37TH BIENNIAL REPORT

AGRICULTURAL RESEARCH IN KANSAS

DIRECTOR'S REPORT FOR THE BIENNIUM

JULY 1, 1992 TO JUNE 30, 1994

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE UNIVERSITY

Agricultural Research in Kansas

37th Biennial Report of the Kansas Agricultural Experiment Station

Report of the Director for the Biennium Ending June 30, 1994

FRONT COVER

Photograph by Paul Maginness.

During the flood of July 1993, the floodgates on Tuttle Creek Dam had to be opened to prevent it from cracking or overflowing. The excess water increased flooding of agricultural land near Manhattan.

We appreciate loans of photographs from:

Robert Bowden, pg. 17, top
Janet Hazelton, pg. 18
Ray Lamond, pg. 3, top
Carl Reed, pg. 17, bottom
Robert Ridley, pg. 8
Bill Sullins, pgs. 2, top; 11, 20
Wamego Times, pgs. 2 and 3, bottom

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Contribution no. 95-320-S from the Kansas Agricultural Experiment Station

Letter of Transmittal

Office of the Director

To the Honorable Joan Finney,
Governor of Kansas

It is my pleasure to transmit herewith the report of the Agricultural Experiment Station of the Kansas State University of Agriculture and Applied Science for the biennium ending June 30, 1994. This report features the effects of the 1993 flood on agricultural research in Kansas. The research highlights include animal and crop production, soil and water management, pest control, animal and human health, and economic aspects of agriculture. In addition, there are lists of publications by Station scientists, lists of research projects still active and those terminated during the biennium, a record of personnel changes, and a financial statement for each year of the biennium.

Marc A. Johnson, Director

A Message from the Director

The Kansas Agricultural Experiment Station generates basic and applied research to foster development of Kansas agricultural industries, communities, and families. Rapid changes in technology, industry, and markets make this research more important now than ever before. Research in genetics and production of crops and livestock, as well as marketing and finance, is designed to keep the Kansas agricultural industry competitive. Research in plant breeding, soil and water conservation, and crop and livestock production methods addresses issues where agriculture interfaces with the environment. Research in value-added livestock and grain products and marketing explores ways to use Kansas agricultural products in new markets. Research in food safety contributes to the protection of our food supply and the image of agriculture. Research in community development explores means of maintaining a high quality of life for people in communities that are losing population. Research on families contributes to the happiness and well-being of our younger and older populations.

This 37th Biennial Report of the Kansas Agricultural Experiment Station displays the results of research reported to the public and the scientific community for the period 1992-94. A talented and dedicated research faculty has produced these results. Resourceful research assistants, graduate students, and classified staff also have contributed greatly to this output.

Kansas has been served well by its investment in the Kansas Agricultural Experiment Station. This investment affects the position held in agricultural and food markets by Kansas farmers and agribusiness people, the economic development of the state, the quality of our environment, and the well-being of our families and communities. The mission of the land-grant university is to address contemporary and future issues. As you study this report, you will see work on the major issues of our day.

Marc A. Johnson
Dean and Director
Agricultural Experiment Station

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The Flood of 1993

Certainly, the major event affecting agriculture in Kansas during the biennium was the flood of July 1993. It caused extensive damage to private farms and also to research areas belonging to the Kansas Agricultural Experiment Station (KAES). Losses of crops and equipment in Manhattan, Hays, and Colby were estimated at $1 million. Research programs in agronomy, animal sciences, entomology, forestry, horticulture, and plant pathology were affected, as well as those at the Agricultural Research Center-Hays and the Northwest Research-Extension Center. Beef cattle research suffered indirectly through the loss of hay bales and forage intended for silage. Reduced income from sale of foundation seed and fees charged for crop performance tests added to the losses.

Trees in research plots were damaged by floodwaters.

Standing water prevented harvest in many fields.

Crop Research

Specific effects of the flood on agronomic and horticultural crops included delayed planting and harvesting, poor stand development, broken stems, reduced growth, and lower yields. Excess water caused soil erosion and encouraged weed infestations. Diseases thrived in the wet conditions.

One way that heavy rain reduced plant growth and yield of crops was by washing fertilizer deep into the soil and promoting root growth at the surface. These roots could not take up sufficient nitrogen to allow normal production of grain.

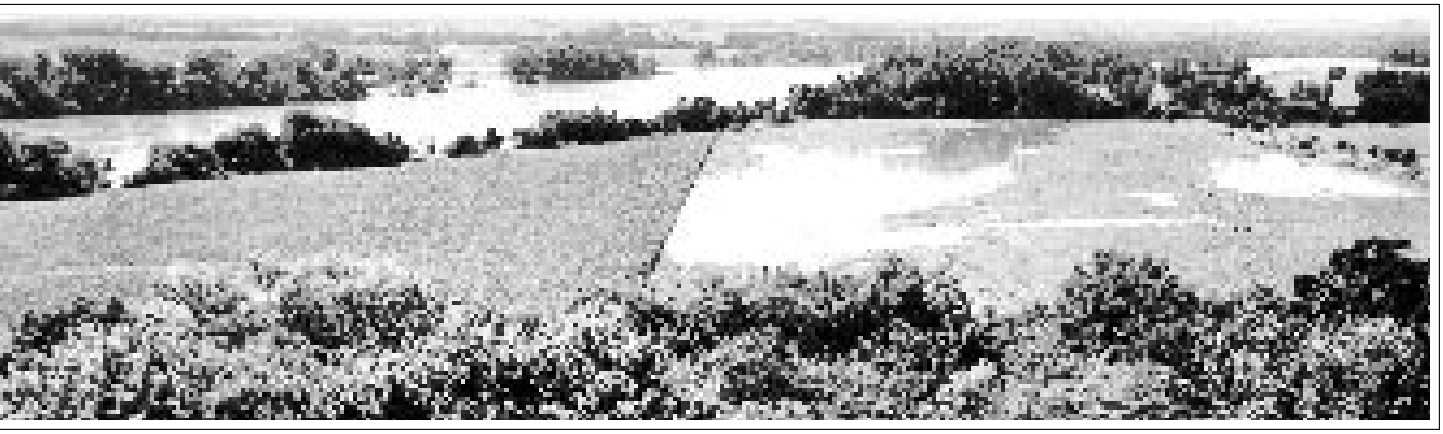
Flood damage prevented collection of enough data to produce the annual performance reports on spring oats, spring and winter barley, spring wheat, and winter canola. Wheat performance tests in Brown and Riley counties and the alfalfa performance test in Brown County were abandoned. The wheat and soybean breeding programs were set back by a year. Data collection was interrupted in research involving herbicides, fertilizers, and cropping systems.

A minor benefit resulting from the flood was a reduction in insect populations. For example, chinch bugs on grain sorghum, aphids on alfalfa, and spider mites on bedding plants were suppressed by the heavy rain.

The information collected during 1993 allowed researchers to compare plant responses under very wet and cool conditions to those under more typical summer conditions in Kansas.

Forestry Research

The floods caused extensive damage to 25-year-old forestry research sites near Tuttle Creek and Milford reservoirs. Losses of trees and property were estimated at $640,000, the greatest amount for any KAES unit. Near Tuttle Creek, 3 feet of water destroyed five research plantings and about 13 acres of trees, including black walnut, silver ash, green ash, and black locust. Flooding at Milford was more dramatic, destroying 50 acres of land with 10 research sites and about 3,000 trees. Among the trees damaged or lost were Scotch pines being grown as sources of a new Christmas tree nursery and ponderosa pines with genetic resistance to the pine tip moth. About 25 percent of a 12-acre hackberry plot was lost. Several high-quality black walnut trees were destroyed, and others were damaged. However, enough trees remained to produce a good crop of seed. Many trees left standing at both sites had severe mechanical injuries like peeled bark and broken branches; their long-term survival was questionable.



Disease Incidence after Flood

Among the diseases favored by wet conditions is wheat scab or head blight. A fungus infects and kills individual spikelets and can kill the entire head. Direct yield losses can range from 25 to 40 percent in severely diseased fields. However, the fungus has potential for more damage through the toxins it produces. These mycotoxins can cause illness or death when food and feed containing them are consumed. Some mycotoxins are carcinogenic.

In response to the long period of wet weather in 1993, researchers in the Department of Grain Science and Industry surveyed the distribution and extent of mold invasion and mycotoxin occurrence in Kansas wheat. Samples for analysis were obtained from all crop-reporting districts.

The incidence of wheat scab in samples was about 100 percent in the East Central and Southeast districts and 79 and 97 percent in the Northeast and North Central districts, respectively. The highest amount of kernels affected per sample was 75 percent from Doniphan County.

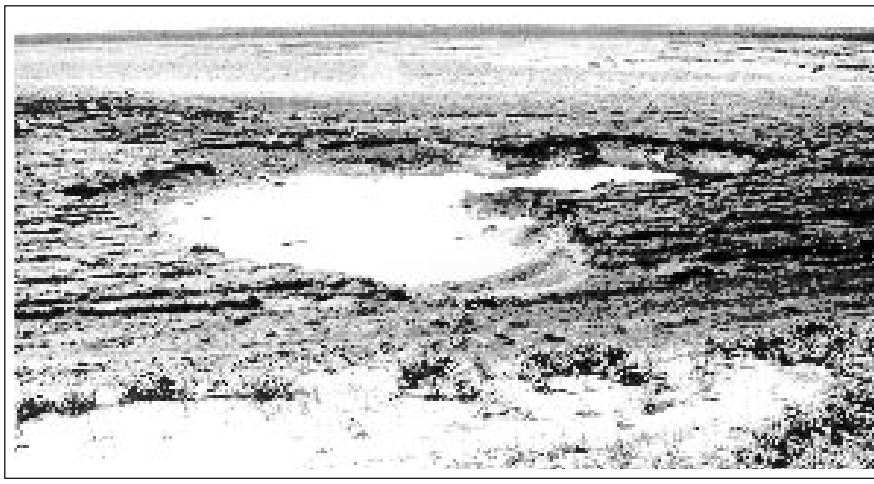
Vomitoxin (a common mycotoxin) was detected in 20 percent of the samples and was correlated to presence of the wheat scab fungus. However, the overall statewide average was below the new advisory level set by the Food and Drug Administration. The sample from Doniphan County also contained another dangerous mycotoxin.

The occurrence of wheat scab and mycotoxins was greatest in wheat from the areas that received the most precipitation. Although several varieties tested showed some differences in susceptibility to scab, infection was more dependent on environmental conditions at flowering.

Aftereffects of Flood on Soils

Flood waters affected soils in several ways. In some places, the soil was compacted, making planting of crops difficult. Growers were advised to determine the extent of compaction and then use appropriate tillage methods to break up the soil, but only if it was dry enough to shatter.

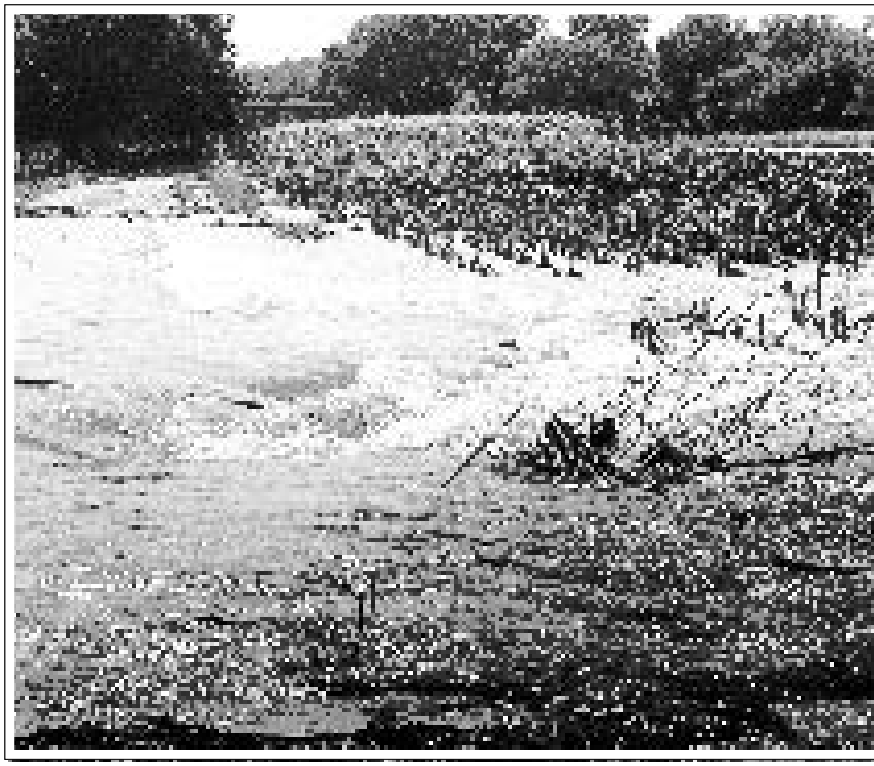
In many areas, silt and sand deposits covered fields and increased the potential for wind erosion. The best long-term control of wind erosion is achieved with a cover crop, but windbreaks and crop residue also help. After wind erosion starts, emergency tillage is the only short-term solution. Tilling at a speed of 3 to 5 miles per hour and perpendicular to the wind direction was recommended. The procedure should produce a rough, cloddy surface that resists the wind.



Sand deposits left by the flood were susceptible to erosion.

Erosion and deposition of materials during the excessive rains may have created soils with different characteristics than preflood soils. Sand can be low in organic matter and nutrients. Testing of soil in flooded fields was recommended, including analyses for general fertility, organic matter, nitrogen, and zinc.

Producers also were warned to be aware of a problem called "fallow syndrome," which occurs on fields that were not planted to a crop in the previous year. Many crops were destroyed by the flood, and the fields remained fallow. Reduced microbial activity in fallow soils produces symptoms of nutrient deficiency, reduced growth, and a poor root system. Starter fertilizer containing phosphorus applied at planting was recommended to lessen these effects.



Flooding reduced yields of several crops.

Research Highlights 1992 to 1994

■ ANIMAL PRODUCTION

Cattle Grazing Strategies

An alternative to season-long stocking (SLS) on shortgrass range is intensive-early stocking (IES), using double the SLS stocking rate for the early grazing season. A combination of these strategies was evaluated over a 4-year period at the Agricultural Research Center-Hays. Pastures were double-stocked during the first half of the summer, then half of the cattle were removed. This system could allow pastures to remain productive and also provide greater beef production per acre. The combination strategy (2X + 1) was compared to IES and SLS.

Total pounds of beef produced per acre were about 24 percent greater with the 2X+ 1 strategy than with IES or SLS. Changes in forage production among years or months were not affected by grazing strategies. Some shifts in plant species composition were induced by grazing treatments in the final year of the study. The results suggest that 2X + 1 stocking may be a viable means of increasing beef production in western Kansas. It also allows marketing of steers at two times of the year. However, lower gains in individual animals and potential to alter the abundance of cool-season grasses may offset some of the benefits.

Different Stocking Rates for Fescue Pastures

Two-thirds to three-fourths of the total seasonal production of dry matter from tall fescue generally occurs by early June. Gains by steers stocked at one head per acre typically have exceeded 2 pounds per day between April and June. A higher stocking rate should be possible to better utilize this forage and still achieve acceptable gains. A study was conducted at the Southeast Agricultural Research Center to determine the effects of spring stocking rate on gain by cattle grazing endophyte-infected tall fescue (IF) and IF overseeded with ladino clover (IFL).

Gains by steers declined as stocking rate increased. At similar stocking rates, steers grazing IF gained more weight than steers grazing IFL. Gain per acre on both forage types was maximized at 2.2 head per acre. Costs of gain increased with higher stocking rates on both forage types but increased much faster on IF pastures. Subsequent feedlot performance of steers was not affected by stocking rate. The lighter steers did not compensate by gaining more weight in the feedlot. Therefore, using higher stocking rates on IF and IFL pastures in the spring can result in substantial reductions in animal gain and also less availability of forage.

Wheat and Triticale for Finishing Rations

Corn is the major grain in finishing rations for beef cattle. However, when the price of wheat is similar, it can be substituted. Triticale, a cross between wheat and rye, also is available in Kansas and shares the high contents of crude protein and essential amino acids that wheat has. A study at the Southwest Research-Extension Center compared diets based on steam-flaked corn to diets in which 25, 50, or 75 percent of the corn was replaced by steam-rolled wheat or triticale.

Generally, replacements of corn by the three levels of wheat or triticale had no effect on feedlot performance. However, carcass merit was improved by feeding the corn diet. Costs-of-gain were lower with diets containing more than 25 percent triticale. Condemnation of livers because of abscesses was decreased with increasing levels of grain substition. These results indicate that steam-rolled triticale could replace more than 25 percent of the steam-flaked corn fed to finishing beef steers and improve economic returns.

Stocking rate can affect forage quality and beef production.

Very Finely Rolled Sorghum in Cattle Feed

Sorghum is the most important feed grain grown in Kansas but often is shunned by cattle feeders, who prefer corn. A project at the Agricultural Research Center-Hays addressed the problem of how to process grain sorghum properly for use in cattle feed.

The sorghum was ground on an improved roller mill that produces very fine particles with a consistent mean size. Finely ground sorghum (fine) similar to that used in a previous study was compared to very finely ground sorghum (ultrafine). Half of the treatments had 2 percent animal fat added. Sorghum contains less fat than corn, so this addition would increase feeding value and also help to bind the ration and prevent wind loss of the fine particles.

The two sizes of sorghum did not affect steer performance or carcass grades. However, addition of fat increased feed intake, average daily gains, and feed efficiency. An economic analysis showed an advantage for the ration combining ultrafine sorghum with fat. The estimated cost of 100 pounds of gain was reduced 5 percent with this treatment compared to the fine sorghum without fat. These results show that both improved processing and ration formulation can raise the value of grain sorghum in cattle feed. Making sorghum more competitive with corn would benefit both Kansas grain producers and cattle feeders.

Time of Feeding for Cattle in Summer

A large amount of heat is generated during fermentation of feedstuffs in the rumen. When ambient temperatures exceed the upper critical limit for cattle (about 77°F), they must expend energy to dissipate excess heat and maintain their body temperature. An animal scientist compared the efficiencies of cattle limit-fed in the morning (8 A.M.) versus the evening (8 P.M.) during the summer. Steers were kept in pens, and feed intakes were adjusted every 14 days based on the assumed rate of gain.

Cattle fed in the evening gained 18 percent faster and showed better feed efficiency than cattle fed in the morning. The average high temperature for the 56-day period was 88°F. Ruminal fermentation of high-grain diets peaks during the first 12 hours after consumption. Hence, cattle fed in the evening digest the bulk of their daily feed during the night, whereas cattle fed in the morning experience a fermentation peak during the hottest part of the day. If cattle are already stressed by high temperature, the heat of fermentation increases the energy expenditure needed for heat dissipation. This study indicated that, during the summer, cattle convert feed to gain more efficiently if they are fed in the evening.

Urea in Diets High in Grain

Current information is limited regarding the requirements of finishing cattle for rumen-degradable nitrogen and metabolizable protein. Urea is a common source of rumen-degradable nitrogen in finishing diets. Animal scientists added three levels of urea to a rolled corn diet and evaluated the effects.

Rumen digestibility increased by 33 percent with the first addition of urea but changed little with further additions. Various chemical changes showed that the efficiency of fermentation also increased, but urea did not increase the supply of metabolizable protein to the small intestine.

Source and Level of Crude Protein

This followup study with urea used diets with two levels of crude protein and containing urea, soybean meal, or cottonseed meal. They were fed to steers implanted with a growth promotant. Such implants can alter nutrient requirements in feedlot steers. Soybean meal contains a degradable protein fraction to nourish rumen bacteria and, unlike urea, also contains an escape fraction to increase protein reaching the small intestine. Soybean meal improved daily gain and feed efficiency more than urea. Carcasses from steers supplemented with soybean meal had larger loin-eye areas, but other carcass traits did not differ. Performance and carcass traits of steers fed cottonseed meal were similar to those of steers fed soybean meal. These results provided further evidence that urea cannot meet the metabolizable protein needs of implanted finishing steers.

Improving Silage

An ongoing research program in the Department of Animal Sciences and Industry studies effects of growing conditions, hybrid, stage of maturity, processing, grain addition, and weather conditions on the yield potential and nutritive value of corn, grain sorghum, and alfalfa silages. This information allows producers to choose a combination that will provide good nutrition and high returns in animal weight gains.

Agronomic performance and chemical composition of silage crops vary from year to year and among hybrids. However, recent tests showed that average daily gains and efficiencies of gain for steers were excellent with both corn and grain sorghum silages, but corn produced the fastest and most efficient gains. Steers fed grain sorghum silage showed the

greatest daily intake of dry matter. Gains and efficiencies were poorer for steers fed forage sorghum silages.

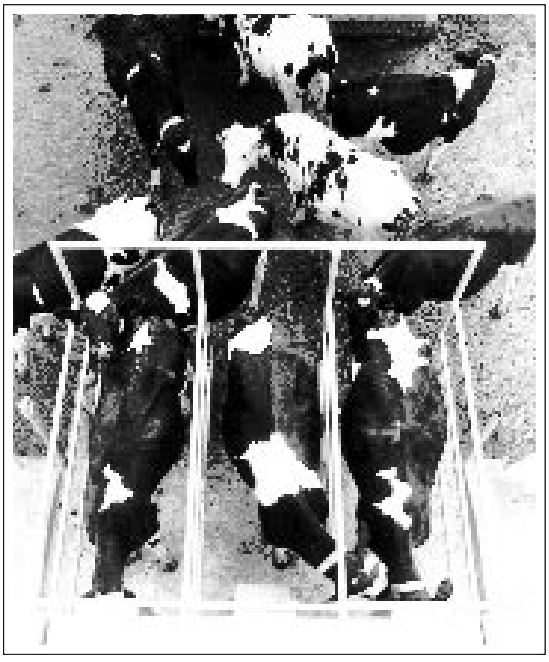
Numerous treatments are available to speed up the fermentation of silages and improve their nutritive value. Two bacterial inoculants were tested on alfalfa and whole-plant corn silages in small silos. The inoculants increased the lactic acid content and lowered the amounts of acetic acid and ethanol in both silages. These changes indicate a more efficient fermentation. The inoculated silages also had higher dry matter recoveries than the untreated controls, which would make them more nutritious.

Storage conditions of silage also can affect its preservation and feeding value. Five sealing treatments were tested for alfalfa silage, and the rate and extent of top spoilage were measured. Sealing silage with plastic dramatically reduced dry matter losses and storage temperatures and maintained quality in the top 20 inches. Silage in unsealed silos was of acceptable quality only below 20 inches. Placing a roof over unsealed silage protected it from rain and reduced dry matter loss at 10 inches.

Reproductive Management of Dairy Cows

Producers have access to a new arsenal of hormones for controlling estrous cycles and improving fertility of dairy cows. Ongoing research by animal scientists tests the best ways to use these new products. Most studies have demonstrated that using gonadotropin-releasing hormone (GnRH) about 10 to 18 days postpartum for dairy cows with problems like retained placenta improves their subsequent reproductive performance. Preventive treatment of cows in the early postpartum period with GnRH or a prostaglandin also improves their reproductive performance. Injections of GnRH at the time of insemination during late estrus in repeat-service cows effectively increases pregnancy rates. As with all new technologies and hormonal therapies, attention must be paid to consistent and accurate heat detection and good artificial-insemination technique. Researchers caution that use of hormones will not replace, only supplement, good management and common sense.

Many new treatments are available to increase fertility of dairy cows.



Use of Prostaglandin and Milk Progesterone Test

Inefficient detection of estrus in dairy herds where artificial insemination (AI) is practiced contributes to a significant reduction in reproductive performance and potential milk yield. Among the effects are prolonged intervals to first service, which lead to unacceptably long calving intervals. Timely insemination of cows at first service is enhanced by the use of prostaglandin (PG). Injections are given after a palpable corpus luteum is detected. An alternative is now available: an on-farm test to detect high levels of progesterone (P) in milk, indicating the presence of a corpus luteum. Researchers in the Department of Animal Sciences and Industry designed a study to determine if the use of this test is warranted to identify cows eligible for PG treatment in a weekly scheduled AI program.

Analysis of the results showed that use of the milk P test plus PG injection cost less per pregnancy than the control treatment (inseminating cows after the first detected estrus after 42 days in milk). However, the combination treatment cost more per pregnancy than previously tested methods of weekly injections of PG or injections after palpation of a corpus luteum. In addition, the milk P test had a high rate of false positive results (52 percent). This study confirmed that use of PG as a tool to control the onset of estrus is warranted in a dairy AI program, because it reduces days to first service, calving intervals, rate or reproductive culling, and cost per pregnancy. The additional use of the milk P test probably is not justifiable, unless its cost is significantly lower than the cost of weekly injections of PG.

Extruded Sorghum Grain and Soybeans Fed to Lactating Sows

The process of extrusion involves heat, pressure, and shear. Extruders reach temperatures high enough to destroy antinutritional factors in soybeans. They also rupture oil cells in soybeans, which allows the oil to be reabsorbed into the product and increases digestibility. Extrusion affects cereal grains by rupturing starch granules and enhancing utilization by animals. Extruded sorghum and soybeans have been shown to improve the growth performance of finishing swine. Animal scientists recently examined the effects of extruded feed in diets for lactating sows. They evaluated the performance of the sows and their litters.

