Partners in Progress
WHEAT

Wheat Research at OSU 2011

Supported by the

Oklahoma Wheat Commission

and the

Oklahoma Wheat Research Foundation

Oklahoma State University
Division of Agricultural Sciences and Natural Resources
Oklahoma Agricultural Experiment Station
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P-1033

OKLAHOMA STATE UNIVERSITY

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Partnerships Enhance Wheat Research

Partners in Progress – Our long-standing partnership with the Oklahoma Wheat Commission (OWC)and the Oklahoma Wheat Research Foundation (OWRF) is a valuable asset for Oklahoma State University's wheat research and Extension programs. The partnership not only provides partial funding for our research programs, but it also provides valuable input from producers that help to keep our research programs focused and relevant. It is truly one of the best examples of the Division of Agricultural Sciences and Natural Resources working in a cooperative relationship with commodity groups to achieve common goals. Partial funding for our research and Extension programs comes from wheat producers through the check-off program. We have been and continue to be accountable for the use of these funds.

The *Partners in Progress Wheat Research Report* is one of a series of annual reports from DASNR highlighting research results and impacts of funded projects. This information is utilized throughout the year in educational wheat programs and is distributed to Oklahoma wheat producers to keep them up-to-date on the latest research findings. The research contained in this report has been directed as closely as possible to meet the needs of Oklahoma wheat producers.

At the beginning of each section is a summary of accomplishments for fiscal year 2010-2011. The narrative that follows explains in more detail the progress made during the year.

The long-term continuous support of our wheat research programs from the OWC and the OWRF has allowed our faculty to make significant progress toward the common goal of keeping Oklahoma wheat farmers competitive in regional, national and international markets. This support makes us truly *Partners in Progress*.

Clarence Watson, Associate Director
Oklahoma Agricultural Experiment Station
Division of Agricultural Sciences and Natural Resources
Oklahoma State University

Oklahoma State University
Division of Agricultural Sciences and Natural Resources
Mission Statement

The Mission of the Oklahoma State University Division of Agricultural Sciences and Natural Resources is to discover, develop, disseminate and preserve knowledge needed to enhance the productivity, profitability and sustainability of agriculture; conserve and improve natural resources; improve the health and well-being of all segments of our society; and to instill in its students the intellectual curiosity, discernment, knowledge and skills needed for their individual development and contribution to society.

A Glass Half Full – Much Better Than a Glass Half Empty

Partners in Progress WHEAT

Many years ago two, tennis shoe salesmen were sent from America to investigate market potential in a foreign market. The first salesman reported back, "There is no potential here-nobody wears shoes." The second salesman reported back, "There is massive potential here-nobody wears shoes." The above simple story provides one of the best examples of how a particular situation can be visualized in two entirely different perspectives – negative or positive. It can be described using another similar example of how an optimist sees a glass half full of water, and a pessimist sees it as half empty.

When looking at the glass of the Wheat Improvement Team (WIT) at Oklahoma State University (OSU) it is safe to say the glass is more than half full. This past year we have seen more wheat producers planting varieties that have been released from OSU. Progress being made on newer varieties that will soon be in the marketplace for farmers will allow Oklahoma wheat producers to keep their competitive edge.

Drought tolerant and nitrogen efficiency genes continue to be important, especially in years like this one. The producer dollars invested into Oklahoma Wheat Commission (OWC) check-off continues to fund the important research that allows the creation of such wheat varieties that have these characteristics. This year we are proud to say we have seen yet another increase of wheat varieties released from OSU that are planted on Texas, Oklahoma and Kansas acres. USDA/NASS reported this past year that in Oklahoma mora than 45 percent of varieties planted in our state were variety releases from OSU.

No doubt! When looking at the number above, one can tell we are fortunate to have great leadership on the WIT at OSU's Division of Agricultural Sciences and Natural Resources (DASNR). We continue to move forward creating wheat varieties for producer benefit while also focusing on the end game with varieties that have good milling and baking characteristics.

As with anything, in order to have a good product in the end, we must remember it is important to start with good quality in the beginning. We encourage soil testing that is made available through your local county Extension office. We also encourage producers to look at the importance of nitrogen applications for increased protein levels.

The percent of protein in flour is important to buyers because it helps create higher gluten levels. Gluten gives a framework to a baked good by swelling as it absorbs water, some flour types absorb faster than others. A higher protein flour absorbs more moisture than a lower protein flour. Bakers have blamed the difference in absorption on humidity, which only makes a minute difference; however, it is a flour's protein level that directly affects the ratio of wet ingredients to dry. Higher protein flours also create stronger products that have firmer rising characteristics, which allow for better consistencies on baking flours.

The OWC along with the OSU WIT and OSU's DASNR continue to work on items that are beneficial not only for our producers but our foreign and domestic customers. It is safe to say that as we move forward our glass is more than half full. As an industry we are optimists working together by being *Partners in Progress*.

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Partners in Progress WHEAT

Genetic Improvement and Varietal Release of Hard Winter Wheat

Wheat Improvement Team

2010-2011 progress made possible through OWRF/OWC support

- **Published variety trial data to web within a few days of harvest of each location. Website was accessed 7,700 times during harvest.**
- **Delivered wheat yield and phenology data through the 2011 Wheat Seed Book to more than 8,000 *High Plains Journal* subscribers in Oklahoma. The Oklahoma Wheat Commission (OWC) was recognized as a funding agency on the cover of this publication.**
- **Provided 13 wheat disease updates to wheat growers, consultants, Extension educators and researchers in electronic format.**
- **Generated disease reaction ratings for nearly 1,400 experimental lines from the Great Plains to the wheat soilborne mosaic virus (WSBMV)/wheat spindle streak mosaic virus (WSSMV) complex. A subset of 435 advanced lines from Oklahoma also was tested in the lab using ELISA to specifically test for resistance to WSBMV, WSSMV or both by detecting virus presence. This ongoing screening process ensures a frequency of WSBMV/WSSMV resistance in OSU elite lines exceeding 90 percent.**
- **Determined the seedling reaction of Oklahoma experimental lines to foliar diseases including leaf rust (324 lines), tan spot (262 lines), septoria (262 lines) and powdery mildew (67 lines).**
- **Expanded efforts to evaluate the reaction of adult plants in the field to powdery mildew (PM) and barley yellow dwarf virus (BYDV).**
- **Documented subeconomic populations of Hessian flies in the major wheat growing regions of Oklahoma.**
- **Demonstrated that OSU elite experimental lines and available cultivars that have resistance to natural Hessian fly populations had lower fly infestations than most susceptible entries.**
- **Found that Jagger has the *Yr17* gene that was transferred from chromosome 2N of *Triticum ventricosum*, previously not detected since Jagger's release almost 15 years ago. This discovery also led to disproof of Jagger's published pedigree.**
- **Mapped *Lr34-A* and *Lr34-B*, which are the homoeologous genes for the critical gene *Lr34-D*, and developed new markers for those genes.**
- **Modified the markers for Lr34E11 and Lr34E12 to provide unambiguous haplotyping of *Lr34-D*.**
- **Determined genotypes of OSU experimental lines and cultivars using gene markers for a triplicate set of loci governing reproductive development, and gene markers for resistance to leaf rust, stripe rust and PM.**
- **Supplied results to the USDA-APHIS-PPQ from 53 wheat samples in 14 counties indicating no detectable levels of Karnal bunt in wheat produced in Oklahoma. This data was used to obtain a phytosanitary certificate allowing Oklahoma wheat to move without restriction into the export market.**

