FELLOWSHIP SUMMARY REPORT

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Research Plant Pathologist
USDA-ARS Cereal Disease Laboratory

Theme 2: Managing risks in a connected world
Subject Title: Translational research in response to international emerging cereal rust disease threats

Host institution: University of Sydney, Plant Breeding Institute

Host collaborator: Prof. Harbans Bariana

Dates of Fellowship: 5 November 2018 through 2 January 2019

I consent to my report being posted on the Co-operative Research Programme's website

1. What were the objectives of the research project? Why is the research project important?

Emerging diseases threaten global production of staple food crops including cereals. Rust diseases of wheat are particularly threatening for their ability to become airborne and move across regions and continents making them a major international concern. However, the most dangerous characteristic of rust pathogens is their ability to change and become more virulent in response to previously resistant wheat varieties. Though abundant resistance genes effective to emerging rust threats including Ug99 are available, progress in mitigating the threat of Ug99 has been slowed by how the resistance genes are deployed. This research project included two objectives that filled current gaps in mitigating international cereal rust threats. First, linkage blocks of multiple Ug99 resistance genes were constructed for facilitating use of multiple genes. Second, guidelines were formulated for sustainable use of disease resistance genes in agriculture. Both research deliverables and guidelines will strengthen the international response to cereal rust threats and serve as an example for responding to future risks.

2. Were the objectives of the fellowship achieved?

As a United States government employee, in the USDA Agricultural Research Service, I was required to return to the United States early because of the partial United States government shutdown starting on December 22, 2018. This early return did impede achievement towards the two objectives of the research project. However, substantial progress was still made on each objective.

Objective 1, Linkage blocks for Ug99 resistance: Molecular marker genotyping on wheat DNA received by the University of Sydney from the USDA-ARS Cereal Disease Laboratory was accomplished. Parents of the wheat populations that were constructed in order to combine multiple rust resistance genes were assessed with several molecular markers on chromosome arm 2BS (SSR, KASP, TNAC markers – 38 total). Polymorphic markers were selected for assessment on corresponding populations. Two wheat populations composed of 288 different recombinant lines were assessed with polymorphic markers. Putative recombinant lines combining *Sr36* and *Sr39* on chromosome arm 2BS were identified. Putative recombinants combining *Sr36* with several leaf rust resistance genes on chromosome arm 2BS (*Lr13, Lr23,* and *Lr16*) were identified. Future work will involve validation of putative recombinant lines through additional phenotyping (at the USDA-ARS Cereal Disease Lab) and genotyping (at both the University of Sydney and the USDA-ARS Cereal Disease Lab).

Objective 2: Guidelines for resistance gene deployment: Interdisciplinary discussions were facilitated with multiple experts in Australia regarding the parameters currently limiting the effective utilization of multiple disease resistance genes in crops. Venues for the discussions included the Australian Cereal Rust Control Program annual meeting (including several private industry wheat breeders, Grains Research and Development Corporation officials, and CSIRO researchers), ad hoc meetings at the University of Sydney plant breeding institute (including with a researcher from the New South Wales Department of Primary Industries), and at the International Marie Bashir Institute Annual Colloquium at the University of Sydney main campus. I was able to present my research at several venues which facilitated many of these discussions (presentations at the Australian Cereal Rust Control Program meeting, at the Plant Breeding Institute seminar series, and at CSIRO, Canberra). The primary outcomes of these discussions included the need for a more holistic understanding of resistance gene utilization in concert with fungicide resistance management. Unfortunately, cutting the fellowship short did not allow the completion of a manuscript draft on disease resistance gene utilisation.

3. What were the major achievements of the fellowship? (up to three)

The primary major achievement was the construction of linkage blocks of multiple wheat rust resistance genes on a single chromosome arm. Once validated, these blocks could be used internationally and without restriction (they are non-GMO) in order to alleviate wheat rust and maintain resistance durability.

The second major achievement is the initiation of several collaborative projects with the University of Sydney Plant Breeding Institute that will constitute a major emphasis of my research in the USDA-ARS Cereal Disease Laboratory for years to come. Specifically, several wheat populations and genetic stocks are now being sent to the USDA-ARS for screening against international isolates of the stem rust fungus in a biocontainment laboratory. This future research will be valuable for Australia, the United States, and other countries for characterizing additional disease resistance genes.

