ASA-CSSA-SSSA Annual Meetings. Phoenix, AZ, Nov. 6-9 2016.