

FY20-21 Research Category Program Descriptions and Research Priorities (PD-RP)

FHB MANAGEMENT (MGMT)

Program Description:

The FHB Management (MGMT) research area supports research to develop effective and economical disease management practices that reduce FHB severity and mycotoxins in small grain crops to meet the immediate and long-term needs of the wheat and barley industries.

This research area involves:

- tillage practices, crop sequences, and other cultural practices targeting *Fusarium*-infested residues;
- fungicides and biocontrol agents with demonstrated field efficacy, and their application technologies;
- the refinement and deployment of disease prediction and forecasting models, and disease management decision tools; and
- studies of pathogen survival, inoculum production, dispersal, infection, colonization, mycotoxin production, fungicide sensitivity, and factors accounting for unacceptable levels of mycotoxins in symptomatic or asymptomatic grain.

NOTE: Priority will be given to multi-PI, collaborative, integrated pre-proposals that address the research priorities listed below. Project pre-proposals pertaining to integrated management (IM) studies will be developed as a multi-PI, collaborative, integrated proposal. The Coordinator for the Integrated Management Coordinated Project (IM-CP) is listed on pages 7 and 30 of the FY20-21 RFP.

FY20-21 Research Priorities derived from the Action Plan Goals:

1. Develop integrated management strategies for FHB and mycotoxins that are robust to conditions experienced in production fields of wheat and barley.
2. Help develop and validate the next generation of management and mitigation tools for FHB and mycotoxin control.
3. Develop a full understanding of the factors influencing infection and toxin accumulation that can be used to develop the next generation of FHB and DON risk assessment measures.
4. Enhance communication and end user education/outreach.

FOOD SAFETY AND TOXICOLOGY (FST)

Program Description:

The Food Safety and Toxicology (FST) research area supports research on food safety and food processing issues related to the presence of *Fusarium* spp. mycotoxins in wheat and barley grain. Practical outcomes of research in this area include: 1) improved toxicological data to assure that current guidelines are providing the appropriate safety factors for the consumer; 2) analytical tools that can be used by small grain producers, elevators, millers, and processors, to rapidly and reliably identify mycotoxin-contaminated grain; 3) develop appropriate strategies to deal with contaminated grain; and 4) diagnostic data on *Fusarium* spp. mycotoxins required for development of FHB resistant/tolerant varieties of wheat and barley.

FY20-21 Research Priorities derived from the Action Plan Goals:

1. Provide analytical support for DON/trichothecene quantitation for the Initiative's stakeholders.
2. Support research on DON/trichothecene safety that is needed by producers, grain processors, researchers, risk assessors, and regulators.

GENE DISCOVERY AND ENGINEERING RESISTANCE (GDER)

Program Description:

The Gene Discovery and Engineering Resistance (GDER) research area (RA) places its primary focus on understanding mechanisms of resistance to *Fusarium* head blight (FHB) and identification of wheat and barley gene variants that can be deployed to increase FHB resistance and/or reduce DON accumulation. The GDER RA also supports utilization of gene editing and transgenic strategies to improve FHB resistance, however places priority on strategies that can be deployed without transgenesis. Gene discovery and transformation of non-cereal systems will be supported only for the purpose of rapidly screening potential anti-*Fusarium* genes.

FY20-21 Research Priorities derived from the Action Plan Goals:

1. Identify native and induced wheat and barley gene variants that improve FHB resistance and/or reduce DON accumulation.
2. Develop assays that can be used to rapidly validate candidate wheat and barley genes for resistance and susceptibility to FHB and/or reduced DON accumulation.
3. Utilize new technologies to develop effective FHB resistance and/or reduced DON accumulation.

PATHOGEN BIOLOGY AND GENETICS (PBG)

Program Description:

Research in this area includes studies that address mycotoxin biosynthesis *in vivo* or *in planta*, host/parasite interactions, and host resistance mechanisms that target the pathogen. Research in PBG should complement and be linked to whole plant research that will lead to disease control and/or toxin reduction strategies.

