Grant Code: AN2714

Title: Development of resistant wheat cultivars for management of Hessian fly in northern Idaho

Personnel: Arash Rashed, Assistant Professor of Entomology
Steve Odubiyi, Support Scientist
Nilsa A. Bosque-Pérez, Professor of Entomology

Address: Arash Rashed, Assistant Professor Dept. of EPPN, University of Idaho, Moscow, ID 83844-2329; 208-885-5972; arashed@uidaho.edu

Justification/Rationale: Hessian fly resistance is one of the most important traits for spring wheat varieties in northern Idaho, where 34% of the acreage is planted to spring wheat. The absence of widespread economic losses in the region in recent years is a result of effective resistance in many of the most widely planted and highest yielding varieties. For example, varieties Jefferson (UI bred), Louise, Diva, Whit, Glee, and Kelse (WSU bred) are leading soft white and hard red spring wheats in the Pacific Northwest (PNW) (based on 2014 acreage) and are Hessian fly resistant. Other important UI-bred varieties with resistance to Hessian fly include Jerome and Cataldo. Hessian fly was found for the first time in southern Idaho (Treasure Valley) in 2015 and the infestations observed in variety trials were severe. With the arrival of the fly in the southern part of the state and its potential spread to other wheat growing areas, screening and breeding for resistance is more important than ever. Hessian fly resistance is a must for a variety to have broad adaptation and high stable yields in regions where the fly is present. Yield reductions due to Hessian fly infestation of spring wheat without resistance range from 11-24% and fly resistance in the PNW is valued from $45 to $104 per acre based on a study by Smiley et al. (2004). Applying these values, a very conservative loss estimate for Idaho in the absence of resistant varieties would be over one million dollars per year. The return on investment of Idaho grower funding for this project is substantial.

We continue to see Hessian fly infestations in Idaho every year. A survey of Hessian fly in northern Idaho locations using pheromone traps was conducted in the spring and summer of 2012 and repeated in 2013. Hundreds to thousands of flies were found at all sites sampled demonstrating that the insect remains a threat to wheat production in the northern part of the state. Furthermore, as mentioned above Hessian fly has now reached the southern part of the state. Heavy Hessian fly pressure has also been reported from states of Washington and Montana, where winter wheat appeared to be also affected. While currently all resistant varieties deployed are spring wheats, there is an indication that warmer falls and wetter springs associated with changing weather patterns might have resulted in higher incidence of Hessian fly in winter wheat. As such screening for Hessian fly resistance in the PNW winter wheat is now essential.

Hessian fly damage is largely managed through genetic resistance that needs to be maintained by expert screening. New spring wheat varieties intended for the Treasure Valley region would have to be fly resistant. None-the-less, the potential emergence of fly biotypes (or genetic variants) capable of attacking resistant wheat, as has occurred in other parts of the US, always exists. Due to the existence of virulence against the *H3* resistant gene and other genes in Idaho fly populations (Ratcliffe et al. 2000), utilization of multiple genes for resistance is important. We

continue our collaborative efforts with plant breeders to develop spring wheat, and now, winter wheat with fly resistance, including hard white, soft white and hard red wheat varieties. Our nationally recognized Host Plant Resistance Laboratory at the University of Idaho, with experienced personnel, is leading efforts to select and retain Hessian fly resistance in new spring and winter wheat varieties.

Hypothesis & Objectives:

1. Screen segregating populations and advanced breeding lines for resistance to Hessian fly in the laboratory.
2. Assist the breeding program in the development of effective molecular markers for Hessian fly resistance genes.

Procedures/Plant of work: Genotypes to be tested include soft white, hard white and hard red spring breeding lines. Incorporation of Hessian fly resistance into adapted germplasm will be a continuing effort. Focus will be on a diversity of genes. Mapping populations will be screened to assist in the development of molecular markers to expedite breeding efforts. Lines will be seeded in pots, placed in cages and infested at the two-leaf stage with Hessian fly females to lay eggs for 24 hours. Response of plants to larval infestation will be evaluated 21 days later. Plants will be dissected and the number of Hessian fly larvae and puparia per plant determined. Measurements of plant height will be taken twice, one-day and 21 days after infestation. Severe stunting is an indication of fly susceptibility. The number of resistant and susceptible plants per entry will be recorded. Screening will take place at the Manis Entomological Laboratory in Moscow, Idaho.

