FHB MANAGEMENT (MGMT)

Goal #1: Develop integrated management strategies for FHB and mycotoxins that are robust to conditions experienced in production fields of wheat and barley.

Milestones/Performance Expectations:

- Conduct experiments that evaluate the flexibility of the integrated management strategies in a wide range of production conditions and environments.
    - These experiments should: 1) consider the best available varieties with a range of FHB resistance for all wheat market classes and malting barley, 2) be conducted in multiple states and production regions, and 3) use the best available fungicides and application technology.
    - Specific areas of emphasis will include but are not limited to 1) developing fungicide recommendations that are more robust to conditions experienced in commercial production, and 2) evaluating the efficacy and economics of these strategies using multi-year, multi-location data.

Performance Measures: Summaries of results that will facilitate further evaluation and refinement of management strategies for FHB and mycotoxin in production fields.

Research Needs: Identify the best management methods for FHB/DON or Good Farming Practices (GFP) for FHB/DON management - through integrated management studies. Studies to measure integrated effects should include but are not limited to:

- Validating the integrated management strategies with next generation of wheat and barley varieties in multiple production environments.
- Developing economic analyses of effective integrated management strategies used alone and in combination (i.e. fungicide, biological control, cultivar, residue management).
- Evaluating flexibility of fungicide application timing within the context of the integrated management strategies. This may include but is not limited to evaluating the effectiveness of fungicides applied after anthesis to address whether slightly later, on-label applications are still profitable (e.g., when weather delays application)
- Deploying current FHB forecasting models: maintain or continue to add independent sources of weather; push commentaries to smart phones, and email.

Outputs:

- Improved or enhanced forecasting systems that help producers and their advisors evaluate the risk of disease based on environment, cultivar resistance and crop residues.
- FHB/DON management recommendations that are more flexible and robust to conditions experienced in production fields of wheat and barley.
- Document adoption of integrated management for FHB/DON on regional and national basis.

Resources: Multiple collaborative locations distributed across grain classes. A team approach will be used to reflect overlap across traditional research areas and regional/national scope. Teams will be composed of breeders, pathologists, economists and other scientists from other disciplines as needed.

Anticipated Impact: Producers will make decisions based on regionally validated science-based information.

FHB MANAGEMENT (MGMT) *(cont.)*

Goal #2: Help develop and validate the next generation of management and mitigation tools for FHB and mycotoxin control.

Milestones/Performance Expectations:

- Improved forecasting models of FHB epidemics and DON contamination.
- Test new fungicides and biological controls that have potential application as part of integrated management programs for FHB/DON.
- Investigate new ways to use current technologies that may improve flexibility of integrated management strategies or address specific knowledge gaps for these technologies.
- Acquire new data on harvest and post-harvest grain handling

Performance Measures: Evaluate the potential of new technologies for the management of FHB/DON.

Research Needs:

- Enhance forecasting capabilities:
    - Improved models predicting severe FHB and DON in wheat and barley.
    - Develop specialized models estimating the risk of DON in wheat.
- Improve performance of biological control agents for potential use in production fields. Multi-environment testing of new compounds (fungicide or biocontrol) for which preliminary data indicate high levels of effectiveness; confirm FHB/DON control levels at recommended label rates for new fungicides.
- Evaluate application timing of new fungicides or biological control agents that may increase flexibility of integrated management.
- Investigate factors that may compromise the efficacy of fungicide products including quantifying properties such as rain-fastness and systemic movement within plants.
- Determine if fungicides and biocontrol agents can be used to suppress the DON contamination of wheat and barley straw.
- Harvest and post-harvest grain handling: conduct experiments to identify practices that minimize DON and yield/test weight losses

Outputs:

- Increased accuracy of FHB and DON forecasts
- Wheat DON forecasting system is made available to stakeholders
- Improved understanding of factors influencing the efficacy of fungicide and biocontrol agents. New guidelines for post-harvest grain handling are made available

Resources: Multiple collaborative locations distributed across grain classes. A team approach will be used to reflect overlap across traditional research areas and regional/national scope. Teams will be composed of breeders, pathologists, and other scientists from other disciplines as needed.