- **Identified two candidate cultivars worthy of continued foundation seed production and potential release in 2012, pending final data analysis and quality testing:**

  OK07209, *Duster/OK99621*

  OK07214, *Duster/OK99711*

- **Placed or continued 11 candidate cultivars under preliminary seed increase or large-scale seed increase by Oklahoma Foundation Seed Stocks, Inc., five of which are on an accelerated track.**
- **Leveraged financial support of OWRF/OWC with funding from either USDA-ARS or Oklahoma Genetics, Inc. to develop experimental materials with resistance to the Ug99 stem rust race, and to develop novel doubled haploid lines featuring stacked traits for insect and disease resistance.**
- **OSU-bred varieties Endurance and Duster are now the top two planted wheat varieties in Oklahoma.**

Oklahoma's Wheat Improvement Team (WIT) is committed to discovering genetic solutions and creating greater economic opportunities for Oklahoma's wheat producers. Eight OSU faculty form an integrated team that combines fundamental and applied components of wheat research to achieve a common goal – that is, to move the entire chain of Oklahoma's wheat industry forward with the infusion of new, improved cultivars. Just as important as the cultivars themselves is the know-how that maximizes their genetic potential. Hence this team places utmost value on the proper match between genetics and the management environment.

Scientists on the WIT are **Jeff Edwards**, information exchange and systems research; **Bob Hunger** and **Art Klatt**, wheat pathology research and development of disease-resistant germplasm; **Kris Giles** and **Tom Royer**, evaluation of Hessian fly diversity and resistance; **Liuling Yan**, QTL discovery and genomic technology; **Patricia Rayas-Duarte**, cereal chemistry; and **Brett Carver**, wheat breeding and variety development.

The 2010-2011 crop season was bumpy and dry, but through it all, the WIT came away with information on stress tolerance and disease resistance previously not obtainable. In this report, you can read more about these and other significant highlights, such as the discovery of tan spot and septoria resistance; much improved understanding of the type of stripe rust resistance prevalent in Great Plains wheat germplasm; the rolling out of doubled haploid experimental lines with targeted trait combinations beneficial to Oklahoma; the economic value provided by Duster in 2011 through displacement of varieties with inferior yield performance; and the next generation of Duster progeny to hit foundation seed fields.

Information Exchange and Systems Research

Jeff Edwards
Plant and Soil Sciences

The information exchange component of the WIT prioritized timely information delivery and on-farm field assessment of advanced experimental lines in 2011. Wheat variety trial results were posted on the small grains Extension website (www.wheat.okstate.edu) within a few days of harvest, which allowed producers in each region to access data quickly. Farmers were notified of new data postings via email and Twitter feed, and variety trial data were accessed 3,400 times during June and July 2011 with 7,700 individual page views. The print version of the small grains variety performance tests was published in early July and distributed to more than 8,000 *High Plains Journal* subscribers in Oklahoma.

Variety characteristic and suitability data published as part of our information exchange efforts have helped producers reduce inputs and increase grain yield. The disease and Hessian-fly resistant cultivar Duster, for example, displaced older cultivars on an additional 8 percent of Oklahoma wheat acres in 2011 and provided a 5 bu/A yield increase over Jagger in statewide trials. This yield advantage is less than previous years but quite remarkable considering the extreme drought stress of 2011. The yield advantage offered by Duster equates to roughly 2 million bushels of wheat statewide with a current market value of approximately $16 million. This is just one example of the success of OSU wheat varieties that were developed and marketed through the WIT. In fact, OSU wheat cultivars occupied 45 percent of planted acres in Oklahoma in 2011, which is a 28 percent increase in adoption of OSU wheat cultivars in a six-year time frame.

Table 1. Performance of two candidate cultivars in the 2010-2011 wheat variety trials.

Variety	*Forage Yield*	*Grain Yield*
	-----lbs/A-----	-----bu/A-----
OK07209	**3,120**	**41**
OK07214	**-**	**39**
Duster	2,820	39
Endurance	2,830	35
Fuller	2,690	36
Armour	2,750	35
Jackpot	3,040	32

In addition to data on released cultivars, we provided phenological, morphological and yield performance data on experimental lines that are candidates for release. Candidate cultivars OK07209 and OK07214 were both tested at eight small grains variety performance sites in 2010-2011. As shown in Table 1, these candidate cultivars offer considerable yield improvement over some of the most popular public and privately-released cultivars in Oklahoma. In addition to grain yield, the candidate cultivar OK07209 produced forage yield greater than Duster and Endurance, which puts it in an elite category. We did not determine forage yield of OK07214 in 2011 but have it in our 2012 forage yield plots. Both of these experimental lines show great promise.

Wheat Pathology Research and Development of Disease-Resistant Germplasm

Bob Hunger
Entomology and Plant Pathology

A linchpin in developing improved OSU wheat varieties is the annual evaluation of several disease reactions, including the WSBMV/WSSMV complex, leaf rust, powdery mildew, tan spot and septoria. Table 2 summarizes the history of this selection component since the 1982-1983 growing season. This information indicates that evaluation of reaction to the WSBMV/WSSMV complex and leaf rust has always been a high priority in the program. Since the 1980s, evaluation of reaction to other diseases such as PM, tan spot, septoria and BYDV has risen in priority as indicated by the expanded testing efforts. Other diseases such as Fusarium head blight (scab) and stripe rust also have received attention and will continue to be emphasized and expanded in the future.

Disease assays can be conducted in the greenhouse/growth chamber (GH/GC), the field or both. During the past several years, funds from the Oklahoma Wheat Research Foundation (OWRF) have been used to expand evaluation efforts to determine reaction to tan spot and septoria through extensive seedling assays in the GH/GC. Such efforts have resulted in more reliable testing for reaction to tan spot and septoria as reported last year. During 2010-2011, effort was made to expand the evaluation of breeding lines for reaction to PM and BYDV in the field. A GH/GC test for PM currently is used to evaluate seedling reaction. A field assay for PM in which susceptible spreader rows are inoculated with PM will complement the GH/GC evaluation, resulting in more complete and reliable ratings of lines being developed for Oklahoma. Prior to this year, ratings for reaction to BYDV have relied on natural occurrence of this disease in the field. Natural infection still will be essential, but several practices were followed to enhance natural infection. This included 1) planting the nursery early (Sept. 21, 2011), 2) planting near grassy terraces to potentially enhance natural infection with aphids and 3) planting experimental lines between susceptible spreader rows to enhance aphid infestation.

Finally, funds provided by the OWC supported the testing of the 2011 Oklahoma wheat crop for the

Table 2. Initial date of testing OSU experimental lines for reaction to specific diseases, and number of entries rated since the beginning of testing.

Testing location	*SB/SS**	*LR**	*PM**	*TS**	*SEP**	*BYDV**
GH/GC*	1983	1983	2000	2003	2004	----
Field	1983	1983	2011	----	----	2011
Approximate number of lines rated since starting date: GH/GC	500	20,000	2,000	1,000	1,000	125
Field	25,000	3,000	500	0	0	125

*SB/SS=wheat soilborne mosaic/wheat spindle streak mosaic virus; LR=leaf rust; PM=powdery mildew; TS=tan spot; SEP=septoria leaf blotch; BYDV=barley yellow dwarf virus; GH/GC=greenhouse/growth chamber.

presence of Karnal bunt. Results from this testing were used to certify that Oklahoma wheat was produced in areas not known to be infested with Karnal bunt, which allowed Oklahoma wheat to move freely into the export market.

