Approved:_____
Date

MINUTES OF THE HOUSE COMMITTEE ON AGRICULTURE.

The meeting was called to order by Vice-Chairperson Steve Lloyd at 9:00 a.m. on January 27, 1994 in Room 423-S of the Capitol.

All members were present except: Representative Bryant - Excused
Representative Gatlin - Excused
Representative Lawrence - Excused
Representative Reinhardt - Excused
Representative Shore - Excused

Committee staff present: Raney Gilliland, Legislative Research Department
Jill Wolters, Revisor of Statutes
Kay Johnson, Committee Secretary

Conferees appearing before the committee: Marc A. Johnson, Interim Dean of Agriculture, KSU
Donald J. Roufa, Professor, Division of Biology, KSU
Karen P. Penner, Professor and Extension Specialist, Department of Foods and Nutrition, KSU
John S. Hickman, Extension Specialist and Coordinator, Environmental Quality, Department of Agronomy, KSU

Vice-Chairman Lloyd called the meeting to order and introduced Marc Johnson, Interim Dean of Agriculture from K-State University to give a report on Extension Systems and Agricultural Research Programs (ESARP), attachment #1. ESARP serves as a research and education partner for agriculture, food processors and distributors, rural communities, family and youth. With the expanding demand for ESARP services and a budget plateau, the policy of growth from within has been adopted. This will focus resources on fewer, high priority topics. Dean Johnson also discussed the use of Forums to focus efforts on solving priority problems and enhance communication and interchange across colleges and departments. Dean Johnson then introduced the individuals who would report on Biotechnology, Food Safety and Agriculture, Water & Environment.

Donald J. Roufa, Professor, Division of Biology, gave a report on biotechnology. Dr. Roufa defined biotechnology as the application of modern genetics, molecular genetics, cell biology and biochemistry and discussed the research initiatives ongoing at K-State.

Karen P. Penner, Professor and Extension Specialist, Department of Foods and Nutrition, reported on food safety, explaining that consumers expect the food they purchase to be safe, wholesome and of acceptable quality. K-State food safety research and Extension education efforts focus on pre-harvest, post-harvest and consumer levels.

John S. Hickman, Extension Specialist and Coordinator, Environmental Quality, Department of Agronomy, discussed the importance of water to agriculture. Kansas agriculture is a major user of water and can be seen as a major contributor to pollution. K-State's research and education's primary areas of emphasis are water quality, water conservation and sustainable agriculture.

A question/answer period followed. Topics discussed include minimizing pollution in beef/dairy confinement areas, the preservative effects of lactic acid on humans, who is making overall policy proposals to shape the future of rural communities, food safety in residential day care homes, the effect of BST in milk production, wheat research and irradiation of food.

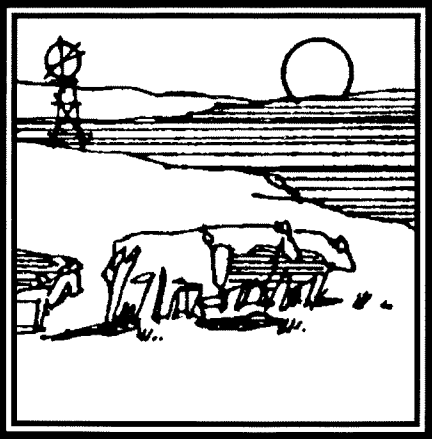
The meeting adjourned at 10:00am. The next meeting is scheduled for February 1, 1994.

THRUSTS IN 1993

BIOTECHNOLOGY

FOOD SAFETY

AGRICULTURE, WATER, AND ENVIRONMENT



A REPORT TO THE KANSAS LEGISLATURE

by the Kansas Agricultural Experiment Station
and the Kansas Cooperative Extension Service

KANSAS STATE UNIVERSITY

House Agriculture
1-27-94
Attachment # 1

KSU
KANSAS
STATE
UNIVERSITY

February 4, 1994

Dear Friends,

Our 1993 report to the Legislature focuses on research and educational efforts associated with three newly appointed forums in Agriculture. These include:

- Biotechnology
- Food Safety
- Agriculture, Water, and Environment

Intra- and inter-departmental relationships in agriculture have always been strong at K-State because researchers and Extension specialists in each discipline are housed together in the same department. Each faculty member is encouraged to form interdisciplinary alliances in addressing basic and applied research and information dissemination opportunities.

The three forums were appointed to enhance communication and interchange across colleges, departments, and between research scientists and Extension specialists.

This has been a stimulating and rewarding effort to focus, strengthen, and expand the significant research and educational efforts already underway in each of these important areas.

Your comments and suggestions are invited.

Sincerely,

Marc A. Johnson
Interim Dean

THRUSTS IN 1993

BIOTECHNOLOGY

FOOD SAFETY

AGRICULTURE, WATER, AND ENVIRONMENT

A REPORT TO THE KANSAS LEGISLATURE

by the **Kansas Agricultural Experiment Station**
and the **Kansas Cooperative Extension Service**

KANSAS STATE UNIVERSITY

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report centers around the research and educational activities associated with three newly appointed forums in agriculture — Biotechnology; Food Safety; and Agriculture, Water, and Environment. The forums serve to enhance communication and interchange across colleges and departments and between research scientists and Extension specialists.

Biotechnology

Plant Systems: Increasingly, K-State scientists are relying on biotechnological techniques to manipulate useful genes to modify functional properties, study photosynthesis, and develop needed insect and disease resistances in plants. Researchers are transferring genes from wild to domestic wheats and have released 21 germplasms with resistance to various insects and diseases. Genome mapping and DNA fingerprinting methods are being used to produce a high-density genetic map for wheat and hasten the release of new and improved food and feed grains.

Animal Systems: Biotechnology and molecular genetics offer promising approaches to genetically improve cattle strains and produce useful biological products. These techniques are used to study inherited diseases, mammalian ribosomes, retinal proteins, and bovine and respiratory diseases. Animal scientists are determining the nutritional requirements for pigs fed porcine somatotropin. K-State biologists have isolated a unique cell that appears to be responsible for inhibiting cell division. Fortunately, the inhibition is non toxic and totally reversible.

Insects and Diseases: Recombinant DNA, molecular genetics, and biotechnological techniques are used to enhance the control of insect and disease pests. Researchers are working to isolate genes controlling greenbug tolerance in sorghum. They hope to attenuate harmful behavior of the red flour beetle by manipulating its genetic material. An inhibitory gene from rice was introduced into alfalfa to interfere with the feeding behavior of weevils. Inhibitors isolated from corn are being regenerated in tobacco for subsequent introduction into alfalfa, tomato, and soybean.

