Small Grains Strategic Plan, 2024-2029

VISION

The Texas A&M AgriLife Small Grains Research and Extension Program will be the world's premier source for new knowledge, superior plant materials, applied problem-solving, and Extension education related to the production and use of winter and spring small grains.

MISSION

In the land-grant tradition, the Texas A&M AgriLife Small Grains Research and Extension Program exists to develop and deliver scientific knowledge and plant materials related to wheat, oat, triticale, rye, and barley.

PURPOSE AND SCOPE

This strategic plan was developed to guide the Small Grains Research and Extension Program (SGREP) by:

- Defining objectives clearly;
- Giving a statewide perspective to the small grains production regions of Texas;
- Facilitating efficient use of all available resources;
- Improving integration (i) across the land-grant functions and (ii) between the Program's two Centers of Excellence;
- Ensuring a sound financial basis for the program; and
- Establishing programmatic points of contact with allied research and Extension programs.

The strategic plan covers all aspects of the small-grains program from scientific manipulation at the molecular level to public education and marketing of released varieties. We emphasize the statewide perspective in the Strategic Plan to maximize coordination and cooperation among regionally administered programs so that their activities complement each other and pursue common goals. The SGREP concentrates resources in a small number of well equipped locations, minimizes unnecessary duplication, and eliminates major deficiencies in expertise, thereby improving efficiency throughout the program. Finally, the Strategic Plan describes a fiscal management strategy that balances income and expenses for program stability and scientific currency.

STRATEGIC PLAN, 2024-2029

INTRODUCTION

The vital importance of small-grain crops to society requires ongoing improvement of those crops and their production systems. Small grains research and Extension programs within the Texas A&M System are a local, state, regional, national, and international source of knowledge, education, and training. The strengths of the TAMUS small-grains program reside in our people and their ability to achieve eight goals:

1. Develop, document, and license superior plant materials;
2. Meet and exceed end-use requirements for marketability of small-grain varieties, including those quality traits associated with improved nutrition, human-health, and livestock-performance outcomes;
3. Integrate conventional and biotechnological research and development;
4. Characterize the stressors of small-grain crops, and identify critical control points for those stressors and their interactions;
5. Optimize small-grain management practices and cropping systems for multiple endpoints defined by consumers, retailers, grain processors, and producers;
6. Accelerate development of superior plant materials through remote sensing, advanced sensors, and data-analytics technologies;
7. Increase the profitability of small-grains production systems; and
8. Transfer knowledge and technologies to students, consultants, small-grains producers, producer associations, and consumers.

BACKGROUND

From 2009-2023, Texas producers have sown 5 to 7 million ac/yr of small grains, consisting of approximately 85% wheat, 10% oat, and 5% rye, barley, and triticale in the aggregate. The farm-gate production value of the grain averaged $420 million per year. Beyond grain production, these crops are also valued as winter pasture and feed sources for domesticated ruminants and wildlife. Thus, production schemes may focus on grain production only, grazing plus grain, grazing only (graze-out), or hay/silage production. An estimated 65% of the small-grain acreage is grazed annually to some degree, with a value exceeding $400 million in livestock products. Oat, rye, and triticale are often valued more for their vegetative production than for grain. Approximately 60 to 80% of oat is grazed out each year, with the ratio of grain to graze-out depending on crop conditions and the relative prices of grain and beef.

Texas has diverse climatic and environmental conditions, and small grains are grown throughout the state. Winter wheat predominates in the northern and southern High Plains and Rolling Plains regions, which together represent about 80+% of the total wheat area statewide. Oat is an important forage crop grown in central and south Texas. Triticale has potential as a winter forage crop throughout the state, and barley may have promise as a feed grain/silage crop

and/or to support micro-breweries in certain areas. Our strategic plan, therefore, assumes that *wherever small grains are grown in Texas, they may serve dual purposes for grain and forage production*.

Beginning with the 2017 wheat crop, planted acres statewide fell below 5 million acres and rebounded beginning in 2021 with the return of more favorable prices. During the ten-year period from 2014 to 2023, Texas farmers planted an average of 5.3 million acres of winter wheat. Total grain production has trended down in recent years with reduced harvested acres and difficult growing seasons. Average total grain production for the same ten-year window is just over 70 million bushels with a statewide average yield of 32 bushels per acre. For the crop years spanning from 2020 to 2023, Texas farmers harvested between 42% and 25% of the acres that were planted. The brewing industry in the Texas Panhandle is small but growing rapidly in response to increased demand for small-batch, craft beer and spirits. The Interstate 40 corridor west of Amarillo now hosts a commercial malting company that provides malted small grains to a growing number of microbreweries and brewpubs in the Panhandle and beyond. Barley, wheat, rye, and triticale are all implicated in this growing market.

A sharp rise in fuel and fertilizer prices during 2021-22 and the accompanying, generalized inflation (>7%/yr) have dramatically increased the cost of inputs for small-grain production. At the same time, geopolitical forces have further contributed to historically soaring prices for wheat, on the order of $8-12/bu, creating transient opportunities for growth in planted acreage, seed sales, and checkoff revenues where planting moisture and in-season precipitation are adequate.

Our strategic plan assumes that over the five-year planning interval (2024-2029):

1. Wheat acres and statewide production will remain steady; and
2. Our research and technology-transfer portfolio will need to focus on (a) reducing inputs and losses while increasing efficiency and resilience, (b) improving end-use quality to improve producer profitability in view of a more competitive, global marketplace, and (c) improving the grazing performance of small-grain varieties used as forage for livestock.

Goals and Objectives

Goal 1. Develop, license, and document superior plant materials.

