Rediscover WHEAT™

The official publication of the Kansas Wheat Commission and the Kansas Association of Wheat Growers

2019 ANNUAL REPORT

Wild Wheat Relatives Improve Today's Wheat Varieties

A team of KSU wheat scientists are tapping into 10,000 years of evolution in the plant's genetic code as part of their continued efforts to understand how historic processes that shaped modern wheat can help to improve the varieties grown by today's farmers.

The exhaustive study involved sequencing the genomes of nearly 1,000 wheat lines collected from different parts of the world with different environments.

"We compared the genomes against each other, and looked for nucleotide base changes, or mutations, that distinguish one wheat accession from another," said Eduard Akhunov, a K-State wheat geneticist. He noted that the researchers found more than 7 million differences in the genetic code of the 1,000 lines.

"These differences can affect the function of genes that control various traits in wheat that helped it adapt to new growth conditions, such as withstanding drought and heat stresses; fighting off diseases; and yielding nutritious grain," Akhunov said.

The changes that occurred in the genetic code can tell researchers a history of each wheat accession.

"When humans started spreading wheat from the site of its origin to other places, they brought it into contact with wild wheat, and wild ancestors accidentally began to inter-breed with bread wheat," Akhunov said. "What happened then was that bread wheat inherited the genetic diversity that was present in the wild emmer wheat."

That process of one species sharing genes with another species is called gene flow, and it is key for explaining the genetic diversity of today's wheat varieties, according to K-State wheat breeder Allan Fritz.

"Understanding gene flow between wild emmer and common wheat is more than just academically interesting," Fritz said. "The importance of historical introgression suggests that a more strategic use of wild emmer should have value for future wheat improvement."

Fritz noted that K-State scientists have been using wild emmer in developing germplasm for new wheat varieties in projects funded by the Kansas Wheat Commission and the university's Wheat Genetics Resource Center.

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Wheat Genome Sequenced, Providing a Map for Researchers

Kansas wheat farmers, through the wheat assessment, were the first to invest in the International Wheat Genome Sequencing Consortium in 2005. This consortium, now made up of 2,400 members in 68 countries, accomplished a major breakthrough in the future of wheat research, sequencing the bread wheat genome. The IWGSC achieved this result by combining the resources it generated over the last 13 years using classic physical mapping methods and the most recent DNA sequencing technologies; the sequence data were assembled and ordered along the 21 chromosomes using highly efficient algorithms, and genes were identified with dedicated software programs.

This was long considered an impossible task, due to its enormous size – five times larger than the human genome—and complexity—bread wheat has three sub-genomes and more than 85% of the genome is composed of repeated elements.

In August 2018, KSU scientists, in collaboration with the IWGSC, published a detailed description of the complete genome. This work is paving the way for the production of wheat varieties better adapted to climate challenges, with higher yields, enhanced nutritional quality and improved sustainability.

With the reference genome sequence now completed, breeders have at their fingertips new tools to address global challenges. They will be able to more rapidly identify genes and regulatory elements underlying complex agronomic traits such as yield, grain quality, resistance to fungal diseases and tolerance to physical stress—and produce hardier wheat varieties.

"Completion of the sequence is a landmark event that will serve as a critical foundation for future wheat improvement," said Dr. Allan Fritz, Kansas State University professor and wheat breeder. "It is the key to allowing efficient, real-time integration of relevant genetics, making the selection process more efficient—it's a turbocharger for wheat breeding!"

> **"Having recently completed a map of the wheat genome — timed with the emergence of gene editing technology — means that we could be entering the golden age for wheat research.**
>
> — Aaron Harries, Vice President of Research and Operations

It is expected that the availability of a high-quality reference genome sequence will boost wheat improvement over the next decades, with benefits similar to those observed with maize and rice after their reference sequences were produced.

"Kansas wheat farmers have been supporting the wheat genome sequencing efforts through the Kansas Wheat Commission's wheat assessment since the establishment of the IWGSC in 2005, with a cumulative amount of nearly a quarter of a million dollars," said Justin Gilpin, chief executive officer for Kansas Wheat. "The sequence of the bread wheat genome has already had a positive effect on wheat improvement, which not only affects the science behind wheat breeding, but has a long-lasting positive outcome in regard to wheat producer productivity, profitability and, ultimately, livelihoods."

Eduard Akhunov, KSU professor of plant pathology, works on research that uses CRISPR technology to develop wheat varieties.