Food Safety

Safeguarding Kansas Products: KSU research programs address food safety, food quality, rapid detection, and processing strategies that impact the Kansas economy. Procedures that enhance shelf life, detect contamination, minimize off-flavors, and speed detection are recognized thrusts. KSU scientists have patented two procedures that speed detection of microorganisms and are addressing the need to test for pesticide residues and bacterial and food-borne viruses. Researchers have determined that catalase activity can be used to ascertain doneness in cooked poultry. Experiments show that sodium lactate can be used as a microbial decontaminant and to protect against fat oxidation with lamb.

Food Safety Extension Education: Extension programs emphasize food safety and nutrition, diet, and health. Quality assurance programs have been organized for beef, swine, and dairy producers. Small processors are helped to identify critical points and develop individualized food safety programs. A hazard analysis training outline was developed for use with managers and line employees. Beginning processors and small entrepreneurs are helped with product analysis, food plant sanitation, and risk assessment. A multi-agency team can assist with technical support, plant layout, product development, and business planning. A model training program about hygiene; storage and serving temperatures; cross-contamination; sanitation; and work habits is available.

Agriculture, Water, and Environment

Agricultural Research: New emphasis is being placed on crop rotations and soil and crop management technology to assure profitable production while protecting water and environmental quality. Engineers are developing a mobile system to map grain yields and apply variable amounts of fertilizer depending on production potential. Agronomists are researching the efficacy of legume and crop rotations and subsurface placement of fertilizer to sustain production, reduce nitrogen need, and reduce leaching loss.

Water Resources Research: Water conservation, water-use efficiency, and water quality are important research thrusts. Water-use efficiency is being enhanced through research with drip irrigation, pre-season irrigation, and drainage. Drainage losses are often significant but can be controlled through management. K-State research in water quality has emphasized translocation of agrichemicals, fate of nitrogen, and protection strategies for wells. Particular attention has been given to the fate and movement of nitrogen and atrazine.

Environmental Quality: Research in environmental quality is designed to address natural resource management, climatic change, biological control, and remediation of contaminated soil. Natural resource management studies are conducted at the Konza Prairie Natural Area. Remediation studies address contamination from mine tailings and heavy metals in southeast Kansas. Studies on the effect of elevated CO_2 on tallgrass prairie show that water will be conserved, production will increase, but forage quality will decline.

Educational Programs: Educational programs are focused on resource, energy, and environmental stewardship. Specialists have developed a best-practices manual to reduce contamination and methods to manage plant nutrients, herbicides, and agricultural chemicals. Extension specialists have demonstrated livestock waste management systems in the Herington Watershed and assisted in managing critical riparian areas and with well plugging workshops, water quality clinics, and farmstead assessment programs.

FORUMS IN AGRICULTURE

Extension Systems and Agricultural Research Programs
Kansas State University

Kansas State University is proud of the close working relationship between the Kansas Cooperative Extension Service and the Kansas Agricultural Experiment Station and the breadth of interest among scientists, specialists, and project teams. To further enhance communication and cooperative effort across department, college, and Extension and Experiment Station boundaries, K-State has established the following Forums:

- Biotechnology
- Food Safety
- Agriculture, Water, and Environment.

The objectives are to:

1. Enhance communication between scientists and educators in each of these important areas.
2. Focus efforts within the Experiment Station and Cooperative Extension to solve priority problems.
3. Enhance resource acquisition for science and education.
4. Stimulate professional and public awareness of K-State problem-solving efforts and expertise in biotechnology; food safety; and agriculture, water, and environment.
5. Augment professional development.

The Biotechnology Forum was asked to develop a strategy for coordinating Experiment Station and university activities in agricultural biotechnology and propose a realistic program that might be achieved rapidly through a modest incremental investment of Station resources and by making the best use of K-State's financial and human resources.

Each forum meets periodically to give brief reports on science and education, discuss central issues, build collegiality, and establish working relationships. A chief objective is to establish awareness and foster interdisciplinary relationships. Each forum includes faculty from a variety of departments, colleges, and disciplines. The forum is not a project team or center, but it is hoped that project teams will arise from interactions in the forum.

Each forum is led by a steering committee and has been allocated a modest amount of funds to enhance the establishment of internal and external relationships with scientists; citizen and industry groups; and potential funding agencies.

OVERVIEW

Marc A. Johnson, Interim Dean of Agriculture

Introduction

We are most appreciative for this opportunity to report developments in research in the Kansas Agricultural Experiment Station (KAES) and education in the Kansas Cooperative Extension Service (KCES).

I'm impressed with the breadth of interest, expertise, and dedication of K-State scientists and educators who are effectively addressing basic and applied research and information dissemination opportunities. Those efforts reach across colleges, departments, and between research scientists and Extension specialists and into county and area extension offices. There is a genuine and close working relationship between Cooperative Extension and the Experiment Station.

Those cooperative relationships were strengthened by legislative action that integrated the Experiment Station and Cooperative Extension into a single budgetary entity designated "Extension Systems and Agricultural Research Programs."

College of Agriculture Forums

In 1993, we have taken several actions to enhance communication, focus cooperative efforts, foster resource acquisition, and stimulate awareness of K-State efforts to address priority problems that impact the economic and social well-being of Kansans. This has been a welcome and rewarding exercise.

Our reports today will center around three intercollege, interdepartmental, and interdisciplinary forums in the College of Agriculture. The forums include:

- Biotechnology
- Food Safety
- Agriculture, Water, and Environment.

Solving Problems with Biotechnology

Biotechnology holds great promise to help solve compelling agricultural, environmental, and health-related problems through bioengineering, molecular biology, gene cloning, and tissue culture techniques. Recombinant DNA is the key to all those advances.

We want to focus, strengthen, and expand those efforts. I'm convinced this will pay dividends with Kansas crops and livestock; on farms and ranches; and in businesses and communities.

K-State scientists have expanded the map of the wheat genome by 50 percent since our last report. This speeds the identification, characterization, and transfer of useful genes. Building on these and other advances, the Experiment Station has released Karl 92, a premium hard red winter wheat. The new wheat is high in protein, has excellent quality, and a 4 bu/a yield advantage. Karl 92 will enhance the Kansas economy by $12 to $15 million annually.

KSU biologists have isolated a unique molecule that controls cell division. The inhibition is nontoxic and totally reversible. Other efforts are addressing problems like enhancing protein synthesis, mobilizing starch reserves, and diagnosing disease.

Food Safety

K-State scientists and Extension specialists are leaders in state, regional, and national efforts to insure a safe and wholesome food supply. We want to safeguard Kansas products and enhance their utilization in domestic, regional, and national markets. Our research and educational efforts focus on pre-harvest, post-harvest, and consumer levels.

Significant effort is being directed to the production, processing, packaging, and distribution of beef and red meat. Scientists are working to enhance shelf life, control microbial hazards, and speed detection methods. Extension specialists have organized beef, dairy, and swine quality assurance programs and are helping processors establish critical control points for hazard analysis.