Evaluation of Hessian Fly Diversity and Resistance

Kris Giles and Tom Royer
Entomology and Plant Pathology

Similar to previous growing seasons, we conducted field experiments during the 2010-2011 growing season in two parts: 1) continual survey of natural Hessian fly populations in Oklahoma and 2) field assessment of resistance that is resident to the OSU wheat improvement program. During the growing season, we collected Hessian fly pupae from the major wheat growing areas in Oklahoma. Similar to 2009-2010, population densities were very low in fields that historically had extremely high densities. Rainfall is essential for emergence of adult Hessian flies and subsequent egg laying, and the persistent drought was partially responsible for low densities statewide. However, we also believe that a proactive approach to managing Hessian fly has contributed to a regional population decline. In areas with previously high populations of flies, producers shifted to planting resistant cultivars (especially Duster and Centerfield) and populations have steadily declined over the past five years. Biotyping data continues to indicate that biotype GP is the most common in Oklahoma.

In replicated studies, we evaluated the reaction of OSU experimental lines (and other selected entries) to natural fly populations near Blackwell and Apache, Okla. In Blackwell, plots were established in very moist soil, which contributed to relatively high yields, whereas in Apache, low soil moisture throughout the growing season contributed to very low yields (Table 3). The natural fly infestations near Blackwell and Apache were lower than any year we have evaluated elite line entries. The highest fly intensity observed at Blackwell was only one-third the economic injury level of 1 fly per tiller. Because of low populations, it was not possible to differentiate the impact of Hessian fly resistance from other yield-influencing factors on final grain yield. However, Duster (Hessian fly resistant) continues to yield highly, even when fly populations were low and the wheat was moisture stressed.

Oklahoma wheat producers have high yielding resistance options for Hessian fly, and future breeding efforts look promising. We are interested in monitoring future Hessian fly infestations on promising candidate lines that are either susceptible or demonstrate some level of resistance. Because effective evaluation of candidate lines may require higher fly populations, we will isolate local nurseries from major production areas. Although regional fly populations are currently low, we recommend a continued proactive approach to managing Hessian fly through rotation of locally adapted cultivars that periodically provide some level of protection against fly buildup.

Table 3. Hessian fly infestations and grain yield in decreasing yield order for the 2010-2011 Oklahoma Elite Trial.

Blackwell Plots			*Apache Plots*		
Entry	*Hf/tiller*	*bu /A*	*Entry*	*Hf/tiller*	*bu /A*
Greer	0.14	82.5	Greer	0.05	44.0
OK07214	0.02	81.9	OK08539	0.08	37.9
Duster	0.00	79.3	Garrison	0.11	35.4
Billings	0.07	77.5	OK08328	0.00	32.8
OK08413	0.02	76.6	Duster	0.01	30.4
OK06336	0.01	74.7	Endurance	0.12	29.9
OK08229	0.00	73.1	OK08127	0.11	29.4
OK08826W	0.06	72.3	OK08229	0.00	29.3
OK07231	0.01	72.3	OK08413	0.00	28.5
OK07216	0.00	71.5	Ruby Lee	0.01	28.1
OK08328	0.00	71.1	Armour	0.09	27.9
OK06617-RHf	0.01	70.0	OK06617-RHf	0.00	27.5
Ruby Lee	0.00	69.9	OK07231	0.02	27.4
OK07209	0.19	68.1	Billings	0.17	26.9
OK08306	0.01	66.3	OK08306	0.03	26.3
Garrison	0.23	65.0	OK08214	0.00	25.9
OK05511-RHf2	0.01	64.9	OK07226	0.04	25.7
OK07226	0.11	64.4	OK08707W	0.03	25.2
Armour	0.09	64.2	OK07216	0.01	25.1
OK08539	0.03	63.2	Chisholm	0.03	24.1
OK08127	0.01	62.4	Everest	0.00	24.0
Endurance	0.10	62.2	OK07214	0.00	23.7
OK07820W	0.03	60.9	OK07418	0.00	22.7
Chisholm	0.01	60.7	OK07209	0.05	22.5
OCW00S063S-1B	0.12	60.5	OK07820W	0.04	21.9
OK08214	0.16	60.3	OCW00S063S-1B	0.04	21.8
Everest	0.02	60.2	OK05312	0.07	21.1
OK07418	0.02	59.8	OK05511-RHf2	0.01	20.8
OK08707W	0.03	59.7	OK08826W	0.01	19.7
OK07218	0.12	58.6	OK07218	0.04	18.4
OK05312	0.32	56.7	OK06336	0.03	17.2
OK07S117	0.02	45.0	OK07S117	0.00	17.0

QTL Discovery and Genomic Technology

Liuling Yan
Plant and Soil Sciences

Stripe rust is one of the most common and persistent wheat diseases worldwide. With continuous evolution of the pathogen, new resistance genes are needed to defend against newly mutated races. We found that a major quantitative trait locus for stripe rust resistance was located on the short arm of chromosome 2A (*QYr.osu-2A*) in a population of recombinant inbred lines (RILs) generated from a cross between Jagger and 2174, two prominent winter wheat cultivars in the southern Great Plains. We mapped the genetic and physical location of this locus after testing the population in Washington, Kansas and China for two years. *QYr.osu-2A* accounted for 36 percent to 85 percent of the total variation in relative area under the disease progress curve value, which is indicative of its broad-spectrum protection against multiple races of stripe rust. Jagger contains a resistant allele at *QYr.osu-2A*, whereas 2174 contains a susceptible allele.

Surprisingly, we also showed Jagger to contain the resistance gene *Yr17* from*Triticum ventricosum*, a distant relative of bread wheat. Diagnostic markers for*Yr17*, also on chromosome 2A, were found to occur frequently in cultivars from the southern Great Plains but only occasionally in cultivars from other U.S. wheat regions, demonstrating that wheat breeders in this region have indirectly incorporated this gene into local wheat cultivars (Table 4). Using molecular markers for a genomic fragment specific to *Triticum ventricosum*, we also proved that the long-reported pedigree of Jagger was incorrect.

Table 4. Allele identity of *Yr17* in common hard winter wheat cultivars.

Yr17 allele	Cultivar
Resistant	Jagger, Cutter, Danby, Doans, Fuller, Jagalene, Jagger, Neosho, OK Bullet, Overley, Protection, Santa Fe, Shocker
Susceptible	Above, Centerfield, Custer, Deliver, Duster, Endurance, Fannin, Guymon, Hatcher, Intrada, JEI 110, Lakin, Okfield, Ok102, Ripper, TAM 110, TAM 111, TAM 112, Trego

In other research, a DNA-sequence approach was used to determine if similar resistance genes serve the same function. Bread wheat (*Triticum aestivum* L.) is an allopolyploid species and contains one pair each of three homoeologous genomes ($2n=6x=42$, BBAADD). Thus, when one homoeologous gene from one of the genomes is cloned, it is expected that the other homoeologous genes located in the other genomes can be readily isolated by DNA amplification and their function characterized. A successful example is that homoeologous genes *VRN-A1*, *VRN-B1* and *VRN-D1* were previously found to play a similar role in the vernalization pathway.

This background information is especially pertinent to a key leaf rust resistance gene, *Lr34*, discovered with OWRF/OWC funding to occur in OSU germplasm. The original gene resides in genome D, and thus it also can be called *Lr34-D*. Bread wheat should have two additional homoeologous genes, *Lr34-A* on genome A and *Lr34-B* on genome B.

We have obtained sequences of 6,616 base pairs (bp) for a partial *Lr34-A* gene and 12,063 bp for the complete *Lr34-B* gene. We have mapped the two homoeologous genes in RILs of the Jagger x 2174 population.

