DUR-CP Milestone Matrix for FY16-17

The DUR-CP will perform FHB research with durum in three of the four research areas proposed in the Action Plan, including **Variety Development and Host Resistance (VDHR)**, **Gene Discovery and Engineering (GDER), and FHB Management (MGMT)**. The specific objectives of the DUR-CP are to:

1. Search for novel sources of resistance to FHB in durum and its tetraploid relatives **(VDHR)**.
2. Identify, map, and validate FHB resistance QTL in the newly identified sources of resistance and develop user-friendly molecular markers to assist selection in durum breeding and germplasm development **(VDHR)**.
3. Investigate the mechanisms of FHB resistance and susceptibility in durum wheat **(VDHR and GDER)**.
4. Incorporate FHB resistance QTL from tetraploid and hexaploid wheat accessions into adapted durum backgrounds and develop elite durum germplasm with the assistance of molecular markers in selection **(VDHR)**.
5. Develop durum varieties with enhanced level of FHB resistance and reduced DON accumulation **(VDHR)**.
6. Evaluate chemical management strategies that reduce FHB and/or DON in durum **(MGMT)**.

For each of the objectives, the related projects and the PIs who are involved as well as the milestone matrix are described as follows. Detailed information is available in the individual PRPs.

RA: Variety Development and Host Resistance (VDHR) and Gene Discovery and Engineering (GDER)

Objective 1. Search for novel sources of resistance to FHB in durum and its tetraploid relatives

1. Identify sources of resistance to Fusarium head blight in durum wheat

PI	Months	Milestones	Progress	Output/Linkages
EE (SZ, FM, SC)	6	Preliminary evaluation of first set of 1000 durum accessions from ICARDA and several selected wild relatives for reaction to FHB in Nanjing, China, and Prosper, ND nurseries.	Initiated	List of putative sources of resistance.
EE (SZ, FM, SC)	12	Second round of evaluation in the greenhouse of putative resistance sources identified from previous year.	Partially completed	Confirm the resistance of previously identifies putative sources of resistance.
EE (SZ, FM, SC)	12	Haplotype identified sources of resistance.	Partially completed	Determine if the sources of resistance are novel.
EE (SZ, FM, SC)	18	Preliminary evaluation of the second set of 1000 durum accessions from ICARDA and other sources for reaction to FHB in Hangzhou, China, and Prosper, ND nurseries.	Partially completed	List of additional putative sources of resistance.

PI	Months	Milestones	Progress	Output/Linkages
EE (SZ, FM, SC)	24	Initiate crossing and backcrossing of putative sources of resistance with adapted germplasm. In addition make crosses between elite experimental lines/varieties and known sources of resistance in the breeding program.	fully completed; continue a new cycle	Introgress sources of resistance into adapted germplasm.

Objective 2. Identify, map, and validate FHB resistance QTL in the newly identified sources of resistance and develop user-friendly molecular markers to assist selection in durum breeding and germplasm development

1. Identification and mapping of novel QTL for FHB resistance introduced into durum wheat

PI	Months	Milestones	Progress	Output/Linkages
Zhong (Xu, SC)	6	Evaluate mapping population of 240 RI lines from the cross of between durum cultivar Joppa and line 10Ae564 in the greenhouse for the 1st season	Initiated	FHB disease severity data from the 1st season.
Zhong (Xu, SC)	12	Evaluate the population in the greenhouse and for the 2nd season and field for the first season	Partially completed	FHB disease severity data from the greenhouse in the 2nd season.
Zhong (Xu, SC)	18	Construction of genetic linage map; initial transfer of the QTL to adapted durum wheat cultivars	Partially completed	1) SNP marker data and a linkage map 2) Identify FHB resistance QTL from Joppa and 10Ae564
Zhong (Xu, SC)	24	Fine mapping of the FHB resistance QTL ; Improved durum lines with FHB resistance	Fully completed	Closely linked markers for marker-assisted selection in durum breeding; Durum lines with improved FHB resistance

Objective 3. Investigate the mechanisms of FHB resistance and susceptibility in durum wheat