Sows fed diets with extruded ingredients tended to wean more pigs with greater survivability compared to sows fed the ground sorghum-soybean meal control diet. No differences occurred in sow backfat losses during lactation, but sows fed extruded soybeans or the blend of extruded soybeans and sorghum lost slightly less weight than sows fed the control diet. Overall, improvements in litter weight gain were 6, 7, and 10 percent with extruded sorghum, extruded soybeans, and the extruded blend, respectively. These data indicate that extrusion of ingredients for lactation diets improves performance of both sows and their litters. In this study, the blend of extruded soybeans and sorghum gave the best results.

Effects of Pellet Quality on Swine Performance

Previous studies showed that pelleting diets for finishing pigs improves nutrient digestibility and growth performance. However, improperly pelleted feed, with a significant amount of fines, results in greater feed wastage, increased requirements for feeder management, reduced palatability, and decreased feed intake. Researchers in the departments of Animal Sciences and Industry and Grain Science and Industry cooperated on a project to determine the effects of pellet fines on the performance of nursery and finishing pigs.

A control diet of meal was compared with screened pellets (fines removed) and pellets with 25 percent fines (for nursery pigs) and 20, 40, or 60 percent fines (for finishing pigs).

For nursery pigs, the pelleted diets improved average daily gain and feed to gain ratio compared to the meal diet. The screened pellets gave better results than the pellets with fines. Finishing pigs fed screened pellets showed nearly a 5 percent improvement in feed to gain ratio compared to those fed the meal. Increasing the amount of fines in the diet caused a decrease in the ratio. The screened pellets and pellets with 20 or 40 percent fines gave similar results for average daily gain. These results confirm that pelleted diets improve pig performance but show that as little as 20 to 25 percent fines can significantly reduce the benefits.

Pelleted feeds can improve performance of nursery pigs.

Performance of Various Breeds of Sheep

Long-term research projects at the Northwest Research-Extension Center are recording numerous performance traits of sheep of different breeds. In one study, Rambouillet and Rambouillet crossbred ewes were bred to Rambouillet, Tunis, Romanov, and Katahdin rams. Ewes bred to Romanov rams produced the most lambs. Survival to weaning was over 90 percent for lambs in all groups, except those sired by Rambouillet rams (76 percent). The preweaning average daily gain was about .5 pound for all breed groups. Postweaning average daily gains were slightly greater for Rambouillet-sired lambs (.7 pound versus .6 pound for other groups). Rambouillet-sired ewe lambs produced the heaviest fleeces with the highest spinning count.

Breed of sheep affects number of lambs born, their survival, and their performance.

Another study considered the effect of several breeds of ewes all bred to one breed of rams. Ewes sired by Rambouillet, Tunis, Romanov, and Katahdin rams were bred to Suffolk rams. The Rambouillet-sired ewes gave birth to the fewest lambs; ewes in the other groups were about equal. Preweaning average daily gains were slightly lower for lambs of the Romanov-sired ewes (.3 to .4 pound versus .5 pound for the other groups). Postweaning average daily gains were about the same for all groups. Survival to weaning was greatest for the lambs born to Katahdin-sired ewes.

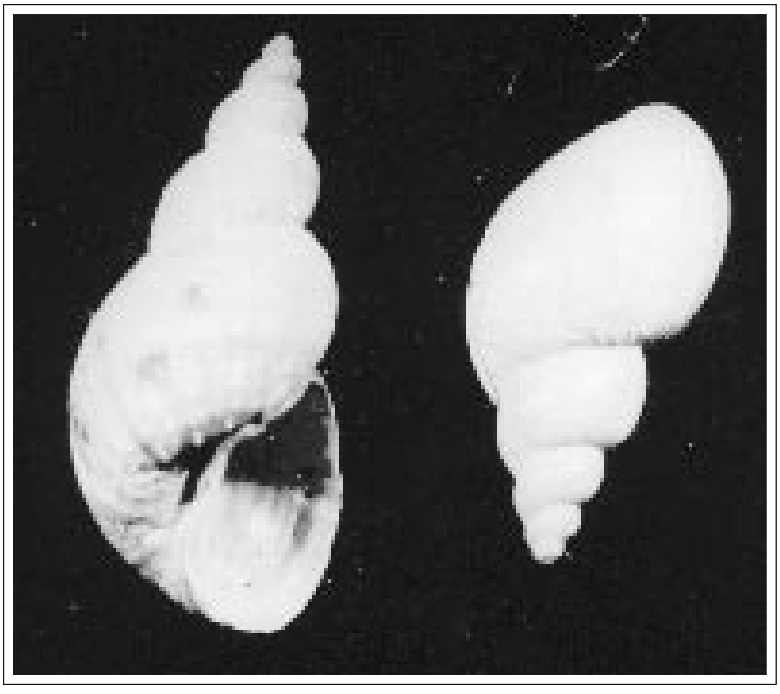
Effects of Feed on Lamb Development

Crossbred ewe and wether lambs were fed ground and mixed rations containing 15 or 30 percent alfalfa. Each ration was fed ad libitum to one group and limit-fed to a second group. Lambs feeding ad libitum on the 15 percent ration were significantly heavier than lambs from any other treatment. Lambs limit-fed the 30 percent ration were lightest. Average daily gain over the 84-day trial followed the same pattern. Backfat measurements taken by ultrasound showed small but significant differences; lambs feeding ad libitum on either ration had thicker backfat cover.

■ *ANIMAL HEALTH*

Occurrence of Liver Fluke Disease in Kansas

Liver fluke disease (fascioliasis) causes great economic losses to the cattle and sheep industries from the direct effect of liver condemnation at slaughter and several indirect effects (decreases in feed efficiency, lower weight gains, and poor reproductive performance). Fascioliasis was reported in Kansas in 1887 and again in 1953, when two outbreaks occurred in Rice County. To determine the current extent of occurrence, researchers in the Department of Pathology and Microbiology conducted a survey of veterinarians. For this disease to be endemic within an area, the proper snail intermediates must exist to allow completion of the parasite's life cycle. Snails from Kansas were tested in the laboratory to determine if they could serve as hosts.



Some snails in Kansas may be carriers of the parasite that causes liver fluke disease.

Questionnaires were returned by 178 veterinarians; one-third reported having seen cases of fascioliasis in their practices. Most of the cattle diagnosed with this disease had been imported from other states. However, in central and southeastern Kansas, some cattle that had never been out of the state were infected. Two species of snails from these regions were infected experimentally with the parasite, and a growth stage obtained from the snails then was used to infect a weanling calf and wild mice, thereby completing the life cycle.

Thus, a significant number of cases of fascioliasis are indigenous in Kansas, and suitable snail hosts exist in the state. Veterinarians who responded to the survey also provided information on methods of diagnosis and improvements seen after treatment. The occurrence of liver fluke disease and advantages of treatment need to be communicated to producers and other veterinarians in central and southeastern Kansas, so that the number of cases and financial losses do not continue to grow.

A Bacterium May Cause Digital Papillomas

The prevalence of digital papillomatosis in dairy cattle is increasing. The characteristic lesion is a papilloma (wart) on the heel of a rear hoof. The epithelium proliferates to eventually form frond-like growths. The prevalence of this problem in a herd can be greater than 70 percent. Severely affected cows are likely to be lame, which reduces milk production and causes economic loses.

Several methods have been used to treat and control these lesions, but none has been completely effective in preventing recurrence. No evidence of viruses has been found, but the presence of a spirochaete in the wart tissue has been reported. Researchers in the departments of Clinical Sciences and Veterinary Diagnostic Investigation set out to isolate and identify this organism. They took samples of

tissue from the surface and inner layers of papillomas from three dairy cattle in two Kansas herds.

The organism isolated was a motile, gram-negative, spiral-shaped rod. It grew on protein substrates but not on carbohydrates. The best growth was observed in anaerobically prepared (without oxygen) brain heart infusion medium with 4 percent gelatin. It grew into the oxidized portion of the medium but would not initiate growth under air. Analysis of the cellular fatty acid profile revealed no match to any of 7,000 previously described bacteria in a computer database. The presence of the organism deep in the epithelial tissues of lesions was confirmed by light and transmission electron microscopy. The researchers are proposing the name *Verrucavibrio dermavorus* for this new bacterium. To confirm that it is the cause of digital papillomas, further studies will attempt to use the bacterium to induce the disease in healthy tissue.

Vaccines Delivered as Aerosol Sprays

Respiratory diseases affect 70 to 90 percent of all animals at least once in their lifetimes. Sick animals may eat less and use their energy to fight the disease rather than gain weight. Preventing these diseases could save the livestock industry thousands of dollars each year. A spray that could directly stimulate the immune system in the lungs could be more effective than an injection to deliver vaccines against such diseases. A researcher in the Department of Pathology and Microbiology is developing a device to deliver vaccines as sprays.

The device produces extremely small particles in a propellant-driven aerosol spray. It uses a gas propellant that vaporizes upon release, leaving vaccine proteins suspended in the air. The animal then inhales the protein particles. Tests indicate that the proteins are still functional after being sprayed, but how long they last in the propellant needs to be determined. Further work also is needed to determine just how much of the vaccine actually is reaching the lungs; not all the particles are small enough to be inhaled deeply into the tissue. When this device is perfected, it could be applied to treatment of respiratory diseases of humans as well as animals.

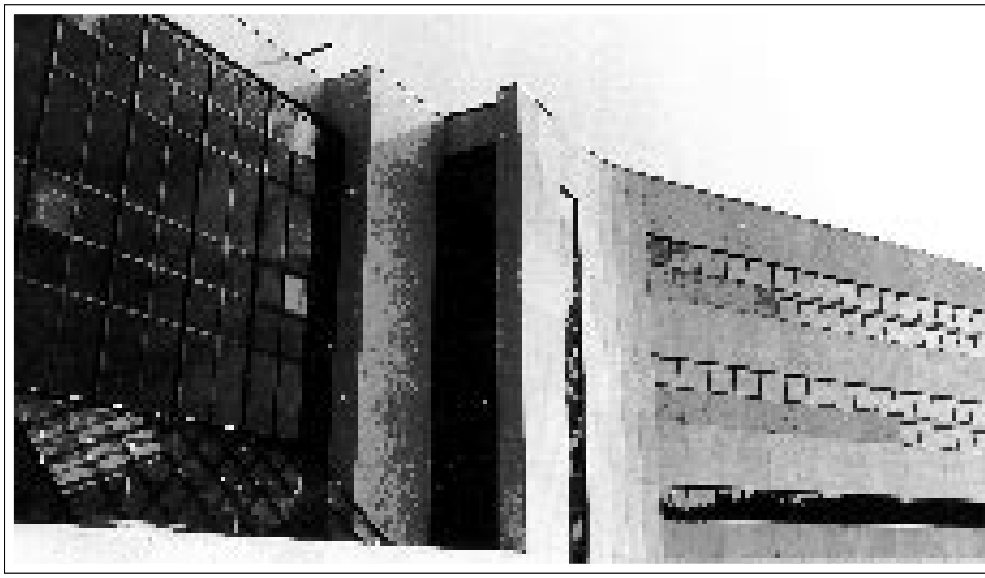
■ *NEW FACILITIES FOR PLANT SCIENCES*

During the biennium, the Throckmorton Plant Sciences Center was completed. This center provides additional space for the departments of Agronomy and Plant Pathology to expand and new space for the department of Horticulture, Forestry and Recreation Resources to join them. The massive complex of connected buildings and greenhouses covers about 390,000 square feet. The 6.7 acres of floor space in the buildings contain 238 offices, 155 work-support spaces, 115 plant growth chambers, 113 research laboratories, 50 rooms with controlled atmosphere and temperature, 20 teaching laboratories, and seven classrooms.

These new facilities will allow expansion of current research programs and development of new ones. More research in plant tissue culture and genetic engineering will be possible. Crops will be grown in the new growth chambers or controlled-environment rooms and screened for tolerance to stresses like drought, heat, or cold. The greenhouses will continue to be used for breeding improved crops, screening plants for resistance to disease and insects, and teaching.

The original center portion of the Throckmorton project began in 1979 and was dedicated in 1981. Ground was broken for the new four-story east and west wings in 1992. Half of the $24 million needed for the expansion came from federal funds, $7 million was appropriated by the Kansas legislature, and the remaining $5 million was obtained through private donations.

The center is named in honor of R.I. Throckmorton, an agronomist who started his career at KSU as a soil-surveying assistant and eventually became dean of the College of Agriculture and director of AES.



The completion of Throckmorton Plant Sciences Center provided new space for research.

New Crop Releases

Among the releases from 1992 to 1994 was KS223 alfalfa, which is resistant to anthracnose, downy mildew, two types of wilt, and three common aphids.

Two germplasms of soybean were released. KS4694 is intended for use in eastern Kansas, and KS3494 for use in northern and northwestern Kansas. As part of a new release procedure, seed producers interested in using the new varieties will form a marketing association for each.

Several germplasms of hard red winter wheat were registered. KS91WGRC11, KS92WGRC15, and KS92WGRC23 all are resistant to leaf rust. KS92WGRC21 and KS92WGRC22 are resistant to wheat soilborne mosaic virus, wheat spindle-streak mosaic virus, and powdery mildew. KS92WGRC26 has resistance to Hessian fly, including Biotype L and a Moroccan population. Two hard white winter wheats, KS92WGRC24 and KS92WGRC25, also were released and feature good grain protein and resistance to stem rust and Russian wheat aphid.

In addition, a new variety of hard red winter wheat called Ike was registered. This drought-tolerant wheat was developed for dryland production in western Kansas. It also possesses resistance to several diseases and Hessian fly and has good milling and baking characteristics. Ike's "tall semidwarf" size lessens the incidence of lodging. The new variety has performed well in annual tests since 1988.

Karl 92, an improved version of the popular variety Karl, also was released. Like its parent, it performs best in the eastern two-thirds of the state. Compared to Karl, it yields more, has slightly better test weight, has slightly better resistance to leaf rust, and has similar good milling qualities.

At the end of the biennium, another variety of hard red winter wheat was released, and the name was submitted for registration. Jagger is named in honor of Joe Jagger, a Kansas farmer whose farm has been the site of wheat performance plots for over 75 years. This variety is adapted to all wheat-growing areas of the state and matures very early. It is resistant to several rusts and viral diseases but is susceptible to some insects. In addition, it has excellent milling and baking qualities, which are so important for successful marketing. Jagger has the potential to become as popular as some previous KSU releases and perhaps provide greater economic returns to wheat producers.

The widow and sons of Joe Jagger and KAES agronomists inspect Jagger wheat.

Success of KSU Varieties

Two varieties of hard red winter wheat developed by KAES researchers tied for first place among all varieties grown in Kansas. Karl and Karl 92 accounted for 23 percent of acreage in 1993 and 23.6 percent in 1994. Average yields ranged from 45 to 50 bushels per acre, with Karl 92 usually yielding slightly more. This KAES release also ranked first in recent wheat trials in Oklahoma, with an average statewide yield of 40 bushels per acre. Karl had the highest test weight in 2- and 3-year statewide averages.

Developing a New Variety

About 10 to 12 years of crossing, breeding, and selecting are involved in the development of a new variety of wheat. During this process, nearly 100,000 lines can be rejected and only one selected. The lines are screened for resistance to four insects and 12 diseases that occur in Kansas. They also are evaluated for 10 agronomic traits, three stress traits, four yield traits, and 14 quality traits. Any wheat that gets to the final stage has been tested in 231 location / years and milled and baked in 11 different tests over 6 years.

The first 2 years of selection occur in a greenhouse. Then crosses are chosen and sent to test plots across the state. Final selections are based

on a combination of agronomic and quality characteristics. These few go on to testing by the Wheat Quality Council and then are considered for release. The committee that evaluates them includes representatives from the departments of Agronomy, Entomology, Grain Science and Industry, and Plant Pathology; the Cooperative Extension Service; and the Crop Improvement Association.

Each new variety costs about $1 million; 60 percent comes from federal and state funds, 35 percent from the Kansas Wheat Commission, and 5 percent from the Kansas Crop Improvement Association. However, a successful wheat variety can return as much as $28 for each $1 invested. For example, Arkan has returned about $40 million, and Newton, more than $200 million.

Fertilizer for Continuous, Dryland, Grain Sorghum

Fertilizing continuous, dryland, grain sorghum requires a high level of management in an already risky situation. The amount of soil moisture stored is a major factor affecting the crop's yield. Sorghum uses stored moisture primarily during July, August, and September, leaving 9 months for soil moisture to accumulate for the next crop. However, precipitation in western Kansas during those months often is sparse. A long-term study was undertaken by a soil scientist at the Agricultural Research Center-Hays to document the effects of fertilizer and soil moisture on yields and economic returns for grain sorghum.

Data averaged over 23 years showed that each increment of nitrogen (N) fertilizer (from 0 to 60 pounds / acre) increased yields and net returns. Although a small yield increase was realized from phosphate addition, it was not enough to offset the added fertilizer costs. The return per dollar invested for fertilizer was highest with the lowest N rate of 20 pounds / acre.

The study of soil moisture showed that average yields increased as depth of soil moisture increased. However, yearly variations in soil moisture at planting time were great.

When investment money is short, interest rates are high, or soil moisture is limited, a low rate of N fertilizer generally will result in a significant return. Anhydrous ammonia can be applied in the fall, before the ground is frozen. Producers also should use field operations (like conservation tillage or contour farming) that will maximize storage of soil moisture.

Crop Residue Removal and Fertilizer Management

Many uses are being developed for crop residue, including livestock feed or bedding, fuel for drying grain, and feedstocks for ethanol production or manufacture of paper products. However, removal of crop residue can affect the soil in terms of erosion; contents of water, nutrients, and organic matter; and physical properties. A study was initiated in 1981 at the East Central Kansas Experiment Field to determine the effects of returning different levels of crop residue on yields and soil properties in a

A low rate of nitrogen fertilizer can result in significant financial returns for continuous, dryland, grain sorghum.

soybean-wheat-grain sorghum rotation receiving different amounts of fertilizer and to determine the quantities of residue produced by these crops in eastern Kansas.

Agronomists compiled 12 years of data, which showed that yields of both grain and residue varied with crop and year. Although all crops were not grown in all years, grain sorghum generally produced the most residue, followed by wheat and soybeans. The various residue treatments usually caused no significant differences in grain or residue yields. However, the fertilizer treatments increased yields of both in almost every year.

Increasing amounts of residue decreased bulk density of soil but increased available phosphorus (P) and especially exchangeable potassium (K). Soil organic matter also increased with more residue; the highest value resulted from double the normal amount of crop residue and a high fertilizer rate.

Overall results indicated that, in situations where soil erosion and soil water relations are not of concern, short-term or intermittent removal of crop residue should cause mostly minor changes in the soil. However, adequate K fertility must be maintained, because this nutrient was affected dramatically by residue removal.

Fertilization of Irrigated Corn and Grain Sorghum

Another long-term study is being conducted by the agronomist at the Tribune Unit of the Southwest Research-Extension Center. The purpose is to determine the responses of continuous corn and grain sorghum grown under flood irrigation to nitrogen (N), phosphorus (P), and potassium (K) fertilization.

A response to P fertilizer has been observed for over 25 years and has increased with time. In 1993, P applications increased corn yields by over 80 bushels / acre when adequate N also was applied. Applications of K have not affected crop yields, probably because the soil already contained a high level of this nutrient. Applying both N and P tended to increase organic matter; N fertilizer tended to increase soil acidity; and P fertilizer increased soil contents of P over the years.

For highest grain yields of irrigated corn and grain sorghum in western Kansas, N and P fertilizers must be applied together. The optimum rate of N (with P) for corn has been about 160 pounds / acre; the optimum rate for grain sorghum has varied.

Link between Fertilization and Productivity of Wheat

Recent breeding of winter wheat in the United States has been done in field nurseries where soil receives ample fertilization. Agronomists investigated the effects of these breeding efforts on productivity of wheat under low-fertility conditions. Thirty genotypes were evaluated: eight Asian land races, 13 standard-height U.S. cultivars released between 1974 and 1971, and nine semidwarf cultivars released between 1977 and 1988. The genotypes were grown under severe fertility stress and with adequate fertilization at three locations, and grain yields were compared.

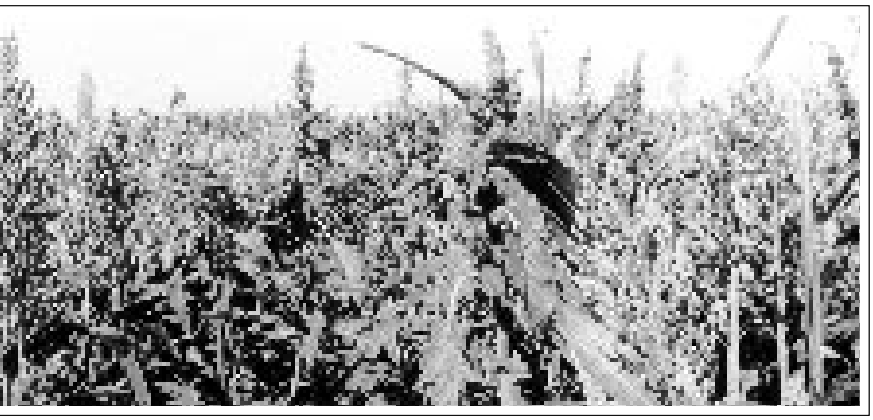
With the fertility stress, modern semidwarf cultivars did not yield significantly more than standard cultivars or land races. However, the semidwarfs tended to respond more (i.e., higher yields) to fertilizer. Analysis of the results showed that a century of wheat breeding has produced no genetic improvement in performance in low-fertility soils. The yield advantage of recent cultivars apparently is expressed only under high fertility. The study did not find evidence that land races or older cultivars perform better in poor soil.

High-Tech Weed Identification

Farmers are interested in reducing herbicide use but need to maintain adequate weed control. Applying herbicides only to infested areas rather than an entire field can reduce the amounts used. However, an operator has trouble locating weeds and controlling a sprayer at the same time. An automatic spray-control system incorporating a weed detector could solve this problem. An agricultural engineer is working on a machine vision system that can identify several weeds commonly found in Kansas wheat fields.

The initial research to develop this system involved analyses of color, shape, and texture of the plants and their soil background. Ratios of pixel gray levels in images taken with four colored filters were useful in distinguishing wheat leaf, weed leaf, weed stem, soil, and sand. A red / green filter pair was

A weed detector can distinguish pigweed from wheat; as part of an automatic spray-control system, it may allow selective application of herbicides.



effective in identifying the reddish stems of redroot pigweed, Russian thistle, and kochia. The use of shape parameters separated broadleaf weed species from wheat. Texture analysis also was able to distinguish wheat leaves from the broader leaves and identify some weed species with fine texture, like kochia.

These data provide a basis for further development of a weed detector that will allow selective application of herbicides.

Sunflower Production

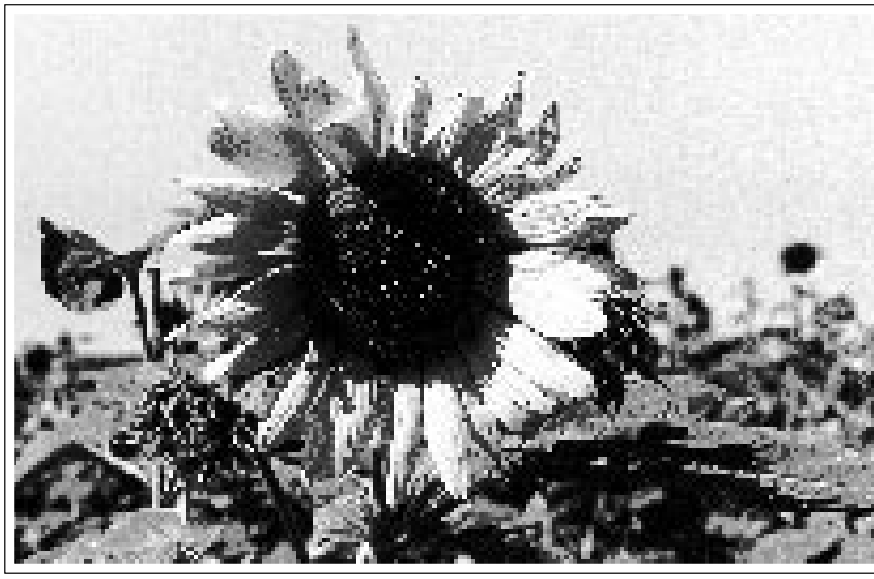
Sunflower is an important alternative crop in western Kansas. Total acreage of both oil and confectionary types have varied in recent years from over 200,000 to less than 100,000 acres. Market value of both types is affected by quality factors. These include seed size, oil content, test weight, and amount of insect damage. Planting dates range from early May to early July, with later planting reducing insect problems. However, some research has shown improved yield and seed quality of oilseed sunflowers with early planting. Population size for sunflowers varies with soil type and moisture conditions. High populations tend to dry more rapidly at maturity but also have more lodging and stalk breakage. Low populations tend to produce larger seeds. A study was started in 1991 at the Northwest Research-Extension Center to determine the effects of planting date and population size on sunflower yield and quality characteristics.

For confectionary sunflowers, the best quality characteristics were associated with the lowest population (14,000 plants / acre) and the May 21 planting date. However, the best yields were obtained with the June 4 planting date. For oilseed sunflowers, the best yields and test weights resulted from the May 21 planting, but oil content of seeds was significantly higher with the June 4 planting date. Effects of population were complicated by varietal differences but generally were minor.

Energy Balance of Sunflower versus Sorghum

The energy balance measures absorption and loss of radiation or heat from plants. Researchers in the Department of Agronomy compared components of energy balance, as well as soil water contents, for dryland sunflower and sorghum.