Gene-Editing To Improve Yields

Kansas wheat farmers are supporting gene editing research at KSU through the wheat assessment.

KSU has been working with wheat gene editing since 2014, and in August 2018, published findings of a study in which they successfully increased seed size in a cultivar of wheat.

Gene editing is a technology that gives scientists the ability to improve an organism's DNA, essentially by repairing a gene that is producing an undesirable outcome in the organism.

K-State scientists have evaluated the entire wheat genome to identify individual genes that affect such traits as disease resistance, drought tolerance, seed size and more, then use a protein known as CRISPR/Cas9 to introduce changes into a DNA code. CRISPR/Cas9 acts as a sort of molecular 'scissors' to cut out the undesired part of a target gene or introduce new parts with improved properties, according to Eduard Akhunov, K-State professor of wheat genetics and pathology.

"This is our first product that shows that the system works and that we can effectively apply it and affect a trait in wheat in a positive way," said Akhunov.

Wei Wang, a postdoctoral research assistant in Akhunov's lab, spent much of the last four years analyzing and editing genes that could be used to improve future wheat varieties. He said he has a set of 25 to 30 genes that are in the project's pipeline, ready to be implemented in the breeding cycle in the next several years.

"We will be working on a larger set of genes that will affect not only yield component traits, but anything that will be relevant to Kansas wheat growers – drought tolerance, disease resistance, nutritional quality…," Wei said. "There are a large number of genes that we will be considering in the future within the scope of the wheat gene editing platform."

Wheat Breeding Program Provides Benefits to Farmers

The Wheat Breeding program at Kansas State University is about more than just developing new wheat varieties for Kansas. While the release of superior varieties is an end goal of the program, many other aspects benefit Kansas farmers. Many of the wheat varieties that are released, from both public and private entities, have pedigrees from K-State varieties.

A few of these benefits include the ability to develop future wheat breeders, perform long-term research and collaborate with a wider scientific community.

K-State has two wheat breeders: Dr. Allan Fritz runs the Manhattan program and develops hard red winter wheat varieties for eastern and central Kansas, and Dr. Guorong Zhang runs the Hays program and develops hard red winter and hard white varieties for central and western Kansas.

Funding from wheat farmers is used for operation of the program, including staff time to plant and harvest in excess of 20,000 yield plots per year, equipment purchases and upkeep, and travel to plots across the state.

The public breeding program helps to develop the future of wheat breeders for the industry. The program employs graduate students and post-doctoral research assistants, who graduate and go on to work in other public and private breeding programs.

Development of a new wheat variety is a long-term process. It takes about 12 years from the initial greenhouse cross until that new variety is available to farmers. With new technologies available, that development time is decreasing. These new technologies include high throughput phenotyping, genomic selection, doubled haploids, speed breeding and DNA markers.

The recent completion of the sequence of the wheat genome "gives you some tools to really do some novel things. We're really at the front edge of having the tools and knowledge to do some very interesting things and potentially revolutionary things with that kind of technology," said Fritz. "So having these technologies is a part of making sure that we're really providing the advantages for Kansas producers."

Because of the continued long-term investment in the program, breeders are able to work on projects that won't provide a return on investment in the short term. One of these allows them to bring in the diversity of wild relatives of wheat.

While generations of cross-breeding have led to modern varieties with better yields and disease resistances, this has meant that other valuable traits found in wild wheat relatives have been left on the table. Wheat researchers are now on a treasure hunt to find those traits and breed them back into our modern varieties.

"The genetic diversity that we're bringing in will benefit all of the wheat community." Fritz said, "We can take some chances on some things that aren't entirely appropriate for a private breeding program to do, things that wouldn't make sense in terms of revenue projects."

"What's really cool about being a wheat breeder at K-State is that you have all these resources around you to make your program better," said Fritz. "The varieties we're producing are really the product of not just the effort that's in our program, but there's all this other research effort that's going on at K-State as well, that feeds information into that. We're just really fortunate to have that infrastructure behind us. That's a lot of the secret to our success."

Stripe Rust Research

Researchers at USDA in Manhattan, Kansas, are striving to create a wheat variety that's resistant to stripe rust.

Their newly-renovated building has the best modern technology that's available. They can grow wheat year-round in their large growth room equipped with LED lights.

