PROJECT NO: BJK968

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

PERSONNEL: Nilsa A. Bosque-Pérez and Lana Unger

ADDRESS: Nilsa A. Bosque-Pérez, Professor Dept. of PSES, University of Idaho, Moscow, ID 83844-2339; 208-885-7544; nbosque@uidaho.edu

JUSTIFICATION: Economically damaging infestations of Hessian fly, *Mayetiola destructor* Say have occurred in northern Idaho in the last 18 years. When environmental conditions favor the pest, populations have the potential to increase rapidly from one generation to the next. Spring wheat is the preferred host plant for Hessian fly. We have conducted surveys of grower's fields to determine the distribution of the fly and its parasites in northern Idaho. Hessian fly was found in all counties surveyed, confirming the pest is widespread in the northern part of the state (Bullock et al. 2004). In field trials we conducted at Kambitsch farm in 2002, 97% of susceptible variety Lolo plants were infested with Hessian fly, while resistant varieties had no infested plants. Additional surveys of growers' fields in northern Idaho in 2004 showed that 0 to 14% of resistant plants were infested compared to 15 to 62% of susceptible plants, illustrating the continuing importance of the fly in this part of the state. A survey of Hessian fly in northern Idaho locations using pheromone traps was conducted in the spring and summer of 2012. The fly was found at all sites sampled demonstrating that the insect remains a threat to wheat production in the northern part of the state. Since it is not always possible to predict when economically damaging infestations of Hessian fly will occur, control methods are mostly preventive in nature. The favored control method is the utilization of resistant wheat varieties. However, 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 in northern Idaho fly populations (Ratcliffe et al. 2000), utilization of multiple genes for resistance is important. We continue collaborative efforts with plant breeders to develop spring wheat varieties with fly resistance, including hard white, soft white and hard red wheats. It is important to continue the development of resistant varieties so as to provide more options for growers. The availability of adapted, fly resistant varieties will provide Idaho wheat producers with an option to minimize the potentially increasing economic losses associated with this pest.

Damage due to Hessian fly in northern Idaho increased during the last decade likely as a result of several factors. These include increased adoption of conservation tillage practices and more acreage planted to spring wheat, partly as a result of tillage and rotation programs designed to reduce soil erosion. Such practices result in more cereal stubble being left on the soil surface. Hessian fly survives on infested cereal stubble and thus, reduced tillage systems could potentially increase survival frequency of this pest. The sustainability of wheat production in northern Idaho will be influenced by our ability to effectively control Hessian fly under conservation tillage. This will require the continuing development of resistant varieties, which effectively control the fly under both reduced tillage and conventional tillage practices (Castle del Conte et al. 2005).

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: Spring wheat continues to be the primary focus of this project. Screening of segregating populations originating from crosses with several resistance sources will continue. This includes sources that carry the *H25* gene for fly resistance, which is of interest because it confers resistance to a broad spectrum of Hessian fly biotypes. Other sources to be utilized carry the *H3* gene for resistance. Lines that potentially carry both resistance genes will also be tested. Genotypes to be tested include hard white, soft white and hard red lines. In addition, mapping populations will continue to be screened for fly resistance to assist in the development of molecular markers for the *H3* gene. 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.

DURATION: 3 years (2012-2014; 3rd year of project)

COOPERATION: UI: J. Chen, Sanford Eigenbrode; WSU: D. See

ANTICIPATED BENEFITS/EXPECTED OUTCOMES/INFORMATION TRANSFER: Results of this work will provide growers with new spring 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 in the region. Additionally, 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 field days, extension publications, and presentations at grower meetings. Results also will be published in journals and 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 northern 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). 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. As many as 200 to 300 eggs are laid per female. 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). Thirty-two genes for resistance have been identified (Sardesai et al. 2005). 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

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.

COMMODITY COMMISSION BUDGET FORM

Allocated by	Idaho Wheat Commission	during FY 2012	$ 37,036
Allocated by	Idaho Wheat Commission	during FY 2013	$ 37,090

REQUESTED FY 2014 SUPPORT:

	Salary	Temporary Help	Fringe	Travel	OE	CO	Grad Fees	TOTALS
Idaho Wheat Commission	$ 18,500	$ 8,000	$ 9,691	$ 2,000	$ 2,000	$ -	$ -	$ 40,191

OTHER RESOURCES (not considered cost sharing or match):

a) Industry	$ -
b) UI (salaries, operating)	$ 15,600
c) Other (local, state) (REACCH)	$ 3,000
d) F&A (34%)	$ 13,665
e)	$ -
TOTAL OTHER RESOURCES	$ 32,265