This study confirmed previous findings that sunflower depletes more water from the soil than sorghum. At the end of the season, the soil profile with sorghum had 180 mm more water. Some aspects of energy movement between the air, the crops, and the soil changed during the growing season or even at different times of day. Although net radiation loss during the day was the same for both crops until late in the season, the loss at night was greater for sorghum. This finding indicated that models of climate change must differentiate nighttime net radiation of agricultural crops. Before leaves started to die, sunflower had greater daytime values for latent heat flux than sorghum.



Planting date and population affect yields of sunflower.

The combination of lower water use and lower latent heat flux would make sorghum better suited to the drier summer weather that is predicted for the northern Great Plains.

Computerized Weather Data

Researchers have collected and used weather data for many years, but computers now make the job easier. The computerized Weather Data Library (partially funded by KAES) maintains a weather history spanning more than 100 years. It also collects weather information on the hour and provides 10-year averages. The weather librarian can extract, manipulate, and tailor the information to suit the specific needs of clients. Data can be printed

This automated weather station records data that are distributed by the Weather Data Library.

out as graphs for use in scientific publications. Weekly printouts of data are mailed to on-campus researchers as well as scientists from commercial firms. The weather data also are fed into the university's mainframe computer for retrieval by scientists. Telephone requests are received daily from on- and off-campus clients.

Automated weather stations on campus and at the four agricultural research or research-extension centers around the state provide information to the library. These stations record hourly air temperature, relative humidity, precipitation, wind direction and speed, and solar radiation and provide daily summary tables. Without computer assistance, this work would require a full-time employee at each site.

■ HORTICULTURE AND FORESTRY RESEARCH

Lacebark elm has potential as a landscape tree in Kansas.

Propagation and Hardiness of Lacebark Elm

Lacebark elm is becoming popular as a landscape tree because of its combined resistance to Dutch elm disease and elm leaf beetle. It also is tolerant to drought and has attractive bark. This species is not dependably hardy throughout Kansas, but cuttings were obtained for testing from a tree that had survived severe winters in Iowa.

Softwood cuttings were quite successful, but young plants needed some winter protection. Recent research has focused on hardwood cuttings that can survive the winter without protection. Several numbered selections have been evaluated. Generally, rooting percentage and number of roots per cutting were greater for cuttings from younger plants. Many cuttings from trees over 5 years old failed to root at all. Rooting percentage generally increased when cuttings were treated with higher levels of a growth-promoting hormone.

Several selections and named cultivars were compared for tolerance to freezing. Twigs were taken from trees in November, December, and February and sealed in test tubes, which were placed in a low-temperature glycol bath. The temperature was lowered gradually to below-zero levels. The frozen samples were removed from the bath, thawed, and kept at room temperature for 1 to 2 days. Then they were sectioned longitudinally and examined for browning of tissues.

All selections collected in November survived 10°F, and most February collections were killed at -4°F. The cultivar with the best midwinter acclimation (Athena) was killed at -13°F in February.

Deciduous Hollies for Kansas

Several species of deciduous holly are available, all featuring a colorful winter display of fruit after the leaves drop. Among these is *Ilex decidua*, native to southeastern Kansas. These hollies offer great potential as landscape shrubs or small trees and could be marketed as container plants in autumn, if fruit displays were adequate to last into the holiday season.

Three species of deciduous holly were grown in 2-gallon containers in three different media with four fertilizer treatments. Growth and fruit set were recorded after 2 years, and then all plants were moved to 5-gallon containers with the same medium and two fertilizer rates.

Ilex decidua was the tallest, but few plants flowered until the third year; *I. laevigata* and *I. verticillata* grew satisfactorily and flowered in the second year. Growth varied somewhat in the three media and generally increased with higher levels of fertilizer. Close attention to moisture and protection from wind is needed to produce quality container stock in Kansas. The native species is best suited to climatic stresses, but the other two species are more fruitful as young plants.

Drought-Resistant Turfgrasses

As water availability becomes more of a concern in Kansas, horticulturists are seeking turfgrasses with drought resistance. Warm-season turfgrasses should require less water, but their growth and water use need to be characterized.

Root Growth of Warm-Season Turfgrass. Grasses with deep roots can tap greater volumes of water deep in the soil profile to avoid stress. Therefore, one study evaluated the depth and distribution of roots for varieties of three warm-season turfgrasses (Bermudagrass, buffalograss, and zoysiagrass) in comparison to tall fescue. Plugs of turf were removed from plots, the roots were removed, and the plugs were planted in plastic tubes containing clay and fertilizer. The tubes were kept in a greenhouse and watered daily. Grass was cut regularly, and roots in all tubes were har-

vested when those in one tube reached the bottom. The same grasses also were studied in outdoor plots. Cores were removed from the plots in August, and root length and density were determined.

In both experiments, root density for all varieties was greatest between 0 and 12 inches. Total root length was greatest for tall fescue. Apparently, these warm-season turfgrasses do not survive drought by reaching water deeper in the soil profile.

Water Use by Warm-Season Turfgrass. The relative rates of water use by warm-season turfgrasses also need to be determined. This is done by measuring evapotranspiration (ET), which is the total loss of water from the soil by evaporation and transpiration of growing plants. Several tools are available to measure or estimate ET, but they have not been compared for accuracy in turfgrass.

This study also used varieties of Bermudagrass, buffalograss, zoysiagrass, and tall fescue in outdoor plots. Each plot contained a device that measured actual water loss (ET) of the soil. Three other devices to estimate ET were installed nearby. One of these was a Bellani plate, which is a porous ceramic plate atop a flask that allows water inside to evaporate. The rate of evaporation was correlated with the measured ET in the turfgrass plots. The Bellani plate had been used to measure water loss in field crops, but this was the first test with turfgrass. Weather data also were recorded at a weather station adjacent to the study area and used in a model to estimate ET.

Results showed that the warm-season grasses had lower ET than the tall fescue. Buffalograss and bermudagrass were similar and used slightly less water than zoysiagrass. However, the ranges of ET for all varieties were rather wide.

The best correlation between estimated ET and actual ET in all turfgrass plots was obtained with the Bellani plate. The ceramic sphere and evaporation pan, which also measured evaporation, were fairly accurate. The model that used weather data to estimate ET gave the worst correlation.

Water conservation could be maximized by using warm-season turfgrasses, monitoring ET with a Bellani plate, and adjusting irrigation amounts as necessary.

Control of Woody Vegetation on Utility Rights-of-Way

Rights-of-way (ROWs) for electric transmission lines are strips of land maintained by utility companies as corridors for safe and reliable transmission of electricity. Tall trees can interfere with the lines, so the main objective of vegetation management is to replace tall trees with low-growing plants. In eastern Kansas, electric transmission line ROWs often cross wooded areas, and eventual natural regrowth of trees can be a problem.

This Bellani plate is used to monitor water use by turfgrass.

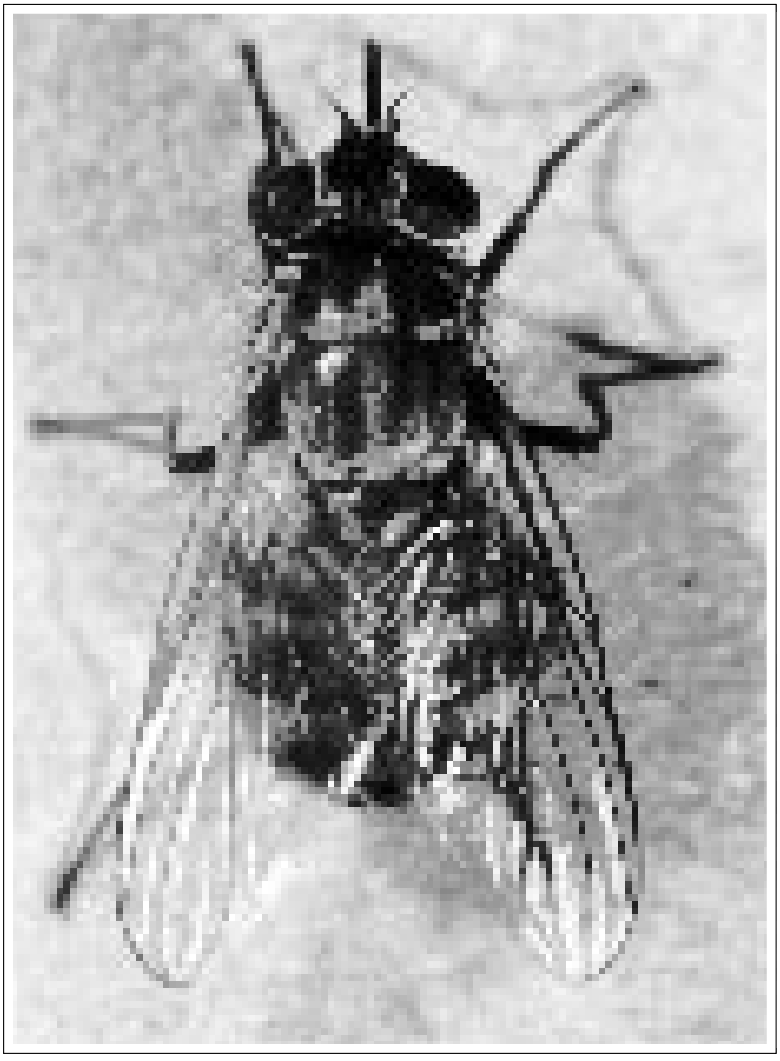
Researchers in the Department of Horticulture, Forestry and Recreation Resources evaluated combinations of mechanical and chemical methods for managing ROWs at several sites in eastern Kansas. The sites contained mixtures of hardwood trees of various sizes. Treatments included spring cutting with brush hog equipment, followed by ground applications of several herbicides to some plots. In the fall, another herbicide was sprayed on foliage of sprouts in some of the cut-only plots.

Evaluation after the third growing season showed that three of the spring herbicide treatments provided about 50 percent tree control. Resprouting of cut trees was reduced 42 percent by all the ground-applied herbicides. The fall application of herbicide did not reduce the number of living sprouts when it coincided with the time of first frost. However, when the application was made earlier, a 58 percent reduction occurred.

These results suggest that several cycles of cutting plus herbicide applications would be necessary to eliminate trees on ROWs and allow more desirable vegetation to become established. In eastern Kansas, grasses probably would be preferred. Some grasses and weeds invaded the study areas, but seeding of grasses could be used to speed up the conversion.

Creating a Safer Pesticide

Killing crop pests without harming the environment is a goal of researchers. They also are concerned about the ability of insects to develop resistance to chemical pesticides. Baculoviruses isolated from insects have proved to be effective insecticides, but insects do not die until several days after application. Biochemists are using genetic engineering to improve these biopesticides. They are taking the chitinase gene from the tobacco hornworm and introducing it into a baculovirus. Chitinase is an enzyme produced normally by insects as an aid to molting. It breaks down chitin, a tough, horny substance. With the added chitinase gene, the baculovirus will kill insects faster by breaking down the exoskeleton and gut lining and preventing proper feeding and molting. The gene makes the virus more potent by delivering the enzyme to insects at the wrong time and to the wrong part of the body.



Release of parasitic wasps is an effective and economical way to control stable flies.

Chitinase also is produced by plants as a defense mechanism but only after they are attacked by insects. A recombinant chitinase gene can be introduced into a plant and cause it to produce chitin at all times and at a high level. Attacking insects will ingest the chitinase in plant tissues and also can be sprayed with the baculovirus expressing chitinase. This double-pronged attack should provide a defense that insects cannot adapt to easily.

The chitinase gene can be used against any insect, because all species have chitin in their tissues. However, chitin does not occur in humans and other mammals, so they would not be harmed by the biopesticide. The researchers anticipate no harmful side effects to the environment.

Control of Stable Flies

The use of parasitic wasp to control stable flies in cattle feedlots has been studied for several years at the Southwest Research-Extension Center. The wasp being used is native to Kansas. It lays an egg in the fly pupa and kills the developing insect. A large-scale test involving mass releases of the wasp on 18 feedlots with various management practices is currently underway. Six feedlots not receiving wasps serve as controls.

Results so far show nearly 50 percent fewer stable flies on feedlots where parasites were released than on the control lots. Adult stable fly emergence and total percentage of parasitism also were significantly greater for feedlots receiving wasps. Manure management was a major factor in the effectiveness of parasite releases. Feedlots that cleaned pens regularly and did not stockpile wet manure (thus reducing breeding areas for stable flies) achieved a greater reduction in flies. This success with releases of parasitic wasps occurred in a cool, wet year. Continuing the study for 2 more years should provide data for other environmental conditions.

An economic analysis of this research showed that the costs of sampling feedlots to monitor populations of stable flies and determine release rates for wasps averaged $.08 per animal. Costs of the parasites averaged $.24 per animal, so total costs of the program averaged $.32 per animal. The year in which this analysis was done had a greater number of stable flies with a longer seasonal duration than previous years. In spite of this, cost of stable fly control in one feedlot decreased by 42 percent compared to costs of a commercial service in the previous year. These control costs are reasonable to prevent the losses of $5

to $10 per head that result from reduced feed efficiency and weight gains of cattle bitten by stable flies.

A Better Trap for Fleas

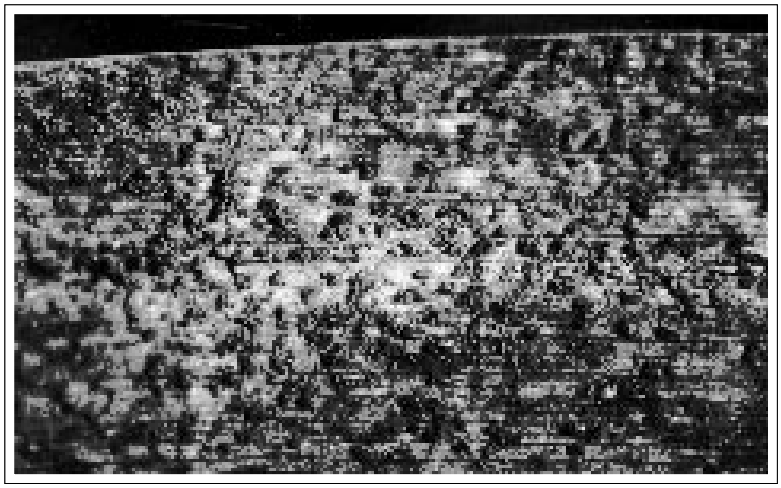
An alternative to the use of insecticides to rid your home of fleas will be available soon. A trap developed by researchers in the departments of Entomology and Pathology and Microbiology was patented recently. It's called the Intermittent Light Trap for Cat Fleas, which are the most common fleas on both cats and dogs.

Fleas are lured to traps when they are emerging from their pupal stage, the last growth stage before they move onto pets. Inside the traps, they get stuck on a sticky base. The new trap has two unique features. A green-yellow filter transmits the kind of light that is most attractive to fleas. A cycle of 10 minutes on / 5 seconds off attracts fleas better than a steady light. During their tests, the researchers noticed that fleas would move a short distance toward a light and then stop. But if an object was passed in front of the light to make a shadow, they would start moving again. The on / off cycle creates this shadow effect.

These features can lure fleas from greater distances, as far away as 28 feet. Thus, the new trap will be much more effective in eliminating fleas from large rooms.

Forecasting Leaf Rust Epidemics

The occurrence of severe epidemics of leaf rust in wheat depends on the survival of the causative fungus, *Puccinia recondita*. Epidemics can originate from spores spread by wind blowing over areas of infected wheat or from spores that overwinter in fields. Previous research showed that temperatures near or below freezing reduced germination of spores. Also, spores that overwintered on dead wheat tissue caused more severe damage. A plant pathologist and a biologist undertook further study to determine if other meteorological variables occurring prior to spring (March) green-up of wheat could be used to model survival of spores. They collected data from 13 years for wheat nurseries in Manhattan, KS.



Temperatures and snow cover affect the winter survival of leaf rust in Kansas.

Models were developed using weather data for 10-day periods prior to 15 December, 15 January, 15 February, and 15 March. Deviations from the optimal temperature for leaf rust development in December accounted for a large part of the variation in overwintering. Certain deviations in temperature and rainfall together indicated periods when reinfection could occur during the overwintering phase. Snow cover, which protects the infected wheat tissue from drastic temperature fluctuations, was extremely important for survival of leaf rust. This tissue was critical for overwintering of *P. recondita* in the winter wheat growing region of the central Great Plains.

Knowing more about the factors that affect overwintering takes us closer to developing long-range forecasts of severe epidemics of leaf rust. Models will be expanded to include data from other crop-reporting districts in the winter wheat area.

■ *GRAIN AND ITS END PRODUCTS*

Quality and Marketing of Stored Wheat

A grain scientist and an agricultural economist collaborated in a long-term study of wheat stored on farms and in elevators in Kansas. They documented on-farm equipment and pest-control practices and typical storage conditions that affect grain quality. Then the cost-effectiveness of aeration, grain protectants, and fumigation was evaluated, as well as wheat marketing practices.

Grain cooling by aeration was the most effective insect-control technique and had the lowest variable cost but often was managed poorly. Automatically controlled fans

During a study of stored wheat, samples of air containing phosphine fumigant were drawn from grain bins.

increased the efficiency and convenience of aeration. Applying protectant was more costly than other techniques but was generally effective. Treatment of farm-stored wheat with phosphine fumigants often was unsuccessful.

Discounting practices at Kansas elevators appeared to provide a weak and mixed message relative to the importance of insect control in farm storage.

For effective and inexpensive pest control in farm-stored wheat, an integrated system of sanitation, aeration, and monitoring (SAM) was recommended. Correct uses of protectant and fumigants were outlined for cases when such additional treatments are necessary.

Testing Bread Dough

Bakers always have recognized differences in the mixing and handling properties of doughs made with different flours or at different times during their processing. Scientists have been studying these properties for about 70 years to find out exactly what happens and why. Rheology is the technical term for the study of deformation, including elasticity and flow.

The rheological properties of bread dough change considerably during every bread-making phase. Extreme deformation takes place during the initial mixing, and various degrees of additional deformation occur when dough is fermented, sheeted and molded, proofed, and baked. Several tests and instruments have been developed to measure these changes, but none so far has measured the fundamental rheological properties. However, they do provide estimates of properties that are important, and the data can be relevant to specific baking formulas, procedures, and products. One of these instruments is the mixograph.

The predecessor of the modern mixograph was developed in the Department of Grain Science and Industry in the 1930s. It was designed to emulate the vigorous mixing action of American commercial mixers for bread dough and, thus, accurately test flours made from American wheat. Flour and water doughs are mixed, and the characteristics of the dough are recorded as a mixogram (a two-part curve with ascending and descending arms). The time to reach a peak and height of the peak are determined by the flour's protein content and the water absorption. Strong, high-protein flours from hard winter and spring wheats produce curves with long mixing times and high peak values. The ascending slope is an indication of the rate of dough development, whereas the descending slope shows the rate of dough breakdown. These are related to the wheat variety, production environment, and protein content of the flour. Generally, the angle between the slopes shows the dough's mixing tolerance. Lower protein, soft wheat flours tend to lack mixing tolerance.

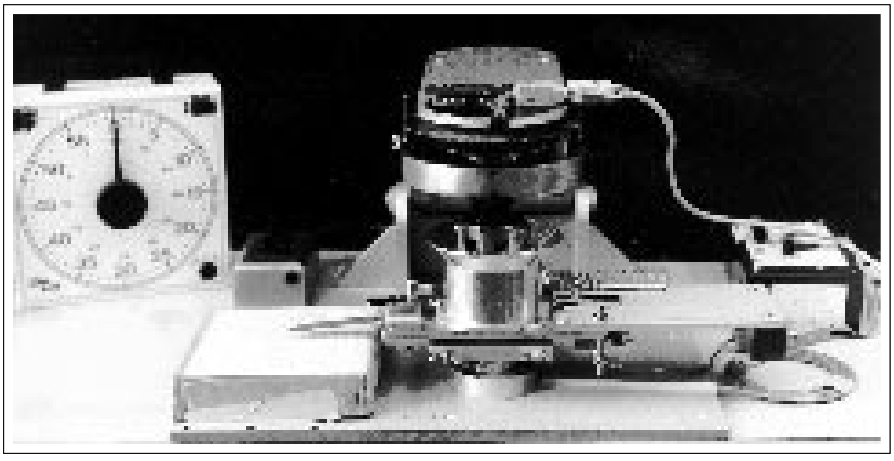
Mixographs are now available for use with 35, 10, and 2 grams of flour and are found in laboratories of several, major, U.S. baking companies. They also are important tools in many research projects of KAES grain scientists, who are still working to understand the complex transformation of dough into bread.

Microwave Baking of Bread

Grain researchers are developing technology for microwave and radio-wave baking of bead. Finding an appropriate pan has been a problem. The solution turned out to be simple: cutting circular holes in the sides and base of an ordinary metal pan.

Tests showed that 43 holes of 24-mm diameter in a pan holding a 1-pound loaf allowed microwaves to pass into the dough. Heat loss by arcing of microwaves from the metal was about 20 percent. The holes were small enough to retain the dough during baking, if the pan was lined with baking paper. The pan improved heating uniformity throughout the dough and loaf quality. A longer, thinner shape for the pan reduced the formation of large gas cells that later collapsed into a dense layer.

The pan was used successfully in an oven combining impingement (using hot air from jets aimed at the bread) and microwave baking. This process accelerated crust formation, so it would not lag so far behind the rapid microwave baking of the inside. Eventual commercial application of this technology will save time and increase the productivity of bakeries.



This modern mixograph has attachments to collect data in three ways.

Soil Testing Laboratory

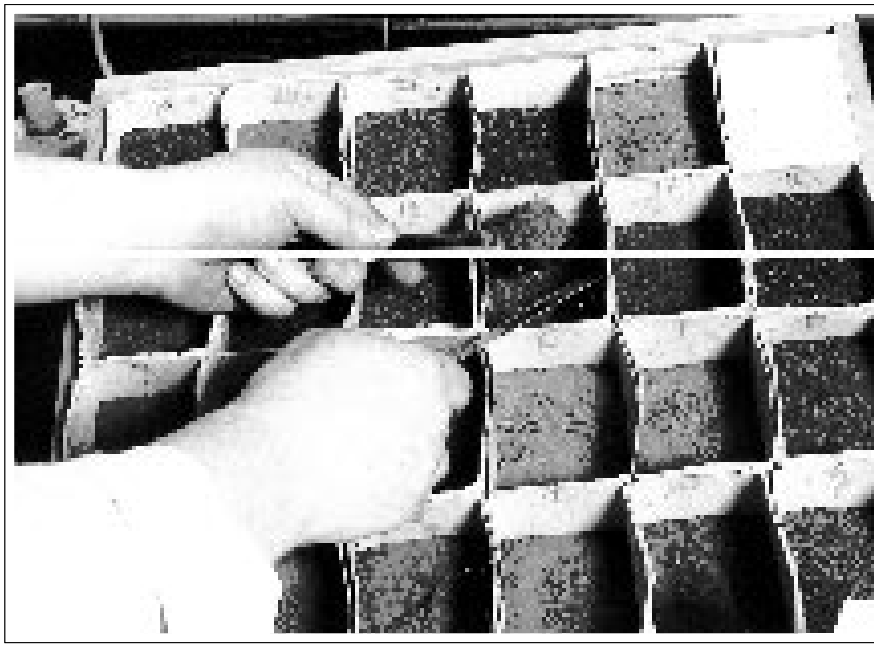
One of the special services available to KAES researchers is the Soil Testing Laboratory in the Department of Agronomy. It offers high quality, inexpensive, basic analysis of soil, plant, and water samples to provide necessary data for research projects. Homeowners and producers in Kansas also can submit samples of soil or irrigation water to be tested for a modest fee.

For the latter clients, analysis of general fertility may be all that is needed. This test determines pH (a measure of acidity of alkalinity), lime requirement for acid soils, available phosphorus, and exchangeable potassium. Further testing can determine the amount of organic matter in soil. This is the storehouse of most of the nitrogen, sulphur, and several micronutrients. Levels of organic matter help agronomists understand soil conditions and determine herbicide rates.

Available profile nitrogen is an extremely important test. Inorganic nitrogen (nitrates plus ammonium) accumulates under continuous, heavy applications of commercial nitrogen fertilizer and/or heavy rates of manure or under summer fallow conditions. Nitrates are water soluble, so they can be washed down into the soil profile by rain or irrigation water. Soil should be sampled below the tillage level (down to 24 inches) and air dried as soon as possible. Available zinc should be tested in areas where topsoil has been removed or in sandy soils low in organic matter when corn, grain sorghum, or soybeans are grown under high-yield conditions. A test for available iron is recommended on the calcareous soils of western Kansas to determine the potential for iron chlorosis in grain sorghum, soybeans, or corn. The 18 tests possible for soil include other minerals and salt-alkali contents.

Tests for water include nitrates (a common contaminant from fertilized fields) and salt content. Plants can be analyzed for numerous minerals, which can indicate what nutrients they are taking up from fertilizer or soil and how they are distributed to various plant parts.

The number of samples analyzed annually by the laboratory has increased steadily in recent years. Soil analyses number 11,000-13,000 for the public (35 percent homeowners and the rest farmers) and 17,000-18,000 for researchers (mostly KSU, a few at other universities). About 14,000 plant analyses are done for researchers. Specific tests of soil average 500, and tests for lime have increased dramatically to about 200 per year. About 100 analyses of irrigation water are done.



Thousands of soil samples are analyzed each year in the Soil Testing Laboratory.

The Soil Testing Laboratory also serves as a teaching center for students, county agents, and others to learn the proper interpretation of soil tests. Technicians also have the opportunity to improve soil test methods and interpretation of results. The test results help researchers to update soil test recommendations for several major nutrients and possibly decrease fertilizer applications.

