1999 REPORT ON

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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by the

Kansas Agricultural Experiment Station

Kansas State University

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INTRODUCTION

We are pleased to provide this update on research and educational activities made possible with checkoff funds from the Kansas Corn, Grain Sorghum, Soybean, and Wheat commissions. The commissions provided $2,063,433 in support in fiscal year 1998—corn, $375,370; grain sorghum, $510,322; wheat, $558,400; and soybeans, $618,981. These funds have been utilized by teams of research scientists and extension specialists to address issues that are important to our clientele.

Agriculture is becoming more complex, and, as the Kansas Agricultural Experiment Station strives to do its part in keeping Kansas agriculture competitive in a global economy, it is more important than ever that we supplement our limited state and federal funds with industry support. Funding from the Commodity Commissions is very much appreciated, both for that reason and because our association with them helps us to focus our efforts on issues important to producers.

Findings reported in this publication span cropping systems, water management and quality, pest management, breeding for resistance and quality, alternative uses, storage, processing, and marketing. Because all the 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 Cooperative Extension educational efforts.

George Ham
Associate Director
Kansas Agricultural Experiment Station

THE EFFECT OF VARIABLE-RATE PRECISION PLANTING ON CORN YIELDS

RESEARCHERS AND UNITS: **SCOTT STAGGENBORG AND KEVIN DHUYVETTER, NORTHEAST AREA EXTENSION OFFICE; DALE FJELL AND BARNEY GORDON, AGRONOMY; RANDAL TAYLOR, BIOLOGICAL AND AGRICULTURAL ENGINEERING**

FUNDS FY (98): **$10,020** COMPLETION DATE: **JUNE 30, 1998**

Justification for Research: In recent years, the primary interest in precision farming has been using global positioning satellite (GPS) equipment to map yields and soil variation. Variable rate applications of fertilizer, pesticides, and seed within a field are now possible. Equipment to adjust planting rates within a field is commercially available. Many corn producers believe that being able to match seeding rates to soil type would increase corn yields for the entire field. This is accomplished by planting higher seeding rates in the more productive areas of the fields and planting lower seeding rates in the less productive areas of the field, where moisture stress may reduce yields if the planting rate is too high. This research was designed to assist corn producers in determining if variable rate corn seeding would increase yields on an entire field basis.

Project Objectives: To determine if variable-rate seeding in corn will increase grain yields by matching planting rates to soil type within a given field.

Results: The results of this 3-year study indicate that variable-rate seeding will not result in higher grain yields compared to adequate, uniform, planting rates. Areas within four fields were designated as high, medium, and low yielding. Yields ranged from 95 to 204 bu / acre under dryland and 165 to 210 bu / acre under irrigation. At all levels, grain yields either increased as plant populations increased or did not change as plant populations increased. These results are similar to results of previous research conducted by Kansas State University and indicate that many corn producers probably are not using high enough planting rates to maximize corn yields.

Significance of Results: These results do not support the widespread use variable-rate corn seeding technology to increase corn yields. However, this technology may be able to reduce seed costs by planting lower seeding rates in areas of the field where expected yields are low every year or areas of a field where stand establishment is difficult and the resulting low plant populations cause lower yields. The results of this study do suggest that corn producers could increase their yields by increasing their overall plant populations. This research supports previous work that indicated that current corn hybrids have better drought tolerance, meaning that yields will not be reduced at higher plant populations during dry years, and yields will increase during highly productive years. These and other research results suggest that across the different growing season conditions encountered in Kansas, increasing corn plant populations from 14,000 to 26,000 plants / acre on average can increase grain yields by 15 bu / acre. Adopting this management practice could result in over $30 million in additional farm income for corn producers across Kansas.

MANAGING CORN PLANTING DECISIONS TO REDUCE RISKS

RESEARCHERS AND UNIT: ***RICHARD VANDERLIP AND DALE FJELL, AGRONOMY***

FUNDS (FY 98): ***$22,273*** *COMPLETION DATE:* ***JUNE 30, 1999***

Justification for Research: Corn and sorghum are planted annually on between 4-6 million acres in Kansas. Our past work with the grain sorghum model SORKAM has led to the development of a decision aid that allows producers to compare alternate management options using the expected range of grain yields produced and their own economic inputs. This project is designed to eventually add corn to this decision aid. By combining the two crops, we then would be able to look at not only the comparisons in grain yields over a period of time but also the economic advantage or disadvantage to shifting from one crop to the other. In recent years, early corn has received considerable interest and promotion as an alternative crop. With this project, we would be able to compare grain sorghum, early corn, and full-season corn from the standpoints of grain yields over time and economic returns. Because we have a parallel program in looking at sorghum planting decisions which is at much more advanced stage of development ,we feel this would be an excellent addition to that project and would provide the Kansas producer with a valuable tool. We have found the CERES-Maize model has serious deficiencies in how adequately it mimics the response of corn yield to plant population. Therefore, we need to make changes in the CERES-Maize model before we are able to accomplish the second objective.

Project Objectives:

1. To modify the CERES-Maize model to better simulate corn yields under Kansas conditions.
2. To utilize the improved CERES-Maize model to develop yield distributions for a wide range of maturity, plant-population, and planting-date combinations.

Results: A graduate student with excellent climatology background has been recruited and has rapidly familiarized herself with the work of the previous student. We have learned that part of the problems encountered in the past were due to incorrect solar radiation data in the weather files. This problem has been corrected. Recently, a revised version of the CERES-Maize model was made available, which appears to have had several major changes. Preliminary runs suggest that simulation of leaf number is greatly improved ,without the associated problems with silking date we reported earlier. Unfortunately, since release of this new version, we have been notified of significant errors and are awaiting a corrected copy. However, we are optimistic that with the improvements that were made, we can now go back and look at the problems of kernel number estimation using the methods that were successful in simulating seed number for grain sorghum.

Significance of Results: If the improvements in the model are successful, we will be able to add corn to the Field Crop Decision Aid computer software for grain sorghum.

EFFECTS OF HYBRID MATURITY AND PLANT POPULATION ON CORN GRAIN YIELDS IN A WESTERN KANSAS WHEAT-CORN-FALLOW ROTATION

RESEARCHERS AND UNITS: ***DANIEL O'BRIEN AND RANDALL BROWN (RESIGNED), NORTHWEST AREA EXTENSION OFFICE; DALE FJELL, AGRONOMY***

FUNDS (FY 98): ***$4,707.93*** *(OF $6,800 APPROVED BUDGET)* *COMPLETION DATE:* ***JUNE 30, 1999***

Justification for Research: Little research has considered optimum populations for dryland corn in the semi-arid western Kansas environment. More research is needed to assess the effects of hybrid maturity and plant population under both favorable and unfavorable growing conditions at alternative western Kansas locations.

Project Objectives:

1. To determine the effects of plant population and hybrid maturity on corn grain yield and profitability in a no-till wheat-corn-fallow rotation in western Kansas.
2. To develop specific plant population guidelines for farm decision makers.

Results: In the first year of this 2-year study, two western Kansas locations were selected. Corn was planted no-till in early May at populations ranging from 8,000 to 24,000 plants / acre. At the Greeley County site, above-average precipitation was favorable to higher plant populations, whereas at the Wallace County site, below-average precipitation early in the growing season stressed the high plant populations. Harvested corn yields averaged 80 bu / acre in the two locations, with a range of 59 to 98 bu across the plots. Ear counts ranged widely and were correlated positively with population levels. Harvested corn moisture levels ranged from 15% to 25% and were correlated negatively with populations. The results indicate that although an initial yield response may have occurred to increasing corn populations from 8,000 to 12,000 plants / acre, little or no additional yield increase resulted as populations increased to 16,000, 20,000, and 24,000 plants / acre. Using 1999 K-State crop budget estimates, the cost of each additional 1,000 planted corn seeds is approximately $1.20 / acre. If cash corn prices average $2.00 / bu, then an increase in yield of only 0.6 bu / acre would be needed to pay for additional seed. For corn prices varying from $1.50 to $3.00 / bu, the added yield needed to justify planting an additional 1,000 units of seed varies from 0.4 to 0.8 bu / acre. Therefore, only minimal yield increases are required to economically justify planting successively higher corn plant populations.

Significance of Results: With high populations of corn, unfavorable moisture conditions did not lead to decreased yields, and favorable conditions caused yields to increase. However, the data also indicate that grain yield reaches a plateau as corn population increases to successively higher levels. Based in part on the preliminary results of this study, KSU agronomists are recommending that dryland corn producers consider targeting their corn populations at 16,000 to 20,000 plants / acre but not to higher levels. This recommendation is an increase from the 10,000 to 19,000 range commonly used by western Kansas dryland corn producers.

INFLUENCE OF ROW SPACING AND PLANT POPULATION ON CORN PRODUCTION

RESEARCHERS AND UNITS: ***W. BARNEY GORDON, DALE FJELL, AND VICTOR MARTIN, AGRONOMY; SCOTT STAGGENBORG AND KEVIN DHUYVETTER, NORTHEAST AREA EXTENSION OFFICE***

FUNDS (FY98): ***$8,020*** COMPLETION DATE: ***JUNE 1998***

Justification for Research: With the development of combine headers for corn capable of harvesting 15- to 20-inch rows, interest in narrow row corn spacing has been renewed among producers in many regions. At a given plant population, corn often yields more grain when distance between adjacent rows is decreased and the distance between plants within a row is increased to give a more equidistant plant spacing pattern. Most narrow-row corn experiments have been conducted in the upper midwest region. Information was lacking on row spacing and population effects on corn production in the western corn belt area

Project Objective: To determine the effect of three row spacings (30, 20 and 15 inches) and four plant populations (20,000, 26,000, 32,000, and 36,000 plants / acre) on yield of corn grown in both dryland and irrigated environments.

Results: Corn yield response to narrow row spacing was inconsistent over the 3 years of this experiment. Yields were increased significantly by utilizing rows narrower than 30 inches in only 3 of 8 site-years. At the dryland site near Belleville in 1996 (a wetter than normal year), corn yields were increased by 16 bu / acre with narrow rows at high plant populations but decreased in 1997 (a drier than normal year) by 25 bu / acre. In 1998 at Belleville, corn yields were not affected by row spacing. At a sprinkler irrigated site near Scandia, 2-year average yields were increased in narrow rows by 18 bu / acre. However, 3-year average grain yields were not affected by row spacing at another sprinkler irrigated site at St. John. Optimum plant population under irrigated conditions was near 32,000 plants / acre. Even in drought-affected corn, high populations did not adversely affect yields.

Significance of Results: Corn with high yield potential, either under irrigation or in favorable dryland environments, can respond well to narrow-row production systems. However, in most Kansas environments, weather conditions cause a large year-to-year variation in corn yield. In general, yield response to rows narrower than 30 inches has been inconsistent. Changing row spacing for corn production in Kansas provides little economic advantage. A greater economic advantage may be realized by increasing plant populations in 30-inch row spacings.

MONITORING AND MODELING NITROGEN MANAGEMENT IN CONSERVATION-TILLAGE PRODUCTION SYSTEMS

RESEARCHERS AND UNITS: ***RAY LAMOND, AGRONOMY; PRASANTA KALITA, BIOLOGICAL AND AGRICULTURAL ENGINEERING***

FUNDS (FY98): ***$21,000*** *COMPLETION DATE:* ***JUNE 30, 1999***

Justification for Research: Because nitrogen (N) is a major input in corn production, management practices that allow for more efficient use of N can greatly affect profitability and minimize environmental risks. Also, Kansas producers continue to increase the use of conservation-tillage management systems. Research objectives 1 through 3 allow evaluation of effects of N sources and a urease inhibitor on the performance of surface-applied N in conservation-tillage production systems. The demand for understanding nitrate movement and transport in and below the root zone has increased considerably because of environmental concerns about nitrates in groundwater. Leaching losses of nitrates are most significant when the rates of fertilizer application exceed the crop requirements. However, enhanced rainfall infiltration into reduced-tilled soils may increase risks of nitrate leaching. In Kansas, several studies have been conducted on the effects of tillage, crop rotations, fertilizer timing, and application rates on corn yield. However, limited data have been reported as to how conservation-tillage systems influence nitrate losses through leaching. Objective 4 will monitor field nitrate transport under one source at the highest N rate. These data will be compared to predicted uptake and transport of nitrate N by computer simulation models to accomplish objective 5.

Project Objectives:

1. To evaluate N rates and sources surface broadcast in conservation-tillage (high-residue) cropping systems.
2. To evaluate the use of a urease inhibitor as an additive to urea-containing fertilizers.
3. To evaluate the chlorophyll meter as an in-field N assessment tool.
4. To monitor the effects of conservation tillage on soil N dynamics in and below the crop root zone.
5. To evaluate computer simulation models used to predict soil N dynamics in and below the crop root zone.

Results: Results indicate that ammonium nitrate and urea + NBPT (urease inhibitor) often outperformed urea and UAN when surface applied in conservation-tillage production systems. The chlorophyll meter works well as an "in-field" N assessment tool. The computer model (LEACHM) has been calibrated and validated to predict N leaching from three Kansas locations.

Significance of Results: Results confirmed that use of a urease inhibitor with urea-containing fertilizers improves their efficiencies when surface applied in conservation-tillage systems. The urease inhibitor tested is available under the trade name of AgrotaiN.The computer model will help predict N-transport processes under conservation-tillage systems in Kansas.

A SHORT-SEASON CORN EXTENSION EDUCATIONAL PROGRAM IN SOUTHEAST KANSAS

RESEARCHERS AND UNIT: ***GARY KILGORE AND MARVIN FAUSETT, SOUTHEAST AREA EXTENSION OFFICE***

FUNDS (FY 98): ***$3,380*** *COMPLETION DATE:* ***JUNE 30, 1999***

Justification for Research: Corn acreage in southeastern Kansas has doubled in the last 11 years. This is due to the planting of short-season corn on the clay upland soil. Experiment station data show that short-season corn is much more reliable in yield than full-season corn. In fact, if the corn is planted early (March 25 - April 10), experimental results show that short-season corn can be more profitable than early-planted grain sorghum.

Project Objectives: To transfer research results to producers by using on-farm demonstration trials that include:

1. Performance of Bt corn in terms of yield and reduction in corn borer infestation.
2. Evaluating weed control using Roundup Ready corn.
3. Determining the effects of nitrogen rate and phosphorus placement on grain yield.
4. Evaluating 15- and 30-inch rows using 20,000 and 28,000 plants / acre.
5. Subjecting all yield results to economic analysis.

Results: Over 2,000 producers visited on-farm plots and learned about the results of the project this past year. Bt hybrids averaged 11.4 bu / acre more corn than their sister hybrids. Bt hybrids showed a 94% reduction in European corn borer infestation. Weed control in Roundup Ready corn needs more work. Time of application can be a narrow target, and two applications of Roundup may be needed some places. Nitrogen rates over 100 lbs / acre did not increase yields and should not be used on upland corn in southeastern Kansas. Weather affected production, and 82 bu / acre was the average yield across all plots. Corn yields increased as rows were narrowed from 30 to 15 inches, although increasing populations over 22,000 plants / acre did not increase production at either row width.

Significance of Results: Short-season corn on upland soils in southeastern Kansas results in at least a 15 bu / acre yield advantage, which provides a $33.00 / acre increase in production. On 130,000 acres of corn, that results in an annual advantage of $4.3 million for area corn producers. The 11.4 bu increase in yield for Bt corn means an additional $25.44 / acre for those acres. A population of 20,000 plants / acre results in 11.8 bu / acre more yield than 26,000 plants / acre. That's equal to an income increase of $27.14 / acre. Over 2,000 producers saw these results. Twelve producers cooperated with on-farm research plots. This one year's educational program is valued at over $5 million for corn producers in southeastern Kansas.

EVALUATING CORN BORER RESISTANCE AND RESISTANCE MANAGEMENT STRATEGIES FOR Bt-CORN

RESEARCHERS AND UNITS: **LAWRENT BUSCHMAN, RANDALL HIGGINS, AND GERALD WILDE, ENTOMOLOGY; VICTOR MARTIN, SANDYLAND EXPERIMENT FIELD; PHILIP SLODERBECK, SOUTHWEST AREA EXTENSION OFFICE**

FUNDS (FY 98): **$32,400** COMPLETION DATE: **JUNE 30, 1998**

Justification for Research: Kansas's farmers routinely experience several million dollars in recognized losses to corn borers annually. Bt-corn was genetically engineered to be resistant to corn borers, and some of these hybrids are nearly immune to attack by both European and southwestern corn borers. However, other Bt hybrids are not this effective and will need insecticide protection for second generation corn borers in Kansas. Therefore, the performance of the different Bt corn hybrids under second-generation corn borer pressure in Kansas should be investigated. Information on the agronomic performance of these hybrids also is needed. In addition, many questions about management of Bt-corn resistance need to be investigated.

Project Objectives:

1. To evaluate the performance of Bt-corn hybrids.
2. To evaluate refuge-planting patterns.
3. To evaluate the virulence of Dipel-resistant and -susceptible strains of European corn borer (ECB) against different Bt corn hybrids.

Results:

Replicated small plots were established at three sites in Kansas and included hybrids from Novartis Seeds, Mycogen, Golden Harvest, Cargill, Pioneer, and DeKalb. Hybrids with Bt11 and MON810 reduced ECB by 91 to 100%, southwestern corn borer by 89 to 100%, and yield losses by 77 to 96%. Hybrids with event 176 and non-Bt-corn hybrids that were insecticide treated reduced ECB by 64 to 82%, southwestern corn borer by 26 to 74%, and yield losses by 32 to 57%. Most Bt corn hybrids yielded as well as or better then their non-Bt counterparts.