Duration: This will be the 3rd year of a continuing project (2017-2020).

Cooperation/Collaboration: UI: J. Chen, J. Marshall; WSU: M. Pumphrey, A. Carter, D. See

Anticipated Benefits, Expected Outcomes and Impacts, and Transfer of Information: Results of this work will provide growers with new spring and winter wheat varieties with resistance to Hessian fly. The availability of resistant varieties will enhance implementation and adoption of conservation tillage that is critical for reducing soil erosion. The project will provide information on the effectiveness of currently deployed fly resistance genes that is needed in order to ensure long-term stability of control. Results will be made available to growers through presentations at grower meetings, cereal schools and through extension publications. Results will also be presented at scientific meetings.

Literature Review: The Hessian fly was identified as a pest of wheat in the US shortly after its accidental introduction into the country over 200 years ago. The fly is a severe pest known to be present in all major wheat growing areas of the US, including the Atlantic Coast, the Great Plains and the Pacific Northwest (Ratcliffe and Hatchett 1997). Feeding by fly larvae on cereal plants results in stunting, reduced grain filling which lowers yield and quality, and weak stems that can break and fall to the ground. Climatic conditions in Idaho are suitable for survival and development of the pest. At least two generations per year, one in the spring and one in the early summer, occur in this area (Castle del Conte et al. 2005). Hessian fly was found in the Treasure Valley for the first time in 2015. It is not clear how many generations a year occur in southern Idaho. Adult flies emerge from infested cereal stubble or wild hosts in the spring. Insects mate

and females lay eggs on leaves of young cereal plants. Each female can lay 200 to 300 eggs. Adults die 3 to 4 days after emergence. Once eggs hatch, larvae migrate to the crown of the young seedlings where they feed on plant sap. In approximately 2 to 3 weeks larvae form puparia (or "flaxseeds"). Larvae survive the summer within puparia in spring wheat or dry stubble. The puparial stage allows survival during adverse weather conditions in both summer and winter (Ratcliffe and Hatchett 1997). Resistant varieties are the most reliable means for Hessian fly control (Ratcliffe et al. 2000, Schotzko and Bosque-Pérez 2002). Over thirty-two genes for resistance have been identified (Sardesai et al. 2005, Carter et al. 2014). Utilization of multiple genes for resistance coupled with the enhancement of existing natural enemies has the potential to enhance durability of resistance. Planting date modifications to escape infestation (i.e., early seeding of spring wheat), destruction of volunteer wheat, and crop rotation also are considered valuable Hessian fly management tools.

References

Carter, A.H., S.E. Cambron, H.W. Ohm, N.A. Bosque-Pérez, and K.K. Kidwell. 2014. Hessian fly (*Mayetiola destructor* [Say]) resistance identified on chromosome 1AS in the spring wheat (*Triticum aestivum* L.) cultivar 'Louise'. Crop Science. 54: 1-11.

Castle del Conte, S.C., N.A. Bosque-Pérez, D.J. Schotzko, and S.O. Guy. 2005. Impact of tillage practices on Hessian fly-susceptible and resistant spring wheat cultivars. Journal of Economic Entomology. 98: 805-813.

Bullock, D.G, N.A. Bosque-Pérez, J.B. Johnson, and F.W. Merickel. 2004. Species composition and distribution of Hessian fly (Diptera: Cecidomyiidae) parasitoids in northern Idaho. Journal of the Kansas Entomological Society. 77: 174-180.

Ratcliffe R.H. and J.H. Hatchett. 1997. Biology and genetics of the Hessian fly and resistance in wheat. pp. 47-56 In: K. Bondari (ed.), New Developments in Entomology, Research Signpost, Scientific Information Guild, Trivandrum, India.

