2002 REPORT ON

K-STATE Kansas State University

GRAINS RESEARCH AND EDUCATIONAL PROGRAMS

SUPPORTED BY

KANSAS CORN, GRAIN SORGHUM, SOYBEAN, AND WHEAT COMMISSIONS

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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INTRODUCTION

We are pleased to provide this update on research and educational activities made possible in Fiscal Year 2002 using check-off funds from the Kansas Corn, Grain Sorghum, Soybean and Wheat commissions. The commissions provided $1,862,110 in FY 2002, down from $2,062,486 in FY 2001. Declining research support over the past three years from the commissions reflects sustained hard times for the Kansas agricultural economy. These hard times have also led to a drop in state appropriations. In this tight budget environment, our faculty sought to make wise use of the funds received in FY 2002 from the commissions, as listed below:

Corn Commission – $139,062
Grain Sorghum Commission – $211,300
Soybean Commission – $438,574
Wheat Commission – $1,073,174

Our faculty is grateful for these funds and is striving to produce results that will offer our clientele opportunities to strengthen their operations. K-State Research and Extension has been forced to focus on high-priority issues and make cuts where we can. Accordingly, we have sought ways to reduce our publications costs, without sacrificing our ability to communicate with constituents who need the results and information we produce. In FY 2003, seven publications have been or will be produced on CD-ROM, including this report. Savings from publishing these reports on CD are expected to be more than $20,000. We anticipate that most users will find the CD reports to be very useful. Articles on the CD are published as Adobe Acrobat PDF files. This allows readers to search either individual documents or the entire CD. The reader can then download or print articles of interest without having to print the entire publication. It also allows us to put several publications on a single CD. For example, as an added bonus on this CD, we included an introductory brochure describing a major K-State initiative for Homeland Security, the Great Plains Diagnostics Network.

Our preliminary research showed that most users have computers with CD-ROM drives, but there still remains a substantial portion of our public who do not routinely use computers in their operations. To accommodate this audience, printed versions are available for a nominal charge through K-State Research and Extension.

Findings reported in this publication span cropping systems, water management and quality, pest management, breeding for disease and pest resistance, genetic studies to improve quality and performance, alternative uses for end products, processing and marketing. Because all projects have the common aim of answering real problems, Kansas producers will benefit directly. The results are already being communicated to various audiences through scientific journals, seminars, workshops and field days, and they are being incorporated into K-State Research and Extension educational efforts.

Forrest Chumley
Associate Director
Kansas Agricultural Experiment Station

KANSAS CORN COMMISSION

Irrigation Scheduling Demonstration of Efficient Water Use by Corn in Western Kansas

Researchers and Units
Mahbub Alam, SW Area Extension Office; Danny Rogers, Biological and Agricultural Engineering;Troy Dumler, SW Area Extension Office; Roger Stockton, Extension Specialist, Crops and Soils, NW Area Office; Curtis Thompson, Extension Specialist, Crops and Soils, SW Area Office; Freddie Lamm, Research Agricultural Engineer, NW Research Center

Funds (FY 02): $21,800 Completion Date: June 30, 2002

JUSTIFICATION: The irrigated and harvested corn acreage across the 37 corn-growing counties in western Kansas was approximately 1.08 million acres (2002 Agricultural Statistics for Kansas). Livestock industries in the area create a large demand for grain. Feeding corn grain to livestock adds value and provides a much larger economic impact for all of Kansas. Irrigation is key to this success. However, a decline in the water level of the Ogallala aquifer has become a major concern. Irrigation management and increasing the efficiency of water use is key to maintaining prolonged economic production in the area. Irrigation scheduling may help in achieving desired improvements in irrigation efficiency. Irrigation scheduling tools are now available. Farmers, though, need hands-on training in use of these tools through field demonstrations, educational meetings, on-site tours, and discussion.

OBJECTIVES:
1. Establish demonstration fields and hold educational meeting on irrigation scheduling.
2. Use KanSched computer software for irrigation scheduling decision.
3. Making ET (crop water use) information available on the Internet - World Wide Web.
4. Conduct center pivot sprinkler distribution uniformity evaluations.
5. Hold irrigation meetings, demonstration field tours, and disseminate results through presentation in irrigation meetings - local and national.

DEMONSTRATION ACTIVITY: Established irrigation scheduling demonstration fields with producer cooperators at Finney, Ford, Grant, Kearny, and Stevens counties in southwest Kansas; and Cheyenne and Thomas counties in northwest Kansas. Stevens and Thomas counties had two demonstration fields each. Five hands-on training sessions were held and 39 producers were shown how to use KanSched irrigation scheduler. Eight staff members of USDA-NRCS and 14 County Extension Agents also received training on the use of the KanSched irrigation scheduling software. The Kansas Conservation Commission provided incentives to producers for adopting irrigation scheduling using KanSched. Sixteen producers signed up in five counties. Irrigation scheduling was presented during fall field day and 50 producers participated. Eleven winter meetings were held and 178 attended. Demonstration sites were fitted with soil water sensors, Etgage, and data collected were shared with the cooperators to give them the opportunity to make irrigation decisions. Three center pivots were evaluated for sprinkler distribution uniformity and results shared with producers. The result of the demonstration program and field trials on irrigation ending date was presented at the Water and Future of Kansas conference at Lawrence; 45 visited the booth that was set up to showcase the project. The results of an irrigation ending date study were presented at the American Society of Agricultural

Engineers national conference. The producer partners scheduled irrigation based on ET and soil water status. ET data from the SWREC weather station at Garden City was posted in the World Wide Web. USDA- NRCS of Kansas and Kansas Conservation Commission has recognized KanSched as a tool for irrigation scheduling for Kansas producers. Pivot evaluation helped in adjusting nozzle package and operation improving distribution.

SIGNIFICANCE: The number of irrigations was reduced. Center pivot tests showed the extent of the problem that was shared with industry. A new state project was developed to address this issue along with educational program on use of the KanSched irrigation scheduling tool.

Intensive Farm Management Education for Kansas Crop Producers

Researchers and Unit

Daniel Bernardo, Michael Boland, Kevin Dhuyvetter, and Terry Kastens, Agricultural Economics

Funds (FY 02): $18,000 Completion Date: June 30, 2002

JUSTIFICATION: The Federal Agricultural Improvement and Reform (FAIR) Act of 1996 marked a dramatic shift in American farm policy, resulting in significant changes in the management environment faced by producers who have traditionally grown program crops. Although the accompanying planting flexibility allows for more profit-maximizing crop choices, these crop choices bring risks of their own. Changes in the management environment faced by Kansas crop producers has created a heightened need for improved farm management skills. In particular, it is especially important for agricultural producers and businesses to increase awareness and understanding of alternative risk management concepts, tools and strategies, as well as improve their decision making skills. Many educational programs have focused on the delivery of one to two hour seminars, or at best, half-day workshops to introduce producers to various risk management tools and concepts. These seminars are generally introductory in nature and focus primarily on a particular risk management tool (e.g., crop insurance, futures contracts). While useful for introducing farm managers to risk management tools, these seminars generally do not progress beyond introductory material and provide little help to the producer in integrating these tools and concepts into their whole-farm decision making process.

Advanced farm management education requires that learners grasp difficult economic concepts and analysis tools. As a result, short workshops and seminars are not conducive to effective delivery of this information. Producers need continuing education opportunities that are flexible and that can be worked into their own schedule. Distance education can provide these types of opportunities. The Intensive Farm Management Institute will provide a curriculum and delivery system that will enable the serious and progressive manager to learn complex risk management concepts and tools and apply them to their unique management situation. Through a combination of face-to-face workshops and distance learning activities, producers will have the opportunity to study and learn risk management and decision analysis tools and concepts.

OBJECTIVE:
The objective of this project is to develop and deliver an intensive farm management education curriculum focusing on risk management tools and fundamentals to improve the decision-making skills of Kansas crop producers.

RESULTS: An integrated curriculum has been developed to assist Kansas producers learn and apply new management tools and fundamentals to improve the decision-making skills. The curriculum combines face-to-face workshops with state-of-the-art distance education techniques to deliver high-level farm management information to Kansas crop producers. The program (now called MAST for "Management Analysis and Strategic Thinking") will begin with a two-day workshop on the KSU campus where program participants are introduced to key tools and concepts to be emphasized in the program. For the next three months, participants will learn through distance education methods, and progress through several learning modules. After completing the distance education portion of the program, participants will return for a final two-day program that will emphasize applying tools and concepts to their individual farm situations.

Participants will move through the curriculum as cohorts, and because of the intensity of instruction, each cohort will be limited to approximately 25 individuals. The focus of the MAST program is to equip the serious farm manager with new management tools. The program will emphasize the use of computer and information technologies for the purpose of analysis and decision making. In particular, participants will gain increased knowledge on the use of spreadsheets in farm management applications. Some of the primary benefits the participant will derive from the program include:

- Learning new analytical tools and concepts for approaching problem solving.
- Gaining a better handle on the use of computer and information technology to increase the efficiency of the farming operation.
- Applying business planning techniques to better identify opportunities for competitive advantage.
- Understanding changes in economic forces on the horizon and what those changes mean for the participant's farm operation.
- Gaining new insights through group activities with other farm managers, providing an enhanced ability to problem solve and think through key issues.

A complete description of the curriculum can be found at the program web site (www.agecon.ksu.edu/MAST/).

SIGNIFICANCE: Funding provided by the Kansas Corn Commission and matched by K-State Research and Extension has allowed for development of arguably the most innovative farm management education program in the country. The program will be offered beginning November 2002. The time line for delivery is:

November 5- 6	On-Campus Session #1
November 7 - March 10	Distance Education Modules
March 11-12	On-Campus Session #2

Distiller's Byproducts for Cattle: Food Safety, Meat Quality and Cattle Performance

Researchers and Unit
Jim Drouillard, Curtis Kastner, and Randy Phebus, Animal Sciences and Industry

Funds (FY 02): $19,876 Completion Date: March 31, 2003

OBJECTIVES: A series of experiments were conducted to evaluate dried distiller's grains with solubles as a component of steam-flaked corn finishing cattle diets. Studies were designed to: 1) identify optimum levels of dried distiller's grains with solubles (DDGS) in finishing diets by feeding diets containing 0, 15, 30, 34, 60, or 75% DDGS as a replacement for steam-flaked corn; 2) determine if replacing flaked corn with DDGS could be employed by cattle feeders as a practical strategy to reduce shedding of potentially pathogenic organisms, including *Escherichia coli*; and 3) evaluate shelf stability and eating qualities of beef steaks derived from cattle fed graded levels of DDGS.

RESULTS: Gain and efficiency of finishing cattle were optimal when DDGS was included at 15% of the diet dry matter. Including DDGS at up to 30% of the diet resulted in performance similar to that of cattle fed steam-flaked corn as the primary source of energy, but higher levels (45-75%) tended to reduce performance. When included at up to 30% of the diet dry matter, DDGS replaces both corn and soybean meal, thus offering the potential for considerable cost savings in formulating finishing cattle diets.

In Trial 1, feeding diets ranging from 0 to 75% DDGS yielded no consistent effect on shedding of *E. coli*. However, in Trial 2, including DDGS at 30 or 75% of the diet reduced acid resistant *E. coli* in manure to approximately one third of the level observed in cattle fed the corn-based diet. This reduction, though relatively small, suggests that DDGS may have potential as a dietary manipulation to reduce coliform shedding from feedlot cattle.

Sensory evaluation by a trained panel indicated that steaks from cattle fed DDGS at any level produced steaks that were equal to those of cattle fed steam-flaked corn as the primary source of energy. Feeding DDGS to cattle resulted in small but consistent improvements in meat tenderness. Color stability of beef steaks during a 7-day retail display period was comparable for steaks from cattle fed 0 to 75% DDGS.

SIGNIFICANCE: Results of our research indicate that including DDGS at moderate levels in finishing cattle diets can effectively improve performance without compromising flavor or shelf-stability of resulting meat products.

Market Development Grant - International Grains Program Market Development Grant

Researcher and Unit
Brendan Donnelly, Grain Science and Industry

Funds (FY 02): $36,600 Completion Date: Ongoing

JUSTIFICATION: The world's feed manufacturers face increased competition. As a result, the costs and benefits of the raw materials used to manufacture their feeds face intense scrutiny. These buyers and potential buyers of U.S. corn are not as familiar as they should be with the many specialized corns available to them. They are especially ignorant of the value of quality raw materials and the benefits to their customers. Additionally, U.S. corn customers are not as familiar with grade, shipping, quality control, proper storage and fumigation, contracting, and sanitation issues as they need to be. Pricing, basis, futures markets, and price discovery fundamentals are not well understood. Genetically modified organisms (GMO's) continue to be a sensitive issue for consumers, requiring additional education on GMO development, use, safety, and value.

OBJECTIVES:
1. To identify potential buyers of corn in cooperation with the US Grains Council (USGC) and the USDA's Foreign Agricultural Service.
2. To seek out corn buyers and users that would benefit from the International Grains Program (IGP) short courses.
3. To identify specific target markets with the USGC where specifically designed short courses would be paramount.
4. To maintain contact with buyers and users of US corn to provide them with the latest information available following participation in IGP programs.

RESULTS: There were 160 persons from more than 50 countries who participated in eight formal IGP short courses during this fiscal year. Three of the short courses covered corn and soybeans, one covered sorghum and four covered wheat. Through numerous visits to meetings by IGP staff and from short term visitors, IGP made contact with several hundred additional US customers.

SIGNIFICANCE: Buyers of US corn have a better knowledge of our grade, contracts, and price discovery mechanisms. They are able to purchase US corn with more confidence and are able to obtain the exact product they need, thus enhancing their margins.

Corn Production in Kansas: Extension and Applied Research

Researcher and Unit
Dale L. Fjell, Agronomy

Funds (FY 02): $4,000 Completion Date: Ongoing

My extension and applied research for corn production in Kansas during July 1, 2001 to June 30, 2002 consisted of many activities across the state. The quarterly reports list my activities. I have listed a few of the highlights during the past reporting year.

1. I established a number of corn population experiments on farmer fields around the state. This data was used at many extension winter meetings.
2. I was an invited speaker at the four state cropping system conference held in Pierre, South Dakota. My topic was extension activities in Kansas concerning cropping systems which included corn production.
3. I traveled to the following regional and national meetings: North Central Weeds Society Annual Meeting in Milwaukee; Agronomy Society of American Annual Meeting in Charlotte, NC; Commodity Classic in Nashville.

With the funding available from this grant I was able to get to more places around the state and not worry about depleting the Extension Agronomy's travel funds. With the next year's extension budget essentially nonexistent the only way that I will be able to travel both in-state and out-state will be with funding from this grant. Thank you for continuing to fund my extension and research efforts.

Food Grade Corn Evaluation Program

Researcher and Unit
Timothy J. Herrman, Grain Science and Industry

Funds (FY 02): $20,000 Completion Date: Ongoing

JUSTIFICATION: It is important to support Kansas corn growers pursuing value-added food processing with timely information about corn hybrid end-use performance.

OBJECTIVES:
1. Assess corn quality characteristics related to dry milling performance;
2. Dry mill a subset of corn samples from the 2001 and 2002 crop years and identify the statistical relationship between quality characteristics and laboratory milling performance.

RESULTS: Corn samples harvested in 2000 and 2001 (approximately 200 per year) were evaluated using the Foss Grain Spec near infra-red (NIR) whole grain analyzer to measure protein, oil, starch, moisture, and specific density (an indicator of hardness). A subset of the 2000 and 2001 corn samples was evaluated for specific density using a gas pycnometer and correlated with the NIR-predicted density. Results of this evaluation indicate that the two tests are significantly correlated ($P<0.001$), however, the correlation is weak ($r=0.49$). The Stenvert grinder was used to measure kernel hardness and its relationship to grit yield. This test includes measurement of grinding time, amount of coarse material (grits), and particle size analysis. Standard operating procedures (SOPs) were developed for tempering corn and performing the Stenvert grinding test. Three different flows for laboratory dry milling were tested to decide which one provided the highest percentage of low fat (<1%) grits. We selected the milling method developed by Reddy (1996). Corn samples 1 kg in weight were milled and the following fractions were created: #1 grits, #2 grits, meal, cones, flour, feed coarse, feed fine. Correlation analysis between corn quality test results and grit yield was performed (Table 1).

Table 1. For each Predictive test, the first row is the Pearson correleation coefficient and the second row is the Probability (P) value.

Predictive Test	#1 Grits	#2 Grits	Total Grits
NIR Density	0.30	- 0.09	0.15
	< .01	0.40	0.16
Pycnometer Density	0.48	0.24	0.49
	< .01	0.02	< .01
Stenvert Grinding Time	0.21	- 0.18	0.03
	0.07	0.10	0.80
Stenvert Volume	0.35	- 0.03	0.06
	< .01	0.79	0.61
Stenvert Coarse to Fine Ratio	-0.08	- 0.02	- 0.01
	0.51	0.84	0.96

SIGNIFICANCE: A newly established K-State research and extension food grade corn evaluation program serves an emerging value-added industry for Kansas corn growers.