The results from five field plantings across Kansas do not support the neighborhood suppression hypothesis. Almost no change in corn borer numbers occurred at different distances from the interface with Bt-corn. Two within-field refuge-planting patterns were practical for some production systems but would need some modifications for common Kansas conditions.

Bt corn hybrids with MON810, Bt11, or event 176 had very good resistance during the whorl stage to first instar larvae from both Dipel-resistant and Dipel-susceptible ECB. Hybrids with DBT418 did not have complete resistance to first instar larvae from either colony. Hybrids with MON810 or Bt11 also had very good resistance during the whorl stage to third instar larvae from both colonies. Hybrids with event 176 or DBT418 were susceptible to third instar larvae from both colonies.

Significance of Results: Bt corn hybrids with Bt11 and MON810 were resistant to both generations of European and southwestern corn borers in Kansas. We did not observe a yield drag associated with Bt corn. The lack of support for neighborhood suppression was disappointing, because it would have been a bonus for planting the refuge. Within-field refuge planting patterns probably will require some inconvenience on the part of Kansas producers. These results also indicate that virulence to Bt-corn can be identified and that resistance management for Bt-corn is essential, if we wish to preserve the long-term usefulness of this technology.

TESTING Bt HYBRIDS AND OTHER CULTURAL PRACTICES TO REDUCE CORN EAR DISEASES

RESEARCHERS AND UNITS: **JAMES LONG, SOUTHEAST AGRICULTURAL RESEARCH CENTER; DOUGLAS JARDINE, PLANT PATHOLOGY; GARY KILGORE, SOUTHEAST AREA EXTENSION OFFICE**

FUNDS (FY 98): **$7,000** COMPLETION DATE: **JUNE 30, 1999**

Justification for Research: Corn production areas in Kansas experience periodic problems with ear disease, especially *Aspergillus flavus* and the resulting aflatoxin. Aflatoxin was reported in many samples for the 1996 growing season by the Kansas Feed Grain Inspection Service. Although drought is widely believed to play a major role in these diseases, many factors including insect attack on the ear and hybrid selection may be very important in development of ear disease. Recent studies have indicated that large differences in levels of aflatoxin may occur between individual hybrids. Anything that prevents drought stress or reduces insect damage may help in reducing ear molds. One promising development is the introduction of Bt (*Bacillus thuringiensis*) genetically engineered hybrids, which prevent insect feeding and also may prevent disease / mold introduction into the ear. Because of the substantial loss of marketable grain if aflotoxin levels are greater than 20 ppb, effects of cultural practices, such as using insect-resistant hybrids like the new Bt corns or reducing plant population, on reduction of ear molds should be investigated.

Project Objective: To determine the effects of corn hybrids, including new Bt hybrids that were genetically engineered to contain biological insecticide, and cultural practices such as planting populations, hybrid maturity, and irrigation on corn ear disease.

Results: Specific diseases such as that caused by *Aspergillus flavus* and subsequent aflatoxin production are highlighted in this study that includes fields at the Southeast Agricultural Research Center and farmer's fields where ear diseases are surveyed. The use of Bt hybrids has reduced the amount of corn earworm damage in some cases. The percentage of corn kernels damaged by the ear worm and susceptible to aflatoxin contamination is reduced when lower plant populations are utilized under nonirrigated conditions. The amount of total damage to irrigated corn was similar to that under nonirrigated conditions in all 3 years. However, with more corn produced under irrigated conditions in 1996, the percentage damage to corn kernels was less than in nonirrigated corn. Nonirrigated corn had more aflatoxin than did irrigated corn in 1997 and 1998.

Significance of Results: The presence of aflatoxin contamination in corn grain can hurt the marketing of grain through the local elevator or of dairy products from cattle that have eaten it. Local elevators also have difficulty marketing grain in bulk that is contaminated. These studies help us to better understand hybrid tolerance to disease and insects, especially Bt insect resistance, and the effect of cultural practices on ear diseases and aflatoxin production in corn grain.

TRANSGENIC CORN FOR PEST MANAGEMENT— RESEARCH AND EXTENSION NEEDS

RESEARCHERS AND UNITS: **RANDALL HIGGINS, LAWRENT BUSCHMAN, AND GERALD WILDE, ENTOMOLOGY; VICTOR MARTIN, AGRONOMY**

FUNDS (FY 98): **$35,110** COMPLETION DATE: **MARCH 31, 1998**

Justification for Research: Kansas farmers routinely experience several million dollars in recognized losses following European corn borer (ECB), southwestern corn borer (SWCB), and corn earworm (CEW) attacks. Dramatic pest control results were observed in initial university trials. These findings foretold very extensive adoption of genetically engineered (or transgenic) corn following registration and commercialization. Unbiased data were urgently needed on control performance provided by genetic insertion events and hybrids. Data assessing the probability that resistance could arise in the pest population also was unavailable. Educational materials explaining the advantages and limitations of this new pest management tool to farmers and consultants also were lacking.

Project Objectives:

1. To evaluate the ability of transgenic (Bt+) and nontransgenic (Bt-) corn to suppress natural infestations of ECB and SWCB.
2. To document changes in predator populations.
3. To evaluate spider mite severity in Bt+ and Bt- corn following applications of broad-spectrum insecticide or no application.
4. To evaluate efficiency of Bt+ corn in reducing kernel damage by CEW.
5. To assess the likelihood that resistance to *Bacillus thuringiensis* (applied in the form of Dipel) may develop.
6. To facilitate development of Extension materials suitable for educating the public about transgenic corn, particularly pest management aspects.

Results: Project personnel developed and delivered (Sept. 29, 1998) a satellite-television program about managing corn borers with traditional (nontransgenic) and genetically engineered (Bt) corn; coauthored a regional publication, entitled Bt Corn and European Corn Borer: Long-Term Success through Resistance Management; updated the same during 1998; and participated (Feb. 1998) in an EPA-sponsored scientific review panel assessing appropriateness of transgenic crop deployment strategies. Corn hybrids possessing MON810 or Bt11 events provided higher levels of full-season suppression than did hybrids possessing the Bt 176 event. Use of Bt corn did not seem to adversely affect predators, but spider mite populations were inadequate to evaluate effects properly. Whorl-stage damage by CEW substantially declined in Bt corn. Kernel damage also dropped by nearly 50% in some Bt hybrids. Overall, some of the Bt corn hybrids yielded more than non-Bt hybrids, whether or not sprays were applied. Laboratory studies showed that ECB has the potential to develop resistance to Bt (at least when formulated as Dipel). Research results have been disseminated via radio, field days, newsletters, publications, and the World Wide Web.

Significance of Results: These experiments demonstrate the high level of economic value associated with Bt corn. Hybrid comparison studies revealed that differences among Bt events exist in terms of late-season protection against corn borers. The risk of resistance development is high enough that active resistance awareness programs and management investigations designed to minimize these risks must be undertaken. As a result of these efforts, corn growers and consultants are more informed about advantages and limitations of growing Bt corn in Kansas.

VARIABLE NITROGEN MANAGEMENT FOR PROTECTING GROUNDWATER QUALITY

RESEARCHERS AND UNITS: **JOHN SCHMIDT AND RAY LAMOND, AGRONOMY; MARK SCHROCK, BIOLOGICAL AND AGRICULTURAL ENGINEERING**

FUNDS (FY98): **$24,000** COMPLETION DATE: **JUNE 30, 2000**

Justification for Research: Irrigated corn is grown on coarse-textured soils in Kansas predominately in the Upper and Lower Arkansas River basins. Irrigation represents about 80% of the total water use in this area. Recent studies have shown groundwater nitrate (NO_3) concentrations between 2 and 60 ppm and that increasing NO_3 concentration was correlated highly to increasing well density and decreasing depth to groundwater. Although fertilizer use in this region has been relatively constant since 1975, well density has increased dramatically, thus increasing groundwater contamination potential. Increasing the accuracy of nitrogen (N) recommendations requires that crop yield goals reflect within-field heterogeneity. Yield monitoring can be used to quantify the spatial distribution of yield potential within a field. Combined with a spatial distribution of potential mineralizable N and soil profile NO_3, variable fertilizer N recommendations should be more accurate than those based on field averages.

Project Objectives:

1. To demonstrate the ability of variable rate application technology (VRAT) to improve the accuracy of predicting N rates and applying fertilizer.
2. To demonstrate the potential for VRAT to increase recovery of fertilizer N by the crop and to decrease fertilizer-related NO_3 loss to groundwater.
3. To demonstrate expected costs / benefits incurred by implementing VRAT N management.

Results: Nitrogen was variably applied on four of five fields at rates ranging from 150 to 250 lbs N / acre. On the fifth field, uniform yield and uniform soil NO_3 levels precluded variable N application. Leaf N content and soil NO_3 content monitored during the growing season throughout the field indicated no areas of N deficiency. In several areas of the field, small plots were used to determine the yield response to N rates (ranging from less than 100 lbs N / acre to greater than 390 lbs N / acre). This was the first year that these small plots were used. In every instance, 150 lbs N / acre was sufficient to produce optimum yield. Post-harvest soil samples (0-4 ft depth) showed no differences in residual NO_3 regardless of N rate.

Significance of Results: On four of five fields, variable N rates did not improve yield, but indicated that these producers were applying sufficient N for the entire field. The potential for variable N application appears to be in increasing N use efficiency by reducing the amount of N applied. Although a single year of small-plot work is insufficient to predict long-term yield response to applied N, N applications of 100 lbs / acre less than the maximum rate were sufficient to produce optimum yield. This indicates that the economic potential, as well as the environmental potential, of reducing N rates for corn production is real.

WEED CONTROL AND ATRAZINE BEST MANAGEMENT PRACTICES IN CORN

RESEARCHERS AND UNITS: **DAVID REGEHR, AGRONOMY; PHILIP BARNES, BIOLOGICAL AND AGRICULTURAL ENGINEERING**

FUNDS (FY 98): **$37,750** COMPLETION DATE: **JUNE 30, 1998**

Justification for Research: Atrazine is an economical and highly effective herbicide used on 79% of Kansas corn acres. It is present at levels of concern in some municipal water supplies derived from surface water. Atrazine concentrations in drinking water can be lowered by using Best Management Practices (BMPs) that reduce the potential for loss in surface water runoff.

Project Objectives:

1. To evaluate atrazine and nontriazine alternatives for weed control in field corn, including timings, formulations, and tank-mixtures.
2. To evaluate the impact of BMPs, including application timings, soil incorporation, and tillage practices, on weed control efficacy and surface water quality.

Results: Balance is an experimental soil-applied herbicide with a new mode of action that controls a spectrum of weeds resembling that controlled by atrazine. Our tests on fine-textured soils of eastern Kansas have shown that 2 oz / acre has excellent promise when supplemented with half rates of chloracetamide herbicides such as acetochlor (Harness, Surpass). Balance is especially effective on velvetleaf and could reduce the need for postemergence treatments where this weed is the main target. In western Kansas, rates of 1 to 1.5 oz / acre show potential for use in both irrigated and ecofallow corn. Balance has been quite effective for control of field sandbur. Other tests have included atrazine alternatives such as Hornet and Basis on conventional corn and Lightning, Roundup Ultra, and Liberty for use on resistant corn hybrids.

Experiments at Ottawa and Manhattan confirm that soil incorporation reduces runoff losses of planting-time atrazine by over 70% compared to soil surface placement under no-till conditions. For no-till fields where mechanical incorporation is not an option, runoff losses can be reduced by applying atrazine during low precipitation months of late winter and early spring. Atrazine applied in December to soybean stubble gave excellent control of winter annual weeds and contributed greatly to weed control in the following crop. Runoff losses from this treatment were 0.03% of applied during the dry winter of 1996-97 and 2.5% of applied in the wet winter of 1997-98.

Significance of Results: Corn producers have access to herbicide programs that are economical, environmentally sound, and provide excellent weed control when properly managed. Moderate use of atrazine is compatible with essentially all these programs, enhancing economics and performance, with minimum contribution to herbicide contamination of drinking water sources.

IRRIGATION SCHEDULING AND WATER MANAGEMENT DEMONSTRATION PROJECT IN SOUTH CENTRAL KANSAS

RESEARCHERS AND UNITS: **GARY CLARK AND DAN ROGERS, BIOLOGICAL AND AGRICULTURAL ENGINEERING; VICTOR MARTIN AND DALE FJELL, AGRONOMY**

FUNDS (FY 98): **$20,000** COMPLETION DATE: **ONGOING**

Justification for Research: Irrigated corn is a major crop in the south central Kansas area with approximately 290,000 acres and annual gross revenues of about $118 million. The groundwater source for irrigation in that region of Kansas is replenished by rainfall and is a renewable source. With proper management and conservation, it can be a continual and sustainable water source for irrigated crop production. However, that water source must be shared with municipalities, industry, and wildlife. The irrigated crop production industry is very interested in water conservation and technology that can help to preserve and protect water resources.

Project Objectives:

General—To improve irrigation water application and water use efficiency for sustainable irrigated-crop production in the south central Kansas area by increasing the understanding, adoption, and use of improved irrigation scheduling and management procedures.

Specific—

1. To provide educational workshops and field days that present and discuss current irrigation system and water management technology for improved water management.
2. To develop, implement, and monitor irrigation scheduling and management programs for specific field partner sites.

Results: Seven irrigation management seminars were conducted during February of 1998 and had an attendance of approximately 190 persons. Seminars focused on the fundamentals of irrigation water management and how to use and access the automated weather system network in central Kansas. Irrigation management folders were sent to each of the 13 field partners for their use during the 1998 summer production season. Weekly site visits were conducted throughout the summer to assess system operation and field water management practices. Six of the field partners called the weather stations and used that data to help schedule their irrigation events. The center pivot irrigation systems were modified on four of the partner sites. Irrigation nozzles were replaced with new nozzles that were pressure regulated. The water flow rate on some of the nozzles was measured continuously, while other nozzles were calibrated to the metered nozzles. Modified nozzles created three water application zones that applied 55%, 75%, and 100% of a target application depth.

Significance of Results: The work is still in progress. Grain yield from the modified zones on the commercial systems will be used to determine if the current water application management plan for each site results in the best yield, or if reduced applications of water would provide similar yield results. Improved management can reduce applications of irrigation water, which saves pumping-related energy and costs and reduces aquifer withdrawals of water. Annual reductions in irrigation system water applications of 1 to 2 inches over the 290,000 irrigated corn acres can save from 1 to 2 billion acre feet of water each year.

IRRIGATION SCHEDULING DEMONSTRATION OF EFFICIENT WATER USE BY CORN IN WESTERN KANSAS

RESEARCHERS AND UNITS: **MAHBUB ALAM AND JAMES SARTWELLE, SOUTHWEST AREA EXTENSION OFFICE; TODD TROOIEN, SOUTHWEST RESEARCH-EXTENSION CENTER; STEVE FROST, GROUNDWATER MANAGEMENT DISTRICT #3; DANNY ROGERS, BIOLOGICAL AND AGRICULTURAL ENGINEERING; ANTHONY STEVENSON, SOUTHWEST KANSAS IRRIGATION ASSOCIATION**

FUNDS (FY 98): **$24,710** COMPLETION DATE: **ONGOING**

Justification for Research: Out of three million irrigated acres within the entire state of Kansas, 2.1 million acres are in the western one third of the state. Irrigation provides for consistent annual production of corn, which covers 1.2 million acres. Processing corn grain through livestock adds value and provides an economic spin effect for all Kansans. But depletion of the water source (Ogallala Aquifer) is a major concern for a sustained production in the future. Management and increased efficiency of irrigation are the keys to maintaining a sustainable production. A practical educational program on irrigation scheduling is essential to provide the producers with the tools to increase irrigation efficiency. Evapotranspiration (ET)-based irrigation scheduling is now available but needs to be brought to the field. Farmers need to be educated through demonstrations, and the tools and techniques need to be applied at their farms.

Project Objectives:

1. To establish demonstration fields and educate producers of irrigated corn about the technique of irrigation scheduling for efficient use of water.
2. To utilize weather-based ETor ET forecast and other techniques for irrigation scheduling.
3. To hold irrigation seminars and demonstration field tours and disseminate results through published reports.

Results: Irrigation scheduling demonstration fields were established in five counties in southwest Kansas. The producer partners of the demonstration fields were located in Finney, Ford, Grant, Kearny, and Stevens counties. Permanent signs for easy identification of the location and understanding of the objectives of the project by viewers were established. Sensors to monitor soil water were installed, and data were collected and shared with the cooperators to give them the opportunity to make irrigation decisions. ET gages were established, and weather station ET data were compared. Irrigation field tours were held in all of these five sites and were attended by 112 individuals. These were farmers, agricultural consultants, bankers, journalists, and agency people. The journalists covered the news of the tours on radio and TV. Four educational seminars were held and were attended by 145 individuals. They were rated very highly for the material and effectiveness.

Significance of Results: The overall amount of irrigation was reduced. The growers used the information to their benefit and reduced pumping hours. The producer partner in Finney County pumped 5 inches of less water compared to the previous year. The producer partner in Stevens County was able to shut down the pivot intermittently for a total of 11 days during the growing season, when other producers kept running their pivots, which is the usual practice of the area. Adoption of irrigation scheduling has a bright future and will help reduce pumping of water.

