2017 USWBSI Durum CP Planning Meeting Report

Fargo, ND
April 4, 2017

The 2017 Durum CP Planning Meeting was held in Loftsgard Hall on the North Dakota State University Campus, Fargo, ND on April 4, 2017. The meeting was announced through the USWBSI FHB Listserv, both durum wheat stakeholders/growers and researchers were invited to attend. There were 10 attendees present: Xiwen Cai (NDSU), Elias Elias (NDSU), Shiaoman Chao (USDA-ARS), Viers Greg (Barilla America Inc.), Shahryar Kianian (USDA-ARS), Louis Kuster (ND durum grower), Xuehui Li (NDSU), Joel Ransom (NDSU), Steven Xu (USDA-ARS), and Shaobin Zhong (NDSU).

The meeting started with research progress updates presented by the individual PIs.

Xiwen Cai updated the progress in transferring FHB resistance from hexaploid wheat and relative species to durum:

- Four hexaploid wheat lines with wild species-derived FHB resistance were identified and they were hybridized with two durum cultivars (Divide and Alkabo).
- About 200 FHB-resistant segregants (F3-F4) have been selected from thousands of progenies from the crosses of four durum varieties/lines, i.e. Divide, Grenora, Alkabo, and D87450, with eight FHB-resistant hexaploid wheat lines that contain non-Fhb1 or wild species-derived resistance genes in the greenhouse.
- A total of 223 advanced durum introgression lines with varied levels of FHB resistance derived from different hexaploid sources have been developed and re-evaluated in the FHB nursery at Fargo, ND. Seventy-eight introgression lines were selected with highest resistance levels and were further evaluated in the FHB nursery at Hangzhou, China.
- Two RIL populations at F6 generation (n=173 and 350) have been developed from the crosses of two major hexaploid FHB resistance sources (Sumai 3 and PI 277012) with FHB-susceptible durum wheat 'Langdon'.
- The wild emmer-derived FHB resistance QTL *Qfhs.ndsu-3AS* have been positioned into a smaller genomic region and new PCR-based DNA markers flanking the QTL in durum have been developed.

Elias Elias updated the progress in identification and development of durum wheat germplasm for FHB resistance:

- Since the action plan was initiated, six new FHB-tolerant durum cultivars ['Divide' (2005), 'Alkabo' (2005), 'Grenora' (2005), 'Tioga' (2010), 'Carpio' (2012), 'Joppa' (2013)], have been released . These cultivars were developed by accumulating the minor QTL in the native durum germplasm.
- The new FHB tolerant cultivars such as Tioga, Alkabo, Grenora, Divide, Carpio, and Joppa are replacing the old susceptible cultivars Ben, Lebsock, Mountrail, and Maier. Currently the new cultivars are grown on 72% of acreage in ND. In 2016, Carpio and Joppa were grown on 27.3% of the acreage in ND. However, Divide remains the leading (21.5%) grown variety in ND followed by Carpio (17%)

- A total of 6,053 durum accessions from ICARDA have been screened and three accessions that maintained disease severity less than 30%. Fifteen populations were developed from crossing the three accessions with adapted germplasm.
- Four durum lines derived from the crosses involving PI 277012 and 'Sumai 3' exhibited a high level of FHB resistance and low DON, and good agronomic traits in the advanced yield trial conducted in 2016. One of the lines been crossed with modern durum cultivars and breeding lines. Approximately 4,000 F2 plants have bene genotyped with markers for *Fhb1* and *Cdu1* and about 600 F2 plants that are homozygous for *Fhb1* and *Cdu1* have been selected.

Shahryar Kianian updated the research progress on enhancing FHB resistance by epigenetic modification of durum cultivars:

- Five to 6 lines of 40 advanced mutant lines (M4) tested at three locations (St. Paul, Fargo and Carrington) during summer 2015 showed significant reduction in disease severity, FDK and DON. Phenotypic evaluation of these lines with 2 more replications in the greenhouse yielded similar results.
- The 40 advanced mutant lines were tested in another replicated trial during summer 2016 at field location in St. Paul yielded similar results for FHB, FDK and DON as tested in 2015.
- Five mutant lines that consistently have low FHB severity (15-25%) and DON, along with parental checks, were inoculated under controlled condition and tissues were collected at 6 different time points (starting with few hours after infection to 2 days after infection) for RNAseq analysis. However, due to cost associated with library construction and sequencing and lack of funding (our allotted budget does not even cover the salary of the postdoctoral scientist (UMN salary minimum $50,000 plus 35% fringe) the number of samples analyzed were reduced to 27 samples (initial plan was for 144 samples). The sequencing has been completed and data analysis is currently underway.
- Two of the most promising lines were crossed to their susceptible parental cultivar and then hybrid progenies have been advanced for three generations without selection or screening for resistance. The F1, BC1 and F3 plants will be evaluated to examine if the modified resistance gene(s) are stably inherited.

Joe Ransom reported the experiments on the value of genetic resistance and fungicides on the control of FHB in durum:

- Six durum cultivars (Alkabo, Carpio, Divide, Joppa, Mountrail and Tioga) and four durum lines (D09555, D09557, D09690, and D101073) were evaluated in the variety by fungicide trials at Carrington and Prosper, ND under misting conditions. The fungicide application when averaged over cultivar had 5.1 ppm DON compared to the non-sprayed level of 7.9. The combination of best cultivar Divide and fungicide resulted in 3.0 ppm and highest yield, more than 10 bushels per acre higher than the next cultivar.