A Short Season Corn Extension Educational Program in Southeast Kansas

Researchers and Unit:
Gary Kilgore and Sarah Fogleman, Southeast Area Extension Office

Funds (FY 02): $3,950 Completion Date: June 30, 2004

JUSTIFICATION: In Southeast Kansas, corn acreage has more than doubled in the last 12 years. In fact, in the last 4 years acreage has increased by 50%. That is due to the planting of short season corn on the upland sites. Experiment station data shows that short season corn is much more reliable in yield than full season corn on upland sites. In fact, if it can be planted early (March 25 to April 10) experimental results show it is more profitable than grain sorghum. The time is now right to hire some part-time labor and greatly expand our education program. Producers are asking for on-farm trials to determine plant populations, correct nitrogen rates and proper hybrids to grow on our shallow upland soils, genetic engineered plants, and starter fertilizer rates. We have developed an outstanding relationship with commercial company representatives, and they also now look for and use our results.

OBJECTIVES: This is an Extension Education Program and is designed to take current research from the Southeast Kansas and East Central Kansas Experiment Stations to farmers' fields and show production and economic benefits. Taking the University to the people is the goal. Objectives are to establish on-farm demonstration trials that will include:
1. Determine the effects of phosphorus placement using different plant populations.
2. Evaluate 15 and 30 inch row corn planted with two different plant populations.
3. Determine optimum nitrogen rates on upland short season corn.
4. Measure response of short season corn to topsoil thickness.
5. Increase the number of on-farm trials to measure BMP's on those farms.

Each of the above objectives will include an economic analysis.

RESULTS:
1. Fertility trials on corn following soybean showed that 40 lb/a nitrogen (N) was all that was required for optimum production. That is a savings of 60 lb N/a and a cost savings of $12.00 per acre.
2. Phosphorus applied below the soil surface resulted in increased yields and reduced the application rate by 20%. This in turn reduces phosphorus runoff by 65% compared to surface applications. In addition, there was a cost savings of $7.50 per acre in fertilizer alone.
3. Weed control in Roundup Ready corn in Southeast Kansas can be a problem. Due to early plantings and slow weed emergence, on-farm trials show that weed growth occurs after corn reaches labeled height for Roundup application. For best results, a preemerge herbicide should be used with drop nozzles for postapplication on corn.
4. At a 90 bu yield level, 15-inch row corn produced 18% lower yields than corn in 30-inch rows at the same population.
5. Planter speed affects seed drop. Planting faster than 6 MPH reduced seed population drop by 18%. Depending upon seeding rate, that reduced population actually increased yields in 3 of the 4 sites.

SIGNIFICANCE: Over 2,300 producers toured the field sites or participated in an educational program where the data were discussed. A survey of Southeast Kansas producers indicated that 70% of those producers accept recommended practices within 3 years after first exposure to the new information. That being a fact, this educational program potentially could increase Southeast Kansas producers' income by $900,000.

Iron Chlorosis: Addressing a Familiar Problem with New Technology

Researchers and Units
Alan Schlegel, Southwest Research-Extension Center; Curtis Thompson, Southwest Area Research and Extension Office; Randal Taylor, Biological and Agricultural Engineering; John Schmidt, Agronomy

Funds (FY 02): $12,000 Completion Date: Ongoing

JUSTIFICATION: Results from 1999 and 2000 were very positive, indicating that the return from increased yield should be greater than the costs of applying the additional fertilizer and should also cover the costs of using new technology. Ten to 20% of the fields in this study had problematic areas that were related to the presence of soil $CaCO_3$ (based on aerial photographs). If we assume that yield is reduced in 15% of the field and that an $FeSO_4$ monohydrate application will increase yield by 35 bu/a in 4 out of 7 attempts (similar to small-plot studies), an estimated per acre return of $3.41 is possible. In the 14 counties that make up SW Kansas, there were 786,000 acres of corn planted in 1998 (Kansas Farm Facts, 1999). This translates to a $2,680,000 net increase in return for corn producers in SW Kansas. Preliminary greenhouse studies in 1999 and 2000 indicated that an additional application of P provided greater corn growth (in 5 weeks) than Fe applied by itself. Applying P with the Fe treatment may result in an even more consistent yield response than observed in 1999 and 2000. Also, at the request of corn producers in SW Kansas, manure has been added as a treatment. Iron deficiency is common to SW Kansas, although the exact extent of Fe-deficient soils is not documented. A realistic estimate for western Kansas is close to 10% of the area. Common remedies to correct for Fe deficiency

include applications of foliar Fe, Fe fertilizer, or manure. None of these remedies have addressed one major problem associated with Fe chlorosis – spatial variability of Fe-deficient soils. With recent advances in precision farming, we now have the technology to apply $FeSO_4$ to only the Fe-deficient areas of the field.

OBJECTIVES:

1. Increase profitability of corn in SW Kansas by using precision farming technology to correct the spatially variable Fe-deficiency problem. To address this problem, several specific tasks will be completed:
   Determine the correct application amount of Fe sulfate (monohydrate) for corn production in SW Kansas. Compare the monohydrate treatment to current Fe-foliar applications, liquid Fe sulfate, additional P treatments, and manure.
2. Successfully identify the spatial distribution of Fe deficiency using yield maps, aerial photography, and selective soil sampling.
3. Demonstrate the use of precision farming technology to apply the appropriate rate of Fe sulfate in the desired areas of the field.
4. Determine the cost of targeting the correct treatment to problematic areas and economic return on a whole-field basis.

RESULTS and SIGNIFICANCE: After 3 years of small-plot work and whole-field work on Fe chlorosis in corn, in-row placement of iron sulfate has proven relatively effective in improving yield in problematic areas of the field. On average, a 70 lb/a rate of $FeSO_4H_2O$ improved grain yield by 13 bu/a. Identifying problematic sites could be accomplished by using yield monitors and/or bare soil aerial photographs. Once these problematic areas are identified then the same maps could be used repeatedly to target $FeSO_4H_2O$ applications to the same area each year. There was some inconsistency in the response among sites. Additional research should be directed at identifying sites that will respond to the fertilizer treatments routinely.

In four out of the seven site-years (1999 and 2000), the addition of $FeSO_4$ monohydrate increased grain yield an average of 35 bu/a with addition of 72 lb product/a (Fig. 1). At the other three site-years, there was not a response to the $FeSO_4$ monohydrate. Grain yield was not consistently affected by any of the other treatments at all of the sites. The return at four of seven site-years is more than sufficient to justify the costs of the $FeSO_4$ monohydrate treatment. In addition to small plots, $FeSO_4$ monohydrate was applied to strips in three separate fields at a rate of 72 lb product per acre. Application strips were positioned to intersect a known Fe deficient area in the field. Aerial photographs, yield maps, and soil samples were used to place these strips across problematic areas. Lighter colored areas on the photographs corresponded to greater soil $CaCO_3$ content and lower yield (1999) compared to other areas of the field. In 2000, yield within the strip (receiving $FeSO_4$) was compared to adjacent areas outside the strip (no $FeSO_4$ applied).When $FeSO_4$ monohydrate was applied in the lighter colored area of one field, grain yield increased by 21 bu/a. At two other fields and for a similar comparison for problematic areas of the field, applying $FeSO_4$ monohydrate increased yield by 6 bu/a in one field and not at all in the other field.

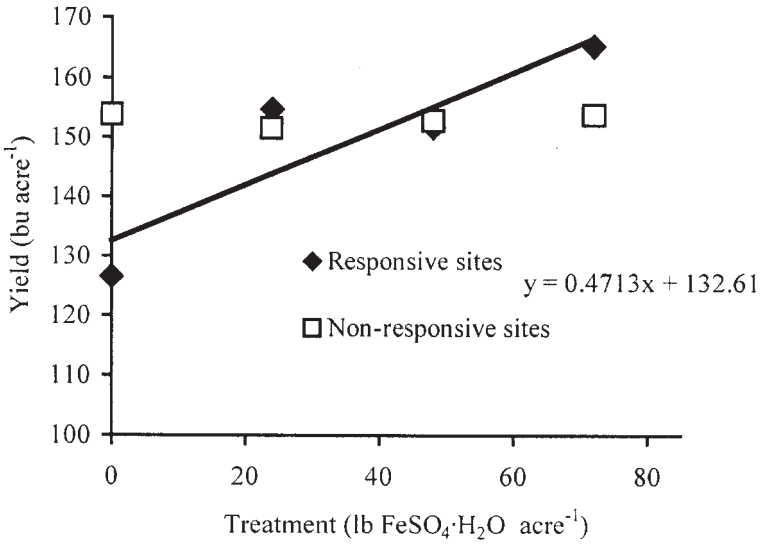

Figure 1. Average grain yield response to $FeSO_4$ monohydrate placed in the seed row at planting for responsive sites (4 total) and unresponsive sites (3 total).

The results from this study have been published in the Fertilizer Research Reports for the last 3 years. These reports are available to all Extension Agents in the State. Additionally, a manuscript has been accepted in the Agronomy Journal, and will be published in 2003. Chad Godsey was the graduate student on this project. He has successfully completed his thesis and M.S. degree and is currently working on his Ph.D. while working in KSU's Soil Testing Laboratory. His thesis has already been forwarded to the Corn Commission office. He provided excellent service to this project and continues to provide the same level of service to Kansas' corn producers in his current position.

Irrigated Cropping Systems to Reduce Irrigation Water Use and Groundwater Depletion While Sustaining Profitability

Researchers and Units
Alan J. Schlegel, Southwest Research-Extension Center; Loyd Stone, Agronomy; Troy Dumler, Southwest Area Extension Office

Funds (FY 02): $12,000 Completion Date: Ongoing

JUSTIFICATION: Most groundwater pumped from the High Plains (Ogallala) Aquifer in western Kansas is used for irrigation, with corn being the predominant irrigated crop. Groundwater withdrawal from the aquifer has reduced saturated thickness and well capacities. While corn responds well to irrigation, it also requires substantial amounts of water to maximize production. Alternative crop management practices are needed to reduce the amount of irrigation water required while striving to maintain economic returns sufficient for producer (and community) sustainability. To prepare for less water available for irrigation in the future, whether from physical constraints (lower well capacities and declining water tables) or from regulatory limitations, information on crop productivity and profitability with less irrigation water will be beneficial for agricultural sustainability.

OBJECTIVES:
1. Determine crop rotations that can be used with limited irrigation to reduce irrigation water use while maintaining producer profitability.
2. Determine the impact of limited irrigation on crop yield and profitability.

RESULTS: Grain yields in 2001 generally increased with increased levels of irrigation.

	Crop			
Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - - - - bu/acre - - - - - - - -			lb/acre
5	124	124	34	1725
10	169	149	41	1978
15	184	172	47	1759

Crop water use efficiency (amount of grain produced per unit of water use) was 3 times greater for feedgrain crops (corn and sorghum) than for oilseed crops (soybean and sunflower). An economic analysis found that grain sorghum was the most profitable (return to land, irrigation equipment, and management) crop with 5 inches of irrigation, while corn was the most profitable crop with 10 or 15 inches of irrigation. For all crops except sunflower, profitability increased with increased irrigation amount.

SIGNIFICANCE: Although this is only the first year's results, corn seems to be a good choice when adequate water is available to obtain good yields. However, at lower levels of irrigation, grain sorghum is a reasonable alternative to corn. Since feed grain crops produce more grain per unit of water than do oilseed crops, the relative price difference between the two types of crops must increase in favor of oilseeds to make them more profitable than feedgrains under irrigation.

Manure and Water Management for Environmental Protection and Corn Production

Researchers and Units
Tom Willson and Alan Schlegel, Southwest Research-Extension Center; Mahbub Alam and Troy Dumler, Southwest Area Extension Office

Funds (FY 02): $10,712 Completion Date: June 30, 2002

JUSTIFICATION: Southwest Kansas includes the leading counties in the state in both irrigated corn production and in animal feeding. Roughly 15% of the nation's beef feedlot capacity is in SW Kansas and this represents the single greatest internal market for Kansas corn producers. A standing stock of over 2 million cattle consume more than 20,000 dry tons of feed a day. If only 40% of that feed were from corn it would represent a total demand of over 100 million bushels per year. These same feedlots produce 5 million tons of manure per year with an N content of about 100,000 tons. If this material were returned to the soil on a plant-need basis it could supply the N needs for virtually all of the corn acreage in SW Kansas, while simultaneously increasing soil quality and micronutrient fertility.

Unfortunately the availability of cheap, convenient anhydrous ammonium, and the high cost of hauling manure have created a situation where far too much manure is applied on far too little acreage, threatening groundwater and surface water quality, and forcing most corn farmers to manage much lower quality (less fertile and more fragile) soil than would be the case if manure application were part of their management system.

OBJECTIVES:

1. To evaluate current best management strategies for the application of dry cattle manure and irrigation water in Western Kansas corm production
2. To quantify the economic and environmental costs of over- and under-applying these resources.

The overall goal is demonstrate the effectiveness of manure management under a variety of irrigation conditions and to develop the simplest possible management tools to encourage responsible manure and irrigation water use. Specific sub-objectives are:

1. Measure the response of corn yield with conventional fertilizer and three rates of manure application under four irrigation water treatments.
2. Estimate the corn nitrogen uptake in response to these fertilization and water treatments.
3. Measure nitrogen leaching in response to these fertilization and water treatments.
4. Monitor changes in soil phosphorous resulting from these fertilizer and water treatments.

RESULTS: Field plots were established under a variable rate, linear move sprinkler system at the KSU SW Research-Extension Center in Tribune in spring 2001, following a previous season with the same design under a pivot system in Garden City, KS. The decision to move the experiment resulted in a later than optimal planting date in Tribune (May 18), and required the use of a short season (100 day) hybrid. Four fertility treatments were established (0 N, 1X fertilizer N, 1X solid feedlot manure N, and 2X feedlot manure N based on soil test) and evaluated in combination with four irrigation treatments (dryland, 0.5X, 1X, and 1.5X full irrigation based on estimated ET). Soil moisture was monitored throughout the growing season using neutron probes and this data was used to verify the ET-based irrigation scheduling model used, a pre-curser to the KanSched 110 model. The plots were harvested during the First quarter of FY 2002 and the soil was sampled for changes in residual nitrate, soil test phosphorous and salt accumulations during the Second quarter of FY 2002. All plant, soil and water use data were evaluated during the Third and Fourth quarter, and a second crop was planted and managed through the Fourth quarter using KanSched 110 for irrigation scheduling. Corn Commission funding was terminated at the end of FY 2002, although some data analysis will be possible this year using a grant from the Kansas Department of Health and Environment.

Treatment yields ranged from 55 to 166 bu/a, which includes a significant yield reduction (about 12% overall) caused by a severe outbreak of common smut. Plots at the edge of the field were infected in a vegetative state (probably aided by wind injury) and the second generation of spores was released into downwind plots causing a 50% or greater yield reduction in the about 20% of the plots.
When the smut effect is removed, there are statistically significant effects of both irrigation and fertility treatments on yield. The manure treatments significantly outperformed the Conventional and Zero N treatments across all irrigation levels. The poor yield performance of the conventional fertility treatment is particularly surprising because this treatment (broadcast ammonium nitrate incorporated prior to planting) resulted in greater vegetative production and much more N uptake overall than any of the other treatments. While the 2X manure treatment did not significantly out-yield the 1X treatment, it did result in a greater accumulation of P. Bray P increased by 8 ppm during the growing season in the

2X treatment whereas it remained about the same in the 1X treatments and decreased in the decreased by 8 ppm in the non- manure treatments. All treatments decreased in nitrate from April to November. The decrease was greatest in the 1X manure treatment, which duplicates the findings of the 2000 growing season in Garden City.

All fertility treatments responded to increased water availability in a nearly linear fashion. It would appear that optimal irrigation was not achieved in the 1X treatment, in part due to an ill-timed breakdown of the linear move system during peak water demand. The greater water storage allowed by "excessively" irrigating allowed that system to weather the down time better than the 1X system. A comparison of theoretical crop ET and actual irrigation inputs confirms that the 1X treatment fell behind demand in July and stayed somewhat in deficit for the remainder of the season. A comparison of model predicted soil moisture with actual soil moisture measurements shows that the model was generally effective in predicting water use, but that it would have been more effective if it were corrected for the use of a short season corn variety. This recommendation will be incorporated into future versions of KanSched.