Lr34-A was mapped in the homoeologous region of chromosome 7A, whereas *Lr34-B* was mapped on chromosome 4A in the region that was translocated from homoeologous 7B. We found no difference in reaction to leaf rust between two alleles of *Lr34-A* or *Lr34-B*, and furthermore, we concluded that Jagger and 2174 have the same allele at *Lr34-A* or *Lr34-B*. The discovered sequences of *Lr34-A* and *Lr34-B* have allowed us to design more specific primers for *Lr34-D* (the relevant gene for actual leaf rust reaction). We have subsequently modified the reported markers for Lr34E11 and Lr34E12, which constitute two of three critical polymorphic sites at exons 11 and 12 of the *Lr34* gene. With this research, we can now produce a more accurate haplotype, whereby the marker data for Lr34E11 and Lr34E12 of *Lr34-D* are not confounded by *Lr34-A* or *Lr34-B*. Before this research, we were often frustrated by the occasional lack of a clean haplotype for *Lr34* that prevented unambiguous confirmation of the presence or absence or *Lr34* in OSU experimental materials.

Sequence data for the three homoeologous *Lr34* genes also will help us develop polymerase chain reaction (PCR) markers to investigate genetic effects of these genes in other populations, such as the Duster x Billings doubled haploid population discussed later in this report.

Cereal Chemistry

Patricia Rayas-Duarte
Biochemistry and Molecular Biology

Forming about 80 percent of the flour protein, gluten proteins are the biochemical compounds mostly responsible for processing performance of flours and for the quality of baked yeasted breads. The extraordinary beauty of gluten protein lies in the 3-D structure formed once water and energy are applied. The complexity of gluten is like a 1,000-piece jigsaw puzzle, but in 3-D. It is not completely solved at the present time, but we are working on a part of the puzzle that helps us to visualize gluten behavior when gluten is deformed.

Gluten is a protein polymer that behaves like soft foam with deformability and spring-back properties. When gluten is deformed it flows (reflecting viscosity), and when deformation terminates it springs back (elastic recovery). These properties are highly descriptive of gluten quality and can be predictive of processing characteristics. We compared these gluten properties of local cultivars and OSU experimental lines, along with their protein quantity. The combination of gluten spring back as recoverability (RCY), flow as viscosity (J-Jr), and flour protein content was represented graphically in two dimensions, explaining 87 percent of the variance among 44 wheat samples grown in three breeding nurseries in 2010 (Figure 1). The horizontal dimension primarily represented spring back, or recovery, and deformation, or viscosity, both which indicate protein quality. This dimension accounted for 53 percent of the variance in this set of samples. In contrast, the vertical dimension, which primarily represented protein quantity, explained 33 percent of the variance. So these samples differed more in protein quality than in protein quantity.

We can identify groups of samples most reflective of gluten spring back or those most reflective of gluten viscosity in Figure 1. We also can identify the group of samples closely related to protein quantity that also was independent of quality. In other words, this latter group of samples can be more easily separated by their protein content but not by their quality. The samples highly associated with deformation of gluten were OK08229, OK05212 (Garrison) and OK05312. This means these samples were more easily deformable. The top six samples highly associated with spring back of gluten were OK08707W, OK08328, OK07216, Endurance, OK07218 and OK05511. These lines would be expected to contain high molecular weight glutenin subunits that lend a dough sponge spring-back capability important in the baking process.

The information reported here complements other indicators of wheat quality and implies the contribution of specific types of glutenin subunits. This research provides innovative approaches to quality assessment previously unavailable in the OSU wheat improvement program. We are integrating this information with another

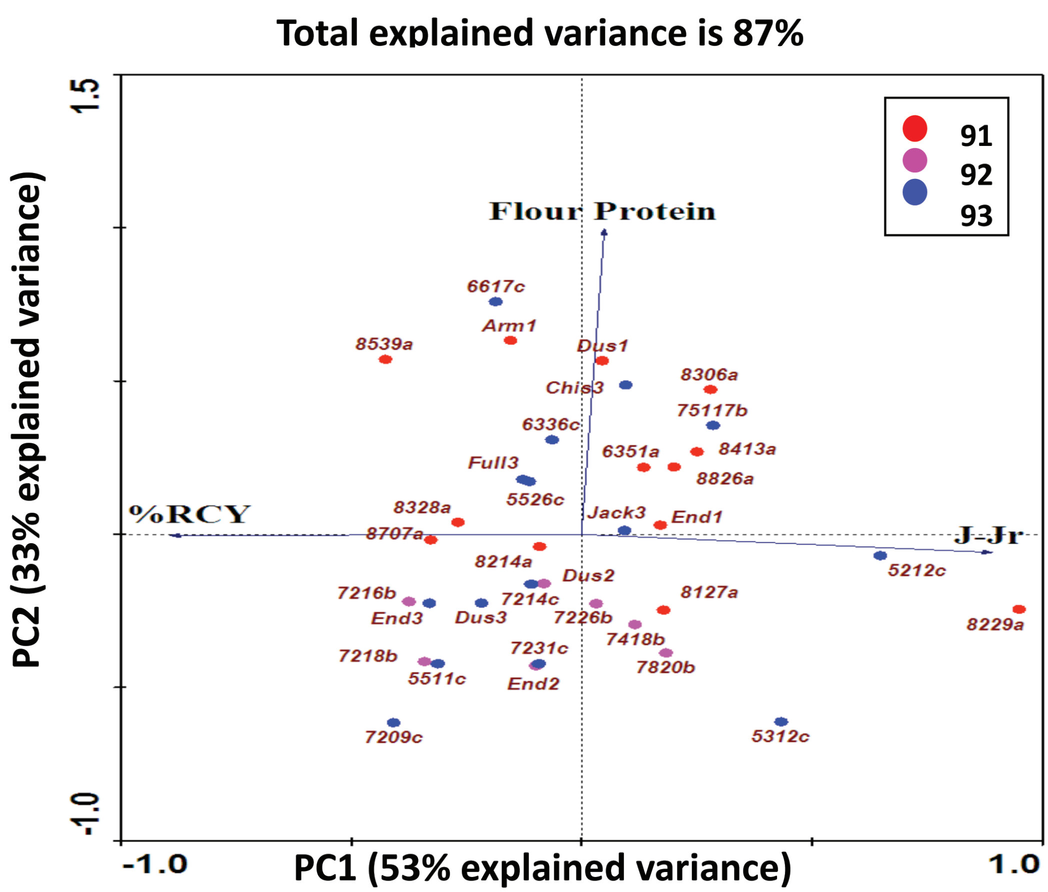

Figure 1. Principal component analysis of three Oklahoma Elite Trials nurseries conducted in 2010 involving two indicators of gluten quality (percent recovery, percent RCY; deformation or viscosity, J-Jr) and one indicator of gluten quantity (flour protein).

gluten test based on gluten compression that produces a larger deformation than the one reported here. We expect this research to help us construct a more complete gluten quality puzzle.

Wheat Breeding and Variety Development

Brett Carver
Plant and Soil Sciences

Not since 2006 have we had a crop season where diseases did not top our list of most important traits. In 2010-2011, selection for fungal disease resistance was mostly limited to greenhouse screening assays or to field environments outside of Oklahoma. Field and laboratory reactions to viruses, as presented in Hunger's report, were collected in the usual and intensive fashion, but severity of WSBMV and WSSMV reactions still fell below typical levels. We entered the 2010-2011 season with a strong slate of breeding lines with effective resistance to leaf rust, stripe rust, PM, BYDV, WSBMV and WSSMV. We came out of the 2010-2011 season with all of that and more. A common theme permeating all generations of breeding trials was the importance of tolerance to drought and heat stress.