"Being able to grow wheat 365 days a year is a huge benefit to wheat research," said Mary Guttieri, USDA Research Geneticist. The building provides space to benefit all aspects of receiving, growing, processing, characterizing, treating, storing and shipping seeds to cooperating wheat breeding programs. Being able to do all of these projects under one roof is a huge benefit for the wheat research team.

Guttieri can replicate the exact conditions farmers see in the field with the technology available in the research unit. She is partnering with the KSU research team to collaborate.

She said, "I want this place to be the best resource for wheat research in the region."

A big goal for the Hard Winter Wheat Genetics Research Unit is to get the wheat to grow rapidly through young stages to the seed production, producing multiple generations per year, to accelerate development of new wheat germplasm. This breeding effort is tightly coupled with DNA marker selection to ensure that the best plants are advanced in every generation. Together with her colleague, USDA Plant Pathologist Bob Bowden, materials she develops are evaluated in growth chambers and finally, in the field, to confirm disease resistance.

Guttieri said, "In the small amount we have done in field testing, the results are amazing."

Sulfur Boosts Yields, Quality

"In recent years, sulfur deficiency has become a big challenge for wheat production in the southern Great Plains," said Romulo Lollato, a wheat production specialist with K-State Research and Extension.

Lollato said sulfur balances in many agricultural fields are now negative, suggesting that farmers may need to apply sulfur fertilizer at some point, especially in fields with sandier soils and low soil organic matter. He said it's not uncommon early in the spring to be driving by a wheat field that looks bright green, a sign that the crop might be sulfur deficient.

"The reason for the deficiency is that over time there has been a lesser amount of sulfur in the rainfall," Lollato said. "We have less pollution going out in the air, and therefore we have less sulfur coming back to the crop."

A sulfur deficiency not only leads to yield losses, but also ultimately affects the quality of the wheat produced, he said.

Lollato and his colleagues have been studying ways in which growers can add safe amounts of sulfur in conjunction with other nutrients, such as nitrogen. Their early data indicates that when sulfur is extremely deficient in a field, the crop showed no response to nitrogen, which inevitably affects its yield and quality. But when sulfur was present in sufficient amounts, "yield increased, and the crop became responsive to the applied nitrogen," Lollato said.

"We are able to use nitrogen more efficiently when sulfur is available or is added to the plant."

Wheat Quality Research Supported by Grain Craft through KWCRF

Grain Craft, the largest independent flour miller in the nation, has provided a significant donation to the Kansas Wheat Commission Research Foundation (KWCRF) in support of impactful wheat research. The gift will be directed toward ongoing research to improve wheat quality and yield through proper fertility management.

"The team conducting this research includes some of the brightest scientists in the wheat research community," said Aaron Harries, V.P. of Research and Operations for Kansas Wheat. "Depending on the discoveries made, this project has the potential to revolutionize the way farmers grow wheat for added value."

Grain Craft has a longstanding relationship with the Kansas Wheat Commission and Kansas State University. The company has supported each with collaborative partnerships, special funding and data analysis assistance throughout the years. In addition, Grain Craft participates in the internship program which is fielded through the KSU Grain Science department.

fields forward
THE CAMPAIGN for a SUSTAINABLE WHEAT FUTURE
by the Kansas Wheat Commision Research Foundation

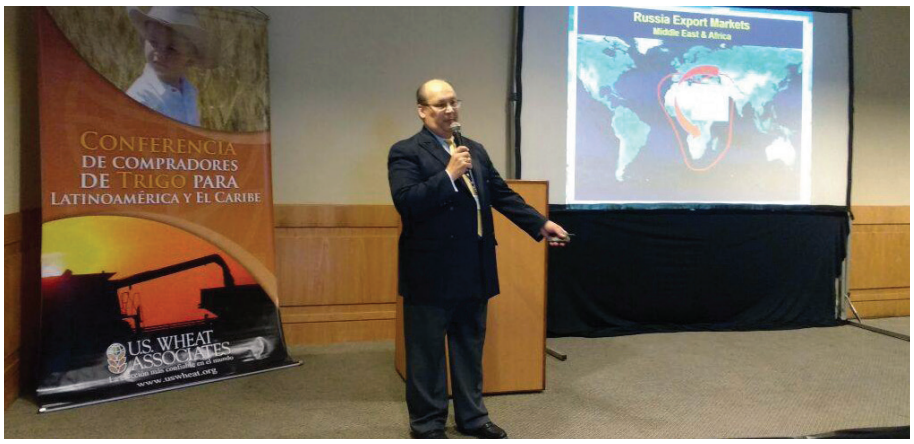
Latin America Increasingly Important Market

The Latin American region of Mexico, Central America and South America imports nearly one billion bushels of wheat annually, with 368 million bushels coming from the United States. Imports from the U.S. are expected to increase to more than 500 million bushels by 2050.