K-State microbiologists have introduced and patented a U-tube system that speeds the detection of microorganisms. They also discovered that Oxyrase™, a bacterial membrane fraction that stimulates the growth of food pathogens, and obtained a patent.

Agriculture, Water, and Environment

Adequate supplies of good quality water and a wholesome environment are critical in sustaining the agricultural and overall economy of Kansas. Experiment Station scientists and Extension specialists are aggressively addressing those issues. Water conservation and environmental protection have become an essential part of virtually every K-State research and educational thrust.

Researchers are aggressively examining fertilizer application methods and recommended rates. In many experiments, incorporating fertilizers has enhanced plant uptake, decreased the needed amount of fertilizer, and reduced runoff and leaching losses. Surface and groundwater quality and the environmental fate of nutrients, pesticides, and other agricultural chemicals are priority research and educational thrusts. Extension specialists have helped in watershed demonstrations to manage riparian areas and abate pollution from livestock waste.

BIOTECHNOLOGY RESEARCH

Donald J. Roufa, Professor, Division of Biology

Introduction

At Kansas State University, biotechnology research is aimed at important agricultural problems in both plant and animal sciences. Kansas Agricultural Experiment Station (KAES) scientists are investigating new products and procedures to improve the quality of Kansas agricultural products through the application of modern genetics, molecular genetics, cell biology, and biochemistry. This research is an attempt to enhance the productivity, and therefore economic return, of Kansas agriculture through use of molecular biology.
K-State scientists are isolating and testing genetically modified and hybrid plant strains that promise increased yields; resistance to common pests and pathogens; and less deleterious effects on Kansas' natural resources and environment. Although in its infancy, biotechnology research already has contributed significantly to major improvements in agriculture. The future promises even larger returns as current investments in research yield anticipated dividends.

Biotechnology research at Kansas State University is supported by the KAES as well as by extramural grants and contracts from both public and private sources. Most KAES projects are designed and implemented by individual K-State scientists or departments, their students, and research staff. A few projects, however, involve interdepartmental collaborations and/or exchanges with other U.S. and foreign research agencies.

Crop Sciences

KAES scientists in the departments of Agronomy, Biochemistry, Grain Sciences, and Plant Pathology are using biotechnology to investigate problems relating to the production of wheat, sorghum, maize, soybeans, barley, and rice. For example, geneticists within the Department of Plant Pathology are constructing a detailed chromosomal map of wheat, *Triticum tauschii.* Their aim is to obtain a clear definition of the wheat genome in order to isolate genes that confer resistance to fungal and viral pathogens and that improve the nutritional properties of wheat storage proteins. In related

efforts, KAES biochemists are studying the genes that encode wheat storage proteins and proteins that affect baking properties of wheat flour. KAES virologists are studying plant genes that confer resistance to wheat streak mosaic virus as well as bacterial and fungal pathogens. Additionally, basic scientists in the KAES are investigating the biochemistry of light, water, nitrogen, and CO_2 utilization to better understand the fundamental biochemical processes upon which plant production depends.

Animal Sciences

Scientists in the departments of Anatomy and Physiology and Animal Sciences are investigating swine genetics using molecular and cytogenetic approaches. Detailed chromosome maps are being constructed to better understand quantitative genetic determinants, so-called Quantitative Trait Loci's, that determine porcine growth and reproductive efficiencies. KAES immunologists are developing antibody reagents for accurate diagnosis and treatment of pathogenic porcine enteric viruses as well as bovine respiratory syncytial virus and herpesvirus. University entomologists are studying insects that attack wheat in the field and in the storage bin. Their studies now focus on the wheat curl mite and red flour beetle. Additionally, several of the KAES basic scientists are characterizing the animal's genetic machinery and factors that regulate normal growth at the cellular level. Newly recruited researchers in the Department of Animal Sciences and the Division of Biology now are developing transgenic methods to introduce new or chemically modified genes into experimental animals, map the transgenes' chromosomal locations, and investigate their expression in chimeric newborns. The long-term goal of this work is to apply state-of-the-art transgenic technology to such economically important livestock species as cattle and pigs.

Planning for the Future

During the past year, a broadly-based KAES Biotechnology Task Force was convened to evaluate the status of K-State biotechnology research in agriculture and to formulate a plan for future enhancement of this area. The Task Force recommended that Kansas State University develop an institutional initiative in molecular genetics, involving both genomics (i.e., chromosome studies) and transgenics (introduction of new genes into plant and animal embryos). This effort is to be targeted specifically to crop and livestock species important for Kansas agriculture. Initially the research will focus on wheat, but with eventual extension to cattle, swine, and sorghum.

The Task Force suggested that KAES scientists target a substantial fraction of their efforts on a few projects of critical importance to the Kansas agricultural economy. This plan requires significant additions to the university's research infrastructure and staff. If successful, the new biotechnology initiative can promote Kansas State University as a world center for cereal grain and livestock genetics, and in turn attract related commercial ventures to Kansas. To develop the program, the university will emphasize the areas of genomics and transgenics in future faculty recruitment and seek financial support from both the public and private sectors.

FOOD SAFETY FORUM

Karen P. Penner, Professor and Extension Specialist, Department of Foods and Nutrition

Introduction

Maintaining the safety of food through its growth, storage, processing, and consumption cycle is an important food system issue and concern. Consumers expect the food they purchase at supermarkets and food service establishments to be safe, wholesome, and nutritious. Today, more than ever before, there is genuine interest throughout the entire food system to assure that all products sold or served to consumers are safe and will not result in food-borne illness or death.

The Food Safety Cycle

Food safety begins on the farm, pre-harvest, where livestock and crops are raised. Livestock drugs and feeds, pesticides, fertilizers, and other agricultural inputs must be utilized in a responsible and legal manner so the wholesomeness and safety of the final product is assured. After harvest, the safety of raw and finished products must be monitored throughout the processing, storage, and manufacturing cycle. Food safety practices are also important at food service and retail markets where consumers are in direct contact with food. And finally, consumers must also assume responsibility for the safety of the food they buy, prepare, and consume.

Food Safety Forum

At Kansas State University, food safety issues at the pre-harvest, post-harvest, and retail/consumer levels are addressed by faculty comprising the Food Safety Forum. Faculty with food safety research, Extension, and/or teaching activities are located in the colleges of Agriculture, Human Ecology, and Veterinary Medicine. Their work involves such diverse topics as monitoring treatment protocols for live animals prior to slaughter; developing rapid detection methods for food-borne, pathogenic microbes or pesticides; developing Hazard Analysis Critical Control Point (HACCP) programs for production units, food processing systems, commercial or institutional food service operations, and homes; training pesticide applicators; certification training for food service sanitation; and communicating food safety issues to consumer audiences about food-borne illness, pesticides, and new technologies.

