FHB MANAGEMENT (MGMT)

Goal #1: Validate integrated management strategies for FHB and DON**.**

Milestones/Performance Expectations:

- Carry out factorial experiments in specific locations or regions with varieties representing a range of resistance levels. Other factors are planting date and fungicide treatments.
- Plant the integrated management experiments by spring 2008 (spring wheat) or fall 2008 (winter wheat). Also conduct barley and durum wheat experiments.
- Make available to industry data from the multi-state trials determining best management practices for FHB management.
- Validate current models using data from the multi-state trials.
- Validate models using 3 year economic data.

Performance Measures: Building a database of disease and mycotoxin responses to specific management strategies alone and in combination.

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 will include but are not limited to:

- Evaluate the potential disease reductions through combinations of host resistance and fungicides.
- Research documenting the impact of tillage, cropping sequence on disease risk and potential role as part of the integrated management for FHB/DON.
- Develop disease forecasting models that help producers and their advisors evaluate the risk of disease based on environment, cultivar resistance and crop residues.
- Develop economic analyses of responses to integrated management strategies alone and in combination (i.e. fungicide, biological control, cultivar, residue management).
- Optimize fungicide and biological control application timing and methodology.
- Deploy improved FHB/DON forecasting systems and validate the use of the disease.

Outputs:

- Improved or enhanced forecasting systems.
- Document good farming practices (GFP) for FHB/DON management on regional and national basis.

Resources: Multiple collaborative locations distributed across US. 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.

Goal #2: Develop the next generation of management tools for FHB/DON control.

Milestones/Performance Expectations:

- Document that there is an actual reduction in DON when “novel” management tools are used.
- New understanding is attained of factors influencing final DON levels in grain.

FHB MANAGEMENT (MGMT) *(cont.)*

- DON risk forecasting tool is available to growers.
- Add additional crop management (previous crop, tillage) to FHB forecasting system.
- Develop content for website describing what does not work.

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

Research Needs:

- Enhance forecasting capabilities:
  - Examine the ability to utilize other sources of weather data and 'ensemble' approaches to forecasting.
  - Develop forecasting tool for DON.
  - Develop and validate forecasting tool for barley.
- Develop control methods that include consistent and effective biological control agent.
  - Support discovery and development of biological control agents showing consistent and effective FHB/DON control.
  - Develop a better understanding of the ecological relationships associated with consistent and effective biological controls.
  - Identify practices or methods that lead to consistent expression of BCA activity.
- Continuous assessment of new control methods for FHB/DON.
- Screen new fungicide compounds across multiple environments as candidates are identified by industry.
- Confirm FHB/DON control levels at recommended label rates for new fungicides.
- Determine factors influencing DON accumulation in wheat and barley grain
  - Evaluate the potential impact of environment during grain filling growth stages on final DON levels
  - Determine the role of environment, pathogen population, and cultivar on the accumulation of mycotoxins.
- Develop a repository for negative data with potential explanations for why control was not attained.

Outputs:

- Uniform research designs
- Data interpretations regionally and nationally
- Enhanced and improved forecasting systems
- GFP document for FHB/DON management on regional and national basis.

Resources:
Multiple collaborative locations distributed across US. 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: Novel methods to integrate in FHB/DON management plans will be identified.

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:

- Year 1 - determine if DON can be detected in asymptomatic grain; establish a relationship between grain symptoms and DON (+/- not quantification).
- Understanding is improved of the roles of host genetics, pathogen genetics, and environmental variables on DON accumulation.
- Years 3-4 - apply the above information to the FHB and/or DON prediction model.
- Publications are submitted on:
  - role of post-flowering weather and late/secondary infections;
  - conditions leading to high DON with low/no visual symptoms; and
  - relative contributions of in-field vs. external inoculum sources.
- Practical recommendations are developed based on the publications.
- The FHB risk forecaster is updated using the results described in the publications.

Performance Measures: Provide information regarding specific factors influencing infection and toxin accumulation, particularly 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, that are essential for the next generation of scab and DON risk assessment models.

Research Needs: Identify host-, weather-, environment-, and pathogen-related factors and interactions involving these factors that are associated with DON accumulation, including accumulation in the absence of visual symptoms or when severity symptoms are low. Specific studies will be conducted to evaluate the effects of the following factors on DON accumulation:

- the role of post-flowering weather in disease and DON accumulation generally;
- late/secondary infections and the influence of post-flowering weather conditions
  - Determine the importance of post-flowering inoculum density and the associations among inoculum density, weather, FHB, and DON accumulation.
  - Determine the influence of weather (and variety) on infection efficiency (IE) at various growth stages between heading and grain maturity.
  - Determine the influence of weather on temporal variation in fungal biomass of grain following inoculation at different growth stages between heading and grain maturation.
- the relative contributions of inoculum from in-field debris vs. airborne spores from nearby and distant sources. These studies should determine regional variability, and translate the findings into regionally appropriate and specific recommendations for debris management.