Ratcliffe, R.H., S.E. Cambron, K.L. Flanders, N.A. Bosque-Pérez, S.L. Clement, and H.W. Ohm. 2000. Biotype composition of Hessian fly (Diptera: Cecidomyiidae) populations from the southeastern, mid-western, and northwestern United States and virulence to resistance genes in wheat. Journal of Economic Entomology. 93: 1319-1328.

Sardesai, N., J.A. Nemacheck, S. Subramanyan, and C.E. Williams. 2005. Identification and mapping of *H32*, a new wheat gene conferring resistance to Hessian fly. Theoretical and Applied Genetics. 111: 1167-1173.

Schotzko, D.J. and N.A. Bosque-Pérez. 2002. Relationship between Hessian fly infestation density and early seedling growth of resistant and susceptible wheat. Journal of Agricultural and Urban Entomology. 19: 95-107.

Smiley, R.W., J.A. Gourlie, R.G. Whittaker, S.A. Easley, and K.K. Kidwell. 2004. Economic impact of Hessian fly (Diptera: Cecidomyiidae) on spring wheat in Oregon and additive yield losses with Fusarium crown rot and lesion nematode. Journal of Economic Entomology 97: 397-408.

FY2020

IDAHO WHEAT COMMISSION - BUDGET FORM

Principal Investigator: Arash Rashed

Allocated by	Idaho Wheat Commission	during FY 2018	$	9,600
Allocated by	Idaho Wheat Commission	during FY 2019	$	9,600

REQUESTED FY2020 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	$ -	$ 5,500	$ 1,333	$ 2,600	$ 1,500	$ -	$ 10,933

TOTAL BUDGET REQUEST FOR FY 2020: $ 10,933

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

Budget Categories	*Rashed*	*Bosque-Perez*
(10) Salaries	$ -	$ -
(12) Temp Help	$ 3,500	$ 2,000
(11) Fringe Benefits	$ 1,159	$ 174
(20) Travel	$ 1,600	$ 1,000
(30) Other Expenses	$ 1,500	$ -
(70) Graduate Student Tuition/F	$ -	$ -
TOTALS	$ 7,759	$ 3,174

Total Sub-budgets $ 10,933

Explanatory Comments:
Slight increase in budget is due to slightly increased OE for additional line testing (winter varieties), and fringe rate

Fall 2018 Version

ANNUAL REPORT

Grant Code: AN2714

Title: Development of resistant wheat cultivars for management of Hessian fly in northern Idaho

Personnel: Nilsa A. Bosque-Pérez, Professor
Arash Rashed, Assistant Professor
Steve Odubiyi, Support Scientist

Address: Nilsa A. Bosque-Pérez, Dept. of EPPN, University of Idaho, Moscow, ID 83844-2329; 208-885-7544; nbosque@uidaho.edu

Accomplishments:

Resistance screening. The Hessian fly colony in our laboratory continues to be used regularly to conduct resistance screening tests. The laboratory screening procedure is working very effectively. We have continued our screening efforts and over 325 advanced breeding lines and varieties were evaluated for fly resistance in the laboratory during 2018. Lines originating from crosses with several Hessian fly resistant sources were tested. Several of the lines evaluated had a high proportion of resistant plants. Some of the lines screened are not only adapted to northern Idaho but also to southern Idaho. This indicates that we are in a better position to release new, Hessian fly resistant varieties in the near future. These varieties would serve growers in diverse areas of the state.

As part of the screening efforts we evaluated the Association Mapping Nursery assembled by breeders from across the western US for Hessian fly resistance. Of 170 genotypes screened 30 showed resistance (Tables 1 and 2).