Addressing Food Safety Issues

Food Safety Forum faculty work on food safety issues within multi-state consortia and across disciplines and with industry, regulatory agencies, and other stakeholders. For example, over the past several years, the College of Veterinary Medicine has cooperated with five other universities in a Food Animal-Production Medicine Consortium to enhance consumer health by focusing on veterinarian/producer practices. Kansas State University, Iowa State University, and the University of Arkansas are part of a three-state Food Safety Consortium. At KSU, the Consortium effort focuses on beef and post-harvest food safety. In the College of Human Ecology food safety efforts are directed primarily at food handling and sanitation concerns. Specialists organized a comprehensive public policy education program on food safety in the food service arena. Follow-up programs included training for food handlers for commercial and institutional food service operations and food safety in family day care home settings for childcare providers, children, and parents. Other specialists targeted the food safety needs of value-added food processors and the implementation of HACCP programs in food processing plants. Another project involves Kansas and three other states in developing a food safety curricula database that is internet-accessible. The objective is to provide Extension Service USDA with data and information to enhance the capacity of Extension specialists in conducting effective food safety programs and workshops nationwide.

Cooperative Efforts

Many food safety efforts involve teams of people from various disciplines because there is no formal food safety discipline. Various industry and regulatory representatives are also involved because food is made available through an industry system that is regulated federally by the Food & Drug Administration and the Food Safety & Inspection Service. In Kansas, regulatory efforts are coordinated by the Kansas Department of Health and Environment and the Kansas State Board of Agriculture.

Summary

Food safety will continue to be an important area of work. New microorganisms will emerge as important food-borne pathogens. New technologies used to produce, manufacture, and package foods will provide new environments for the growth of microorganisms. No doubt, consumers will also continue to consume foods prepared away from home by individuals for whom there are no requirements for training in food safety and sanitation. Although the issues and challenges may change, there will be a continuing need for food safety research, Extension, and teaching programs to ensure the safety, quality, and nutrition of our food supply.

AGRICULTURE, WATER, AND ENVIRONMENT FORUM

John S. Hickman, Extension Specialist and Coordinator, Environmental Quality, Department of Agronomy

Introduction

An Agricultural, Water, and Environment Forum has been established at Kansas State University. Approximately 50 on- and off-campus research, Extension, and teaching faculty participate. The primary areas of emphasis are water quality, water conservation, and sustainable agriculture. The Dean of Agriculture and Vice Provost for Research provided funding for the forum in 1993-1994.

Forum Objectives

a. Enhance communication between scientists and educators in the Agricultural Experiment Station and Cooperative Extension Service to address topics related to agriculture, water, and the environment.

b. Encourage a focused effort within the Agricultural Experiment Station and Cooperative Extension Service to solve important water and environmental issues.

c. Enhance resource acquisition for science and education in agriculture, water, and the environment.

d. Stimulate greater professional and public awareness of K-State's efforts in the science and education of agriculture, water, and the environment.

Planned Activities - 1993/1994

- An electronic mail server has been established to encourage and enhance communication between forum members.
- Faculty are interested in serving in an advisory capacity to KSU administration for working with state agencies and private organizations.
- Several mini-grants with an interdisciplinary, intercollege research and Extension focus may be funded.
- An informal brown bag seminar series has been established.
- A statewide conference on sustainable agriculture is planned.
- Information products highlighting K-State activities in water and the environment will be produced.
- Opportunities for training and faculty development will be explored.
- Liaison with agencies such as EPA will be enhanced.
- Cooperation and interaction with funding agencies and regional research and Extension committees will be enhanced.

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Research and Educational Thrusts

Research and educational thrusts in this report are focused on nutrient and water-use efficiency; environmental quality and protection; and information transfer.

Agriculture

K-State scientists have combined efforts to apply and utilize fertilizer more efficiently. Engineers are mapping grain yields so fertilizer can be applied in variable amounts according to production potential. Agronomists are taking new approaches to fertilizer placement, rates, and utilization. In some cases, fertilizers incorporated at half-rates gave yields comparable to full fertilizer rates.

Water

KSU research in water management is directed to efficient irrigation systems (drip irrigation and Low Energy Precision Application (LEPA)) and water quality. Off-season irrigation is inefficient, but drip irrigation efficiencies approach 95 percent. In gravity irrigation systems, drainage losses are significant but can be controlled with proper management. The goal is to minimize loss of water and chemicals and protect groundwater quality.

Environmental Quality

Kansas Agricultural Experiment Station research in environmental quality involves natural resource management, biological control, climatic change, and remediating contaminated sites. In southeast Kansas, K-State scientists are working to reclaim soils contaminated with heavy metals from mining activities. At Manhattan, they are studying climatic change and the effect of elevated CO_2 on tallgrass prairie ecosystems.

Educational Programs

Extension specialists are coordinating development of a Best Management Practice Manual to help reduce contamination. Soil testing is promoted to minimize nutrient loss and production costs and to insure safe and effective use of agricultural chemicals. Specialists have organized demonstration projects in watersheds and with livestock waste systems. They are actively assisting producers with waste management problems in riparian areas and establishing wellhead protection, well plugging, and water testing programs.

BIOTECHNOLOGY

Biotechnology promises to help solve agricultural, environmental, and health-related problems through advances based in recombinant DNA. This entails identifying genes with special functions in plants or animals and then modifying these genes for use in other organisms (plant, animal, bacteria, or fungi.) The genes identified may regulate development of resistance to insect, fungal or microbial pests; growth or cell division; nitrogen fixation; or other beneficial characteristics.

Biotechnology also employs tissue culture and organism regeneration, gene cloning, molecular genetics, and gene regulation. The objective is to find useful qualities in cells or protoplasts (plant cells from which the cell wall has been removed) and to transfer or clone them into useful biological backgrounds.

At K-State, biotechnological research and information-transfer programs are conducted in several of the university's departments and colleges. Most projects are interdisciplinary and involve teams of cooperating scientists and specialists. A task force has been convened by the Dean of Agriculture and Director of the Experiment Station to develop a strategy for coordinating Experiment Station activities in this vital area.

PLANT SYSTEMS

In the near future, crop improvement programs will rely extensively on biotechnological innovations to identify, characterize, and transfer useful genes that modify functional properties and enhance pathogen and pest resistance in crop plants. For example, the KSU Wheat Genetics Resource Center (WGRC) now catalogs more than 2,200 strains of wheat collected from around the world. Each accession has been or is being evaluated for resistance to leaf rust, stem rust, yellow rust, leaf blotch, tan spot, powdery mildew, wheat streak mosaic virus, barley yellow dwarf virus, Hessian fly, greenbug, Russian wheat aphid, and wheat curl mite.