- Objective 1.1. Develop high-yielding, drought tolerant, and disease- and insect-resistant small grains cultivars with excellent intrinsic grain and forage qualities.
- Objective 1.2. Develop small grain varieties and germplasm adapted for multi-purpose uses, including grain, grazing, silage, and cover crops.
- Objective 1.3. Evaluate the evolutionary progenitors of wheat, oat, and barley for improved traits and incorporate those traits into adapted small grains.
- Objective 1.4. Contribute to and participate in regional, national, and international small-grain nurseries.
- Objective 1.5. Increase the rate of adoption of certified seed within Texas.

Objective 1.6. Promote the extramural exchange of germplasm, as appropriate, to improve the competitive positions of Texas small-grains producers and AgriLife's research and Extension programs through Material Transfer Agreements (MTAs) and contracts for evaluation.

Objective 1.7. Promote the regional and interstate evaluation of Texas germplasm.

Objective 1.8. Protect and leverage the intellectual property developed by System scientists to ensure positive return on investment and to return royalties to the SGREP.

Goal 2. Meet and exceed end-use requirements for marketability of small-grain varieties, including those quality traits associated with improved nutrition, human-health, and livestock-performance outcomes.

Objective 2.1. Improve our understanding of (a) the determinants of small-grain quality, including gluten, protein, enzymes, convertible starch, and fiber, and (b) their relationships to key measures of human and livestock health.

Objective 2.2. Expand research into sustainable, alternative, and unique uses for small grains and their production and processing residues.

Objective 2.3. Identify qualities that meet or exceed end-use requirements for yeast breads, flatbreads, brewing, and alternative uses.

Objective 2.4. Investigate the genetic and molecular basis of end-use quality and incorporate improved and/or novel traits into modern cultivars.

Objective 2.5. Incorporate advanced technologies to develop small grains that address specific population concerns with small-grain components (e.g., reduced or modified carbohydrates).

Objective 2.6. Generate evidence on how the small grains complex carbohydrates and bioactive molecules influence gut microbiome and human health.

Goal 3. Integrate conventional and biotechnological research and development.

Objective 3.1. Improve our understanding of the molecular genetics of wheat, oat, triticale, rye, and barley.

Objective 3.2. Incorporate molecular genetic traits into adapted germplasm to achieve both production and quality outcomes.

Objective 3.3. Accelerate small-grain breeding programs through gene editing, marker-assisted selection, high-throughput phenotyping, hybridization, doubled haploidy, genomic prediction, and other technological advances.

Objective 3.4. Integrate field-based research and development with on-campus laboratories dedicated to genomics, gene editing, and tissue culture.

Goal 4. Characterize the stressors of small-grain crops, and identify critical control points for those stressors and their interactions.

Objective 4.1. Develop and implement strategies for long-term management of important disease and insect pests of small grains.

Objective 4.2. Describe the genetic basis of plant resistance to important diseases and insects of small grains.

Objective 4.3. Elucidate the molecular basis of pathogenicity.

Objective 4.4. Elucidate the biotic and abiotic interactions that reduce yield and quality.

Objective 4.5. Evaluate the biological cost of abiotic stresses on small-grain plants.

Objective 4.6. Evaluate conditions important to pathogen ecology and epidemiology.

Goal 5. Optimize small-grain management practices and cropping systems for multiple endpoints defined by consumers, retailers, grain processors, growers, and livestock producers.

Objective 5.1. Optimize crop rotations and integrated crop-livestock systems that incorporate small grains; that provide benefits through increased biodiversity, carbon capture, and weed control; and that emphasize conservation, storage, and efficient use of soil water.

Objective 5.2. Improve producer understanding of soil management, tillage, seedbed preparation, and erosion control, and foster the adoption of practices that promote soil health in support of small-grains production.

Objective 5.3. Reduce the environmental footprint of Texas' small-grains production by refining nutrient requirements and fertilizer placement and timing for all production areas statewide as well as revisiting older recommendations.

Objective 5.4. Improve producer understanding of best practices for weed, insect, and disease management in small grains, and foster adoption of those practices.

Objective 5.5. Expand and coordinate research and education on production and grazing management of dual- or triple-purpose small grains including grazing intensity, silage quality, frequency, and duration as they influence both animal-protein and grain production.

Objective 5.6. Optimize and foster the use of small grains as individual cover crops or as components of cover-crop seed blends.

Objective 5.7. Develop and communicate an industry-funded, retrospective, life-cycle assessment of wheat production across the United States, including all major classes of wheat.

Goal 6. Accelerate development of superior plant materials through remote sensing, advanced sensors, and data-analytics technologies.

Objective 6.1. Develop, refine, standardize, and automate the collection, processing, and interpretation of remote-sensing data related to growth status, biotic and abiotic stress, yield potential, and grain and forage quality.

Objective 6.2 Develop improved sensors for phenology.

Objective 6.3. Reduce the time and resources required to get new small-grain varieties into the market.

Objective 6.4. Enhance SGREP revenues and increase producer impact through fee-based, continuing-education programs for professional practitioners featuring remote sensing in their service portfolios.

Goal 7. Increase the profitability of small-grains production systems.

Objective 7.1. Reestablish a critical mass of faculty expertise in the economics and marketing of small grains.

Objective 7.2. Evaluate the economic implications of international, federal, and state trade policies on the viability of small-grains producers.

Objective 7.3. Educate producers to improve their marketing and management skills.

Objective 7.4. Optimize risk-management strategies for small-grains production systems.