EXTRUSION TECHNOLOGY FOR ADDING VALUE TO CORN DRY-MILLED PRODUCTS

RESEARCHERS AND UNITS: **JOHN BRENT AND CAROL KLOPFENSTEIN, GRAIN SCIENCE AND INDUSTRY; CAROLE SETSER, FOODS AND NUTRITION**

FUNDS (FY98): **$36,852** COMPLETION DATE: **DECEMBER 31, 1998**

Justification for Research: Cornflakes are among the major breakfast cereals in the U.S. market. Traditional methods of cooking employed batch techniques, which are still in use today. Extrusion processing, as an alternate cooking process, already has been shown to reduce the cooking time during cornflake manufacture. An additional benefit of extrusion processing is that lower-cost raw materials such as flour or snack meal can be used to formulate a majority of the recipe. This research has capitalized on the unique capabilities of the extrusion process to not only incorporate healthier, minor ingredients such as corn bran and soy fiber, but also to enhance further the nutritional benefits of the added ingredients. Hence, the outcome was to develop new products that add value to underutilized raw materials, while creating new and potentially healthier foods.

Project Objectives:

1. To determine the role of the thermomechanical treatment in changes that occur in cereal components during extrusion processing to manufacture simulated flaking grits.
2. To measure chemical, physical, nutritional, and sensory changes that occur during processing and in the final products.

Results: Animal feeding studies with hamsters showed that formulation and extrusion process conditions are influential in reducing serum cholesterol levels. Testing by 95 breakfast cereal-eating consumer panelists determined acceptance in comparison with commercial products. Three of the five commercial brands of cornflakes were ranked significantly above the other test samples in terms of overall acceptance, flavor, and texture. This level of acceptance was determined even after 3 minutes in milk. With regard to extruded cornflakes, the consumer tests indicated a range of products with varying levels of acceptability. For example, after 3 minutes in milk, six of the extruded cornflake samples were not significantly different in overall acceptability than two commercial products.

Significance of results: Nutritionally enhanced cornflakes have been developed using lower value corn flour and extrusion technology. Incorporation of soy fiber has been shown to have potential benefits in reducing serum cholesterol, while maintaining an acceptable product.

COMPARISON AMONG FRANKFURTERS PREPARED WITH CORN STARCHES: RHEOLOGICAL, SENSORY, AND MICROBIOLOGICAL ANALYSES

RESEARCHERS AND UNITS: **THOMAS HERALD, KATHY HACHMEISTER, AND RANDALL PHEBUS, ANIMAL SCIENCES AND INDUSTRY; JANE BOWERS, FOODS AND NUTRITION**

FUNDS (FY 98): **$31,907** COMPLETION DATE: **JUNE 30, 1998**

Justification for Research: Consumers are eager to reduce dietary fat; however, they want foods that are satisfying, rich, and flavorful. The food industry has developed many ingredients to replace fat (e.g., proteins, modified starches) in food systems. This has created a vast market for fat substitutes in food product such as comminuted meat products. In an attempt to facilitate production of reduced-calorie meat products, the USDA (1988) adopted a rule permitting the substitution of water for fat. However, the substitution of water created unacceptable textural characteristics in reduced-calorie frankfurters. The most cost-effective way to manufacture reduced-fat comminuted meat products may be to remove the fat and use binders such as corn starch to retain added water. Researchers have indicated that starches helped to stabilize emulsions by binding excess water and improving yields. Furthermore, inclusion of starch in meat products such as frankfurters resulted in low drip loss, firm texture, and other desirable characteristics. Modified starches are present in the market that possess characteristics similar to fat and are able to withstand the physical and chemical abuses that accompany processing.

Project Objectives:

1. To evaluate the sensory attributes and physical characteristics of reduced-fat frankfurters containing modified corn starches.
2. To compare textural attributes of reduced-fat frankfurters containing modified corn starches.
3. To evaluate the shelf stability of frankfurters containing modified corn starches.

Results: A descriptive sensory panel found the texture, aroma, and flavor of frankfurters acceptable after 35 days of storage. Consumers found that the frankfurters formulated with the selected corn starches were acceptable for overall color, ranking higher than frankfurters purchased from the supermarkets. Thus, modified corn starches displayed sensory characteristics similar to those of modified potato starch that currently is used in frankfurter formulations. Cross-linked starches from dent corn and waxy maize minimized purge, cooking, and reheating losses. The firmness of the frankfurters formulated with these cross-linked starches did not change after 6 weeks of refrigeration. Freeze/thaw stability testing and other textural attributes all showed that corn starches performed well. Longer shelf life for frankfurters formulated with modified corn starches was noted; lactic acid bacteria counts were low and the pH remained stable. Shelf lives of frankfurters stored at 3 and 8C were 42 and 21 days, respectively.

Significance of Results: Approximately 811 million pounds of frankfurters are consumed each year. This research has shown that certain modified corn starches function like potato starch in a meat batter system. These starches can replace the modified potato starch that is used commonly in the meat industry. Consumer acceptability of frankfurters formulated with modified corn starches may equate to increased applications for corn starches. Furthermore, the data collected will assist processors in formulating acceptable low-fat frankfurters.

MANAGING MARKETING AND PRODUCTION RISK IN THE POST-DEFICIENCY-PAYMENT PERIOD

RESEARCHERS AND UNITS: ***G. A. (ART) BARNABY, JR. AND WILLIAM I. TIERNEY, JR., AGRICULTURAL ECONOMICS; DAN O'BRIEN, NORTHWEST AREA EXTENSION OFFICE***

FUNDS (FY 98): ***$20,000*** *COMPLETION DATE:* ***JUNE 30, 1999***

Justification for Research: Many growers are now faced with price and yield risk management in the post- deficiency-payment period. Growers had many opportunities to preharvest price their crop above the market price at harvest time. However, very few growers took advantage of those opportunities. A recent survey showed that about 15% of Kansas farmers have used options, 30% have forward contracted, and less than 5% have used futures. Those growers who use forward pricing tools, currently price less than 1/3 of their expected production. The risk-assessed marketing (RAM) approach is to develop a corn case study that would allow growers to work through various marketing strategies with price and yield risk. Although many growers received a temporary "bail out" from a $6 billion market and ad hoc disaster program that covers yield losses and a 50% increase in agricultural marketing transition payment, this level of financial help is unlikely to be available in the future. Therefore, better risk management will be a requirement for successful Kansas growers.

Project Objectives:

1. To continue development of the successful corn RAM workshops, which include helping farmers increase their average corn price and increase profits, develop risk plans that include currently available private risk tools, and develop plans that would allow them to price up to 100% of their crop by harvest without increased financial risk.
2. To help growers develop risk plans that would allow them to price up to 80% of their expected crop up to 2 years ahead of harvest without increased financial risk.
3. To develop a corn marketing handbook with a chapter on crop insurance and production risk.
4. To develop World Wide Web site for corn marketing and risk that would be updated with new information for corn growers to access.

Results: Work on the Web site is underway, and portions have been completed. It is already providing valuable risk-management strategies. An example includes, pricing crops for delivery after the FSA loan expires. This simple storage would provide a price that is 30 to 40 cents higher than the current market. The Web page can be found at *http://www.agecon.ksu.edu/risk/*. We also have conducted 19 RAM workshops that utilize a case study to teach marketing and risk management techniques. We have a similar number of workshops scheduled for this winter meeting season.

Significance of Results: Managing price and yield risk has taken on new urgency given the current low market prices. Many growers who have utilized the risk management tools clearly have limited their 1998 losses.

MARKET DEVELOPMENT GRANT—INTERNATIONAL GRAINS PROGRAM GRAIN STORAGE, HANDLING, AND SANITATION SPECIALIST

RESEARCHER AND UNIT: ***BRENDAN DONNELLY, GRAIN SCIENCE AND INDUSTRY***

FUNDS (FY 98): ***$36,600*** *COMPLETION DATE:* ***ONGOING***

Justification for Research: The number of animal feed manufacturing operations in the world has increased because of demand, and the number of organizations that now have to procure their own raw materials has increased because of worldwide privatization. Consequently, grain procurement executives are less sophisticated than they should be. Buyers of corn also are not as proficient in grain grading, quality control, proper storage, shipping, contracting, and sanitation issues as they should be. Pricing, basis, futures markets, and price discovery fundamentals are not understood. In addition, genetically modified organisms (GMO's) versus traditional varietal development techniques confuse potential buyers, and their subsequent values and uses are little understood.

Project 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 in order to provide them with the latest information available following participation in IGP programs.

Results: Five of the 10 short courses conducted at the IGP specifically dealt with corn. Two of the short courses were designed specifically for corn users in cooperation with USGC. One course dealt with high oil corn, an added-value or value-enhanced variety.

Significance of Results: World corn buyers that have participated in IGP short courses are confident in the information disseminated. Participants return to IGP for additional information on new technology. IGP's improved relationship with USGC has resulted in an increase in USGC-sponsored participants and additional short courses. Also, a 3-year $298,000 grant has been awarded to IGP's grain storage specialist to study tropical storage problems. The IGP will be the vehicle to extend results of this work to the foreign buyer.

BREEDING GRAIN SORGHUM FOR IMPROVED DRYLAND PRODUCTION

RESEARCHERS AND UNITS: ***MITCHELL TUINSTRA AND MARK CLAASSEN, AGRONOMY; KENNETH KOFOID, AGRICULTURAL RESEARCH CENTER-HAYS; MERLE WITT, SOUTHWEST RESEARCH-EXTENSION CENTER; LARRY CLAFLIN, PLANT PATHOLOGY***

FUNDS (FY98): ***$41,000*** *COMPLETION DATE:* ***JUNE 30, 1998***

Justification for Research: Grain sorghum is of great importance to Kansas agriculture and also across all of the central plains. Sorghum is valued because of its capacity to produce stable yields under hot and arid conditions. In Kansas, about 92% of the sorghum production is under dryland conditions and only 8% from irrigated acreage. The highest rate of return for grain sorghum producers is from dryland production. The development of elite, stress-tolerant lines and hybrids will reduce production problems and contribute to increased grain yield potential and stability.

Project Objectives:

1. To characterize and incorporate germplasm sources of preflowering and postflowering drought tolerance into high yielding lines that can be utilized by the sorghum seed industry.
2. To identify chinch bug- and green bug-resistant germplasm accessions and introgress these resistance genes into elite genetic backgrounds.

Results: Two KSU sorghum germplasm lines were released in 1998. KS 97 represents a new source of greenbug resistance to biotype I. KS 98 is a pollinator parent line that produces outstanding, early-maturing hybrids with excellent adaptation to dryland production conditions.

Significance of Results: The development of KS 97 and KS 98 is an important contribution to the commercial seed industry. These lines can be used to diversify and improve the germplasm base of commercial parent lines. This contribution should translate into improved yield potential and stability of hybrids that are adapted for production in Kansas.

CONSTRUCTING AGRONOMICALLY USEFUL GENES FOR SORGHUM PLANT TRANSFORMATION

RESEARCHERS AND UNITS: ***S. MUTHUKRISHNAN, BIOCHEMISTRY; GEORGE LIANG, AGRONOMY***

FUNDS (FY98): ***$16,000*** *COMPLETION DATE:* ***JUNE 30, 1998***

Justification for Research: Pests and abiotic stresses cause considerable yield losses for grain sorghum in Kansas. Among the fungal diseases, *Fusarium* stalk rot, charcoal rot, sooty stripe, and the potentially hazardous ergot have caused millions of dollars in losses for producers and farmers; among the insects, corn borers and greenbugs have always been threats. Chemical spraying is the only means of control currently available. With global warming and increased CO_2 concentration in the atmosphere, drought-tolerant crops will be needed urgently. With the advent of molecular genetics or biotechnology, desirable and agronomically useful genes can be incorporated into sorghum plants from incompatible species. Although Bt-corn, Bt-cotton, and herbicide-resistant crops are available, no known transgenic sorghum has ever been released to the commercial market.

Project Objectives:

1. To construct vectors containing agronomically useful genes.
2. To incorporate genes conferring pest resistance and drought tolerance into sorghum inbred lines.
3. To evaluate the performance of transgenic sorghum plants.

Results: Several gene constructs have been made for the transformation project. These include the ß-1,3 glucanases and chitinases from wheat and the chitinases from rice (G11) and RC 7. Their incorporation into sorghum inbred line TX 430 will provide resistance to fungal pathogens. In fact, the chitinase gene, G11, has been transferred to plants of TX430, which are being tested for resistance to fungal pathogens. The construct containing *hva1*, a drought-tolerance gene from barley, is still under development. That gene eventually will be transferred to TX 430 for further evaluation.

Significance of Results: The limitation to gene transfer from the species barrier can be overcome by using cloned genes and appropriate vectors with a biolistic gun or *Agrobacterium tumefaciens*, a soil bacterium and a natural vector for gene transfer. Several vectors with agronomically important genes have been constructed and will be incorporated into sorghum plants. Pyramiding of useful genes in sorghum plants will result in greater protection against pests and abiotic stresses and lead to better crop performance.

BREEDING SORGHUM WITH IMPROVED GRAIN YIELD, GREENBUG AND VIRUS RESISTANCE, AND PREFLOWERING DROUGHT TOLERANCE

RESEARCHERS AND UNITS: ***KEN KOFOID AND DALLAS SEIFERS, AGRICULTURAL RESEARCH CENTER-HAYS; JOHN REESE, TOM HARVEY, AND GERRY WILDE, ENTOMOLOGY; PHILLIP SLODERBECK, SOUTHWEST AREA EXTENSION OFFICE***

FUNDS (FY 98): ***$88,300*** COMPLETION DATE: ***JUNE 30, 1998***

Justification for Research: Greenbugs continue to be the most serious insect pests of sorghum production in Kansas. The development of new, more virulent biotypes is a constant reminder of the devastation that can be caused by this insect pest. The utilization of genetic resistance is an important component of an integrated pest management system that emphasizes reduced input costs and less reliance on chemical control. The potyvirus complex, which includes maize dwarf mosaic, sugarcane mosaic, johnsongrass mosaic virus, and sorghum mosaic virus, is present in Kansas sorghum fields every year. Host plant resistance is the only control measure available for these diseases, which are spread by greenbugs and corn leaf aphids. The development of sorghum lines with higher grain yields using genetic protection adds no additional expense and will allow for greater net profit and maintain sorghum's place as a valuable crop in Kansas agriculture.

Project Objectives:

1. To develop and release grain sorghum parental lines with higher levels of grain yield that incorporate genetic factors for: a) greenbug resistance; b) resistance to viral diseases including sugarcane mosaic virus (SCMV), maize dwarf mosaic virus (MDMV), johnsongrass mosaic virus (JgMV), and wheat streak mosaic virus (WSMV); and c) preflowering drought tolerance.
2. To evaluate tolerance to greenbug in sorghum using SPAD meter measurements of chlorophyll loss.
3. To determine the distribution of greenbug biotypes and distribution and abundance of insecticide resistant greenbug populations.

Results: Greenbug: Progress towards the development of greenbug-resistant germplasm continued. Nine biotype E greenbug-resistant, early maturing, A-B parental lines were increased for release. These lines will be useful in short-season areas where the greenbug biotype has not yet changed. Nine biotype I-resistant R lines were increased and are being readied for release. These lines also have increased levels of resistance to biotype K greenbugs. Yield trials were conducted with greenbug-resistant sources developed by this project. The development of A-B lines was continued during 1997 and 1998 including the winter nursery. The first year of hybrid testing is being conducted in 1998. The second cycle of selection and recombination of greenbug-tolerant lines using biotype K greenbugs was completed. Under natural infestation in the field, several of these lines showed significantly less damage. Selection is being continued. **Virus:** Infection with johnsongrass mosaic virus (JgMV) revealed four distinct symptoms for this disease. Infection of hybrids showed that these symptoms were controlled genetically, and that different genes were involved in the expression of the mosaic symptom. **Drought:** Sources of known drought tolerance, both pre- and postflowering, were grown at high population pressure to simulate drought. Differences were noted in their responses to this stress condition. **Biotyping:** Results of biotyping studies showed that of the 47 greenbug collections tested at Hays, 37 were biotype I and the other 10 were mixtures of E and I. Biotype K greenbugs were found in samples from eastern Kansas.

Significance of Results: Significant damage occurred in sorghum in 1998 from greenbugs. Yield losses were reported in the range of 10-20 bu / acre. With the depressed market price for sorghum, losses like this could be the difference between making or losing money. Biotype K greenbugs were found in limited numbers this year. This gives us a little more time to develop sources with resistance to the new biotype. Development of germplasm that utilizes tolerance will decrease the need for chemicals and also will reduce input costs to the Kansas sorghum producer. The differences noted in the amount of damage found in the field on this material indicates that progress is being made. The use of plant genetics contributes to a more sustainable production agriculture for insect resistance, drought tolerance, and virus resistance.

A NOVEL APPROACH TO IDENTIFY DURABLE GENETIC RESISTANCE TO GREENBUG IN SORGHUM

RESEARCHERS AND UNITS: **SCOTT HULBERT, PLANT PATHOLOGY; GERALD WILDE, ENTOMOLOGY; MITCHELL TUINSTRA, AGRONOMY**

FUNDS (FY98): **$27,699** COMPLETION DATE: **JUNE 30, 1998**

Justification for Research: Grain sorghum is host to several important insect pests including the greenbug which can cause severe crop damage and economic loss. Hybrids expressing host-plant resistance to greenbugs have been developed to minimize insect damage; however, new virulent biotypes have overcome many of these sources of resistance. The identification of lines that express multiple greenbug resistance genes is viewed as the best long-term solution to development of durable host-plant resistance. Molecular markers may provide a tool to more efficiently develop and identify parent lines that contain multiple greenbug resistance genes.

Project Objectives:

1. To characterize target sorghum populations for seedling survival and adult-plant tolerance to greenbug biotypes I and K.
2. To tag important greenbug resistance genes with molecular markers.

Results: Two sorghum populations were characterized for greenbug resistance in 1997-98. The results of studies suggest that a subset of greenbug resistance genes provide protection during both the seedling and adult plant stages. Segregation analysis also indicated that some genes contributing to greenbug biotype I resistance are also effective against biotype K.