Genome Mapping - DNA Fingerprinting:

Host Plant Resistance in Wheat: No wheat cultivar is immune to wheat streak mosaic virus, and good sources of resistance genes were only known in rye and wheatgrass species. Therefore, their genes were added to complementary wheat chromosomes, and the modified chromosomes were transferred to wheat cultivars. Resistances to wheat streak mosaic virus and leaf rust resistance then were transferred to commercial wheat cultivars. The alien chromosomes are tracked by chromosome fingerprinting techniques.

Chromosome Fingerprinting in Wheat: Chromosomes and chromosome segments now are being identified using

DNA fragments as markers in *Triticum tauschii* to generate a more saturated chromosomal map. The current map consists of 280 DNA loci, 260 of which have been assigned to specific chromosome linkage groups. This allows for the detection of smaller chromosome fragments and facilitates the precise mapping of chromosome segments.

High Density Wheat Chromosome Maps: KSU researchers are developing protocols to generate high density genetic maps for particular wheat chromosome segments. The chromosome segment controlling resistance to Hessian fly, a destructive wheat pest, is of particular interest. DNA sequences isolated from rye will help scientists generate the wheat map.

Rust Resistance Genes in Maize: Plant pathologists are working to identify and clone genes that specify rust resistance in maize. Nearby DNA sequences have been identified and multiple strategies are being implemented to walk from the DNA markers down the chromosome to the resistance genes. Mapping techniques are being used to generate DNA markers near the resistance genes.

Hormone-Responsive DNA Elements in Barley: The aleurone layer cells secret α-amylases during germination to mobilize the reserve starch for seedling growth. This process is under positive control by the hormone gibberellic acid and negative control by abscisic acid. The genes for α-amylases have been isolated and characterized by DNA sequencing. The location of these regulatory elements are located within an approximately 50 nucleotide-long chain.

Genetic Scissors: K-State cytogeneticists have developed a "genetic scissor" system to obtain plants missing small pieces of specific chromosomes. If plants with a "deleted chromosome segment" are deficient in a certain trait, then the gene specifying that trait must lie on the missing chromosome segment. Obtaining deletion chromosomes for each wheat chromosome entails the production of approximately 400 deletion chromosome plants. This important strategy will help to decode the genetic blueprint of wheat.

Gene Tagging and Quantitative Trait Loci: Restriction fragment length polymorphisms (RFLP) are used to identify and map the exact locations of traits on chromosomes. To date, 137 RFLP probes from the *Triticum tauschii* map have been assayed. Only a few of the probes produce signals with sufficient intensity to be scored. However, by using electrophoresis on selected lines, scorable markers should be available for wheat chromosomes 1D and 6D.

Nitrogenase Enzymes: Nitrogenase is the enzyme that converts nitrogen gas (N_2) in the air and nitrate salts into ammonia, which plants can use as fertilizer. Studies have been conducted to identify the locations in the enzyme for a dozen mutations. A map of the mutations has been developed from studies of crystals. Long-range efforts include stabilizing the enzyme, increasing its efficiency, and determining how it works under different environmental conditions.

Identifying Functional Properties

Mobilizing Starch Reserves for Seedling Growth: The genes for α-amylases, which mobilize starch reserves for seedling germination, have been isolated and characterized by DNA sequencing. DNA sequences upstream of the protein-coding sequences control hormone responsiveness. This development is expected to suggest novel ways to control precocious germination and accelerated malting.

Storage Proteins in Wheat: For breadmaking, the quality of wheat is dependent on proteins (gliadins and glutenins). Genes for these proteins have been isolated and characterized. K-State biochemists are studying large DNA segments that encode several genes for gliadins to determine how cells control protein synthesis. They want to determine how to turn these genes on or off.

Sticky Wheats: The 1B/1R translocation in wheat enhances disease resistance and improves yield. However, these wheats often produce sticky doughs, a serious problem in high-speed bakeries. Because grain scientists have developed objective tests for stickiness, lines containing the sticky factor can be identified and removed from breeding programs.

Kernel Analysis: Infrared microscopy is used to analyze wheat kernel parts, even down to single cells in some cases. Since the kernel is wheat's biochemical factory, the kernel is probed to follow compositional development. This is then compared to structural information from conventional microscopy. Researchers want to find the chemical basis for environmental, genetic, and seed developmental effects and their impact on processing efficiency and quality of baked goods.

Photosynthesis

Photosystem I: Photosynthesis is the major source of biological energy as well as oxygen on earth. KSU biologists hope to control the rate of photosynthesis by regulating the interaction between pigment protein complexes (Photosystem I) and soluble proteins (electron donors and acceptors) using a cyanobacterium as a model organism. A mutant strain of Photosystem I, which lacks a protein that may function as a switch controlling energy flow, has been generated. This and other genetic changes are being examined to determine their effects on photosynthesis.

Rubisco and CO_2 Fixation: Rubisco is an enzyme that catalyzes the fixation of carbon dioxide into sugar. K-State biologists determined that certain metabolites inhibit the rate at which rubisco fixes CO_2. These metabolites bind to the enzyme at sites different from the active site. Once characterized, it may be possible to modify these sites genetically and to improve the efficiency of CO_2 fixation.

Genetic Improvement of Plants

KS89H48: In 1992, losses to leaf rust approximated 11.3 percent. If the new release, KS89H48, replaces TAM 107, a variety susceptible to leaf rust, the economic impact would approximate $35 million annually. If rust resistance in KS89H48 proves effective in the field, improved yield could add an additional $30 million to the economy each year.

Karl 92 Wheat: Karl 92, a hard red winter wheat, has been released by the Experiment Station. Karl 92, is essentially equal to Karl except it has a 4 bu/a yield advantage. If Karl 92 replaces Karl, it would enhance the economy by $12 to $15 million annually.

Arlin Wheat: Arlin, a new hard white wheat, provides improved yield, test weight, protein, color, straw strength, milling and baking quality, and represents an important advance for hard white wheat in the Great Plains.

Sorghum: Ten germplasm restorer lines with resistance to greenbug (biotype E) have been released. Another germplasm with resistance to greenbug (biotype I) also has been released. This will broaden the germplasm base of sorghum hybrids for both male and female parents.

Development of a field screening program based on rearing large numbers of chinch bugs on barley and then on corn has been a critical development. Four new sources of resistance were discovered, and tremendous differences in susceptibility among commercially available hybrids were found.

Soybean: Soybean releases include KS4390, an early group IV variety with good yield potential, and KS292, an early group V variety with excellent yield potential and resistance to the soybean cyst nematode.

Additional Developments - Plant Systems

Wheat Regeneration and Transformation: Genes from wild wheat species in the Wheat Genetics Resource Center (WGRC) are being transferred to domestic wheats. To date, 21 germplasm releases containing genes for resistance to Hessian fly and greenbug pests; leaf rust and powdery mildew fungi; and wheat soilborne and spindle streak mosaic viruses have been developed.