Steven Xu updated his research on development and characterization of elite durum wheat lines with scab resistance:

- A total of 320 genotypes, including 258 durum lines (BC1F5 - BC1F7) and 62 parents and checks, were valuated using replicated experiments in two FHB nurseries (Fargo and Prosper, ND) in the summer of 2016.

- A subset of 288 genotypes selected from the 320 genotypes described above were have been genotyped as an association panel using wheat 90K iSelect array and evaluated in the greenhouse in spring 2017.
- Ten elite durum lines, their parents and major ND durum cultivars were evaluated in the field FHB nursery in Fargo using single-spikelet inoculation. They were also evaluated in a trial for evaluating agronomic performance, yield, and quality in two locations (Prosper and Langdon, ND). Due to severe outbreak of FHB disease in Langdon, the durum lines and checks in Langdon trial were evaluated for FHB resistance in the natural environment. Four durum lines showed the high level of FHB resistance and acceptable agronomic traits
- Three elite durum lines with the high level of FHB resistance and acceptable agronomic traits have been crossed to six durum breeding lines (D101073, D08900, D09555 and three isogenic lines with low cadmium in Carpio, Divide, and Joppa background) recently developed by ND durum breeding program. Over 20,000 F2 seeds have been produced from the crosses. Approximately 6,000 F2 plants have been genotyped with the markers for *Fhb1* and *Cdu1* and about 250 F2 plants that are homozygous for *Fhb1* and *Cdu1* have been selected.

Shaobin Zhong reported the progress on identifcation and mapping of novel QTL for FHB resistance introduced into durum wheat from PI 277012:

- A total of 182 recombinant inbred lines (RILs) from the cross between PI 277012-derived durum line 10Ae564 (Lebdock/PI 277012//Lebsock) and Joppa were evaluated in greenhouse for two seasons in 2015 and 2016 as well as in field FHB nurseries for three experiments (Fargo 2015, China 2015, and Fargo 2016)
- The RIL population was genotyped with the 90K iSelect array. QTL analysis indicated that one QTL on chromosome 2A from Joppa and two QTL each on 5A and 7A from 10Ae564 were associated with FHB resistance.

The members then discussed research plans and expected accomplishments for the next 2-year cycle of funding. Potential projects discussed were summarized in the followings:

- Develop and release 1-2 new durum cultivars with increased FHB resistance that is combined with low cadmium uptake, excellent yield potential and overall quality (Elias).
- Finish screening of a new set of 1,000 durum accessions from ICARDA. Also obtain additional 3,000-5,000 accessions from ICARDA (Elias).
- Incorporate and characterize the hexaploid-derived FHB resistance genes in the durum background and the role of D-genome chromosomes in FHB resistance, identify and manipulate the genetic factors that influence expression of FHB resistance genes in durum, and incorporate FHB resistance QTL from hexaploid wheat into adapted durum backgrounds for gemplasm development (Cai).
- Characterize advanced durum lines for retention of epigentically modified resistance, incorporate epigentically modified resistance into durum cultivars, and conduct transcriptome analysis of epigentically modified durum lines for understanding the changes that contribute to resistance (Kianian).
- Characterize the durum lines missing portions of durum chromosome 2A for their effect of FHB resistance (i.e., removal of the suppressor locus) (Kianian).

- Evaluate USDA-ARS einkorn wheat collection for FHB resistance. Approximately 1,500 einkorn wheat accessions (960 *T. monococcum* subsp. *aegilopoides*, 274 *T. monococcum* subsp. *monococcum*, and 282 *T. urartu* accessions) maintained in USDA-ARS National Small Grain Collection (Aberdeen, ID) will be evaluated for resistance to Type II resistance (Xu).
- Develop 200-300 new durum lines with a high level of FHB resistance that is combined with low cadmium uptake, excellent yield potential and overall quality and characterize the FHB resistance in a durum line derived from the crosses for pyramiding FHB-resistance QTLs from PI 277012 and 'Sumai 3' using a bi-parental mapping population (Xu).
- Identify and map the FHB-resistant QTL in *T. dicoccum* accession PI 254188 using a bi-parental mapping population (Zhong).
- Evaluate fungicide application strategies that reduce FHB and/or DON in durum by including any new cultivars. This trial will be a genotype by fungicide trial, with the objective of trying to determine the relative importance of genetic resistance and fungicides and how the newer genotypes are performing relative to others commonly grown by farmers (Ransom).
- Develop a synthetic durum wheat population by crossing 20-30 durum lines to a durum male sterile line (Ms3-Carpio) and conduct 2 cycles of phenotypic selection on FHB resistance. Develop a genomic selection model and conduct 2-4 cycles of genomic selection using the same synthetic population. By combining the phenotypic and genomic selection, develop about 20 half-sib families with better FHB resistance compared to original parents for further selection on grain yield and end-used quality traits (Xuehui Li).

Louis Kuster and Viers Greg presented their point of views representing growers and industry. Louis indicated that durum acreage is decreasing due to FHB epidemic in the region and current research and breeding for improving durum for FHB resistance is needed. Producers are now in a big transition by growing durum cultivars with best FHB resistance and low DON. Viers commented that durum industry is affected by FHB epidemic occurred in northern regions and the research conducted in the coordinated project is important. The members also discussed budget issues, future collaborations between projects, and reviewed currently-available germplasm and genomic resources that could be further utilized for the improvement of FHB resistance in U.S. durum wheat. Through this meeting, we prioritized research items for the next funding cycle to strengthen collaboration and avoid possible duplication of efforts.