Anticipated Impact: These projects provide the next generation of strategies that will be tested through larger multi-state projects on integrated management. These projects address specific knowledge gaps identified through interaction with wheat and barley producers.

FHB MANAGEMENT (MGMT) *(cont.)*

Goal #3: Develop a full understanding of specific factors influencing infection and toxin accumulation that can be used to develop the next generation of scab and DON risk assessment measures.

Milestones/Performance Expectations:

- Improved understanding of the: 1) conditions leading to high DON with low/no visual symptoms; 2) relative contributions of in-field vs. external inoculum sources; 3) sensitivity to triazole fungicides in natural populations of the pathogen in different cereal production regions and implications for efficacy of fungicidal control.
- Management recommendations are refined based on new information gained through these applied research projects.
- The FHB and DON risk forecasting models incorporate the results of these research projects.

Performance Measures: Information is acquired regarding factors essential for the next generation of FHB and DON risk assessment models, including: the role of post-flowering weather and late/secondary infections, the conditions leading to high DON with low/no visual symptoms, and relative contributions of in-field vs. external inoculum sources.

Research Needs:

- Evaluate the role of post-flowering weather on DON accumulation.
- Determine the potential contribution of late/secondary infections on DON accumulation including the importance of post-flowering inoculum density and the associations among inoculum density, weather, FHB, and DON accumulation.
- Further define the influence of weather and variety on infection efficiency between heading and grain maturity and how the timing of infection influences symptom development and DON accumulation.
- Evaluate the relative contributions of inoculum from in-field debris vs. airborne spores from nearby and distant sources; determine regional variability of the findings; and investigate ways to bring this information into disease forecasting models.
- Assess the sensitivity of *F. graminearum* population to triazole fungicides within different cereal production regions in the U.S. where there has been intensive use of these fungicides. These projects will likely involve laboratory assays for evaluating sensitivity within naturally occurring populations of the fungus.
- Documentation of *F. graminearum* populations that are resistant to triazole fungicides, and investigate the influence of fungicide resistance on product efficacy.

Outputs:

- Models describing associations among inoculum density/dose, inoculation timing, weather and variety on infection, fungal biomass and DON accumulation.
- Improved accuracy of FHB risk assessment models and development DON risk models.
- Regionally appropriate, specific recommendations for corn and small-grain debris management based on full understanding of relative contributions of inoculum from in-field debris vs. nearby and distant sources.
- Established "base line" for triazole sensitivity within the U.S. population of *F. graminearum*.

Resources: A multi-state collaborative effort involving researchers from all major U.S. wheat and barley-growing regions.

FHB MANAGEMENT (MGMT) *(cont.)*

Anticipated Impact: Risk forecasting and management recommendations available to growers are more useful because they reflect enhanced understanding of conditions throughout wheat development that affect FHB and DON levels.

Goal #4: Enhance communication and end-user education/outreach for an audience including, but not limited to, producers, agricultural advisors, research community, and grain processors.

Milestones/Performance Expectations:

- Resources and recommendations related to the integrated management of FHB/DON on the USWBSI and ScabSmart web sites.
- Information on FHB resistance of all contemporary varieties readily available to growers in an accurate, user-friendly manner.
- Improve and increase dissemination of scab information and management techniques through an interdisciplinary approach.

Performance Measures: Best FHB/DON management methods, validated by science-based research, are thoroughly publicized to producers, their advisors, and grain processors.

Research Needs:

- Continue to update and enhance the content of the ScabSmart web site.
- Make commentaries from the FHB forecasting site available USWBSI blog website and sent to users via mobile devices.
- Develop web-cast training modules on FHB biology and management that can be distributed via the Plant Management Network, ScabSmart or other similar outlets.
- Conduct surveys of growers to assess how they acquire information about scab and adoption of FHB management techniques, and to identify barriers to adoption.
- Develop tools that will help growers assess and understand the value of adopting scab management practices.

Outputs:

- Timely information about scab risk is reaching growers via FHB alerts received by mobile devices.
- Information on FHB management available via national websites and customized for distribution through extension programs in states with a history of severe FHB.

Resources: Multiple collaborative locations distributed across grain classes. A team approach will be used to reach across traditional research areas and regional/national scope. Teams will be composed of pathologists, crop consultants, breeders, economists and scientists from other disciplines as needed.