Outputs:

- Uniform experiments conducted using locally-adapted varieties.
- Models describing associations among inoculum density/dose, inoculation timing, temperature, RH, and variety on infection, fungal biomass and DON accumulation in the absence of visual symptoms.
- Improved accuracy of FHB risk assessment models and development DON forecasting models.
- Generate data suitable for the development of process-based FHB and DON risk assessment models.

FHB MANAGEMENT (MGMT) *(cont.)*

- 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.

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

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. We recognize that our audience includes, but is not limited to producers, agricultural advisors, research community, and grain processors.

Milestones/Performance Expectations:

- Document negative data for why management was ineffective in reducing FHB.
- A database with the results from Goal 1 is available on the USWBSI web site.
- An interdisciplinary team is formed to improve the USWBSI web link to the work of MGMT; design a "ScabSmart" web site that can be customized by state; and design a USWBSI brochure for growers, including best management practices that can be customized by state.

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

Research Needs:

- Develop "ScabSmart" outreach materials and platform for exchange of information.
    - Develop Industry-University alliance to interpret Good Farming Practices.
    - Conduct "Train-the-Trainers" workshops to ensure a common message and understanding of what is different in certain circumstances.
    - Conduct region-wide training events for influencers (growers, consultants, and influencers).
    - Partner with CCA organization to deliver on-line training for crop advisors via the Crop Advisors Institute and ICCA magazine. Pre- and Post-testing (learning assessments) would "certify" a crop advisor as a "Certified FHB Manager - 2007". Only the year of testing would be certified.
- Develop economic assessment tools based on discounts/premiums assessed by millers and maltsters, market prices at terminals, and other factors (a model for this tool is available at NDSU in the form of a crop value calculator).

Outputs:

- Science-based educational materials/training tools with a unified message.
- GFP document for FHB/DON management on regional and national basis.

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

FHB MANAGEMENT (MGMT) *(cont.)*

Research Needs: Improve communication within the scientific community:

- Establish a separate section for FHB reports in Plant Disease Management Reports.
- Arrange for a Plant Disease feature article series on progress in each RAC
- Feature speaker at the next Forum to provide a synthesis of progress in managing FHB/DON since the inception of the USWBSI.

Outputs:

- Research reports in refereed journals.
- Communicate a clear message to the scientific community about progress of USWBSI.
- Communicate to researchers the need for realistic interpretations and timely and definitive results.

Resources: Individual and collaborative reporting of data. A dedicated site established for reporting FHB/DON data.

Anticipated Impact: Increased adoption of practices by producers and decision makers will result in FHB/DON reduction and leading 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:

- Standardized sampling protocols adopted for regional (commercial field) and research testing for DON and posted on the USWBSI's website. (Completed)
- Accurate information and analysis regarding ADONs and DON is publicly available in a form accessible to the FHB research community and the interested public.
- Provide DON data in a timely manner.
- Increase coordination amongst labs with an effort towards matching lab utilization to potential impact (Completed)

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

Research Needs: Lack of awareness about optimal sampling and grinding protocols for grain industry, milling industry and initiative researchers. This may result in incorrect data and inhibit effort to reduce DON

Outputs:

- Short term
  - Session/meeting devoted to sampling /analytical methods. Present at next initiative meeting (Completed).
  - Protocols will be included in USWBI web page within the year. (Completed)
  - Links to protocols will be provided to initiative users. (Completed)
  - Expand internal check samples

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: Increase capacity for the analysis of DON and other trichothecenes. (Completed)

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

Outputs:

- Diagnostic labs
  - Survey of initiative users for anticipated needs, and continued evaluation of new technology. (Completed)
  - Request to EC for expanded capacity (existing labs or new lab, if needed), and increased capabilities on- line within 12- 16 months. (Completed)

Food Safety, Toxicology and Utilization of Mycotoxin-contaminated Grain (FSTU) *(cont.)*

  - 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 (Completed and determined not to be practical).
    - Continued evaluation of new technologies.
- Facilitate on-site rapid testing
  - Suggested rapid screening protocols 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:
- Multi-year year survey data on occurrence of different trichothecenes and relative ratios of these analytes.
- Prepare a review on the glycosidic forms of DON that can be included on the USWBSI web page

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.
- Improved safety protocols and strategies established for workers (researchers, growers, grain-elevator operators).
- One or more studies are in progress regarding DON and related trichothecenes that will allow extrapolation from animals to humans.
- A scientific publication is generated from this study or studies.
- The information is used to produce accessible outreach materials for the public.
- A list is compiled of commodity groups, food safety groups, and other interested parties that have received the access outreach material.

