Washington Grain Commission
Wheat and Barley Research Annual Progress Reports and Final Reports

Project #: 6451

Progress Report Year: *__3__ of _3___ Final Report*

Title: A Genetic Arsenal for Wheat Production under Drought

Project PIs: Camille Steber, Kimberly Garland Campbell, and Scot Hulbert
Cooperators: Michael Pumphrey, Arron Carter

Executive summary: This project identified genes associated with drought tolerance. The molecular markers associated with these QTLs can be used by the Washington wheat breeding programs to select for drought-tolerance-associated traits. Some of the lines generated are being considered for release, or will be used in the wheat breeding programs.

Objective 1. Characterize lines from the three RIL mapping populations Louise/Alpowa, Alpowa/Express, and Drysdale/Hollis for drought tolerance, map drought tolerance loci, and make breeding selections that create unique combinations of drought tolerance mechanisms. The goal was to improve yield under drought by developing populations from parents that use different mechanisms to yield well under drought. The resulting populations allowed selection of lines that yielded better than either parent under drought, and mapping of quantitative trait loci (QTLs) for drought tolerance traits. Molecular maps were developed based on SNPs and SSR markers. QTL analysis is completed in the Alpowa/Express and the Hollis x Drysdale population, and the Louise/Alpowa population will be finished by June 2015. Drought tolerance mechanisms and ability to yield well under drought (measured based on drought susceptibility index) was examined in Louise/Alpowa and Alpowa/Express in the 2011 and 2012 field seasons, and the Hollis/Drysdale population in the 2012 and 2013 field seasons. Selected lines that yielded well under drought were further analyzed in the field in 2013 and 2014. Selected Louise/Alpowa derived lines that yielded better than both parents were crossed to related lines carrying the Yr5 and Yr15 stripe rust resistance genes as a collaboration with M. Pumphrey. However, Louise/Alpowa lines carrying HTAP resistance will be placed into the Western Regional Trials and in the WSU Cereal Variety Trials for further evaluation for release. Although Drysdale is a Australian line, it performed very well in Washington and appears to be an excellent source of drought tolerance for this region. Selected lines from the Hollis x Drysdale will be developed in collaboration with M. Pumphrey, and have been included in the WSU Cereal Variety Trials.

Objective 2. Using Hollis and Louise as standard hard red spring and soft white spring backgrounds, develop lines that have new sources of drought tolerance introgressed into locally adapted germplasm. The previous project identified CIMMYT lines showing drought tolerance in eastern Washington. 516 lines from crosses between CIMMYT germplasm and Hollis or Louise were examined in Lind. Of these, 98 were selected for advanced testing in 2013 and 2014. A further 17 more advanced CIMMYT lines and varieties showing good performance at Lind were crossed to Hollis, and the F1's intermated to begin making a single Multiparent

Advanced Generation Inter-Cross (MAGIC) population for both QTL mapping and line selection. The lines have now been intercrossed three times and 500 of the resulting plants have been self-fertilized to begin establishing lines. This will provide an excellent resource for future breeding for drought tolerance. Two very promising lines were recovered from the second backcross of Dharwar Dry to Louise. These lines yielded better than Louise under drought stress at Lind Farm in 2014.

Objective 3. Generate and use genomic selection indices based on the available populations to increase the speed of drought tolerance breeding.
This project has identified molecular markers linked to water use efficiency, canopy temperature, and yield under drought that can be used to improve selection for drought tolerance within breeding programs. Surprisingly, higher water use efficiency did not show a strong correlation to yield under drought. However, lines with high water use efficiency tend to be among the best yielding under drought. This suggests that there is not a simple relationship because yield and water-use efficiency. Future work in collaboration with Dr. Asaph Cousins, an expert in photosynthesis, will examine what physiological properties allow Louise to benefit from high water use efficiency. A QTL for delayed flag leaf senescence on chromosome 4A linked to marker IWA4319 with a LOD of 6.18 explained 35% of the variation for yield under drought. This emphasizes the importance of maintaining photosynthetic capacity under stress. A QTL for cooler canopy under drought stress on chromosome 3B linked to marker IWA4311 (LOD 6.02) explained 15% of the variation for yield under drought. In general, cooler canopy under drought stress was associated with higher yield. Previous work showed that cooler canopies are associated with deeper and healthier root systems (Lopes et al., 2010). This suggests that root architecture is very important to performance under drought stress in the eastern Washington environment. This will be further investigated in the next project led by Dr. Karen Sanguinet, an expert in root physiology who was recently hired in the Washington State University, Department of Crop and Soil Science.