FY20-21 Research Priorities derived from the Action Plan Goals:

1. Characterize plant-fungal interactions to identify important genes, proteins or small molecules that may be used to develop FHB resistance or to reduce DON contamination in barley and wheat.
2. Gain new understanding of initial fungal infection that may be utilized to boost FHB resistance.
3. Discover epiphytic or endophytic microbes or microbial communities and viruses that may be useful for development of effective biological control practices for FHB.
4. Develop an improved understanding of plant-pathogen interactions in relation to abiotic factors and identify genes or genetic variants that contribute to pathogen adaptation to wheat and barley agroecosystems.

VARIETY DEVELOPMENT AND HOST RESISTANCE (VDHR)

Program Description:

The VDHR research area will be Uniform Nursery based in the case of soft winter wheat and spring wheat. States will be aligned with the uniform nurseries as follows: Uniform Regional Scab Nursery for Spring the Wheat Region (ID, MN, MT, ND, SD, WA); Uniform Northern Winter Wheat FHB Screening Nursery (IN, IL, KY, MI, MO, NY, OH); Uniform Southern Soft Red Winter Wheat FHB Screening Nursery (AR, GA, LA, NC, SC, VA). VDHR research will be commodity-based in the case of barley, durum and hard winter wheat coordinated projects.

Each Uniform nursery will be coordinated by a regional committee. Nurseries will be conducted in collaboration with a pathologist wherever possible and a subset of promising entries may be grown at multiple locations in Integrated Management Trials. The nurseries will also be evaluated for milling and baking quality, and haplotyped at the USDA regional genotyping labs. The most promising lines may be entered in the nurseries for a second year of testing at the lines originator's request. Collaborators will submit candidate parents for crossing, and prebreeding populations derived from these crosses/populations will be shared. Mapping of new resistance sources will be accomplished through joint phenotyping of populations. All collaborators will screen varieties and breeding lines entered into statewide performance trials for FHB resistance and provide this information to growers.

FY20-21 Research Priorities derived from the Action Plan Goals:

1. Increase and document the number of varieties with improved FHB resistance and high grain yield and grain quality that are tested in statewide variety trials and available to farmers, to reduce DON in the US grain supply.
2. Increase efficiency of coordinated project breeding programs to develop and release FHB resistant varieties.
 - Enhance cooperation and coordination of research among programs. For example, phenotypic data should be uploaded to the T3 database, and early generation populations would be shared among programs.
3. Evaluate and implement new breeding technologies and germplasm to further enhance short term and long-term improvement of FHB resistance and to efficiently introgress effective resistance genes into breeding germplasm.
 - Enhance selection efficiency through technologies such as genomic selection, marker-assisted selection, doubled haploid production and/or high throughput phenotyping.

BARLEY COORDINATED PROJECT (BAR-CP)

Project Description:

Minimizing the impact of Fusarium head blight (FHB) on barley production in the U.S. requires a multi-dimensional, yet focused and coordinated research effort. The Barley Coordinated Project (CP) seeks to combine existing lines of productive research with new avenues of investigation to develop a set of tools and disease management strategies that will minimize disease risk and mycotoxin contamination to producers and end-users of barley. This toolbox will be developed in coordination with other research areas (see below) and will consist of: 1) varieties with enhanced levels of resistance to FHB, lower levels of mycotoxins, superior agronomic performance, and good end-use quality; 2) chemical and biological formulations, application procedures, and a disease forecasting model that maximize efficacy; 3) cultural management strategies that reduce the potential of pathogen inoculum to contribute to disease epidemics; and 4) a set of best management practices that incorporate our current understanding of the tools available to combat this disease.

FY20-21 Research Priorities derived from the Research Areas:

The Barley CP is organized around four of the Research Areas (RA) outlined in the USWBSI Action Plan. A set of 10 objectives are established within these four RAs that the CP will address either directly or indirectly via coordination with these other RAs.

I Variety Development and Host Resistance (VDHR)

- Objective 1. Screen Hordeum germplasm to identify new sources of resistance.
- Objective 2. Map and validate novel QTL for resistance to FHB and the accumulation of mycotoxins in barley.
- Objective 3. Evaluate and implement new breeding methods to increase resistance to FHB and the accumulation of mycotoxins.
- Objective 4. Develop new barley varieties with enhanced resistance to FHB and lower mycotoxins.

II. Gene Discovery and Engineering Resistance (GDER)

- Objective 5. Identify barley gene variants that increase FHB resistance and/or reduce mycotoxin accumulation.
- Objective 6. Identify or create variation for genes and mechanisms of resistance within germplasm collections and mutant populations and introgress novel variants into adapted germplasm.