SIGNIFICANCE: We have been able to show that manure is an effective tool for enhancing yield in irrigated and non-irrigated corn production, and that its use, even at high rates and in combination with "excessive" irrigation poses no threat to groundwater in the first year of application. While excessive levels of residual N and N leaching have been associated with long-term over-application of manure, a single high manure application is probably less dangerous to groundwater than an over-application of commercial N fertilizer, provided that the future mineralization of this manure is accounted for by soil tests and appropriate credits. The KSU manure credit system is being greatly revised this year, but it remains to be seen whether the new system improves results, or merely makes application more complicated – and therefore less desirable – for producers. We advocate the simplest possible system that includes annual tracking of residual soil N.

The relatively poor yield performance of conventional pre-plant fertilization may be an important result for farmers in SW Kansas given that excess fertilizer N was taken up in vegetative tissue, but not converted to grain in this experiment. Excessive N fertility early in the season produced lush vegetation, but probably reduced root growth and root:shoot ratio. When water stress occurred later in the season, the commercially fertilized plants were the most susceptible and were unable to convert their high N content into yield. The manure-amended corn performed much better under water stress. It is likely that this is due to a more gradual release of N (in which case a split fertilizer application would have performed better than pre-plant); other factors such as water holding capacity and micronutrient fertility likely are also involved.

Finally, this experiment displays both the advantages and the dangers of using an ET-based irrigation scheduling approach to irrigation applications. For maximum yield under optimum conditions it is best to manage irrigated corn to a shallow root zone (approximately 2 ft for full irrigation). Unfortunately, choosing to do this with an ET-based model reduces the margin for error. In this case, moisture levels below the irrigated root zone were low, so even a temporary deficit in the top 2 ft resulted in significantly reduced yields in the 1X treatment. It is clear that a safety net should have been established (either before or during the season) by allowing irrigation water to penetrate to a depth greater than 24 inches. It is common – indeed normal – for equipment to break down or for ET to exceed the maximum application rate for a typical commercial sprinkler system. Our BMP's for water management (including the use of irrigation scheduling programs) must be adjusted to recognize this concept or both yield and application efficiency will be reduced when a problem does occur.

KANSAS GRAIN SORGHUM COMMISSION

Grain Sorghum Production in Kansas: Extension and Applied Research

Researcher and Unit
Dale L. Fjell, Agronomy

Funds (FY 02): $4,000 Completion Date: Ongoing

My extension and applied research for grain sorghum production in Kansas during July 1, 2001 to June 30, 2002 consisted of many activities across the state. The quarterly reports list my activities. I have listed a few of the highlights during the past reporting year.

1. I established a number of grain sorghum population experiments on farmer fields around the state. This data was used at many extension winter meetings.
2. I was an invited speaker at the four state cropping system conference held in Pierre, South Dakota. My topic was extension activities in Kansas concerning cropping systems which included grain sorghum production.
3. I traveled to the following regional and national meetings: North Central Weeds Society Annual Meeting in Milwaukee; Agronomy Society of American Annual Meeting in Charlotte, NC; Commodity Classic in Nashville.

With the funding available from this grant I was able to get to more places around the state and not worry about depleting the Extension Agronomy's travel funds. With the next year's extension budget essentially nonexistent the only way that I will be able to travel both in-state and out-state will be with funding from this grant. Thank you for continuing to fund my extension and research efforts.

Improving the Crop Safety and Weed Control Efficacy of Metsulfuron Based Herbicide Programs for Sorghum

Researchers and Unit
Kassim Al-Khatib and David L. Regehr, Agronomy

Funds (FY 02): $12,800 Completion Date: June 30, 2002

JUSTIFICATION: Although metsulfuron is effective on several common weeds in grain sorghum, sorghum injury may occur. There have been complaints of injury due to metsulfuron, and there have been reports of possible differential grain sorghum hybrid responses to metsulfuron. Grain sorghum treated with metsulfuron exhibits stunting, lodging, chlorosis, excessive tillering, and yield reductions. Grain sorghum injury may be mitigated when metsulfuron is tank mixed with 2,4-D. Metsulfuron + 2,4-D tank mixes may also increase the weed control spectrum compared to metsulfuron applied alone. While research has shown that 2,4-D may safen against metsulfuron injury to grain sorghum, the level of safening has not been determined. In addition, it is not known whether other growth regulator herbicides, such as dicamba, clopyralid, or fluroxypyr, will also safen against metsulfuron injury.

OBJECTIVES:

1. Evaluate weed control with metsulfuron herbicide (DuPont trade name, *Ally*) applied in tank mixtures with 2,4-D, dicamba (*Clarity*), clopyralid (*Stinger*) and fluroxypyr (*Starane*).
2. Compare metsulfuron safety on grain sorghum when applied with 2,4-D, dicamba, clopyralid and fluroxypyr.
3. Evaluate grain sorghum hybrid response to tank mix of metsulfuron + 2-4-D.

RESULTS: Field and greenhouse experiments were conducted to evaluate the efficacy and safening of metsulfuron applied with dicamba, 2,4-D, clopyralid, and fluroxypyr with and without nonionic surfactant (NIS). We also studied the response of 20 sorghum hybrids to metsulfuron + 2,4-D. Greenhouse data shows that 2,4-D and dicamba safened sorghum against injury, but fluroxypyr did not safen sorghum against injury. In the field study, sorghum injury decreased when 2,4-D and dicamba was tank mixed with metsulfuron, whereas clopyralid and fluroxypyr caused little to no reduction in injury. Sorghum injury was greatest at 1 and 2 WAT, but plants recovered from injury at 4 WAT. Ivyleaf morningglory was controlled at 4 WAT by 95, 84, 59, and 91%; and velvetleaf was controlled by 88, 82, 78, and 95% when metsulfuron was tank mixed with 2,4-D, dicamba, clopyralid and fluroxypyr, respectively. This study shows that 2,4-D, and dicamba safened metsulfuron to sorghum injury, while maintaining high levels of weed control.

Field experiments to study differential sorghum hybrid responses to metsulfuron + 2,4-D were conducted in 2000 and 2001 at Ashland Bottoms research farm near Manhattan, Kansas. Sorghum hybrids were selected to represent a broad range of genetic diversity, and to encompass sorghum hybrids popular among producers in Kansas. In general, metsulfuron + 2,4-D caused visible injury to all hybrids at 1 and 2 weeks after treatment (WAT). However, plants recovered from symptoms, and some hybrids appeared normal at the end of the growing season. Differential hybrid responses to metsulfuron + 2,4-D application were observed at 1 and 2 WAT in 2000, and 4 WAT in 2001. In addition, plant heights of Garst 5440, Garst 5515, and Mycogen 1506 were reduced by application of metsulfuron + 2,4-D in both 2000 and 2001. Furthermore, there was a differential delay in flowering data in 2000. In 2001 metsulfuron +2,4-D delayed flowering by as much as 3 days, averaged over all hybrids, but there was no differential hybrid response. Overall, this study shows a differential hybrid response to metsulfuron + 2,4-D.

SIGNIFICANCE: This study shows that metsulfuron applied alone injures sorghum. However, grain sorghum injury safening does occur when 2,4-D and dicamba are tank mixed with metsulfuron. Morningglory and velvetleaf injury were greater when metsulfuron was tank mixed with 2,4-D or dicamba. In spite of excellent weed control with application of metsulfuron + fluroxypyr, fluroxypyr and clopyralid should not be incorporated in a metsulfuron-based herbicide program as they do not decrease metsulfuron injury to sorghum. Finally, differential hybrid responses in flowering date, plant height, visible injury and yield occur when metsulfuron + 2,4-D is applied.

Breeding Sorghum with Improved Grain Yield, Greenbug and Virus Resistance, and Pre-Flowering Drought Tolerance

Researchers and Units
K.D. Kofoid and D.L Seifers, Agricultural Research Center – Hays: T.L. Harvey and J. Reese, Entomology; M.R. Tuinstra, Agronomy

Funds (FY 02): $70,000 Completion date: June 30, 2002

JUSTIFICATION: Greenbugs are the most economically important insect pest of sorghum in Kansas. Genetic resistance is the most cost effective control of this pest. Development of tolerance to the greenbug may help reduce the occurrence of biotype changes in the future. Other important considerations for making sorghum a preferred crop in Kansas include development of improved drought tolerance, increasing yields, and developing disease resistance. Viral diseases are a major problem in western Kansas.

OBJECTIVES:
1. To develop and release grain sorghum parental lines and germplasm with higher grain yield that incorporates genetic factors for greenbug resistance, virus resistance and pre-flowering drought tolerance.
2. To evaluate tolerance to greenbug in sorghum using SPAD meter measurements of chlorophyll loss.

RESULTS: *Greenbug:* Screening of segregating families for greenbug resistance was continued. More than 2,000 lines were screened and over half were found to be resistant. Development of new parental lines with greenbug resistance was continued in the winter nursery. More than 200 A/B pairs, most with tan plant color, were backcrossed utilizing both summer and winter nurseries. Several of these A/B's are being considered for release in the fall. Hybrids involving new R lines were also planted in the field. A new reciprocal recurrent selection scheme involving greenbug resistant B and R populations was initiated. These populations are tan plant types and both red and white seeded types are being developed. More than 1,200 new exotic germplasm lines were screened for greenbug resistance. Four of these lines survived and will be screened again to determine if they are resistant.

Greenbug tolerance: The fourth cycle of selection for tolerance was continued. Analysis of data from the first 4 cycles of this study showed that selection has increased the percentage of tolerant types from just over 10% in the first cycle (screened with biotype I greenbugs) to nearly 50% in the fourth cycle (screened with biotype K greenbugs). With appropriate random mating, we expect the proportion of tolerance to increase even more rapidly.

Drought: Two greenbug resistant populations (one B and one R population) were grown under high population density (240,000 plants/a). Photosynthesis (Ps) will be measured on S1 families and selection will be based upon the maintenance of Ps under stress.

Virus: Infection of a susceptible genotype (KS 81) with sugarcane mosaic virus resulted in one plant surviving and producing seed. Each of the 51 seeds was planted in the greenhouse and the resultant plants were harvested and their seed was planted in the field. The seed produced on these plants will be harvested and their progeny will be compared to selections from KS 81 that have not been infected with SCMV. The objective of this project is to determine if changes can be made in the plant's genome by infection with the virus.

SIGNIFICANCE: The development of new A/B lines with greenbug resistance means resistance can come from either or both parents in a hybrid. The greenbug resistant selections that survived the screening have very high levels of resistance since the greenbug resistant check hybrid was killed in many of the tests. Finding additional sources of resistance should help broaden the genetic base of greenbug resistance. We will also need to keep a close watch on the greenbug biotype to determine any shifts in the predominate biotype. The association of greenbug feeding, chlorophyll loss, and reduced photosynthesis has helped to confirm our determination to develop tolerance. In addition, the steady increase in tolerance combined with the change of biotypes after the second cycle reaffirms our idea that tolerance can be induced. Reducing chlorophyll loss by greenbug feeding should improve plant performance. Using viruses to select for yield improvement is a new concept and will require further testing to determine if this is a feasible approach. If this works, it may be possible to introduce new genes into sorghum to improve quantitative traits.

Transformation of Sorghum for Enhanced Stalk Rot Resistance and Drought Tolerance

Researchers and Units
George H. Liang, M.R. Tuinstra, Agronomy; S. Muthukrishnan, Biochemistry

Funds (FY 02): $57,500 Completetion Date: Ongoing

JUSTIFICATION: Grain sorghum is the number two crop in Kansas, second only to wheat. Sorghum plants are well adapted to the climatic conditions found in Kansas and throughout the southern Great Plains. It is an important source of feed for the cattle industry. However, loss of grain sorghum due to fungal pathogen attacks is measured in millions of dollars each year. The unpredictable dry weather has often reduced the yield – for example, in the drought-stricken year of 2002 the sorghum crop was the worst in 17 years. Increasing atmospheric CO_2 concentration (260 ppm in 1860 and an estimated 360 ppm in 2000), global warming, and a drier climate are expected in the future. The worsening of biotic and abiotic stresses for sorghum plants provide strong rational to produce pest resistant plants that also are tolerant to water stress through novel means or genetic engineering techniques. Pyramiding genes for better resistance to fungal pathogens is a safeguard against yield loss. We have been trying to incorporate the genes encoding chitinase and thaumatin-like proteins, respectively, into sorghum inbred lines, C401 and Tx 430, using biolistic bombardment and *Agrobacterium*-mediated transformation for stalk rot resistance.

Our preliminary data have shown that the gene encoding for thaumatin-like protein also provide drought tolerance in addition to resistance to stalk rot caused by fungal pathogens (*Fusarium thapsinum* and *F. moniliforme*). In addition, we have made the construct for *Hva 1* gene encoding the late-embryogenesis-abundant protein for drought tolerance. The protein produced by the *Hva 1* gene, which leads to accumulation of low-molecular-weight osmolytes resulting in increased tolerance to water and salt stress in transgenic plants, plays a protective role in plant cells under various stress conditions. Increased drought tolerance has been shown in rice, wheat, and creeping bentgrass where the *Hva 1* gene is incorporated. The gene (G 11) that encodes chitinase is able to hydrolyze chitin present in cell walls of most fungi and thus protect transgenic plants from attack by pathogens causing stalk rot, sooty stirpe or charcoal rot. We have shown that G11 is able to confer partial resistance to stalk rot.

OBJECTIVES: The goal of this project is to transform grain sorghum plants with genes conferring resistance to stalk rot caused by Fusarium species and those conferring drought tolerance. In addition, we will use the new reporter gene, green fluorescence protein (GFP) and a new selectable marker, mannose 6-phosphate isomerase (MPI), to facilitate the selection of putative transgenic plants.
To accomplish those goals, we propose to:

1. Make vector constructs containing the reporter gene, GFP, and the selectable marker, MPI (and the target genes of interest, such as *TLP*, *G11*, *Hva 1)*, and test their effectiveness in selecting transgenic plants.
2. To avoid gene silencing, we use *Agrobacterium*-mediated transformation to produce more and stable transgenic plants carrying *TLP* gene and *GFP* reporter gene. When the technique is successful, *G11* gene also can be incorporated using *Agrobacterium*.
3. Testing a new transformation approach, pollen-mediated transformation, that could bypass the use of tissue culture.

RESULTS: *Construction of pPZP201-GFP-TLP plasmid:* The plasmid DNA containing GFP and TLP have been mixed with competent cells of *Agrobacterium* strain EH101 and electroporated; the recombinant colonies were checked and verified. The resulting *Agrobacterium* strain containing pPZP201-GFP-TLP has been utilized for sorghum transformation.

Sorghum transformation: Both GFP and MPI have been successfully incorporated into sorghum plants, where an accurate screening and identification of the marker genes are made. Green fluorescence appeared in shoots, roots, and leaves of those regenerated putative transgenic plants of C401, indicating transformation is effective. Selection of transformed calli and regenerated seedlings was made by incorporating mannose (2.0%) into the medium in which the calli and seedlings were grown. Transgenic plants are identified suggesting that MPI also can be an effective selectable marker gene. Both GFP and MPI should replace the *bar* gene and *cah* gene, which are not desirable markers after repeated trials. *Agrobacterium*-mediated transformation with pZP201-GFP-TLP was successful, confirming our previous experiments that the bacterium can be effectively used as a transformation tool. Transgenic plants from both C401 and a commercial hybrids (name to be identified later) are produced.

Pollen-mediated transformation: To circumvent tissue culture where most sorghum genotypes fail to respond, we are developing and testing a pollen-mediated transformation approach in which pollen grains are treated with plasmid DNA solution from pPZP201-GFP-TLP and pollinate the male sterile plants. Results have yet to be determined.

Irrigated Cropping Systems to Reduce Irrigation Water Use and Groundwater Depletion While Sustaining Profitability

Researchers and Units
Alan J. Schlegel, Southwest Research-Extension Center; Loyd Stone, Agronomy; Troy Dumler, Southwest Area Extension Office

Funds (FY 02): $12,000 Completion Date: Ongoing

JUSTIFICATION: Most groundwater pumped from the High Plains (Ogallala) Aquifer in western Kansas is used for irrigation, with corn being the predominant crop. Groundwater withdrawal from the aquifer has reduced saturated thickness and well capacities. While corn responds well to irrigation, it also requires substantial amounts of water to maximize production. Alternative crop management

practices are needed to reduce the amount of irrigation water required while striving to maintain economic returns sufficient for producer (and community) sustainability. To prepare for less water available for irrigation in the future, whether from physical constraints (lower well capacities and declining water tables) or from regulatory limitations, information on crop productivity and profitability with less irrigation water will be beneficial for agricultural sustainability.

OBJECTIVES:
1. Determine crop rotations that can be used with limited irrigation to reduce irrigation water use while maintaining producer profitability.
2. Determine the impact of limited irrigation on crop yield and profitability.

RESULTS: Grain yields in 2001 generally increased with increased levels of irrigation.