Rust Resistance in Corn: Rust resistance genes in corn are characteristic of genes that control resistance to fungal pathogens. The gene, Rp1, is perhaps the best characterized locus for resistance to any complex disease. KSU scientists have transferred several resistance genes to one chromosomal location so they can be manipulated as a single genetic locus. To provide durable resistances, methods also have been identified to generate sources of disease resistance for easy manipulation by plant breeders.

Sorghum Disease Diagnosis: Determining the presence of pathogens in seed and grain is difficult and time consuming. A monoclonal antibody that will give 24-hour test results is being developed. A protein in the bacterium that causes bacterial leaf streak was cultured in mice and then fused with a myeloma (cancer cells) to form a hybridoma. More than 1,200 hybridoma were screened to recognize one that met all criteria for a reliable diagnostic test.

Male Sterility: Male-sterility-inducing cytoplasms in sorghum were found to have a 165-base-pair deletion located in the RNA polymerase rpoC2 gene. The deletion was consistently observed in cytoplasmic male sterile plants but not in their fertile counterparts. Thus, a chloroplast genome may be involved in the failure of normal microsporogenesis leading to pollen production.

Grapes: Cold-hardy lines of grape hybrids have been selected using cell culture techniques. The cold-tolerance trait is stable, and selected lines are 10° C more cold tolerant than their original counterparts. The genes for cold tolerance are being identified so plant types that can survive harsh winters might be developed.

ANIMAL SYSTEMS

In the past, development of improved stock depended on selective breeding strategies and sound genetic principles. Biotechnology and molecular genetics now offer promising new approaches to improve livestock strains and to further use animals for producing food and other useful biological products. Genetic maps identifying the locations and functions of specific animal genes are being developed. These can be used to accurately locate genes for heritable diseases and to develop valuable animal by-products.

Swine

Nutrition and Porcine Somatotropin: Administration of recombinant porcine somatotropin (pST) enhances growth, carcass characteristics, and nutrition of swine. K-State scientists have determined that growing pigs optimally require diets with high lysine content (1.5-1.9 percent), more than double the level recommended (0.7 percent) by the National Research Council (NRC). Our scientists also find that high lysine diets (1.2-1.4 percent) enhance the quality of finishing pigs over finishing diets that contain the NRC-recommendation of 0.6 percent lysine. Consumers want lean pork, and the use of pST and an upgraded nutritional program may meet that need.

Detecting Pathogens with Monoclonal Antibodies: Diagnostic antibodies produced by the Kansas and South Dakota agricultural experiment stations for enterotoxigenic *E. coli* provide rapid, specific tests to identify this pathogen. New antibodies also are being used to identify transmissible gastroenteritis virus in tissues and feces of infected pigs and to characterize swine dysentery, which causes bloody diarrhea and death in affected animals.

Bovine Diseases

Bovine Respiratory Syncytial Virus (BRSV): An assay to identify tissue culture cells infected with BRSV has been developed. Using this assay, BRSV isolates from locations throughout the United States as well as a strain isolated from goats can be distinguished from prototype isolates of human (HRSV) and sheep respiratory syncytial viruses (RSV). The new assay greatly enhances the speed, sensitivity, and accuracy of BRSV diagnostics.

Bovine Herpesvirus (BHV): The viruses evaluated include the BHV-1.1 (non-neuroviolent/respiratory/abortogenic), BHV-1.2 (genital), and BHV-1.3 (neuroviolent) strains. The viruses' DNA regions encoding important gene sequences (gIII and gIV) have been identified and cloned. Restriction maps of these DNA fragments revealed differences between BHV-1.3 and BHV-1.1 strains. Recombinant fusion proteins and monoclonal antibodies now are being developed to identify coding sequences important for neutralizing viral effects.

Respiratory Diseases: Monoclonal antibodies (MAbs) have been developed to detect the viral agents that cause bovine respiratory disease. These antibodies are used in many university and industrial laboratories. Anti-idiotypic research now focuses on identifying the cellular receptors to which the virus attaches. The goal is to block cell receptors, inhibit infections, and prevent disease.

Additional Developments - Animal Systems

Retinal Proteins: The retina of the eye is a highly modified sensory receptor. Biochemists have cloned and sequenced retinal proteins and determined their defects inherited in immune uveitis and diabetic retinopathy. A sera screening procedure to test animals for autoimmunity to retinal proteins has been developed for use in horses. Additionally, an anti-diabetic retinopathy drug has been tested for its effect on the activities of retinal proteins.

Mammalian Ribosomes: A ribosome is the cell's protein factory. Each of the 84 nucleic acid and protein molecules in a ribosome is encoded by a separate gene and is stringently co-regulated to ensure component availability. DNA technology was used to isolate three ribosomal proteins, S14, S17, and S24. The complex regulatory signals governing the biosynthesis of S14 and S17 have been analyzed. Such information is critical in designing and predicting the function of genetically engineered plant and animal products.

Regulating Cell Proliferation: Animal and plant cells contact their environment by surface components that respond to extracellular cues. KSU biologists have isolated a unique cell surface molecule from bovine brain tissue that appears to be responsible for inhibiting cell division. They have learned how this cell surface element inhibits cell division, where the cells are arrested in the cell cycle, and that the inhibition is nontoxic and totally reversible. Bovine, human, mouse, rat, and insect cells are sensitive to this regulatory component.

Avian Respiratory Disease: Eleven monoclonal antibodies to Budgerigar fledgling disease (an avian papovavirus) have been developed. In addition, the virus' DNA has been cloned and DNA-recombinant systems now are being used to produce large amounts of viral proteins for biochemical characterization and analysis.

INSECTS

Biotechnology focuses on the use of recombinant DNA, gene regulation, and molecular genetics in host plants to control insect pests. Use of a biotech approach to insect control significantly enhances environmental quality by reducing the need for chemical pesticides. This approach may result in the modification of enzymes, antibodies, and other biochemicals produced by the plant and their controlling genes.

Greenbug

Greenbug Enzymes: Greenbugs inject enzymes into sorghum to facilitate their feeding. Molecular techniques now are being used by K-State scientists to isolate the controlling genes and to develop better tests for greenbug tolerance in sorghum. New procedures have been developed to assess the result of greenbug feeding on seedling growth and to evaluate tolerance to greenbug biotypes E and I. Some sorghum accessions show tolerance to biotype E, but only a few are tolerant to biotype I.

Biotype I Resistance: Resistance to greenbug biotype I has been discovered in two sorghum cultivars from the Soviet Union. Research demonstrates that growth temperature greatly influences these cultivars' resistance to greenbug biotype I.

Red Flour Beetle

Genetic Transformation: Researchers hope to use an alterable, transposable element in red flour beetles (RFB) as a vector to manipulate the insect's genetic material and to control or attenuate its harmful behavior. This significant pest for stored grain also can serve as a model for other harmful beetles. DNA sequencing shows that the transposable element active in beetles is related to retroviruses, a class of viruses which includes the HIV-1 virus that causes AIDS in humans.