Anticipated Impact: Increased adoption of practices by producers and decision makers will result in FHB/DON reduction and lead to substantially reduced frequency of unacceptable DON levels in grain loads.

FOOD SAFETY, TOXICOLOGY AND UTILIZATION OF MYCOTOXIN-CONTAMINATED GRAIN (FSTU)

Goal #1: Provide analytical support for DON/trichothecene quantitation for Initiative's stakeholders.

Milestones/Performance Expectations:

- Maintain awareness of standardized sampling protocols adopted for regional (commercial field) and research testing for DON.
- Maximize coordination and efficiencies amongst labs with an effort towards matching lab utilization to potential impact to provide DON data in a timely manner.
- Provide accurate information and occurrence data regarding DON, ADONs and DON glucoside in a form accessible to the FHB research community

Performance Measure 1.1: Ensure awareness about optimal sampling, grinding and test protocols for mycotoxin analysis.

Research Needs: There is need to increase and maintain awareness about optimal sampling and grinding protocols for grain industry, milling industry and initiative researchers. This will minimize incorrect data and enhanced effort to reduce DON

Outputs:

- Session/meeting devoted to sampling /analytical methods will be provided as needed.
- Protocols will be included in USWBI web page
  - Links to protocols will be provided to initiative users.
  - Recommended methods will be updated/modified taking into account FGIS- and EU-recommended protocols.

Resources: Diagnostic lab directors

Anticipated Impact: Clarify stakeholder concerns over test accuracy and repeatability of data. Implementation of standardized sampling and grinding protocols can improve comparability/quality of data.

Performance Measure 1.2: Maximize capacity for the analysis of DON and other trichothecenes.

Research Needs: Initiative members need increased test capacity and turnaround time to make progress since the future focus will continue to be less DON.

Outputs:

- Diagnostic labs
  - Survey of initiative users for anticipated needs, and continued evaluation of new technology
  - Workshop(s)/continuing education devoted to sampling /analytical methods at initiative meeting(s) in order to optimize use of lab resources.
  - Coordinate use of labs to maximize USWBSI impact -
    - Solicit bulk discounts for initiative users.
    - Continued evaluation of new technologies.

FOOD SAFETY, TOXICOLOGY AND UTILIZATION OF MYCOTOXIN-CONTAMINATED GRAIN (FSTU) *(cont.)*

- Facilitate on-site rapid testing
    - Suggested rapid assay protocols (e.g. FGIS) will be included in USWBI web page. Links to protocols will be provided to initiative users.

Resources: Diagnostic lab directors.

Anticipated Impact: Increased testing will enable breeders to achieve goals of DON reduction sooner.

Performance Measure 1.3: Diagnostic labs will include measurement of ADONs, other trichothecenes and glycosidic forms in selected surveillance samples.

Research Needs: There is concern about change in *Fusarium* genotypes and masked (glycosidic) trichothecene forms but there are limited data on occurrence individual toxins other than DON. FDA survey data is very limited.

Outputs: An archive of data on occurrence of different trichothecenes and their relative ratios of these analytes.

Resources: Diagnostic lab directors.

Anticipated Impact: This data will assist discussion of "shifts" in observed mycotoxin profiles.

Goal #2: Provide requisite information on DON/trichothecene safety issues to producers, millers, researchers, risk assessors and regulators.

Milestones/Performance Expectations:

- Validate current FDA standard of DON ppm in flour and grain
- Scientific studies of DON and related tricothecenes that enable extrapolation from animals to humans.
- Presentation of scientific study data at meetings and in high impact journals
- Utilization of information to produce accessible outreach materials for the public

Performance Measure 2.1: Conduct research on adverse effects of consuming DON and related trichothecenes that allow extrapolation from animals to humans and inform regulators thus enabling science-based risk assessment. Key considerations are groups at high risk and biomarkers of exposure/toxicity.

Research Needs: EU has established DON regulatory standards that are much lower than U.S. and there is pressure on CODEX to follow suit. There is continued concern about change in *Fusarium* genotypes and mycotoxin profiles as well as the occurrence of masked forms of DON

Outputs:

- Publication of research/reviews in high impact journals that inform international risk assessors and regulators.