Future of Conservation Reserve Program Land

Congress established the Conservation Reserve Program (CRP) in 1985 as a voluntary, long-term, cropland-retirement program. Participants receive an annual per-acre rent and half the cost of establishing a permanent cover of grass or trees in exchange for retiring highly erodible or environmentally sensitive cropland for 10 years. Expiration of CRP contracts will be debated before a new farm program is delivered in 1995. When this reserved land is released, producers have several options. To find out what might happen to the nearly 3 million acres of CRP land in Kansas, researchers in the departments of Agricultural Economics and Horticulture, Forestry and Recreation Resources surveyed 3,000 holders of CRP contracts (about 10 percent of the total).

A majority of respondents were satisfied with the CRP program; 89 and 85 percent would continue in the program for another 5 and 10 years, respectively. Most producers had removed their land from production of wheat and sorghum, and most of this land was in western Kansas. The main reason for initial

enrollment in CRP was soil erosion. Wildlife habitat was a consideration in choosing farming practices for about 68 percent of respondents, and hunting was the most frequent form of recreation allowed on CRP land. More producers planned to keep CRP land in forage production for livestock than to return it to crop production; over a third was undecided. Market prices for crops, forage, and livestock were the key factors in the decision about future use of CRP land.

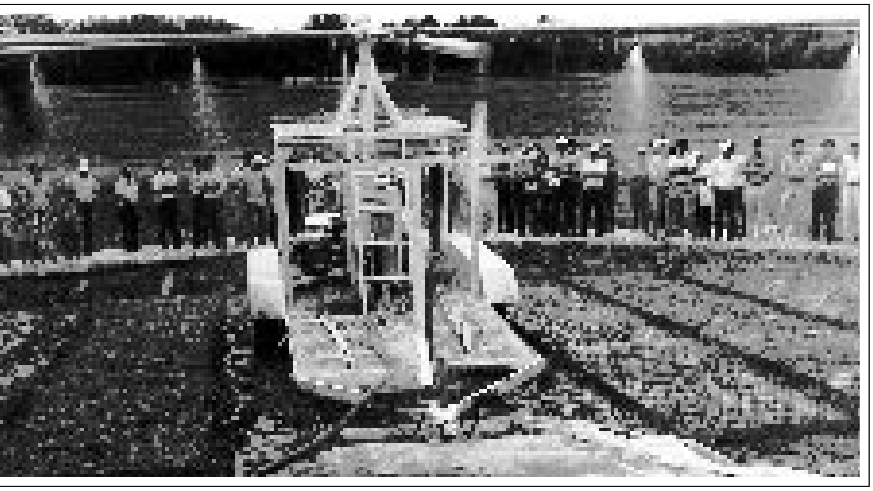
Conservation Reserve Program Affects Soil

Land that has been in the Conservation Reserve Program (CRP) for 10 years may be returned to other uses. The condition of the soil could affect the value of that land for crop production. An agronomist and two geographers compared the same silt loam soil in native tallgrass prairie, a cultivated field, and a previously cultivated field that had been reseeded to native grass in 1986 (CRP).

Soil samples were analyzed for several microbial properties. The soil in each field apparently had a distinct microbial community. The CRP soil had a lower microbial biomass but higher microbial activity. After 6 years in CRP, soil showed different levels of several indicators of microbial quality than prairie soil. These results confirmed that cultivation (even with native grasses) has a great impact on native prairie soils. Although more study is needed, researchers estimated that restoring quality and productivity of soil on CRP land may take longer than a decade.

Rainfall Simulator, a New Tool

A rotation-boom rainfall simulator constructed in Nebraska was borrowed for demonstrations in Kansas in 1992. The favorable audience response prompted KSU agricultural engineers to design and construct one. It has been used by extension agronomists for numerous demonstrations at field days throughout the state. A videotape of a demonstration was produced recently to make the information more widely available.



This rainfall simulator is used to demonstrate ways to reduce runoff and control erosion.

Major objectives of the rainfall-simulator demonstrations are to raise awareness of water-management problems (poor water use and soil erosion); to explain the basic process of soil erosion; to show the effectiveness of crop residue, contour farming, and terraces for improving infiltration, reducing runoff, and controlling erosion; and to discuss the need to address problems of erosion, runoff, and water quality.

Four plots are used for a demonstration. Two have extremes of residue levels, more than 80 percent and less than 10 percent. The other two plots show contour farming, terraces, or moderate levels of ground cover. The plots are surrounded by metal borders with flumes at the bottoms. Rain gauges are installed, and white plastic tubes are inserted into the soil to show differences in splash erosion. This setup works very well; usually no runoff occurs from plots with high residue cover when up to 3 inches of rainfall are applied, whereas runoff is produced from low-residue plots after only 0.25 to 2 inches of rainfall. Soil covered with as little as 20 percent residue shows substantially more water infiltration than bare soil.

A survey of audiences at demonstrations showed that 40 percent of producers were convinced to change their farming practices, and another 40 percent said that they might change. These changes would include less tillage and more crop residue. The rainfall simulator has proven to be a powerful tool to demonstrate water management. The program has significantly impacted awareness of water conservation, erosion, and conservation compliance in Kansas.

Pesticides in Surface Runoff

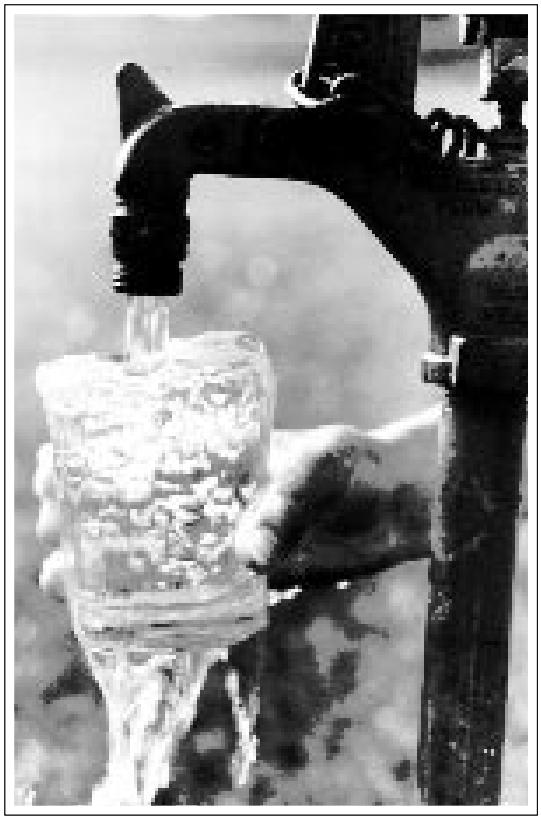
Analysis by the Kansas Department of Health and Environment indicated that 42 percent of its surface-water monitoring sites are contaminated by pesticides. The Kansas River Basin is the most affected, and atrazine is the most frequently detected pesticide. Because atrazine is not removed effectively by conventional water-treatment processes, it often is detected in tap water derived from surface-water sources. The Environmental Protection Agency (EPA) has set a maximum contamination level for atrazine. Enforcement of this regulation could cause some of the water utilities along the Kansas River to adopt more complex and expensive methods of contaminant removal.

Research has shown that most pesticides occurring in streams and reservoirs are transported in runoff. However, studies of surface runoff

have concentrated on fields with greater than 1 percent slope. A study was conducted at the Kansas River Valley Experiment Field on plots with less than 1 percent slope and two soil types; alachlor and atrazine were incorporated or surface applied. Corn was planted in the plots, and sprinkler irrigation was used to supplement rainfall so that runoff could be analyzed at certain time intervals.

Herbicide concentrations were higher in runoff from the surface-application plots than from the incorporation plots. This difference was maintained throughout the growing season. During the first 15 days after application, atrazine and alachlor concentrations in the runoff were significantly higher than the EPA standard for drinking water. Greater amounts of herbicides were lost form the silty clay loam soil than from the silty loam soil; 80 percent more atrazine and 45 percent more alachlor.

The most significant result of the study was the consistent improvement in quality of runoff water when herbicides were incorporated into the soil. Over the entire runoff period, the total mass of atrazine leaving the incorporation plots averaged 63 percent less than that leaving the surface-application plots.



Herbicides in surface runoff can contaminate drinking water; incorporation of herbicides into soil reduces this risk.

■ THE PRAIRIE ECOSYSTEM

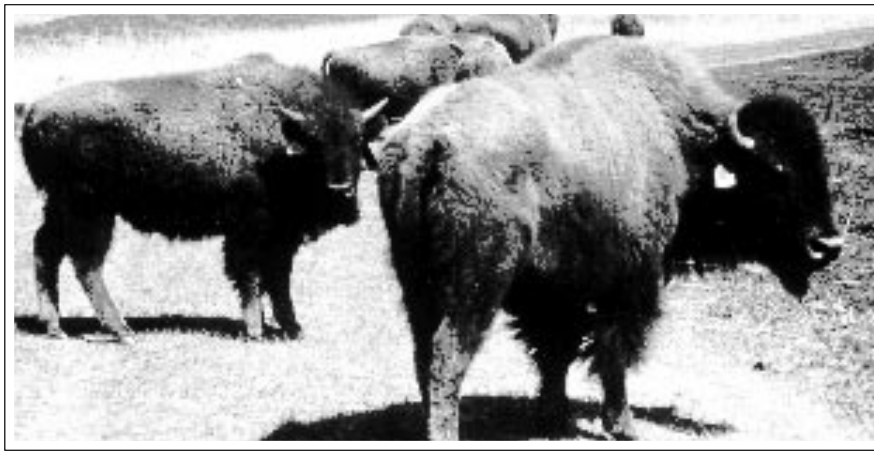
The Konza Prairie Research Natural Area is the site of long-term ecological studies by researchers in the Division of Biology and is available for more specific studies by researchers in other departments.

Effects of Grazing and Fire

Little bluestem (a bunchgrass that grows in tufts) and big bluestem (a rhizomatous grass with individual plants arising from an underground stem) were studied to compare their responses to fire and bison grazing and to determine how fire influenced their relative use by bison.

Plant density and size of little bluestem increased with burning. These characteristics plus tiller number per plant decreased with grazing, with a more pronounced effect in burned plots. When little bluestem was unburned, it developed persistent clumps of standing dead tillers that seemed to prevent grazing. Although burning improved the growing conditions for little bluestem, it also removed this protective canopy of dead tillers and exposed the plants to large grazers. Thus, little bluestem would decline on grazed sites, if they were burned. However, big bluestem showed a high tolerance to both burning and grazing. It should persist in tallgrass prairie under a wide range of conditions.

Bison grazed on little bluestem far less frequently than on big bluestem on unburned prairie but grazed equally on the two species on burned sites. Grazing frequency for little bluestem also was affected by plant size. On burned prairies, plants of intermediate sizes were least abundant but were grazed most frequently. Small plants were most abundant but were grazed least frequently. Grazing and burning shifted the population structure of little bluestem; grazing increased the occurrence of smaller plants, whereas burning increased the occurrence of large plants. These



Bison grazing patterns are affected by burning and growth form and size of prairie grasses.

results indicated that plant growth form, population size structure, and fire interact to influence bison grazing patterns on these two dominant grasses of the tallgrass prairie.

New Tool to Study Water Use by Plants

An agronomist designed and tested a new instrument for taking direct measurements of water use by two grass species on the tallgrass prairie. Small heat-balance, sap-flow gauges were attached to stems of big bluestem and Indian grass for several days in late summer.

Results showed that the gauges continuously measured water use by grasses under field conditions and that sap flow responded rapidly to fluctuations in environmental conditions. Extrapolating these measurements of individual grass stems to canopy-level estimates of water vapor flux in heterogeneous vegetation is possible, when the sap flow and percentage of ground cover for the dominant species are known.

Nitrogen Transport by Prairie Streams

Water quality and relations in the tallgrass prairie are the subjects of other research by biologists. One study considered the discharge and nitrogen (N) content of surface water flowing from four watersheds on Konza prairie over a 6-year period. Previous works indicated that N is recycled rapidly through plants and microbes and relatively little is lost through leaching. However, the relative magnitudes of different pathways of N loss from prairie ecosystems are not well known.

Big bluestem, the dominant plant on tallgrass prairies, uses less water under conditions of high carbon dioxide.

Results showed that flow of streams was highly variable and obviously affected by conditions that included a flood and a drought. Annual N yield per unit area increased with larger watersheds and greater annual precipitation. Total N loss from the prairie via streams was only a small portion of the N input from precipitation. The absolute rates of N export were among the lowest documented for terrestrial ecosystems. Nitrate and total N concentrations decreased significantly as the length of time since the last fire increased. Nitrate was the dominant inorganic N ion in stream water; levels of ammonium generally were below detection limits. This indicates that reduction of nitrates is relatively unimportant to N flux in these systems.

Effects of Carbon Dioxide on Plants

Levels of carbon dioxide (CO_2) in the atmosphere continue to increase, and we need to know how they will affect crops, native plants, and soil in Kansas. A 6-year research program funded by the U.S. Department of Energy has involved scientists in the Department of Agronomy, the Division of Biology, and the Agricultural Research Center-Hays. The group pioneered an ecosystem-level approach to studying the greenhouse effect. They measured responses directly instead of estimating.

Large plastic chambers placed on the tallgrass prairie allow researchers to apply different levels of CO_2 and measure the effects. In one study, ambient and twice-ambient levels were used; half of the plots in chambers were irrigated to maintain a high level of water and half were kept at a low level. Canopy temperature; photosynthetic rate, transpiration rate, and stomatal resistance of big bluestem; and soil water content were measured over a 2-year period.

Soil in chambers with doubled CO_2 was consistently wetter, and the difference in moisture was greater under dry condition. Less water was lost from the soil under elevated CO_2, because it caused stomata on leaves to close and reduced the transpiration rate of big bluestem. This, in turn, increased the canopy temperature but not the rate of photosynthesis. Climate modelers, who predict that soil in the Great Plains will become drier in the summer as atmospheric CO_2 increases, must consider these effects.

A second study also used ambient and twice-ambient levels of CO_2 to evaluate the impact of limited nitrogen (N) on plant biomass pro-

duction in the tallgrass prairie over a 2-year period. Half of the plots received N fertilizer and half did not. Measurements included aboveground and belowground biomass production, leaf area, and N concentration of all plants in the plots.

Biomass and leaf area of plants in fertilized plots were greater with elevated CO_2, especially in a dry year. The increased root biomass apparently increased N uptake by plants. These results indicated that response to CO_2 was suppressed by N limitation, especially in years with below-normal precipitation.

A followup study determined the effects of increased CO_2 on the amounts of carbon (C) and N stored in soil organic matter and microbial biomass and soil microbial activity. The same levels of CO_2 and N fertilization of half the plots were used for 2 years.

Soil organic C and N increased significantly under elevated CO_2. Microbial biomass C and N also increased in a dry year but were unaffected by CO_2 treatments in a wet year. Added N increased microbial C and N under elevated CO_2. Microbial activity was consistently greater with higher CO_2 because of better soil water conditions and was stimulated further by N fertilizer. The increases of C in the soil and microbes might indicate future storage of atmospheric C. A previous study showed that tallgrass prairie responded to increased C storage by increasing the efficiency of plant use of N and N turnover in the ecosystem; so N might not become limiting.

The results of these studies show that the responses of tallgrass prairie to higher levels of CO_2 are complex and depend on amounts of nutrients and availability of water. However, no long-term negative effects have been identified.

■ ECONOMICS OF PRODUCTION

Economies of Size for Beef Cow Production

Economies of size measure the relationship between the size of operation and the average cost of production or break-even price. They exist if average total cost decreases as size increases, so they can be used to determine possible advantages in farms becoming larger. Economies of size can result from an increase in efficiency as size increases, from quantity discounts for inputs, or from adoption of capital-intensive technology. Also, as a producer increases the size of an enterprise, fixed costs (such as unpaid operator labor, depreciation, and interest) are spread over more units. Two agricultural economists used enterprise data from farms enrolled in the Kansas Farm Management Associations to examine economies of size for beef cow operations. Differences in cost of production were evaluated to determine which factors had the greatest impact on profitability.

Results showed that total cost per head declined as the number of beef cows increased. Substantial variability in costs of production occurred among producers. These costs varied more among producers of a given size, so the variability was not due to size alone. The cost advantages of large farms were related to fixed costs; variable costs did not differ significantly. This result was verified by looking at the top profit group among the farms studied. About 46 percent of the difference in cost of production for this profit group was attributable to fixed costs. Feed costs accounted for 37 percent of the difference, and other variable costs for 17 percent. The researchers identified five critical factors that affect the profitability of a beef cow enterprise: size of the herd, feed costs, fixed costs, pounds of beef produced per cow, and sale price of calves. Controlling production costs is imperative for any size of operation.

Profitability of Finishing Cattle

The relative contributions of fluctuating cattle performance; interest rates; and prices of feeder cattle, fed cattle, and feed grain to profitability of cattle feeding were evaluated by researchers in the Department of Agricultural Economics. Closeout data from 6,696 pens of steers placed on feed over a 10-year period at two western Kansas custom feedyards were used. Combined prices of feeder and fed cattle explained 70 to 80 percent of profit variability, depending on placement weight. Overall, cattle prices and feed-

Cattle prices and feed costs had the greatest effects on profitability of cattle feeding.

ing costs accounted for at least 85 percent of variation in profitability. Animal performance explained 5 to 10 percent of the variation. Procurement or marketing strategies that help manage cattle price risk significantly influenced profit risk. Producers placing lightweight cattle need to be more concerned with fed cattle prices and changes in feed grain prices. Purchase price is the most important variable affecting profit for feeding heavyweight cattle.

Cost of Gain for Feedlot Steers

Cost of gain is a function of input costs and cattle performance. Closeout data from the same feedyards used in the profitability study were analyzed by agricultural economists to determine the relative effects of corn price and cattle performance on cost of gain and any seasonal differences.

Corn prices, feed conversion, and daily gain explained about 94 percent of the variation in cost of gain for finishing steers. About 60 percent of the variation was related to corn price alone. Cost of gain and feed conversion rates were below average for steers placed from February through August. Daily gain was high for steers placed from March through August. Because cost of gain is influenced heavily by the volatility and seasonal patterns of corn price and cattle performance, cattle feeders should consider this information when making placement decisions.

Merit Pricing for Swine Carcasses

Consumers are willing to pay for high quality lean pork. Producers can control the leanness and yield of pork through genetics and production methods. However, they need economic incentives. Value-based pricing of swine, based upon end-use values of carcasses, is one method to help enhance retail pork quality. Although value-based buying is increasing, most swine are still purchased without knowledge of specific carcass-quality characteristics. An agricultural economist examined how price structures of pork packers reflect value-based pricing systems.

Cutout data from 794 carcasses were used to estimate values based upon carcass characteristics. Packers' pricing schedules were compared with carcass values to determine how closely their pricing systems reflected carcass values.

Results showed that carcasses varied considerably in yields of fabricated cuts. Carcass values had a range of $17 per hundredweight. Assuming 74 percent dressing, this translates into a range of $12.50 per hundredweight in live hog prices. Pricing schedules of some packers were highly consistent with estimated carcass values, but schedules of others were not. Producers of high-yielding lean swine would benefit from searching for packers that pay highest for this trait.

Alternative cropping systems including soybeans can be profitable in Kansas.

Economics of Alternative Cropping Systems

Environmental benefits of alternative agricultural systems can include reduced soil erosion, elimination or reduction in water contamination by agrichemicals, and improvement of wildlife habitat. Agronomic benefits (like increased yield) can be linked directly to such factors as improved soil moisture and soil fertility. Alternative systems also can provide economic benefits through lower expenditures for inputs and machinery and reduced fluctuation in income. To obtain more data on the profitability of these systems, a team of agricultural economists constructed whole-farm budgets for a conventional cropping system, four alternative systems, and four transitional systems (incorporating both conventional and alternative elements) in northeast Kansas.

The conventional system (corn-soybean, sorghum-soybean, wheat-sorghum, wheat-soybean, continuous corn) ranked only sixth in net return among the nine systems studied. The highest net return was from the alternative system of wheat/clover-sorghum-soybean. A yield sensitivity analysis showed that severe yield penalties were required for most of the alternative and transitional systems before the conventional cropping system became economically preferable. Each of the four major crops could be produced with fairly low variable costs in one of the alterna-

tive systems, whereas production in the conventional system generally resulted in higher variable costs.

Thus, the economists concluded that several alternative cropping systems have the potential to improve net returns to northeast Kansas producers.

Returns from Wheat-Soybean Rotations

Farmers producing wheat and soybeans in southeastern Kansas select a cropping sequence that enables them to maximize soil fertility, control weeds, and maximize income. An ongoing experiment at the Parsons Unit of the Southeast Agricultural Research Center provides biological data about alternative cropping systems. Agricultural economists collaborated with an agronomist there to determine economic returns of three rotations. Budgeting was used to calculate income above variable costs.

Based on 1993 yields and prices, income above variable costs favored a 2-year sequence of wheat followed by double-crop soybeans and full-season soybeans. This same analysis showed maturity group IV soybeans to be best for double-crop use. Income above variable costs for average prices and yields favored a 1-year sequence of wheat and double-crop soybeans. However, previous studies have shown that double-cropping is not always the most profitable strategy. Moreover, some producers will not have adequate labor and machinery to double-crop every year.

Education Affects Marketing Practices

The marketing practices of Kansas agricultural producers and factors affecting their adoption of forward pricing techniques were investigated by two agricultural economists. Considerable educational efforts have been made by both public (extension programs) and private (commodity exchange programs) sources to inform producers about alternative marketing techniques and to teach them how to use such techniques in risk management.

Two-thirds of the 539 farmers surveyed had participated in educational programs. Factors affecting participation included farm size, level of education, percentage of total farm acres used for crop production, leverage, and risk preference. About 50 percent of the farmers had adopted forward pricing techniques. The amount of production that was forward priced varied from 33 percent for corn to over 20 percent for wheat and soybeans to none for hogs. Adoption of forward pricing decreased with years of experience.

The results indicated that participation in educational programs about marketing / risk management significantly increased the probability of adopting forward pricing techniques, particularly for wheat, soybeans, and cattle.

■ *POTENTIAL RECYCLING OF FOOD WASTE*

The food service industry in the United States in 1993 employed over nine million people and generated $264 billion in sales. A common feature of all food service establishments is solid waste, including packaging materials and food. Food waste accounts for about 13 million tons or nearly 7 percent of the total waste stream in the United States. Food service wastes generally are sent to landfills or go through garbage disposals and into the sewer system. The cost of hauling waste to landfills is increasing, and many are filled nearly to capacity. Garbage disposals cost less but use water and energy. An alternative is recycling food waste as animal feed, as compost, or for bioconversion to energy or fuel. However, information about the chemical contents of food waste is needed before recycling decisions can be made.

Researchers in the Department of Hotel, Restaurant, Institution Management and Dietetics devised a method to collect food waste in a dining hall at KSU and two dining facilities at Fort Riley. Samples were frozen and stored until analysis for contents of protein, fat, ash, carbohydrate, moisture, and energy.

Food waste from preparation of meals in dining facilities could be recycled.

The results showed that food waste is an excellent source of basic nutrients and could be used as feed for swine, cattle, or fish. The nitrogen content of food waste is not ideal for composting, but it could be combined with another material like paper, which also is discarded from food services. The high contents of protein, fat, and carbohydrate indicate that food waste could be digested or fermented for recovery of energy. Thus, the huge amounts of nutrients and energy that are lost by disposal of food waste could be recycled and provide financial and environmental benefits.

■ HUMAN HEALTH

Spraying beef carcasses and subprimal cuts with lactic acid can reduce microbial contamination.

Decontamination of Beef Carcasses and Subprimal Cuts

Animal scientists involved in the Food Safety Consortium are examining better ways to minimize carcass contamination during slaughter and subsequent processing, thus improving safety and extending the shelf life of meat and meat products. Spraying or rinsing carcasses with hot water and sanitizers has been used to reduce contamination. Recent studies have compared effects of rinsing carcasses immediately after rail inspection and / or after spray chilling and rinsing subprimal cuts before vacuum packaging and storage. Water, chlorine, and lactic acid were used on carcasses and only lactic acid on subprimals (initial tests showed that chlorine was not effective).

All treatment combinations involving chlorine or lactic acid reduced carcass contamination, but two sprays of lactic acid, about 8 hours apart, were most effective. However, this carcass decontamination did not carry over to subprimal cuts. Another treatment of subprimals with lactic acid before vacuum packaging decreased the bacterial counts. Retail cuts from the treated subprimals had a longer display life. Treatment of subprimals was more effective than treatment of carcasses, especially when retail cuts were packaged in oxygen-permeable film. For both subprimal and retail cuts, good temperature control (at 30°F) enhanced the effectiveness of the lactic acid treatments.

Juice that lacks redness is the best indicator of a properly cooked hamburger.

When Is Ground Beef Well Done?

Outbreaks of food-borne illness have emphasized the need for proper cooking of ground beef patties. Because of difficulty in measuring the internal temperature of patties, visual indicators usually are used to estimate the degree of doneness. Guidelines from the U.S. Department of Agriculture indicate that the safe temperature of 160°F is indicated by clear juices and a grayish-brown color in the center of the patty. Researchers in the Department of Animal Sciences and Industry tested patties of ground beef from three sources and cooked to several internal temperatures.

The internal color of patties overestimated the temperature; they appeared brownish at lower temperatures than the recommended value. Cooking the patties to 170°F did not produce clear juices. Overall, expressible juice was a more reliable indicator of doneness for these meat samples. When ground beef has reached a safe internal temperature, the juice is described more accurately as lacking redness than as clear.