Resistance in Red Flour Beetles: Research has shown that the RFB is capable of developing resistance to *Bacillus thuringiensis* (B.t.). A single gene that yields a 1,000-fold resistance to synthetic pyrethroids has been identified and is being mapped and characterized. While B.t. is not currently approved for control of RFB, future formulations should be monitored carefully to prevent the rapid development of resistance.

Additional Developments - Insect Systems

Wheat Curl Mite: Wheat curl mite is the carrier of the virus which causes wheat streak mosaic disease. In Kansas, this disease is estimated to reduce yields by 16 million bushels. Resistance to wheat curl mite was discovered in 1991. Losses will be significantly reduced when the resistance genes are incorporated into commercial varieties.

Alfalfa Weevil: An inhibitory gene from rice that interferes with the weevil's feeding behavior has been introduced into alfalfa. The digestive enzyme that was introduced is not normally found in alfalfa. Using another approach, genetically engineered traits were used to produce somatic hybrids between cultivated alfalfa and wild annual alfalfa species. Based on that work, hybrid cell lines were produced successfully, but whole plants were not.

Parasitic Wasps: Parasitic wasps sting the host (soybean looper), lay an egg, and inject a virus into the host. The virus disrupts host development, knocks out the immune system, and prevents an immune response against the wasp's egg. This compromises the soybean looper's ability to feed, form pupae, and eventually kills the caterpillar. Entomologists are characterizing the gene that causes these physiological effects. They want to develop specific pesticides and transfer the gene to other viruses that attack caterpillar pests.

Insect Granulosis Virus: Monospecific antibodies have been produced to specific viral proteins. These antibodies can be used to detect viral proteins in infected tissues and to study mechanisms and prevention of infection.

DISEASES

Biotechnology allows researchers to genetically engineer the transfer of antibiotic genes from one organism to another, to search more effectively for the genes controlling disease resistance, to devise DNA probes for rapid diagnosis of disease, and to consider strategies that modify the disease symptoms.

Rice

Host Recognition of a Bacterial Pathogen: The ability of rice plants to recognize certain bacteria is dependent on the presence of a resistance gene (Xa10) in the plant and avirulence gene (avrXa10) in the bacterium. This "gene for gene" relationship between the pathogen and plant is common in host-pathogen relationships and is not limited just to rice and the rice pathogen. The avrXa10 gene has been isolated and its nucleotide sequence determined. Plant pathologists now are determining 1. whether the Xa10 protein is secreted from the bacterium so that the plant makes contact with it, and 2. whether the amino acid that controls the Xa10 protein's specificity can be identified.

Avirulence Genes: Two avirulence genes have been identified for which the corresponding resistance genes are known. However, 10 to 12 genes exist for which we do not know corresponding resistance genes. Pathologists are introducing the bacterial genes to weakly virulent strains to determine whether the avirulence genes increase aggressiveness or enhance the resistance response.

Bacterial Blight: DNA probes have been developed to diagnose bacterial blight of rice. Unfortunately, the probes are not suitable for detecting the low numbers of infecting organisms found in seed stocks. However, KSU researchers have developed DNA primers and polymerase chain reactions that allow detection of low levels of this pathogen. The assay's specificity now is being improved by development of primers specific for the disease organism.

Additional Developments - Plant Disease Systems

Biocontrol of Soil-borne Plant Pathogens: Methods have been devised to test large numbers of fungi capable of inhibiting tan spot pathogens in wheat straw. Additionally, the means by which a bacterial strain, Pf-5, prevents the growth and spore production of tan spot was investigated, and portions of the bacteria's DNA were identified. Researchers are actively transferring the antibiotic genes to other bacteria that inhabit straw so that tan spot fungus can be controlled in conservation-tillage farming systems.

Biologically Engineered Pest Resistance: Genes for proteinase inhibitors have been isolated from corn and rice and genetically introduced into tobacco, a model system that regenerates rapidly from tissue culture. The objective is to increase the amounts of inhibitors produced in tobacco and to biologically engineer pest resistance for use in alfalfa, tomato, and soybean. This will provide new sources of genetic traits and more effective pest resistance in Kansas crops.

Turnip Crinkle Virus (TCV): Most plant viruses contain a coat protein and one or more molecules of a nucleic acid (DNA or RNA). The coat protein protects the nucleic acids and stabilizes the virus' genetic information. Minor changes in the coat protein cause drastic changes in the symptoms expressed by infected plants. At KSU, scientists have observed that mutation of a calcium-binding site in TCV significantly reduces the virus' capacity to move from cell to cell. This reduces infection, not because the virus cannot replicate, but because it cannot efficiently infect cells.

HUMAN SYSTEMS

While much of the research conducted in the Agricultural Experiment Station is directed at plants and animals, some has application to the well-being of humans directly. These include delivery of oxygen to the heart, blood coagulation, and resistance to several infectious agents.

Mammalian Heme Proteins: Myoglobin is an important respiratory protein. The oxygen delivered to tissues is bound within cells by the heme of myoglobin. Recombinant forms of myoglobin have been examined to determine the role of a particular myoglobin histidine residue in hydrogen-bonding and stabilization of bound oxygen and water. Mutants are being developed to explore the effects of amino acid size (steric factors) on water binding. This will help us to understand how myoglobin delivers oxygen to the heart and muscle cells.

Blood Coagulation: A trypsin inhibitor has been isolated from *Cucurbita maxima* seeds (CMTI-V). KSU biochemists have identified the inhibitory protein's reactive site and its structural properties. Structural changes and functional properties now are being characterized. This will suggest new therapeutic strategies for blood coagulation disorders and new approaches to purify blood coagulation proteins.

Resistance to Infectious Agents: In humans, specific disease resistance has been traced to genes of the major histocompatibility complex (MHC). Regulatory T-cells recognize foreign proteins bound to the MHC molecule. In mice, MHC genotypes determine which of two basic responses occur. KSU researchers have narrowed the MHC site that causes these T-cell responses to a 12 amino acid segment. They want to determine which residues contact the MHC and which contact the T-cell. This is important because T-cell immunity elicited during an immune response can determine whether the individual is resistant or susceptible to an infectious pathogen.

Chryptosporidium Parvum: This pathogen causes gastrointestinal illness, diarrhea, and weight loss in humans and animals. No therapy is currently known. Twenty proteins on the parasite have been identified, and monoclonal antibodies for many of these proteins have been developed. A genomic library has been generated, and the DNA and amino acid sequences of each surface molecule are being determined. A monoclonal antibody that reduces parasitemia 50-60 percent in infected mice has been produced.