FOOD SAFETY, TOXICOLOGY AND UTILIZATION OF MYCOTOXIN-CONTAMINATED GRAIN (FSTU) *(cont.)*

- Participation in national/international research meetings/ forums/committees that inform risk assessors.
- Develop preliminary data for NIH-funded human epidemiology studies.

Resources: Food safety researchers

Anticipated impact: Risk assessors and regulators will use data to make sound scientifically valid decisions that ensure public health but minimize economic effects to wheat and barley industries.

Performance Measure 2.2*:* Summarize known toxicology information on DON/other trichothecenes, their risks and rationale for regulations.

Research Needs: There is lack of easily comprehensible information on DON and its risks. This creates confusion among producers, millers and Initiative scientists.

Outputs:

-Web pages with questions and answers about DON safety.
-Initiative-originated reviews/position paper(s).

Resources: Scab Web support facility, food safety researchers.

Anticipated Impact: Improved understanding/communication of the importance of the problem among the producers, millers, researchers and government.

GENE DISCOVERY AND ENGINEERING RESISTANCE (GDER)

Goal #1 – Gene Discovery: Increased efficiency of identification of candidate genes for resistance against FHB and reduced DON accumulation.

Milestones/Performance Expectations:

- Utilize high-throughput genomics approaches (e.g., next generation sequencing, metabolomics, functional genomics in model systems) to identify genes that confer increased FHB resistance and/or lower accumulation of DON.

Performance Measures: Identification of genes and transgenes that improve FHB resistance and/or reduce DON accumulation.

Research Needs:

- Rapid identification of wheat and barley genes essential for resistance to FHB and DON.
- Rapid identification of genes that confer susceptibility to FHB. If such genes are identified, incorporation of non-expressing alleles or silencing via transgenic approaches may provide a novel path to FHB resistance.
- Priority will be given to resistance strategies that can be implemented using wheat or barley DNA sequences.
- Rapid identification of transgenes that can be utilized to increase resistance to FHB and/or reduce DON accumulation.
- Rapid high capacity assays for discovery and validation of genes with function in FHB and DON resistance.

Outputs: Genes and transgenes that can be incorporated in new wheat and barley lines with improved FHB resistance and/or reduced DON accumulation.

Resources:

- USWBSI funding of gene discovery.
- New high throughput assays for genes functioning in FHB resistance and susceptibility and DON reduction.

Anticipated Impact:

- Additional genes available for breeding FHB and DON resistant barley and wheat.
- Proof of gene efficacy will speed up breeding with native resistance genes and provide options for incorporating resistance transgenes into commercial wheat and barley.

Goal #2 – Plant Transformation: Develop effective FHB resistance through transgenic strategies.

Milestones/Performance Expectations:

- Assess the activity of the candidate genes when expressed in wheat and barley.
- Once efficacy of transgenic lines is established, cross or transform the transgene loci/constructs into elite germplasm for use by breeders.

Performance Measure: Establishment of a central laboratory for the generation of transgenic plants and T1 seed stocks for Initiative funded research projects.

GENE DISCOVERY AND ENGINEERING RESISTANCE (GDER) *(cont.)*

Research Needs:

- Establish and support centralized transformation facility(s) for more efficient generation of transgenic plants and seed stocks for Initiative funded research projects. Establishment and optimization of wheat and barley transformation is expensive and requires much time and specialized skills. Support of one or a few transformation facilities would provide a great benefit to research into transgenic solutions for FHB.
- Develop transformation capacity in elite wheat and barley genotypes.
- Work with PBG to characterize the impact of transgenes on infection and DON accumulation.
- Preliminary data for efficacious transgenes must be provided for Initiative support.
- The Initiative should support centralized facilities for field testing transgenic wheat and barley.
- Development of tools for optimized gene expression in wheat and barley.
- More collaboration with breeders to incorporate validated transgenics into VDUN programs.

Outputs: Validated genes and/or transgenes conferring resistance to FHB and/or reduced levels of DON accumulation in wheat and/or barley.