Lyme Disease in Kansas

The microorganism that causes lyme disease is transmitted between hosts almost exclusively by a few species of ticks. Cases of lyme disease have been reported in Kansas, but little is known

about the occurrence of infected hosts and ticks that could transmit it. An entomologist and biologists collaborated to find this information.

About 20 species of ticks occur in Kansas, although people regularly encounter only a few of them. Ticks usually feed only once per life stage (larva, nymph, and adult). Virtually all species of ticks are carriers (vectors) of one or more microbial pathogens. Some can disseminate disease among several species of animals. None are adapted to human hosts, so people are accidental victims and not essential to the ecology of the ticks or the pathogens.

The closest populations of the major vector of lyme disease, the deer tick, are in northern Illinois and eastern Iowa. However, a related species, the blacklegged tick, occurs in eastern Kansas as far north as Jefferson County and infrequently as far west as Riley and Marion counties. It's probably common in wooded areas of southeastern Kansas and along the Missouri border. Although this tick is an efficient vector of the lyme disease pathogen in laboratory conditions, few cases of the disease have been associated directly with its bites. An unrelated species, the lone star tick, often is abundant in the eastern third of Kansas and occasionally farther west. In this area, it's the most common tick biting humans. A low rate of infection of this tick by the pathogen has been documented in several states. From 1982 through 1991, Kansas reported 52 cases of lyme disease, with 22 cases or an incidence of 0.87 per 100,000 people in 1991.

White-tailed deer and white-footed mice are the primary animal hosts for lyme disease, and both occur in Kansas. Blood samples were obtained from these species and other rodents; serum was separated and tested for reaction to antibodies to the pathogen. About one-third of serum samples from deer and 10 to 15 percent of samples from rodents reacted positively—indicating the possible presence of the pathogen. Isolation of the pathogen from the animals is needed to prove its presence.

To protect yourself from lyme disease, avoid unnecessary contact with tick habitats, wear long sleeves and long pants that keep out ticks, use safe repellents, carefully inspect yourself and your children after any possible exposure, and remove ticks before they become firmly attached.

Nutrition of Aging Women

Recent studies on aging have focused on factors that contribute to people maintaining their health as they age. A researcher in the Department of Foods and Nutrition studied a group of 100 women older than 65 years to determine effects of living arrangement, demographic characteristics, health habits, and social contacts on their nutrient intakes.

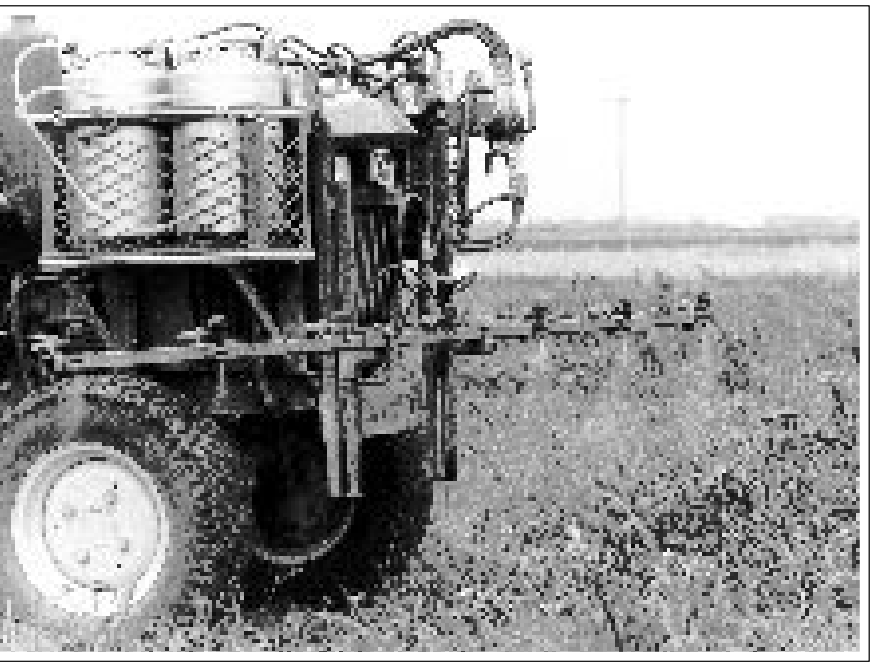
Many elderly women, even those who live alone, eat well-balanced diets.

Although women living alone often are perceived as not eating well, results of this study showed no effect of living arrangement on nutrition. Living arrangement also did not affect health habits, although women living alone had fewer social contacts. The women's caloric intake generally was below the recommended daily amount. However, they were receiving enough of most nutrients, meaning that they were eating nutrient-dense foods. Amount of exercise had a positive impact on the nutrient status and health of these older women. Those who were more active took in more calories and usually more than the recommended daily allowance of nutrients. Other important predictors of nutrient intake were education and smoking.

The good nutritional habits of this group of older women are encouraging but may not be typical. Because volunteers were recruited from a university community, their level of education was above the national average. Thus, they probably were better informed about the importance of good nutrition.

Health and Environmental Effects of Pesticides

Agriculture accounts for 75 percent (over 800 million pounds) of all pesticides used in the United States. Herbicides comprise nearly two-thirds of that amount. Most of the pesticides are applied to three major crops: corn, soybeans, and cotton. Insecticide use generally has declined in recent years, partly because most chlorinated hydrocarbons are



Pesticides are linked to many health problems; anyone who applies or is exposed to them is at risk.

banned or restricted severely in the U.S. However, these have been replaced by more acutely toxic formulas. A researcher in the Department of Sociology, Anthropology, and Social Work compiled a report on what is known about the adverse effects of pesticides.

Workers like farmers who formulate, mix, and apply pesticides have the greatest exposure. Other people living adjacent to agricultural areas can be exposed through drift from sprayed fields. Pesticides can be absorbed through the skin and the eyes, by the respiratory tract (via inhalation), and by the gastrointestinal tract (via ingestion).

Health effects can be acute or chronic. Among the acute effects are poisoning and death. An estimated 300,000 U.S. agricultural workers are poisoned by pesticides each year. Poison control centers reported that about 4 percent of deaths from poisoning were due to pesticides. Agricultural workers have a four times greater risk of skin disease than other workers, and pesticides are the major causes.

Chronic effects of pesticide exposure include cancer, birth defects, neurotoxicity, and problems of reproduction and fertility. Significantly increased risks of several cancers have been reported in farmers in the U.S. and other countries.

Adverse environmental effects include animal poisoning and contaminated products, destruction of natural predators, pesticide resistance in pests, crop losses, water contamination, and fishery losses.

Over 500 insect and mite species, nearly 150 plant pathogen species, and about 275 weed species worldwide have developed resistance to pesticides. This necessitates additional applications of chemicals or sometimes abandoning a crop, both of which increase the costs of production. Crop damage and loss also occur when pesticides drift from target areas, when they are applied under the wrong conditions, or when the harvested product exceeds regulatory limits for pesticide residues.

Although federal and state regulations address such concerns as worker protection, certified application, and residues on food or in water, pesticides still adversely affect human health and the environment. Farmers should realize that their use of and direct exposure to these chemicals puts them and their surroundings at risk.

■ *RURAL ECONOMY AND RAILROADS*

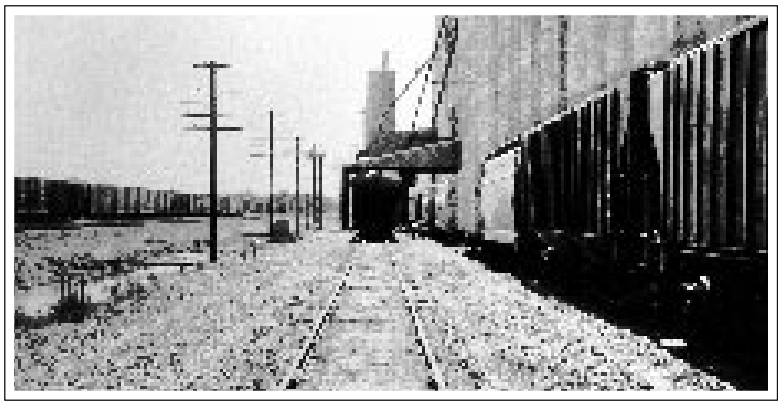
The economic viability of Great Plains agriculture depends on efficient, low-cost rail transportation. As large railroads, such as Santa Fe, reduce the size of their systems, many rural businesses face loss of rail service. Short-line railroads have acquired many miles of rural branch lines that otherwise would have been abandoned. In Kansas, short lines currently operate 36 percent of total railroad mileage. Thus, short-line railroads are viable transportation alternatives for Kansas shippers. However, the long-term financial survivability of the lines is questionable.

Therefore, a researcher and graduate students in the Department of Economics collaborated with a civil engineer to determine the economic viability of short-line railroads. The study included six short lines in Kansas, six in Iowa, and 264 shippers located along these railroads. Questionnaires and personal interviews of shippers and railroad executives were used to gather data.

Shippers generally voiced approval of short-line railroads and regarded the price and service as equal to those of previous larger railroads and motor carriers. However, some shippers requiring quick delivery and frequent service rated motor carriers as superior alternatives to railroads. The researchers compiled a 24-point profile of a successful short-line railroad, divided into major categories of traffic, management and labor, relationships to Class 1 railroads, finance, track quality, and state assistance. A profitable short line would have most of the components listed in each of these categories.

The results also led to several recommendations for government assistance to short-line railroads. For example, their costs could be lowered if the federal government reduced regulatory requirements and states paid some of the costs of maintaining rail-highway crossings. States also could consider grants for rehabilitation of tracks and short-term leasing of grain hopper cars that could be subleased to short lines.

This study provides guidelines for short-line railroads to become more profitable and for states to help maintain their service.



Low-cost and efficient rail service is vital to the rural economy of Kansas.

■ EDITORIAL OFFICE

A total of 1,181 manuscripts received contribution numbers during the biennium, and 792 (about 68 percent) were edited. The average number processed per month was 50. The numbers of manuscripts in the eight accepted categories were:

Journal articles	882
Proceedings of meetings	119
Books or chapters	68
Station publications including 1 Bulletin	53
Department reports	27
Trade publications	24
Extension publications	5
Computer programs	3

Annual and special publications produced by the Editorial Office received numerous national and regional awards during the 2-year period. The categories included poster, technical publication, in-house desktop design, news writing, brochure copywriting, institutional promotional material, and fundraising brochure. The Biennial Report for 1990-1992 received awards in two national competitions sponsored by the National Association of Government Communicators and the Agricultural Communicators in Education. The cover illustration was awarded first place for graphic design in the following year's national ACE competition. It was produced originally as large limited-edition prints to be given to major contributors to the College of Agriculture.

Publications produced by the Editorial Office feature the latest results of agricultural research in Kansas.

Personnel Changes

■ APPOINTMENTS

M. Kathy Banks, civil engineering
Lawrence A. Beck, horticulture, forestry and recreation resources
R. Scott Beyer, animal sciences and industry
Alan R. Brown, pathology and microbiology
Ralph E. Charlton, entomology
Hyung-Min Choi, clothing, textiles and interior design
William A. Erb, horticulture, forestry and recreation resources
Fred J. Fairchild, grain science and industry
Paul Flinn, U.S. grain marketing research laboratory
Joseph D. Gaines, clinical sciences
John C. Galland, clinical sciences
Richard Hahn, head, grain science and industry
Srinivas Kambhampati, entomology
Kelley K. Kreikemeier, southwest research-extension center
Frances Alice Leduc, horticulture, forestry and recreation resources
Thomas M. Loughin, statistics
Ronaldo G. Maghinang, biological and agricultural engineering
Kenneth B. Marcum, horticulture, forestry and recreation resources
Ronald Marler, dean, college of veterinary medicine
Donald E. Mock, entomology
Paul Neumann, grain science and industry
Jerome Nietfeld, veterinary diagnostic investigations
Paula K. Peters, foods and nutrition
Randall K. Phebus, animal sciences and industry
John A. Pickrell, clinical sciences
Om Prakash, biochemistry
William L. Rooney, agronomy
Christopher R. Ross, anatomy and physiology
Carol W. Shanklin, hotel, restaurant, institution management and dietetics
Sheri L. Smithey, biological and agricultural engineering
Kyle W. Stiegert, agricultural economics
Mitchell Strauss, head, clothing, textiles and interior design
Curtis R. Thompson, southwest research-extension center
Michael Timberlake, head, sociology, anthropology, and social work
Evan C. Titgemeyer, animal sciences and industry
John M. Tomich, biochemistry
Eric S. Vanzant, agricultural research center-Hays
Carolyn Wilker, human development and family studies
Ina Zayas, U.S. grain marketing research laboratory

■ RESIGNATIONS

Howard Barnes, human development and family studies
Lawrence A. Beck, horticulture, forestry and recreation services
Huang-Min Choi, clothing, textiles and interior design
Barbara A. Daniels Hetrick, plant pathology
Steven S. Duncan, agricultural economics
Rolando Flores, biological and agricultural engineering
A. Steve Freeman, southwest research-extension center
Barry Goodwin, agricultural economics
Albert J. Heber, biological and agricultural engineering
Chi-Tai Huang, biological and agricultural engineering
P.B. Kenney, animal sciences and industry
Bettie C. Minshall, clothing, textiles, and interior design
Loren J. Moshier, agronomy
Kenneth Olson, agricultural research center-Hays
Carole Prather, human development and family studies
James Schaffer, southwest research-extension center
James Tracy, biological and agricultural engineering

■ RETIREMENTS

Lerance C. Bolte, U.S. grain marketing research laboratory
James V. Craig, animal sciences and industry
Arlin M. Feyerherm, statistics
Ahmed M. Kadoum, entomology
John R. Lawless, northwest research-extension center
Stanley E. Leland, Jr., associate director, agricultural experiment station
Harry L. Manges, biological and agricultural engineering
Robert McEllhiney, grain science and industry
Harold A. Roberts, animal sciences and industry
Walter H. Smith, animal sciences and industry
George R. TenEyck, biological and agricultural engineering
Gerald Thierstein, biological and agricultural engineering

■ TITLE CHANGES

Orlan Buller
from: professor, agricultural economics
to: interim head, agricultural economics

Patrick Coyne
from: head, Fort Hays branch experiment station
to: head, agricultural research center-Hays, northwest research-extension center, and southwest research-extension center

Charles Deyoe
from: head, grain science and industry
to: director, international grains program

Marc A. Johnson
from: interim dean of agriculture and director of agricultural experiment station
to: dean of agriculture and director of agricultural experiment station

Brian Spooner
from: professor, biology
to: head, biology

■ DEPARTMENT CHANGES

Agricultural engineering changed to biological and agricultural engineering

Fort Hays branch experiment station changed to agricultural research center-Hays and along with northwest research-extension center and southwest research-extension center formed the western Kansas agricultural research centers, tri-center operations

Laboratory medicine and pathology merged into pathology and microbiology

Southeast branch experiment station changed to southeast agricultural research center

Veterinary diagnosis changed to veterinary diagnostic investigation

Station Publications

■ BULLETINS

660 Quality Maintenance and Marketing of Wheat Stored on Farms and in Elevators in Kansas: Description, Techniques, and Innovations

■ REPORTS OF PROGRESS

661 1992 Turfgrass Research
662 Conservation Tillage Research 1992
663 Kansas Farmland Sales and Characteristics: 1971-1990
664 1992 Woody Ornamental Evaluations
665 1992 Kansas Performance Tests with Winter Wheat Varieties
666 Dairy Day 1992
667 Swine Day 1992
668 1993 Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland
669 1992 Kansas Performance Tests with Corn Hybrids
670 Kansas Fertilizer Research 1992
671 1992 Kansas Performance Tests with Sunflower Hybrids
672 1992 Vegetable Investigations
673 1992 Kansas Performance Tests with Soybean Varieties
674 1992 Kansas Performance Tests with Grain Sorghum Hybrids
675 1992 Kansas Performance Tests with Spring Oats, Spring and Winter Barley, Spring Wheat, and Winter Canola
676 1992 Kansas Performance Tests with Alfalfa Varieties
677 Milling and Baking Test Results for Hard Winter Wheats Harvested in 1992
678 1993 Cattlemen's Day
679 Kansas Sheep Research 1993
680 Roundup 1993
681 1993 Agricultural Research. Southeast Kansas Branch Experiment Station
682 Field Research 1993. Agronomy and Agricultural Engineering Experiment Fields
683 1992 Bedding Plant Field Trials
684 Cattle Feeders' Day 1993
685 1993 Turfgrass Research
686 Winter Barley Varieties in Kansas
687 An Economic Analysis of Conventional and Alternative Cropping Systems for Northeast Kansas
688 1993 Agricultural Research. Northwest Research-Extension Center
689 1993 Field Day Report. Southwest Kansas Research-Extension Center
690 The Future of Conservation Reserve Program Land in Kansas: The Landowner's View
691 1993 Kansas Performance Tests with Winter Wheat Varieties
692 Marketing Practices and Seminar Participation of Kansas Agricultural Producers
693 1993 Woody Ornamental Evaluations
694 Dairy Day 1993
695 Swine Day 1993
696 1993 Kansas Performance Tests with Corn Hybrids
697 Kansas Fertilizer Research 1993
698 1994 Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland
699 1993 Kansas Performance Tests with Grain Sorghum Hybrids
700 1993 Kansas Performance Tests with Sunflower Hybrids
701 1993 Kansas Performance Tests with Soybean Varieties
702 1993 Kansas Performance Tests with Alfalfa Varieties
703 Kansas Sheep Research 1994
704 1994 Cattlemen's Day
705 Conservation Tillage Research 1994
706 Roundup 1994
707 Milling and Baking Test Results for Hard Winter Wheats Harvested in 1993
708 1994 Agricultural Research. Southeast Kansas Branch Station
709 Field Research 1994 Agronomy and Agricultural Engineering Experiment Fields
710 1993 Bedding Plant Field Trials

■ KEEPING UP WITH RESEARCH

104 Symptom Response of Sorghum Hybrids Infected by Sugarcane Mosaic Virus Strain MDMV-B
105 Effects of Early-Cutting Management on Forage Yield and Quality of Alfalfa in Northeast Kansas
106 Using Reduced Rates of Postemergence Herbicides in Soybeans

■ SPECIAL PUBLICATIONS

- Agricultural Research in Kansas: Thirty-Sixth Biennial Report of the Agricultural Experiment Station, 1990-92
- Ag Facts

SUFFIX LETTERS FOR CONTRIBUTION NUMBERS *(pages 32—76)*

A Proceedings of Meeting or Symposium
B Bulletin published by KAES; Book or Chapter for Book
C Computer Program
D Department Report
E Extension Publication (co-authored by a KAES researcher but published by Cooperative Extension or externally as educational material) or research by an Extension person to be published in a refereed journal.
J Journal
S Station Publication: Report of Progress, Keeping Up With Research, Special Publication
T Trade Publication

Categories are based on information received before manuscripts are published. Place of publication sometimes changes later. Numbers are deleted if authors cannot supply publication data.

Station publications including Bulletins are available from KAES Editorial Office. Department Reports are available only from the appropriate department office. Copies of journal articles or other outside publications must be obtained from the authors.

Publications of Station Scientists *(By Department and Station Contribution Number)*

1. Agricultural Economics

90-463-J Modeling the Economic Evaluation of Wheat Flour Milling Operations
R.A. Flores, E.S. Posner, R. Phillips, and C.W. Deyoe
Trans. Am. Soc. Agric. Engin. 36(4):1143-1149, 1993

91-338-J A Risk Programming Analysis of Crop Rotations Including Double-Cropping
M.F. Crisostomo, R.O. Burton, Jr., A.M. Featherstone, and K.W. Kelley
Rev. Agric. Econ. 15(3):443-461, 1993

91-356-E Tracking the Life Cycle of Rural Communities
D.L. Darling and J.R. Pillarisetti
J. Comm. Dev. Soc. 25(1):62-79, 1994

91-511-J Crop Insurance and Disaster Aid Designs for Wheat and Grain Sorghum
J.R. Williams, G.L. Carriker, G.A. Barnaby, and J.K. Harper
Am. J. Agric. Econ. 75(2):435-447, 1993

91-555-J Resource-Conserving Crop Rotations and the 1990 Farm Bill Provisions
J.R. Williams and P.L. Diebel
J. Soil and Water Cons. 47(2):145-151, 1992

91-563-J Product Test Data for Processed Foods: An Analysis of Brand Label
O. Grunewald and D.J. Faulds
J. Food Prod. Marketing 1(2):3-22, 1993

92-54-J Profitability of a Resource-Conserving Crop Rotation: A Case Farm Analysis of a Central Kansas Farm
K.L. Herbel and J.R. Williams
J. Sust. Agric. 2(4):31-45, 1992

92-116-B A Risk Analysis of Alternative Crop and Irrigation Strategies using Biophysical Simulations
A.M. Featherstone, A. Osunsan, and A.W. Biere
In: *Issues in Agricultural Development.* IAAE Occas. Pap. 6, pp. 102-110, Dartmouth Publishing Co., Brookfield, VT, 1992

92-143-B Soil Conservation: Using Farming Systems Development as an Aid
D.W. Norman
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A.M. Featherstone and B.K. Goodwin
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92-268-J Farm Value of Eroded Topsoil for Spring Wheat Production
J.R. Williams, D.L. Tanaka, and K.L. Herbel
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92-301-A The Research-Research Interface
D.W. Norman
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92-431-J An Empirical Analysis of Brand Label, Product Quality, and Package Size as Determinants of Unit Price for Frequently Purchased Consumer Packaged Goods
D.J. Faulds and O. Grunewald
Southwest Bus. Rev. 2(2):13-26, 1992

92-454-A Interdisciplinary Research: A Vehicle for Meeting the Information Needs of Grassland Producers
R.O. Burton, Jr., K.P. Coffey, J.L. Moyer, L.W. Lomas, and P.T. Berends
Proc. XVII Int. Grassland Cong., pp. 628-629, 1993

92-455-J The Value of Genetic Traits in Purebred Dairy Bull Services
T.C. Schroeder, J.A. Espinosa, and B. Goodwin
Rev. Agric. Econ. 14:215-226, 1992

92-456-J Low-Input Agriculture as a Groundwater Protection Strategy
P.L. Diebel, D.B. Taylor, S.S. Batie, and C. Heatwole
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92-514-J The Demand for Beef Specialty Products
V.H. Smith and B.K. Goodwin
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92-540-J Forecasting Cattle Prices in the Presence of Structural Change
B.K. Goodwin
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92-542-J Evidence of Agglomeration in Quality Space—Revisited
O.C. Grunewald and D.J. Faulds
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92-562-J Applied Policy Analysis of the Rice Marketing Subsector of Guinea-Bissau
J.D. Lea
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92-586-J Farm Consumption and Liquidity Constraints
M.R. Langemeier and G.F. Patrick
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92-624-J An Empirical Analysis of the Demand for Multiple Peril Crop Insurance
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92-652-J Determinants of Cattle Finishing Profitability
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92-655-J Farm Household Consumption Patterns
G.L. Carriker, A.M. Feathersone, and T.C. Schroeder
Rev. Agric. Econ. 15(1):63-73, 1993

92-662-J Railroad Differential Pricing in the Kansas Wheat Transportation Market
M.W. Babcock, Y.W. Kwon, and L.O. Sorenson
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92-671-J An Economic Analysis of the Integrated Farm Management Option for Corn and Wheat Rotations
P.L. Diebel and J.R. Williams
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93-8-D An Economic Analysis of Soil Erosion Control and Low-Input Agriculture
P.L. Diebel, D.B. Taylor, S.S. Batie, and C. Heatwole
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93-39-D Impacts of Policy Changes on Discounts for Insects in Farm-Stored Wheat
B. Schurle, S. Duncan, C. Reed, F. Worman, and J. Pedersen
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93-68-J The Propensity to Consume Farm Family Disposable Income from Separate Sources
G.L. Carriker, M.R. Langemeier, T.C. Schroeder, and A.M. Featherstone
Am. J. Ag Econ. 75:739-744, 1993

93-103-J Substitutability of Fertilizer and Rainfall for Erosion in Spring Wheat Production
E. Arce-Diaz, A.M. Featherstone, J.R. Williams, and D.L. Tanaka
J. Prod. Agric. 6(1):13-14, 72-76, 1993

93-104-D Estimation of the U.S. Import Demand Elasticity for Beef: The Importance of Disaggregation
G.W. Brester
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93-121-J The Impacts of Quality on Cash Fed-Cattle Prices
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93-142-S Swine Day 1992
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93-163-J The Impact of Forward Contracting on Fed Cattle Prices
T. Schroeder, R. Jones, J. Mintert, and A. Barkley
Rev. Agric. Econ. 15:325-338, 1993

93-207-D Farming Systems Research: Past, Present, and Future
D.W. Norman
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93-210-J Discrete/Continuous Contingent Valuation of Private Hunting Access in Kansas
B.K. Goodwin, L.A. Offenbach, T.T. Cable, and P.S. Cook
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93-230-B Community Change
A. Biere
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93-236-J Real Interest Rate Equalization and the Integration of International Financial Markets
B.K. Goodwin and T.J. Grennes
J. Intl. Money and Finance 13:107-124, 1994

93-267-D An Economic Comparison of Composted Manure and Commercial Nitrogen under Imperfect Information
P.T.Berends, P.L. Diebel, J.R. Williams, and A.J. Schlegel
Agric. Econ. Dept. Rep. (Staff Pap. 93-7):1-17, 1993
(available from dept. only)