Objective 7.5. Assess the end-use value of wheat and other small grains with respect to market trends, consumer demand, and human-health outcomes.

Objective 7.6. Evaluate the economic feasibility of small grains in emerging markets (e. g., biofuels production).

Objective 7.7. Maximize net returns to producers through understanding and promoting the economic and environmental benefits of small grains in cropping systems.

Objective 7.8. Evaluate and promote agronomic practices with the potential to increase profitability.

Goal 8. Transfer knowledge and technologies to students, consultants, small-grains producers, producer associations, and consumers.

Objective 8.1. Improve the timeliness and accessibility of knowledge transfer to producers, leveraging advances in multimedia and social-media technology.

Objective 8.2. Assess the quality and relevance of local and regional farm shows with respect to the participation of small-grains producers, and where necessary, identify and implement strategies and tactics to reinvigorate those technology-transfer events for the benefit of those producers.

Objective 8.3. Develop, test, and evaluate management recommendations for dual-purpose, small grains that farmers are willing and able to adopt and that optimize economic returns from small-grains crop rotations and integrated crop-livestock systems.

Objective 8.4. Identify popular messaging to consumers for which the putative scientific basis is thin, contradictory, inadequately nuanced, or inaccurate, and design and execute technology-transfer programs, educational curricula, and social-media campaigns to correct or refine public understanding of the relevant science.

Objective 8.5. Identify and exploit social-media strategies and tactics to increase public awareness of small-grains research and its value to consumers.

Objective 8.6. Work with the Institute for Advancing Health through Agriculture to integrate research-based findings relevant to consumer preferences and behaviors into regional and statewide initiatives focused on the relationships between diet and human health, equipping county Extension educators, teachers, and volunteers to enrich those programs with the latest findings.

Objective 8.7. Integrate SGREP projects with undergraduate and graduate training in the Texas A&M College of Agriculture and Life Sciences.

ORGANIZATION

The Texas A&M AgriLife Small Grains Research and Extension Program consists of the Small Grains Advisory Committee, two Centers of Excellence at College Station and Amarillo, Texas A&M AgriLife Foundation Seed (TAFS) in Vernon, and a variety of farms and facilities statewide and beyond (*e. g.*, Arizona) devoted to small-grains research, variety evaluation, seed increases, and technology transfer.

Small Grains Advisory Committee

History. The Vice Chancellor for Agriculture and Life Sciences established the Small Grains Advisory Committee (SGAC) on August 23, 1999, to "establish a framework of activity and issues for an External Assessment Panel to pursue" during their review of research and education programs in small grains.

Charge. As set forth in a memorandum from the Vice Chancellor for Agriculture and Life Sciences on January 14, 2000, the charge of the SGAC is threefold:

1. Develop a long-term, statewide, small-grains improvement strategy that addressed all major points identified in the Small Grains Review;
2. Monitor progress against that strategy; and
3. Recommend actions that will enhance the competitive position and prestige of Texas A&M AgriLife's small-grains program.

Membership. To accommodate the increased significance of licensing and the competitive forces that attend the licensing process, SGAC membership was revised in 2018. Faculty membership includes one representative from each of the two Centers of Excellence and a third individual with statewide small grains responsibility. Faculty representatives are elected by their peers (e. g., the Small Grains Workers Group). Membership is reviewed periodically by the SGAC with recommendations for appropriate changes sent from the committee to Texas A&M AgriLife administration.

SGAC membership (Table 1) now includes:

- Three faculty members from the Texas A&M AgriLife small-grains program (*ex officio*; not present for evaluation of grant proposals);
- The Executive Vice President of the Texas Wheat Producers Board;
- The Director of Texas A&M AgriLife Foundation Seed;

- The unit heads from each of the System units with key faculty participation in the statewide Small Grains Program (College Station, Vernon, Amarillo, Soil and Crop Sciences, Entomology, Food Science, and Plant Pathology);

- The Associate Directors of Texas A&M AgriLife Research and Texas A&M AgriLife Extension;

- The Director of the Texas A&M AgriLife Office of Corporate Engagement and Research Support; and

- The Senior Licensing Manager for Texas A&M Innovation.

Table 1. Roster of the Small Grains Advisory Committee (SGAC) as of 08 Nov 2024.

SEAT	2024 INCUMBENT	STATUS
Faculty #1 - College Station Center of Excellence	Dr. Shuyu Liu	*ex officio*
Faculty #2 - Amarillo Center of Excellence	Dr. Jackie Rudd	*ex officio*
Faculty #3 - Statewide	Dr. Brandon Gerrish	*ex officio*
TWPB Executive VP	Mr. Rodney Mosier	**retiring Spring 2025
TAMFS Director	Dr. Richard Vierling*	*dual role
Center Director - Vernon	Dr. Richard Vierling*	*dual role
Dept. Head - Soil and Crop Sciences	Dr. David Baltensperger	Chair
Assoc. Dept. Head - Soil and Crop Sciences	Dr. Larry Redmon	
Center Director - Amarillo	Dr. Brent Auvermann	
Dept. Head - Entomology	Dr. Phillip Kaufman	
Dept. Head - Plant Pathology	Dr. WonBo Shim	
Associate Director - Research	Dr. Amir Ibrahim	
Program Director - CERS	Mr. Carl Muntean	
Senior Licensing Manager - TAMU Innovation	Ms. Janie Hurley	
Associate Director - Extension	Dr. Dan Hale	
Dept. Head - Food Science and Technology	TBD	

Institutional Relationships. The SGAC was organized to coordinate and to be an advocate for the Small Grains Research and Educational Program within Texas A&M AgriLife. To accomplish this, the SGAC:

- Makes specific recommendations to the Texas A&M AgriLife administration for enhancing the effectiveness of small-grains research and educational activities;
- Provides a mechanism for faculty, farmers, and industry to exchange ideas and refine their shared vision for Texas' small-grains industry;
- Coordinates and prioritizes all small-grains programs administered by Texas A&M AgriLife Research and the Texas A&M AgriLife Extension, and solicits participation in those programs by faculty and staff; and
- Periodically reviews membership and leadership of the SGAC and recommends appropriate changes to agency administrators.