Significance of Results: These results confirm that certain greenbug resistance genes are nonspecific and provide protection against more than one biotype and at different stages of plant development. The utilization of these genes in breeding should provide the basis for durable greenbug resistance in sorghum.

WEED CONTROL AND ATRAZINE BEST MANAGEMENT PRACTICES FOR GRAIN SORGHUM

RESEARCHERS AND UNITS: ***DAVID REGEHR, AGRONOMY; PHILIP BARNES, BIOLOGICAL AND AGRICULTURAL ENGINEERING***

FUNDS (FY 98): ***$24,750*** COMPLETION DATE: ***JUNE 30, 1998***

Justification for Research: Atrazine is the most important herbicide for weed management in Kansas grain sorghum. Because it moves readily with water, some atrazine inevitably is lost in surface water runoff that may affect drinking water quality downstream. Our work helps assure efficient weed control and reductions in potential for off-site movement of atrazine.

Project Objectives:

1. To evaluate atrazine and nontriazine, alternative herbicides for weed control in grain sorghum, including different timings, formulations, and tank mixtures.
2. To evaluate the impact of atrazine best management practices (BMPs) on weed control efficacy and water quality.

Results: Two ALS-inhibiting herbicides, Peak and Permit, were evaluated for control of Palmer amaranth and velvetleaf. Atrazine at 0.5 to 0.75 lb / A often is tank-mixed with these herbicides to improve weed control. Mixtures of 2,4-D and atrazine also were tested. Control was good, but sorghum injury often was unacceptable from this mixture.

The effect of soil incorporation on atrazine loss in runoff was studied with experiments at Ottawa and Manhattan. At Manhattan, shallow soil incorporation of atrazine at planting time decreased runoff losses by 51 and 78%, respectively, in 1997 and 1998. At Ottawa, incorporation of mid-May applications decreased runoff by 81% over 3 years, compared to surface applications at the same time under no-till and ridge-till practices. Runoff losses from atrazine applied at different times of year were measured under no-till conditions near Manhattan. Fall-applied atrazine was of special interest, because of the reduced potential for runoff in winter when precipitation is low and less intense. In 1996-97, total runoff losses from the fall treatment were 0.03% of the applied amount. In 1997-98, atrazine was applied in December to already-wet soils, and in January, two thunderstorms caused runoff. Total runoff losses in 1997-98 from the fall treatment were 2.5% of applied, about 80-fold greater than the previous year. These losses are still modest compared to the 10% losses often associated with soil-surface applications at sorghum planting time.

Significance of Results: Producers who soil incorporate atrazine could use somewhat higher rates and still have less runoff than those who surface apply the herbicide. We are pursuing a 24c label allowing atrazine application in fall to row-crop stubble. This would be an especially good fit for no-till farmers who rotate grain sorghum and soybeans.

ECONOMICS OF INTEGRATED WEED MANAGEMENT IN DRYLAND GRAIN SORGHUM

RESEARCHERS AND UNITS: **PHILLIP STAHLMAN AND CARLYLE THOMPSON, AGRICULTURAL RESEARCH CENTER-HAYS; DANIEL O'BRIEN, NORTHWEST AREA EXTENSION OFFICE**

FUNDS (FY98): **$21,700** COMPLETION DATE: **JUNE 30, 1998**

Justification for Research: Weeds are the major pests limiting crop production, despite widespread use of highly effective herbicides. This is because current crop-weed management systems lead to highly adapted weed species that exploit given sets of cultural, chemical, and environmental conditions. High production costs, declining profitability, and public concerns over possible health and environmental risks from agricultural chemicals have renewed interest in alternative control methods. Integrating cultural and chemical weed control methods may slow or prevent establishment of weed species that are highly adaptable to given management strategies and may be a way to reduce herbicide use and limit input costs.

Project Objectives:

1. To determine the interactions of hybrid growth form, plant population, and row spacing on grain sorghum yield and competitiveness with annual weeds in western Kansas.
2. To compare sorghum production using combinations of cultural practices and herbicide treatments and determine the effects on weed spectrum, species population, and growth.
3. To compare the economics of each combination of factors and determine the most profitable production system.

Results: Net returns in 1997 varied with weed population and were affected more by differences in crop yield than input costs. Averaged over cultural practices, net returns for conventional-till sorghum infested with predominately broadleaf weeds were about +$75.00 and +$56.50 / acre with preemergence and postemergence herbicide treatments, respectively. In contrast, net returns for no-till sorghum densely infested with highly competitive and difficult-to-control prairie cupgrass were -$61.00 and -$21.75 / acre, respectively. These negative returns were the results of poor weed control.

Sorghum planted at 90,000 seed / acre had a higher net return (+$39.00 / acre) than sorghum seeded at 30,000 seed / acre. Sorghum was more profitable (+$16.00 / acre) when seeded in 12-inch than in 30-inch row spacing. The taller of two hybrids produced the higher net return (+12.50 / acre), presumably in part because of better competitiveness with weeds.

Significance of Results: Composition and density of the expected weed population should be major considerations in planning and implementing effective weed management strategies. Weed control can be enhanced and profitability increased by basing herbicide selection on the expected weed population, planting adapted competitive hybrids that rapidly form dense canopies, increasing seeding rate, and narrowing row spacing.

USE OF GRAIN SORGHUM IN DIETS FOR LIMIT-FED, GROWING STEERS

RESEARCHER AND UNIT: ***EVAN TITGEMEYER, ANIMAL SCIENCES AND INDUSTRY***

FUNDS (FY 98): ***$26,416*** *COMPLETION DATE:* ***JUNE 30, 1998***

Justification for Research: Dry-rolled grain sorghum leads to less efficient gains than does dry-rolled corn when fed to finishing cattle. We conducted this research to evaluate an alternative production situation, namely limit-feeding of growing cattle, where we felt the value of rolled grain sorghum would be enhanced. The ultimate goal was to match grains with production situations that emphasize their value.

Project Objectives:

1. To determine the energy value of grain sorghum (steam-flaked and dry-rolled) relative to dry-rolled corn when limit-fed to growing steers.
2. To compare combinations of steam-flaked and dry-rolled grain sorghum and dry-rolled corn on performance of limit-fed steers to determine if positive associative effects are present.
3. To determine optimal protein supplementation strategies for steers limit-fed diets based on grain sorghum.

Results: Limit-fed, growing steers performed much better (higher gains and efficiencies) when they were fed dry-rolled corn or steam-flaked grain sorghum than when they were fed dry-rolled grain sorghum. Combinations of grains yielded results very similar to the average of the grains fed individually. Performance of limit-fed cattle fed dry-rolled grain sorghum was optimized when diets were formulated to contain up to 18% crude protein.

Significance of Results: These data, as well as other data recently collected at Kansas State, indicate that limit-fed cattle have digestion characteristics very different from cattle that naturally consume low quantities of feed. The meal pattern of feed consumption that results from limit-feeding actually may lead to more rapid passage through the gut. Thus, limit-fed cattle probably respond best to diets that are rapidly fermented. Slowly digested grains, such as dry-rolled grain sorghum, probably cannot be beneficial parts of limit-feeding programs.

INCREASING SORGHUM UTILIZATION ON KANSAS FEEDLOTS WITH IMPROVED PROCESSING TECHNOLOGY

RESEARCHERS AND UNITS: **JAMES DROUILLARD AND GERRY KUHL, ANIMAL SCIENCES AND INDUSTRY; KEITH BEHNKE, GRAIN SCIENCE AND INDUSTRY**

FUNDS (FY 98): **$39,252** COMPLETION DATE: **FEBRUARY 1, 1998**

Justification for Research: Grain sorghum requires extensive processing in order to compete effectively with other feed grains as a source of energy for beef cattle in feedlots. This extensive processing comes at a significant cost, often exceeding that required to process alternative grains. Consequently, methods of grain processing that increase throughput and reduce energy usage are needed in order to allow sorghum to compete with other grains. Additionally, protein content of sorghum is typically higher than that of corn, which should be to its advantage when fed to finishing cattle.

Project Objectives:

1. To improve efficiency of grain sorghum processing using partial decortication prior to steam flaking.
2. To characterize nutritional advantages of grain sorghum relative to corn, emphasizing the inherent differences in protein content.

Results: We developed a pneumatic grain handling system equipped with abrasive surfaces in order to partially decorticate grain prior to flaking. This system alone was not sufficiently effective in removing bran. In subsequent experiments, we rolled sorghum to a coarse texture and then subjected the material to flaking. Flaker throughput was increased dramatically when grain was dry-rolled prior to flaking. Utilization of the sorghum also was improved with prerolling, resulting in greater feed efficiency by finishing beef cattle.

Increasing protein levels in finishing diets improved performance to a greater degree with grain sorghum than with corn. These results suggest that the protein in flaked sorghum, though greater than that in corn, is not readily available.

Significance of Results: Prerolling grain sorghum prior to flaking could be utilized to reduce energy expenditure for flaking and to increase efficiency of sorghum utilization in cattle. Finishing diets containing grain sorghum also may benefit from the addition of higher protein levels than used in corn-based diets.

PROCESSED GRAIN SORGHUM AND GRAIN SORGHUM COMBINATIONS FOR DAIRY COWS

RESEARCHERS AND UNITS: ***JOHN SHIRLEY, EVAN TITGEMEYER, AND JAMES DROUILLARD, ANIMAL SCIENCES AND INDUSTRY; KEITH BEHNKE, GRAIN SCIENCE AND INDUSTRY***

FUNDS (FY 98): ***$25,568*** COMPLETION DATE: ***JUNE 30, 1998***

Justification for Research: Extensive processing by steam-flaking or by a grinding-extruding-pelleting technique improves the nutritive value of grain sorghum for dairy cattle by increasing starch and protein digestion. The negative effect observed when these products are fed is a depression in % milk fat. Blending processed products with dry-rolled grain sorghum would reduce processing cost per ton of final feed and potentially improve the fat content of the milk. Data obtained from a direct comparison of pelleted and steam-flaked grain sorghum are needed as well as data on the amount of processed grain sorghum to include in dairy cattle diets.

Project Objectives:

1. To compare the feeding value of steam-flaked and extruded grain sorghum for lactating dairy cows.
2. To determine if combining processed grain sorghums (steam-flaked and extruded) with dry-rolled grain sorghum is beneficial.

Results: No difference was observed in the utilization of steam-flaked grain sorghum and pelleted grain sorghum obtained by adding water to finely ground grain sorghum prior to extrusion and oven drying at a temperature of 200%F. Extensive processing (pelleting or steam-flaking) improved feed efficiency ($P<.01$) relative to dry rolling; cows fed diets containing more extensively processed grains ate less feed ($P<.01$) but produced the same amount of milk as cows fed diets containing dry-rolled grain. Significant differences between the two were not observed. Processing did not affect plasma glucose or total amino acids but significantly ($P<.01$) depressed plasma urea nitrogen (PUN). The decrease in PUN supports the argument that processing improves starch digestion in the rumen and demonstrates that diets high in rumen undegradable protein (39.4% of total protein) respond positively to rumen available carbohydrate when dry matter intake is high. Cows in this study weighed approximately 1380 lbs and consumed 4.45% of body weight in dry matter on the processed grain diets and approximately 4.6% of body weight on the combination diets (processed and dry-rolled). The depression in PUN probably resulted from both a decrease in dry matter intake and an increase in energy available to the rumen microorganism.

Significance of Results: Extensive processing improves the feeding value of grain sorghum in diets for lactating dairy cows. Processing grain sorghum by either steam-flaking or extruding decreased feed cost in this study by $0.1365 / cow / day compared to diets containing a mixture of dry-rolled and either of the processed products.

EFFECTS OF ENDOSPERM WAXINESS AND PROCESSING ON THE NUTRITIONAL VALUE OF SORGHUM FOR SWINE AND POULTRY

RESEARCHERS AND UNITS: **JOE HANCOCK AND ROBERT HINES, ANIMAL SCIENCES AND INDUSTRY; KEITH BEHNKE, GRAIN SCIENCE AND INDUSTRY**

FUNDS (FY 98): **$27,800** COMPLETION DATE: **JUNE 30, 1998**

Justification for Research: More than 90% of the sorghum produced by Kansas farmers will be used in diets for livestock. Additionally, the burgeoning ethanol industry is a market that cannot be ignored. For these reasons, demonstrating the competitiveness of sorghum as a feed grain and ethanol feedstock is of paramount importance to sorghum producers in our state. Improving the overall quality of finished diets, by defining processing x genotype interactions that yield maximum nutritional value, will 'put at ease' the nutritionists who influence decisions about feed ingredient use.

Project Objective: To determine the effects of alternative sorghum genotypes (e.g., waxiness of the endosperm) and advanced processing technologies on the nutritional value of sorghum grain.

Results: Our experiments were designed to evaluate both the milled grain and the distillers dried grains resulting from using various sorghums to produce ethanol. Our results suggest that normal, hetero-waxy, and homozygous waxy endosperm sorghums have similar nutritional values and fermentation characteristics. However, increasing waxiness provided definite advantages during milling (e.g., improved pellet quality and decreased energy consumption during the pelleting process). These results suggest that increased endosperm waxiness can decrease the cost of producing feed and many of the problems associated with poor pellet quality (e.g., complaints about fines, difficulty in feeder management, and the inevitable loss in efficiency of growth from excessive fines accumulating in the feeders). In a final series of experiments, investigation of a sorghum-specific enzyme system suggested that a consistent improvement in rate and(or) efficiency of gain was not achieved.

Significance of Results: Our results demonstrated generally good feeding value of sorghum grain and the sorghum-based distillers grains regardless of endosperm type. However, modification of endosperm type (increased waxiness) apparently can improve the utility (processing characteristics) of sorghum grain as a component of diets for livestock. Of course, the widespread adoption of waxy endosperm sorghums will be contingent upon seed companies supplying ample quantities of high-quality hybrid seeds in varieties that yield well.

PROCESSING TECHNIQUES TO IMPROVE SORGHUM DIGESTIBILITY

RESEARCHERS AND UNITS: ***R. SCOTT BEYER AND JOHN SHIRLEY, ANIMAL SCIENCES AND INDUSTRY; KEITH BEHNKE, GRAIN SCIENCE AND INDUSTRY***

FUNDS (FY 98): ***$38,922*** *COMPLETION DATE:* ***ONGOING***

No report submitted.

LABORATORY TEST TO EVALUATE THE WET-MILLING OF 100G SAMPLES OF GRAIN SORGHUM AND ITS APPLICATION TO CULTIVARS WITH VARIOUS AMYLOSE LEVELS

RESEARCHERS AND UNITS: ***PAUL SEIB, GRAIN SCIENCE AND INDUSTRY; GEORGE LIANG, AGRONOMY***

FUNDS (FY 98) ***$ 3,500*** *COMPLETION DATE:* ***JULY 1998***

Justification for Research: Grain sorghum is a cereal crop grown principally in regions of Asia, Africa, and North America. It is more tolerant than corn to semi-arid and cool climate conditions. In the USA, grain sorghum is used predominantly as feed, but hybrids of food-grade sorghum are available. Exhaustive wet-milling of grain sorghum has ceased wherever corn (maize) is available, mainly because grain sorghum contains a smaller proportion of germ, resulting in low yields of cooking oil, and because starch extraction is more difficult. Much of the starch in grain sorghum is associated with protein in the flinty zone of the kernels, and the protein resists softening in water. The goal of this research is to devise a wet-processing scheme to separate grain sorghum into fractions whose value allows a profitable return. We envision that grain sorghum can be wet-processed near the semi-arid region of the Great Plains, and that sorghum starch can be converted into a myriad of products, such as sweeteners, adhesives, thickeners, detergents, beverage alcohol, power alcohol, organic acids, and biodegradable plastics.

Project Objectives:

1. To devise a laboratory wet-milling test for grain sorghum starting with 100g of grain.
2. To collect grain sorghum samples with various levels of amylose and determine their wet-milling quality.

Results: We first assembled wet-milling laboratory equipment to process 100g (~ 1/4 lb) of grain sorghum. We then exhaustively extracted and separated starch from yellow grain sorghum, as well as from corn. The recovery of pure starch from either grain was over 95%, and the recovery of total solids was over 99%. Wet-milling of red and white grain sorghums gave 93-94% starch. The pasting consistency of the grain sorghum starch matched that of corn starch. In addition to the starch, five other fractions were separated during wet-processing, namely steep solids, protein, process-water solids, fine fiber, and bran plus germ. The wet-milling procedure was repeated five times on yellow grain sorghum, and yields of starch varied by 0.3%, whereas yields of fiber, gluten, and germ plus bran varied by 5%.

Significance of Results: A yellow grain sorghum whose endosperm was medium hard by mechanical measurement gave the same high recovery (95%) of starch as did maize. Moreover, starches were of equal purity and quality. Because resistance of kernels to molds is associated positively with grain hardness, grain sorghum with a medium hard endosperm is best grown where rain is unlikely near harvest time. We conclude that grain sorghum with good wet-processing potential could be cultivated in the correct climate. The 100 g wet-milling procedure developed in this project could be used to screen grain sorghum samples for wet-milling quality. Our findings have been presented at meetings of cereal chemists.