Impact: Improved drought tolerance in selected lines has the potential to improve yield and cropping systems on the dry side of Washington by reducing production risk and the number of fallow seasons.

WGC project number: 6451
WGC project title: A Genetic Arsenal for Wheat Production under Drought
Project PI(s): Camille M.. Steber, Kimberly Garland-Campbell, Scot Hulbert
Project initiation date: 7/1/2012
Project year: 3 of 3 (2015)

Objective	Deliverable	Progress	Timeline	Communication
1. Characterize lines from two RIL mapping populations for drought tolerance, map drought tolerance loci, and make breeding selections that create unique combinations of drought tolerance mechanisms.	A. SSR and SNP analysis was performed on two RIL populations, and by SNP analysis on a third. B. Molecular markers linked to QTL for drought tolerance mechanisms including canopy temperature, water use efficiency, and delayed flag leaf senescence were identified. C. Cooler canopy showed the strongest correlation to yield under drought, suggesting that deeper root systems are very important. D. New germplasm available for testing in Western Regional Nurseries by June 2015.	1. Drought tolerance traits segregating in the Louise x Alpowa, Alpowa x Express, and Hollis x Drysdale RIL populations have been characterized. 2. QTL analysis has been used to map drought tolerance genes in two mapping populations, and a third will be completed by June of 2015. 3. A linkage map for use in QTL analysis has been generated for the Louise/Alpowa population. 4. Promising lines have been shared with the spring wheat breeding program, entered into the Western Regional Nursery, and entered into the Cereal Variety Trial.	Tasks completed: 1) Analysis of selected lines from each population for drought tolerance in the field; 2. Analysis of stripe rust resistance of the selected lines in the field to determine which drought tolerant lines have sufficient stripe rust resistance to be entered into regional trials; 3. Completion of data analysis and QTL mapping for drought tolerance traits.	Results were communicated at the Wheat Research Review, and at the Lind and Spillman Field Days.
2. Using Hollis and Louise as standard hard red spring and soft white spring backgrounds, develop lines that have new sources of drought tolerance introgressed into locally adapted germplasm.	A. New genetic sources of drought tolerance introgressed into locally adapted cultivars Louise and Alpowa. These pre-breeding lines have been made available to wheat breeding programs at WSU	1. Crosses of Australian and CIMMYT lines to Louise and Hollis have been completed. 2. Selections have been made from crosses to Hollis. 3. Prebreeding lines derived from Hollis/Drysdale have been selected for increased water use efficiency in a Hollis background.	Selection for improved drought tolerance in the locally adapted backgrounds of Louise and Hollis were made in the 2014 and the 2015 field seasons.	Results were communicated at the Wheat Research Review, and at the Lind and Spillman Field Days.
3. Generate and use genomic selection indices based on the available populations to increase the speed of drought tolerance breeding.	Markers for drought tolerance loci from Alpowa, Louise, and Drysdale that can be used to move loci within the spring and winter breeding programs by June 2015.	1. Molecular markers were identified linked to: a. high water use efficiency on chromosomes 2B and 3B; b. delayed flag leaf yellowing on chromosome 4A; and c. cooler canopy temperature on chromosome 2B . 2. Intercrosses between selected Louise/Alpowa lines to sources of stripe rust resistance genes Yr5 and Yr 15 to select germplasm with both increased drought tolerance and stripe rust resistance.	Populations derived from crosses between drought tolerant Louise/Alpowa RILs and Alpowa and Louise-like lines with Yr5 and Yr15 are under development. Molecular markers linked to drought tolerance loci will be used to follow gene deployment.	