Centers of Excellence

The Small Grains Advisory Committee endorsed the recommendation of the Texas Small Grains External Assessment Panel to support two (2) Centers of Excellence for small-grains research in Texas. These Centers of Excellence are located in Amarillo and College Station. The SGAC recommended that small-grains research and Extension programs at those locations adopt a focused, multi-disciplinary, team approach.

The Centers of Excellence concept enhances coordination and encourages multi-disciplinary research while increasing resource efficiency and effectiveness. Texas A&M AgriLife Research must provide sufficient financial support and appropriate personnel to achieve the goal of two nationally and internationally recognized Centers of Excellence for small-grains research in Texas. The team approach based on the Center concept will be more effective in attracting new sources of funding and more successful in winning outside grants than an investigator-centered approach.

College Station. The Center of Excellence at College Station focuses on research and Extension efforts for the more temperate areas of Texas, especially the Blacklands, central Texas, and south Texas. Small grains breeding, pest management, and production research are primary objectives. This team is also responsible for all oat research in Texas. The team includes a small-grains breeder, a molecular biologist, a wheat quality specialist, and an Extension small-grains specialist.

The Center at College Station will stress small grains breeding, molecular genetics/ biotechnology research on small grains, industrial quality assessment of breeding materials, statewide leadership in Extension education, and the involvement of graduate students in the small grains research program. Additional research domains that support the small-grains program include ground-based and airborne lidar ("LIght Detection And Ranging") for plant phenotyping, nuclear magnetic resonance imaging of roots and root structures, and weed science.

Amarillo. The Center of Excellence at Amarillo focuses on research for the semi-arid High and Rolling Plains, including both rain-fed and irrigated small grains in dual-purpose production systems. The team consists of a breeder, a small-grain genetics specialist, and support from research or Extension faculty in entomology, plant pathology, plant physiology, agronomy, animal science, economics, and water-management engineering. The Amarillo team also features partial appointments from several support disciplines including soil fertility, plant pathology, entomology, risk management, and marketing; it also enjoys collaborative research with modeling specialists at the Texas A&M AgriLife Research and Extension Center in Temple, TX.

The Texas A&M AgriLife Research and Extension Center at Amarillo is located in Texas' major wheat-growing region, and the existing small grains research program has strong support from the agricultural community. The Amarillo Center is less than a mile from the headquarters of the Texas Wheat Producers Board (TWPB) and enjoys an active, mutually beneficial relationship with TWPB. The Amarillo Center is responsible for developing winter wheats and winter forage triticale for irrigated and rainfed conditions of the High and Rolling Plains. Developing cultivars and improved management practices for the dual-purpose system is also a primary objective, and a multi-disciplinary research and Extension team in Vernon complements that research effort for the Rolling Plains. The Amarillo team, with professional, technical, and marketing support from Texas A&M AgriLife Foundation Seed and the Texas A&M AgriLife Research and Extension Center at Vernon, will be primarily responsible for developing cultivars for the Rolling Plains, which is ecologically distinct from the High Plains. Since the 2008 revision of the SGREP Strategic Plan, the Amarillo Center has added the Geneticist/Germplasm Development Scientist (1.0 FTE) to work closely with the small-grains breeder. This geneticist is responsible for introgressing greater genetic variability into the breeding program and developing breeding materials with improved resistance to biotic and abiotic stresses; this individual will also pursue biotechnology applications (*e. g.*, markers) for the breeding program.

Vernon and Commerce. Vernon and Commerce will continue as selection and testing sites for small-grains germplasm. The Amarillo program will develop materials for the Rolling Plains and High Plains regions and will provide leadership for improvement activities at Vernon. The program in College Station will develop materials (wheat and oat) for the south, central, and Blacklands regions and will lead the testing of varieties and advanced experimental lines in north-central Texas. Despite those specific roles, the statewide team works as one group to leverage resources and expertise.

Critical Components of Success

Germplasm Modification

Germplasm is the pool of genetic diversity of a crop species, and includes wild relatives, land races, plant introductions, intermating populations, haploid lines, breeding lines, mapping populations, segregating populations, cytogenetic lines, and developed varieties. Tissue culture lines, cell lines, and even molecular genetic libraries of genes and gene constructs are also part of the genetic germplasm pool that plant improvement scientists can use for genetic diversity. Biotech modification of germplasm includes the development of transgenic plants, identifying molecular markers for specific genes, editing genes, chromosomal and molecular cytogenetic mapping, and other applications for capitalizing on an ever-increasing knowledge of molecular biology. More conventional germplasm modifications include introgression of genes from wild relatives and unadapted lines into adapted genotypes, generation and selection of novel genetic mutations, and development of breeding lines with specific trait polymorphisms. Scientists involved in germplasm modification and development should include molecular biologists, cytogeneticists, and basic science-oriented chemists, physiologists, pathologists, and entomologists. Screening germplasm is a critical process in identification of useful germplasm focused on incorporating specifically identified traits into genetically stable plant material that can be readily hybridized with adapted varieties and breeding lines. Besides discipline-oriented scientists (pathologists, entomologists, etc.), plant geneticists and plant breeders are involved in these screening and development processes. Doubled-haploid techniques can shorten by 3-4 years the development time for pure lines of winter wheat. The Center of Excellence at Amarillo has established and optimized a medium-throughput process of doubled-haploid development; improved facilities and increased funding could support a regional or national Center for doubled haploids in small grains.