	Crop			
Irrigation amount	Corn	Sorghum	Soybean	Sunflower
inches	- - - - - - - - - - bu/acre - - - - - - - -			lb/acre
5	124	124	34	1725
10	169	149	41	1978
15	184	172	47	1759

Crop water use efficiency (amount of grain produced per unit of water use) was 3 times greater for feedgrain crops (corn and sorghum) than for oilseed crops (soybean and sunflower). An economic analysis found that grain sorghum was the most profitable (return to land, irrigation equipment, and management) crop with 5 inches of irrigation, while corn was the most profitable crop with 10 or 15 inches of irrigation. For all crops except sunflower, profitability increased with increased irrigation amount.

SIGNIFICANCE:
Although this is only the first year's results, corn seems to be a good choice when adequate water is available to obtain good yields. However, at lower levels of irrigation, grain sorghum is a reasonable alternative to corn. Since feed grain crops produce more grain per unit of water than do oilseed crops, the relative price difference between the two types of crops must increase in favor of oilseeds to make them more profitable than feedgrains under irrigation.

Breeding Grain Sorghum for Improved Dryland Production

Researchers and Units
M.R. Tuinstra, M. Claasen, W.B. Gordon, K.A. Janssen, V.L. Marting, Agronomy; L.E. Claflin, Plant Pathology; K.D. Kofoid, Agricultural Research Center – Hays

Funds (FY 02): $55,000 Completion Date: June 30, 2002

JUSTIFICATION: Sorghum is economically important in areas where low and erratic rainfall and high temperature limit the production of other summer crops. The United States is the largest producer of grain sorghum in the world with nearly 10 million acres of grain production in 2001. The highest rate of return for grain sorghum producers is from dryland production.

OBJECTIVES:

1. Fusarium stalk rot resistance genes derived from SC134, SC564, SC580, SC599, SC1039, and C1154 will be characterized and incorporated into elite lines to improve stalk strength and lodging resistance.
2. Genetic sources of host-plant resistance to sooty stripe will be identified, characterized, and incorporated into elite U.S. parent lines.
3. Applied plant breeding efforts will focus on parent line development and germplasm enhancement to incorporate genetic sources of stalk rot resistance, sooty stripe resistance, and other important agronomic characteristics into lines that produce high yielding hybrids with broad adaptation across environments.

RESULTS: Sorghum lines and hybrids with tolerance to environmental stresses and resistance to disease and insect pressure are being developed to improve the profitability of sorghum production in the United States. This project has shed light on the genetic and physiological bases for important agronomic traits leading to increased stress tolerance and yield potential. Two dominant sources of Fusarium stalk rot resistance and one dominant source of charcoal rot resistance were identified in 2001. These genes are being incorporated into new pollinator and seed parent lines. One elite, pollinator line with outstanding yield potential and lodging resistance was identified for potential release in 2002. At least one dominant source of sooty stripe resistance was also tentatively identified in 2001. These lines are being tested in hybrid combinations to evaluate agronomic performance and yield potential in statewide trials.

SIGNIFICANCE: Our research will focus on applied germplasm enhancement and parent line development in order to deploy genes for stress tolerance into Kansas-adapted sorghum hybrids. The development of stress-tolerant cultivars will reduce production problems and contribute to improved management and production strategies. These breeding efforts are crucial to technology transfer because the commercial seed industry generally is not prepared to use “raw” germplasm sources identified through basic research activities. The development of lines with improved drought tolerance should translate into improved yield potential and stability of hybrids that are adapted for production in Kansas.

KANSAS SOYBEAN COMMISSION

Market Development Grant - International Grains Program Market Development Grant

Researcher and Unit
Brendan Donnelly, Grain Science and Industry

Funds (FY 02): $36,600 Completion Date: Ongoing

JUSTIFICATION: The world's feed manufacturers face increased competition, subsequently the costs and benefits of the raw materials used to manufacture their feeds face intense scrutiny. Additionally, they are often unaware of the US grain grading system, quality control procedures, and proper storage, shipping, handling, and sanitation processes. Foreign manufacturers often fail to properly use pricing, basis, futures markets, and price discovery because they are not trained in the fundamentals of these tools. An added complication is consumer sensitivity to genetically modified organisms (GMOs), requiring stronger educational efforts for consumers and manufacturers on GMO development, use, safety, and value.

OBJECTIVES:
1. To identify potential buyers of US soybean and soy meal in cooperation with the American Soybean Association (ASA) and the United Soybean Board (USB) and the USDA's Foreign Agricultural Service.
2. To solicit potential buyers and users to participate in short courses at the International Grains Program (IGP) that address the issues outlined above.
3. To identify opportunities in specific targeted markets with the ASA and USB where specifically designed IGP courses could be conducted in the country or countries targeted.
4. To maintain contact with individual participants to continually provide them with the latest information concerning soybean and soy meal utilization.

RESULTS: There were 160 persons from more than 50 countries who participated in eight formal IGP short courses during this fiscal year. Three of the short courses covered soybeans and corn, one covered sorghum and four covered wheat. Through numerous visits to meetings by IGP staff and from short term visitors, IGP made contact with several hundred additional US customers.

SIGNIFICANCE: Buyers of US soybean, soy meal and soy oil have a better knowledge of our grade, contracts, and price discovery mechanisms. They are able to purchase US soy products with more confidence and are able to obtain the exact product they need, thus enhancing their margins.

Soybean Production in Kansas: Extension and Applied Research

Researcher and Unit
Dale L. Fjell, Agronomy

Funds (FY 02): $4,000 Completion Date: Ongoing

My extension and applied research for soybean production in Kansas during July 1, 2001 to June 30, 2002 consisted of many activities across the state. The quarterly reports list my activities. I have listed a few of the highlights during the past reporting year.

1. I was an invited speaker at the Kansas Soybean Expo held in Topeka in January. I spoke on my trip to Brazil to view soybean production in that country.
2. I was an invited speaker at the four state cropping system conference held in Pierre, South Dakota. My topic was extension activities in Kansas concerning cropping systems that included soybean production.
3. I traveled to the following regional and national meetings: North Central Weeds Society Annual Meeting in Milwaukee. Agronomy Society of American Annual Meeting in Charlotte, NC. Commodity Classic in Nashville.

With the funding available from this grant I was able to get to more places around the state and without depleting the Extension Agronomy's travel funds. With the next year's extension budget essentially nonexistent the only way that I will be able to travel both in-state and out-state will be with funding from this grant. Thank you for continuing to fund my extension and research efforts.

Planting Date and Maturity Group Effects on Soybean Production in Kansas

Researchers and Units
Barney Gordon, Dale Fjell, Larry Maddux, and Bill Heer, Agronomy; Gary Kilgore, Southeast Area Extenstion Office; Jim Long, Southeast Research Center; Scott Staggenborg, Northeast Area Extension Office; Stewart Duncan, South Central Area Extension Office; Merle Witt, Southwest Research and Extension Center; Rob Aiken, Northwest Research and Extension Center; Carlyle Thompson, Agricultural Research Center – Hays.

Funds (FY 02): $70,000 Completion Date: June 30, 2003

JUSTIFICATION: Soybean acres continue to increase in Kansas. Soybean tolerance to a relatively wide range of planting dates has helped boost acceptance of this crop across the state. Nevertheless, soybean does have an optimum planting date that can differ by both region and cultivar. Identification of optimum planting date for yield would allow a crop to respond more favorably to effects of temperature, water stress, and photo period. Results from studies conducted in the north-central region that included combinations of planting dates, row widths, and cultivars, found that planting date was the variable having the greatest effect on yield. There has been interest in planting varieties in groups shorter than are normally grown in Kansas. Conflicting reports exist in the literature concerning optimum planting date for these short season soybeans. Little current information is available concerning soybean planting dates in Kansas with modern cultivars.

OBJECTIVES:
1. Identify optimum planting date for soybeans from a wide range of maturities over several environments in Kansas.
2. Characterize water use of soybeans in different maturity groups.
3. Study growth and development of soybeans as affected by planting date and maturity group.

RESULTS: Optimum planting dates in Kansas differed by location. At eastern and southeastern locations, yields were stable over a wide range of planting dates. Yields did not decline significantly until planting was delayed into the first week of July. Early maturing soybeans did not yield as well as soybeans in Groups IV and V. In central Kansas, yields declined when planting was delayed past the first few days in June. In general, soybean in Group II did as well or better than later maturing soybeans. Group V soybeans yielded poorly in south-central Kansas locations.

In areas of limited late summer precipitation, shorter season soybeans planted early in the season yielded better than fuller season soybeans. Fuller season soybeans use 3-5 inches more water during the growing season than did soybeans in Group II. The number of days from emergence to physiological maturity declined by 25% when planting date was delayed from late April until late June. Plant heights also declined as planting date was moved later in the growing season. Dryland soybean production in western Kansas proved to be a very risky enterprise.

SIGNIFICANCE: Soybean yields tend to decline with later planting dates. In central Kansas, yields decline when planting date is delayed past the first of June. In areas of limited rainfall, yields of short season soybeans have been stable over years and have been equal or better than yields of soybeans in later groups. The earliness of these soybeans allows producers to spread out harvest work load and more easily rotate to wheat following fall harvest.

Investigations of the Soybean Stem Borer in Kansas

Researchers and Units
R. Higgins, P. Sloderbeck, L. Buschman, S. Ramaswamy, Entomology; W. Schapaugh, Agronomy

Funds (FY 02): $36,600 Completion Date: June 30, 2002

Accomplishments since last report:
Objective 1. Investigate the seasonal occurrence of the soybean stem borer (SBSB) in Kansas. Data from 2001 is currently being combined with the data from 1999 and 2000 to develop a better understanding of the life cycle of the soybean stem borer under Kansas field conditions. In Republic County the beetles normally begin to appear about the 20th of June and peak adult numbers (based on sweep samples) occurred about the middle of July, but some adults were still being found in early September. In 2001, 76% of the beetles in the samples were collected in the three samples between July 2nd and July 16th. The first signs of larval damage began to become evident in the July 16 sample when up to 3% of the plants were recorded as having leaves dying due to stem borer larval feeding. Leaf death peaked on August 20th when up to 49% of the plants were showing signs of premature loss. This type of information will be very important in trying to pick the best time to treat for soybean stem borer adults. Treatments will need to be made after a significant percentage of the adults have emerged, but before the eggs are laid in the leaf petioles.

Objective 2. Evaluate varieties and cropping history to assess factors that may predispose fields to be heavily infested with soybean stem borer. Data are still being analyzed from the samples taken in the variety trials during 2001. Preliminary results indicate that lodging levels in a variety seem to vary greatly between trials, which may be an indication that other factors such as stem diameter, plant vigor or growing conditions may influence the amount of lodging. Lodging notes were taken 10 different times on selected varieties over a 7-week period from mid October to late November. In the dryland trial lodging was fairly stable over the period at about 12%, but in the irrigated trial lodging increased from 24% to 40% during the same time period.

Objective 3. Test the efficacy of various insecticides for reducing damage from the soybean stem borer. We developed a poster summarizing the insecticide bioassays completed on lambda-cyhalothrin (active ingredient in Warrior formulations), permethrin (active ingredient in Pounce and Ambush) and carbaryl (active ingredient in Sevin formulations). Our trials showed that very low concentrations of the pyrethroids, lambda-cyhalothrin and permethrin, caused high mortality of soybean stem borer adults and thus would be good candidates for future field trials.

Effects of Crop Rotation and Tillage Systems on Soybean Yield in SE Kansas

Researchers and Unit
Kenneth Kelley and Dan Sweeney, Southeast Agricultural Research Center

Funds (FY 02): $11,513 Completion Date: June 30, 2003

JUSTIFICATION: In southeastern Kansas, approximately 1.65 million acres are devoted to crop production. Soybean occupies 49% of the total acreage in the 15 county area, with wheat occupying 27%, grain sorghum 15% and corn 8%. Because of the diversity of crops grown in the area, this research seeks to investigate the long-term effects of crop rotation, tillage, and row spacing on full-season and double-crop soybean yield. Research is needed to determine which production practices produce optimum soybean yields for the climatic and claypan soil conditions in southeastern Kansas.

OBJECTIVES:
1. Evaluate crop rotation and tillage effects on full-season and double-crop soybean yield in a 3-yr rotation of [corn / grain sorghum] - soybean - [wheat - double-crop soybean].
2. Evaluate previous crop and tillage effects on double-crop soybean yield in a 2-yr rotation of [corn / grain sorghum / soybean] - [wheat - double-crop soybean].
3. Evaluate effects of tillage, row spacing, and Roundup (glyphosate) herbicide applications on full-season soybean yield in 2-yr rotation following grain sorghum.

RESULTS: In 2001, soybean grown in narrow row spacing (7.5- and 15-inch) yielded 33 bu/a compared to 28 bu/a for 30-inch rows; however, grain yields were affected very little by tillage method (conventional chisel - disk versus no-tillage) when full-season soybean followed grain sorghum in the crop rotation. In addition, one application of glyphosate applied 3 weeks after planting gave similar weed control and soybean yield as a split application of glyphosate (3 wks + 2 wks) or a residual herbicide at planting followed by a postemergence glyphosate application.

In a 2-yr cropping rotation, double-cropped soybean yielded 35 bu/a when corn or grain sorghum preceded wheat compared to 29 bu/a when full-season soybean preceded wheat. Also, double-crop soybean planted no-till into wheat stubble yielded the same or higher than soybean grown with disk tillage (no burning).

SIGNIFICANCE: Results indicate that double-cropped soybeans can be successfully grown using conservation tillage practices in shallow, claypan soil conditions. In addition, crop rotation is an important management tool for maintaining optimum soybean yields. Because of the acreage devoted to double-cropped soybean production in extreme southeast Kansas, significant long-term benefits to the soil and environment are possible. However, additional research is needed to determine where conservation tillage methods are best suited for the cropping systems used in southeastern Kansas.

A Soybean Extension Educational Program in Southeast Kansas

Researchers and Unit
Gary L. Kilgore and Sarah Fogleman, Southeast Kansas Area Extension Office

Funds (FY 02): $11,180 Completion Date: Ongoing

JUSTIFICATION: In an average year, soybean producers in the 21 counties that make up the Southeast Kansas State University Extension Administration Unit produce over 21 million bushels of soybeans. Eight of the top 10 soybean producing counties are in Southeast Kansas, and Southeast Kansas produces over 50% of the state's soybean crop. Southeast Kansas has special problems. Shallow soils result in reduced yields; but by planting date, tillage systems and variety selection yields have improved. Most of the production efficiencies were first learned by research then transferred to the farm. Shallow soils and long wet periods affect seedbed preparation. Research shows that only one or two passes of a tillage tool is necessary for optimum yields. Soybean row spacing and plant population has been shown to affect yields in research trials. Some producers have started using drills for planting, but are planting too much seed for optimum yields. Actual seeding rates with drills must be demonstrated on farms.

OBJECTIVES: There is considerable "lag time" between proven results at our experiment stations and adoption by producers on the farm. Our goal is to greatly speed up that process by taking the University research to the producer as an extension program. We will:

1. Use Roundup Ready soybeans and conventional soybeans in weed control programs and compare costs.
2. Establish trials with soybean varieties that are resistant to the Soybean Cyst Nematode (SCN) on SCN infested sites.
3. Use the field trials, not only to generate data for use at winter crop schools, but also show them off at county crop tours.
4. Other on-farm trials will include: plant population, soil fertility, row spacing, inoculation and pelletized lime.
5. Continue to conduct double-crop soybean variety trials.
6. Subject the production results to economic analysis to see if they are profitable.

RESULTS:
1. Four of the five upland no-till sites produced less yields than tilled plots. However, on bottomland, all no-till sites produced equal or higher yields than the tilled treatments. We saw higher water intake on the tilled treatments, and that is important on upland soils.
2. A fertility study comparing the recommendations of KSU with commercial soil test companies was very interesting. Recommendations ranged in cost from $12.42 for KSU to $32.81 per acre for one commercial company. KSU recommendations and other company's yields were about equal (3 bu difference), with KSU being the highest. That's a savings of $20.39 per acre and no yield decrease.
3. Planter speeds over 6 MPH resulted in lower plant populations than slower speeds. Partly due to "seed bounce," but mostly due to the fact that planters do not drop as much seed at higher speeds.
4. Surface applications of lime on no-till did not neutralize the soil or increase yields when compared to lime incorporated into the seedbed. The long-term effect has yet to be determined.

SIGNIFICANCE: Surface applications of lime on no-till ground has not neutralized the soil, resulting in yield loss of 4 bu/a. Following K-State soil test recommendations saved producers up to $20.00 per acre. A survey of producers showed that 70% accepted new production practices within 3 years after first exposure. Based on this fact and the fact that over 2,700 producers were "exposed" to this program, crop production efficiency potentially could increase more than $1.4 million.