Table 1. Percent plants from an Association Mapping Nursery infected with Hessian fly after screening in the laboratory and rating score, Moscow, ID, May - July 2018.
S = Susceptible; R = Resistant; MR = Moderately resistant

Class	Genotype	% infected plants	Rating
SWS	Treasure	92	S
SWS	Jubilee	92	S
SWS	UI Pettit	100	S
SWS	IDO629	100	S
SWS	IDO851	100	S
SWS	IDO852	100	S
HRS	UI Winchester	100	S
HRS	Jerome	0	R

HRS	IDO702	0	R
HRS	Jefferson	0	R
SWS	Alturas	100	S
SWS	Cataldo	17	MR
HWS	Lolo	100	S
HWS	UI Lochsa	0	R
HWS	IDO694	67	S
SWS	IDO686	100	S
SWS	IDO671	100	S
SWS	UI Stone	92	S
SWS	IDO644	100	S
HWS	IDO377s	100	S
SWS	Pomerelle	100	S
HWS	IDO696	100	S
SWS	IDO854	100	S
HWS	IDO858	0	R
HRS	IDO868	0	R

Table 2. Percent plants from an Association Mapping Nursery infected with Hessian fly after screening in the laboratory and rating score, Moscow, ID, July - August 2018. S = Susceptible; R = Resistant; MR = Moderately resistant

Class	Genotype	% infected plants	Rating
SWS	IDO687	100	S
SWS	IDO440	100	S
SWS	IDO488	100	S
SWS	IDO582	36	S
HWS	IDO560	92	S
SWS	Whitebird	100	S
SWS	Centennial	100	S
HRS	Kelse	0	R
HWS	Macon	0	R
HWS	Otis	64	S
HRS	Scarlet	100	S
HRS	Tara 2002	0	R
HRS	WA8016	91	S
HRS	WA8034	100	S
HRS	WA8074	0	R
HRS	WA8099	0	R
HWS	WA8100	0	R
SWS	Alturas (S check)	100	S
HRS	Hollis (R check)	0	R

Projections:

The goal of this work is to provide growers with new spring wheat varieties that combine resistance to Hessian fly, disease resistance and improve agronomic characters and quality. The work is also aimed at providing updated information on the nature of Hessian fly populations in Idaho. Yield reductions due to Hessian fly infestation of spring wheat without resistance range from 11-24% and fly resistance in the Pacific Northwest is valued from $45 to $104 per acre based on a study by Smiley et al. Applying these values to Idaho, a very conservative loss estimate without resistant varieties would be over one million dollars per year. We continue to see Hessian fly infestations in northern Idaho every year, and sampling with pheromone traps has produced hundreds to thousands of flies at every location sampled. Hessian fly has been detected in southern Idaho and it has the possibility to spread via the movement of cereal residue. Hessian fly has not gone away, it is being largely controlled through genetic resistance that needs to be maintained by expert screening. Selecting for and maintaining Hessian fly resistance in new varieties requires the reliable resistance screening procedure that we utilize in our laboratory at UI. The return on investment of Idaho grower funding for this project is substantial. Evaluation of breeding materials and mapping populations in the laboratory will continue during 2019-2020. Information from this work will help growers manage pest populations and optimize productivity of wheat.

Publications (funded by the WGC; for information purposes only):

Ando, K., S. Rynearson, K.T. Muleta, J. Gedamu, B. Girma, N.A. Bosque-Pérez, M.-S. Chen, and M.O. Pumphrey. 2018. Genome-wide associations for multiple pest resistances in a Northwestern United States elite spring wheat panel. *PLOS One.* https://doi.org/10.1371/journal.pone.0191305

Kidwell, K.K., M.O. Pumphrey, J.S. Kuehner, G.B. Shelton, V.L. DeMacon, S. Rynearson, X.M. Chen, S.O. Guy, D.A. Engle, B.-K. Baik, C.F. Morris, and N.A. Bosque-Pérez. 2018. Registration of 'Glee' hard red spring wheat. *Journal of Plant Registrations.* 12: 60-65.

PRESENTATIONS:

Bosque-Pérez, N.A., E.A. Alalwan, S.O. Odubiyi, V.A. Oliveras, and M. Pumphrey. 2018. Response of a differential panel of wheat varieties to geographically diverse Hessian fly populations. 23rd Biennial International Plant Resistance to Insects Workshop. Harpenden, England, March 7-9, 2018. (Poster presentation).