Germplasm modification in the Texas A&M AgriLife small grains improvement program must continue to be a multidisciplinary activity with close collaboration between basic and applied sciences and will facilitate rapid introgression of new genes and new traits. Traditional plant breeding, historically a hallmark of the Texas A&M AgriLife small grains improvement program, will continue to be a cornerstone. Small grains breeders fill several critical roles in the total small grains program including training of new plant breeders, incorporation of newly generated germplasm into products with commercial potential, testing of potential new products, and generating unbiased data. It is the responsibility of the breeder and the breeding teams to ensure that the highest standards of science are observed in the development and release of improved plant materials.

Biotechnology

Texas must continue to position itself as a leader in new technologies. New discoveries relating to genes, gene processes, gene products, and gene function promise to revolutionize agriculture. While commercialization of transgenic wheat is not an immediate reality, the success of transgenics in other crops suggests a bright future for transgenic wheat. Consequently, continued research on wheat transformation is a critical component for the future. Biotechnological research is expensive, and many of its essential elements are proprietary. Partnerships with other research programs, both private and public, are also critical components for future success. Continued and enhanced molecular and biotechnology research in small grains should focus on the following major categories:

a. Marker-assisted selection and genomic prediction;

b. The molecular basis of factors associated with grain development and quality;

c. Gene expression as it relates to biotic and abiotic stresses;

d. Genome organization, gene expression, and gene editing; and

e. Wheat transformation, tissue culture, and doubled-haploid development.

Entomology

Major areas to be addressed in wheat entomology research include greenbugs, Russian wheat aphid, Hessian fly, stem sawfly, vectors of barley yellow dwarf virus and wheat streak mosaic virus, armyworms, other minor pests, and multifaceted ecological evaluations. Those challenges can be met with multidiscipli-nary teams, enhanced coordination of research conducted by faculty at research and Extension centers, and basic research concentrated in the Department of Entomology and the Crop Biotechnology Center on the Texas A&M campus. Significant strides have been made in understanding the basic biology of many entomological pests of wheat important to Texas, but additional research is needed in biology and epidemiology. Long-term solutions can be achieved by combining traditional approaches with new technologies. For example, resistance in wheat to Russian wheat aphid is difficult to track in wheat-breeding populations naturally or artificially infested with aphids. Currently identified resistance is multigenic. A collaborative program could result in developing a marker-assisted selection process to facilitate identification of multigenic inheritance in segregating populations without infesting with aphids. Substantial evidence suggests that commonality exists between wheat and sorghum genomes, making collaborative research between commodities attractive both intellectually and financially.

Hessian fly has been a historic small grains pest in some regions of Texas. Recently its range has expanded, and it currently occurs at damaging levels in all major wheat regions of Texas, except the Panhandle. Host-plant resistance and delayed planting have been effectively used by other states as control methods. However, that combination of controls has limited effect in Texas. An integrated approach to Hessian fly is a critical component of future success.

Wheat and other small-grain crops are part of a larger ecosystem. Pests in wheat are likely dependent on multiple interacting factors. To improve integrated pest management (IPM), long-term research is needed to build a usable database and to develop predictive models of the seasonal abundance of all aphids, predators, and parasitoids in wheat, other small grains, and wild hosts (e. g., native grasses and other refugia).

Plant Pathology and Microbiology

Diseases are major limiting factors in producing small grains in Texas. In traditionally lower rainfall areas (principally the High Plains), virus diseases and diseases that affect the roots tend to be more common and severe than other diseases. Small grains produced in those areas that have greater amounts of rainfall (Rolling Plains, Cross Timbers, Blacklands, East Texas, Central Texas, South Texas, and the Gulf Coast) tend to suffer more from fungal and bacterial diseases, although viral diseases such as barley yellow dwarf virus (BYDV) and wheat streak mosaic virus (WSMV) are common and cause significant annual loss. Wheat streak mosaic virus and its vector, the wheat curl mite, require greater, multidisciplinary emphasis in upcoming years because of the yield and quality losses that have accelerated recently. New challenges include stripe rust and new races of stem rust.

In oats, the primary disease problems are crown rust, stem rust and BYDV. On barley, BYDV is the most widespread and damaging disease. Smuts and bunts occur on small grains in Texas. Efficient management of Texas small grains includes inherent disease resistance, crop protectants, and improved cultural practices.

Resources for genetic management of the major small grain diseases are a major objective of the small-grains improvement team. A major thrust in breeding for resistance to the rusts and major viral diseases of small grains will result in cultivars with durable resistance to these pathogens. For genetic improvement in disease resistance to succeed, the program must employ modern techniques including molecular markers and transgenics, with traditional resistance breeding, and must be guided by the application of epidemiological principles.

A Small Grains Pathology Research Scientist with statewide responsibility is a critical component to success. Extension Associate positions at key locations (such as the Rolling Plains and Blacklands) should be developed as part of the statewide effort in Extension Pathology.

Agronomy, Production, and Management

Weather variables that damage small grains include drought, heat, winter kill and spring freeze injury, improper grazing management, inadequate or improper fertilizer management, post maturity damage from excessive rainfall, crop damage from aphids (greenbug and Russian wheat aphid), Hessian fly and mites, and yield and quality damage from weeds. Each of these is affected by basic small grains management techniques. Increased commodity prices create a need to revisit input opportunities for wheat production. Practices previously considered to be of marginal economic benefit may now be profitable.