Resources:

- USWBSI funding for research identifying and developing effective transgenic solutions for FHB resistance and reduced DON accumulation.
- New website with latest information (positive and negative) from USWBSI-funded research about the efficacy of transgenes for FHB resistance and/or DON reduction.
- This website would also give up-to-date information about the latest tools for effective expression of transgenes in wheat and barley in FHB resistance strategies (organ/tissue specific promoters, introns, 5’ and 3’UTRs etc.)

Anticipated Impact:

- Development of transgenic wheat and barley plants with FHB resistance and DON reduction that can be used to complement natural genetic resistance or as a standalone solution.
- More efficient use of individual lab time and resources.

PATHOGEN BIOLOGY AND GENETICS (PBG)

Goal #1: Characterize plant-fungal interactions in plant lines (including transgenic lines) being developed by USWBSI.

Milestones/Performance Expectations:

- Characterization of cultivar/strain interactions with respect to colonization, infection, mycotoxin production and inoculum potential on residues.
- Determine where and when DON is produced in different cultivars.

Performance Measure: Information of how plant infection occurs and DON accumulates in plants over time and how these processes vary between resistant and susceptible varieties, with consideration of the problem of high-DON, asymptomatic grain.

Research Needs:

- Understand when resistance impacts fungal invasion.
- Understand the infection process, including late infections, the influence of environment on infection, and the role of trichothecenes in the initial infection.
- Characterize the infection process in barley, in particular the role of lemma and palea as they relate to toxins in the mature grain.
- Understand the interaction between FHB resistance and resistance to DON accumulation
- Develop effective screens for identification of resistance other than Type II.
- Determine the effect of fungicide application on DON biosynthesis.
- Determine whether mechanical barriers in disease resistance (i.e. long awns) are effective.
- Characterize transgenic lines of wheat and barley.
- Understand the linkage between greenhouse testing and field testing.
- Characterize the mechanism of fungal resistance to DON accumulation.
- Novel methods for extending protection against the pathogen and toxin accumulation.

Outputs:

Short-Term:

- Detailed histology of infection and accumulation of DON over time in different cultivars.
- Standardized techniques for screening, sampling and testing varieties were developed based on knowledge of pathogen biology.
- Identification of infection patterns and accumulation of DON.

Long-term:

- Understanding of the biology of DON accumulation of asymptomatic wheat and the role of DON as a pathogenicity factor in barley.
- Collaboration with VDHR, GDER and MGMT to implement discoveries into control programs.

Resources: USWBSI funding for understanding the infection process and mycotoxin accumulation over time.

PATHOGEN BIOLOGY AND GENETICS (PBG) *(cont.)*

Anticipated Impact:

- Understanding of how asymptomatic grain with high DON develops.
- Understanding of how infection and grain colonization occurs.

Both of these will have impacts on breeding for resistance and will also impact development of more effective fungicide applications.

Goal #2: Develop new strategies for reducing impact of FHB disease and mycotoxin contamination in barley and wheat. Focus on pathogen genes and responses, including specific host target genes**.**

Milestones/Performance Expectations:

- Identify potential pathogen target genes/processes.

Performance Measure: Strategies for disease and mycotoxin management based on knowledge of pathogen fitness, biology, genome and genetics are developed. Potential pathogen target genes/processes are identified.

Research Needs:

- Discover genes for pathogenesis, trichothecene reduction, novel antifungal compounds, etc.
- Development of molecular approaches to modulate pathogen genes for disease control and mycotoxin reduction (e.g. blocking DON biosynthesis).
- Develop new strategies to reduce sporulation on potential inoculum sources of the pathogen (e.g., residues of corn).
- Understand the dynamics of trichothecene production during plant growth and grain development in both wheat and barley
- Implement knowledge of genes identified as essential to pathogenicity and collaborate with GDER for evaluation.
- Identify genes under selection in the pathogen necessary for survival/fitness/aggressiveness under field conditions.
- Identify enzymes to detoxify DON.

Outputs:

Short-term:

- Develop web-based resources for access to information on mutants created and their phenotypes.
- Determine patterns of pathogen gene expression and protein accumulation vital to disease and trichothecene accumulation.

Long-term:

- Identify genes potentially useful to reduce disease or mycotoxin contamination when introduced into transgenic plants.
- Develop new strategies for pathogen gene silencing.