On the Brighter Side of 2011

As painful as the 2011 drought was to Oklahoma's wheat crop, the WIT did gain something from it. We had no choice. Selection decisions were made on the basis of drought and heat tolerance. As an example, candidate cultivars such as the high yielding synthetic derivative, OK07S117, and the Hessian fly-resistant line, OK06617-RHf, were removed from consideration due to their inability to handle such dry conditions. On the other hand, candidates such as OK08229 were moved forward on an accelerated track to take advantage of its drought resistance that may not have caught our attention in previous years. We will come back to the 2012 candidates later in this report.

A couple other bright spots warrant mentioning here, and were made possible by leveraging OWC/OWRF financial support with funding from USDA-ARS and Oklahoma Genetics, Inc. First, in a defensive move against potential invasion of the highly devastating race of stem rust, Ug99, from other parts of the world, field tests were established for the first time across Oklahoma for 89 backcross-derived lines featuring novel stem rust resistance genes (*Sr22*, *Sr35*, *Sr39* and *Sr40*) combined with unknown sources. These materials were highly adapted to Oklahoma because they descended, for the most part, from Duster, Fuller, 2174 and various combinations thereof. Field testing will continue, but we also will sidestep this process to hybridize desirable progenies and stack resistance genes in appropriate combinations. This two-tier breeding process should provide a highly suitable agronomic platform for the southern Plains from which to build and further incorporate multiple sources of stem rust resistance, if the need should present itself.

Second, approximately 1,000 highly inbred lines were produced via doubled haploid technology, providing the necessary seed stock to either evaluate the lines in greenhouse or DNA-based assays or to test them under field conditions in 2011-2012. This technology allows propagation of inbred lines from an F_1 hybrid in 12 to 15 months. Rather than replace, we will supplement our ***Grazen****Grain* breeding system with doubled haploid technology, as it is best utilized in narrow-based, elite breeding materials where the resulting variation can best be captured in finite populations of 100 to 500 lines. For example, we have already identified doubled haploid progeny containing two insect resistance genes (greenbug, Hessian fly) and two key genes for leaf rust resistance and PM resistance. Now that those genes are fixed and will not segregate in subsequent progeny, our task is to evaluate and select for yield and quality. As another example, we are currently identifying doubled haploid progeny from the cross, Duster x Billings, with desirable disease and insect resistance genes combined from each parent. Already produced in a separate track through the ***Grazen****Grain* breeding system are Duster x Billings progeny with outstanding yield records, so we are confident this parental combination has agronomic value of interest to Oklahoma wheat producers.

A third and final bright spot from the 2010-2011 crop season was the identification of breeding lines already in the pipeline with high levels of resistance to tan spot, septoria leaf blotch, or both. Favorable reactions to these diseases have eluded us in past years due to inappropriate parent materials (i.e., low frequency of resistant donors) and the lack of reliable greenhouse assays. The latter has been resolved through dedicated attention given by Hunger, as mentioned further in his report. Note in Figure 2 the enormity of these assays and that disease reactions are ascertained on juvenile plants with only two to four leaves. Briefly, 16 of the 26 experimental lines tested in the 2011 Oklahoma Elite Trial (OET)showed a moderately resistant reaction to one or both of these diseases, a phenomenal turnaround from results obtained only two or three years ago. Candidate cultivars such as OK07209 and OK08328 are compelling examples, as are the up-and-coming lines OK09125, OK09634 and OCW02S158T-2.

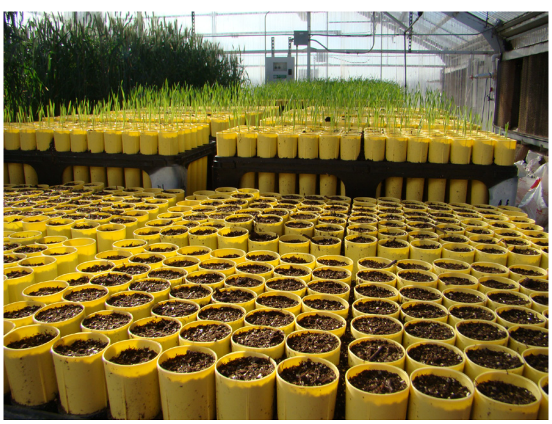

Figure 2. Greenhouse seedling testing for tan spot resistance requires extensive replication and tightly controlled environmental conditions.

2011 Oklahoma Elite Trial

The OET represents the final stage of yield testing before the most desirable lines are entered as candidate cultivars in the Oklahoma Wheat Variety Trials. Table 5 contains yield results from the 2010-2011 season, with the 38 entries (32 experimental lines) listed in decreasing order for mean yield. Only six locations were worthy of reporting, though trials were attempted at Marshall with grazing and under dryland conditions at Goodwell. The data in Table 5 are primarily a reflection of two factors, yield potential and tolerance to season-long dry conditions. Cultivars or lines that typically require an extended grain-filling period—such as Garrison, Endurance, OK06336, OK05312 and

Table 5. Grain yield summary for the 2011 Oklahoma Elite Trial. Rank from 1 to 32 is shown in italics for individual locations.