Texas small grains provide a major source of income for both beef and dairy producers. Agronomic constraints to efficient production of small grains may be exacerbated by grazing. Multidisciplinary research and education teams currently are developing region-specific databases that incorporate new knowledge on nutrient management, basic cultural practices such as planting date and planting rate, efficient grazing management techniques such as grazing duration and grazing intensity, use of small grains for novel forage systems and economic analyses of the total system. Continued investigations of efficient small grains management systems, science-based data on production inputs, and documentation of quality attributes for both grain and forages/silages are critical components for future success.

Dual-purpose management systems were initially targeted by the 2000 External Review Panel as critical to success, but the use of small grains as a biofuel or silage begs some emphasis

for future research and education programs. Management systems which incorporate biofuel potential may help transition Texas small grains from a dual-purpose to a triple-purpose crop.

Grain Quality

Wheat buyers demand increasingly higher grain quality with consistent and predictable performance across a range of environments. There also is a domestic movement to rapidly increase amounts of identity preserved (IP) grain in which the IP system is preserved from the farm gate to the final processor. Many larger baking companies in the United States already are involved in IP programs or are developing IP capabilities. Texas is unprepared for this change due to inadequate storage capacity and an inadequate database on genotype/ environment interaction. Texas is poised to become the world leader in wheat enhancement for tortilla quality. It is critical that research on flour quality for tortilla production be expanded at the Texas A&M Cereal Quality Laboratory.

If Texas A&M AgriLife Research is to remain competitive in wheat germplasm enhancement and wheat cultivar development, a critical component for success is increased emphasis on enhancement of intrinsic quality. Texas is challenged in this regard in several ways. Its diversity creates opportunities for intermingling market classes and a consequent discount in quality. Environmental diversity also decreases predictability of quality. Some of the proteins with major effects on intrinsic quality are deposited in the grain late in the grain-filling process. These proteins are highly heat sensitive and respond negatively to the temperature load in Texas wheat fields during grain filling.

Educational Programs

There are two essential components to educational programs in small grains. The first component is the Extension and outreach education of producers, millers, and consumers of small grain products. The second component is the education and training of students for a career in small grains, including breeding, biotechnology, pest management, and quality.

Extension education in small grains relies heavily on in-field demonstrations of new technologies, including seed treatments, weed control, tillage, forage and grazing management, varietal comparisons, seed quality, pesticide and herbicide resistance, and agronomic management practices such as planting dates, seed rates, and nutrient management. Varietal comparisons, traditionally managed within research programs, have transitioned to Texas A&M AgriLife Extension specialists as a part of the small-grains improvement effort. This successful transition has added efficiencies and should serve as a model for other applied research efforts.

Training of undergraduate and graduate students in all major areas of small grains is critical to meet the need for academic and industry positions. Faculty and staff from the Texas A&M University System teach classes related to small grains production, biotechnology, and cereal quality. Faculty will also train and mentor undergraduate and graduate students through course work, internships, and research projects.

Texas A&M AgriLife Foundation Seed (TAMFS)

TAFS has five major objectives of the in relation to the small-grains breeding programs:

- Work with plant scientists to develop entrance strategies for the orderly purification and multiplication of new varieties and exit strategies for the commercial release and long-term maintenance of varieties;

- Increase seed of the controlled-generation classes (Breeder, Foundation, Registered, and Certified) of new small grain varieties as rapidly as possible, with production redundancy as appropriate;
- Keep seed pure during increase and through the certification process;
- Have pure seed of new varieties available to licensees on an equitable basis and at a reasonable price; and
- Maintain adequate supplies of pure seed of previously released TAM varieties, and increase as necessary.

Seed purification and multiplication (P & M) are begun by the breeder. The sooner P & M activities are initiated, the sooner large quantities of seed can be made available to licensees. Besides the production and maintenance of breeder seed, the plant breeder is responsible for the preparation and completion of all information and forms relating to Plant Variety Protection (PVP), and the preparation of information and advertisements that relate to a new variety. P & M activities should be a cooperative effort between the breeder and TAMFS, with responsibility for purity gradually moving away from the breeder and toward TAMFS as generations of selfing increase. Redundancy in seed increase locations could provide a backup and prevent the delay in commercialization due to loss caused from extreme environmental events.

Intellectual Property and Commercialization

Texas A&M AgriLife Research seeks to develop strong relationships with private companies that can promote a Texas small-grains industry that is sustainable and competitive. Primary goals of these relationships are production and sale of high quality and pure seed, support of the Texas certified seed industry, and delivering to Texas farmers the benefits of new technologies. To facilitate these goals, Texas A&M AgriLife Research works with the commercial seed industry to release improved cultivars and grant commercial licenses to private companies that can maximize availability and benefits of quality seed. Moreover, Texas A&M AgriLife Research looks to those relationships to generate revenue needed to sustain small-grains research and education programs (e. g., purchase and maintenance of equipment and instrumentation, maintenance of TAMFS, and marketing varieties with limited utility or distribution).