III. Pathogen Biology and Genetics (PBG)

- Objective 7. Investigate plant-pathogen interactions that increase our understanding of the infection process; pathogen colonization; sporulation and spread; and accumulation of mycotoxins.
- Objective 8. Elucidate the epidemiology of colonization and survival of Fusarium graminearum on host tissue, disease development, and mycotoxin accumulation.

IV. FHB Management (MGMT)

- Objective 9. Evaluate chemical, biological and cultural management strategies that reduce FHB and/or mycotoxin accumulation in barley.
- Objective 10. Develop and promote best management strategies through integrated disease management that is robust to conditions experienced in barley production fields in diverse geographies.

DURUM COORDINATED PROJECT (DUR-CP)

Project Description:

The Durum Coordinated Project (DUR-CP) has been created under the direction of the USWBSI to accomplish the initiative action plans. The DUR-CP's main objective is to develop FHB resistant durum wheat germplasm (lines/cultivars) with low DON levels, good agronomic traits, and good quality traits that will serve the producers, the domestic pasta industry, and the international export market. Reducing the impact of FHB requires a multidisciplinary effort and therefore the CP includes plant breeders, pathologists, geneticists, agronomists and other researchers working in the area of disease management. The CP also includes stakeholders such as millers and pasta manufactures.

FY20-21 Research Priorities derived from the VDHR Research Area:

1. Search for novel sources of resistance to FHB in durum and its relatives.
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.
3. Incorporate FHB resistance QTL from diploid, tetraploid and hexaploid wheat accessions into adapted durum backgrounds and develop elite durum germplasm with the assistance of molecular markers in selection.
4. Develop durum varieties with enhanced level of FHB resistance and reduced DON accumulation.
5. Investigate genetic mechanism of suppressors and enhancers affecting FHB resistance expression in durum wheat.
6. Evaluate chemical management strategies that reduce FHB and/or DON in durum.
7. Develop and promote best integrated management strategies to reduce FHB and/or DON in durum wheat.

HARD WINTER WHEAT COORDINATED PROJECT (HWW-CP)

Project Description:

The HWW-CP is an efficient coordinated project that will measure its success by reducing DON in the hard winter wheat grain supply to the food grade level acceptable in the European Union (EU). This level is currently lower than the US standard. Because half of our grain is exported and the majority of it shipped to the EU, the risk is that it can be sourced from high scab areas within the HWW region (e.g. the Eastern Great Plains). As the popularity of whole grain products increases, our goal is to ensure that the DON concentration in these products is also below established thresholds. Based upon the timelines expected for success in reducing DON, the HWW-CP includes the scientific activities of plant breeders, pathologists, geneticists and supporting research programs. We coordinate with disease management efforts because we realize that in addition to improved varieties, improved management will optimize project success (as measured by reducing DON) within expected timelines. HWW-CP germplasm and information are publicly available and made available to other participating researchers in other research areas of the USWBSI. The HWW-CP remains focused on reducing DON levels as quickly as possible and by using the most efficacious methods to do so (breeding and management). Membership in the HWW-CP includes all researchers currently funded within the CP, individuals designated as representatives from other research areas of the USWBSI, all interested FHB researchers who may or may not be funded by the USWBSI, stakeholders representing members from groups that fund our research (e.g. the KS, NE, SD, ND, and MT Wheat Commissions), and members of groups that are key to our industry and who non-monetarily support HWW-CP research. These are “independent” stakeholders, such as major mills and bakeries, private wheat breeders, and chemical company representatives.