Fostering relationships with this expanding market has been a long-term priority of U.S. Wheat Associates, the export market development organization for the U.S. wheat industry. USW holds a Latin American Buyers Conference every other year.

Attended by 97 participants representing 16 countries, the 2018 conference was held July 18-20 in Brazil, as a way to nurture relationships between U.S. wheat farmers and buyers in the region.

"It's significant that the conference was held in Brazil this year because Brazil is one the world's leading wheat importers," said Kansas Wheat CEO Justin Gilpin.



Participants at the 2018 Latin American and Caribbean Buyers Conference heard from U.S. Wheat Associates President Vince Peterson on "Changing World Wheat Trade Dynamics: Impact on our Business in the Americas."

Brazil Trade Team

Six representatives from the largest flour mills in Brazil visited Kansas in June 2019 to learn more about the wheat crop.

The team visited FGIS where they toured the laboratories and saw the equipment used to determine wheat quality characteristics. They also got the opportunity to meet with grain inspectors and learn how the grain inspection process works, tips and tricks of the trade and how the inspection process impacts their businesses at home. They also toured analytical and quality labs.

After the conclusion of their U.S. wheat industry tour, these executives went back to their mills with a greater understanding and appreciation for the American grain industry, from the field to their mills.

Mexico Is Essential Market

With discussions on trade dominating the public discourse, it is vital for Kansas wheat farmers to preserve a trading partnership with our neighbor to the south. Mexico has become the largest buyer of U.S. wheat in the world. Mexico buys about 106.5 million bushels of wheat from the United States each year, including 55 million bushels of hard red winter (HRW) wheat.

Flour millers in Mexico generate strong demand for U.S. hard red winter wheat, the primary class of wheat grown in Kansas. In MY 2015/16, Mexico surpassed Nigeria and Brazil to become the top market for U.S. HRW.

A rising number of industrial bakeries, along with traditional artisan bakeries, account for about 70 percent of wheat consumption according to CANIMOLT, the association representing Mexican millers. That puts Kansas farmers and other HRW producers in a good position to meet that demand. Being closer to HRW production and having a highly functioning ability to import a large share of HRW directly via rail from the Plains states, is an advantage for Mexico's buyers.

Kansas Wheat CEO Justin Gilpin represented Kansas farmers during a railroad and transportation panel at the Mexico Wheat Trade Conference hosted by U.S. Wheat. Mexico is an important market for Kansas farmers and has imported around 122 million bushels of U.S. wheat (around 5.15 billion loaves of bread) in the last year.

KWC Chairman David Radenberg, Claflin, receives the gavel from Immediate Past Chairman Mike McClellan, Plainville, at the August 2018 board meeting.

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California and Utah Bakers Win National Festival of Breads

Merry Graham of Newhall, California, and RaChelle Hubsmith of North Logan, Utah, were the grand prize winners in the 2019 National Festival of Breads baking competition, sponsored by Red Star Yeast, King Arthur Flour and the Kansas Wheat Commission.

Judges selected Graham's Blackberry Ginger Speculaas Danish Wreath from among four finalist recipes in the Food Blogger Division and Hubsmith's Chai Ube Rosette Rolls among the four finalists in the Home Baker Division. All eight finalists baked their recipes at the public competition on June 8 in Manhattan. They also participated in a wheat industry tour, visiting a wheat farm, flour mill and the Kansas Wheat Innovation Center.

The champions and all eight finalists' recipes are available at http://nationalfestivalofbreads.com.

Farmers Visit Cuba, Discuss Future

Delegates from the U.S. agriculture industry were in Cuba for the Cuba-U.S. Agriculture Business Conference. The conference brought about much interest from the Cuban Ministry of Agriculture, Ministry of Foreign Affairs and the Cuban media.

Representing the soybean, corn, wheat, poultry, potato, rice, sorghum and barley industries, the 20 conference participants met with Cuban government officials and farmers on November 8-10, 2018.