Texas A&M AgriLife Research recognizes that free release of small-grain varieties to independent seedsmen does not effectively promote modern business principles or a healthy, certified seed industry for small grains. To follow modern business principles, Texas A&M AgriLife Research now files protection instruments in the United States to license new varieties including patents, plant patents, or certificates of protection. Private-sector partnerships develop business mechanisms, assure proper seed distribution, confirm quality controls for seed production, and protect and enforce intellectual-property rights. Partnership activities include:

- Performance-testing services for licensed varieties, to identify and promote regional adoption of licensed varieties and other intellectual property;
- Evaluation of intrinsic quality of licensed varieties using industry protocols and standards;
- Assurance that sublicensees, distributors and associates have valid contracts for production and sale of licensed varieties;

- Effective monitoring of seed sales and usage;
- Audits that assure accurate reporting of sales of licensed varieties;
- Enforcement of intellectual property rights in Texas and in other states that protects licensed varieties from infringement and abuse;
- A program for seed increase and production for licensed varieties that effectively and reliably meets public and market demand;
- Pricing of licensed variety seed similar to pricing of other proprietary varieties that have similar demand and that have been released for equivalent periods;
- Working with Texas A&M AgriLife Research scientists on release of new varieties, developing marketing and production plans for those varieties;
- Maintaining all certification standards as required by certifying agencies for jurisdictions where production takes place;
- Increasing the rate of adoption of certified seed within the state of Texas;
- Using care in all aspects of production, conditioning, distribution and sale of licensed products to ensure quality and purity of all products sold; and
- Selling licensed products to the public under a commercial name that identifies the variety as originating from the Texas A&M University System, and only using a variety name and not selling as Variety Not Stated ("VNS").

Program Needs

Human Resources

Faculty in the Department of Soil and Crop Sciences play the central roles dedicated to the small-grains program, with other departments (Entomology, Plant Pathology, Agricultural Economics, Animal Science, Biological and Agricultural Engineering) providing additional critical support. The following personnel are required to staff the Soil and Crop Sciences program at College Station fully:

- *Cereal Chemist* (1.0 FTE). Evaluate advanced breeding lines for quality characteristics required by industry.
- *Grain Quality Specialist* (1.0 FTE). This faculty member will provide statewide leadership to the evaluation of small-grain varieties against accepted and emerging grain-quality criteria.
- *Dual-purpose system agronomist* (0.25 FTE). Work closely with economist(s) and animal scientist(s) to investigate the complex management system for central, northeast and south Texas. This research will be closely coordinated with the research at Vernon and Amarillo. Research on oats as a forage crop is justified for the central and southern regions of Texas.

In Amarillo, research faculty working in small grains include a breeder, a geneticist, a plant physiologist, an agronomist, an entomologist, and a plant pathologist. The plant-pathology

position vacated in Apr 2022 was filled in Jul 2023, and approximately reciprocal, joint Research/Extension appointments were approved for the two plant pathologists there. A regional Extension specialist in forages would be tremendously useful at Amarillo. However, the long-term availability of AgriLife-controlled, arable acres for the small grains improvement program is not sufficient to support additional faculty with research appointments.

To facilitate research, trained support staff (research associate or research assistant) must be stationed at Vernon (1.5 FTE) and Dallas/Commerce (1.0 FTE). Support staff must be supervised by respective project leaders at Amarillo and College Station. Sufficient travel support will be needed for off-station trials and field and lab facilities at respective sites, and appropriate equipment will be needed for the small-grains improvement program and related research activities. Timely replacement of the field and lab equipment will be required.

Facilities and Equipment

Adequate facilities and transportation are required for the program, with sufficient financial support for travel requirements. The capital asset management strategy must replace and upgrade field and lab equipment on a timely basis. Modern greenhouse facilities dedicated to the small grains breeding program are a critical need.

Facilities. With the planned move of the Amarillo Center to a new building on the WTAMU campus in Canyon, TX, a modern, small-grains laboratory will need to accommodate traditional breeding programs as well as specialized growth chambers for new lines produced by doubled-haploid, synthetic hexaploid, gene-editing, hybridization, and other advanced techniques.

Research farmland. In February 2017, Texas A&M AgriLife Research closed on the purchase of ~51 formerly leased acres (known as the "Collard Unit") devoted to the wheat-breeding and genetics program at Bushland, TX. The Amarillo Center will need to deliver additional irrigation capacity to the Collard Unit to ensure small-grain germination even under drought conditions. Texas A&M AgriLife Research's research portfolio at Bushland is increasingly vulnerable to real-estate market forces impinging on our four-year lease of the 58.34 acres known as the "Emeny" property. On the assumption that the Emeny lease is not sustainable for the long term in the face of rapid suburban development around Bushland, the need for additional irrigated farmland west or south of Bushland is now critical and requires urgent attention within a development strategy coordinated through the Texas A&M AgriLife Research Associate Director for Operations and Development, the Texas A&M AgriLife development office, and the Texas A&M Foundation. In addition, there is increasing interest in providing backup acreage for small-grain seed increases in the Amarillo/Bushland area.

Farming equipment. The Research and Extension Centers and the small-grains programs in the Soil and Crop Sciences Department have plot equipment for small-grains research and education programs. Recently, a significant reinvestment has been made into the program in the form of new equipment and vehicles. College Station has seen the greatest reinvestment in new equipment and vehicles due to the addition of new faculty in research and Extension. Although scientists have obtained grant funds to pay for operating costs, getting grants for major equipment items is difficult.

Laboratory equipment and instruments. Programs requiring specialized laboratories are located mostly in College Station and include the grain-quality laboratory and the biotech laboratory. The grain-quality laboratory needs more equipment and personnel to serve the

wheat-improvement program with research on grain quality and new products. In the rapidly changing area of molecular biology/genetics, updating equipment and facilities is a critical need. Texas A&M AgriLife Research at Amarillo also has a wheat-genetics laboratory in which DNA research with molecular markers and marker-assisted selection is conducted by a wheat geneticist who is supervising a Research Scientist (an expert in doubled-haploid development) and two additional, grant-supported, full-time employees.