Food Safety, Toxicology and Utilization of Mycotoxin-contaminated Grain (FSTU) *(cont.)*

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 new concern about change in *Fusarium* genotypes and mycotoxin profiles.

Outputs:

- Publication of research/reviews in high impact journals that inform international risk assessors and regulation.
- 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, /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.
-Define chronic and acute risk
-Web page with USWBSI worker safety guidelines
-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.

Performance Measure 2.3*:* Conduct research on inhalation risks of DON and related trichothecenes, exposure and risk management

Research needs: Inhalation of DON and other trichothecenes poses unknown hazard to farmers, grain handlers, millers and researchers. Inhalation is more effective than ingestion in delivering these toxins. Effects could involve increased infection, inflammation and asthma.

Food Safety, Toxicology and Utilization of Mycotoxin-contaminated Grain (FSTU) *(cont.)*

Outputs:

- New data/publications on effects of trichothecene/contaminated grain dust inhalation on toxicity markers.
- New data /publications on occupational exposure to DON in grain dust.
- Provide information about “at-risk” occupations and mitigation strategies.
- Develop preliminary data for NIH-funded human epidemiology studies.

Resources: Environmental and occupational safety workers

Anticipated Impact: Ensure safety of wheat and barley industry workers.

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 functional screening assays 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: for example, virus-induced gene silencing and Physcometrella.

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 – Engineering FHB Resistance and DON reduction: Develop effective FHB resistance through transgenic strategies.

Milestones/Performance Expectations:

- Assess the activity of the candidate genes when expressed in wheat and barley. It is anticipated that 5 genes, each with different modes of action, will be tested by 2012.
- Hold a “Field Day” exhibition in which the FHB resistance of latest transgenic wheat and barley lines is compared to the current nontransgenic FHB resistant cultivars.
- Once efficacy of transgenic lines is established, cross or transform the transgene loci/constructs into elite germplasm for use by breeders.

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

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

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.
- Preliminary data for efficacious transgenes must be provided for Initiative support.
- The Initiative should support centralized facilities for field testing transgenic wheat and barley. This need is being fulfilled through GDER funding of a transgenic wheat and barley FHB nursery.
- Development of tools for optimized gene expression in wheat and barley.
- Incorporation of 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 genetic variation in FHB pathogen population especially with regard to aggressiveness toward plants and mycotoxin potential.

Milestones/Performance Expectations:

- Characterize the interaction of these genetic variants with various cultivars to determine the biological relevance.
- Undertake aggressiveness testing of populations representing genetic diversity.

Performance Measure: Information useable for making decisions on performance of plant varieties toward specific genetic variants of the pathogen.

Research Needs.

- Understand the biological relevance of genetic variation in FHB pathogen populations in the U.S., strains that are likely to travel here, and characterize their threat to fungicide resistance (i.e. triazoles) and host resistance being developed by USWBSI.
- Understand long-term use of fungicides on pathogen populations.
- Understand the linkage between greenhouse testing and field testing.

Outputs:

Short-term:

- Coordinated interactions between PBG researchers and other RACs in which information was exchanged and common research goals were developed.
- Publications and on-line resources were created for stakeholders explaining significance of genetic variation to disease resistance and mycotoxin potential in wheat and barley.

Long-term:

- Efficient strategies were developed for monitoring population shifts and assessing their threat.
- On-going discussions with other RACs.

Resources:

- USWBSI funding for research to characterize the effects of individual strains on varieties.

Anticipated Impact: Deploy, stable resistance across environments.

Goal #2: Characterize plant-fungal interactions in plant 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.

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

Research Needs:

- Studies on pathogen infection, movement, and DON accumulation during grain maturation.
- 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.
- Identification of fungal genes involved in spore germination and infection.
- Understand the interaction between FHB resistance and resistance to DON accumulation
- Develop effective screens for identification of resistance other than Type II.
- Assess inoculum survival on resistant vs. susceptible cultivars.
- Determine the effect of fungicide application on DON biosynthesis.
- Determine whether mechanical barriers in disease resistance (i.e. long awns) are effective.

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.

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.

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 #3: 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.

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

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.

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.

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 grain delivered to US flour mills.
- 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:

- A positive trend in acreage planted to cultivars with enhanced FHB resistance and reduced DON levels in delivered grain.
- Improved 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 growers.
- 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:

- Increased 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.
- Increase 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 1 yr)
- 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.

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

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

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.
- Identify novel sources of FHB resistance and initiate plans to introgress the resistance gene(s) into variety development programs.
- 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.
- Maintain list all FHB resistance sources, their FHB resistance relative to checks, their haplotype, information on any QTL, and the effectiveness of associated markers.
- Identification and incorporation of different types of FHB resistance into germplasm lines and varieties.
- Development 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.

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

- 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).
- Initiate research on breeding methods.

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.

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.