PATHOGEN BIOLOGY AND GENETICS (PBG) *(cont.)*

Resources:

- Funding from USWBSI and competitive federal funding for gene discovery.
- Continued use of data obtained from USWBSI funds to procure other federal funding.

Anticipated Impact:

- Identification of genes to be used in the development of resistant, transgenic plants.
- Identification of novel means for controlling the scab pathogen based on gene discovery or other biochemical strategies.

VARIETY DEVELOPMENT AND HOST RESISTANCE (VDHR)

Goal #1: Increase acreage planted with varieties with improved FHB resistance to reduce DON in the US grain supply.

Milestones/Performance Expectations

- Where possible, determine the percentage of acreage planted to varieties with improved FHB resistance. This information will be collected annually and used to document the change of commercial acreage planted to wheat and barley with improved FHB resistance to document progress on reducing this disease.
- Document trends in DON level in newly released cultivars relative to susceptible checks.
- Develop and maintain a public access database with information on FHB reaction (DON, index, severity etc.) and agronomic performance of available wheat varieties and breeding lines that are likely to be released.
- Increase seed in preparation for commercial release of at least three new breeding lines with scab resistance each year in each class of wheat/barley and each region.

Performance Measures:

- Attempt to document a positive trend in acreage planted to cultivars with enhanced FHB resistance and reduced DON levels in delivered grain.
- Continued improvement of the FHB resistance of breeding lines being increased for commercial release and/or varieties released and targeted for FHB prone regions by USWBSI breeders.
- Establish a commercial cultivar database and document usage.

Research needs:

- Data base results from comprehensive evaluation of breeding lines being increased for release and current commercial cultivars for FHB reaction (DON, index, severity, etc.) and other important traits under appropriate management practices.
- Evaluation of cultivars with improved FHB resistance in best-management practices for control of DON in conjunction with MGMT.
- Mechanisms to determine acreage planted to FHB resistant varieties and to collect DON data from flour mills. Mechanism to co-analyze this data along with epidemiological data to determine trends.

Outputs:

- Grower access to comprehensive information on FHB resistance of adapted cultivars for so they can fully incorporate FHB resistance in their variety selection.
- Information on best management practices involving varieties with enhanced FHB resistance
- Documentation of impact of VDHR and associated USWBSI programs on DON in grain channels.

Resources:

- Multi-location regional nurseries and existing trials of commercial cultivars.
- Database and website management.
- Mechanism for funding large regional projects for multiple years with MGMT and other programs.

VARIETY DEVELOPMENT AND HOST RESISTANCE (VDHR) *(cont.)*

Anticipated Impacts:

- With access to an improved variety selection tool, growers will select varieties with improved FHB resistance and therefore acreage of such varieties will increase.
- A package of Best Management Practices involving new varieties with FHB resistance can be promoted and adapted by usage.
- More stable supply of high quality wheat and barley with reduced DON for end-users.

Goal #2: Increase efficiency of coordinated project breeding programs to develop and release FHB resistant varieties.

Milestones/Performance Expectations:

- Continue to increase the FHB resistance of entries submitted to the USWBSI sponsored FHB nurseries, in other regional performance nurseries, and among breeding lines that in preparation for release.
- Continue the cooperation among USWBSI sponsored breeding programs.
- Establish database to facilitate sharing of information and genetic resources among breeding programs; will include information from USWBSI breeders on:
  1) crosses made to improve FHB resistance,
  2) performance data from non-USWBSI funded trials (yield, quality, resistance to other diseases etc.) on lines with improved FHB resistance,
  3) populations and plans for MAS,
  4) sources of FHB resistance,
  5) QTL for FHB resistance present in advanced lines, and
  6) release status of lines with improved FHB resistance, More rapid release of improved cultivars with FHB resistance so growers have better choices.

Performance Measures:

- Establish database and data submission protocols from all USWBSI sponsored breeders (within 2 yrs.)
- Improved FHB resistance (DON, index, severity, etc.) of entries submitted to the USWBSI sponsored FHB nurseries and other regional nurseries.
- Number of breeding lines from USWBSI sponsored breeding programs with enhanced FHB resistance that are being increased for commercial release and/or have been released.