Enhancing Soybean Germplasm Development

Researchers and Units
William Schapaugh, Agronomy; Tim Todd and Harold Trick, Plant Pathology; Jim Long, Southeast Research and Extension Center

Funds (FY 02): $203,500 Completion Date: June 30, 2002

JUSTIFICATION: This project provides information and technology that farmers in the state need to make their operations more profitable and will help solve on-farm problems by developing varieties for local adaptation and providing improved germplasm with enhanced traits such as yield, Soybean Cyst Nematode (SCN) resistance and iron efficiency. Host resistance continues to be the most successful and widely used approach to managing SCN. Continued management of this important soybean pest increasingly recognizes the necessity to integrate new sources of resistance with strategies to increase the durability of both new and existing resistance genes, as well as utilizing alternatives to classical resistance.

OBJECTIVES:
1. Develop soybean varieties for integration into Kansas cropping systems.
2. Develop germplasm to further genetic improvement.
3. Develop procedures and strategies to improve selection efficiency in soybean.
4. Evaluate strategies to manage important soybean diseases and pests using genetic resistance.

RESULTS: Over the past two years, nine soybean varieties were released by the Kansas Agricultural Experiment Station. Parent seed was distributed to growers of three conventional varieties (two varieties possess resistance to SCN), and six special purpose varieties (two high protein, a large seeded and three small seeded varieties). Several Roundup Ready varieties are nearing release.

The long–term study comparing strategies for deployment of resistance genes in the presence of diverse SCN populations has shown that: (1) continued planting of a resistant cultivar can result in increased nematode reproduction on the parental source of resistance, even when the level of resistance (i.e. number of resistance genes) varies between the cultivar and resistance source; (2) selection of a SCN population on a resistant cultivar is associated with a steady decline in performance of that cultivar; and (3) rotation of resistance sources is not a reliable method of managing selection pressure on SCN populations.

Our transformation efforts are continuing with over 50 independent soybean transformation experiments ongoing. These experiments include the introduction chitinase and glucanase genes for potential fungal control, chitinases and novel synthetic genes for nematode resistance and an antisense phospholipase D gene for increased shelf life of oil. Transgene analyses are continuing with these clones. We are also harvesting seeds from these transgenic lines to be added to greenhouse SCN and charcoal rot resistance trials.

SIGNIFICANCE: The varieties developed through this research represent high-yielding alternatives for soybean growers in Kansas. Evaluation of yield losses and population dynamics involving diverse SCN populations has emphasized the importance of increasing and maintaining diversity in the types of SCN resistance available to growers. New genetic material developed through the transformation effort may provide solutions to practical problems facing soybean production and soybean utilization.

Over-Expression of Antifungal Proteins in Transgenic Soybean

Researchers and Units
Harold N. Trick, Plant Pathology; Subbaratnam Muthukrishnan, Biochemistry; William T. Schapaugh, Agronomy

Funds (FY 02): $65,181 Completion Date: Ongoing

OBJECTIVES:
The goal of this project is to express the antifungal proteins in genetically engineered soybean to develop fungal disease resistance, especially to charcoal rot. To accomplish this goal we will:
1. Introduce chitinase and glucanase genes into soybean via particle bombardment.
2. Recover genetically engineered soybean plants and progeny with high levels of expression of the introduced genes.
3. Test transgenic plants for resistance to charcoal rot fungus as well as other pests such as soybean cyst nematodes.

RESULTS: Thirty-nine independent soybean transformation experiments are currently ongoing. Out of these experiments we have recovered 66 transgenic clones testing positive for the introduced genes. More clones are expected as the cultures progress through the selection process. At least 36 of these clones have been converted to plants and are being grown to maturity in the greenhouse. Transgene analyses are continuing with these clones to confirm integration and copy number of the introduce gene(s). We are also harvesting seeds from a few of these new transgenic lines that will be added to SCN and charcoal rot bioassays.

Molecular analysis continued for five transgenic plants previously generated. We have identified homozygous lines for each of these lines expressing the transgene (two chi11, two msc, and one PTO). Two further SCN bioassays (a total of three run to date) and one charcoal rot assay were performed in 2002. The initial analysis of the third SCN bioassay suggests that, so far, no significant resistance has been observed. We compared the number of cysts/gram of root tissue and found it to be highly variable within the 10 replicates tested. However this variability may be due to the variability of gene expression in some of the clones tested, even though integration patterns indicate siblings of a single event still retained the same patterns as the parent line. We are currently re-evaluating our data to see if this gene expression variability will change our bioassay interpretations. The charcoal rot bioassay ran this spring did not show any enhancement of resistance when compared with the control plants. However expression analysis of the seedlings in the test indicated that gene expression was not complete in all lines even though they are homozygous for the gene. This silencing in particular lines may have resulted in mis-interpretation of the data. Currently we are re-evaluating our data and reassessing our results.

SIGNIFICANCE: Charcoal rot is the major fungal disease in the state of Kansas and one in which symptoms are amplified during drought conditions and high soil temperatures. The fungus infects roots in lower stems causing loss of vigor on mature plants and yield loss. Yield losses of over 12% or 12 million bushels have been estimated during extreme seasons. Current management methods are not effective to control this disease and natural disease resistant lines have not been isolated. Using a genetic engineering approach to this problem will give us better options to build in protection against this disease.

KANSAS WHEAT COMMISSION

The Potential to Increase U.S. Demand for Wheat: Emerging Domestic Markets

Researchers and Unit
T. Marsh, S. Call, A. Barkley, and M. Boland, Agricultural Economics, Kansas State University

Funds (FY 02): $24,000 Completion Date: September 30, 2002

JUSTIFICATION: Wheat consumption in the U.S. is changing rapidly. There is a strong need to identify the causes and consequences of wheat product consumption, and the implications of these changes for the wheat industry.

OBJECTIVE:
We analyzed the likelihood that an individual consumed a wheat-based product (flour, grain, bran, or germ) on a daily basis using USDA's Continuing Survey of Food Intakes by Individuals of 1994-96 and the Supplemental Children's Survey of 1998.

RESULTS: Of the individuals surveyed, 96.8 percent consumed a food item each day that contained wheat flour (27.6 percent for wheat grain, 11.1 percent for wheat germ, and 3.8 percent for wheat bran). Increases in income and age and a decrease in household size tended to increase the likelihood of consuming grain and germ. Expected consumption of wheat bran increased with age, smaller households and lower income. Expected consumption of wheat flour increased with larger households and higher income. Important regional and other demographic factors also emerged. Individuals in the West have a lower likelihood of consuming wheat flour. In general, wheat flour consumption increases up to the age of 50 and then declines thereafter. In comparison, wheat grain, bran, and germ consumption increases for older individuals (age greater than 40). Finally, larger households (more than four persons) were less likely to consume wheat grain, bran, and germ and more likely to consume flour.

SIGNIFICANCE: These results have important implications for programs aimed at educating consumers about wheat-based products. Clearly, a generic (one-size fits all) approach has less potential than targeted approaches. Wheat flour is common in fast foods, breads, and similar foods and is relatively invariant of income. Wheat germ, bran, and grain tend to be more common in specialized breads and higher-valued wheat products that tend to be consumed by older people with higher incomes. Generic education and promotion would likely be effective at increasing consumption of wheat flour-based products but likely not effective at increasing consumption of wheat germ, bran, and grain products. These need a targeted approach informing people about the nutritional value or health claims of these products. Because many of these products have higher value and are more likely to be associated with a brand name, it is important that the image of wheat grain, bran, and germ be associated with the value of health and nutrition.

Protein/Hardness Screening of Early Progeny Wheats

Researcher and Unit
Robert E. Bennett, Grain Science and Industry

Funds (FY 02): $14,700 Completion Date: Ongoing

JUSTIFICATION: Kansas Agricultural Experiment Station (KAES) wheat research has historically emphasized improved milling and bread baking quality along with improved field performance. Varieties and germplasm released by the KAES have improved overall quality of Kansas wheat and are used as "quality parents" in breeding programs of private seed companies as well as other state experiment stations. In the 1960's protein content of hard red winter wheat produced in the Great Plains decreased rapidly due to grower management practices that improved retention of soil moisture and increased per-acre yields. Protein content of the 1969 Kansas winter wheat crop averaged only 10.7%.

OBJECTIVES:
1. To identify early-generation winter wheat lines and germplasm having above average protein content.
2. To identify early-generation winter wheat lines and germplasm that are too hard or too soft.

RESULTS: More than 3500 samples have been submitted each year since 1999 by KAES breeders for early generation screening. Fifteen gram samples of wheat for Near Infrared (NIR) testing of protein and hardness are delivered to the Grain Science Department, Analytical Laboratory, shortly after harvest each year. Test results are reported to KAES breeders and geneticists before September 1 each year. Having early test results impacts fall planting decisions and improves the efficiency of breeding programs.

SIGNIFICANCE: Wheat kernel hardness and protein content are heritable properties that are important in domestic and export markets. Protein content is a primary factor determining baking performance of hard wheat. Per-acre yield increases are usually accompanied by decreases in protein content of the grain. Consequently, breeders must select for increased genetic protein potential as they increase yield potential. Continued development and production of higher protein varieties, such as Karl 92 and Jagger, will make Kansas wheat more attractive in domestic and export markets.

Quality Evaluation of Materials from KAES Wheat Breeding Programs

Researcher and Unit
Robert E. Bennett, Grain Science and Industry

Funds (FY 02): $60,523 Completion Date: Ongoing

JUSTIFICATION: Wheat researchers, to improve agronomic performance, must often cross existing hard wheat varieties with soft wheats and diverse grass-like relatives of wheat having unacceptable quality. Breeding groups can measure factors that determine agronomic performance among the segregating progeny. However, laboratory tests carried out by persons with specialized equipment, training, and experience are required to identify lines that have acceptable or superior hardness, protein quantity and quality, milling, and physical dough, bread baking and Oriental noodle properties.

OBJECTIVES:

1. To provide timely evaluation of important milling, bread baking and other end use quality properties of agronomically promising lines developed by KAES wheat breeders.
2. To cooperate with research staff and graduate students in Agronomy, Plant Pathology, Entomology, Grain Science and the USDA in studies designed to determine influence of diseases, insects, soil and environmental factors, and grain storage and processing on milling and bread baking quality needed in ethnic breads and Oriental noodles.

RESULTS: Data collected on wheat samples harvested in 1999 were used by Kansas Agricultural Experiment Station wheat breeders to make quality selections among agronomically promising early and advanced generation lines for planting, crossing, and increase and release decisions. A total of 186 samples of about 1000 g each were analyzed for chemical constituents, test weight, kernel size distribution, kernel hardness, milling performance, mixing characteristics, and test baking. Additionally, starch quality characteristics and color stability (as related to Asian noodle quality) were determined. An additional 292 samples were milled and analyzed for mixing characteristics. In a separate project related to wheat improvement in Kansas, over 4500 additional early generation samples were screened solely for protein content and hardness.

SIGNIFICANCE: As a result of testing experimental lines in the wheat quality evaluation program, new varieties like Lakin, Stanton and Trego are available to Kansas wheat producers. Additional advanced hard white wheat lines continue to be extensively tested and these lines exhibit acceptable to outstanding milling and baking quality. This project helps identify varieties having improved field performance and acceptable or improved processing quality for domestic wheat and flour processors and international buyers of U.S. hard winter wheat. These varieties and others being developed will make significant contributions to the Kansas economy.

Development of Barley Yellow Dwarf-Resistant Wheat Cultivars for Kansas

Researchers and Unit

William Bockus and Robert Bowden, Plant Pathology

Funds (FY 02): $25,500 Completion Date: June 2005

JUSTIFICATION: From 1976 through 1986, there was only one year where barley yellow dwarf (BYD) virus caused a loss in the wheat crop exceeding 1%. However, during 9 of the past 16 years, BYD has caused crop losses of more than 1%, and in both 2000 and 2002 it was the most important wheat disease in the state. Because of the increasing importance of this disease in Kansas and the potential for significant damage, control measures should be sought to protect producers from losses to BYD. There are cultural and chemical control methods for BYD, but they are either ineffective, expensive, or do not fit into popular cropping practices. Therefore, genetic resistance offers the best hope for economic management of this disease. The greatest constraint to developing wheat cultivars for Kansas with increased resistance to BYD is the lack of a good correlation between yellow foliar symptoms late in the season and damage to the plant. Visual estimates of disease late in the season is the usual way that BYD is evaluated, yet it may not be useful in breeding evaluations, making it difficult for breeders to make progress in developing resistant cultivars. An accurate method to evaluate breeding material needs to be developed and used to screen existing Kansas cultivars and breeding material. The long-term goal of this research is to develop high yielding, high quality, hard red or white winter wheat cultivars adapted for Kansas with improved resistance to barley yellow dwarf.

OBJECTIVES:

1. The first objective is to develop an accurate, practical method to screen breeding material in the field or reaction to BYD that correlates with yield loss.
2. Once there is an accurate method to evaluate the reaction of wheat to BYD, current commercial cultivars may be screened and the results disseminated to producers.
3. The evaluation method that is developed may also be used under Kansas conditions to test germplasm from around the world that has been reported to be resistant to BYD. Promising lines can be incorporated into Kansas breeding programs. Disease-screening nurseries can also be established to help breeders in Kansas test their material.

RESULTS: Several methods and times of rating BYD severity correlated significantly with yield. The method with the highest correlation was the degree of stunting rated on May 28, 2002. Another method that had significant correlation with yield was the use of an antibody technique ("ELISA") to quantify the amount of virus in a plant. An offshoot of the latter technique is that only three of the five strains of BYD (pav, rmv, and rpv) were detected in wheat with the pav and rpv strains dominating and the rmv strain occurring very late in the season and at low concentrations. This information is important in targeting which virus strain(s) wheat cultivars in Kansas must be resistant to.

SIGNIFICANCE: The development of a method to evaluate the reaction of wheat germplasm to BYD is a necessary prelude to progress in producing resistant cultivars. Because of year-to-year variability and refinement of the rating technique as additional information is obtained, several years are required to develop a final protocol for rating the reaction of wheat lines to BYD. Once an accurate rating method is developed, the reaction of common Kansas commercial cultivars can be quantified and results disseminated to wheat producers. Similarly, advances in breeding can only be made if an accurate selection method is available. Additional studies will allow us to meet the overall objective, which is to develop wheat cultivars with improved resistance to BYD.

Development of Wheat Germplasm with Multiple Disease and Insect Resistance for the Southern Great Plains

Researchers and Units

Gina Brown-Guedira, USDA-ARS and Agronomy; Allan Fritz, Agronomy

Funds (FY 02): $6,000 Completion Date: Ongoing

JUSTIFICATION: Each year in the southern Great Plains (SGP), yields are reduced an estimated 20-25 % by both plant diseases and insect damage. Under average cropping conditions, that amounts to an estimated 500 million dollar loss. The results of this loss can be measured not only in poorer on-farm yields, but also as poorer milling and baking quality of the harvested crop. The difficulty in breeding and releasing disease and insect resistant wheat varieties, to prevent such large losses, is primarily due to the large number of pests that attack wheat in the SGP. It is dangerous for wheat breeding programs to focus on one or a few diseases or insects. By emphasizing the development of germplasm with multiple pest resistance that can be incorporated into wheat breeding programs, the quality of the wheat grown in Kansas will improve.

OBJECTIVES: The proposed program would provide a new source of resistance genes, ones that have not been previously utilized in any wheat breeding program. This germplasm could be utilized to diversify resistance genes across the SGP, thus making the resistance in all likelihood more stable and longer.

RESULTS: Priorities for this year included identification of new molecular markers linked to genes for resistance to leaf rust that can be used to build gene pyramids and introgression of genes conferring durable resistance to leaf rust from hard red spring wheat lines into HWW germplasm for release to wheat breeding programs.

Molecular analysis identified additional markers linked to leaf rust resistance genes *Lr39, Lr41* and *Lr50*. These genes and markers are being used by the KSU wheat breeding program to develop lines with pyramids of rust resistance genes. However, a race of leaf rust was detected at Hutchinson, KS and at other locations in the SGP that is virulent on many of the germplasm lines having leaf rust resistance genes transferred from wild wheat species, including *Lr39, Lr41* and *Lr50*. The genes and linked molecular markers can still be used in gene combinations but these pyramids will now be more vulnerable to changes in the rust population. Efforts are under way to identify and transfer new leaf rust resistance genes conferring resistance to all known races of leaf rust.

Large numbers of backcross F1 progeny were produced in the greenhouse from hybrids between Kansas HRW wheat cultivars and hard red spring wheat lines having three to six durable or adult plant genes for resistance to leaf rust. These backcross populations will be screened for resistance to leaf rust and other diseases in the field and greenhouse in order to transfer these durable leaf rust resistance genes into wheat germplasm adapted to the Southern Great Plains.
A mapping population is being constructed for use in identifying molecular markers linked to the adult-plant resistance genes in these lines.