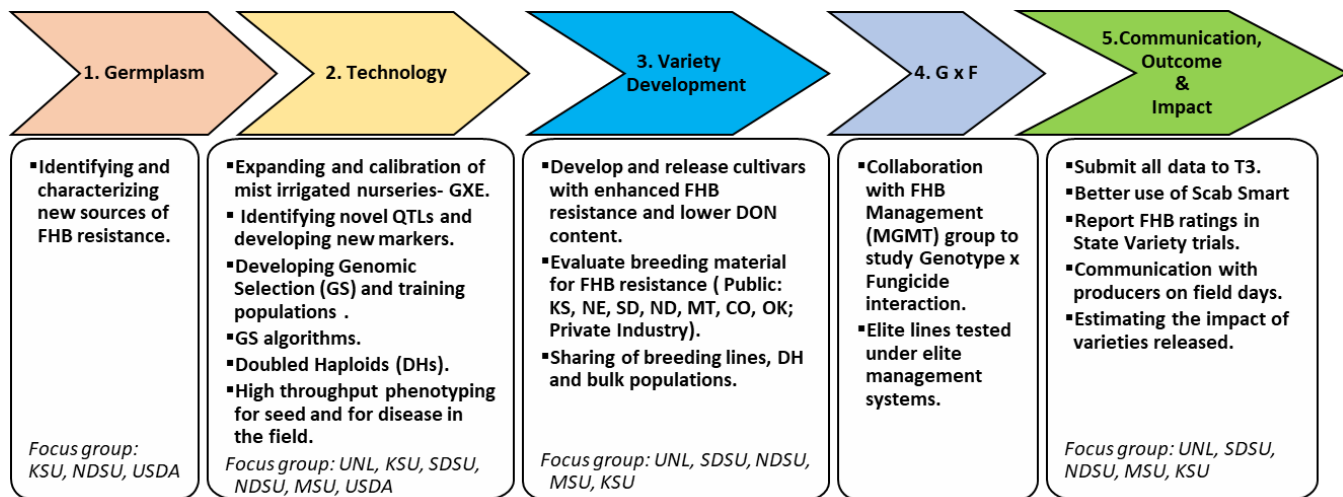


Fig. 1 Flowchart of HWW-CP activities.

FY20-21 Research Priorities derived from the VDHR and MGMT Research Areas:

The HWW-CP is organized around two of the research areas – **Variety Development and Host Resistance (VDHR) and FHB Management (MGMT)** as outlined in the USWBSI Action Plan. Three major objectives and associated research activities have been established within this CP. In addition, the HWW-CP works closely with other USWBSI Research Areas (RAs) to support the stated goal of reducing DON levels specified by the EU. Specifically, the HWW-CP works most closely with the MGMT RA.

Objective 1. Increase and document the number of varieties with improved FHB resistance and high grain yield and grain quality that are tested in statewide variety trials and available to farmers, to reduce DON in the US grain supply.

Associated Research Activities:

- Increase efficiency of coordinated project breeding programs to develop and release FHB resistant varieties. Enhance cooperation and coordination of research among USWBSI supported programs. For example, phenotypic data should be uploaded to the T3 database, and early generation populations would be shared among programs.
- Characterize genotype x fungicide "specific" treatment responses for enhancing FHB resistance and the reduction of DON so information can be given to the MGMT group to help them optimize their program using advanced breeding lines and new varieties. Management practices need to use the most resistant varieties to develop the best systems with the lowest DON concentrations.
- Test and evaluate regional germplasm to include breeding lines from the public (including programs which are not part of the CP, but develop lines which may be grown within the scab prone regions of the CP) and private breeding programs as well as irrigated field nurseries representative of all FHB environments throughout the region.

Objective 2. Evaluate and implement new breeding technologies and germplasm to further enhance short term and long-term improvement of FHB resistance and to efficiently introgress effective resistance genes into breeding germplasm.

Associated Research Activities:

- Create new genetic resources and efficiently introgress resistance genes into breeding germplasm for long-term improvement in FHB resistance. Example: New sources of FHB resistance should be introgressed into winter backgrounds and rapidly tested in mist nurseries to quantify their level of resistance.
- Enhance selection efficiency through technologies such as genomic selection, marker-assisted selection, doubled haploid production and/or high throughput phenotyping leading to pyramiding of major and minor genes for FHB resistance.

Objective 3. Enhance communication and coordination to increase the impact of our research beyond the region.

Associated communication activities:

- Enhance communication and end-user education/outreach relating to resistant varieties and effective management practices and have end use stakeholder representatives on the HWW-CP.
- Enhance cooperation with other RAs by having HWW-CP representatives on MGMT and GDER RAs.

Associated coordination activities:

- Coordinate efforts among RA groups on FHB management in hybrid wheat and the CRISPR-CAS9 system for improved FHB resistance.