1. Characterization of epigenetic changes of FHB-resistant durum lines produced by altering the DNA methylation and characterization of durum cultivars missing a FHB resistance suppressor

PI	Months	Milestones	Progress	Output/Linkages
SK (EE, FG)	6	Select the most FHB resistant lines with epigenetic modification based on field data; Begin DNA bisulfite sequencing	Initiated	Population development and DNA sequence raw data
SK (EE, FG)	12	Continue DNA bisulfite sequencing; Data analysis and validation	Partially completed	Population development and preliminary results for identification of epigenetic changes
SK (EE, FG)	18	RNAseq analysis; Initial development of RH lines will also begin on the second year of this project	Partially completed	Population development and identified epigenetic changes
SK (EE, FG)	24	Continue development of RH lines; RNA-seq data analysis	Fully completed	1) Information on the stability of resistance produced in lines treated; 5-methyl-azacytedine 2) Expression profiles of the genes involved epigenetic changes; 3) Information on the location of suppressor and tightly linked markers to the suppressor; 4) Durum lines without the suppressor.

2. Characterization of inheritance of hexaploid-derived FHB resistance genes in durum backgrounds and the role of D-genome chromosomes in FHB resistance

PI	Months	Milestones	Progress	Output/Linkages
XC (EE, SZ)	6	Evaluate the two RIL populations for FHB resistance in 2-3 greenhouse seasons; Identify D-genome chromosomes in the RILs using D-genome chromosome-specific markers. Genotype the RIL populations using Illumina 90K SNP array or GBS.	Initiated	Durum lines with D-chromosomes added; genotype data
XC (EE, SZ)	12	Evaluate introgression lines and materials at early generations for FHB resistance. Analyze haplotypes at the molecular marker loci flanking the FHB resistance QTL and validate the markers in the durum germplasm with improved FHB resistance. Make initial crosses of new hexaploid	Partially completed	Introgression lines that contain the resistance QTL and different D-genome chromosomes; hybrids of hexaploid by durum crosses

PI	Months	Milestones	Progress	Output/Linkages
		resistance sources with adapted durum wheat cultivars and screen segregating materials for FHB resistance to select resistant segregants and advance generations of resistant progeny		
XC (EE, SZ)	18	Perform genetic mapping and QTL analysis. Analyze D-genome chromosomes in the RIL and determine their role in FHB resistance. Evaluate advanced durum introgression lines for FHB resistance and agronomic performance at multiple locations in ND and China and select elite durum germplasm with improved resistance.	Partially completed	Knowledge of the effect of individual D-genome chromosomes on FHB resistance in the durum backgrounds; elite durum lines with improved FHB resistance
XC (EE, SZ)	24	Make backcrosses and advance generations of the new crosses to develop genetically stabilized introgression lines with improved FHB resistance in the greenhouse. Analyze haplotypes at the molecular marker loci flanking the FHB resistance QTL and validate the markers in the durum germplasm with improved FHB resistance. Present and publish results.	Fully completed	Strategy to improve FHB resistance in durum wheat by manipulating D-genome chromosomes in the durum backgrounds; Durum germplasm with improved FHB resistance

Objective 4. Incorporate FHB resistance QTL from tetraploid and hexaploid wheat accessions into adapted durum backgrounds and develop elite durum germplasm with the assistance of molecular markers in selection

1. Development and characterization of elite durum wheat lines with FHB resistance QTL from PI-277012 and other tetraploid wheat sources

PI	Months	Milestones	Progress	Output/Linkages
SX (EE, TF, XL)	6	Produce F1 and F2 seed by crossing two durum lines 15FAR603 and 15FAR908 to five ND durum breeding lines with low cadmium. Evaluate a set of 298 durum lines and their parents in FHB nurseries in Fargo and Prosper, ND.	Initiated	Hybrids from simple crosses between durum lines carrying major FHB resistance QTL; Disease severity data for durum lines