SIGNIFICANCE: The identification of diverse sources of resistance to leaf rust and incorporation of resistance into hard winter wheat germplasm is essential to minimize loss of production due to this disease.

Market Development Grant - International Grains Program Support Project

Researcher and Unit
Brendan Donnelly, Grain Science and Industry

Funds (FY 02): $200,000 Completion Date: Ongoing

JUSTIFICATION: The world's flour millers face increased competition, subsequently the costs and benefits of the wheat they purchase face intense scrutiny and the US wheats face fierce competition. Due to worldwide privatization, many millers are no longer being supplied by their government buying agencies, but are buying their own wheat. They are unfamiliar with the world grain trade. Additionally they are unaware of the US grain grading system, quality control, and proper storage, shipping, handling, and sanitation. Pricing, basis, futures markets, and price discovery fundamentals are not utilized adequately.

OBJECTIVES:
1. To identify potential buyers of US wheat in cooperation with US Wheat Associates (USWA) and the USDA's Foreign Agricultural Service.
2. To solicit potential buyers and users to participate in short courses at the International Grains Program (IGP) that address the issues outlined above.
3. To identify opportunities in specific targeted markets with USWA where specifically designed IGP courses could be conducted in the country or countries targeted.
4. To maintain contact with individual participants in order to continue to provide them with the latest information concerning wheat utilization.

RESULTS: There were 160 persons from more than 50 countries who participated in eight formal IGP short courses during this fiscal year. Three of the short courses covered corn, one covered sorghum and four covered wheat. Through numerous visits to meetings by IGP staff and from short term visitors, IGP made contact with several hundred additional US buyers. IGP also hired a full time flour miller during this fiscal year.

SIGNIFICANCE: Buyers of US wheat have a better knowledge of our grade, contracts, and price discovery mechanisms. They are able to purchase with more confidence and are able to obtain the exact product they need, thus enhancing their margins.

Improvement of Hard Red Winter Wheat for Kansas

Researchers and Units
Allan Fritz, Agronomy; Joe Martin, Agricultural Research Center — Hays

Funds (FY 02): $97,000 Completion Date: Ongoing

JUSTIFICATION: More than two-thirds of the wheat planted in Kansas in 2002 was planted to varieties developed at KSU. Continued effort is needed to deliver varieties that meet the needs of Kansas wheat producers.

OBJECTIVES: Develop hard red winter wheat varieties adapted to Kansas.

RESULTS: KS940786-6-7 continued to perform very well compared to Jagger. This line, on average, has a 16% yield advantage over Jagger in central Kansas. It is similar to Jagger in heading date, but appears to have slightly better winter hardiness. Other agronomic attributes include good resistance to tan spot, *Septoria tritici*, soil borne mosaic virus, and spindle streak mosaic virus. It is tolerant to acid soils and wheat streak mosaic virus. KS940786-6-7 is a large seeded variety with better test weight than Jagger. In terms of baking quality, KS940786-6-7 has been equal to Jagger in our tests. The primary concerns on this line are a tendency to shatter (similar to Jagger) and potentially its reaction to the new races of leaf rust identified in Texas this year. It has been submitted to the Wheat Quality Council. Permission to increase was obtained in August 2002 for potential release in 2003. Approximately 160 bushels of seed were produced in 2002.

KS940786-6-9 is a sister line of KS940786-6-7 that is more similar to 2137 in maturity. Across years, it has been about 10% better than Jagger, but outyielded Jagger by 19% this year. It has historically been a better performer in western Kansas than KS940786-6-7, which probably explains its yield advantage relative to KS940786-6-7 this year. It has been placed on a small scale increase for the fall of 2002.

SIGNIFICANCE: This research is part of a continuing effort to develop new wheat varieties for Kansas wheat producers and the wheat industry. It is critical that these efforts are continued so that we can address production constraints and continue to improve quality parameters.

Improvement of Hard White Winter Wheat for Kansas

Researchers and Unit
Allan Fritz and G.M. Paulsen, Agronomy

Funds (FY 02): $45,000 Completion Date: Ongoing

JUSTIFICATION: More than two-thirds of the wheat planted in Kansas in 2002 was planted to varieties developed at KSU. A sustained, long-term effort is needed to continue to deliver varieties that meet the needs of Kansas wheat producers.

OBJECTIVES: Develop hard white winter wheat varieties adapted to Kansas.

RESULTS: Several new white lines were identified and tested in 2002. Some of the lines had low PPO and all lines that performed better than the checks (Jagger and 2137) will be tested for sprout tolerance in the summer of 2002. An additional 200 new white lines will be tested in 2002-2003. Several segregating populations with parents reported to have tolerance to preharvest sprouting were evaluated in the field. Those showing promise were sampled and tested for sprouting tolerance in the summer of 2002. The crossing program has had an increased emphasis on white wheat with special attention to sprout tolerance. Cayuga (a soft white wheat from Cornell with tolerance derived from Clark's Cream), CIMMYT material and lines from Joe Martin's program have served as sources of additional sprout tolerance.

SIGNIFICANCE: This research is part of a continuing effort to develop new wheat varieties for Kansas wheat producers and the wheat industry. It is important that these efforts are continued so that we have the opportunity to address production constraints and improve quality parameters.

Wheat Genetics Resource Center and Its Contributions to the Kansas Wheat Industry

Researcher and Unit
Bikram Gill, Plant Pathology

Funds (FY 02): $85,000 Completion Date: Ongoing.

JUSTIFICATION: The Wheat Genetics Resource Center (WGRC) was established in 1984 at Kansas State University to collect, maintain, evaluate, and document the genetic resources of wheat. To assure future advances in wheat breeding, the WGRC is involved in broadening the crop genetic base and the development of genetic and cytogenetic stocks for rapid and efficient gene transfer for breeding superior wheat cultivars. Resistance genes are incorporated into wheat lines through interspecific hybridization and released as germplasm. The WGRC also develops new cytogenetic stocks and chromosome and DNA-based assays for plant genome analysis and efficient germplasm development.

OBJECTIVES:
1. To collect, conserve, evaluate, and distribute wheat germplasm for crop improvement.
2. To develop wheat germplasm with improved resistance to wheat streak mosaic virus (WSMV), leaf rust and other pests.

RESULTS: The Hessian fly-resistance gene *H21* is present on the wheat-rye whole-arm translocation chromosome T2BS·2RL and was recently transferred to durum wheat. We have attempted to reduce the rye segment in T2BS·2RL using *ph*-mediated recombination. Two recombinants (5.1 %) with very small distal wheat segments retained the gene and were resistant to the insect. The distal recombinants with *H21* gene were vigorous and had normal seed set. These results are valuable to durum wheat breeders, but in addition these new translocations with the *H21* gene and very small rye segments will be a bonus to bread wheat breeders.

We received 77 new accessions of *Haynaldia villosa*. *Haynaldia villosa* is considered to be a good source of resistance genes to powdery mildew and eyespot fungi and also has a high level of seed-storage proteins and good quality traits. Twenty accessions were resistant to two of the most virulent pathogen isolates. Although some of the lines were segregating for resistance to leaf rust, only three of the lines were susceptible to both isolates of the pathogen.

We received 82 wild wheat lines and 40 common wheat landraces from scientists in Tajikistan. This germplasm was collected in collaboration with the USDA–ARS at Kansas State University. These collections are valuable as very little germplasm has been collected from this area.

The resistance to wheat streak mosaic virus in germplasm line WGRC27 has been bred into advanced wheat-breeding lines. One hundred eighty-two of these lines were analyzed by DNA markers, and we identified six critical lines where we may have trimmed off the unwanted wheatgrass genetic material while retaining resistance to wheat streak mosaic virus.

SIGNIFICANCE: The WGRC uses or provides to others, immune and resistant strains of wild wheats for the development of improved germplasm for wheat breeding.. The germplasm collection now stands at 10,784, an increase of 22 % over last year. In 2001, 67 requests for WGRC germplasm and materials were sent to scientists throughout the U.S. (56 requests to 15 states) as well as to foreign countries (11 requests). WSMV and leaf rust are two of the most important diseases of wheat and their control will significantly improve yield and quality of the harvested crop.

Gluten Proteins that Improve Bread Quality

Researchers and Units
George H. Liang, Agronomy; George L. Lookhart, USDA-ARS Grain Marketing Production and Research Center

Funds (FY 02): $39,600 Completion Date:

JUSTIFICATION: This project is designed to characterize the novel gluten proteins that have been found associated with shorter mixing time and improving baking quality in some *Triticum tauschii* x wheat crosses and transform the proteins into Kansas-adapted red and white hard winter wheats. *Triticum tauschii*, an ancestral parent of modern bread wheat, is thought to be the ancestral donor of the D genome in modern wheat and is a source of novel HMW-GS, which are especially significant as some HMW-GS in the D genome are attributed to high baking quality. Preliminary breeding work led to the production of new bread wheat lines that contain novel HMW-GS**.** Some of the resulting lines exhibited shorter mixing times and improved miling and baking characteristics when compared to parental hexaploid lines. The characteristics of these novel gluten proteins need to thoroughly examined and compared to other D genome HMW-GS, in order to understand how to improve quality in bread wheats.

Today's wheat economy is a buyers market with many countries now producing and exporting wheat that competes for US markets. Buyers are becoming more selective of quality and can purchase from numerous sources, therefore it is important to continually improve Kansas wheat. One method of doing this is to incorporate novel (not found in any other wheat) gluten proteins. A concerted effort is urgently needed among breeders, geneticists, cereal chemists, and protein biochemists to target those agronomic traits that will improve the quality of wheat grown in Kansas. This group plans to combine basic and applied wheat protein research to provide a unique approach to improving the quality of Kansas red and white hard winter wheat cultivars.

OBJECTIVES: The main objective of this project is to transform the genes encoding novel HMW-GS subunits from *Triticum tauschii* and examine the effects of these HMW-GS transformed into Kansas red and white winter wheats on end product quality. These experiments will utilize wheat cultivars economically important to Kansas producers, such as the HRW wheats Jagger and Karl, and white wheat Lakin (KS 115) rather than the experimental cultivar Bobwhite. This process will enable the production of wheats of enhanced quality adapted to Kansas and thus save the time required to breed the novel subunits from experimental lines into adapted cultivars. The genes encoding the HMW-GS isolated from *T. tauschii* have been inserted into a vector containing a selectable marker (the Bar gene). We will use an *Agrobacterium*-mediated transformation approach to incorporate the genes. The transgenic wheat plants will be identified and screened for the presence of specific DNA via Southern blot analysis. Identified transgenic plants will be assessed for expression of novel HMW-GS in the endosperm. Seeds exhibiting expression of the transgenes in the endosperm will be grown to examine the stability of the transgene expression and to accumulate sufficient grain to examine the quality parameters.

RESULTS:

Protein characterization. Three different *T. tauschii* lines, that are known to contain unique gluten proteins that improved mixing properties in bread systems, were studied using several techniques. These studies were done to compare the properties of the proteins in the *T. tauschii* lines to the proteins found in typical U.S. hard red winter wheat cultivars. Results demonstrated that gluten proteins (gliadins and HMW-GS) of *T. tauschii* were similar to those of bread wheat.

HMW-GS gene characterization. The coding regions of HMW-GS 43 and 44 were amplified from genomic DNA prepared from *T. tauschii* accession lines TA2450 and TA2460 via the polymerase chain reaction (PCR) using oligonucleotide primers specific for Dx and Dy HMW-GS. The PCR products were subcloned into smaller pieces amenable for DNA sequencing. Analysis of the DNA sequence and the predicted amino acid sequences revealed the proteins to be typical of Dx and Dy HMW-GS of bread wheat. Homology searches of the GenBank database (BLAST) with the sequence of HMW-GS 43 revealed 97.1% identity to HMW-GS Dx2 and 96% identity to HMW-GS Dx5. The predicted amino acid sequence reveals a protein of 845 amino acids, slightly larger than Dx2 and Dx5 at 838 and 839 amino acids, respectively, and has an insertion of the hexapeptide repeat PGQGQQ. The additional cysteine residue in the N-terminal region of Dx5 is absent in HMW-GS 43 from *T. tauschii*. The DNA sequence HMW-GS Dx44 is of a typical Dy glutenin gene of 1872 base pairs, with a predicted protein of 624 amino acids with greatest identity to subunit Dy10 (90.8%) and a previously described Dy HMW-GS from *T. tauschii.*

The results indicate that the storage proteins of *T. tauschii* are similar to those found in HMW wheats and thus function in a similar manner as HRW gluten proteins. This means that the improvements to bread-making when the novel proteins found in the *T. tauschii* lines are bred into modern HRW cultivars are due to subtle differences in the proteins and not large changes in the proteins. Finding out what these subtle differences are will lead to better understanding of the interactions of gluten proteins in dough and to best improve the protein quality of HRW wheats in Kansas.

Gene constructs and transformaton. Dx and Dy genes are linked to the selectable marker gene, *bar*, in the gene construct. We are not able to incorporate the green fluorescence protein reporter gene (GFP) into the construct because it lacks the restriction site to ligate. Incorporation of the Dx and Dy genes are made using two different approaches – by biolistic bombardment where co-bombardment is made using the DNA with Dx and bar, Dy and bar, and the GFP gene. GFP provides a quick identification of the putative transgenic wheat plants as it fluoresce under the fluorescence microscope. The addition of the Dx and Dy genes are also made using *Agrobacterium* where a different gene construct is necessary. According to reports, *Agrobacterium*-mediated transformation could reduce gene silencing in later generations and may have a higher efficiency. An analysis of the putative transgenic plants later will confirm whether the hypothesis is true. Plant materials used were Bobwhite, Jagger, Lakin (KS 115), and Karl – all of which are responsive to tissue culture operations, such as callus induction and plant regeneration.We also found that sonication of the calli before co-culture with *Agrobacterium* cells did not increase the efficiency. In fact sonication, even just 10 seconds, could break the friable callus cells and kill the bacterium. It is not recommended to use the sonication device in transformation.

Chemical/Physical Modification of Gluten Protein and Characterization

Researchers and Units
Finlay MacRitchie, Grain Science and Industry; DoSup Chung, Biological and Agricultural Engineering; Thomas Herald, Animal Science and Industry

Funds (FY 02): $48,304 Completion Date: June 30, 2002

JUSTIFICATION: A portion of wheat produced in the United States is utilized for manufacture of gluten and starch. In recent times, the world market for gluten has been flooded due to overproduction; consequently, sale price has decreased. One approach to counter this problem is to develop value-added products from gluten. Value addition of other protein sources, such as soy, eggs and milk, has been achieved as a result of research; however, wheat protein has not been researched as extensively, particularly in the United States. This grant has allowed us to explore possibilities for value added products through modifications of gluten.

OBJECTIVES:
1. To evaluate the effects of several standard modification procedures for gluten.
2. To combine several of these processes to enhance the physical properties.
3. To characterize the changes and evaluate the modified products in model food systems.

RESULTS: Four main approaches to gluten modification have been researched.

Ultrasound (sonication). Solubility of gluten protein has been enhanced by sonication. An obvious application is the use of gluten in beverages. In addition, sonication can be used as a first step in other modification procedures.

pH Optimization. The use of pH optimization has resulted in a gluten with considerably enhanced foaming capacity and stability. This product has been shown to have potential as an ingredient in products such as meringues and angel food cake, being able to replace commonly used products such as egg-white protein.

Hydrothermal treatment. A jet cooker has been used to subject gluten dispersions to high temperatures (up to 300 F) and to incorporate compounds such as sugars in the structure. Enhanced viscosity and gelling capacity of the products have potential as texturized meat substitutes.

Transglutaminase. The enzyme transglutaminase has been used as a cross-linking agent. In addition, it has been used to incorporate free amino acids such as lysine with beneficial effects on foaming and emulsification properties of gluten.

SIGNIFICANCE: Wheat presently sells for about $0.05/lb. Gluten has been selling for $0.6-$0.7/lb, but recently the price has dropped and is barely meeting production costs. Value-added protein from soy and egg (egg-white protein) sell for between $2.00 and $3.00/lb. Results have shown that modified gluten can have properties making it capable of competing in the market with these other proteins. If value added gluten products can be developed, there could be significant economic benefits for the wheat industry.

Fast Food Sales: The Potential to Increase Wheat Product Consumption

Researchers and Unit
T. Marsh, J. Fanning, A. Barkley, M. Boland, Agricultural Economics; K. Stiegert, Applied Economics, University of Wisconsin

Funds (FY 02): $8,632 Completion Date: September 30, 2002

JUSTIFICATION: Fast food purchases have a large and growing impact on U.S. wheat consumption. Given this major change in food consumption, there is a need to identify the causes and consequences of fast food product purchases and the implications of these changes for the wheat industry.