Research Needs:

- Increased capacity for field testing in mist-irrigated inoculated nurseries.
- Increased capacity for DON testing at breeder and analytical lab level.
- Increased capacity for MAS including backcrossing and haplotyping as appropriate.
- Facilitate sharing of breeding information on populations relevant to FHB improvement to enhance individual programs and germplasm exchange.

Outputs: More frequent release of FHB resistant varieties with high yield and other desirable attributes that insure widespread adoption by producers and end-users.

VARIETY DEVELOPMENT AND HOST RESISTANCE (VDHR) *(cont.)*

Resources:

- Genotyping labs
- Mist-irrigated inoculated nurseries
- DON testing labs
- Infrastructure of university sponsored breeding programs.
- Mechanism for funding large regional projects for multiple years.

Anticipated Impacts: Every grower in an FHB affected region will have an expanded and enhanced array of commercially competitive varieties with adequate FHB tolerance to select for growing on their farm. New varieties with improved FHB resistance will be released and available more frequently than they are now.

Goal #3: Develop 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.

Milestones/Performance Expectations:

- Identify basic research needs of the breeding programs in each region and class of wheat and barley. Coordinate activities to address agreed upon priorities.
- Documenting the progress of the mapping and introgression of resistance from all sources. Annually, breeders/geneticists in each market class contribute data on the progress of the introgression.
- Identification and incorporation of different types of FHB resistance into germplasm lines and varieties.
- Development and implement improved breeding and selection methods all FHB resistance sources and describing any associated markers; keep this site updated.

Performance Measures:

- Establishment of priorities for basic research (within 1 yr).
- Establish cooperative teams of researchers to undertake the strategic testing of putative sources of resistance, all proposed mapping, and subsequent introgression.
- Establishment of research teams and initiation and completion of research (within 1 yr)
- Identification of novel QTL and markers systems for the QTL (within 3 yrs).
- Validation of discovered genes (within 4 yrs).
- Initiation of efforts by breeders to use the new resistance genes (within 2 yrs).
- Performance of breeding lines with new sources of resistance in their pedigree.
- Establishment of database on sources of resistance, mapping and introgression efforts, and developed germplasm (within 1-2 yrs).
- Identification of new mechanisms of resistance and/or improved technologies to assay for the mechanisms (within 5 yrs).
- Update breeding methods based on current technology.

VARIETY DEVELOPMENT AND HOST RESISTANCE (VDHR) *(cont.)*

Research Needs:

- Improved technology to establish novelty of sources of FHB resistance and inventory the frequency of resistance alleles in current breeding programs.
- Coordination to develop teams to conduct basic research and initiate introgressions.
- Investigate and elucidate the genetic basis of different types of FHB resistance gene expression.
- Identify novel mechanisms of FHB resistance and ways to screen for them.
- Sharing of pre-breeding populations, germplasm and information for MAS.
- Enhanced cooperative phenotyping of mapping populations (more environments in fewer years).
- Use of molecular markers to pyramid resistance genes in suitable germplasm.
- Investigation of integrated methods to improve FHB resistance to commercially needed levels.
- Enhanced technology for accurate test for DON content.
- Uses of new genomic technologies (i.e. SNP genotyping using the wheat 9K platform and genotype by sequence) for efficiently mapping resistance QTL and for MAS in development of adapted germplasm and cultivars.

Outputs: Identification of novel genes for FHB resistance, development of improved germplasm with diverse resistance, and development of improved methods for improving FHB resistance.

Resources:

- Basic disease technology and capacity for assessing potential sources of FHB/DON resistance.
- Shared information on resistant sources, breeding population development, marker haplotypes, and mapping and introgression efforts.
- Regional coordination meetings / regional grants to facilitate establishment of priorities and collaboration.
- Mechanism for funding large regional projects for multiple years.
- High-throughput genotyping labs.
- Labs for DON analysis.
- Misted nurseries for FHB assessments.

Anticipated Impacts:

- Development of improved germplasm and breeding methodology (MAS, selection schemes, etc.) that will enhance the efficiency of breeding for FHB resistance.
- Improved understanding of the genetic basis of the mechanisms of FHB resistance.
- More collaborative, rapid, and efficient execution of basic research and incorporation of the results into variety development programs.