TOTAL PROJECT ESTIMATE FOR FY 2014:	$ 40,191 *(Requested)*	$ 32,265 *(Other)*	$ 72,456 *(Total)*

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

	(PI name)	*(PI name)*	*(PI name)*	*(PI name)*
Salary	$ -	$ -	$ -	$ -
Temporary Help	$ -	$ -	$ -	$ -
Fringe Benefits	$ -	$ -	$ -	$ -
Travel	$ -	$ -	$ -	$ -
Operating Expenses	$ -	$ -	$ -	$ -
Capital Outlay	$ -	$ -	$ -	$ -
Graduate Student Fees	$ -	$ -	$ -	$ -
TOTALS	$ -	$ -	$ -	$ -

Total Sub-budgets $ -

10.26.2012 - Version

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CURRENT AND PENDING SUPPORT Form:

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Name: **Nilsa A. Bosque-Pérez**

NAME (List PI/PD #1 First)	SUPPORTING AGENCY AND AGENCY NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Current:				
N.A. Bosque-Pérez and Lana Unger	Idaho Wheat Commission	37,090	2012-2013	5%	Development of resistant wheat cultivars for management of Hessian fly in northern Idaho
M. Pumphrey, K. Campbell and N.A. Bosque-Pérez	Washington Grain Commission	15,000	2012-2013	3%	Evaluation of wheat breeding lines for management of Hessian fly in the Pacific Northwest
S.D. Eigenbrode, N.A. Bosque-Pérez, and A. Karasev	USDA-AFRI	349,993	2009-2013	10%	Vector responses to virus-induced changes in the host plant: Implications for disease spread
N.A. Bosque-Pérez, S.D. Eigenbrode, et al.	NSF-IGERT	3,200,000	2009-2014	25%	Evaluating resilience of ecological & social systems in changing landscapes
	Pending:				
N.A. Bosque-Pérez and Lana Unger	Idaho Wheat Commission	40,191	2013-2014	5%	Development of resistant wheat cultivars for management of Hessian fly in northern Idaho
M. Pumphrey, K. Campbell and N.A. Bosque-Pérez	Washington Grain Commission	15,000	2013-2014	3%	Evaluation of wheat breeding lines for management of Hessian fly in the Pacific Northwest

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INTERNAL PEER REVIEW/PRINCIPAL INVESTIGATOR VERIFICATION FORM

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INTERNAL PEER REVIEW VERIFICATION

Commodity commissions/organizations require internal peer review by colleagues familiar with the subject matter. This proposal has been peer reviewed by the following individuals:

Reviewer 1: _Sanford Eigenbrode_____ _____ 12/4/2012
(Type/Print name) (Signature) (Date)

Reviewer 2: _Alex Karasev_____ A. Karasev 12/4/12
(Type/Print name) (Signature) (Date)

Dept. Head/ ___James B. Johnson_____ James B. Johnson 5 Dec. 2012
Unit Administrator (Type/Print name) (Signature) (Date)

PROGRESS REPORT

PROJECT NO: BJK968

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

PERSONNEL: Nilsa A. Bosque-Pérez, Professor
Lana Unger, Research Support Scientist 1

ADDRESS: Nilsa A. Bosque-Pérez, Dept. of PSES, University of Idaho, Moscow, ID 83844-2339; 208-885-7544; nbosque@uidaho.edu

ACCOMPLISHMENTS:

Resistance screening. The Hessian fly colony established in our laboratory in 1998 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 210 advanced breeding lines and varieties were evaluated for fly resistance in the laboratory during 2012. Lines originating from crosses with several Hessian fly resistant sources were tested. This included hard red spring wheat lines derived from the crosses JFSN*4/IDO584 (70-5) and JFSN*4/IDO584 (70-5) // Lassik. In addition, HWS/HRS lines derived from the cross IDO586/Jerome (66-4) // Lassik were tested. Several of the lines evaluated had a high proportion of resistant plants (Table 1).

Table 1. Percent plants resistant to Hessian fly in the laboratory, Moscow, ID, January-February, 2012.

Line no.	Genotype	Pedigree	Class	% Resistant plants
10878	A09438S	JFSN*4/IDO584 (70-5) // Lassik	HRS	100
10882	A09438S	JFSN*4/IDO584 (70-5) // Lassik	HRS	100
10873	A09438S	JFSN*4/IDO584 (70-5) // Lassik	HRS	100
10888	A09438S	JFSN*4/IDO584 (70-5) // Lassik	HRS	100
10889	A09438S	JFSN*4/IDO584 (70-5) // Lassik	HRS	100
10892	A09438S	JFSN*4/IDO584 (70-5) // Lassik	HRS	100
10919	A09438S	JFSN*4/IDO584 (70-5) // Lassik	HRS	100
10920	A09438S	JFSN*4/IDO584 (70-5) // Lassik	HRS	100
10856	A09427S	IDO586/Jerome (66-4) // Lassik	HWS/HRS	83
10912	A09438S	JFSN*4/IDO584 (70-5) // Lassik	HRS	79
10914	A09438S	JFSN*4/IDO584 (70-5) // Lassik	HRS	90
10874	A03767S-IJ-3	JFSN*4/IDO584 (70-5)	HRS	100
10875	Lassik	Lassik	HRS	10

Mean of 16 to 20 plants per genotype.