OBJECTIVE:
We analyzed the likelihood that an individual consumed fast food on a daily basis using USDA's Continuing Survey of Food Intakes by Individuals of 1994-96 and the Supplemental Children's Survey of 1998.

RESULTS: Results of the analysis indicate that 26.9% of individuals consumed fast food on a daily basis. In addition, 29.1% of all fast food consumed per day contained wheat product (flour, grain, bran, or germ). Important regional and demographic factors emerged. Consumers in the Midwest (including Kansas) and South were most likely to consume fast food. Individuals were more likely to consume fast food until they reached 30 years of age, at which point the likelihood that they consume fast food decreases throughout their life. In terms of gender, men were more likely to consume fast food than women. African-Americans and Native Americans had a higher likelihood of consuming fast foods than other races. Larger households (especially those with more than four persons) were much less likely to consume fast food. Finally, households with income levels under $50,000 to $60,000 are expected to consume fast food more often than those with higher incomes.

SIGNIFICANCE: Fast food consumers are an important market for wheat-based products. In particular, the results suggest that single people (especially males), and families with small households, located in suburbs in the Midwest and South are the most likely to purchase fast foods with wheat product in them. The fact that the structure of the U.S. population is changing is key to more effective promotion. For example, the aging U.S. population suggests that wheat product consumption may decrease in the future. New product development should be aimed at products that are more likely to be consumed by older consumers in an effort to increase consumption. Moreover, marketing and promotion should be targeted at younger consumers (especially women) in an effort to increase wheat consumption.

Kansas Dual Purpose Pest Resistant White Wheats

Researchers and Unit
T.J. Martin, D.L. Seifers, and T.L. Harvey, Agricultural Research Center – Hays.

Funds (FY 02): $84,000 Completion Date: Ongoing

JUSTIFICATION: The driving force behind the development of hard white wheat varieties adapted for production in Kansas is to increase demand for Kansas wheat, thereby increasing our world market share. Much of the improvement in world market share should come from Asia, where white wheat is used for noodle production. Our current white wheat varieties are good bread wheats, but do not produce good quality Asian noodles. Hard white wheats grown in Kansas need to meet the quality requirements for both bread and Asian noodle production. The intent of this project is to develop white wheat varieties that combine good bread and noodle quality with improved levels of pest resistance. Kansas production efficiency can be improved by as much as 15% if our most serious pests are controlled with pest-resistant varieties.

OBJECTIVE:
Develop high yielding hard white wheat varieties adapted for production in Kansas that are capable of resisting our most serious wheat pests and producing grain with good bread and noodle production characteristics.

RESULTS: The 2002 crop year allowed us to make significant progress in developing experimental hard white lines with improved levels of pre-harvest sprouting resistance. Based on sprouting tests conducted in 2002 we will enter three experimental white seeded lines in our most advanced tests for 2003 that have sprouting resistance equal to or better than that of the hard red winter variety Jagger. Jagger is currently our most popular red wheat cultivar.

SIGNIFICANCE: The high level of sprouting tolerance in these experimental hard white wheats would allow white wheat to be produced in the wetter areas of the state without the danger of pre-harvest sprouting, which is a major limitation of our currently grown hard white varieties.

Wheat Crop Improvement by Genetic Engineering

Researchers and Units
Subbaratnam Muthukrishnan, Biochemistry; George H. Liang, Agronomy; Bikram S. Gill, Harold Trick, Plant Pathology

Funds (FY 02): $54,000 Completion date: June 30, 2002

JUSTIFICATION: Wheat crops in Kansas suffer from diseases that lead to economic losses totaling in the millions of dollars. Improved host plant resistance is one strategy that will help to reduce these losses.

OBJECTIVES:
1. To generate transgenic plants with constitutive expression of genes for pathogenesis-related proteins
2. To bioassay transgenic plants for disease resistance

RESULTS AND SIGNIFICANCE: We have generated several lines of transgenic wheat containing combinations of genes encoding pathogenesis-related proteins (PR-proteins). Twenty-six transgenic wheat lines containing different combinations of PR-protein genes have been generated to date. Of these, six are found to be stably expressing the bar gene and chitinase and/or glucanase, as revealed by PCR, RNA analysis and western blot analyses. Four of these lines have been carried through the T4 generation and identified to be homozygous for the transgene locus. These four homozygous lines (T3 and T4) were tested for scab resistance by the single floret inoculation assay. In greenhouse trials, a line expressing a combination of a wheat chitinase and a wheat glucanase was found to be more resistant than the line expressing a chitinase or glucanase alone. The transgenic lines and a control susceptible line and two resistant check lines were tested in the scab nursery at Rocky Ford (in collaboration with Dr. Bill Bockus) for resistance to scab. It was found that the transgenic lines were not statistically more resistant to scab compared to controls while the resistant check varieties showed good resistance. It is concluded that the combination of chitinase and glucanase does not confer resistance to scab under field conditions. Data from this project has generated several publications, a listing of which is available from S. Muthukrishnan.

Use of Low-Protein Hard White Winter Wheats in Asian Noodles

Researcher and Unit
P. Seib, Grain Science and Industry

Funds (FY 02): $37,465 Completion Date: June 30, 2003

JUSTIFICATION: 'Lakin' is a hard white winter wheat that can be processed into bright white or yellow Asian noodles. Low to medium protein Lakin is likely to be even better for Asian noodles because protein is positively associated with darkening of noodles. Low-protein hard wheats are usually discounted in price compared to those with high protein content. If it can be demonstrated that low-protein Lakin, or wheat lines similar to Lakin, is the preferred wheat for Asian noodles, the discount may be eliminated.

OBJECTIVES:
1. Obtain Lakin and advanced breeding lines of hard white winter wheats containing a low level of polyphenol oxidase and with low to medium protein contents (10-12%); measure quality parameters of the wheats.
2. Mill the wheats to 50-60% extraction flour and measure physical, chemical and biochemical quality factors important to noodle flours.
3. Prepare alkaline noodles; follow the color of the raw noodles for 24h and measure their cooking and eating qualities.

RESULTS: We selected five Kansas hard wheats with two protein levels and two Kansas hard wheats with one protein level from 22 Kansas wheat varieties or lines. The 12 wheats, all harvested in 2000, were four commercial varieties (Trego, Lakin, Ike, and 2137) and three experimental lines (KS98H239-1, KS99H121, and KS99HW24). Those wheats also varied in starch quality as measured by hot-water swelling power (SP_{95}) from high to medium to low. All 12 wheats were milled on a Buhler experimental mill to obtain three break-flours and three reduction-flours. Different flour streams were blended to produce 12 straight-grade (~68% extraction rate) and 12 fancy-patent (~55% extraction rate) flours, which then were characterized by their protein, moisture, ash, and total starch contents, as well as their hot-water (95° C) swelling powers (SP_{95}) at ~1.65% flour solids. The protein levels in the 24 flours and their SP_{95}'s ranged from 8.8-12.9% and 16.7-22.6g/g, respectively. The partially waxy flours, with reduced amylose levels from Trego, Ike, KS99H121, and probably KS99H239-1, showed elevated swelling powers. The color, cooking qualities and textures of the noodles will be determined in later studies. High-swelling starch in a low-protein flour may substitute for some protein, which would increase the value of low-protein wheat.

SIGNIFICANCE: A preliminary study has been done on alkaline noodles made from wheat flours with almost the same protein levels of ~11% but with varying hot-water swelling power (SP_{95}). The cooked noodle made from a flour with elevated hot-water (SP_{95}) power had a tensile strength higher than that from a low-swelling flour, and the noodle yield increased 5%. It may be possible to increase the value of low- and intermediate-protein hard wheats by changing the quality of starch. This would be an added benefit because low-protein hard white wheats should give improved color.

Wheat Research/Extension Assistant

Researchers and Units
James P. Shroyer, Agronomy; Scott Staggenborg, Stu Duncan, Curt Thompson, Area Extension Agronomists; Bob Bowden, Plant Pathology

Funds (FY 02): $20,000 Completion Date: June 30, 2002

JUSTIFICATION: Kansas is a very diverse state with wheat being grown in every county. New technologies that have been developed at research centers and experiment fields need to be tested and observed over many environments. We know that the interval from the time a new technology becomes available until farmer acceptance is about 10 years and we would like to shorten that lag time. On-farm trials and plot tours allow local farmers to see new technologies and, because farmers are "practicing researchers," they can make the needed modifications so these practices are suitable for their farms early during this lag time of the transfer and adoption process.

OBJECTIVES:
1. To speed the time of farmer acceptance of new wheat technologies through use of on-farm trials and plot tours.
2. To broaden the database of research that has been conducted at experiment fields.

RESULTS: Blending white wheat varieties, Betty and Trego in a 10:90 proportion resulted in yields similar to planting Trego alone. Pure Trego yields were 9 bu/a greater than pure Betty. Yields of the 30 Betty:70 Trego blend were 2 bu/a less than Trego alone and the 50:50 blend had yields equal to the average of Trego alone and Betty alone. Last year, because Trego was damaged by stripe rust, yields were nearly equal for Betty and Trego. Milling and baking results indicate that up to 30 % Betty in the blend resulted in quality parameters that were similar to planting Betty alone.

White wheat varieties were planted in all county extension plots in western KS for farmer observation. Yields of no-till wheat planted after soybeans were 11 bu/a higher than wheat no-till planted after grain sorghum. Also, some wheat varieties performed better than others when planted after soybeans and grain sorghum. This year, 2137 and Dominator had higher yields after soybeans and 2137, Coronado, and Dominator had higher yields after grain sorghum.

An IMI-resistant wheat variety and its IMI-susceptible sister-line variety were planted alone and in blends with 50:50 %, 66:33 %, and 33:66% proportions and treated with an IMI herbicide at three times throughout the growing season. At one location, the herbicide destroyed the IMI-susceptible variety with each treatment time, whereas at the other location only the late spring treatment destroyed the susceptible variety. Generally, with each herbicide treatment date the blends yielded in a positive relationship to the percentage of the IMI-resistant variety in the blend.

SIGNIFICANCE: In the future, farmers may use white wheat variety blends to add value to their crop. No-till planting wheat after row crops has gained more acceptance and farmers can select varieties that perform well under these conditions. This research showed the significance of IMI herbicide application timing and also showed the compensatory affect of varieties in a blend when one is damaged.

Molecular Diagnosis Of Wheat Aphid Resistance

Researchers and Unit
C. Michael Smith, Elena V. Boyko, Entomology

Funds (FY 02): $59,138 Completion Date: Ongoing

JUSTIFICATION: The development and use of insect resistance genes in wheat, especially aphid resistance genes, is an underdeveloped area of wheat integrated pest management that can greatly improve producer profitability. The first greenbug resistant wheat cultivar, ‘TAM 110’ was released by the Texas Agricultural Experiment Station in 1997. The Russian wheat aphid resistant wheat cultivar ‘Halt’ was grown for the first time in 1996 in Colorado. ‘Stanton’, is a newly released KAES cultivar with Russian wheat aphid resistance. Additional Russian wheat aphid resistant cultivars are being bred at the University of Idaho. All of these breeding programs will benefit from the availability of diagnostic molecular markers linked to aphid resistance genes in their germplasm.
The annual value of greenbug resistant sorghum in the U. S. ranges from is $54 to $113 million; the yearly value of greenbug resistance in wheat in Kansas, Texas, and Oklahoma alone is estimated at over $20 million each year. Researchers in my laboratory have identified molecular markers linked to genes for resistance to the Russian wheat aphid, the greenbug, and the wheat curl mite on wheat chromosomes 1DS, 6DS, and 7DS. These molecular markers can be used to select aphid resistant genotypes at an early stage in the development of new cultivars. The increased speed and efficiency with

which aphid resistance genes can be identified and tracked will increase the accuracy and rate at which new wheat cultivars can be developed. Wheat cultivars with greenbug and Russian wheat aphid resistance will also benefit producers by reducing producer losses from aphid damage and reducing or eliminating insecticide use costs for aphid resistance.

OBJECTIVES

1. Evaluate segregating F2 and F3 plant populations expressing the Gb3, Gb4, Gbx, and Gby genes for reaction to greenbug feeding symptoms.
2. Prior to phenotyping, collect DNA from individual plants and genotype each with microsatellite markers showing tentative linkages in preliminary studies.
3. Dependent on results in Objective 2, identify rflp markers from the same chromosome locations as loosely linked microsatellite markers and evaluate each for closer linkages to the 4 Gb genes. Develop PCR primers from the rflp probes most closely linked to Gb genes.
4. Use the molecular markers identified in Objectives 1 – 3 to develop a diagnostic set of markers to detect genes for greenbug resistance in advanced Kansas breeding lines and cultivars.

RESULTS:

Gby. Gby is a new greenbug resistance gene from Sando's wheat line #4040 with a pedigree of (Chinese Spring/Agropyron elongatum) X [(Arlando X Leafland) X Comet 125]. A mapping population used in this study was derived from the cross Sando's 4040 X PI220127. The greenbug susceptible parent PI220127 contained the new Russian wheat aphid resistance gene Dnx. RFLP (restriction fragment length polymorphism) and WMS (wheat microsatellite) markers were used to determine the chromosome location of Gby. Grouping molecular markers at a LOD threshold of 3.0 yielded a linkage group of 23 RFLP and WMS loci, including wheat WMS332 (wheat chromosome 7A), and ESTs for a putative zinc finger protein, (XZnfp) and a pathogenesis-related protein (Pr1b). Gby was flanked by two RFLP markers on the short arm of wheat chromosome 7A - Xcdo91-7A.1, distally at 11.3cM, and Xbcd385, proximally at 7.5cM. A cytogenetic map created using makers common between our 7A genetic map and wheat group 7 physical maps further suggests that Gby is located in the subtelomeric region of the short arm of wheat 7A. The distal regions of group 7 chromosomes are characterized as having a high recombination rate and a high marker density. Thus, Gby is a very good candidate for map-based cloning. This is a first report of chromosome location of and molecular markers linked to genes from *Agropyron elongatum* expressing resistance to greenbug in wheat.

Gbx. Gbx is a greenbug resistance gene originating from (KSU97-85-3, which was developed from the cross (TA1675 x Wichita)). Preliminary data indicates that Gbx is also linked to a microsatellite loci on wheat chromosome 7, but the chromosome arm location is unclear. Data on Gb3, Gb4, and Gbx has been preliminary or anecdotal. Gbx F2 populations are being derived from the crosses (Stanton x 97-85-3) and (Jagger x 97-85-3) by Liecheng Zhu, to provide more accurate data on the chromosome location of Gbx.

Gbz. Gbz is a greenbug resistance gene originating from (WGRC4 (Wheat Genetic Resource Center) line 4, which was developed from the cross TA (*Aegilops tauschii*) line 1695 x Wichita). Using an F4:5 population derived from [WGRC4 x TX3308 (susceptible)], Gbz has been linked ~7 map units to a wheat microsatellite loci on the long arm of wheat chromosome 7. Research has shown that Gb3, Gb4, and Gbz are likely alleles of the same gene.

SIGNIFICANCE: The most significant progress has been made in mapping Gby, a greenbug biotype I-resistance gene from Sando's 4040, a composite of many sources of stress resistance. Using progeny from a cross involving Sando's 4040, Gby was mapped to the subtelomeric region of wheat 7A chromosome, in a region containing several other wheat disease resistance genes. More importantly, comparative mapping of Gby with several other greenbug and Russian wheat aphid resistance genes indicates that several Dn (Russian wheat aphid resistance) and Gb genes are also located in the distal region of wheat 7S. We now have an excellent candidate gene (Gby) for map-based cloning. With additional mapping in the 7S region we plan to identify markers very closely flanking Gby in physical distance. Additional mapping studies using populations developed with Dnx and Dnz should provide more accurate information on the map locations of these genes in reference to Gby.

Spinosad: A Safe and Effective Alternative for Managing Stored-Wheat Insects

Researchers and Units
Bhadriraju Subramanyam and Carl Reed, Grain Science and Industry; Frank Arthur, USDA-ARS, Grain Marketing and Production Research Center

Funds (FY 02): $17,774 Completion Date: Ongoing

JUSTIFICATION: The organophosphate chlorpyrifos-methyl (Reldan®) registered for use on stored wheat will no longer be available for use after December 2004 because of voluntary cancellation by the registrant. Additional data required by the US-EPA under the 1996 Food Quality Protection Act led to this voluntary cancellation notice. Furthermore, chlorpyrifos-methyl is not effective in controlling the lesser grain borer, *Rhyzopertha dominica* (F.), the most important and damaging pest of stored wheat in Kansas, US, and throughout the world. Alternative pesticides are needed to replace chlorpyrifos-methyl to control *R. dominica* and other stored wheat insect pests. We evaluated spinosad, a reduced-risk commercial bacterial pesticide, as a potential grain protectant.

