Project #: 7768

Progress Report Year: __3__ *of* __3__ *(maximum of 3 year funding cycle)*

Title: A Genetic Arsenal for Drought Tolerance, Getting to the Root of the Problem

Cooperators: Karen A. Sanguinet, Camille M. Steber, Kimberly Garland-Campbell, Timothy Paulitz, Scot Hulbert, Arron Carter

Executive summary: Dryland farms in eastern Washington routinely experience yield losses due to drought stress. Improving wheat root structure can help to resist such stresses by increasing access to water. The combined issues of drought, no-till practices and the changing pathogen load affect all market classes of wheat and barley. Traditional breeding for wheat and barley has mainly focused on the health of the aboveground parts of the plant. As a result, many modern varieties have small and/or shallow root systems compared to landraces. The primary goal of this research project is to identify root architectures in current breeding populations of both spring and winter wheat cultivars associated with better yield under drought stress. We assessed the root structures of Hollis, Drysdale, Louise, and AUS28451, as well as the 10 best and worst yielding lines from Hollis/Drysdale population in the summers of 2015 and 2016 at the Lind Dryland Research Station. Quantification of the root traits has been completed for the greenhouse trials for two years using Hollis, Drysdale, Louise, AUS28451, Alpowa, and Dharwar Dry with clear differences between cultivars in rooting depth, volume and area. The field trials with Hollis, Drysdale, and the RILs showed considerable variation and there was no correlation between rooting traits and yield in the RILs, but differences were observed in the between Hollis and Drysdale. Currently, we are performing another greenhouse trial in larger bins with well-watered control vs. water-withheld challenges for the varieties Louise, Drysdale, Hollis, AUS20451, Onas, Alpowa, and Dharwar Dry. Winter wheat genotypes (*wt, Rht1, Rht2, Rht1 Rht2*) in the Brevor and Golden backgrounds were sown at Spillman Farm in October 2015 and November 2016. Root scans were taken throughout the growing seasons in 2016 and 2017 in additions to soil coring after crop maturity. Preliminary findings showed that there were no statistically significant differences for rooting depth at maturity conferred by *Rht* alleles.

Impact: Combined drought and heat routinely experienced in the PNW can cause 20-50% losses in grain yields as experienced in recent years. Previous research has shown root traits cannot be predicted or selected for using aboveground traits. The long-term impact of this research is to develop *in situ* root imaging technology for winter wheat, spring wheat, club wheat and barley cultivars under selection with the overall goal of improving the salient root traits important for drought tolerance. The ultimate goal of this research project is to improve root traits, architecture, and structure in current breeding populations of both spring and winter wheat cultivars to improve yield under drought stress. The root system has been touted as the next frontier in crop improvement. This work has helped provide preliminary data for federal grant applications, and data is being complied for peer-reviewed scientific publications as well as for articles in Wheat Life and data for field days to benefit PNW growers.

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Project PI(s): K. Sanguinet, C. Steber, K. Campbell, T. Paulitz **Collaborator: S. Hulbert, A. Carter**
Project initiation date:7/1/2015
Project year: final year