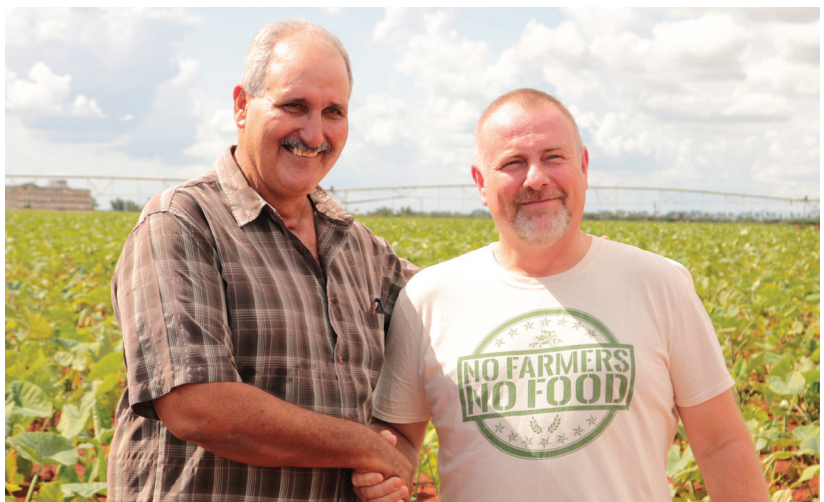
While about 30% of Cuba's 42,000 square miles of land area is currently used for farming, Cuban farmers do not have access to the latest technologies, equipment and inputs to reach their yield potential. The majority of the food production in Cuba is done through farmer-owned cooperatives, but it's not sufficient. Due to the climate, there is no wheat grown commercially. In fact, much of the food for Cuba's 11 million people and 4 million annual tourists must be imported, including an estimated 30 million bushels of wheat, which comes primarily from the EU and Canada.

According to Alejandro Mustelier Zamora, chairman and CEO of Alimport, Cuba's food importing enterprise, "When buying grains from Argentina, it takes a long time to get here and affects the quality of the food we import." Rice imported from Japan can take up to five months to arrive.

There are many advantages of importing food from the United States, most notably the proximity in terms of getting high quality food in a timely and freight-efficient manner.

After hearing from Cuban government officials, participants had the opportunity to visit a farmer's market in Havana and tour two farmer cooperatives.

At the wrap-up meeting, Ambassador Juan Jose Leon Vega told the group, "Farmers in the U.S. and Cuba can have better relationships. There is a strong distinction in Cuba between the American government and the American people. We want people to be able to do business together."



Kansas wheat farmer Doug Keesling (right) is pictured with a Cuban farmer in a field of tarot root.

Subsaharan Africa Trade Team

A group of representatives from food companies and flour mills around Sub-Saharan Africa (South Africa and Nigeria) was in Kansas June 15-19, 2019, to meet with wheat producers, discuss the current quality aspects of U.S. wheat and to learn about new wheat varieties.

The trade team was organized by U.S. Wheat Associates, the industry's market development organization, and while in the state they were guests of the Kansas Wheat Commission. While the trade team was stateside they were able to meet with various grain traders and grain/wheat export companies and hear updates on the global grain trade, global supply and demand and estimates on price movements. Team members included representatives from Seaboard, Honeywell Flour Mills, Dufil Flour Mills, Flour Mills of Nigeria and RCL Foods in South Africa. The companies represented on the trade team mark some of the largest wheat purchasers in the region.

Wheat Foods Council Shares Nutrition Information with Personal Trainers

Wheat has become an easy punching bag for fad diets and those who profit from them, but the Wheat Foods Council has adopted a strategic plan to help inform consumers about the merits of wheat foods by influencing the influencers and telling the story of wheat.

WFC's initiatives focus on building and maintaining relationships with dietitians and personal trainers, as well as improving the images of enriched wheat products and modern breeding and farming practices.

Research found that many personal trainers had little to no nutrition education, but were actively giving out dietary advice. The WFC has found that this is information those professionals desperately want, and we are among the first to actively reach out and provide it. This is an amazing opportunity for the wheat industry to help shape the discussion surrounding our product with these influencers.