Entry	*Pedigree*	*Overall mean*[a]	*Granite*		*Kingfisher*		*Lahoma*		*Cherokee*		*Goodwell irrigated*		*Enid low pH*	
OK08229	TX98D1170/OK98697	38	21	*23*	27	*4*	50	*4*	23	*6*	67	*1*	29	*26*
Duster	Duster	37	22	*17*	30	*1*	52	*2*	21	*9*	61	*7*	50	*2*
Ruby Lee	KS94U275/OK94P549	36	28	*3*	20	*15*	40	*20*	27	*2*	63	*2*	33	*21*
OK07209	OK93P656-(RMH 3299)/OK99621	35	20	*24*	28	*3*	40	*21*	26	*3*	63	*3*	27	*29*
OK07214	OK93P656-(RMH 3299)/OK99711	35	23	*14*	21	*14*	52	*1*	20	*10*	58	*11*	47	*4*
OK08328	GK Keve/Ok101//OK93P656-RMH3299	34	24	*7*	25	*6*	41	*19*	20	*11*	61	*6*	46	*5*
Everest	Everest	34	29	*1*	19	*19*	42	*17*	24	*4*	56	*16*	53	*1*
Armour	Armour	34	23	*12*	22	*9*	51	*3*	17	*19*	56	*17*	45	*8*
OK07231	OK92P577-(RMH 3099)/OK93P656-(RMH 3299)	33	21	*22*	20	*17*	45	*9*	21	*8*	57	*15*	45	*7*
OCW00S063S-1B	(KAUZ/STAR)//U1254-1-5-1-1/TX89V4213	33	24	*9*	24	*8*	35	*29*	22	*7*	57	*12*	43	*12*
Greer	Greer	32	23	*13*	20	*16*	38	*25*	27	*1*	54	*20*	48	*3*
Billings	Billings	32	22	*19*	19	*21*	46	*7*	14	*26*	62	*5*	45	*9*
OK08214	GA84414 FFR 522W/Ok102//OK99215	32	26	*4*	20	*18*	44	*11*	20	*12*	53	*24*	42	*14*
OK08707W	OK98G508W/Lakin//Trego	32	24	*8*	28	*2*	46	*6*	14	*24*	49	*27*	34	*20*
OK07226	OK99207/OK99621	32	25	*6*	16	*27*	43	*15*	18	*17*	59	*8*	18	*32*
OK08413	2174/(CHOIX/STAR/3/HE1/3*CNO79//2* SERI)//Duster	32	15	*32*	27	*5*	44	*12*	16	*20*	58	*9*	39	*17*
OK07216	OK99219/OK93P656-(RMH 3299)	32	22	*15*	13	*31*	49	*5*	19	*15*	56	*18*	44	*10*
Garrison	OK95616-1/Hickok//Betty	32	22	*18*	17	*26*	43	*13*	14	*27*	62	*4*	42	*13*
OK05312	TX93V5919/WGRC40//OK94P549/WGRC34	32	28	*2*	21	*11*	40	*23*	16	*21*	54	*21*	30	*25*
Endurance	Endurance	31	23	*11*	18	*23*	45	*10*	19	*14*	52	*25*	42	*15*
OK07218	OK99219/OK99621	31	25	*5*	17	*25*	38	*26*	18	*16*	58	*10*	24	*31*
OK06336	Magvars/2174//Enhancer	31	20	*27*	25	*7*	36	*27*	23	*5*	53	*22*	35	*19*
OK08306	Ludwig/2174//OK93P656-RMH3299	31	19	*29*	19	*20*	45	*8*	18	*18*	53	*23*	46	*6*
OK08127	Intrada/Dominator//OK93P656-RMH3299	30	20	*25*	21	*12*	43	*14*	13	*29*	56	*19*	44	*11*
OK05511-RHf2	TAM 110/2174	29	21	*21*	19	*22*	40	*22*	9	*31*	57	*14*	40	*16*
OK08826W	TX89V4132/TX90V6913//(PYN/BAU)	29	24	*10*	18	*24*	30	*31*	15	*23*	57	*13*	32	*24*
OK08539	NE93405/TAM 302//OK99711	29	19	*30*	21	*13*	36	*28*	16	*22*	51	*26*	36	*18*
OK07418	Karl92*2/3/TAM101//Chisholm/ PI366616/4/OK98699	29	19	*28*	15	*29*	42	*16*	19	*13*	47	*28*	29	*27*
OK07820W	OK97611/Trego//OK81306/TR810200	28	19	*31*	22	*10*	42	*18*	12	*30*	45	*30*	28	*28*
OK06617-RHf	FAWWON 06/2137//OK95G703-98-61421	27	22	*20*	16	*28*	39	*24*	13	*28*	45	*29*	33	*22*
Chisholm	Chisholm	23	20	*26*	11	*32*	35	*30*	14	*25*	34	*32*	32	*23*
OK07S117	[ALTAR84/AE.SQ//OPATA]/OK98G508W	21	22	*16*	14	*30*	29	*32*	4	*32*	36	*31*	24	*30*
Mean		31	22		20		42		18		55		38	
CV		13	12		20		9		22		11		14	
LSD		5	4		6		5		5		8		7	

a Enid (low pH) not included in overall mean

OK07S117—did not fare well under the conditions of accelerated kernel filling in 2011.

Three of the four highest yielding lines featured Duster as a parent: OK07209, OK07214 and OK08328. Take special note of these lines because they will be mentioned again when presenting the Southern Regional Performance Nursery (SRPN) results from 2011. The fourth line, OK08229, performed extremely well at all locations except Granite and at Enid with low pH. OK08229 has not ranked lower than fourth in any yield trial dating back to 2008. We believe it may be best suited for western Oklahoma, including the Oklahoma panhandle. One of its two parents, OK98697, was almost released in the early 2000s, specifically for production in the Oklahoma panhandle. Our decision at that time was to hold out for a subsequent release with broader adaptation, named OK Bullet. Another line to watch for in western Oklahoma will be OK08328. We will rely on the 2011 Oklahoma Wheat Variety Trials to help guide the WIT in their final decision.

The Numbers

Field evaluation, relevant molecular and greenhouse assays and extensive end-use quality testing were conducted on 2,596 breeding lines in preliminary (F_6), intermediate (F_7) and advanced inbreeding generations (F_8 and beyond). Of those, 477 breeding lines (18 percent) belonged to the hard white class, with the balance being hard red winter or in rare cases, soft red winter (<1 percent). With exception of populations enriched by marker-assisted selection (about 5 percent of the experimental line output), a modified bulk population selection method was invoked in the early inbreeding generations (F_2 through F_4), using the ***Grazen*n*Grain*** breeding system.

Performed in 2010-2011 were 1,059 unique hybridizations strictly for the purpose of breeding population development. About 14 percent of those will potentially lead to populations that contain genes fixed for white kernel color or otherwise segregate for kernel color. About one-third of these hybridizations were limited to elite local parentage, underscoring the emphasis placed on germplasm introgression from foreign sources to improve disease and insect resistance.

The Genetic Pipeline

A record 11 candidate cultivars were entered into the OSU Wheat Variety Trials in fall 2011. Two candidates, which are targeted for release in February 2012, are half-sibs to the common parent, Duster, yet they differ for several key adaptive traits. OK07209 is a moderately late maturing line with broad adaptation similar to Duster but with improved yield potential and test weight patterns, and with leaf rust resistance conferred in part by *Lr34*. OK07209 will be targeted for production throughout the southern Plains and central Plains. On the other hand, OK07214 is a moderately early maturing line with an adaptation range restricted to areas east of the high Plains. It offers better resistance to stripe rust, BYDV, Hessian fly and acidic soils than OK07209, but it lacks *Lr34*. Breeder seed of both candidates was transferred to Oklahoma Foundation Seed Stocks, Inc. for eventual production and distribution of foundation seed, pending release approval by the Oklahoma Agricultural

Table 6. Comparison of two candidate hard red winter cultivars with common parentage in Duster.

OK07209	*OK07214*
Intermediate maturity	Early maturity
Acid soil intolerant	Acid soil tolerant
Weaker reaction to stripe rust	Stronger reaction to stripe rust
Stronger reaction to tan spot	Weaker reaction to tan spot
Weaker reaction to barley yellow dwarf	Stronger reaction to barley yellow dwarf
Hessian fly intolerant	Hessian fly resistant
Contains Lr34	Lacks Lr34
Broader yield range	Higher yield potential
Lower but stronger wheat protein	Higher but weaker wheat protein

Experiment Station. Table 6 summarizes how these two candidates complement one another and underscores the importance of familiarity producers should have in choosing the right variety for their conditions.

Of 38 entries submitted by seven public breeding programs in the 2011 SRPN, OSU claimed the top ranking position in Texas, Oklahoma and Kansas, based on mean yields reported for each state. This position rotated among three OSU candidate cultivars already mentioned: OK07209, OK07214 and OK08328 (Table 7). Texas, Oklahoma, and Kansas accounted only for 10 of the 25 regional sites included in the region-wide means, which was dominated by test sites well north of our target adaptation zone, including five in Colorado and three each in Nebraska and South Dakota. Nevertheless, two candidates (OK07209 and OK08328) occupied two of the top three positions when computing the mean yield across all 25 sites. OK07209 also was the second-highest yielding entry in the 2010 SRPN, so its yield consistency and broad adaptation will be key factors when proposing its release.

The genetic pipeline for OSU candidate cultivars is flowing at full capacity. In Fall 2011, 11 candidates were either placed under preliminary

Table 7. Grain yield (bu/A) and rank (1 to 38) of three OSU candidate cultivars in the 2011 Southern Regional Performance Nursery.