DEVELOPMENT OF A DRY/WET MILLING METHOD TO INCREASE STARCH RECOVERY FROM SORGHUM

RESEARCHERS AND UNITS: ***ROLANDO FLORES AND PAUL SEIB, GRAIN SCIENCE AND INDUSTRY; GEORGE LIANG, AGRONOMY***

FUNDS (FY 98): ***$25,500*** *COMPLETION DATE:* ***JUNE 30, 1999***

Justification for Research: Kansas is the number one grain sorghum producer in the nation. Grain sorghum is used mainly as animal feed; thus, finding alternative uses of grain sorghum in the industrial starch sector would increase its utilization and benefit Kansas farmers. The determination of potential starch yields through laboratory methods is the first step needed to develop alternative processes. Finding ways to reduce water consumption in the starch-extraction process from grain sorghum with reasonable starch yields would make this process more feasible. Dry-milling grain sorghum prior to starch extraction should result in a shorter time and more efficient process of starch extraction compared to the traditional wet milling.

Project Objectives:

1. To test dry-milling laboratory-scale procedures for recovering starch-rich fractions from grain sorghum.
2. To develop methods to wet-peel grain sorghum.
3. To develop combinations of dry and wet milling procedures to recover at least 75% of the starch present in grain sorghum.

Results: Recently, a 100 g-scale wet-milling method was assembled and used to recover 95% of pure starch and 99% of the solids from commercial samples of grain sorghum and maize. In the present work, the small-scale system was modified to achieve low-input wet-milling that gave a 75% recovery of pure starch plus a coproduct animal feed. A yellow grain sorghum gave 77-90% recovery of pure starch plus a feed stream having a small particle size and four times more protein level than the the grain (dry solids basis). Decorticated sorghum produced fractions in which ash and crude fat contents of sorghum grits were reduced. Grain sorghum with 2.34% fat (db) and 1.34% ash was conditioned for 3 minutes prior to dry milling to produce grits with low ash (0.36% db). The same conditioning time under water at a temperature of 30 ºC produced the same grits with crude fat of 0.417% (db).

Significance of the Results: The high recovery of over 75% of starch from a yellow grain sorghum using a 0.5-2.0 h steep time at 55 ºC in 0.2% sulfur dioxide / 0.55% lactic acid was unexpected. Other samples of grain sorghum currently are being tested to determine the ease of release of their starch. Our results indicate that a high yield of starch can be obtained by limited wet-milling of a commercial grain sorghum or a high-endosperm dry-milled grits containing low ash and crude fat fractions from grain sorghum. At the same time, a coproduct valuable as a ruminant animal feed was obtained. Efforts are underway to minimize the consumption of water in the process by determining the best grits fraction from which to extract starch.

CHARACTERIZING FLAVORS OF CULTIVARS POTENTIALLY USEFUL FOR FOODS

RESEARCHERS AND UNITS: **CAROLE SETSER, FOODS AND NUTRITION; KRAIG ROOZEBOOM, AGRONOMY; X. SUSAN SUN AND CHARLES WALKER, GRAIN SCIENCE AND INDUSTRY**

FUNDS (FY98): **$33,600** COMPLETION DATE: **JUNE 30, 1999**

Justification for Research: Concerns about the bitterness and astringency of sorghums, particularly dark sorghums, have kept the grain from being utilized to its full potential in food products. Investigations were aimed at determining if some hybrids might be less bitter and less astringent and more appropriate for food usage.

Project Objectives:

1. To characterize flavors of commercially produced sorghum cultivars and their flours for potential uses in food.
2. To optimize flavor properties of sorghum flours for use as food ingredients by making composite flours using two or more cultivars if necessary.
3. To characterize the bread-baking properties of commercial sorghum flours and composite flours using sorghums.
4. To develop a model for sorghum-based bread making.

Results: Eleven flavors identified in sorghums were evaluated by trained panelists in flours of 41 sorghum hybrids from Kansas and Texas. Green aroma, dusty flavor, bitterness, sweetness, and astringency were the five characteristics that differentiated most of the sorghum hybrids. However, when the three least astringent and least bitter sorghum flours were compared for acceptability to the three most astringent and most bitter flours in 100% sorghum flour muffins, 53 consumers did not find differences among them for overall acceptability or for flavor acceptability. This unexpected finding led to further investigations related to the color and appearance of the muffins, which indicated higher acceptability for a reddish yellow over a greenish yellow color. Lightness or darkness of the color did not affect acceptability, if it was not greenish in appearance.

Composite flours containing 50% sorghum flours were used to make yeast breads and characterized for bread-baking properties. Sensory ratings by a trained panel of breads optimized for volume indicated that sorghum breads were higher in astringency, denseness, coarseness, and graininess than a commercial bread. Rating of the sorghum composite bread by 37 consumers indicated that they liked the bread moderately, which indicates good acceptance even before all sensory attributes have been optimized.

Significance of Results: These results showed that appearance is critical if flavors are nearly equivalent, and flavor is more critical if the colors are similar but not greenish. The final product color did not correspond to the flour, pericarp, or endosperm color; thus, it is important to optimize for appearance, flavor, and textural attributes in each food product. A grain should not be eliminated on the basis of its own color, but evaluated after checking its appearance when used in a product where it interacts with other ingredients. Green color notes were unacceptable in muffins and likely would be unacceptable in most cereal products, because green is not an expected color for these foods. Results thus far for yeast breads, indicate that acceptance of mixed-flour sorghum bakery products optimized for texture, flavor, and appearance is likely.

NOVEL SORGHUM COMPOSITE FLOURS DESIGNED FOR BREAD MAKING

RESEARCHERS AND UNIT: ***X. SUSAN SUN, CAROL KLOPFENSTEIN, AND CHARLES WALKER,GRAIN SCIENCE AND INDUSTRY***

FUNDS (FY98): ***$35,715*** *COMPLETION DATE:* ***JUNE 30, 1999***

Justification for Research: Bread quality, such as crumb grain, volume, and texture, is affected by many factors including composition, dough properties, and processing conditions. One of the major factors affecting dough rheological properties is the formation of a gluten matrix. Composite flour is not just a physical blending of several food components. Proper blending to get the desired end properties requires understanding of the interactions of the different components at the physicochemical level.

Project Objectives:

1. To characterize functional properties of wheat gluten and soybean protein components in sorghum-based composite flour.
2. To characterize bread-baking properties of selected sorghum cultivars using the sorghum composite-flour system developed.
3. To compare sensory properties of a sorghum-based bread with various flavor additives with those of rye breads.

Results: The dough properties of sorghum-based composite flour were improved by using wheat gluten and dough improvers including xanthan gum, sodium stearoyl lactylate, and diacetyl tartaric ester of monoglycerides. For example, volume of the bread with 50% sorghum flour has been increased by 80% using the designed composite-flour system. The appearance of the breads, such as crumb grain, color, and volume, were very comparable to those of most commercial rye breads. Two sorghum cultivars from Kansas State were found to have potential for use in foods, and white sorghum grain had the most potential for bread making.

Significance of Results: The outcome of this research indicates that selected sorghum cultivars can be used to make leavened bread that is compatible to rye composite bread. From the nutrition point of view, sorghum contains some phenolic compounds that could prevent colon cancers. Also, the carbohydrate of sorghum digests more slowly than that of other grains, so sorghum is may help prevent diabetes or be beneficial to people with diabetes.

MARKET DEVELOPMENT GRANT—INTERNATIONAL GRAINS PROGRAM GRAIN STORAGE, HANDLING, AND SANITATION SPECIALIST

RESEARCHER AND UNIT: ***BRENDAN DONNELLY, GRAIN SCIENCE AND INDUSTRY***

FUNDS (FY 98): ***$36,600*** *COMPLETION DATE:* ***ONGOING***

Justification for Research: The buyers and potential buyers of U. S. grain sorghums are unfamiliar with the myriad of potential uses of the grain, including products for human consumption, and with the many feed formulations available. In addition, they also 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 significantly.

Project Objectives:

1. To identify potential buyers of U.S. grain sorghum in cooperation with the US Grains Council (USGC) 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 USGC 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 sorghum utilization.

Results: The IGP conducted 10 short courses during 1998, eight of which included participants from feed manufacturing organizations. One of the short courses with 18 participants was devoted totally to grain sorghum. The Grain Sorghum Food Utilization Seminar, sponsored by the USGC, included food researchers from eight countries. Participants in IGP short courses totaled 135 with only 23 not potential sorghum users.

Significance of Results: International buyers of grain sorghum are confident in the information disseminated by IGP. Participants continue to request information from IGP years after attending a short course. The IGP's improved relationship with the national commodity organization has resulted in increased USGC-sponsored participation, additional USGC-sponsored short courses, and a 3-year $298,000 grant to IGP's grain storage specialist to study tropical storage problems. Although the research is corn specific, the results will be applicable to sorghum. The IGP will be the vehicle to extend results of the work to the foreign buyer.

EFFECTS OF CROP ROTATION AND TILLAGE SYSTEMS ON SOYBEAN YIELD IN SOUTHEASTERN KANSAS

RESEARCHERS AND UNIT: ***KENNETH KELLEY AND DANIEL SWEENEY, SOUTHEAST AGRICULTURAL RESEARCH CENTER***

FUNDS (FY98): ***$6,500*** *COMPLETION DATE:* ***FY2000*** *(1ST CROPPING CYCLE)*

Justification for Research: In southeastern Kansas, approximately 1,600,000 acres are devoted to crop production, which consists primarily of soybean, wheat, grain sorghum, and corn. Because of the diversity of crops grown in the area, this research seeks to investigate the combined effects of both crop rotation and tillage on full-season and double-crop soybean yields. Research is needed to determine which tillage methods produce optimum soybean yields for the climatic and claypan soil conditions in southeastern Kansas. Options include: i) grow all crops with conventional tillage, ii) plant all crops no-till, or iii) alternate conventional and no-till systems.

Project Objectives:

1. To evaluate crop rotation and tillage effects on full-season and double-crop soybean yields in a 3-yr crop rotation of [corn / grain sorghum] - soybean - [wheat - double-crop soybean].
2. To evaluate previous crop and tillage effects on double-crop soybean yield in a 2-yr crop rotation of [corn / grain sorghum / soybean] - [wheat - double-crop soybean].

Results: In 1997 and 1998, tillage did not have a significant effect on grain yield of double-crop soybean in the 2-yr cropping rotation. Yields averaged 37 bu/a in 1997 and 30 bu/a in 1998 in 30-inch row spacing, with no difference between disking wheat stubble (no burning) and planting no-till. However, crop rotation did have a significant effect on yield of double-crop soybean. Yields averaged 5 bu/a higher when corn or grain sorghum preceded wheat compared to soybean. Tillage and crop rotation effects on full-season soybean will be evaluated in the 1999 crop year.

Significance of Results: Results indicate that double-crop soybeans can be grown successfully using conservation tillage practices in shallow, claypan soil conditions. Because of the acreage devoted to double-crop soybean production in extreme southeast Kansas, significant long-term benefits to the soil and environment are possible.

IMPROVEMENT OF SOYBEAN VIA BIOTECHNOLOGICAL APPROACHES

RESEARCHERS AND UNITS: **LOWELL JOHNSON, FRANK WHITE, AND TIMOTHY TODD, PLANT PATHOLOGY; XUEMIN WANG, BIOCHEMISTRY; YI LI, BIOLOGY**

FUNDS (FY 98): **$58,380** COMPLETION DATE: **JUNE 30, 1998**

Justification for Research: Susceptibility to the cyst nematode and the nature of soybean seed oil relative to commercial needs are among the major problems of commercial soybeans. We are attempting to solve these and other problems by the application of genetic engineering accomplished via gene cloning and plant transformation. Development of these techniques also will facilitate the introduction and use of other equally important genes by soybean breeders. If Kansas varieties are to compete into the next century and beyond with those of industry and other states, establishment of these research capabilities is essential.

Project Objectives:

1. To develop tissue culture and transformation techniques for genetic engineering of soybean.
2. To isolate and characterize genes affecting seed and seed oil production and nematode resistance and transform soybean with these genes.
3. To test all plants for improved oil content and / or cyst nematode resistance.

Results: In order to genetically engineer soybean, we are using the bacterium *Agrobacterium tumefaciens* to introduce the gene of interest into inoculated cotyledonary nodes, followed by plant regeneration. Transformation procedures have been successful in the introduction of genes into these nodal tissues, but efforts to target the specific regenerating cells continue. Several genes with a potential for soybean improvement have been identified. A phospholipase D gene has been cloned with the potential for improvement of seed oil and seed quality. When introduced in an “antisense” orientation, it actually will reduce the seed phospholipase D. This will enhance stress tolerance and reduce seed damage caused by adverse field or storage conditions. An auxin synthesis gene with the potential to increase seed size by 30% and several genes with potential for nematode control also have been identified.

Significance of Results: Genes are now available with potential for soybean improvement. When procedures for their introduction into soybean are in place, the genes will be tested for their utility in soybean improvement.

IMPROVING SOYBEAN PROFITABILITY THROUGH BREEDING

RESEARCHERS AND UNITS: ***WILLIAM SCHAPAUGH, AGRONOMY; TIMOTHY TODD, PLANT PATHOLOGY; JAMES LONG, SOUTHEAST AGRICULTURAL RESEARCH CENTER***

FUNDS (FY 98): ***$154,847*** COMPLETION DATE: ***JUNE 30, 2002***

Justification for Research: Soybean yields have increased by approximately .44 bu / acre / year since 1970. About 50% of this increase is due to the genetic improvement in varieties. This project contributes to this genetic improvement by addressing adaptation and pest problems of concern to Kansas producers. The growing acreage infested with soybean cyst nematode (SCN) necessitates a strong emphasis on the development of varieties with broad-based resistance to the nematode. Opportunities exist for the soybean producer to supply seed for specialty markets involving industrial or food uses of specific varieties. A portion of this project is directed at developing varieties for special uses. This project also enables Kansas producers to benefit from improvements in public variety development throughout the country.

Project Objectives:

1 To develop high yielding, pest resistant varieties for full-season and double-crop production.

2 To develop varieties to meet specific needs, including varieties tolerant to iron chlorosis, varieties suitable for food uses, and varieties suitable for specific industrial uses.

3 To evaluate the productivity and impact of current public and private, cyst nematode-resistant varieties.

4 To develop procedures and strategies for improving the selection efficiency of important traits in soybean.

Results: The two most recent KAES releases, Delsoy 5500 and KS4997, became available to producers for the first time in 1998. Delsoy 5500 has yielded well above average in both the SCN and standard tests in southeast Kansas. KS4997 yielded 116% of the test average in the Labette County soybean variety performance test in 1998 and possesses the highest yield average from 1995 through 1998 of any entry in the combined Labette and Cherokee County tests. These varieties are high-yielding alternatives for the soybean growers in southeast Kansas. Two cooperative releases, A94-774021 (maturity group III) and Anand (maturity group V), were recommended in 1998. The procedures and timetable to distribute seed to growers are currently under development.

Significance of Results: Integration of new, disease-resistant varieties into cropping systems increases seed yields by about .1 to .2 bu / acre / year. In Kansas, this improvement potentially increases farm revenue by $1.2 to $2.4 million per year. SCN-resistant varieties and sound management practices for this pathogen are estimated to increase farm revenue by $1 million per year. Identification of several yield-competitive, cyst-resistant varieties provides useful alternatives to soybean producers, who are reluctant to plant resistant varieties because of the potential yield penalty on uninfested fields or areas of fields.

A SOYBEAN EXTENSION EDUCATIONAL PROGRAM IN THE SOUTHEAST EXTENSION AREA

RESEARCHERS AND UNIT: ***GARY KILGORE AND MARVIN FAUSETT, SOUTHEAST AREA EXTENSION OFFICE***

FUNDS (FY 98): ***$11,180*** *COMPLETION DATE:* ***JUNE 30, 2002***

Justification for Research: In an average year, soybean producers in the 21 counties that make up the Southeast KSU Extension Administration Unit produce over 21 million bushels of soybeans. Eight of the top 10 counties are in southeastern Kansas. This area has special problems, such as shallow top soils that reduce yields. Research at experiment fields and research centers shows production efficiencies, and these must be transferred to the farm. This grant allows us to hire a person that helps with on-farm demonstrations and replicated research plots for use in the transfer of knowledge.

Project Objectives:

1. To establish on-farm trials comparing Roundup Ready soybean varieties with conventional varieties.
2. To demonstrate weed control methods using Roundup Ready soybeans.
3. To establish on-farm demonstrations using soybean cyst nematode-resistant varieties.
4. To continue tillage and population trials.
5. To continue double-crop soybean variety trials
6. To subject production results to economic analysis.

Results: Soybean cyst nematode (SCN)-resistant varieties increased yields by 40% compared to susceptible varieties. Roundup Ready weed control programs can result in a cost savings of $5.00 / acre compared to traditional programs. No-till double-crop soybean resulted in the lowest performance of all seedbed preparation methods. Root development is reduced in no-till systems on upland soil. Ten counties held fall tours. More than 800 producers visited on-farm trials and saw the results.

Significance of Results: When fields are infested with SCN and resistant varieties are used, producers can increase yields by 12 bu / acre. That results in an increased income of over $63.00 on each SCN-infested acre. Producers that plant double-crop soybean no-till can expect to have 4.3 bu / acre less yield than when the field is burned and field cultivated once before planting. The latter practice results in increased income of over $22.00 / acre. Producers could expect an increased income of over $2.6 million per year if just these two practices were adopted on 30% of the soybean acres.

COVER CROP AND CROP ROTATION USED TO MEET CONSERVATION COMPLIANCE FOR SOYBEANS

RESEARCHERS AND UNITS: **PHILIP BARNES, BIOLOGICAL AND AGRICULTURAL ENGINEERING; WILLIAM SCHAPAUGH, AGRONOMY; GARY KILGORE, SOUTHEAST AREA EXTENTION OFFICE**

FUNDS (FY 98): **$23,200** COMPLETION DATE: **JUNE 30, 1998**

Justification for Research: Sediments continue to be the major contaminants in Kansas streams, lakes, and water supplies. Farmers that are in the USDA Farm Programs are required to maintain surface cover residues of 30% or greater on highly erodible soils. Many times after soybean harvest and through crop planting in the next year, farmers have trouble meeting these residue requirements. This study will look at cover crops and crop rotation as alternatives to meet conservation compliance. During 1998, another wrinkle has been added to the water quality issues in Kansas. The Region 7 Environmental Protection Agency and the State of Kansas have been sued by various environmental groups to establish total maximum daily loading required by the Clean Water Act for various contaminants that impair Kansas water supplies. Sediments currently impair most of these water supplies.