Unmanned aerial systems. Starting in 2017, aided by timely and targeted funding from Texas A&M AgriLife Research administration as well as local, professional-development funds, the Units associated with the small-grains program statewide have invested substantially in capacity building in unmanned aerial systems (UAS). The Amarillo Center now has eleven multi-rotor UAS with visual, multispectral, hyperspectral, and thermal sensors, one fixed-wing UAS with visual and multispectral sensors, and seven FAA-licensed UAS pilots. Enhancing the program-wide UAS fleet with additional sensors (e. g., lidar, thermal/LWIR) and fixed-wing vehicles to cover larger acreages will permit research and validation studies at greater spatial scales, with finer spatial and temporal resolution, and from innovative, scientific perspectives.

College Station

- New greenhouse (breeding program)
- Seed-processing facilities (breeding program)
- Upgrade of the cereal-quality laboratory (cereal-quality program)
- Laboratory for marker-assisted breeding and molecular genetic research (breeding program)
- Wheat field lab facilities (breeding and statewide agronomy program)
- Irrigation facilities for high management, small-grains research

Amarillo

- Wheat genetics research laboratory for marker-assisted selection/breeding (in design for new AgriLife Center in Canyon, TX)
- Large growth chambers for doubled haploid and related breeding-program accelerators (in design for new AgriLife Center in Canyon, TX)
- Small-grains pathology research and Extension laboratory (in design for new AgriLife Center in Canyon, TX)
- Linear-move sprinkler system for wheat nursery and seed increases on the Collard Unit (in negotiations and final design with contractor as of 08 Nov 2024)
- Development, repair, and enhancement of ground water resources at Bushland and Bush Farm (underway)

Commerce

- Equipment storage for research and education activities and research farm

Vernon

- 55-60 acres of additional farmland for TAMFS production of early-generation lines for testing and seed production

Implementation Plan

The small grains research and education program described above will be implemented by the Vice Chancellor and Dean, Agriculture and Life Sciences; the Director, Texas A&M AgriLife Research; and the Director, Texas A&M AgriLife Extension, guided by the Strategic Plan for Small Grains and other recommendations of the Small Grains Advisory Committee.

Equipment Purchase and Replacement

Investigators in small grains have working knowledge of the condition of capital assets in inventory and any additional equipment requirements for their projects. Investigators should be encouraged to seek outside funding for capital assets as they are available. It is the intent of the Small Grains Advisory Committee to coordinate funds available from state initiatives, redirected Texas A&M AgriLife Research, Texas A&M AgriLife Extension and unit funds, and funds from the Texas Wheat Producers Board, as well as monies from royalties, contracts, and grants, as appropriate. The ultimate objective will be to prevent the lack of capital assets from limiting the scope of small-grain research and education programs. The small-grains program and its two Centers of Excellence will be a statewide, multi-disciplinary effort to improve production and profitability of the largest crop in the state. The success of this strategic plan will hinge on the buy-in from the leadership of the departments and units involved. If a truly successful *statewide* program is to be accomplished, it needs statewide coordination by scientists, administrators, and representatives of the wheat industry. The SGAC should serve that function concerning capital asset management, reviewing equipment condition and needs annually, and making recommendations regarding allocation of pooled resources.

Financing

To bring stability and assure adequate resources for the small grains program, there must be continued sources of income, consistent with the program requirements. Full funding for implementing the Statewide Small Grains Strategic Plan as recommended herein will require new resources. Sources of funding should include but are not limited to:

- Reinvigorated pursuit of federal contracts and grants, including both integrated and narrowly focused projects;
- Royalties from wheat varietal development and sales, especially with increased adoption of certified seed;
- Industry including the Texas Wheat Producers Board, with the SGAC serving in a technical review and advisory role;
- Redirected resources within Texas A&M AgriLife Research, Texas A&M AgriLife Extension and/or specific units thereof;
- Partnerships with other institutions or agencies (e. g., WTAMU, USDA-ARS, KSU); and
- Participation in state and federal legislative initiatives.

The distribution of any new state resources that may become available will be most effective if allocated and committed on a 2- to 4-year basis (except large, non-recurrent expenditures such as capital equipment). Funds distribution should be made according to program goals and objectives outlined in this strategic plan. The SGAC should play a central role in the development and allocation of additional resources to assure fulfillment of the strategic plan.

Moreover, because funds will be needed to implement the recommendations in this strategic plan, the prior System policy on royalties should be continued (excluding payments to inventing scientists and OTC; i. e., currently 37.5% of the total allocated by TAMUS-OTC) from licensing small grains varieties. Specifically, the SGAC recommends that Texas A&M AgriLife Research continue its policy of earmarking all royalties received for small grains for use solely by the statewide small-grains program. The SGAC should reevaluate this policy at 5-year intervals to ensure the development and delivery of high-quality, timely programs and products.

Oversight

The Small Grains Advisory Committee (SGAC) annually reviews implementation and functions of the program and submits recommendations to Texas A&M AgriLife administration. The SGAC will meet semi-annually, review new and ongoing issues in small grains, and make additional recommendations to the Vice Chancellor and the Directors of Texas A&M AgriLife Research and Texas A&M AgriLife Extension, as appropriate. The SGAC will modify the Small Grains Strategic Plan as needed to maintain a truly statewide perspective within the small-grains program and to enhance the acquisition and efficient use of resources.

APPENDIX A – HUMAN RESOURCES

APPENDIX B – EQUIPMENT INVENTORY