PROJECT NO: BJK868

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

PERSONNEL: Nilsa A. Bosque-Pérez, Professor of Entomology
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JUSTIFICATION: Hessian fly resistance is one of the most important traits for spring wheat varieties in northern Idaho (District 10), 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 northern 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. Additionally, as mentioned above Hessian fly has now reached the southern part of the state.

Hessian fly has not gone away from northern Idaho; it is being largely controlled 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. 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. 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 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.

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: 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 the *H3* and *H25* genes. Mapping populations will be screened to assist in the development of molecular markers for the *H3* gene and 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: 3 years (2014-2017; 3rd year of a continuing project)

COOPERATION: UI: J. Chen, A. Rashed, J. Marshall; WSU: D. See, M. Pumphrey

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. 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. Results also will 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 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). 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). 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.

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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.

IDAHO WHEAT COMMISSION - BUDGET FORM

Allocated by	Idaho Wheat Commission	during FY 2015	$	20,000
Allocated by	Idaho Wheat Commission	during FY 2016	$	10,987

REQUESTED FY 2017 SUPPORT:

	Salary	Temporary Help	Fringe	Travel	OE	Grad Fees	TOTALS
Idaho Wheat Commission	$ -	$ 8,500	$ 213	$ 2,500	$ 3,000	$ -	$ 14,213

OTHER RESOURCES (not considered cost sharing or match):

a) UI (salaries, operating)		17,000
c) F & A (34%)	$	6,796
TOTAL OTHER RESOURCES	$	28,796

TOTAL PROJECT ESTIMATE FOR FY 2017:	$ 14,213 *(Requested)*	$ 28,796 *(Other)*	$	43,009 *(Total)*

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

	(PI name)	*(PI name)*	*(PI name)*	*(PI name)*
Salary	$ -	$ -	$ -	$ -
Temporary Help	$ -	$ -	$ -	$ -
Fringe Benefits	$ -	$ -	$ -	$ -
Travel	$ -	$ -	$ -	$ -
Operating Expenses	$ -	$ -	$ -	$ -
Graduate Student Fees	$ -	$ -	$ -	$ -
TOTALS	$ -	$ -	$ -	$ -
			Total Sub-budgets	$ -

10.7.2015 - Version

ANNUAL REPORT

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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 200 advanced breeding lines and varieties were evaluated for fly resistance in the laboratory during 2015. Lines originating from crosses with several Hessian fly resistant sources were tested. This included spring wheat lines derived from IDO1406 (A09447S-8), IDO1408 (A09438S-105), IDO1409 (A09438S-153), A09427S-1 and A09438S-4. In addition, hard white spring wheat lines derived from other crosses were tested. Several of the lines evaluated had a high proportion of resistant plants (Table 1). 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.

Table 1. Percent plants resistant to Hessian fly in the laboratory, Moscow, ID, June to July 2015.

Genotype	% Resistant plants
A09438S-146-22	100
A09438S-146-23	100
A09438S-146-24	0
A09438S-139-2	0
A09438S-139-3	100
A09438S-139-5	100
A09438S-139-7	100
A09438S-139-8	0
A09438S-139-10	17
A09427S-1-1	100
Hollis (Res. check)	100
Lassik (Susc. check)	0

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. Lines derived from multiple crosses were examined. Several of the lines identified screened combine resistance to multiple diseases and to Hessian fly. The identification of individuals that possess marker alleles for resistance to Hessian fly and wheat diseases indicates that it is possible to pyramid multiple resistant genes in spring wheat using marker-assisted selection. This should allow the breeding program to accelerate efforts to develop varieties that combine resistance to multiple biotic constraints and other desired characteristics.

Monitoring Hessian fly. With assistance from Marty Schraer from Syngenta, spring wheat plant samples that appeared to be infested by Hessian fly were collected at Nampa. Plants were examined at our laboratory in Moscow and the identification of Hessian fly confirmed. This represents the first report of Hessian fly in southern Idaho. Adult insects collected from the infected plants were used to establish a new insect colony that is been kept in Moscow for screening purposes. In collaboration with the REACCH project and colleagues from UI (Juliet Marshall, Chad Cheney, Erik Wenninger, and James Barbour) and Marty Schraer, pheromone traps were deployed in multiple locations in southern Idaho to determine possible Hessian fly presence and abundance. The traps use a lure to attract male flies. Traps were deployed from July to August. No adult flies were found at any of the locations surveyed but this could be due to the late deployment of the traps and insects being on diapause at that time.

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 was detected from southern Idaho for the first time 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 2016-2017. Information from this work will help growers manage pest populations and optimize productivity of wheat.

PRESENTATIONS:*

Alwan, E.A., N.A. Bosque-Pérez, L.M. Unger, S. Odubiyi, D.R. See, and M. Pumphrey. 2015. Identification and characterization of new sources of resistance to Hessian fly in Pacific

Northwest spring wheat germplasm. National Association of Plant Breeders Meeting. Pullman, Washington, July 27-30, 2015. (Poster presentation).

Alwan, E.A., N.A. Bosque-Pérez, L.M. Unger, S. Odubiyi, D.R. See, and M. Pumphrey. 2015. Identifying new sources of resistance to Hessian fly in Pacific Northwest spring wheat germplasm. Entomological Society of America Pacific Branch Annual Meeting. Coeur d'Alene, Idaho, April 12-15, 2015. (Poster presentation).

*For information purposes. No IWC funds were utilized for research reported in the above presentations.