Project Objectives:

1. To measure the effects of cover crops on two-crop rotations and their ability to meet conservation compliance requirements.
2. To measure the cover crop's impact on the soil moisture for the following crop in the rotation.
3. To measure the cover crop's ability to use or recover nutrients for the following crop in the rotation.

Results: Continuous soybean plots without cover crops did not achieve 30% cover during any of the years of the study or at any of the study locations. Residue levels on plots that had cover crops all exceeded the 30% cover requirement at planting. Soybeans planted after corn or grain sorghum also exceeded the 30% residue requirement.

Fields with shallow soils and limited soil-moisture holding capacity at the Brown and Wilson County sites did not carry enough soil moisture to meet crop needs after the cover crops were chemically burned down. If timely rains did not occur after burn-down, the new crop emergence was poor and led to reduced yields. The deep soils at the Doniphan County site stored adequate moisture to achieve excellent crop emergence and full yields.

Winter cover crops and crop rotation can contribute a significant amount of nitrogen to the succeeding crop and reduce fertilizer required for that crop

Significance of Results: Crop rotation provided the most consistent residue levels, while maintaining sufficient soil moisture to raise the following year's crop. If multiyear or continuous soybeans are planted, then some form of cover crop will be required to protect field soils from erosion.

INTEGRATED MANAGEMENT OF THE SOYBEAN CYST NEMATODE AND CHARCOAL ROT

RESEARCHERS AND UNITS: **TIMOTHY TODD AND FRED SCHWENK, PLANT PATHOLOGY; JAMES LONG AND KENNETH KELLY, SOUTHEAST AGRICULTURAL RESEARCH CENTER; WILLIAM SCHAPAUGH, AGRONOMY**

FUNDS (FY 98:) **$36,855** COMPLETION DATE: **ONGOING**

Justification for Research: The known distribution of the soybean cyst nematode (SCN) in Kansas continues to increase by several counties per year. Increases in SCN-infested acreage have been accompanied by better adapted SCN-resistant soybean varieties, resulting in a greater reliance by Kansas soybean producers on resistance as a primary management strategy. With increased use of resistance, however, comes the risk of selection pressure and race shifts in SCN populations. Rotation of cultivars with different sources of resistance has been proposed as a method of minimizing or even managing selection pressure. Crop rotation is an alternative strategy for managing SCN and other soybean diseases, such as charcoal rot, but data from long-term experiments are needed before recommendations can be developed across the range of environments common to Kansas.

Project Objectives:

1. To evaluate rotations of resistance sources for management of the race structure of SCN populations.
2. To examine integrated approaches to the long-term management of SCN and charcoal rot, including resistance, crop rotation, tillage, double-cropping, and fungicide use.
3. To develop predictive models for soybean yield loss to SCN that incorporate the role of soybean maturity and determinacy, phenology, charcoal rot severity, and nematode population density.

Results: The ability of SCN populations to reproduce on the resistance source PI 88788 has increased steadily at all locations in plots planted to the cultivar Delsoy 4210, which has resistance derived from PI 88788. Reproduction on the resistance source Peking and on cultivars derived from Peking has remained stable. No consistent benefit from rotating sources of resistance has been observed to date. Field populations increased at a higher rate on resistant cultivars in rotation vs. continuous cropping. Changes in race structure did not result in additional yield loss through 1997. In southeastern Kansas, rotation to grain sorghum for as little as 1 year increased soybean yields by 5 bu / acre in non SCN-infested soil because of reduced charcoal rot severity. In the presence of SCN, even long-term rotations of 3-4 years did not reduce yield loss from the nematode. Resistant cultivars outyielded susceptible cultivars by 7-18 bu / acre across all studies.

Significance of Results: Recent surveys suggest that 1-2% of the soybean acreage in Kansas currently is infested with SCN, and this amount is increasing rapidly. Based on the 20% average yield loss measured in infested fields in Kansas during the past 6 years, the potential annual yield loss from this pathogen is 150,000 to 300,000 bushels worth $1 to $2 million. Additional yield losses of approximately 10% from charcoal rot have been documented for continuous soybean production in southeastern Kansas. Information resulting from this project will be utilized to improve guidelines for managing both the density and race structure of SCN populations and minimizing soybean yield losses from both SCN and charcoal rot. This project also complements current efforts by the KSU breeding program to develop resistant soybean germplasm.

REDUCING HERBICIDE RATES, COSTS, AND CARRIER VOLUMES USING METHYLATED SEED OILS

RESEARCHERS AND UNIT: ***DALLAS PETERSON AND MICHAEL HORAK, AGRONOMY***

FUNDS (FY 98): ***$4,800*** *COMPLETION DATE:* ***JULY 31, 1998***

Justification for Research: Herbicides play an important role in weed management for most soybean producers but also are among the major costs of production. Research on optimal adjuvants (spray additives) and spray volumes may lead to improved efficiency and lower costs of production, while maintaining a high level of weed control and soybean yields.

Project Objectives:

1. To improve herbicide performance and reduce herbicide application rates and chemical costs through the use of methylated seed oil adjuvants.
2. To reduce herbicide carrier volumes, while ensuring satisfactory weed control.

Results: Pursuit and Blazer generally provided better weed control with early postemergence application (about 3 weeks after planting and 2- to 3-inch weeds) compared to postemergence applications (about 4 weeks after application and 4- to 8-inch weeds). The addition of methylated seed oil (such as Sun-It II) spray adjuvant to Pursuit and Blazer provided equal or better weed control than the addition of nonionic surfactant, the standard recommended additive. Weed control with Pursuit or Blazer was not different for 5, 10, and 20 gal / acre (gpa) spray volume, regardless of application timing or spray adjuvant.

Significanc of Results: The use of methylated seed oil such as Sun-It II as an adjuvant with herbicides like Pursuit and Blazer can provide more consistent and better weed control than the use of nonionic surfactant. However, the methylated seed oils cost more and also may increase the risk of crop injury. The methylated seed oils may allow for the use of lower rates, if the herbicides are applied under ideal application conditions. Timing is a key factor to achieve good spray coverage and good weed control. Producers can reduce spray volumes from 20 gpa to 5 gpa without sacrificing weed control, as long as the lower volumes are applied with proper technique to achieve good spray coverage. Using lower spray volumes improves efficiency by reducing the water and sprayer loading requirements.

SOYBEAN RESPONSE TO SIMULATED HERBICIDE DRIFT

RESEARCHERS AND UNITS: ***KASSIM AL-KHATIB AND DALLAS PETERSON, AGRONOMY***

FUNDS (FY 98): ***$8,800*** *COMPLETION DATE:* ***MAY 31, 1998***

Justification for Research: Herbicide drift is a problem in many soybean-producing areas of Kansas, especially when farmers apply herbicides under environmental conditions that favor volatilization and redeposition. Soybean injury resulting from drift or misapplication of corn herbicides is an important concern, because the two crops often are grown in close proximity. In addition, Roundup Ready soybeans frequently are grown adjacent to Roundup-susceptible soybeans. Therefore, Roundup applied on Roundup Ready soybeans may move off-target and injure the susceptible soybean. At this time, no data are available to illustrate the impact of low rates of corn herbicides or Roundup on Roundup-susceptible soybeans.

Project Objectives:

1. To determine injury and yield reduction of soybean caused by herbicide drift from corn or Roundup Ready soybean fields.
2. To determine if early symptoms of injury are predictive of yield reduction.

Results: Soybean plants responded differently to simulated drift of various herbicides. The order of yield reduction after soybean exposure to herbicide drift was Peak>Banvel> Exceed> Basis>Beacon. Soybean yields were not reduced by Roundup, Liberty, and Accent drifts. The herbicide rate that caused 50% yield reduction was always much higher than the rate that caused 50% injury symptoms, indicating the ability of soybean plants to recover from injury caused by simulated herbicide drift. Our research showed that injury symptoms from herbicide drift are not reliable indicators for yield reduction, especially when they are minor. Symptoms that usually are worrisome to growers, such as mottled chlorosis, crinkling, discoloration, cupping of terminal leaf, and necrotic spots, occur at rates much lower than required to reduce yield.

Significance of Results: Our research developed practices to reduce herbicide drift injury on soybean. The results of this research helped determine soybean susceptibility to herbicide drift from corn fields and predict the level of injury symptoms that reduce yield. In addition, this research developed recommendations to avoid using certain herbicides when soybeans are planted in close proximity of corn.

WEED CONTROL IN SOLID-SEEDED VERSUS ROW-PLANTED GLYPHOSATE-RESISTANT SOYBEAN

RESEARCHERS AND UNITS: **PHILLIP STAHLMAN, AGRICULTURAL RESEARCH CENTER-HAYS; MARK CLAASSEN, LARRY MADDUX, W. BARNEY GORDON, AND DALLAS PETERSON, AGRONOMY; GERALD WARMANN, SOUTH CENTRAL AREA EXTENSION OFFICE**

FUNDS (FY98): **$15,000** COMPLETION DATE: **JUNE 30, 1998**

Justification for Research: Narrow row spacing for crops has several advantages over wide row spacing, including earlier canopy development, better light interception, improved weed control, and potentially higher crop yields. Despite these advantages, most growers use wide row spacing so they can cultivate to control escaped weeds, if needed. The development and success of glyphosate-resistant (Roundup Ready) soybean offers an inexpensive alternative weed management system with wide flexibility in application timing. This potentially will reduce the need for cultivation and facilitate adoption of narrow row spacing.

Project Objectives:

1. To compare rates and application timings of Roundup Ultra versus competitive standard herbicides for crop safety, weed control, and grain yields of glyphosate-resistant soybean.
2. To compare soybean production using combinations of cultural practices and herbicide treatments and determine the effects on weed spectrum, species population, and growth.
3. To compare the economics of each combination of factors and determine the most profitable production system.

Results: Averaged over row spacing and herbicide treatment, Roundup Ready soybeans were more profitable than non-Roundup Ready soybeans at each of three locations, and narrow row spacing was more profitable than wide row spacing at two of those locations. Returns for soybeans grown in narrow rows at Hays and Hesston were 1.9- and 1.3-times greater, respectively, than returns for soybeans grown in wide rows. Poor stands reduced the profitability of narrow-row soybean treatments at Manhattan. Stand establishment was more problematic for soybeans seeded in narrow rows at each location.

Two applications of Roundup Ultra were needed to maximize profitability at Hays and Manhattan, but only one application was needed at Hesston. The optimum rate of Roundup Ultra varied among locations depending on the weed spectrum. However, at each location, treatment with Roundup Ultra was more profitable than treatment with competitive, standard, herbicide treatments.

Significance of Results: The research demonstrates the improved utility and economics of glyphosate-resistant soybean compared to conventional weed management in non-glyphosate-resistant soybean. Two applications of Roundup at labeled rates will be needed in most instances to achieve season-long weed control. Use of glyphosate-resistant soybean technology will facilitate movement to narrow row spacings, which will enhance weed control and improve profitability.

INTEGRATED WEED MANAGEMENT

RESEARCHERS AND UNIT: ***MICHAEL HORAK AND DALLAS PETERSON, AGRONOMY***

FUNDS (FY 98): ***$14,300*** *COMPLETION DATE:* ***JUNE 30, 1999***

Justification for Research: Soybean production is heavily reliant upon herbicides, and at least one herbicide application is used on more than 85% of Kansas soybean acres. To determine if chemical weed control of a secondary weed flush is economically justified, information is needed about competitive effects of weed species. Implementation of an integrated weed management system may reduce herbicide use, while maintaining productivity, thus saving money for farmers .

Project Objective: To determine the densities at which three detrimental pigweed species cause significant soybean yield loss so that farmers can decide whether a remedial control treatment is necessary or justified.

Results: Palmer amaranth reduced soybean yield from 8 % at low densities (1 plant in 6ft) to 60% at high densities (1 plant in 6in) when it emerged with the crop. Common waterhemp reduced yield up to 40% over the same densities. Redroot pigweed did not reduce yield at these densities. When these species emerged later than the 4th leaf stage of soybean, they were not competitive.

Significance of Results: This work will allow farmers to make better weed management decisions concerning the need to control secondary flushes of these common weeds. If secondary flushes occur at low densities and after crop establishment, the weeds may have a small effect on crop yield, and control may not be economical.

FEEDING RAW SOYBEANS TO FINISHING STEERS

RESEARCHERS AND UNITS: **KELLY KREIKEMEIER, SOUTHWEST RESEARCH-EXTENSION CENTER; TWIG MARSTON, ANIMAL SCIENCES AND INDUSTRY; JAMES SARTWELLE III, SOUTHWEST AREA EXTENSION OFFICE**

FUNDS (FY98): **$13,800** COMPLETION DATE: **JUNE 30, 1998**

Justification for Research: Soybean is a major cash crop for Kansas farmers. It fits well in crop rotation systems and is economical to grow, and the seeds are high in protein and oil contents. Two of the more expensive ingredients in finishing cattle diets are protein and energy. Oil meal by-products, animal products, urea, and animal fat have been traditional sources of these two nutrients. The perception exists that whole soybeans must be processed and (or) heated to destroy their anti-nutritional properties. For nonruminants, this is definitely the case. However, studies involving ruminants, both sheep and cattle, have indicated that raw soybeans can be incorporated successfully in growing diets. Kansas has the one-time capacity to feed in excess of 2 million head of finishing cattle. If raw soybeans can be substituted for conventional sources of proteins and fat in finishing cattle diets, increased demand and price for soybeans should result.

Project Objective: To determine if raw soybeans can replace soybean meal and beef tallow in a cattle-finishing diet.

Results: Three separate feeding trials have indicated that raw soybeans can be included in finishing cattle diets without compromising animal performance. Different sources of roughage, grain mixtures, and grain processing methods were studied, and they had no effect on the utilization of the protein or added fat sources. Feeding raw soybeans replaced a substantial amount of traditional protein and added fat supplements without affecting dry matter intake, feed efficiency, or any of the carcass traits that are used to formulate USDA quality or yield grades.

Significance of Results: This research indicates that cattle feeders have the option to include up to 7.5% of raw soybeans in the finishing cattle diet. Carcass data indicate that the quality of the beef product is maintained. Verifying animal performance and feed efficiency allows for economic comparisons and the establishment of ingredient values. In finishing cattle diets, the economic value of raw soybeans ($/lb) is equal to 80% of the price of (44% crude protein) soybean meal ($/lb) plus 20% of the price of beef tallow ($/lb). Historical price relationships indicate that the inclusion of raw soybeans in finishing diets allows soybean growers to capture part of the handling charges that normally are not realized.

SOYBEAN HULLS AS AN ENERGY SOURCE IN ROUGHAGE-FREE DIETS FOR GROWING CATTLE

RESEARCHERS AND UNIT: ***DALE BLASI, JAMES DROUILLARD, AND EVAN TITGEMEYER, ANIMAL SCIENCES AND INDUSTRY***

FUNDS (FY 1998): ***$33,014*** *COMPLETION DATE:* ***FEBRUARY 1, 1998***

Justification for Research: Soybean hulls are becoming increasingly available in the domestic market as a result of the shift toward export of dehulled soybean meal. Increasing the supply of soybean hulls without increasing domestic demand likely will depress their value. Growing programs for beef and dairy cattle traditionally have employed a high percentage of roughages. Increasing concerns over the contribution of animals wastes to environmental contamination has spawned greater interest in limit-feeding programs. Replacing roughages and grains with soybean hulls may reduce manure output by cattle, while maintaining high levels of performance.

Project Objectives:

1. To compare growth performance of cattle backgrounded on roughage- or grain-based diets to that of cattle fed roughage-free diets comprised predominantly of soybean hulls.
2. To evaluate the response to ruminally protected methionine in diets comprised predominantly of soybean hulls.

Results: Results of an experiment with growing beef cattle demonstrated that soybean hulls can be used effectively as the primary component of the diet. Performance of cattle fed diets composed of soybean hulls was intermediate to that of cattle fed roughage-based diets and limit-fed corn diets. Addition of methionine, previously believed to be the first-limiting amino acid for soybean hull diets, was not effective in improving performance of growing cattle. Additionally, work began on a brochure pertaining to the utilization of soybean hulls. When completed, this brochure will summarize dozens of research trials and will provide valuable information about production, nutritive value, storage, and other factors.

Significance of Results: These research results provide an example of how innovative feeding programs can be developed to add value to agricultural by-products, while minimizing impact on the environment. Compilation of this and other research into an informative brochure will allow for distribution of valuable information to potential end users.

EXTRUSION CONDITIONS TO OPTIMIZE UTILIZATION OF FULL-FAT SOYBEANS BY FINISHING PIGS

RESEARCHERS AND UNITS: **JOE HANCOCK, ROBERT HINES, AND TERRY GUGLE, ANIMAL SCIENCES AND INDUSTRY; KEITH BEHNKE, GRAIN SCIENCE AND INDUSTRY**

FUNDS (FY 98): **$25,500** COMPLETION DATE: **JUNE 30, 1998**

Justification for Research: Justification for this project results from the continually growing interest, domestic and worldwide, in the use of full-fat soybean products. This interest undoubtedly will promote use of soybean products in new and unique situations, but it is hampered to an unacceptable extent by the lack of knowledge concerning appropriate processing methodology to achieve maximal nutritional value. Furthermore, developments in plant breeding and biotechnology are rapidly creating soybean genotypes with extreme differences in chemical composition (e.g., unusual concentrations of oil, protein, and carbohydrates). These changes in chemical composition will alter, to an unprecedented extent, the processing characteristics of full-fat soybeans.