Kansas Wheat Commission
Results of Operations & Cash Roll Forward*
July 1, 2018 to June 30, 2019

Cash at July 1, 2018		$3,740,011
Wheat assessment collected	$5,062,008	
Building related income	402,830	
Other income	192,025	
Sponsorship income	76,215	
Interest income	30,512	
Refunds of wheat assessments	(325,804)	
International marketing	(1,509,062)	
Research	(1,477,611)	
Administration	(434,107)	
Domestic marketing	(1,291,018)	
Public issues	(243,238)	
Net cash effect of operations		$482,750
Cash at June 30, 2019		$4,222,761

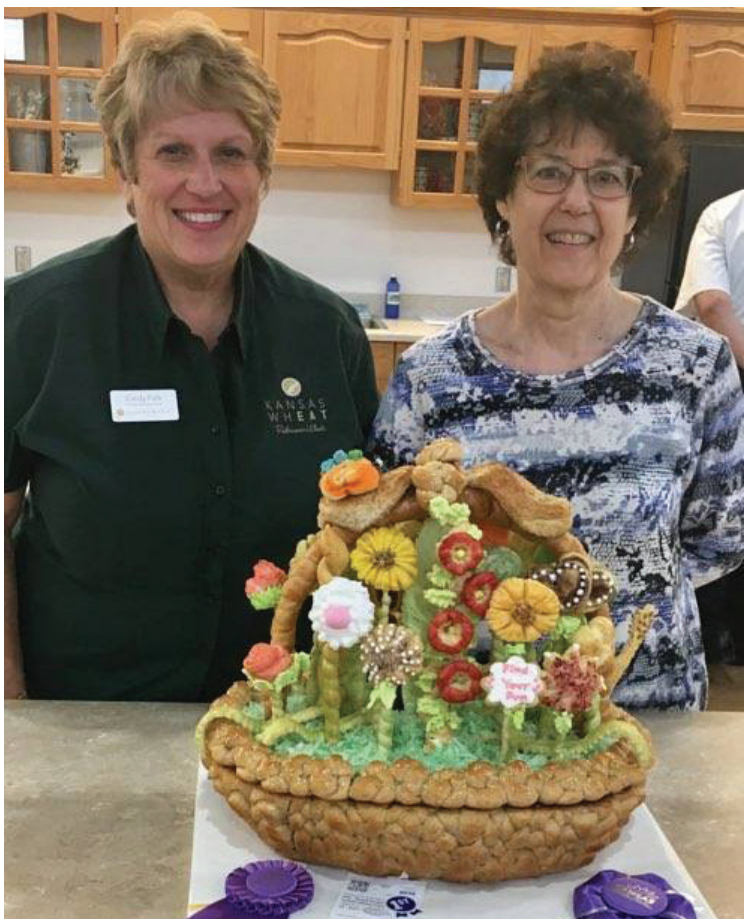
This financial statement is an unaudited document.

Income received each year by the Kansas Wheat Commission depends upon the size of the state's wheat crop. In 2018, farmers produced 277.4 million bushels of wheat, down 17% from 333.6 million bushels in 2017.

The Commission collected about $5.1 million from the voluntary Wheat Assessment, and refunded $325,804. Each year, the budget is subject to approval by the farmer-elected board of the Kansas Wheat Commission.

In FY 2012, the KWC began construction of the Kansas Wheat Innovation Center, a major investment that has helped shape a bright future for wheat production in Kansas.

Bread Sculpting Champ



Wilma Olds from Wilson, Kan., was the champion of the first Kansas State Fair bread sculpting contest. Her braided basket with a variety of flowers, wheat and butterflies was well executed. It won all the points for design and visual impact. Creativity, color design and well-written instructions took it to the top. Olds (right) is pictured with Cindy Falk, Kansas Wheat nutrition educator.

Wheat buyers from Morocco and Tunisia toured the Kansas Wheat Innovation Center in April.