OBJECTIVES:
1. Determine the effectiveness of spinosad on four classes of wheat against five stored-product insects.
2. Determine the persistence and efficacy of spinosad residues in farm-stored wheat.
3. Determine the effect of wheat temperature and moisture on the residual activity of spinosad against *R. dominica* adults.

RESULTS: Spinosad at 0.1 and 1 mg of active ingredient/kg of wheat killed all *R. dominica* adults and suppressed progeny production on hard red winter, soft red winter, hard red spring, and durum wheats. A rate of 1 mg/kg was effective against the rice weevil, *Sitophilus oryzae* (L.), sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.), and red flour beetle, *Tribolium castaneum* (Herbst), only on durum wheat. However, progeny suppression of *T. castaneum* and *O. surinamensis* was excellent on the remaining wheat classes at 1 mg/kg. On all wheat classes, 1 mg/kg effectively suppressed egg-to-adult emergence of the Indianmeal moth, *Plodia interpunctella* (Hübner). Spinosad residues at 0.1, 0.5, 1, 3, and 6 mg/kg were stable in farm-stored wheat for 1 year and provided 100% mortality of *R. dominica* adults in laboratory bioassays. Furthermore, spinosad provided complete control of *R. dominica* adults on 12.5 and 14.5% moisture wheat at 22, 28, and 34^{O}C during the entire 4-month test period.

SIGNIFICANCE: Spinosad had excellent activity at 1 mg/kg or less on *R. dominica* and other stored-wheat pests, as opposed to the 6 mg/kg rate for chlorpyrifos-methyl. The persistence of spinosad in farm-stored wheat and consistent performance against *R. dominica* during the 1 year storage make it a promising stored-grain protectant. Dow AgroSciences, the manufacturer of spinosad, applied for an experimental use permit (EUP) in December 2001 based on our test results. The EUP for 1 mg/kg was approved by the US-EPA in May 2002 and full scale farm trials were initiated in July 2002 on three Kansas farms and at the USDA Grain Marketing and Production Research Center site to further document spinosad's efficacy.

Biodegradable Plastics from Wheat Starch and Polylactic Acid

Researchers and Unit
X. Susan Sun and Paul Seib, Grain Science and Industry

Funds (FY 02): $29,980 Completion date: June 30, 2001

JUSTIFICATION: Kansas is number one in wheat production. About 70% of the components of wheat is starch. This research will enhance the utilization of wheat starch in industrial materials, which will help to boost the rural economy. In addition, environmental protection has become one of the highest priorities of both national and international government agencies. The public also supports this priority. This research plan will provide technology for producing low cost, durable, and biodegradable wheat starch based plastics.

OBJECTIVES:
1. To investigate the feasibility of processing biodegradable plastics from wheat starch and poly(lactic acids) using extrusion and injection molding
2. To identify workable processing conditions and formulations for extrusion.

RESULTS: We obtained optimum extrusion and injection molding parameters at the lab scale; these were used for formulation studies. Several plasticizers were used. One of them, triethyl citrate (TC), was identified as a better plasticizer for the blend of Poly(lactic acid) and starch in the presence of methylenediphenyl diisocyanate (MDI). TC improved the elongation at break and toughness, and at the same time decreased tensile strength and modulus. However, TC did not significantly affect the coupling effects of MDI on starch and PLA. The tensile strength of the blend with MDI was much higher than tensile strength without MDI at the same TC level. The tensile properties of the blend changed dramatically as TC concentration increased from 5% to 12.5%. At TC concentration of 7.5%, the blend produced desirable elongation and toughness with fairly good tensile strength.
A useful formula for biodegredable plastics from starch and PLA has been identified; it can be processed using existing equipment for petroleum based plastics. This bioplastic has potential for rigid plastics, packaging containers, and single-use or short-term items.

Thermal properties and micro structure of the blends were characterized. Thermal transition temperatures (glass transition, crystallization and melting) of starch/PLA/MDI blends decreased as TC content increased. The crystallinity of the blends increased as TC content increased within the concentration tested.

The coupling reagent used for this bioplastic is methylenediphenyl diisocyanate (MDI). The amount of MDI was only about 0.5%, which can't be detected after reaction. The materials containing this small amount of MDI should be considered as nonhazardous material.

SIGNIFICANCE: Large solid-plastic wastes are produced from packaging, public or medical services and travel locations, grocery bags, trash bags, fast food serving and eating utensils, and even flower/plant pots. The newly developed plastics from this research could provide possible solutions to the problem of disposing of these materials. Also, the plastics from this proposed research could be used as biomedical and pesticide slow-releasing carrying matrix. The outcome of this research will enhance the utilization of wheat as an industrial material. The results obtained from this research will also be useful to both academic and industrial scientists.

Cancer Protective Effects of Wheats with Different Antioxidant Potentials

Researchers and Units
D. Takemoto, Biochemistry; C. Klopfenstein

Funds (FY 02): $25,240 Completion Date: June 30, 2002

JUSTIFICATION: Diets rich in wheat are associated with a decreased risk for colon cancer. Our studies are the first to correlate the levels of specific antioxidants with the degree of protection against colon cancer. We have established *in vitro* assays to measure antioxidant levels in whole wheat samples and have set up two assays to measure anticancer activity. Levels of orthophenols directly correlate with anticancer activity. These findings will allow wheat growers to select for cultivars with high antioxidant activity. This will provide for a value added product and assist in further breeding and selection programs.

OBJECTIVES:
1. To determine the levels of orthophenols in wheat cultivars and correlate them with in vitro anti cancer activity
2. To determine if wheats high in orthophenols can prevent tumor formation and raise orthophenol levels in blood of mice fed wheat diets.

RESULTS: We are completing the project that has been funded for the rest of this year. Continued funding was not supported. Therefore, studies to determine enzyme activity of wheats and to initiate cloning of the gene for PAL have been terminated. We are now in the process of writing up results to include the assays on orthophenols and cell protection assays, both established in the Takemoto lab. In addition we have completed studies on all wheat orthophenol levels, and have determined the levels of orthophenols in mice after feeding a diet of wheats that were high, mid, and low level in protection against colon cancer cells. In collaboration with Dr. John Carter, the tumor studies have been completed and the number and size of tumors have been determined at Kansas State University in the Veterinary Pathology Department. Results show a strong correlation between orthophenol levels and the ability to prevent the formation of tumors in mice.

SIGNIFICANCE: Wheat diets have been correlated with anticancer activity. This was thought to be due entirely to fiber content. In this study we have correlated orthophenol content with anticancer activity of wheat. Furthermore, we have established simple assays to determine orthophenol content and have identified caffeic acid as being one orthophenol that is strongly associated with anticancer activity. This project has established a mechanism for identifying wheats with high anticancer activity. This should provide added value to wheats high in orthophenol content.

Introduction of RP1 Genes of Maize Into Wheat to Confer Resistance to Leaf Rust

Researchers and Unit
Harold N. Trick and Scot H. Hubert, Plant Pathology

Funds (FY 02): $27,000 Completion Date: June 30, 2002

OBJECTIVES:
The goal of this project is to transfer leaf rust resistance genes from maize (corn) to wheat plants by genetic engineering. To accomplish this goal we have identified five measurable objectives to be completed over the next three years.

1. Finish making the necessary DNA constructions so the rust resistance gene(s) can be expressed appropriately in wheat.
2. Produce genetically engineered wheat plant (T0) using the particle gun.
3. Screen putative T0 plants for stability and proper expression of the rust resistance gene.
4. Collect and further analyze T1, T2, and T3 progeny.
5. Screen engineered plants for leaf rust resistance.

RESULTS: The third year of funding was focused on the collection and analysis of progeny, continued leaf rust bioassays, and confirmation of the functionality of our constructs in transgenic maize. In total, 16 independent Rp1-D transgenic wheat lines and 24 of Rp1D-21 lines were analyzed up to the T4 generation. Approximately 30% of these transgenic lines showed stable transcription of the transgenes as determined by RT-PCR and northern blot analysis. Confirmation of a protein product was not possible due to the inability to develop antibodies against the RP1 proteins. Unfortunately, none of the transgenic wheat lines tested exhibited any noticeable increase in resistance to wheat leaf rust (*Puccinia triticina*) or any chlorotic or necrotic spotting. In similar experiments with transgenic maize plants expressing the transgene (Rp-1D) we observed a resistant reaction against maize leaf rust whenever the transgene was expressed above a certain threshold level. This observation indicated that the constructs were functional, at least in maize.

We also investigated if wheat leaf rust would elicit a resistant reaction on these transgenic maize lines and if the maize leaf rust could interact with the transgenic wheat. Normally these two conditions would not elicit a resistant response because of host/pathogen incompatibilities. In these experiments the wheat leaf rust did produce a hypersensitive reaction in maize but the reciprocal experiments in wheat still had no effect. The above results indicate: 1) the Rp1-D gene can confer resistance to maize leaf rust in maize, 2) the transgenic corn lines do recognize the wheat leaf rust and produced a hypersensitive reaction, and 3) wheat lines challenged with either rust do not elicit a resistant response. The lack of function in the wheat lines may be due to the absence of other downstream factors required for pathogen recognition or signaling. Future work will involve domain-swapping experiments with other resistance genes to possibly establishing the downstream pathways and eventual rust resistance.

SIGNIFICANCE: Rusts are one of the most economically damaging pathogens of cereals worldwide and in epidemic years yield loss from leaf rust in Kansas can reach as high as 11%. Although great effort has gone into developing rust resistant wheat lines in the past few decades, wheat resistance has not been totally effective. All of the current resistance genes to rust available to wheat breeders have been derived from conventional breeding programs using either different cultivars of common wheat or its close relatives. New cultivars released with improved disease resistance currently have a life

expectancy of about 5 years before virulent strains arising from mutations or from immigration from some other region typically minimizes their effectiveness. This 'boom and bust' cycle of wheat rust resistance results in unpredictable fluctuations in the yield and quality of wheat. Continued research as described above may help find a durable resistance that is currently lacking against leaf rust.

Wheat Quality for Chinese Northern-Style Steamed Bread

Researchers and Unit
C.E. Walker and X. Susan Sun, Grain Science and Industry

Funds (FY 02): $43,000 Completion Date: July 1, 2003

JUSTIFICATION: Most wheat (95%) in China is produced for human food. Of the amount used for human food, 46% is used for steamed bread. China was once the largest customer for US wheat exports, especially for Kansas hard winter wheat. During the latter half of the 1990s, China switched to importing wheat primarily from Canada and Australia. This was influenced by several circumstances including perceived quality issues, concern about disease, political events and economics. Much of the research done in the United States on steamed breads assumed that the properties for white pan bread would also be best for Chinese steamed bread. We realize now that this is not necessarily the case. This project will demonstrate the usability of some new varieties of Kansas wheat in order to become competitive in the international wheat markets in China.

OBJECTIVES:
1. To compare KS HRW and HWW wheat with US SRW and Australian HW, and Chinese hard white wheats.
2. Blend KS hard with US soft and Chinese wheat flours (Chinese wheats are often blended with US, Australian or Canadian hard wheat to improve quality).
3. Investigate effects of flourmill streams (varying extraction, ash and protein) on steamed bread quality.
4. Study how KS wheat flours respond to different processing and fermentation methods used in steamed bread.

RESULTS: Suitability was tested for several major varieties of Kansas hard wheat with different protein levels. Tests were conduced with single varieties as well as blends. Most varieties of the Kansas hard red and hard white wheats exhibited higher quality scores for northern-style Chinese steamed bread than did the Chinese wheats. All Kansas wheats showed improved volume and internal grain texture; however, at very high protein levels, there were exterior problems of skin shrinkage and wrinkles on the surface. Kansas hard wheats with protein content of 10-11.5% showed the best performance with good eating quality and shape, smooth surface, fine crumb texture, bright white skin, and adequate loaf volume.

SIGNIFICANCE: The immediate benefit of this project is a deeper understanding of the product as consumed in China and hence the wheat properties needed to better compete in the Chinese market. This information can be used by plant breeders, quality evaluation operations and by domestic and international marketing groups. It is impossible to fully estimate the ultimate impact of this project, but if successful it will at least partially contribute to regaining those 66 million bushels annually that Kansas once sold to China.

Market Scale Evaluation of White Winter Wheat in Flour Tortilla Manufacturing

Researchers and Unit
C.E. Walker, Grain Science and Industry

Funds (FY 02): $23,882 Completion Date: July 1, 2002

JUSTIFICATION: Promoters of hard white wheat have claimed that the miller can use a higher extraction rate to produce flour that could be used to manufacture the same quality of products made from flour at a lower flour extraction. The purpose of this study was to manufacture flour tortillas from flour at three different extraction rates at a commercial tortillaria in northern Mexico. Northern Mexico has long been known for production of flour tortillas, as opposed to corn tortillas which are better known in the south. With the cooperation of colleagues at the University of Sonora in Hermosillo, Mexico, three hard white flours from Kansas, three hard red flours from Kansas, and three locally grown flours from Sonora were milled to 74, 80 and 100% extraction. Textural and sensory tests were carried out at the University of Sonora.

OBJECTIVES:
1. Evaluate the white winter wheat flour from Kansas and a locally grown variety from Sonora, milled at different flour extractions in commercial mills in the manufacturing of tortillas at the University of Sonora, Hermosillo, Mexico, using commercial tortilla practices.
2. Evaluate the storage time effect on the tortillas made with the different wheat flours.
3. Evaluate textural and sensory attributes of each flour at each extraction.

RESULTS: Analytical tests were run on all 9 flours (3 flours at 3 extractions) prior to making the tortillas in a commercial tortillaria in Hermosillo. The research staff worked in conjunction with the owner and operators of the tortillaria to assure that commercial processes were being used. After the tortillas were made, they were taken back to the lab at the University of Sonora where they were tested for various physical measurements and then in a sensory study with an untrained panel.

SIGNIFICANCE: Currently Mexico uses a blend of Canadian and US flour and local Mexican wheat. Kansas wheat typically has higher protein than the indigenous flour, and this white wheat had even higher protein. The white wheat makes acceptable tortillas, by Mexican standards; however, the flour would probably be blended, negating the lighter color and bland flavor advantages. The Mexicans also prefer their tortillas darker, with more brown spots, or toast points. They are accustomed to higher extraction, darker flours; however, the tortillaria manager told us that the Kansas white wheats made good tortillas and he would be glad to buy it, but not at a higher price.

Wheat Screening for Natural Desirable Lipids

Researchers and Units
David L. Wetzel, Grain Science and Industry; Alan Fritz, Agronomy; Joe Martin, Agricultural Research Center – Hays

Funds (FY 02): $39,960 Completion date: June 30, 2002

JUSTIFICATION: The purpose of this research is to provide our Kansas Agriculture Experimental Station wheat breeders with an important factor concerning wheat quality for breadmaking.

OBJECTIVES:
1. Practical utilization of 1978 and 1998 wheat lipid Ph.D. research to predict end use quality.
2. Scale up of research extraction and analysis system for routine production application.
3. Provide quantitative analysis of natural desirable lipid content of experimental KAES breeding lines directly to our wheat breeders for consideration in their selection processes to enhance efficiency.

RESULTS: Drastic differences were noted in the content of naturally occurring desirable lipids among experimental lines under consideration in the KAES breeding program. Differences ranged from 300 m g of lipid per gram of flour or less to a high of approximately 2500 m g lipid per gram of flour. This range, a nearly 9-fold difference, was much greater than anticipated. Previously, determinations of lipids in flours from wheats deliberately chosen to represent widely differing breadmaking characteristics showed barely a 5-fold range. Released varieties grown in performance plots of the KAES had an even smaller range because these wheats were the product of the selection process in breeding. Genetic differences for different cultivars grown at the same location are the proof of the principle that it is worthwhile to know the desirable lipid content as an aid to the breeding program. As anticipated, environmental differences were also observed. Although the same cultivar grown at different locations had different absolute values of the lipid content, the rank by variety was consistent for different locations. Prior to the 12 month period reported, conversion of a research scale analysis scheme to the production situation with custom made equipment was a major accomplishment that made this reliable reporting of experimental wheats possible. Future analyses of wheat lines from a single nursery to identify genetic differences could provide valuable and timely breeding information regarding wheat quality. Only when successive years of specimens are analyzed and those that are carried forward are tested will we know the full advantage of this high-tech method.

SIGNIFICANCE: Maintaining our reputation for excellent bread quality wheat is essential to getting our share to the export and domestic market. We are using testing methods that were the direct result of KAES sponsored Ph.D. research at KSU. Application of these analytical procedures for quality determination during the breeding process will contribute to quality wheat and help avoid undue expenditure of efforts throughout this process with undesirable plant material.

Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Manhattan 66506

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