	Oklahoma (4 sites)		*Kansas (3 sites)*		*Texas (3 sites)*		*Region (25 sites)*	
	Yield	Rank	Yield	Rank	Yield	Rank	Yield	Rank
OK08328	47	2	52	18	55	1	54	2
OK07209	40	15	56	1	51	2	54	3
OK07214	47	1	54	6	50	4	53	12
Fuller (contemporary check)	39	18	49	31	45	25	48	30
All entries (n=38)	39	--	51	--	45	--	50	--

Table 8. OSU candidate cultivars placed under seed increase in Fall 2011 with Oklahoma Foundation Seed Stocks, Inc.

Candidate	*Pedigree*	*Increase status*	*Adaptation*
OK07209	Duster/OK99621	Large (year 2)	Statewide
OK07214	Duster/OK99711	Large	Statewide
OK08328	GK Keve/Ok101//Duster	Large (year 2)	Western OK
OK05312	TX93V5919/WGRC40//Endurance/WGRC34	Large	Panhandle
OK08229	TAM 303/OK98697	Small	Western OK
OCW00S063S-1B	(KAUZ/STAR)//U1254-1-5-1-1/TX89V4213	Small	Panhandle
OK0986146W	N02Y5106/OK03716W	Small	Panhandle
OK09915C	N91D2308-13/OK03908C//OK03928C	Small	Clearfield(2-gene)
OK09935C	N91D2308-13/OK03928C//OK03928C	Small	Clearfield(2-gene)
OK09634	OK95616-98-6756/Overley	Small	Statewide
OK09528	TAM 303/Ok102	Small	Statewide

seed increase or continued under large-scale seed increase by Oklahoma Foundation Seed Stocks, Inc. (Table 8). Five of these are on an accelerated track and were not featured in the 2011 OET. These candidates provide an expanded slate of diverse options, especially for western Oklahoma, as we look beyond prevailing OSU cultivars in production today, such as Endurance, Duster, Billings and Centerfield. Ending on the same theme as we started at the beginning of this report, all of these candidates showed a common strength of resilience to the devastating drought of 2011.

2011 Small Grains Variety Performance Tests

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The 2010-2011 wheat production season can be characterized as record breaking, but not in a positive sense. The year was marked by record drought, record cold and record heat that exacted a toll on the Oklahoma wheat crop. At the time of writing this report, 2011 Oklahoma wheat production is estimated to be approximately 74.8 million bushels or 38 percent less than 2010 (Table 9). Lower production was offset to some extent by higher prices with cash prices at harvest exceeding $8 per bushel at some locations.

Most areas of the state had just enough moisture for wheat emergence in the fall of 2010. This moisture was quickly used but never replenished in southwestern Oklahoma and the western tier of counties in northern Oklahoma. As a result, early sown wheat intended for grazing was parched by mid winter and never recovered. Most of the fields in this situation were "zeroed out" for insurance purposes and not harvested for grain. The same can be said for a good portion of the dryland wheat in the Oklahoma Panhandle where drought conditions were exacerbated by record low temperatures. This was especially true in Cimarron County where a mere 1.4 inches of precipitation occurred between planting and wheat maturity. Despite the harsh environmental conditions, wheat at the Keyes test site averaged 22 bu/A illustrating the benefits of fallow and confirming that wheat is an amazing plant.

A few light rains and relatively large snowfall events gave wheat in central and northcentral Oklahoma just enough moisture to make it through the winter in good condition. Given the relatively good condition of the wheat crop in this region during December and January and the favorable price outlook, most farmers chose to topdress at average to above-average rates. The condition of

Table 9. Oklahoma statistics for 2010 and 2011 production years.

	2011	*2010*
Harvested Acres	3.4 million	3.9 million
Yield (bu/A)	22	31
Total bushels	74.8 million	120.9 million

wheat in this area rapidly deteriorated as February, March and April passed without appreciable precipitation, however, and a large portion of topdress nitrogen (N) remained on the soil surface and unavailable to roots. Rains finally arrived in northcentral Oklahoma in May and were just in time to retain at least part of the yield potential present. These rains only added to the problem of too much moisture in northeastern Oklahoma where many growers were forced to aerially apply herbicides and N due to waterlogged soil conditions. Finally, Mother Nature offered a challenge for central and northcentral Oklahoma wheat producers in the form of late-May hail storms. The extent of hail damage is illustrated by the 19 bu/A average yield at Kingfisher, where wheat plots were estimated to be in the 35 – 45 bu/A range prior to the hail event.

Lowest average yield among the OSU wheat variety test sites was at Gage (9 bu/A) where plots were grazed during the winter and inadequate moisture was available for recovery after grazing. Grazing reduced grain yield of wheat by an average of 12 bu/A at the Marshall site. Highest average yield was at the McLoud site (48 bu/A), which was sown after a full-season corn crop in a corn/wheat/double-crop soybean rotation. Drought combined with heat during grain fill can frequently result in shriveled seed, but this was not the case in 2011. Test weights were generally 60 lbs/bu or greater in early harvested wheat but decreased slightly in later-harvested wheat.

Application of a foliar fungicide had no effect on average grain yield at Apache or Lahoma. This was not surprising, as very little foliar disease was present during the 2010-2011 production year. The most frequently observed disease of wheat in 2011 was barley yellow dwarf virus (BYDV), which is transmitted by aphids. Infection probably occurred as a result of a late-winter or early spring infestation of aphids and symptoms typically included purpling and yellowing but not stunting. In addition to BYDV, there were a few reports of wheat spindle streak mosaic virus (WSSMV) and high plains virus in the Oklahoma Panhandle.

While weeds were a problem, reports of excessive dockage and foreign material were not as widespread as in 2010. This was probably due to multiple factors, not the least of which was greater emphasis on wheat quality by grain elevator managers. It was made clear in 2010 that stricter dockage and foreign material standards would be in place for 2011, and most growers heeded the warning by placing greater emphasis on timely and accurate weed control.

Methods

Cultural Practices

Conventional plots were eight rows wide with 6-inch row spacing. No-till plots were seven rows wide with 7.5-inch row spacing. Plots were 20 feet long and wheel tracks were included in the plot area for yield calculation. Conventional till plots received 50 lbs/A of 18-46-0 in-furrow at planting. No-till plots received 5 gals/A of 10-34-0 at planting. The Apache, El Reno, Marshall dual-purpose (DP) trials were sown at 120 lbs/A. All other locations were sown at 60 lbs/A. Grazing pressure, N fertilization, and insect and weed control decisions were made on a location-by-location basis and reflect standard management practices for the area.

Additional Information on the Web

A copy of this publication and a complete copy of the wheat variety performance tests, as well as additional variety information and more information on wheat management, can be found at www.wheat.okstate.edu.

Marketing Rights

Breeding programs responsible for varietal release are indicated as the source in results tables. In many cases, however, a separate entity has the marketing rights for these varieties. For this reason, a list of wheat seed companies and the varieties they market is provided below.