Project Objective: To determine the extrusion conditions that optimize nutritional value of full-fat soybeans in growing pigs, with particular attention to the interaction of cutting-edge soybean genotypes with extrusion conditions.

Results: For this project, we included commercial varieties available now, contacted university personnel for entries into our project, and solicited experimental soybeans from seed companies. For the commercially available varieties, we planted five acres of Flyer, Stressland, Kunitz, and Stine just outside of Manhattan. The soybeans were harvested and extruded at a low temperature (250°F) and a more conventional temperature (300°F). Although not different when fully processed, some of the soybean genotypes were of greater nutritional value than others when exposed to minimal processing. As for the university and experimental varieties, high oleic acid (supplied by Dupont Quality Grain) and high palmitic acid (supplied by Dr. Bill Schapaugh in our KSU Dept. of Agronomy) soybeans resulted in a greater degree of saturation in the fat than mill-run soybeans. These results suggest that modified soybean genotypes could be used to give greater firmness of the belly when problems with bacon slicing are encountered.

Significance of Results: Different soybean genotypes did have lower processing needs and, therefore, potentially lower processing costs than others. The key will be to develop rapid screening techniques to identify soybean genotypes that require fewer processing inputs. Also, modified fatty acid profiles in whole soybeans did increase fat firmness in pig carcasses. In the not-so-distant future, we may be matching identity-preserved soybeans to a particular feedmill (processing) setup and a particular stage of production (e.g., fat-hardening diets just before slaughter) in pigs.

MOLECULAR STRUCTURE, DYNAMIC BEHAVIOR, AND FUNCTIONAL PROPERTIES OF SOY PROTEINS.

RESEARCHERS AND UNITS: ***X. SUSAN SUN, GRAIN SCIENCE AND INDUSTRY; OM PRAKASH, BIOCHEMISTRY***

FUNDS (FY98): ***$58,600*** *COMPLETION DATE:* ***JUNE 30, 1999***

Justification for Research: Because of the large amount of plastic waste produced each year from single-use products, research efforts recently have centered on utilizing biopolymers as alternatives for petroleum polymers. Soy proteins have been considered promising biodegradable polymeric alternatives in applications including adhesives, molded or extruded articles, or medical capsules. Pressure, temperature, and protein physical modification are major parameters in plastic processing. The curing behavior of native or modified soy protein and soy protein components in the presence of various plasticizers and chemicals needs to be studied.

Project Objectives:

1. To continue studying the functional properties of native soy protein and protein fractions at varying plasticizing conditions and identifying key components of soy proteins for plastic matrix performance.
2. To characterize the functional properties of hydrophobic amino acids of soy proteins in plastic matrix performance.
3. To characterize effects of curing temperature and pressure on properties of native and modified soy protein and defatted soybean flour as plastic resins.

Results: Two amino acids (proline and cysteine) have been found to increase water resistance and flexibility. The content of both amino acids are higher in 11S components than in 7S, and that is why 11S is stronger, more flexible, and more water resistant than 7S. Thermal analysis results showed that soy protein is a pressure-sensitive polymer and starts to decompose at 230ºC. The optimum molding temperature occurred at the thermal transition temperature of the soy proteins. Although degrees of denaturation of various soy proteins by heat and some selected chemicals were the same, the denatured proteins had very different properties.

Significance of Results: Partial denaturation by selected chemicals has shown great potential for use of soil proteins in adhesives, films, and molded articles. The results indicate that soy proteins are good polymer resources. The outcome will be useful to soybean breeders, who can modify their soybean varieties in the future to provide better quality products for biodegradable resin applications.

UTILIZATION OF SOAPSTOCK AND SOYBEAN MEAL IN MANUFACTURING A NOVEL, VALUE-ADDED PROTEIN SOURCE FOR CATTLE

RESEARCHERS AND UNITS: ***JAMES DROUILLARD AND DALE BLASI, ANIMAL SCIENCES AND INDUSTRY***

FUNDS (FY 1998): ***$31,820*** *COMPLETION DATE:* ***MARCH 1, 1998***

Justification for Research: In its native state, soybean meal is a relatively poor source of bypass protein. Efforts to increase the proportion of bypass protein will enhance the value of soybean meal for certain classes of cattle, such as dairy cows and rapidly growing beef calves. The resulting protein product will be positioned to replace animal proteins that historically have dominated the bypass protein market.

Project Objectives: To develop a value-added soybean meal for cattle that contains a high proportion of bypass protein.

Results: A series of laboratory studies was conducted to identify novel methods of increasing the proportion of bypass protein in soybean meal. Several processes were developed, including one that relied on the use of soybean soapstock. It was oxidized, producing compounds that reacted with soy proteins to produce a complex that was resistant to ruminal degradation (high bypass). The soapstock method, though effective in protecting the protein, required the addition of large amounts of hydrogen peroxide, thus rendering the process very expensive to apply commercially. A second process was devised using digestive enzymes. This process has resulted in the development of a soybean meal with approximately three times the normal level of bypass protein.

Significance of Results: Development of a high-bypass soybean meal has commercial application in the cattle feeding and dairy industries. The product that has been developed has several advantages over competing protein sources: it is plant-based, it is a more concentrated source of bypass protein, and treatment cost is lower.

EXTRUSION TECHNOLOGY FOR NOVEL, EXTRUDED, HEALTHY FOODS FROM GRAINS

RESEARCHERS AND UNITS: **CAROL KLOPFENSTEIN AND JOHN BRENT, JR., GRAIN SCIENCE AND INDUSTRY; CAROLE SETSER, FOODS AND NUTRITION**

FUNDS (FY98): **$38,352** COMPLETION DATE: **DEC. 31, 1998**

Justification for Research: Emphasis is being put on developing new value-added products from soybeans. A primary focus is on creating new lubricants, adhesives, and plastics that predictably will increase the use of soybean oil and soy protein by billions of pounds. To make those projects economically feasible, new uses will have to be found for the major by-product of that processing, namely the residual 40% of complex carbohydrate component of the soybean, dietary fiber. We are proposing to add value to the soybean fiber by creating the technology to prepare new foods containing it through extrusion processing.

Project Objectives:

General— To add value to soybean fiber fractions by developing the technology to produce novel, tasty, nutritious foods for humans by extrusion processing.

Specific—

1. To show that tasty, high-quality, nutritious, ready-to-eat breakfast cereals and snack foods can be produced using extrusion technology and convey that technology to the food processing industries and ingredient suppliers.
2. To measure chemical, physical, nutritional, and sensory changes that occur in the foods during extrusion processing, including changes in their cholesterol-lowering potential.

Results: New extrusion technology has been developed to produce novel, nutritious (reduced fat, high- fiber) snack foods and ready-to-eat breakfast cereals with good commercialization potential. The sensory attributes of the new snacks, breakfast cereals, mini-breads, or other grain- and fiber-rich products are enhanced at the same time their nutritional value is improved. A co-extruded, chocolate- filled snack with a crispy cereal shell and a fiber-rich, cornflake, ready-to-eat, breakfast cereal show promise for commercial development. Studies have shown that products extruded under certain processing conditions have greatly enhanced cholesterol-lowering activity. A recent feeding study showed that soy-fiber-enriched, extruded cornflakes lowered animals' cholesterol levels more than any of the five commercially available products with which they were compared. The tested products included Kellogg's Corn Flakes, General Mills' Total, General Mills' Country Corn Flakes, Post Toasties Corn Flakes, and Always Save Corn Flakes. Fermentability of our fiber-rich products in the digestive tract was affected by processing conditions, which might account for their enhanced effectiveness.

Significance of Results: The market for soy fiber, as well as its value, should increase when these new snacks become viable commercial products. Not only will Kansans benefit economically from this research, but the availability of these new types of extruded foods can make them healthier. Much public interest has been expressed as a result of media coverage of this work.

MODIFICATION OF THE FLAVOR AND COLOR OF EXTRUDED, SOY-BASED, MOZZARELLA CHEESE ANALOGS

RESEARCHERS AND UNIT: ***KAREN SCHMIDT, IKE JEON, AND THOMAS HERALD, ANIMAL SCIENCES AND INDUSTRY***

FUNDS (FY 98): ***$21,500*** *COMPLETION DATE:* **ONGOING**

Justification for Research: In the past 2 years, a process and formulation have been developed for a mozzarella cheese analog containing soy protein. Though this soy analog had good stretching and melting qualities, the flavor was nondescript, and the color was slightly gray. Thus, more research was necessary to optimize the flavor and color of the mozzarella cheese analog.

Project Objectives:

1. To improve the flavor of mozzarella cheese analogs whose formula and process have been developed.
2. To produce mozzarella cheese analogs that have white-yellow color similar to commercial mozzarella cheese.

Results: Results from this year indicated that colorants needed to be added to the formulation to help improve the color, because the combination and alignment of the soy and dairy proteins induced a grayish hue to the mozzarella cheese analog. Data indicated that small amounts of titanium dioxide (<0.005%) and annatto (<0.005%) are necessary to produce a more yellow / white color in the mozzarella cheese analog. Although these colorants can be added with other dry ingredients prior to final processing, they appear to affect the light-scattering properties of the proteins in the mozzarella cheese analog, affecting the overall color.

To improve the flavor of the cheese analogs, the best method appears to be adding a commercial enzyme-modified cheese (1-2%) with food-grade lactic acid (1-2%). This combination of flavor and flavor enhancer will produce a mozzarella cheese analog that has a flavor more similar to that of commercial mozzarella cheese.

Significance of Results: These results have indicated that we can produce a mozzarella analog that has acceptable melting and stretching qualities as well as a flavor and color more similar to those of commercial mozzarella cheese.

MANAGING MARKETING AND PRODUCTION RISK IN THE POST-DEFICIENCY-PAYMENT PERIOD

RESEARCHERS AND UNITS: **G. A. (ART) BARNABY, JR. AND WILLIAM TIERNEY, JR., AGRICULTURAL ECONOMICS; DAN O'BRIEN, NORTHWEST AREA EXTENSION OFFICE**

FUNDS (FY 98): **$25,933** COMPLETION DATE: **JUNE 30, 1999**

Justification for Research: Many growers are now faced with price and yield risk management in the post deficiency payment period. Growers had many opportunities to preharvest price their crop above the market price at harvest time. However, very few growers took advantage of those opportunities. A recent survey showed that about 15% of Kansas farmers have used options, 30% have forward contracted, and less than 5% have used futures. Those growers who use forward pricing tools currently price less than 1/3 of their expected production. The risk-assessed marketing (RAM) approach is to develop a soybean case study that would allow growers to work through various marketing strategies with price and yield risk. Although many growers received a temporary "bail out" with a $6 billion market and ad hoc disaster program that covers yield losses and a 50% increase in agricultural marketing transition payment, this level of financial help is unlikely to be available in the future. Therefore, better risk management will be a requirement for successful Kansas growers.

Project Objectives:

1. To continue development of the successful soybean RAM workshops, which include helping farmers increase their average soybean price and increase profits, develop risk plans that include currently available private risk tools, and develop plans that would allow growers to price up to 100% of their crop by harvest without increased financial risk.
2. To help growers develop risk plans that would allow them to price up to 80% of their expected crop up to 2 years ahead of harvest without increased financial risk.
3. To develop a soybean marketing handbook with a chapter on crop insurance and production risk.
4. To develop an World Wide Web site for soybean marketing and risk that would be updated with new information that soybean growers could access.

Results: Work on the Web site is underway and portions have been completed. It is already providing valuable risk-management strategies, for example, pricing crops for delivery after the FSA loan expires. This simple storage would provide a price that is 30 to 40 cents higher than the current market. The web page can be found at *http://www.agecon.ksu.edu/risk/*. We also have conducted 19 RAM workshops that utilized a case study to teach marketing and risk management techniques. We have a similar number of workshops scheduled for this winter meeting season.

Significance of Results: Managing price and yield risk has taken on new urgency given the current low market prices. Many growers who have utilized the risk management tools clearly have limited their 1998 losses.

MARKET DEVELOPMENT GRANT—INTERNATIONAL GRAINS PROGRAM GRAIN STORAGE, HANDLING, AND SANITATION SPECIALIST

RESEARCHERS AND UNITS: ***BRENDAN DONNELLY, GRAIN SCIENCE AND INDUSTRY***

FUNDS (FY 98): ***$36,600*** *COMPLETION DATE:* ***ONGOING***

Justification for Research: International users of soybeans and soybean meal are dismayed by the complexities of purchasing these raw materials. The most significant difficulty is the value of the raw material as it relates to quality and price discovery. The recent development of genetically modified organisms and the renewed interest in full-fat soybean meal have further increased the complexities. Also, with privatization, the numbers of international buyers are increasing, and these new players are unfamiliar with grain grading, quality control, shipping, and contracting.

Project Objectives:

1. To identify the potential users and buyers of soybeans and soybean meal and to determine their specific end-product needs.
2. To assist the American Soybean Association (ASA) and the United Soybean Board in educating their clienteles.
3. To support the national commodity associations with short courses and consultants both in the United States and abroad.
4. To maintain contact with buyers and users of soybeans and soybean products to ensure a continuing education program.

Results: Five of the 10 International Grains Program (IGP) short courses specifically addressed in detail the issues pertinent to soybean and soybean meal purchasing. Five faculty conducted an ASA-sponsored short course in Izmir, Turkey that had over 200 participants. The IGP prepared a program for an Algerian soybean meal purchasing team. An IGP faculty member addressed the Greek Feed Manufacturers annual meeting for ASA.

Significance of Results: The increased demand for IGP programs by the national commodity organization as well as their request for faculty consultations overseas has enabled the IGP to influence sales of soybeans and soybean meal from the U.S. Participants are decision makers in their own organizations, and they are influencing others to participate in IGP short courses. The international buyers are purchasing raw material with more confidence because of their increased understanding of the U.S. grain system.

DEVELOPMENT OF HARD WHITE WINTER WHEAT FOR KANSAS

RESEARCHERS AND UNITS: ***ROLLIN SEARS AND GARY PAULSEN, AGRONOMY; T. JOE MARTIN, AGRICULTURAL RESEARCH CENTER-HAYS***

FUNDS (FY 98): ***$34,000*** *COMPLETION DATE:* ***ONGOING***

Justification for Research: Hard white wheat is the preferred over hard red wheat, all other quality characteristics being equal. Kansas has grown hard red winter wheats primarily because of tradition. Western Kansas is ideally suited to safely produce high quality hard white wheat, which can be used both by domestic millers as well as international buyers. Hard white wheat is the class of choice for the very large and growing Asian market.

Project Objectives:

1. To develop premium hard white wheat varieties for Kansas with high protein, strong dough-mixing characteristics, good bread-baking performance, and good noodle properties.
2. To improve the kernel color of hard white wheat, allowing for easier classification and separation from hard red wheat.
3. To improve preharvest dormancy in hard white wheat and reduce the chances of preharvest sprouting of the crop.

Results: After nearly 15 years of research and development, two new hard white wheat varieties were released by K-State Research and Extension during 1998 to Kansas wheat producers. Betty (KS84063-2W) is a sister selection from the same wheat population that produced Jagger. It is best adapted to western Kansas and has demonstrated in tests to have bread-baking properties superior to those of either Jagger or Karl 92. Heyne (KS85W663-42) has outstanding general disease resistance and is best adapted to central Kansas. It also has outstanding bread-baking quality, equal to that of Jagger or Karl 92. Approximately 500 bushels of foundation seed were distributed to category 1 seed producers within the Kansas Crop Improvement Association during the fall of 1998.

Significance of Results: To attract the milling and baking industry to utilize and specifically buy hard white wheat, a clear preference for the products must be demonstrated in the supermarket. To attract Kansas wheat farmers to plant them, these varieties also must perform in the field as well or better than competing hard red wheat varieties. Betty and Heyne have demonstrated both outstanding yield and quality characteristics compared to the best hard red wheat varieties, and they are paving the way for Kansas to begin producing hard white wheat rather than hard red wheat.

IMPROVEMENT OF HARD RED WINTER WHEAT FOR KANSAS

RESEARCHERS AND UNITS: ***ROLLIN SEARS, AGRONOMY; T. JOE MARTIN, AGRICULTURAL RESEARCH CENTER-HAYS***

FUNDS (FY 98): ***$92,000*** COMPLETION DATE: ***ONGOING***

Justification for Research: Plant breeding is the only way to incorporate improved biotic and abiotic resistance, higher protein, better milling quality, and better baking characteristics into Kansas winter wheat. Producing high quality wheat does not cost wheat growers extra. Meeting the requirements of customers who demand quality and competing with a quality product in the marketplace certainly will be advantageous. High yield and quality are not mutually exclusive. Developing wheat varieties with improved pest resistance is also the best way to reduce the amounts of chemicals utilized to protect the wheat crop from damage. Improved disease and insect resistance can be built into new varieties, making their performance more consistent and also reducing the need for chemical protection.

Objectives:

1. To increase the protein content and quality to consistently acceptable levels.
2. To increase size and uniformity of kernels.
3. To develop premium hard red wheats to increase buyer recognition and demand for Kansas wheat.