The most unexpected major achievement of the fellowship arose after discussions with CSIRO researchers visiting the University of Sydney Plant Breeding Institute during the Australian Cereal Rust Control Program meeting. By interacting with these scientists directly, it came to our knowledge that both CSIRO and the USDA-ARS had made substantial progress on a very similar research project in identifying the stem rust resistance allele gene sequences of the same locus. We were able to share our data which facilitated a significant discovery that will likely be published in a relatively high-profile journal within the next year.

4. Will there be any follow-up work?

I anticipate that several publications will emerge from this research fellowship. First, a publication in a scientific journal will be produced from the work on constructing linkage blocks of rust resistance genes on chromosome arm 2BS. Second, I anticipate a publication will be produced on the collaborative work with CSIRO on identification of the gene sequences of stem rust resistance genes. I anticipate that these publications will be made public within a year.

The University of Sydney is continuing research on linkage blocks that was initiated during the fellowship. As indicated in part 3, several wheat genetic stocks and populations from the University of Sydney are now planned to be sent to the USDA-ARS. This represents the start of a new collaboration between USDA-ARS and the University of Sydney.

The research is likely to result in novel products: wheat lines with linkage blocks of rust resistance genes. We anticipate making this material as accessible as possible through Material Transfer Agreements.

5. How might the results of your research project be important for helping develop regional, national or international agro-food, fisheries or forestry policies and, or practices, or be beneficial for society?

The linkage blocks of Ug99 resistance genes developed will be disseminated to CIMMYT (with a broad international reach), PBI (where backcrossing to Australian cultivars is routinely performed), USDA-ARS (including multiple USDA-ARS research groups where pre-breeding is performed), and select wheat breeders targeting Ug99 resistance. Ultimately the research on linkage blocks will be published, the genetic stocks will be deposited in gene banks (including the USDA-ARS National Small Grains Collection and the Australian Grains Genebank) and the genetic material will be distributed to any interested party. This dissemination of the result of the research project will be beneficial towards food security (increased production because of reduced wheat yield losses caused by rust) and increased plant and environmental health (better resistance which could possibly reduce fungicide use).

6. How was this research relevant to:

This research project was relevant to the objectives of the CRP in the following ways:

The research was relevant to food security and inter-connectedness of trade and scientific co-operation. This research project facilitated interactions with diverse interdisciplinary scientists. The wheat research community currently lacks clear guidelines in using disease resistance genes in agriculture. This problem is not just within the scope of scientists, but includes variety release committees, governmental and non-governmental policy makers, the seed industry, and ultimately farmers. Our work towards developing resistance gene deployment guidelines involved interactions with individuals across this spectrum. Also, distribution of the linkage blocks developed to breeders will

allow further opportunities to collaborate with these users of the research and inform them of the value of the linkage blocks in the context of resistance gene deployment and sustainably managing risk.

This research project was relevant to the objective of Theme 2, "Managing Risks in a Connected World" as follows:

The research specifically addressed the threat of emerging diseases. Our objectives were designed to contribute towards both 1. Coping with and managing an emerging disease risk (Ug99) and 2. Anticipating and pre-empting future crop disease risks. Ug99 is an imminent disease risk for major wheat producing areas in the world and our objective to develop linkage blocks of stem rust resistance genes fills a gap in other efforts to pre-emptively prepare for this threat (Borlaug Global Rust Initiative).

7. Satisfaction

- Did your fellowship conform to your expectations?

The fellowship exceeded my expectations in providing several fruitful opportunities for research collaboration. Unfortunately for our research, the US Congress and President failed to reach an agreement to fund the USDA past December 22, 2018 with resulted in cutting the fellowship short.

- Will the OECD Co-operative Research Programme fellowship increase directly or indirectly your career opportunities? Please specify.

The OECD CRP fellowship will directly increase my research productivity and has expanded the range of my close collaborators. This will benefit my career going forward and will also benefit the US taxpayers that I serve by facilitating more relevant research.

- Did you encounter any practical problems?

The two biggest practical problems were (1) the US government shutdown cutting the fellowship short (already discussed) and (2) receiving DNA samples for molecular marker assessment. Receiving the DNA samples from USDA-ARS took longer than anticipated due to difficulty in clearing customs in Australia. Going forward it would be good to plan for plenty of time necessary to clear customs.

- Please suggest any improvements in the Fellowship Programme.

None.

8. Advertising the Co-operative Research Programme

- How did you learn about the Co-operative Research Programme?

I learned about the program from a colleague of mine who completed a fellowship a few years ago.

- What would you suggest to make it more "visible"?

You could advertise the program at scientific meetings of your target audiences.

- Are there any issues you would like to record?

None