PI	Months	Milestones	Progress	Output/Linkages
SX (EE, TF, XL)	12	Grow F3 plants with low cadmium to produce F_4 seeds. Evaluate a set of 298 durum lines and their parents for FHB resistance in greenhouse. Perform genotyping analysis and selection mapping	Partially completed	Advanced progenies from the crosses; genotyping and phenotyping data
SX (EE, TF, XL)	18	Grow F_4 plants to produce about 300 durum lines (F_5) and evaluate them field nurseries in Fargo and Prosper, ND. Evaluate a set of 298 durum lines and their parents for FHB resistance in greenhouse and FHB nurseries in Fargo and Prosper, ND. Continue genotyping analysis and selection mapping.	Partially completed	Advanced progenies from the crosses; genotyping and phenotyping data
SX (EE, TF, XL)	24	Evaluate the new durum lines selected based on field evaluation in greenhouse for two seasons using RCBD with three replications. Perform data and statistical analysis from disease evaluation and genotyping analysis	Fully completed	Improved durum lines carrying the FHB resistance QTL accumulated from different sources; DNA markers associated with the resistance QTL

Objective 5. Develop durum varieties with enhanced level of FHB resistance and reduced DON accumulation

1. Develop durum wheat resistant to Fusarium head blight

PI	Months	Milestones	Progress	Output/Linkages
EE (SZ, FM, SC)	4	Make 50 - 60 new crosses between durum cultivars and lines such as Divide, Carpio, and Joppa to the durum germplasm carrying known sources of resistance (e.g. Tunisian durum lines, Sumai 3-derived lines, and wild emmer chromosome 3A and 7A substitution lines.		Produce 50 – 60 new hybrids
EE (SZ, FM, SC)	8	1) Grow F_1 plants to produce F_2 seed from the crosses made in previous season; 2) Evaluate previous materials in the pipeline in the greenhouse (Note: This is an ongoing project that there are crosses, all breeding generations, and yield trials every year).		Develop F_2 populations and identify progenies and breeding lines with tolerance/resistance to FHB from previous materials in the pipeline

PI	Months	Milestones	Progress	Output/Linkages
EE (SZ, FM, SC)	12	1) Grow F_2 populations (50 - 60) for selection in the field ; 2) Evaluate previous materials in the pipeline in the field FHB nurseries at Prosper, Carrington, and Langdon, ND (Note: Every summer the FHB nurseries will have $F_{2:3}$ and previous materials in the pipeline such as selected $F_{3:4}$, $F_{4:5}$, PYT's, AYT's, EDA, and URDN).		Conduct single-plant or single-head selections from F_2 populations; identify potential experimental lines that have better FHB resistance than current cultivars for potential release.
EE (SZ, FM, SC)	16	1) Evaluate selected $F_{2:3}$ and $F_{3:4}$ lines in the greenhouse and send some of the lines to New Zealand or Yuma, AZ for advancement; 2) Made new crosses		Identify progenies and breeding lines with tolerance/resistance to FHB from previous materials in the pipeline and produce new hybrids
EE (SZ, FM, SC)	20	1) Grow F_1 plants from the crosses made in previous season in the greenhouse; 2) Evaluate previous materials in the pipeline in the greenhouse		Develop F_2 populations and identify progenies and breeding lines with tolerance/resistance to FHB from previous materials in the pipeline
EE (SZ, FM, SC)	24	1) Evaluate $F_{2:3}$ and $F_{3:4}$ head rows in the FHB nursery; 2) Grow F_2 populations from new crosses; 3) Evaluate all yield trials for FHB at Prosper, Carrington, and Langdon, ND.		Conduct single-plant or single-head selections from the new F_2 populations; identify potential experimental lines that have better FHB resistance than current cultivars for potential release.

RA: Fusarium head blight management (MGMT)

Objective 6. Evaluate chemical management strategies that reduce FHB and/or DON in durum

1. Verify the value of genetic resistance and fungicides on the control of FHB in durum in ND

PI	Months	Milestones	Progress	Output/Linkages
JR	12	Conduct year 1 experiments at Carrington and Prosper, ND.	Initiated	USWBSI report; ND Crop Production Guide report; Research Extension Center reports; Producer meetings.
JR	24	Conduct year 2 experiments at Carrington and Prosper, ND.	Fully Complete	USWBSI report; ND Crop Production Guide report; Research Extension Center reports; Producer meetings.