93-282-J Agricultural Research in Developed Countries: Past, Present, and Future of Farming Systems Research and Extension (FSRE)
D.W. Norman, T.R. Frankenberger, and P.E. Hildebrand
J. Prod. Agric. 7(1):124-131, 1994

93-295-B Exporting Kansas Grains to Selected Asian Pacific Rim and Latin American Countries through Port Topolobampo, Mexico
L.D. Garzon and H.L. Kiser
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93-308-J Risk and Returns for Different Time Periods during 1976-1990: Differences Were Dramatic!
K.S. Claassen and R.O. Burton, Jr.
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93-318-S Cattlemen's Day 1993
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93-334-J An Evaluation of Hog Carcass Merit Pricing Systems
T.C. Schroeder
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93-358-J Factors Affecting Cattle Feeding Profitability
T.C. Schroeder, M.L. Albright, M.R. Langemeier, and J. Mintert
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93-363-D Staff, Programs, and Publications in Agricultural Economics
V. Kaul
Agric. Econ. Dept. Rep. (Staff Pap. 93-8):1-29, 1993
(available from dept. only)

93-390-S 1993 Agricultural Research. Southeast Kansas Branch Station
Kans. Agric. Exp. Stn. Rep. Prog. 681:1-89, 1993

93-398-J Barriers to Low-Input Agriculture Adoption: A Case Study of Richmond County, Virginia
P.L. Diebel, D.B. Taylor, and S.S. Batie
Am. J. Altern. Agric. 8(3):118-124, 1993

93-423-J Vertical and Horizontal Price Linkages and Market Concentration of the U.S. Wheat Milling Industry
G.W. Brester and B.K. Goodwin
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93-440-J Providing Relevant Training for African Agronomists
D.W. Norman
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93-476-D Impact of a BTU Tax on Production Costs for Kanss Farm Management Association Farms and Crop Enterprises
J.R. Williams and F.D. DeLano
Agric. Econ. Dept. Rep. (Res. Rep. 17):1-29, 1993
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93-488-D Kansas Country Elevator Wheat Storage Practices, 1991
F. Worman, C. Reed, B. Schurle, S. Duncan, and J. Pedersen
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93-514-B Quality Maintenance and Marketing of Wheat Stored on Farms and in Elevators in Kansas: Descriptions, Techniques, and Innovations
C. Reed and F. Worman
Kans. Agric. Exp. Stn. Stn. Bull. 660:1-56, 1993

93-530-D Returns to Resource-Conserving Crop Rotations with and without Government Programs
J.R. Williams and P.L. Diebel
Agric. Econ. Dept. Rep. (Staff Pap. 93-10):1-23, 1993
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93-533-D A Yield Sensitivity Analysis of Conventional and Alternative Whole-Farm Budgets for a Typical Northeast Kansas Farm
P.L. Diebel, R.V. Llewelyn, and J.R. Williams
Agric. Econ. Dept. Rep. (Staff Pap. 93-11):1-16, 1993
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93-536-A Comparison of Conventional and Alternative Whole-Farm and Crop Enterprise Budgets for a Northeast Kansas Representative Farm
P.L. Diebel, R.V. Llewelyn, and J.R. Williams
Proc. Integrated Res. Manag. and Landscape Modification for Envir. Prot. Conf., pp. 368-377, Amer. Soc. Agric. Engin., St. Joseph, MI, 1993

93-539-S An Economic Analysis of Conventional and Alternative Cropping Systems for Northeast Kansas
Kans. Agric. Exp. Stn. Rep. Prog. 687:1-62, 1993

93-542-J The Kansas Agricultural Economy: Trends and Perspectives
A.M. Featherstone, J. Mintert, and S.R. Goering
Kans. Bus. Rev. 17(1):9-19, 1993

93-545-J Measurement of Farm Risk: Alberta Crop Production - Comment
R.O. Burton, Jr. and K.S. Claassen
Can. J. Agric. Econ. 41(3):357-361, 1993

93-549-J Clearance Sales in the Farmland Market?
A.M. Featherstone, B.W. Schurle, S.S. Duncan, and K.D. Postier
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93-550-D Active/Passive Ratios of County Personal Income: A New Economic Measure for Kansas Community Developers
Md. Habibur Rahman and D.L. Darling
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Publications of Station Scientists (Continued)

93-557-J Economic Impact of a BTU Tax on Farm Production Costs in Kansas
J.R. Williams, F.D. DeLano, and L.N. Langemeier
J. Am. Soc. Farm Manag. and Rural Apprais. 58(1):95-101, 1994

93-565-J Quantifying the Effects of New Product Development: The Case of Low-Fat Ground Beef
G.W. Brester, P. Lhermite, B.K. Goodwin, and M.C. Hunt
J. Agric. and Res. Econ. 18(2):239-250, 1993

93-571-D Impact of the U.S. House of Representatives' BTU Tax Proposal on Whole-Farm and Enterprise Production Costs in Kansas
J.R. Williams and F.D. DeLano
Agric. Econ. Dept. Rep. (Staff Pap. 94-1):1-16, 1993
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94-12-D Determinants of Cattle Feeding Profit and Cost of Gain Variability
T.C. Schroeder, M.L. Albright, M.R. Langemeier, and J. Mintert
Agric. Econ. Dept. Rep. (Staff Pap. 94-2):1-23, 1993
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94-31-J Kansas State University Lean Value Marketing Program: Assisting Swine Producers to Maximize Their Marketing Returns
G.L. Keeler, M.D. Tokach, R.D. Goodband, J.L. Nelssen, and M.R. Langemeier
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T. Kastens and T.C. Schroeder
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94-69-A CRP, Wildlife, and the Future: The Kansas Landowner's View
P.S. Cook, P.L. Diebel, and T.T. Cable
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D. Norman, K. Friedrich, B. Gohl, and L. Singogo
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94-373-S 1994 Cattlemen's Day
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H073 An Economic Analysis of Farm Management Issues and Resource Use of Kansas Farms
H119 *(number applies to title above)*
H122 The Impact of Agricultural Commodity Programs on Food and Feed Grain Markets
F214 Economic and Environmental Implications of Expiring Conservation Reserve Contracts
F634 Policy Implications for Farm Household and Rural Community Responses to Economic Change
F691 Domestic and International Marketing Strategies for U.S. Beef
H698 Innovative Red Meat Production and Processing Systems for the Modern Consumer
F707 Performance of the U.S. Grain Marketing System
R754 Use of a Legume-Grain Sorghum Rotation in a Crop-Livestock System
F767 Quantifying Long-Run Agricultural Risks and Evaluating Farmer Responses to Risk
F835 Changing Patterns of Food Demand and Consumption Behavior
H887 Economic Analysis of Alternative Production Practices for Soybeans and Beef
H900 Irrigation Management to Conserve Water and Maintain Income
H943 Measuring Economic Impacts of Groundwater Protection Policies on the Great Plain States
H950 Pricing and Marketing in the Livestock Sector under Structural Change
H984 Diversification and Specialization Benefits for Livestock Producers
H997 Commercial Greenhouse Crops to Complement Spring-Grown Bedding Plants

Agronomy

520033 Soil Fertility and Soil Management Investigations
520035 Crop Physiology - Production Research
520040 Crop Performance
520044 Range and Pasture Brush and Weed Control
520046 Corn and Grain Sorghum Production and Management
520050 Seed and Plant Parts Certification
520052 Field Herbicidal Evaluations
520412 Breeding Sorghum for Tolerance to Fusarium Stalk Rot
520663 Breeding Grain Sorghum for Improved Dryland Production
520669 Breeding Soybeans for Increased Productivity
520681 Simultaneous Selection for Drought and Heat Resistance
520685 Breeding Sorghum for Improved Digestibility and Feed Efficiency
520688 Simulation of Soil Stability, Wetness, and Range Vegetation for WEPS
520691 Stratification and Fate of N in Soil Profiles: Management-Induced Changes
520694 Increasing Soybean Production through the Use of Cyst Nematode
520696 Testing and Adapting a Decision Model for Postemergence Weed Control
520697 Introducing Soybeans into Crop Rotation in South Central Kansas
520698 Support for the Development of Pioneer Germplasm and Varieties at KSU
520701 Technical Support for the Acquisition of Pioneer Germplasm and Varieties
520706 Digitization of the Kansas Soil Survey
520707 Row Crop Nonpoint Source Pollution Control Demonstration Project
520708 Digitization of Soil Surveys
520711 Phosphorus Bioavailability in Cultivated Soils
520713 Development of Hard White Winter Wheat for Kansas
520716 Row Crop Pollution Control Demonstration Project: Atrazine Analyses
520720 Denitrifier Ecology in Stratified Soil Profiles: Implications for Water Quality
520721 Development of a New Heterotic Group in Wheat
520722 Canola Research
520723 Alfalfa Research
520725 Contribution of Soybean Residue N for Corn Products in Corn-Soybean Rotations
520726 Variable Nitrogen Management for Improving Groundwater Quality
520727 Tillage, Irrigation, and Hybrid Maturity Class Effects on Corn Production
520728 Yield Effects of Double- and Intercropping Soybeans into Wheat Stubble on Irrigated Sandy Soils
520729 Effect of Row Width, Planting Population, Planting Date, Variety, and Different Weed Control Levels on Soybean
520730 Improving Atrazine Management for Weed Control in Grain Sorghum: Evaluating Field-Scale Atrazine and Alachlor Movement in Surface Water in Northeast Kansas
520731 Improving Atrazine Management for Weed Control in Corn: Evaluating Field-Scale Atrazine and Alachlor Movement in Northeast Kansas
520732 Improvement of Hard Winter Wheat
520738 Soil Respiration in Prairie Ecosystems Exposed to Ambient and Elevated CO_2
520740 Effect of Catalytically Conditioned Water on Soil Microbial Activities
520741 Water Conservation-Increased Efficiency in Usage
520742 Substituting Legumes for Fallow in U.S. Great Plains Wheat Production
520743 Evaluation of *Tyta luctuosa* for Biological Control of Field Bindweed
520744 Crambe: Evaluation of Swathing Time Practices in Kansas
520745 Improving Atrazine Management for Weed Control in Corn
520747 Assessing the Potential for Biological Control of Field Bindweed with the Gall Mite and a Moth
520748 Water Quality Use of Nitrogen Mineralization in Spatially Variable Nitrogen Recommendations
520751 Providing Soil Sample Analysis for Soil Survey Activities
520752 Development of Commercial Soybean Varieties for Kansas
520753 The Effect of Conditioning and Seed Size on Soybean Seed Quality
520754 RH-1965 Application Timing for Cheat Control in Hard Red Winter Wheat
520755 Double-Crop Soybean Performance
520757 Workshop on Heat Tolerance in Temperate Cereals
520758 Crambe Germplasm/Cultivar Adaptation to the Central Great Plains
520759 Postemergence IVM Weed Control with XCE-570 and XDE 564
520760 Evaluation of Starter Fertilizer Materials on Corn, Grain Sorghum, and Soybeans
520762 Development of an Alfalfa Genome Database
529149 Rangeland Plant Response to Elevated CO_2
522266 Development of Grain and Forage Sorghums Resistant to Chinch Bug
524470 Breeding Soybeans for Increased Productivity
524521 Using Cultural Practices to Reduce Soybean Cyst Nematode and Charcoal Rot Damage in Soybeans
525754 Canola Research
525757 Tillage, Irrigation, and Hybrid Maturity Class Effects on Corn Production
525958 Canola Research
526167 Tillage, Irrigation, and Hybrid Maturity Class Effects on Corn Production
526396 Using Cultural Practices to Reduce Soybean Cyst Nematode and Charcoal Rot Damage in Soybeans
527954 Bioremediation of Hydrocarbon-Contaminated Soils Using Vegetation: A Field and Greenhouse Study
H019 Development, Production, and Quality of Forage Crops in the Central Great Plains
R020 Potential for Incorporating the Kansas Farmer in the Agricultural Research Process
H021 Development of Productive, Disease-Resistant Soybean Varieties
H035 Plant Nutrient Cycling in Soils
H040 Prediction and Correction of Zinc Deficiency in Sorghum in Kansas
H052 Organelle Analysis, Chromosome Banding, and Tissue Culture of Crop Species
H056 Use of Crop Models in Sorghum and Corn Management
H061 Production, Quality, and Physiology of Eastern Gamagrass
H063 Development of Hard White Winter Wheat Varieties for Kansas
H064 Effect of Previous Crop on Ammonium Nutrition of Corn
F079 Integrated Systems for Improved Water and Nitrogen Management in Irrigation Environments
R086 Tillage and P Fertilizer Management Effects on Surface P Runoff and Crop Yield
R087 Effects of Phosphorus Application Method and Rate on Furrow-Irrigated, Ridge-Tilled Grain Sorghum
R088 Variable Nitrogen Management for Improving Groundwater Quality
R089 Nitrogen Management in Conservation Systems
H092 Physiological Control of Crop Productivity
H093 Alfalfa Breeding and Genetics
H096 The Biology and Ecology of Weeds in Crop Ecosystems
H103 Crop Sequence and Tillage Interaction Effects on Crop Yield and Soil Environment
H106 The Impact of Fertilizers and Herbicides on Water Quality
H143 Forage Crop Genetics and Breeding to Improve Yield and Quality
F162 Water and Carbon Economy of Plants in Relation to Rhizospheric and Atmospheric Dynamics

H271 Improvement of Hard Winter Wheats and Other Small Cereal Grains for Kansas
F287 Introduction, Maintenance, Evaluation, and Utilization of Plant Germplasm
R378 Coordination of Crop Variety Testing
H488 The Absorption, Solubility, and Kinetics of Reaction of Phosphorus in Soils
R550 Field Crop Variety Identification and Pure Seed Maintenance
H603 Genetic Improvement of Sorghum
H669 Fertilizer Management Technology for Western Kansas
H681 Genesis, Classification, and Mineralogy of Kansas Soils
H687 Nutritional Management and Grazing Behavior of Beef Cattle on Bluestem Range
H724 Range Improvement Investigations
H741 Mechanisms of Insect-Plant Interactions: Sorghum Resistance to Insect Pests
F779 Variables in Agriculture—Weather Information Systems
H833 No-Till Wheat-Sorghum-Corn Rotation for South Central Kansas
F838 Chemistry and Bioavailability of Waste Constituents in Soils
H881 Planting Wheat in a Ridge-Till Crop System
H882 Winter Annual Legume and Grass Adaptation and Use in Eastern Kansas
H884 Reduced Tillage and Crop Rotation Systems for Winter Wheat and Grain Sorghum in Central Kansas
F932 Pesticides and Other Toxic Organics in Soil and Their Potential for Groundwater Contamination
F933 Characterization and Management of Soil Water and Solutes in Field Soils
F935 Environmental and Genotypic Control of Assimilate Allocation in Grain Crops
F936 Biological and Ecological Basis for a Weed Management Model to Reduce Herbicide Use in Corn
F941 Nutrient Management to Sustain Productivity while Protecting Surface and Groundwater Quality
H946 Effects of Soil Compaction on Soil Physical Properties and Crop Growth
R957 Phosphorus, Potassium, and Chloride Effects on Alfalfa and Birdsfoot Trefoil Establishment, Yield, and Quality
H961 Genetic Investigations of Pest Resistance in Alfalfa
H976 Crop Responses in Stressful Environments
R993 Agronomy/Agricultural Engineering Experiment Fields Research

■ *Anatomy and Physiology*

481878 Regulation of Porcine Mucosal Immunity
528257 Anti-Idiotypic Immunity and Receptor Interactions in Bovine Respiratory Disease
528575 Neurons and Neuropeptides in Sea Anemones
528577 Limbic Sites Involved in Cardiovascular Dynamics
528578 Cytogenetic Approaches to Food Animal Gene Mapping
528580 Mechanisms of Limbic Forebrain Control of ACTH Release
528581 REU Supplement to: Neurons and Neuropeptides in Sea Anemones
528582 Myocardial Membrane Proteoglycan Expression after Ischemia
528583 Immunohistochemical Localization of Heparin Sulfate in Myocardium
528584 Development and Regulation of Porcine Neonatal Neutrophil Function
528585 Immune Enhancement and Medicated Early Weaning
528586 Mechanisms of Capillary Stress Failure in Exercise-Induced Pulmonary Hemorrhage
528587 Influence of B-1,3-Glucan on Nonspecific Immunity in Pigs
528588 Pharmacological Analysis of Neurotransmitter Neurotoxicity
529292 Mechanism of Exercise Inhibition during Lung Congestion
529302 Coronary Collateral Function in the Conscious Pony
529311 Control of Rhythmic Sympathetic Activity in Acute Stress
H004 Ultrastructure of Lung with Experimentally Induced Pneumonic Pasteurellosis
H075 Mechanisms of Capillary Stress Failure in Exercise-Induced Pulmonary Hemorrhage
F076 Mapping the Pig Genome
H077 Intestinal Cellular Immunity: Cytokine Interactions
H120 Cell-Surface Attachment Proteins for Bovine Herpes Virus-1
F579 Stress Factors of Farm Animals and Their Effects on Performance
F704 Metabolic Relationships in Supply of Nutrients for Lactating Cows

■ *Animal Sciences and Industry*

481878 Regulation of Porcine Mucosal Immunity
481882 Cloning of *Fusobacterium* Leukotoxin Gene for Potential Recombinant Vaccine
521718 Animal Science Food Safety Consortium KSU
521721 The Utilization of Solubilized Wheat Protein in Diets for Early-Weaned Pigs
521729 Influence of Amaferm on Ruminal Fermentation
521731 A Study of the Effect of Lysocellin on Legume Bloat
521732 The Determination of ME Values for Extruded Soybeans in Pigs of Various Ages
521737 Determination of Available Amino Acids in Extruded Feedstuffs for Growing and Finishing Pigs
521738 Inheritance of "Rat-Tail" Condition in Cattle
521740 Feedlot Cattle Liver Abscess Microbial Survey
521743 Alfalfa Research
521745 The Effects of Three Levels of Dietary Lysine and Two Litter Sizes during Lactation on Sow and Litter Performance
521747 International Livestock Program-International Trade Development
521748 Effect of Nutrition on Timing of Puberty Onset in Beef Heifers
521749 Beef Curry Product Development
521750 The Effect of Bacterial Inoculants on Preservation and Nutritive Value of High Moisture Corn
521751 KSU Technical Assistance to Kansas Meat Processors
521752 The Effect of Biological Inoculants and Enzymes on the Preservation and Nutritive Value of Corn Silage
521753 Effects of a Microbial Food Additive on Nutrient Digestibility in Greyhound Dogs
521754 Use of Wheat Gluten in Phase 2 Nursery Pig Diets
521755 The Effect of Bacterial Inoculants on the Preservation and Nutritive Value of Whole-Plant Corn Silage
521756 Use of Enzymes and Bacteria to Improve the Nutritional Value of Sorghum Grain for Finishing Pigs
521757 Gluconic Acid as a Fresh Meat Decontaminant
521761 An Evaluation of a Calf-Starter Protein Source
521762 Vacuum Packager and Equipment for Animal Sciences Meat-Processing Lab
521763 National Animal Health Monitoring System Beef Survey—Nutrition Portion
521765 Induced Hepatic Abscesses in Cattle Immunized with Leukotoxin of *Fusobacterium necrophorum*
521766 Animal Science Food Safety Consortium—Kansas State University
521768 Investigation of Microbiological Safety and Shelf-Life of Tofu Products
521770 Development of Educational Material for the Kansas Feedlot Industry
521771 Breeding Sorghum for Improved Digestibility and Feed Efficiency
521772 Evaluation of Norwegian Fishmeal as a Protein Source for Starter Pig Diets
521773 Evaluation of Trace Mineral Complexes Supplemented for Wheat Pasture Cows
521774 The Effect of Amino Acid Chelated Minerals on Starter Pig Performance
521775 Beef Cattle Copper Proteinate/Immune Response Research Study
521776 Kansas Horse Industry
521778 Shelf-Stable Pumpkin Pies
521779 Palatability, Color, and Shelf Life of Beef Subjected to Low-Dose Irradiation
529233 Embryo-Uterine Interactions during Early Pregnancy
H016 Nutrition of Developing, Gestating, and Lactating Swine
H018 Optimum Processing to Maximize Utilization of Cereal Grains in Swine Feeding
H024 Neuroendocrine Regulation of Adrenocorticotropic Hormone in Swine
H043 Ruminal Microflora in Relation to Function and Dysfunction of the Rumen
H084 Management of Beef Cattle Grazing Tallgrass Prairie
H090 Process Optimization for Value-Added Dairy Products
H091 Optimum Use of Harvested Forage Crops for Ruminant Livestock Production
H111 Sterilization of Beef Cattle Using Recombinant Peptide Vaccines
H112 Sulfur Amino Acid Utilization by Cattle
H114 Biodegradation of Aflatoxins in Agricultural Products and Culture Media
H126 NIR Analysis of Forage and Grain Sorghum
F207 Methods for Improvement of Fertility in Cows Postpartum
F579 Stress Factors of Farm Animals and Their Effects on Performance
F588 Dairy Herd Management Strategies for Improved Decision Making and Profitability
F628 Development of New Processes and Technologies for the Processing of Poultry Products
H687 Nutritional Management and Grazing Behavior of Beef Cattle on Bluestem Range
H698 Innovative Red Meat Production and Processing Systems for the Modern Consumer
F704 Metabolic Relationships in Supply of Nutrients for Lactating Cows
H739 Cow/Calf Nutrition and Management in Kansas
H748 Forage Protein Characterization and Utilization for Beef Cattle
H765 Pelvic Area of Bulls as a Predictor of Maternal Calving Ease
F771 The Genetics of Body Composition in Beef Cattle
F785 Reproductive Performance in Domestic Ruminants
H799 Respiratory Disease and Environmental Stress in Food Animals
R817 Analytical Services Laboratory
H854 Non-Enzymatic Browning Products as Antioxidants in Restructured Beef
H860 Enhancing Digestion and Metabolism of Fats and Soybean Proteins in Weanling Pigs

H890 Cause and Control of Flavor Deterioration during Aseptic Storage of Ultra-High Temperature Sterilized Milk
H897 Management Systems for Optimizing Beef Production
H920 Utilization and Metabolism of Fats by Ruminants Fed High-Grain Diets
F937 Modeling Responses of Growing Pigs
H968 Reproductive Efficiency of Sows
H985 Influence of Exercise on Proliferation/ Differentiation of Equine Satellite Cells in Vitro
H998 Improving Reproductive Efficiency in the Equine

■ *Biochemistry*

527177 Sheath Blight and Expression of Chitinase and B-Glucanase Genes in Resistant and Sensitive Cultivars of Rice
527179 2D NMR of Protein-Inhibitors of Blood-Coagulation Factor
527190 The Role of NA+ K+ ATPase in Diabetic Retinopathy
527191 Pest Control by Manipulation of Insect Chitinolytic Enzymes and Their Genes
527192 Structure of Cyclic Nucleotide Phosphodi-esterase
527195 Structure/Function Analysis of Mutant Human Myoglobins
527196 Structural Studies of Pumpkin Seed Inhibitors of a Blood-Coagulation Factor by 2D NMR
527197 Insulin Activation of Pyruvate Dehydrogenase Phosphatase
527200 Mutations Affecting the Fe Protein of *Klebsiella pneumoniae* Nitrogenase
527201 Function of Phosphatidylcholine Hydrolysis by Phospholipases D and C in Plants
527202 Metabolic Control of Mammalian Pyruvate Dehydrogenase Complex
527203 Peptide Synthesis Studies
527204 Protein Structure and Dynamics by High Field NMR
527206 Structure/Function Analysis of Engineered Mutants of Human Myoglobin
527207 *(number applies to title above)*
527208 Structure of Recombinant and Mutant Cyclic Nucleotide Phosphodiesterase
527210 Improvement of Soybean via Biotechnological Approach
527211 Insulin Activation of Pyruvate Dehydrogenase Phosphatase
527212 Studies of Human Lysosomal Glucocerebrosidase
527213 Corn Rootworm Proteinases and Their Inhibitors
527215 Wheat Mitochondrial DNA and Cytoplasmic Male Sterility
529087 Regulation of Mammalian Pyruvate Dehydroge-nase
529215 *(number applies to title above)*
529252 Immunoglobulin-Related Proteins in Insect Hemolymph
529253 *(number applies to title above)*
529275 Role of Ordered Helical Segments in Membrane Proteins
529281 NMR Studies of Protein-Inhibitors of a Blood Coagulation Factor
529321 NMR Studies of a Blood-Coagulation Factors Inhibitor
538550 Construction of Male Sterile Wheat
538730 *(number applies to title above)*
H006 Regulation and Function of Phosphatidylcholine Hydrolysis in Plants
H013 Serine Proteinase Inhibitors in Insects
H045 Identification of Hormone-Responsive DNA Elements in Barley -Amylase Genetics
H047 2D NMR Studies of Protein Inhibitors of a Blood Coagulation Factor
H100 Detection and Characterization of Inhibitory Allosteric Sites on Rubisco
H104 Chromosomal Regions Involving Genes for Gliadins and Glutenins
H133 Biotechnology Instrumentation Laboratory
H134 High Field Nuclear Magnetic Resonance Laboratory for Macromolecules
H541 Biochemistry of Cyclic GMP
H744 Biochemistry of Genetic Systems
H906 Efficiency of Nitrogen Fixation
H918 Function and Regulation of Mammalian α-Keto Acid Dehydrogenase
H982 Structure/Function Correlations for Mammalian Heme Proteins