Results: 1998 represented the second consecutive record wheat crop for Kansas. Although not the largest crop on record, the average yield shattered the previous standard set in 1997. The 1998 crop averaged 49 bu / acre, which was an increase of 3 bu / acre over the 1997 record and an increase of 7 bu / acre over the previous standing 1982 record of 42 bu / acre. These increases really demonstrate that given the correct growing environments, the present wheat varieties grown by Kansas farmers are capable of remarkable yields. Two new hard red winter wheats were advanced for release consideration. KS89180B and KS97P0630-4-5 both have been tested in elite Kansas trials and the Southern Regional Performance Nursery (USDA-ARS) and have demonstrated excellent potential and wide adaptation across Kansas. Pending 1999 quality and performance data, recommendations regarding their potential increase and release will be made. Approximately 2,000 new lines are being evaluated presently for variety release potential in the wheat breeding program. Although most (if not all) of these lines never will be released because of one or more deficiencies discovered through our evaluation process, many will serve as outstanding sources for new parents in crosses to create new populations for the future.

Significance of Results: Successful new wheat varieties have a very large economic impact on the state's economy. Karl, released by the KAES in 1988, and Karl 92 were the leading varieties planted in Kansas between 1991 and 1997. Jagger released in 1994 and 2137 released in 1995 are currently the top two varieties planted in Kansas, occupying 29.2 and 22% of the planted acreage, respectively. All three varieties make up better that 57% of the total planted acreage in Kansas. These varieties have a combination of better yields, improved quality, and disease resistance. An economic analysis of the wheat research program at K-State estimated that for every dollar invested in research, the state benefitted by receiving $12 in return.

WHEAT GENETICS RESOURCE CENTER AND ITS CONTRIBUTIONS TO THE KANSAS WHEAT INDUSTRY

RESEARCHER AND UNIT: ***BIKRAM GILL, PLANT PATHOLOGY***

FUNDS: ***$80,000*** *COMPLETION DATE:* ***ONGOING***

Justification for Research: The Wheat Genetics Resource Center (WGRC) was established in 1984 to collect, conserve, 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 in developing genetic and cytogenetic stocks for rapid and efficient gene transfer to breed superior wheat cultivars. Resistance and other agronomically useful genes are incorporated into wheat lines through interspecific hybridization, and the lines are released as germplasm. The WGRC also generates new cytogenetic stocks and chromosome and DNA-based assays for plant genome analysis and efficient germplasm and cultivar development.

Project Objectives:

1. To develop hard red winter and white wheat germplasms with sources of resistance, quality, and other useful traits usually derived from unadapted or wild wheat germplasm.
2. To develop biotechnological approaches that expedite the development of improved germplasm.

Results: Center scientists prepared 31 research publications. Eight WGRC scientists participated in the 9th International Wheat Genetics Symposium in Saskatoon, Canada (held every 5 years) and made presentations that covered the range of WGRC research from genetic resources, genome mapping, and biotechnology to germplasm development. For the first time, Center scientists have introduced antifungal protein genes into the wheat plant to enhance its survival against pathogen attacks. One transgenic wheat line gave enhanced resistance to wheat scab, a devastating disease of this crop. The status of wheat genetic resources for the 21st century was assessed, with discussion on the topics of duplication, taxonomy, and passport data. An invited article in the prestigious journal Current Opinions in Plant Biology highlighted the status of specialized plant genetics research. The list of released germplasm now stands at 39. The newly released germplasm (KS98WGRC41) contains a rye-derived gene that conditions resistance to Hessian fly. Improved germplasm and genetic materials were mailed to 68 scientists. By free sharing of germplasm, materials, and technical knowledge, the WGRC has become a major player in public and private research on wheat. Ten scientists worked at the WGRC laboratories on collaborative research projects.

Significance of Results: Germplasm is the foundation on which wheat breeders construct superior wheat cultivars that provide the livelihood for wheat farmers, drive the economic engine of society, and provide sustenance and nourishment to humankind. The germplasm pool must be deep, secure, and replenished from time to time to serve the crop needs of today, tomorrow, and forever. Tools to utilize germplasm must be honed constantly. Cutting-edge technology must be applied to enhance the efficiency of wheat breeding, sustainability of crop varieties, and competitiveness of producers. The WGRC research results ensure these outcomes in the near future and beyond.

ON-FARM WHEAT ACTION RESEARCH

RESEARCHERS AND UNITS: ***JAMES SHROYER, DALE FJELL, WILLIAM HEER, AND W. BARNEY GORDON, AGRONOMY; SCOTT STAGGENBORG, STEWART DUNCAN, AND CURTIS THOMPSON, NE, SC, SW AREA EXTENSION OFFICES; ROBERT BOWDEN, PLANT PATHOLOGY***

FUNDS (FY98): ***$15,000*** COMPLETION DATE: ***JUNE 30, 1998***

Justification for Research: 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 farmers' 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.

Project 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: A variety x planting date x seeding rate study near Colby looking at tiller development throughout the growing season determined that maximum tiller number occurred in the first week of May in northwest Kansas, and numbers decreased by 35-40% by June 1.

Forage yields were taken at two growth stages (10 days after heading and early dough stages) of eight triticale and wheat varieties at three locations (Dighton, Manhattan, and Hutchinson). Dry matter yields ranged from 6,000 to over 17,000 lbs / a depending on location and growth stage. Generally, Presto, Roughrider, and Tricale 2+2 were the highest yielding varieties, and all triticale varieties outperformed Jagger.

In an on-farm study of row spacing near McPherson, the cross-drilled treatment yielded 75 bu / acre, whereas the standard 8-inch spacing yielded 70 bu / acre, and the 4-inch spacing yielded 66 bu / acre. At Hutchinson, yields were 55, 56, and 49 bu / acre for the 4-inch, 8-inch, and cross-drilled treatments, respectively. At Belleville, yields were 67, 68, and 68 bu / acre for those three row spacings.

We observed an 8 bu / acre decrease with no-till wheat after grain sorghum compared to wheat double-cropped after the sorghum was tilled in Sumner County, but only a 2.1 bu / acre decrease in northern Riley County. No-till wheat after soybeans yielded 1.3 bu / acre more than the tilled wheat after soybeans in Clay County. We observed a significant yield response (10 to 12 bu / acre) with additional nitrogen (90 and 120 lbs / acre) over traditional rates (60 lbs / acre) with no-till wheat after grain sorghum. 2137 appears to do well no-till after grain sorghum or soybeans, whereas Jagger and Karl 92 performed well only after soybeans. Coronado performed better after soybeans than grain sorghum, whereas Mankato was slightly better after sorghum.

Significance of Results: These trials of various management systems for wheat in different parts of the state provided useful information for producers. However, they raised some concern for possible yield reductions with double-cropping no-till after grain sorghum. This concern will be addressed in the future.

GENETIC DEVELOPMENT OF HIGHER DISEASE RESISTANCE AND GRAIN PROTEIN IN NEW WHEAT VARIETIES

RESEARCHERS AND UNIT: ***T.JOE MARTIN, DALLAS SEIFERS, AND TOM HARVEY, AGRICULTURAL RESEARCH CENTER-HAYS.***

FUNDS (FY98): ***$70,000*** *COMPLETION DATE:* ***ONGOING***

Justification for Research: Increasing the average protein content of Kansas hard winter wheat will have a positive effect on both domestic and foreign markets. Increased protein will allow us to compete better with the higher protein spring wheats in the foreign markets, while, at the same time, it will decrease the demand for spring wheat in our domestic markets. However, Kansas wheat producers are not likely to accept high protein varieties unless they see a direct economic advantage. The improvement in protein levels must be accompanied by concurrent improvements in production efficiency. This could be improved in Kansas by 16%, if our most serious pest problems can be controlled by developing pest-resistant varieties.

Project Objectives: To develop high yielding varieties for Kansas that are capable of resisting serious wheat pests and contain genetically controlled, increased levels of grain protein.

Results:. Significant results were obtained in two areas of pest resistance breeding in 1998. A Russian wheat aphid- resistant wheat (KS95H167-3) and a wheat streak mosaic virus-resistant wheat (KS96HW10-3) will begin initial large-scale increases for next year. Both possibly could be distributed to seed producers in the summer of 2000. KS95H167-3 is a hard red winter wheat that has compiled an excellent performance record over the last 3 years in dryland nurseries in far western Kansas. The western third of Kansas is the area that has the highest potential for losses caused by the Russian wheat aphid. KS96HW10-3 is a hard white wheat that has the potential of reducing losses to wheat streak mosaic virus to zero. It carries resistance to wheat streak mosaic virus that was transferred on half of a chromosome derived from western wheatgrass. KS96HW10-3 has performed well in western Kansas nurseries not affected by wheat streak mosaic virus during the last 3 years. This year's nursery in Barton County was infected heavily with wheat streak. KS96HW10-3's yield was 67 bu / acre, whereas the mean yield for the other susceptible to moderately resistant entries was 35 bu / acre.

Significance of Results: Damage from the Russian wheat aphid has been sporadic in western Kansas. However, a major outbreak could occur any time. The only wheat varieties with Russian wheat aphid resistance have been released by Colorado. These varieties have not performed well in western Kansas in the absence of Russian wheat aphid. If we should experience major outbreaks of Russian wheat aphid in the next few years, KS95H167-3 could save millions of dollars as the result of reduced yield damage and reduced insecticide costs.

State losses to wheat streak mosaic virus have averaged about 2% per year over the last 25 years. Almost all of that loss comes in the western half of the state. The deployment of KS96HW10-3 could result in an additional $20 million each year added to the economy of western Kansas just from the control of wheat streak mosaic virus. Additional benefits may be derived if its resistance to wheat streak mosaic virus enables western Kansas producers to graze volunteer wheat on fallow acres, instead of having to destroy it in an effort to control the virus.

QUALITY EVALUATION OF MATERIALS FROM KAES WHEAT BREEDING PROGRAMS

RESEARCHERS AND UNIT: ***PATRICK MCCLUSKEY AND BRENDAN DONNELLY, GRAIN SCIENCE AND INDUSTRY***

FUNDS (FY98): ***$40,000*** *COMPLETION DATE:* ***ONGOING***

Justification for Research: To improve agronomic performance, wheat researchers often must 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 the lines that have acceptable or superior hardness; protein content; and milling, physical dough, bread-baking, and Oriental noodle properties.

Project 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, and Grain Science in studies designed to determine influences 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 1997 were used by KAES wheat breeders to make quality selections among agronomically promising early- and advanced-generation lines for planting, crossing, and increase and release decisions. We analyzed 300 samples of about 1000 grams each for chemical constituents, test weight, kernel size distribution, kernel hardness (two methods), milling performance, mixing characteristics, and test baking. Additionally, starch quality characteristics and color stability (as relates to Asian noodle quality) were determined. An additional 531 samples were milled and analyzed for mixing characteristics. In a separate project related to wheat improvement in Kansas, over 5000 additional samples were screened solely for protein content and hardness.

Significance of Results: As a result of testing experimental lines in the wheat quality evaluation program, new varieties like Betty and Heyne are available to Kansas wheat producers. Additional advanced hard white wheat lines that exhibit acceptable to outstanding milling and baking quality continue to be tested extensively. 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 US hard winter wheat. These varieties and others being developed will make significant contributions to the Kansas economy.

CONTROL OF RESIDUEBORNE WINTER WHEAT DISEASES

RESEARCHERS AND UNITS: WILLIAM BOCKUS AND ROBERT BOWDEN, PLANT PATHOLOGY; MARK CLAASSEN, AGRONOMY; GERALD WILDE, ENTOMOLOGY

FUNDS (FY 98): ***$28,400*** *COMPLETION DATE:* ***JUNE 30, 1998***

Justification for the Research: Farmers increasingly leave crop residues on the soil surface rather than incorporating them into the soil. This practice helps reduce soil erosion, conserve energy, increase soil moisture, and increase crop yields. However, many plant pathogens survive in the previous year's crop residue, making some diseases more problematic under reduced-tillage conditions. Additional information is needed in Kansas to determine which wheat diseases increase under reduced-tillage cropping regimes; whether crop rotations to corn, sorghum, or soybean can help control those diseases; and whether germplasm that is resistant to them can be produced.

Project Objectives:

1. To investigate the impact of various tillage practices and crop rotations on severity of wheat diseases.
2. To screen wheat germplasm and breeding lines for resistance to diseases that can be important under reduced-tillage wheat production.

Results: Rotations to corn, sorghum, or soybean significantly reduced foliar diseases on wheat relative to the continuous wheat, chisel, or no-till treatments. No differences occurred among the rotation crops; therefore, corn, sorghum, or soybean provided similar levels of control of wheat foliar disease. Among the continuous wheat treatments, burning the wheat stubble resulted in lower disease than the chisel and no-till treatments. In fact, the burning treatment was similar to wheat following a rotation crop. Of particular note was that different foliar pathogens dominated under different rotation/tillage conditions. Tan spot predominated where significant wheat stubble was left on the soil surface (wheat/wheat, chisel and wheat/wheat, no-till). On the other hand, speckled leaf blotch was the dominant pathogen causing disease on wheat after a rotation crop.

Progress was made toward identifying resistance to the wheat diseases scab and tan spot. The level of scab resistance present in the screened population may not be as high as will be needed; however, excellent levels of tan spot resistance are present in many advanced breeding lines. Additionally, 15 possible germplasm lines were identified that had resistance to barley yellow dwarf equal to or better than that of the resistant check cultivar.

Significance of the Results: These findings help to identify those wheat diseases that can become problematic under reduced tillage. Additionally, they show that crop rotations to corn, sorghum, or soybean, when coupled with reduced tillage, result in high levels of control of many of the diseases. Finally, progress reported here toward identifying resistance to wheat pathogens should help in the development of resistant wheat cultivars to aid wheat producers in managing diseases that can be important under reduced tillage.

WHEAT MIDDLINGS RESEARCH

RESEARCHERS AND UNITS: **DALE BLASI, JAMES DROUILLARD, AND GERRY KUHL, ANIMAL SCIENCES AND INDUSTRY; CARL REED, KEITH BEHNKE, DIONISIA TRIGO-STOCKLI, AND FRED FAIRCHILD, GRAIN SCIENCE AND INDUSTRY**

FUNDS (FY 98): **$15,000** COMPLETION DATE: **AUGUST 1998**

Justification for Research: Observations by K-State Research and Extension personnel have indicated a tremendous opportunity for livestock producers to reduce their feeding costs through use of wheat middlings, a by-product produced by the Kansas flour milling industry. In 1997, Kansas produced 735,729 tons or 10% of the total amount produced in the United States. Astute livestock producers have purchased middlings during periods of price slippage and stored them on-farm until needed during the feeding season. However, producers' experiences with extended on-farm storage of middlings during the summer months have been variable and frequently unsatisfactory. A recent survey conducted by K-State Research and Extension, indicated that over 30% of the survey respondents encountered mold, spoilage, and bridging when attempting to store middlings long-term. Another area of research identified by survey respondents was the determination of feeding value of wheat middlings for beef cattle growing diets.

Project Objective: To evaluate and develop recommendations for feeding and storage of wheat middlings so producers can capitalize upon their value for improved livestock production and efficiency.

Results: The results of the feeding study indicated that middlings had a feeding value almost equal to that of corn and soybean meal when used in full-fed roughage-based rations but had a value of 83% when used in limit-fed diets. Storage studies have shown that pelleting virtually eliminates molds in middlings, reducing the level to about 4% of that present in nonpelleted material. These data were used to develop a set of guidelines for successfully storing wheat middlings from June until use during the feeding season.

Significance of the Results: The availability of research-based recommendations for effective, safe, long-term storage of wheat middlings will stimulate demand for them during periods of time when demand traditionally has been low. When coupled with the very positive results obtained from the growing cattle research, this translates into a greater value of wheat to the millers because they will be able to realize a greater millfeed credit. For example, if the economic value of middlings is improved by $5 or $10/ton, mill bids for wheat could increase up to 4.5 and 9 cents/bu, respectively.

MARKET DEVELOPMENT GRANT—INTERNATIONAL GRAINS PROGRAM
GRAIN STORAGE, HANDLING, AND SANITATION SPECIALIST

RESEARCHER AND UNIT: ***BRENDAN DONNELLY, GRAIN SCIENCE AND INDUSTRY***

FUNDS (FY 98): ***$184,000*** *COMPLETION DATE:* ***ONGOING***

Justification for Research: The world's wheat buyers, because of privatization, are very unfamiliar with the complexities of procurement. The value of the raw material as it relates to quality and price discovery is an enigma for some. Many international buyers need additional training in grade standards, quality control, milling potential, shipping, contracting, sanitation, pricing, basis, futures markets, and price discovery fundamentals. Manufacturing techniques and end use needs are challenging flour millers in this ever increasingly competitive world marketplace.

Project Objectives:

1. To identify users and buyers of wheat and determine their specific technical capabilities and needs.
2. To work with US Wheat Associates and other organizations to assist in their market development needs.
3. To offer short courses and consulting services that address the specific needs of the end users of US grown wheats.
4. To maintain contact with buyers and users to ensure a continuing education program as new wheat types and uses come to the marketplace.

Results: Four of the 10 International Grains Program (IGP) short courses specifically addressed the objectives outlined above. Several special teams were met by IGP staff at the request of US Wheat Associates and the Kansas Wheat Commission. Several consultants conducted programs for US Wheat Associates overseas, and three international milling organizations' annual meetings were attended by IGP faculty. An IGP wheat advisory board was established encompassing the contiguous hard red winter and Gulf exportable wheat states. A consultant was hired to address the specific issue of Gulf exportable marketing problems.

Significance of Results: Participants in IGP short courses and visitors to the IGP all held procurement responsibilities. These international buyers are more confident in their decision capabilities because of the information disseminated by the IGP. Repeat attendance in new short courses by organizations familiar with the programs has occurred, as well as attendance by additional executives from the participating organizations.

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

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