Objective	Deliverable	Progress	Timeline	Communication
1. Characterize the root systems of the five RIL parental lines: Louise, AUS28451, Dharwar Dry, Hollis and Drysdale using a digital in situ root imaging system to measure root traits such as root hair length and density root mass and rooting depth.	Methods and analysis of two key traits for drought stress: root architecture and lignin content in Louise, AUS28451, Dharwar Dry, Hollis and Drysdale (2017).	We ave successfully imaged Louise, AUS28451, Hollis, and Drysdale in the field in Summers of 2015 and 2016. In addition, we performed two years of (2015-2016 and 2016-2017) greenhouse trials on Louise, Hollis, Drysdale, Alpowa, AUS28451, and Dharwar Dry.	The first round of field trials and quantification of root architecture was completed by the end of 2015. Lignin content measurements will be performed in the greenhouse in winter 2015-16 of the parental lines.	Our findings will be reported in the July 2016 issue of Wheat Life . They were also presented at the Tri-societies meeting in Fall 2016. In addition, we attended the Lind and Spillman field days in 2015, 2016 and 2017. We will publish a short communication in a peer-reviewed journal regarding our spring wheat work, which is in preparation.
2. Examine the Hollis/Drysdale RIL population to determine if yield under drought and canopy temperature correlate with a specific root trait or traits.	Determine the link between canopy temperature, root architecture traits and yield (end of 2017).	With the aid of Dr. Hulbert, the 10 highest and lowest yielding RIL populations from Hollis/Drysdale RIL populations were sown at Lind in summer 2015 and then again in summer of 2016. Images were taken every two weeks. We found different growth trends in the field for Hollis and Drysdale, but the RIL data were inconsistent.	After analysis of RIL data from summer 2015 and summer 2016, there was no clear correlation between measured root traits and overall yield in the RILs.	We will communicate these findings at field days and in an extension publication.
3. Examine backcross lines in the Louise background with specific root traits from AUS28451 including higher root lignin, root depth, root branching, root biomass, and root hair density to improve yield under drought and to select breeding lines with vigorous roots. Also backcross lines of Dharwar Dry to Louise will be analyzed for improved drought resistance and root architecture traits.	Development of breeding lines with increased lignin and root vigor which are predicted to show enhanced drought tolerance (2018-2020).	We have begun analyzing the parental lines. With help from Dr. Garland-Campbell's group, backcrossing to Louise is advancing and we will be evaluating the Louise/AUS28451 advanced BC lines.	The BC1F6 lines are now ready for analysis and will begin in 2018. We were behind schedule in their analysis.	Our findings will be communicated at field days at Lind and Spillman farms. In addition, we will again prepare a publication for Wheat Life.
4*. Examine root architectural traits in wild type, *Rht1, Rht2* and *Rht1 Rht2* dwarf winter wheat lines in the Brevor and Golden backgrounds.	Development tools and imaging to assess the importance of root growth and the *Rht* alleles on winter wheat cultivars (2017-2018).	With the help of Dr. Carter, *wt, Rht1, Rht2* , and *Rht1 Rht2* lines in the Brevor and Golden backgrounds were sown in October 2015 and November 2016 at Spillman Farm. Imaging tubes were places after sowing. Seeds were be bulked for more expansive testing in Fall 2016-Summer 2017. We also performed deep soil coring of the lines at maturity to capture final rooting depth.	Imaging and analysis of root growth of winter wheat (*wt, Rht1, Rht2,* and *Rht1 Rht2* occurred at Spillman Farm in 2016 and 2017. The same lines were sown in vernalization chambers in the wheat greenhouse followed by growth in the WSU wheat greenhouse (performed Winter 2015-2016 and repeated Winter 2016-2017). Preliminary analysis just of rooting depth showed no significant difference between standard and *Rht* lines. However, further analysis of other root traits are underway.	Our findings will be communicated at field days at Lind and Spillman farms, on the small grains website and in a publication for Wheat Life, and will be submitted for publication in a peer-reviewed journal.
Expected impacts over the next 3 years: Previous data has shown that root and shoot traits are not correlated. The proposed research uses *in situ* root imaging techniques to add another metric for selection of breeding lines and determination of the supposed link between deeper rooting, canopy temperature and yield by addressing which root traits (depth, branching, thickness, angle, root hairs, lignin content) most influence yield. Once precise traits and their impact on yield are determined, this provides another tool in the breeding tool box for selection of plant traits that correlate with increased yield particuarly in drought or water-limiting conditions.				

The expected outcomes are:
1) Increasing the knowledge regarding root architecture and drought tolerance in wheat;
2) Selecting for key root architecture traits in wheat cultivars for improved drought tolerance;
3) Improving drought tolerance in the Spring White Wheat Louise in backcross populations with the landrace AUS28451 and the drought-tolerant cultivar ;
4) Determining the link between canopy temperature, yield and root architecture;
5) Determining the role of root lignin in drought stress and root pathogen resistance;
6) Development of in situ root imaging techniques for breeders as an additional metric and tool in their breeding arsenal
7)* Determine the impact of *Rht* mutantions on root development in winter wheat genotypes adapted to the PNW

*-new objective and outcome for years 2-3.