■ *Biological and Agricultural Engineering*

520716 Row Crop Pollution-Control Demonstration Project: Atrazine Analyses
520726 Variable Nitrogen Management for Improving Groundwater
520729 Effect of Row Width, Planting Population, Planting Date, Variety, and Different Weed Control Levels on Soybean
522899 Single-Kernel Physical Properties and Wheat Millability Hardness
522906 Utilization of Corn, Grain Sorghum, and Wheat in the Production of Plastic Goods
522907 *(number applies to title above)*
522918 Starch Thermoplastic Project KVAC
527676 Effect of Single-Kernel Physical Properties of Wheat on Milling and Energy Requirements
527684 *(number applies to title above)*
527685 *(number applies to title above)*
527686 *(number applies to title above)*
527698 Water Conservation—Increased Efficiency in Usage
527699 Value-Added Thermal Processing Laboratory
527700 Development of Small-Scale Wet-Processing Lab Facility for Wheat and Other Kansas Grains for Food and Nonfood Uses, Phase II
527704 Evaluating Field-Scale Atrazine and Alachlor Movement in Surface Water in Northeast Kansas
R847 Forestry Investigations in the Great Plains of Kansas
H893 Single-Kernel Physical Properties and Wheat Millability Hardness
H007 Irrigation Water Movement in Silty Clay Loam Soil
H053 Bioenvironmental Control System for Enclosed Spaces
H066 Quantifying the Spatial Variation of Yield for Kansas Crops
H123 Spatially Variable-Rate Herbicide Application in Kansas Winter Wheat Fields
F195 Improvement of Thermal Processes for Foods
H422 Efficient Surface Irrigation Systems
H469 Laboratory Mill for Wheat Grinding Tests
H721 Gathering, Cleaning, and Yield Mapping Processes in Grain Harvesting
H862 Efficient Irrigation and Drainage Systems
H896 Crop Sequences, Fertilizer N, and Weed Control Effects on Corn and Soybean
H899 Evaluating Practices for Water Quality Enhancement
H946 Effects of Soil Compaction on Soil Physical Properties and Crop Growth
H962 Analysis of Soybean Meal Flow Characteristics
R993 Agronomy/Agricultural Engineering Experiment Fields Research

■ *Biology*

481865 Epizootic Potential of Lyme Disease in Kansas
526579 Mycorrhizal Mediation of Plant Competition and Community Structure
526580 Fire, Grazing, and Climatic Interactions in Tallgrass Prairie
526583 Establishment and Operation of the Kansas Cooperative Fish and Wildlife Research Unit
526589 Stomatal and Photosynthetic Responses in Crop Species to Variable Sunlight
526591 Mechanisms of Persistence in Tallgrass Prairie Forbs: An Experimental Approach Coupled with a Retrospective Analysis of Long-Term Patterns
526593 Methane Emissions from *Typha* Wetlands along a Latitudinal Gradient
526594 An Evaluation of Low-Input Sustainable Agriculture for Wildlife Habitat
526595 Influence of Animal-Generated Disturbances on Multi-Scale Patterns of Resources and Vegetation
526596 Synchrocell Project for the Commercial Development of Biologicals
526597 Productivity of Avian Species in Diverted Farmland
526598 REU Supplement to Fire, Grazing, and Climatic Interactions in Tallgrass Prairie
526599 REU Supplement in Conservation Biology: Mechanisms of Persistence in Tallgrass Prairie Forbs
526601 Function and Assembly of the Accessory Subunits of Photosystem I
526602 Interaction of Photosystem I with Its Electron Donor and Acceptor
526603 Regulation of Glutamine Synthetase in Legumes
526604 Culture of Crayfish in the North Central Region
526606 Effects of Earthworms on Nitrogen Cycling Processes and Decomposer Community Structure in Organic-Based and Conventional Agroecosystems
526607 Molecular Analysis of Homeotic Genes in *Tribolium*
526608 Effects of Altered Soil Moisture and Temperature on Soil Communities, Primary Producers, and Ecological Processes in Grassland Ecosystems
526609 Molecular Requirements on Type-IV Human Collagen-Induced Interferon-Y Production
526611 Role of the HSP70 Homologue from Chloro-plasts in the Assembly of the Photosynthetic Apparatus
526612 Lipid Metabolism in the Hibernating Marmot
526614 The Genetic Control of Developmental Decision
526615 Topology and Assembly of the Photosystem 1 Reaction Core
526616 Ultracentrifuge for Molecular Plant Biology Research
526617 Transgenic Technology Applied to Basic Science in Agriculture
526618 Evaluation of Wildlife Management Practices on Fort Riley
526619 Effects of Record Precipitation Inputs on Soil-Plant Relationships in Tallgrass Prairie
526620 Planning Activities: Development of a Master Plan for Konza
526621 Use of Conservation Research Program (CRP) Land by Pheasants
526622 The Cultivation of *Cryptosporidium parvum* in Vitro
526623 MHC Control of DC4 T-Cell Function
526624 Mycorrhizal Mediation of Grassland Biotic Interactions
526625 Effects of Earthworms on Nitrogen Cycling
526626 REU Supplement—Effects of Record Precipitation/Prairie
526627 Estimating Effects of Ultraviolet Irradiance in Streams

526628 Mycorrhizal Mediation of Grassland Biotic Interactions
526630 Research of Iodinated Resins in Air and Water
529016 Molecular Genetics of Human Ribosomal Proteins
529060 Studies in Polyoma Transformed Cells-Virion Proteins
529223 In Vitro Studies on *Cryptosporidium*, an Opportunistic Infector of AIDS Patients
529242 Proteins of *Cryptosporidium*, an Opportunistic Infector of AIDS Patients
529243 *(number applies to title above)*
529267 Bioserve Space Technologies—A NASA Center for the Commercialization of Space
H001 Regulations of Animal Cell Proliferation
H002 Glutamine Synthetase from Root Nodules of Legumes
H008 In Vivo Analysis of Functional CD4 T-Cell Subsets
H011 Regulation of Mammalian Protein Gene Expression
H048 Konza Prairie Research Natural Area Vegetation Research
H049 Function, Assembly, and Regulation of the Photosynthetic Apparatus
H054 Use of Iodinated Resins to Disinfect Water Supplies in Poultry and Swine Production
H057 Membrane Lipid Interactions with the EGF Receptor
H078 *Tribolium castaneum* as a Model Genetic System for the Coleoptera
H105 Vegetation Responses to Cattle and Bison Grazing on Tallgrass Prairie
R170 Studies on the Flora of the Grasslands
F280 Regulation of Photosynthetic Processes
F709 The National Atmospheric Deposition Program
H788 Electrophoretic Characterization of *Cryptosporidium parvum*
481881 Molecular Requirements of T Helper TH-1 and TH-2 Antigen Recognition in Vivo
F849 Pathogenesis, Epizootiology, and Control of Avian Respiratory Diseases
H852 In Situ Immunity in Infectious Diseases
H863 Crayfish Culture in Kansas
R927 Transmission Electron Microscope Service Facility
F940 Avian Species in Diverted Farmland
H971 Interaction of Wheat Fungal Diseases on Yield Determinations
H996 Cell Killing by Sindbis Virus

Chemical Engineering

H113 Gasification/Pyrolysis of Wood and Grain
H898 Modern Systems Techniques for Value-Added Processes of Grain and Grain Products

Civil Engineering

527573 State Short-Line Railroads and the Rural Economy
527954 Bioremediation of Hydrocarbon-Contaminated Soils Using Vegetation: A Field and Greenhouse Study
527955 Water Quality Assessment of Banner Creek Watershed
527956 Inspection of Principal Spillway Conduits in Wisconsin
H132 Effect of Vegetation on Leaching of Heavy Metals from Mine Tailings
H314 Impact of Colloid-Associated Transport of Pesticides on Groundwater Quality

Clinical Sciences

481864 Pharmaceutical Inactivation of Endotoxin from Gram-Negative Bacteria
481875 Can RRNA Probes Diagnose Ruminal Dysfunction before Health Is Affected?
481876 Bovine Pneumonic Pasteurellosis: Immunity and Pathogenesis
481883 On-Farm Food Safety and Environmental Monitor
528260 Virulence Factors of Salmonellas in Greyhound Dogs
528756 A Safety Study of Formula I in Dogs
528757 Dermal Safety Study in Dogs and Cats on Carpet Deodorizer
528759 Role of the Equine Pancreas in the Pathogenesis of Colic in Quarter Horses
528760 Safety Study of Flea Carpet Powder Product in Dogs and Cats
528762 Dermal Safety Study in Dogs and Cats on Carpet Deodorizer (Pet Fresh)
528763 Dermal Irritation and Sensitization Study of Pet Fresh II Carpet Deodorizer in Dogs and Cats
528764 In Vitro and in Vivo Identification of Polysulfated Glycosaminoplycan in Serum and Synovial Fluid of the Racing Greyhound
528765 The Influence of Intratendinous Sodium Hyaluronate on Tendon Healing in Horses
528766 Dermal Safety Study of Improved Pet Fresh in Dogs and Cats
528767 Comparison of Sensitivities to Various Ionophores of Strains of Lactic Acid-Producing Bacteria from the Bovine Rumen
528768 Contract to Conduct Statistical Analysis Activities for the Metal Multi-Site Study Cherokee County Subsite in Galena, KS
528769 Safety Study of Ceramic Superconductors with Rats
528770 A Dermal Irritation and Sensitization Study in Cats on Cat Litter Deodorizer
H074 Dust, Ammonia, and Dust-Associated Ammonia in Swine Confinement Buildings
H080 Advancement in Bovine Orthopedics
H082 On-Farm Computer Program for Monitoring the Use of Livestock Production Chemicals
H116 Epidemiology of Reproductive Performance of Kansas Dairy Herds
H739 Cow/Calf Nutrition and Management in Kansas
H765 Pelvic Area of Bulls as a Predictor of Maternal Calving Ease
H769 Determination of the Inheritability of Episodic Weakness due to Hyperkalemia
H897 Management Systems for Optimizing Beef Production
F990 Prevention and Control of Enteric Diseases of Swine

Clothing, Textiles and Interior Design

528044 Use of Natural Sorbent Materials for Pesticide Spill Cleanup
528005 GIS Technology: A New Approach to Modeling Rural Trade Area Capture
H012 Solid Waste Management in the Foodservice and Hospitality Industry
R014 Successful Coping Strategies of Rural Communities
F025 Assessment of the Environmental Compatibility of Textiles and Other Polymeric Materials
H326 Development of Biogeneric Polymers from Agricultural-Based Carbohydrates and Polypeptides by Solvent Spinning Techniques
F708 Enhancing Health and Safety through Textile Systems
F768 Rural Retailing: Impact of Change on Consumer and Community

Dean of Agriculture

525056 High Erucic Acid Development Effort—Crambe and Rapeseed
525057 Agricultural Research Activities (Research Apprenticeship in High School Studies)
525063 Feasibility Study for Establishment of Ethanol Testing
H466 High Erucic Acid Development Effort—Crambe and Rapeseed

Dean of Human Ecology

R770 Advances in Human Ecology Research

Director of Research

520208 Cooperative Educational Preceptorship Program for University Students to Gain Specialized on-the-Job Knowledge and Experience in Various Research Projects in the Agricultural Sciences
520209 Agricultural Research Activities
525053 Mid-America World Trade Center Support for Agricultural Products
H397 Planning and Coordination of Cooperative Research
R403 Agricultural Research Publications
F573 The Planning and Coordination of Cooperative Regional Research

Entomology

520100 Insecticide Management of Foliar and Stalk-Boring Insects Affecting Alfalfa, Corn, and Soybeans in Northeastern Kansas
520103 Chemical Control of Insect Pests of Corn and Other Field Crops, Small Grains, and Forages
520347 Insecticide Management of Field Crop Insects in Southwestern Kansas
520709 A Geographical Information System Procedure for Pesticide Impact Assessment
522266 Development of Grain and Forage Sorghums Resistant to Chinch Bug
522284 A Recombinant Map of Virulence Genes in the Hessian Fly
522289 Endogenous Factors an Chemical Cues Influencing Behavior of Hessian Fly
522290 The Role of Parasitoid Factors in Developmental Disruption of Multiple Hosts
522292 Catecholamine Metabolism for Insect Cuticle Tanning
522293 Genetics and Bionomics of Organophosphate Resistance Mediated by Two Esterase Systems in the Greenbug
522307 Density and Origin of Urban Flies which Threaten Livestock Operations
522308 Testing for Greenbug Biotype and Resistance
522310 Assessing the Integration of Several Control Tactics to Manage Spider Mites in Corn
522312 Bacteria in Filth Flies in Greyhound Kennels and in Airborne Insect Particles Generated by Insect Traps
522314 Evaluation of Insecticide Alternatives for Control of Cutworms, Aphids, and Other Pests of Wheat
522316 Ecology of Screwworms in Panama
522318 Methods for Control of Livestock Insects
522320 A Geographical Information System for Pesticide Impact Assessment
522321 Aphid Biological Control for Greenhouse/Cut Flower Crops
522323 Assessing the Integration of Several Control Tactics to Manage Spider Mites in Corn
522324 Evaluation of *Tyta luctuosa* for Biological Control of Field Bindweed
522325 Evaluate the Efficacy of Ecogen's *Bacillus thuringiensis*-Based Products

522326 Chemical Signal Interception by Insect Antennae
522327 Elucidating the Mechanisms of Mating Disruption for the Artichoke Plume Moth
522328 Development of Sorghum Germplasm with Enhanced Tolerance to Greenbug Sugarcane Mosaic Virus and MDMV
522329 Assessing the Integration of Several Control Tactics to Manage Spider Mites in Corn
522330 Assessing the Potential for Biological Control of Field Bindweed (*Convolvulus arvensis*) with the Gall Mite *Aceria*
522331 Monitoring the Distribution and Testing Insecticides for Control of Insecticide-Resistant Greenbugs
522332 Control of the Corn Rootworm in Experiments with Ecogen Products
522335 Response of Cat Flea Larvae to the KSU Flea Trap
522336 Insect Physiology and Biochemistry
522337 Arboviral Surveillance in 1993 Flood-Affected Areas
522339 Evaluation of European Corn Borer Injury and Yield Effects in Corn
522343 Genetic and Molecular Analysis of Anterior Development in *Tribolium castaneum*
H033 Biosystematics of Insects and Arachnids
H036 Corn, Sorghum, and Wheat Arthropod Pests and Their Management
F083 Biological Control in Pest Management Systems of Plants
H101 Biology and Control of Arthropod Pests on Corn in Southwestern Kansas
H118 Evaluation of *Gryon pennsylvanicum* for Biological Control of the Squash Bug
H128 Molecular Systematics of the Hymenopteran Family Aphidiidae
F144 Biology, Ecology, and Population Management Strategies for Muscoid Flies Affecting Cattle
H548 Grasshopper Feeding and Plant Chemistry
H564 Biology, Distribution, and Control of Insects Affecting Man and Animals
H613 Within-Plant Distribution and Sampling of Two Mite Species on Corn in Kansas
H741 Mechanisms of Insect-Plant Interactions: Sorghum Resistance to Insect Pests
H766 Genetics of Biotypes in the Hessian Fly (*Mayetiola destructor*)
H776 Resistance of Wheat and Sorghum Arthropod Pests and the Control of Horn Flies
H789 Reproductive Strategies in the Hessian Fly
H797 Evaluation of Factors Affecting Biological Control of the Squash Bug
R826 Scanning Electron Microscope Service
F942 Integrated Crop Management Effects on Stalk-Boring Lepidoptera

■ *Foods and Nutrition*

528108 Food Product Development
528111 Zinc Deficiency: Its Effect on Vitamin A Transport
528124 Effects of Copper on Cholesterol Metabolism in Ovariectomized Rats
528125 Utilization of Wheat Protein in Films and Coatings
528129 Antioxidative Effect of Selected Antioxidants Obtained from Natural Sources for Soybean Oil
528130 Odor Evaluation of Pet Foods
528132 Consumers' Perceptions of Pan Bread Quality
R017 Factors Affecting Functional Independence of the Oldest-Old in Rural Kansas
H070 Sucrose Loading Effects on Cognitive Function in Young Adults
F072 Behavioral and Health Factors that Influence the Food Consumption in Young Adults
H130 Sensory/Physical Assessments of High-Fiber Snack Foods to Improve Oral Health
R131 Sensory Analysis Consulting for KAES Scientists
F195 Improvement of Thermal Processes for Foods
F628 Development of New Processes and Technologies for the Processing of Poultry Products
H698 Innovative Red Meat Production and Processing Systems for the Modern Consumer
H851 Nutritional Status and Physical Activity of Older Rural Women Living Alone
H934 Effect of Zinc Deficiency on the Metabolism of Retinol
F945 Health Maintenance Aspects of Dietary Recommendations Designed to Modify Lipid Metabolism

■ *Grain Science and Industry*

520150 Large-Scale Milling and Baking Trials of New Wheat Varieties
522861 Factors Controlling the Viscosity of Batter Systems
522877 Computer Interface to the Mixograph
522885 Evaluation of End-Use Properties of Hard Winter Wheat Breeders' Progenies
522894 Extrusion Technology for Food Applications of Soybeans
522896 International Grains Program Support Project
522898 Prediction of Wheat Milling Performance
522899 Single-Kernel Physical Properties and Wheat Millability Hardness
522902 Optimization of Technical Parameters for Milling of Debranned Wheat
522906 Utilization of Corn, Grain Sorghum, and Wheat in the Production of Plastic Goods
522907 *(number applies to title above)*
522909 Determination of Factors Controlling Crumb Grain of Bread
522910 Thermal and Mechanical Properties of Dough-Based Foods
522911 Removal of Bran from Wheat Flour
522918 Starch Thermoplastic Project, Kansas Value-Added Center
522920 Chlorine Replacement of Cake Flour
522924 Effect of a Fat Replacer on Bread Firming
522925 Reducing Stability Problems Associated with High Urea Pellets
522928 Development of Mechanisms for the Rapid Loss of Mixing Tolerance
522929 Wheat Starch Modification
522932 Research on Milling of Grain Sorghum
522934 Novel Bread Baking via the HTST Extruder
522935 Use of Kansas Wheat in Chinese-Style Noodles: Heat-Moisture Treatment of Wheat
522936 Treatment of White Wheat Bran to Improve Bread Making Performance
522939 Research and Product Development on Grain-Based Foods
522942 Factors Affecting the Extrusion of Cereal-Based Foods
522943 Replacing Marine Meals with Wheat-Soy in Shrimp Diets
522945 Quality Evaluation of Materials from KAES Wheat Breeding
522946 Evaluation of Kansas Wheats in Oriental Noodles/Pasta Type
522948 Utilization of Wheat in Starch Thermoplastics Technology
522950 Mechanism of Glucose Oxidase in Bread Making
522951 Application in Flour Milling of Shenango Die Cast Rolls
522952 Microbial and Yeast Feed Additive Survivability during Pelleting
522953 Comparative Study of Pellet Binders in Turkey and Swine Production
522954 Fluorescence Microchemical Analysis of Fiber Alignment
522955 Value-Added Wheat Products
522956 Development of a Bromate Replacement System
522957 Alveograph as a Predictor of Hard Winter Wheat Quality
525170 Database of Funded Research on Corn Quality and Utilization
525182 Data Base Searches for Corn Utilization Research
525186 Southeast Consortium for International Development-Haiti: Productive Land Use Systems Project
525187 El Salvador Private Basic Grains and Edible Bean Markets
525188 Crop Utilization Research Database—Wheat Option
525190 Food and Feed Grains Institute Program
525194 Technical Assistance for Famine Mitigation Relief/Iraq
525195 Research on Latin-American Grain-Based Food Companies
525199 Crop Postharvest Handling Analysis
525754 Canola Research
525958 *(number applies to title above)*
H018 Optimum Processing to Maximize Utilization of Cereal Grains in Swine Feeding
H051 Improvement of Bread Quality: Kansas High Protein Wheats for Frozen Dough and Specialty Breads
H063 Development of Hard White Winter Wheat Varieties for Kansas
F072 Behavioral and Health Factors that Influence the Food Consumption in Young Adults
H117 Early Generation Wheat Quality Testing
F124 Occurrence of Mycotoxins and the Implications to Animal Health and Human Health
F213 Marketing and Delivery of Quality Cereals and Oilseeds
R600 Agriculture Institute - International Grains Program
H668 Functional Properties of Certain Components from Cereals in Baked Products
H696 Effect of Kernel Hardness on Wheat Millability
F711 Market Quality of Hard Wheat for Domestic and International Foods
H778 Improvement of Bread Quality: Role of Fats in Bread Staling
H822 Kansas Wheat Quality Profile
H823 Large-Scale Milling and Baking
H827 Influence of Wheat Type, Flour Extraction, and Formulation on Quality of Leavened Flat Bread
H844 Effects of Processing on the Nutritional Impact of Dietary Fiber
H867 Wheat Utilization: Nonfood and Nonfeed Uses
H868 Infrared Wheat Protein Screening
H883 New and Nutritionally Improved Food Products from Wheat and Other Cereal Grains
H888 Factors Affecting the Baking Quality of Whole Wheat Bread
H893 Single-Kernel Physical Properties and Wheat Millability Hardness
H898 Modern Systems Techniques for Value-Added Processes of Grain and Grain Products
H959 End-Use Objective Quality Determination in Grain Processing
H960 Utilization of Cereal Co-Products in Animal Feed Processing
H962 Analysis of Soybean Meal Flow Characteristics

Horticulture, Forestry and Recreation Resources

520152 Turfgrass Investigations
520163 Herbicides for Weed Control around Woody Plants
520165 Evaluation of Garlon 3A Herbicide and Related Formulations
520166 Great Plains Energy Forest
523860 Pecan Cultivar Evaluation
523862 Efficacy of Insecticides against Vegetable-Feeding Insect Pests
523869 Turfgrass Water Conservation in Kansas
523870 The Evaluation and/or Assessment for Turfgrass
523871 Stress Tolerance and Tatter Resistance of Sugar Maple Cultivars
523872 Root Control of Selected Container-Grown Landscape Plants
523873 The Evaluation and/or Assessment for Turfgrass
523874 *(number applies to title above)*
524057 The Evaluation and/or Assessment for Turfgrass—1992 Official Tall Fescue National Test
H012 Solid Waste Management in the Foodservice and Hospitality Industry
H023 A Study of Chilling Injury in Susceptible Plant Species
H044 Climate and Weather Effects on Woody Plant Growth and Development
H065 Sustainable Intensive Vegetable Production Using Legumes, Manures, and Municipal Compost as Fertilizer Sources
H067 Turfgrass Water Conservation in Kansas
H102 Evaluation of Grape and Red Raspberry Cultivars for Kansas
H127 Determining Drought and Salinity Stress Tolerance Mechanisms of Turfgrass
F135 Seed Biology and Technology Investigations
H640 Herbaceous Ornamental and Native Perennial Plant Species as Florist Crops
F710 Improved Systems of Control for Pecan Arthropod Pests
R732 Adaptation, Propagation, and Stress of Ornamentals and Turfgrass in South-Central Kansas
M742 Tree Improvement for Kansas
H783 Evaluation of Landscape Plants for Kansas
R814 East Central Kansas Horticulture Field
H856 Studies on the Cold Hardiness of Peach Flower Buds and Grapes
H875 Pecan Experiment Field
M876 Woody Biomass Energy Plantations: Seedling Production, Establishment, and Growth
M892 Kansas Landowners' Rationale for Windbreak Establishment, Maintenance, or Removal
H901 In Vitro Propagation and Culture of Ornamental Plants
F938 Freeze Damage and Protection of Fruit and Nut Crops
H979 Overcoming Iron Chlorosis and Planting Shock in Oak Species Using Polyacrylamide
F991 Rootstock and Interstem Effects on Pome and Stone Fruit Trees
H997 Commercial Greenhouse Crops to Complement Spring-Grown Bedding Plants

Hotel, Restaurant and Institution Management and Dietetics

H012 Solid Waste Management in the Foodservice and Hospitality Industry
H069 Applying Expert Systems Technology to the Implementation of a Forecasting Model in Foodservice

Human Development and Family Studies

528055 Evaluation Proposal for the Head Start Family Service Center Demonstration Project
528056 Arboviral Surveillance in 1993 Flood-Affected Areas
R014 Successful Coping Strategies of Rural Communities
R017 Factors Affecting Functional Independence of the Oldest-Old in Rural Kansas
H028 Identification and Assessment of a Rural Helping Network
H110 Parent Development, Home Environment, and Young Children's Development
H915 Ecological Factors Affecting Rural Children's Mental and Social Development
H930 Monitoring the Pulse of Kansas Families
H931 Factors Affecting the Transition to Adulthood in Contemporary Rural Settings

Kansas Water Resources Research Institute

525419 The Economic Impacts of Water Supply Reductions
525420 Development of a Watershed Scale Flow Model
525421 Water Use Efficiency of New Warm-Season Turfgrass
525422 Narrow Corn Row Spacing for Cost Effective Water
525423 Existing and Economic Aspects of Kansas Water Markets
525424 Role of Methanotrophic Bacteria in Kansas Reservoirs
525425 Effects of Soil Variability on Nitrate Transport