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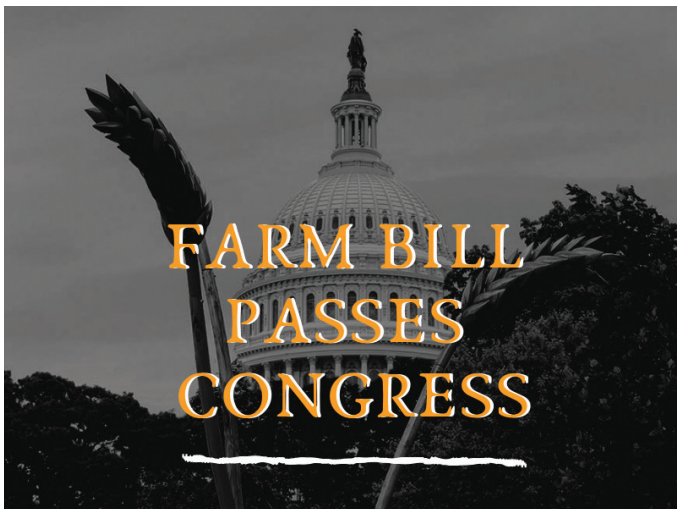
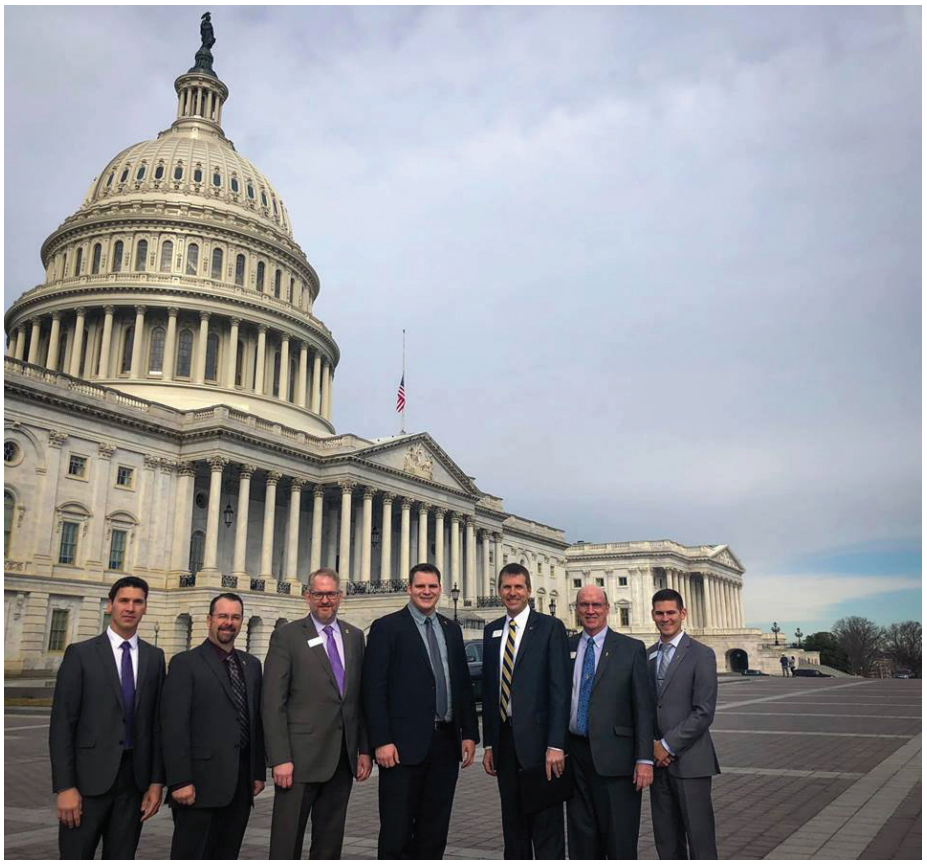
2018 Farm Bill Signed into Law



On December 20, 2018, President Trump officially signed The Agriculture Improvement Act of 2018, commonly known as the Farm Bill, into law. The signing ceremony was held in the Eisenhower Executive Office Building at the White House. NAWG President and Sentinel, OK wheat farmer Jimmie Musick was invited to attend the official signing of the bill and made the following statement: "Today marked a historic event not only for wheat growers but all of American agriculture. The 2018 Farm Bill provides farmers with the certainty and stability they need to continue producing a safe and nutritious food supply, while using fewer resources, and maintaining healthy soil for their crop. NAWG would like to thank the Senate and House Agriculture Committee Members and their staff for their hard work, time, and patience they put into getting a bill finalized and to the President's desk for signature. We are looking forward to working with the U.S. Department of Agriculture and the 116th Congress in 2019 to implement this bill."



The Kansas Association of Wheat Growers (and friends) spent a few days in February talking wheat on the Hill. Pictured left to right: Shawn Thiele (IGP Institute), Chris Tanner (KAWG Secretary/ Treasurer), Aaron Harries (Kansas Wheat VP of Research and Operations), Taylor Williamson (Kansas Wheat Director of Governmental Affairs), Justin Knopf (KAWG President, Gypsum), Ken Wood (KAWG Past President, Chapman) and Kyler Millershaski (KAWG VP).