AgriPro
Doans
Greer
Fannin
Jackpot
TAM 111
TAM 203
TAM 401

CO Wheat Res. Found.
Bill Brown
Hatcher

Husker Genetics
Mace

Kansas Wheat Alliance
Everest
Fuller
Jagger
Overley

Limagrain Cereal Seeds
T158

OKFoundationSeed
2174
Deliver
Endurance

Oklahoma Genetics
Billings
Centerfield
Duster
Garrison
Guymon (W)
OK Bullet
Pete
Ruby Lee

WestBred
Armour
Aspen (W)
Santa Fe
Shocker
WB-Cedar
WB-Stout
Winterhawk

Watley Seed
TAM 112

2011 Oklahoma Wheat Variety Trial Yield Summary

Variety	Afton	Alva	Apache	Apache Fungicide	Balko	Buffalo	Cherokee	El Reno	Elk City	Frederick	Gage	Goodwell Irrigated
	--------	--------	--------	--------	--------	grain yield (bu/A)	--------	--------	--------	--------	--------	--------
2174	-	-	-	-	-	-	-	-	-	-	-	-
Armour	44	43	18	19	43	14	17	24	31	25	8	42
Aspen	-	-	-	-	-	-	-	-	-	-	-	35
Bill Brown	-	-	-	-	40	-	-	-	-	-	-	32
Billings	38	40	20	22	39	13	19	28	23	18	10	36
Centerfield	36	-	-	37	21	42	36	39	16	31	47	19
Deliver	-	34	-	-	-	-	15	30	-	-	7	-
Doans	27	42	16	17	37	17	20	32	26	20	10	31
Duster	37	49	22	22	45	18	27	40	28	29	9	41
Endurance	36	43	18	19	41	14	24	38	31	22	10	37
Everest	43	-	19	18	-	-	24	39	-	23	-	-
Fannin	-	-	13	12	-	-	-	24	24	18	-	-
Fuller	35	40	26	26	36	19	26	34	31	24	10	30
Garrison	-	42	19	20	37	16	19	32	32	18	-	-
Greer	32	39	19	19	40	18	28	32	30	26	10	31
Guymon	-	-	-	-	-	-	-	-	-	-	-	28
Hatcher	-	-	-	-	41	-	-	-	-	-	-	40
Jackpot	32	36	21	19	41	15	21	31	26	26	10	29
Jagger	32	41	20	21	36	14	28	33	24	26	9	32
Mace	-	-	-	-	37	-	-	-	-	-	-	35
OK Bullet	29	40	20	20	34	15	21	36	24	25	10	32
OK Rising	-	-	-	-	-	-	-	-	-	-	-	28
Overley	23	46	-	-	-	-	23	34	-	27	-	-
Pete	-	-	16	18	-	-	-	29	22	25	-	-
Ruby Lee	-	-	-	-	-	-	-	37	-	26	-	-
Santa Fe	38	41	19	19	37	13	23	33	29	26	11	28
Shocker	21	-	-	-	-	-	15	28	-	-	-	-
T158	-	-	-	-	42	16	-	-	-	-	-	39
TAM 111	-	41	-	-	41	9	-	-	28	-	9	41
TAM 112	-	55	-	-	43	20	-	-	30	-	10	44
TAM 203	37	44	29	30	-	17	32	36	29	23	9	-
TAM 401	-	40	17	19	-	-	25	30	28	24	7	-
WB-Cedar	32	-	-	-	-	-	19	35	-	-	-	-
WB-Stout	33	38	20	21	40	16	11	29	21	21	9	35
Winterhawk	-	-	-	-	44	22	-	-	-	-	10	38
OK05312	-	-	-	-	44	25	-	-	-	-	-	-
OK05511-RHf2	-	-	-	-	-	-	-	-	22	24	-	-
OK06336	-	-	-	-	-	-	-	-	-	-	-	-
OK07209	43	47	25	27	-	-	24	36	26	29	-	-
OK07214	46	45	20	25	-	-	20	-	-	-	-	39
OK07231	-	-	-	-	-	-	-	33	-	-	-	-
OK07S117	-	-	-	-	-	-	-	19	-	-	-	-
OK08328	-	-	25	28	-	-	-	-	-	29	-	-
Mean	34	42	20	21	40	16	22	32	27	24	9	35
LSD (0.05)	7	10	4	4	4	6	7	8	6	5	3	9

2011 Oklahoma Wheat Variety Trial Yield Summary (continued)

Variety	Homestead	Hooker	Keyes	Kildare	Kingfisher	Lahoma	Lahoma Fungicide	Lamont	Marshall DP	Marshall GO	McLoud	Olustee
	--------------------	--------------------	--------------------	--------------------	--------------------grain yield (bu/A)--------------------							--------------------
2174	-	-	-	-	-	-	-	-	-	-	48	-
Armour	39	23	19	40	20	45	50	43	13	33	47	16
Aspen	-	-	-	-	-	-	-	-	-	-	-	-
Bill Brown	-	25	21	-	-	-	-	-	-	-	-	-
Billings	37	20	19	31	21	46	47	36	14	29	46	11
Centerfield	21	36	-	-	-	11	17	32	30	28	11	-
Deliver	30	-	-	-	17	32	29	37	19	26	-	-
Doans	41	21	28	29	21	43	43	37	21	27	42	16
Duster	39	21	23	51	27	53	52	47	23	32	52	20
Endurance	41	21	20	41	17	46	48	46	24	30	47	18
Everest	42	-	-	36	16	48	50	46	24	30	48	15
Fannin	-	-	-	-	-	-	-	-	-	-	-	11
Fuller	36	20	21	39	23	46	46	41	20	32	45	18
Garrison	39	-	-	46	21	44	47	40	13	30	-	12
Greer	39	-	-	49	16	43	42	44	20	30	52	19
Guymon	-	-	-	-	-	-	-	-	-	-	-	-
Hatcher	-	24	19	-	-	-	-	-	-	-	-	-
Jackpot	38	23	22	33	17	41	38	39	19	32	46	18
Jagger	40	19	21	31	23	48	46	36	19	32	42	17
Mace	-	24	17	-	-	-	-	-	-	-	-	-
OK Bullet	34	20	26	40	18	44	47	40	15	26	41	17
OK Rising	-	-	-	-	-	-	-	-	-	-	-	-
Overley	43	-	-	36	15	43	41	48	14	31	47	20
Pete	-	-	-	-	18	40	39	-	14	29	-	17
Ruby Lee	-	-	-	40	-	-	-	-	-	-	53	-
Santa Fe	42	-	-	43	16	47	45	44	15	26	42	19
Shocker	30	-	-	34	10	39	38	46	13	27	52	-
T158	-	22	23	-	-	-	-	-	-	-	-	-
TAM 111	-	21	23	-	-	-	-	-	-	-	-	-
TAM 112	-	24	33	-	-	-	-	-	-	-	-	-
TAM 203	37	-	-	28	27	49	49	43	24	24	48	19
TAM 401	35	-	-	-	14	41	42	44	14	30	-	15
WB-Cedar	37	-	-	26	13	44	49	39	24	29	49	-
WB-Stout	34	18	23	36	14	49	43	38	14	26	46	11
Winterhawk	-	-	-	-	-	-	-	-	-	-	-	-
OK05312	-	25	24	-	-	-	-	-	-	-	-	-
OK05511-RHf2	-	-	-	-	-	-	-	-	-	-	-	-
OK06336	-	-	-	38	-	-	-	-	-	-	50	-
OK07209	-	-	-	52	25	52	52	-	22	-	54	-
OK07214	-	-	-	-	-	51	52	-	-	-	56	14
OK07231	34	-	-	35	-	45	42	-	-	-	-	-
OK07S117	-	-	-	-	-	-	-	-	-	-	-	-
OK08328	-	-	-	-	-	-	-	-	-	-	-	-
Mean	37	22	22	38	19	45	45	42	18	29	48	16
LSD (0.05)	6	3	5	12	7	8	8	8	4	5	5	1

DP=Dual Purpose

GO=Grain Only

OKLAHOMA STATE UNIVERSITY

RESEARCH