Pathology and Microbiology

481868 Vaccine Potential of *P. haemolytica* Growth Condition-Dependent Antigens
481872 Immunologic Intervention against *Streptococcus suis* Infections
481873 Molecular Biological Investigations of Bovine Herpesvirus Type I Pathogenesis
481874 Eradication of Economically Important Swine Diseases by Medicated Early Weaning
481876 Bovine Pneumonic Pasteurellosis: Immunity and Pathogenesis
481877 Mediation of Bovine Herpes Virus I Infection by Growth Factor Binding Proteins
481879 Molecular Approaches to Identify RSV and Study Cell-Mediated Responses in Cattle
481880 Is C-Reactive Protein the Best Indicator of Stress in Pigs?
481885 Mediators of *Actinobacillus pleuropneumonia*-Induced Permeability in Porcine Pulmonary Endothelium
520321 Pathogenesis and Diagnosis of Congenital Defects in Cattle
528255 Characterization of *Salmonella*, *C. jejuni*, and *E. coli* Recovered from Greyhounds and Greyhound Diets
528257 Anti-Idiotypic Immunity and Receptor Interactions in Bovine Respiratory Disease
528261 Confirm Efficacy of MK-324 as (MPA) Parasites in Dogs
528262 Molecular Studies on BIV and BHV Interactions
528263 Evaluate the Effects of Pitman Moore Insecticides/Cat Fleas
528265 Confirming Cause of "Alabama Rot" in Greyhounds
528359 Purification of Bovine Neutrophil Acyloxacyl Hydrolase
528365 Bald Thigh Syndrome in Greyhounds
528366 Greyhound Race Track Deaths
528367 Babesiosis in Kansas Greyhounds
528370 Amplification of *Cryptosporidium* DNA for Assessing Agricultural Waste
523871 *Cryptosporidium parvum*/Enterocyte Interactions
H010 Bovine Herpesvirus Type I Molecular Pathogenesis
H050 Identifying BRSV by RNA Polymerase Chain Reactions and Hybridizations
H055 Resistance to Bacterial Respiratory Diseases: Efficacy of Local Immunization
H059 Temperature Regulation of Virulence of *Salmonella typhimurium*
H060 Transmission and Control of Nematode Parasites in Kansas Greyhounds
F068 Genetic Enhancement of Health and Survival for Dairy Cattle
H125 Microsatellite Mapping of Deleterious Genes in the Bovine Genome
F285 Improving Dairy Cattle Genetically
F644 Integrated Methods of Parasite Control for Improved Livestock Production
H739 Cow/Calf Nutrition and Management in Kansas
H769 Determination of the Inheritability of Episodic Weakness due to Hyperkalemia
H777 Immunological Expression of Proteins Pertinent to Bovine Respiratory Syncytial Virus
H794 A Search for Restrictive Fragment Length Polymorphisms (RFLP) in Bovine Genome
F831 Bovine Respiratory Diseases: Risk Factors, Pathogens, Diagnosis, and Management
H907 Development of an Assay for Porcine Transferrin Receptors
H958 Antigens Responsible for Infection-Acquired Immunity to Porcine Pleuropneumonia
H994 Serotype Specific Antigens of *Rhodococcus corynebacterium equi*

Plant Pathology

520194 Characterization of *Fusarium moniliforme* Populations Isolated from Corn in Kansas
520199 Soybean Foliar Fungicide and Seed Treatment Tests
520201 Evaluations and Testing of Fungicides and Nematicides on Horticultural Crops
520202 Seed Treatment
520205 Chemical Control of Phytoparasitic Nematodes
520412 Breeding Sorghum for Tolerance to Fusarium Stalk Rot
520669 Breeding Soybeans for Increased Productivity
524460 Use of Oligonucleotide Synthesizer
524470 Breeding Soybeans for Increased Productivity
524478 Fusarium Research
524490 Increasing Soybean Production through the Use of Cyst Nematode-Resistant Cultivars
524492 Wheat Genetics Resource Center and Its Contributions to Kansas Wheat Industry
524498 Identification and Quantification of Nematodes in Interaction with Bacterial and Fungal Incitants in Stalk Rot Complexes of Millet
524502 Winter Wheat Seed Treatment Tests
524504 Molecular Diagnostics for *Xanthomonas campestris* pv. *oryzicola*
524505 Analysis of the RPL Locus of Maize
524506 Ecological Effects of Microorganisms Applied to Crop Residues
524508 Sorghum/Millet Collaborative Research Program with the Egyptian National Ag Research Program (NARP)
524510 Molecular Cytogenetic Analysis in Wheat
524516 The Turnip Crinkle Virus Capsid Protein as a Plant Pathogenic Determinant
524519 Molecular Basis of Production of Fumonisin on Corn Infected with *Fusarium moniliforme*
524521 Using Cultural Practices to Reduce Soybean Cyst Nematode and Charcoal Rot Damage in Soybeans

524522 Gene Tagging and QTL Mapping in Hexaploid/ Diploid Wheat Crosses
524523 Cytogenetically Based Physical Map of Wheat Genome
524524 Development of a High Density Chromosome Map Using Region-Specific Libraries
524525 Development of an RFLP Linkage Map for Cultivated Wheat
524529 The Role of AVRXA10 in Host Recognition of a Bacterial Pathogen of Rice
524530 Compilation of a Wheat Cytogenetic Mapping Database
524532 Novel Strategies for Disease-Resistant Rice: Physiological Basis for Resistance to Bacterial Blight
524533 Tracking and Identification of Genetic Diversity within Populations of *Fusarium* Section *Liseola* from Corn
524534 U.S.-Japan Seminar: Classical and Molecular Cytogenetic Analysis of Cereal Genomes: March, 1994, Manhattan, KS
524535 Wheat Genetics Resource Center at Kansas State University
524536 Ecological Effects of Microorganisms on Crops
524537 Analysis of Antifungal and Herbicide Activities of a Biocontrol Bacterium
524538 Improvement of Soybean via Biotechnological Approach
524540 North Central Soybean Cyst Nematode Research Project
524541 Inheritance of Mycorrhizal Dependence in Wheat
524542 Mechanisms in the Biocontrol of Grass Weeds/ Rhizobacteria
524544 Application of Rhizobacteria for the Biocontrol of Weeds
524548 Myco-Pharmaceuticals
524549 Effects of Timing of Foliar Fungicides and Winter Wheat Genotype on Large Seed Production
524550 Characterization Mapping of Five New Leaf Rust Resistant Genes
524551 Gene Tagging and QTL Mapping in Hexaploid/ Diploid Wheat Crosses
524552 North Central Soybean Research Program
524554 Research Collaboration Group on Molecular Mapping in Wheat
526396 Using Cultural Practices to Reduce Soybean Cyst Nematode and Charcoal Rot Damage in Soybeans
527954 Bioremediation of Hydrocarbon-Contaminated Soils Using Vegetation: A Field and Greenhouse Study
F005 Interaction of Nematode - Host Variability and Abiotic Factors on Crop Losses
H021 Development of Productive, Disease-Resistant Soybean Varieties
H022 Crop Improvement through Cell Culture and Genetic Engineering
H058 Molecular and Genetic Characterization of a Gene Controlling Avirulence
H081 Genetic Analysis of the Mechanisms of Weed and Pathogen Biocontrol by Rhizobacteria
H107 Genome Mapping and Tagging of Useful Genes in Wheat
H547 Genetics and Physiology of *Fusarium* spp.
R732 Adaptation, Propagation, and Stress of Ornamentals and Turfgrass in South-Central Kansas
H772 Fungal Diseases of Wheat and Their Control
H858 Genetic Analysis of Disease Resistance in Maize
H895 Etiology, Epidemiology, and Control of Sorghum Diseases
F923 Biocontrol of Soil-Borne Plant Pathogens
H961 Genetic Investigations of Pest Resistance in Alfalfa
H971 Interaction of Wheat Fungal Diseases on Yield Determinations
H975 Mycorrhizal Symbiosis: Potential for Bioremediation of Heavy Metal-Contaminated Soil
H977 Assessment of Yield Losses to Multiple Diseases of Winter Wheat
H986 Assessment of Grain Sorghum Yield Loss by Sooty Stripe (*Ramulispora sorghi*)
H989 Pathogenicity Determinants Carried by TCV and WSMV Capsid Proteins
H992 Reduction of Straw-Borne Tan Spot Inoculum in Conservation-Tillage Residue

■ *Sociology, Anthropology and Social Work*

527623 From Research Knowledge to Community Action: Toward the Application of Research Knowledge to Effective Community Action
527624 Consequences of Rural Population Decline in the Great Plains
R020 Potential for Incorporating the Kansas Farmer in the Agricultural Research Process
H034 Cancer Morbidity among Kansas Farmers
H115 The Effects of Economic and Social Restructuring on Well-Being in Nonmetropolitan Kansas
H129 New Kansans: Immigrant Minority Students and School Adaptation Patterns
F939 Community Change and Resistance: A Restudy of the Rural Life Study Series

■ *Statistics*

527606 Analysis and Interpretation of Insect Ecology and Control
527608 Assessing the Potential for Biological Control of Field Bindweed with the Gall Mite and a Moth
527609 Design and Analysis of Experiments that Involve Multiple Processing Steps
R825 Statistical Laboratory

■ *Veterinary Diagnostic Investigation*

481874 Eradication of Economically Important Swine Diseases by Medicated Early Weaning
528900 Eradication of Swine Respiratory Pathogens by Medicated Early Weaning
528902 Vitamin E-Adjuvanted Vaccination Immune Response in Racing Greyhounds
H018 Optimum Processing to Maximize Utilization of Cereal Grains in Swine Feeding
H799 Respiratory Disease and Environmental Stress in Food Animals
F990 Prevention and Control of Enteric Diseases of Swine

■ *Veterinary Medicine*

528950 Determination of the Immunoenhancing Effects of Recombinant Bovine Interleukin-1B in Cattle Utilizing *P. haemolytica* Challenge Model
R650 Exploratory Research in Animal Health and Disease

■ *Agricultural Research Center-Hays*

520239 Breeding for Wheat Improvement and Wheat Pest Control in South-Central Kansas
525953 An Alternative to Landfills for Disposal for Yard Waste and Newspaper
525954 Genetic Development of Higher Disease Resistance and Grain Protein in New Wheat Varieties
525955 Pearl Millet Breeding KS-101
525956 Triasulfuron in Winter Wheat in Kansas
525957 Broadleaf Weed Interference in Winter Wheat
525958 Canola Research
525959 Native Soil Bacteria as Selective Weed Control Agents in Wheat
525961 Biological Control of Winter Annual Grass Weeds in Winter Wheat
525962 Crambe: Evaluation of Swathing Practices in Kansas
525963 Development of Sorghum Germplasm with Enhanced Tolerance to Greenbug Sugarcane Mosaic Virus MDMV
525964 Biocontrol Project for Downy Brome Control in Wheat
H046 Genetics and Breeding of Sorghum
H062 Improvement of Pearl Millet, Sunflower, and Rape
R252 Beef Cattle Feeding Investigations
R255 Beef Cow Herd Management
R291 Management of Soil in Dryland Regions
R645 Managing Range to Increase Forage-Conversion Efficiency
H739 Cow/Calf Nutrition and Management in Kansas
H846 Genetic Improvement of Wheat
R847 Forestry Investigations in the Great Plains of Kansas
H869 Pathogen-Host Investigations in Wheat, Sorghum, and Sunflower
H978 Weed Management and Control Investigations

■ *Northwest Research-Extension Center*

520365 Sunflower Performance Testing Program
520722 Canola Research
520727 Tillage, Irrigation, and Hybrid Maturity Class Effects on Corn Production
525752 Winter Rape Testing Project
525754 Canola Research
525755 Characterization of Overwinter Nitrate Nitrogen Leaching Potential in Northwest Kansas
525756 Sunflower Date of Planting and Plant Population Studies
525757 Tillage, Irrigation, and Hybrid Maturity Class Effects on Corn Production
525758 Water Conservation-Increased Efficiency in Usage
525759 Integrated LEPA Sprinkler Irrigation and Fertigation Management to Preserve Water Quality
525760 Increasing Subsurface Dripline Aeration with the Mazzei Differential Pressure Injector
F094 Micro-Irrigation for Optimum Crop Productivity and Minimum Groundwater Contamination
H095 Water and Nitrogen Management Using Sprinkler and Subsurface Drip Irrigation
R293 Crop Improvement in Northwest Kansas
R294 Soil Management in Northwestern Kansas
R847 Forestry Investigations in the Great Plains of Kansas
F865 Increased Prolificacy in Sheep and Its Impact on Nutritional Needs
H911 Production Methods for Increased Efficiency of Ewe-Lamb Enterprises
R956 Improving N Fertilization for a WSF Rotation in a Reduced-Tillage Environment

Southeast Agricultural Research Center

520254 Weed Control in Farm Crops
526367 Effect of Sulfur Fertilization on Tall Fescue and Winter Wheat in Southeastern Kansas
526396 Using Cultural Practices to Reduce Soybean Cyst Nematode and Charcoal Rot Damage in Soybeans
526397 Effect of Yeast Supplementation on Ruminal Fermentation Patterns
526398 Southeast Kansas Warm-Season Annual Grass Trials
526399 Double-Crop Soybean Performance Test
526401 Effect of Supplementation with Levucell SC20 on Ruminal Fermentation Patterns
526402 Development and Evaluation of Commercial Soybean Varieties for Kansas
526403 Performance by Grazing Cattle Offered Magnesium-Mica
526405 Development of Minority Student/Field Tests
H015 Evaluation of Cropping Systems for Southeastern Kansas
H030 Forage Production and Use in Southeastern Kansas
H031 Evaluations of Alternatives in Soil and Water Management Practices in Southeast Kansas
H109 Cultivar Evaluation and Cultural Practices for Soybeans in Southeastern Kansas
R174 Beef Cattle Production and Management in Southeast Kansas
R754 Use of a Legume-Grain Sorghum Rotation in a Crop-Livestock System
H914 Use of a Tall Fescue with Different Rates of *Acremonium coenophialum* Infections
R957 Phosphorus, Potassium, and Chloride Effects on Alfalfa and Birdsfoot Trefoil Establishment, Yield, and Quality

Southwest Research-Extension Center

520249 Evaluation of New Products to Improve the Efficiency of Production in Feedlot Cattle
520251 Herbicides for Weed Control on Fallow Ground
526151 Weed Control Research in Southwest Kansas
526152 Quality Testing of Fly Parasites for Cattle Feedlots
526154 Variety Testing of Alternative Crops
526155 Soil Fertility and Soil Management Research for Western Kansas
526156 Yield Appraisal of Crops for Southwest Kansas
526157 Water Management for Southwest Kansas
526161 Frost-Damaged Grain Sorghum—An Evaluation of Varying Grain Test Weight Sorghums as Livestock Feed
526164 Effect of a Previous Soybean Crop and Nitrogen Fertilizer on Irrigated Corn and Grain Sorghum Production and Profitability
526165 Cattle Feedlot Management Program
526166 Integrated Management of Stable Flies in Cattle Feedlots
526167 Tillage, Irrigation, and Hybrid Maturity Class Effects on Corn Production
526170 Water Conservation-Increased Efficiency in Usage
526171 Effect of a Previous Soybean Crop and Nitrogen Fertilizer on Irrigated Corn and Grain Sorghum Production and Profitability
526172 Low Pressure/Canopy Sprinkler Management for Corn on Slopes over One Percent
526173 Evaluation of New Products to Improve the Efficiency of Production in Feedlot Cattle
526176 Potential Sting Rate of Searching *Spalangia nigroaenea*
H029 Efficient Resource Management for Dryland and Irrigated Soils
R085 Fertilizer Management for Reduced-Tillage Dryland Winter Wheat
H101 Biology and Control of Arthropod Pests on Corn in Southwestern Kansas
R834 Irrigation Management for Southwest Kansas
R847 Forestry Investigations in the Great Plains of Kansas
H967 Dryland Cropping Systems for Southwest Kansas
H969 Crop Improvement for Southwest Kansas
H973 Developing Weed Management Systems for Southwest Kansas
H981 Pest Management of Livestock Insects in Western Kansas

F = Regional projects
H = Hatch projects
M = McIntire-Stennis projects
R = State projects
Numbers = Sponsored projects

Research Projects Terminated

Agricultural Economics

520452 Management of Stored Grain Insect Problems
520456 Kansas Value-Added Center-Ag Economics
520463 The Kansas Agricultural Economy: Trends and Perspectives
520465 Economic Impact of Zero Depletion in Northwest Kansas
522872 Management of Stored-Grain Insect Problems
526372 Agronomic Effects, Profitability, and Riskiness of Long-Term Crop Rotations in Southeastern Kansas
F071 Organization and Performance of World Food Systems: Implications for United States Policies
F773 Conservation Tillage Systems
H775 Impact of Agricultural Policy on Producers, Consumers, and Taxpayers
H781 Forage Management and Utilization
H824 Economic Analysis of the Impact of USDA Farm Programs Cropping Systems and Rural Income in Kansas
H916 An Experimental Stubble-Mulch Tillage Device for Sandy Soil
H917 Enhancing Export Opportunities for Processed Kansas Wheat and Meat Products

Agronomy

520007 Breeding White Corn for Milling Use
520053 Fertilizer Tests and Demonstrations
520667 Ash Reclamation for Kansas City Power and Light
520676 Fertilizer Recommendation Computer Software
520678 Substituting Legumes for Fallow in U.S. Great Plains Wheat Production
520680 Genetic Improvement of Winter Wheat for Kansas
520682 Determining the Force Exerted by Wheat Coleoptiles
520690 Synchrony and Contribution of Legume Nitrogen for Grain Production under Different Tillage Systems
520692 Protecting Soybean Production Using Cyst Nematode-Resistant Cultivars
520695 Using Reduced Rates of Postemergence Soybean Herbicides
520699 Evaluation of Techniques for Optimizing Ammonium Availability during Vegetative Growth Stages of Corn
520700 Management of Split N Applications of Varying NH_4:NO_3 Ratios for Optimum Corn Production
520703 Modeling Millet and Sorghum Establishment and Growth for Sustainable Crop Production
520709 A Geographical Information System Procedure for Pesticide Impact Assessment
520712 Improvement of Market Quality of Kansas Wheats by Breeding
520714 Upgrading SOYSELECT, Variety Selection Computer Software
520717 Fire Frequency and Trace Gas Flux in Grassland: Relationship to Remotely Sensed Indices of Net Primary Production
520724 Evaluation of Canola Varieties and Germplasm in Kansas
520733 Irrigation Water Conservation Program
520746 Rapeseed: Selecting for and Improving Winter Hardiness
520756 Foundation Seed Maintenance
522304 Evaluate Sorghum Germplasm for Tolerance to Biotype I Greenbug
522926 Canola Research
529147 Rangeland Plant Response to Elevated CO_2
529148 *(number applies to title above)*
538722 Improvement of Market Quality of Kansas Wheat by Breeding
F278 Integrated Irrigation Water and Nitrogen Management to Sustain Groundwater Quality and Quantity
H407 Nitrogen Fertilizer Use Efficiency
H428 Sorghum and Corn Ecology and Management
R479 Assessing Lime Needs in South Central Kansas
H574 Improvement of Eastern Gamagrass as a Domestic Forage Crop in Kansas
H595 Genetic Improvement of Corn by Breeding for Greater Production Efficiency in Environmental Stresses
H597 Physiology of Crop Plants
H620 Physiological and Ecological Response of Weeds to Control Measures
H658 Crop Improvement and Germplasm Development through Chromosomal and Cytoplasmic Manipulations
H659 Development of Premium Quality Hard White Winter Wheat Varieties
H686 Breeding Soybeans for Increased Productivity
H725 DNA Restriction Fragment Length Polymorphism Analysis
F729 Seed Production of Breeding Lines of Insect-Pollinated Forage Legumes
H730 Atrazine and Nitrate Leaching through Soil and into Groundwater
R749 Transport of Agricultural Chemicals through Soil
H781 Forage Management and Utilization
R810 North Central Kansas Experiment Field, Belleville
H842 NH_4:NO_3 Ratio Mangement on Corn
H896 Crop Sequences, Fertilizer N, and Weed Control Effects on Corn and Soybean
H916 An Experimental Stubble-Mulch Tillage Device for Sandy Soil
H926 Naturally Occurring Isotopes as Indicators of Water Source and Movement in Northeastern Kansas
R951 Rate and Timing of Nitrogen Application Interactions with Starter Fertilizer
R952 Maximizing Nutrient Use Efficiency in Dryland Cropping Systems
R953 Evaluation of Nitrogen Soil Test in Eastern Kansas
R954 Diffusion of Urea in Soils from Solid Urea and Urea Ammonium Nitrate Sources
H974 Optimum Spacing of Driplines for Drip-Irrigated Corn

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527690 Evaluating Field-Scale Atrazine and Alachlor Movement in Surface and Groundwater in Northeast Kansas
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FY93 and FY94 Kansas Agricultural Experiment Station Income and Disbursement Statement

	8.2%	50.8%	13.0%	28.0%		
FY93 FUNDING	**$3,487,985**	**$21,501,277**	**$5,510,327**	**$11,865,976**	**$42,365,565**	
	Federal	**State***	**Fees**	**Sponsors**	**Total**	
FY93 EXPENDITURES						
Faculty & Administrative Salaries	$2,426,783	$12,820,961	$397,411	$5,739,999	**$21,385,154**	**50.5%**
Classified & Student Salaries	$273,156	$5,298,409	$710,584	$1,272,387	**$7,554,536**	**17.8%**
Contract Services & Travel	$281,678	$1,367,527	$1,060,220	$2,384,494	**$5,093,919**	**12.0%**
Supplies & Material	$278,737	$1,199,597	$2,277,913	$1,531,513	**$5,287,760**	**12.5%**
Equipment	$227,631	$814,783	$1,064,199	$937,583	**$3,044,196**	**7.2%**
Other	$0	$0	$0	$0	**$0**	**0.0%**
Totals	**$3,487,985**	**$21,501,277**	**$5,510,327**	**$11,865,976**	**$42,365,565**	**100%**

	8.1%	50.0%	14.6%	27.3%		
FY94 FUNDING	**$3,493,307**	**$21,652,146**	**$6,302,287**	**$11,806,402**	**$43,254,142**	
	Federal	**State***	**Fees**	**Sponsors**	**Total**	
FY94 EXPENDITURES						
Faculty & Administrative Salaries	$2,475,059	$12,805,397	$334,251	$6,046,588	**$21,671,295**	**50.1%**
Classified & Student Salaries	$319,580	$5,495,909	$799,418	$1,262,937	**$7,877,844**	**18.2%**
Contract Services & Travel	$269,130	$1,408,960	$1,092,726	$1,713,733	**$4,484,549**	**10.4%**
Supplies & Material	$321,768	$1,252,463	$2,595,408	$1,325,557	**$5,495,196**	**12.7%**
Equipment	$107,770	$689,417	$1,470,484	$1,457,587	**$3,725,258**	**8.6%**
Other	$0	$50	$0	$0	**$0**	**0.0%**
Totals	**$3,493,307**	**$21,652,146**	**$6,302,287**	**$11,806,402**	**$43,254,142**	**100%**

*Includes MOE, IGP, and ILP

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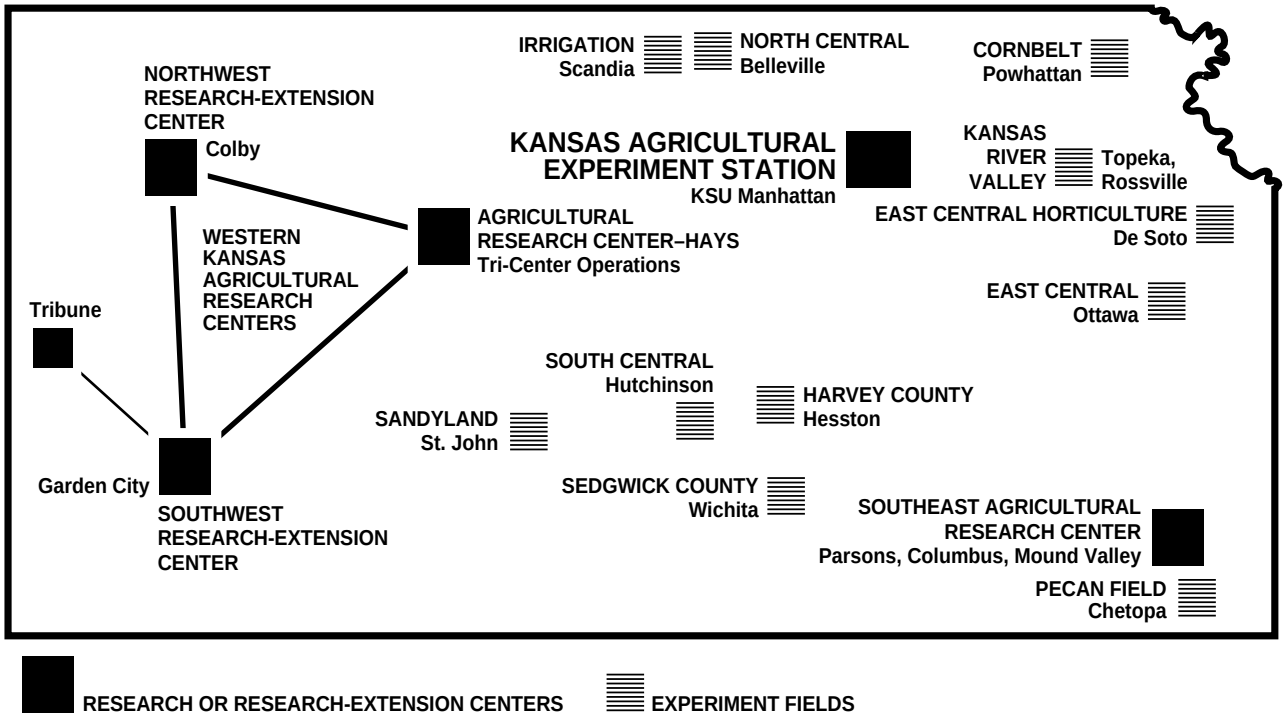
KANSAS STATE UNIVERSITY
STATEWIDE AGRICULTURAL RESEARCH SERVICES



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