Work continued in collaboration with Drs. Jianli Chen at Aberdeen and Deven See at WSU-USDA to develop molecular markers for Hessian fly resistance genes. *F1* individuals were derived from the cross JFSN*4/IDO584 // Lassik. IDO584 carries *H25* and is fly-resistant. Lassik is a fly-susceptible, disease resistant genotype that carries the genes *Yr36* for stripe rust resistance and *FHB1* for FHB resistance based on the markers *Uhw89* and *Umn10*, respectively. *F3* lines derived from the cross were screened. Marker *Xgwm610* was effective for detecting the *H25* gene as indicated by PCR product bands of 195bp and 191bp for the resistant and susceptible alleles, respectively. All of the lines exhibiting a Hessian fly resistant phenotype showed the presence of the 195bp band. All of the moderately resistant lines showed both the 191bp and 195bp bands, indicating these lines are still segregating for Hessian fly resistance.

Uhw89F is a marker tightly linked to high protein gene *Gpc-B1,* which is tightly linked to the *Yr36* gene for resistance to stripe rust. The PCR product band of 121bp identifies lines carrying this resistance gene. Marker *Umn10V* detects lines with the *FHB1* gene for resistance to Fusarium head blight, as illustrated by a PCR product band of 265bp for the resistant allele. Several of the lines screened (for example 10882, 10892, and 10920) combine resistance to the two diseases and to Hessian fly. The identification of *F3* individuals that possess marker alleles for resistance to Hessian fly, stripe rust and Fusarium head blight, indicates that it is possible to pyramid multiple resistant genes in spring wheat using marker-assisted selection.

Monitoring Hessian fly. In collaboration with the REACCH project and the Purdue University/USDA Lab, Hessian fly pheromone traps were deployed in 15 locations in northern Idaho to determine fly incidence and abundance. The traps use a lure that attracts male flies. Flies were found in all locations surveyed but male abundance varied greatly. Testing by the USDA lab at Purdue would assist us in determining the genetic variability of flies in Idaho.

Table 2. Locations for Hessian fly pheromone traps and mean number of male flies captured per location, June-July, 2012.

Locations	Mean number of flies per location
Genesee	252
Genesee	216
Genesee	153
Genesee	108
Genesee	1692
Genesee	1935
Greencreek	630
Greencreek	162
Kendrick	1152
Lapwai	189
Moscow	1242
Moscow	27
Tensed/Worthy	27
Tensed/Worthy	135
Tensed/Worthy	27

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. Evaluation of breeding materials and mapping populations in the laboratory and sampling to assess fly populations in the field will continue during 2013-2014. Information from this work will help growers manage pest populations and optimize productivity of wheat.

PUBLICATIONS AND PRESENTATIONS:

*Kidwell, K.K., G.B. Shelton, V.L. DeMacon, X. Chen, S.O. Guy, J.S. Kuehner, B.-K. Baik, D.A. Engle, and N.A. Bosque-Pérez. 2012. Registration of 'Babe' wheat. *Journal of Plant Registrations.* 6(2): 156-160.

Bosque-Pérez, N.A., J. Chen, L.M. Unger, D.R. See, S. Odubiyi, and J. Wheeler. 2012. Marker-assisted breeding for Hessian fly and disease resistance in spring wheat. 20th Biennial International Plant Resistance to Insects Workshop. Minneapolis, Minnesota, April 1-4, 2012. (Poster presentation)

Bosque-Pérez, N.A., J. Chen, L.M. Unger, D.R. See, S. Odubiyi, and J. Wheeler. 2012. Marker-assisted breeding for Hessian fly and disease resistance in spring wheat. Entomological Society of America Pacific Branch Annual Meeting. Portland, Oregon, March 25-28, 2012. (Poster presentation)

*Odubiyi, S., L.M. Unger, K. Ando, M. Pumphrey, and N.A. Bosque-Pérez. 2012. Screening wheat genotypes for resistance to Hessian fly and development of DNA markers for resistance breeding. Entomological Society of America Annual Meeting. Knoxville, Tennessee, November 11-14, 2012. (Poster presentation)

* For information purposes. No IWC funds were utilized for this research.