FOOD SAFETY

Food safety is an important issue in local, state, and national food systems. At Kansas State University, interdisciplinary food safety research and Extension education efforts focus on pre-harvest, post-harvest and consumer levels. Consumers expect the food they purchase at supermarkets to be safe, wholesome, and nutritious.

Research in the Experiment Station is focused on safeguarding Kansas products; developing rapid detection methods for microorganisms, viruses, and chemical contaminants; and protecting against contaminants. Such research assists processors in identifying and minimizing food safety hazards. It also helps farmers, businesses, and government in their efforts to insure an adequate supply of safe and nourishing food products for the consuming public.

Extension education efforts are directed at food safety on the farm and for processors, consumers, and children. Extension specialists in Kansas are working to expand the capability of the Extension system to deliver effective food safety programs, not only in Kansas but regionally and nationally as well.

PROTECTING KANSAS PRODUCTS

The Kansas Agricultural Experiment Station, with its extensive crop and livestock research facilities; meat and crop value-added processing plants; and Kansas Value-Added Center is in a unique position to help farmers, ranchers, processors, and small businesses identify critical points and establish procedures that ensure product safety and enhance consumer confidence.

Beef and Cattle

Antioxidants in Restructured Beef: The enhancement of shelf life and consumer acceptance of pre-cooked beef is of great economic importance. However, the oxidized flavor that develops during storage is a serious problem. Because of concern about the use of chemical additives, KSU researchers are investigating the use of natural antioxidants. Wheat and soybean components are hydrolyzed and sugar is added to the protein hydrolysate to form brown-colored pigments that may delay the development of off-flavors in meat.

Shelf Life of Boxed Beef: Because Kansas is the largest beef processing state, enhancement of the safety and shelf life of boxed beef is critical to the economy. Treatment of beef carcasses with lactic acid and chlorine decreases microbial contamination but does not necessarily increase shelf life. Researchers are applying procedures approved for use with carcasses to beef subprimals just before packaging to determine if safety and shelf life can be enhanced. A 3-5 day increase in shelf life could increase the value of a beef carcass by $100.

Acid Decontaminations of Beef: Treatment of beef carcasses with lactic acid decreases bacterial contamination but has little effect on the shelf life of subprimals. The bacterial count of loins treated with lactic acid prior to vacuum packaging tended to be lower than those treated after opening the

bag. Overall, lactic acid treatment proved very effective. Most loins stored at 2°C had higher bacterial counts than those stored at -1°C. Temperature as well as acid treatment play a synergistic role in controlling microorganisms.

Microbial Condition and Display Quality: Lactic acid was used to determine its effect on microbial condition and display quality of boneless beef. Strip loins sprayed with lactic acid before and after vacuum storage were slightly darker than control steaks. On the basis of color, subprimal storage life and steak display life were shorter for lactic acid treated cuts than for controls. However, on the basis of bacterial spoilage, lactic acid applied to strip loins resulted in longer storage and display life.

Cattle Identification Systems: Modern cattle management systems require reliable means of identifying individual animals to improve health programs and decision-making capability. In collaboration with a ranch in Montana and feedlots in Kansas, 150 calves were implanted with electronic I.D.'s and followed from birth to weaning. The calves will be slaughtered under the supervision of federal and state personnel to evaluate the practical application and retrieval of electronic I.D. devices. A complete summary of the retrieval potential of implants used from birth to slaughter will be published.

Dairy

Ultra-High Temperature Sterilized Milk: Ultra-high temperature (UHT) sterilization (heating milk at 140 to 150° C for 2-10 seconds) allows milk to be stored at room temperature. Studies at K-State show that small amounts of the enzyme lipase survives and could cause undesirable flavors and shorten shelf life. Since the enzyme may have originated from a bacterial source, the raw milk used for UHT processing must be low in bacterial count.

Poultry

Determining Doneness in Poultry Products: KSU researchers, cooperating with USDA scientists at the Russell Research Center, Atlanta, GA, determined that catalase activity can be used to ascertain doneness of poultry products. For safety, USDA regulations require that cooked poultry be heated to 71.1°C. A catalase reaction test verifies that the end-point temperature was reached. Samples with end-point temperatures of 68°C or less always tested positive while those with an end-point temperature of 72°C or greater always tested negatively. The test is valid even in cooked and pre-cooled cuts.

Lamb

Lamb Meat Quality and Sodium and Potassium Lactates: The effect of sodium lactate on the quality of vacuum packaged lamb steaks was evaluated. Results indicate that up to 3 percent sodium lactate did not affect pH, water activity, and thiobarbuteric acid (TBA). Under retail conditions, those steaks were redder than steaks treated with 0 percent or 1 percent sodium lactate. Treating lamb roasts with sodium lactate resulted in a 1.5 log reduction in aerobic plate and lactic acid bacteria counts. Thus, sodium lactate can be used as a microbial decontaminant and to protect against fat oxidation.

MICROBIAL AND CHEMICAL SAFETY

KSU research programs address food safety and quality questions that impact the Kansas economy. It is well recognized that rapid detection procedures, improved processing strategies, and enhanced shelf life increase consumer confidence in domestic and international markets. Research is critical in efforts to add value to Kansas products in markets where food safety, prolonged storage, and consumer acceptance are decisive in establishing one's competitive standing and profitability status.

Food-borne diseases are attributed primarily to agents transmitted through the food chain but can arise on farms and in processing facilities, markets, and homes.

Microbes in Food

Salmonellosis: Salmonellosis, a foodborne, infectious disease, is probably the most common bacterial disease in Kansas and the nation. Research is under way to study the disease-causing mechanism when the organism is exposed to low temperature for extended periods. The study shows that the organism attaches to intestinal walls in a very aggressive manner. This is especially true when the organism grows at room temperature.

Enhancing Microbiological Safety: Several antioxidants, BHA, BHT, TBHQ, and PG, are used as antibacterial agents to arrest the growth of *Escherichia coli* 0157:H7, an emerging pathogen. K-State scientists have previously developed methods for simultaneous extraction and detection of the antioxidants. Complex food systems like ground beef attenuate antibacterial efficacy and, in this study, efficacy depended on the initial microbial load. BHA, the most effective of the four antioxidants, was bactericidal at 200 ppm regardless of the inoculum level.

Rapid Detection Methods

***Listeria* Bacteria**: Food scientists at K-State have developed and are refining a U-tube system using an enzyme for rapid detection, isolation, and enumeration of *Listeria* and other bacteria in meat. The system decreases the time required for detection from 5 days to 24 hours. This allows time for decision making by Kansas processors before meat and meat products are shipped. This minimizes recalls and improves consumer confidence. The university has been issued a patent on the process.

Recovering Injured *Listeria* Cells: *Listeria* pathogens are not always destroyed by high temperatures. A comparison of

the Hungate Tube (the standard method) and Fung's Double Tube method was used to determine the most effective way to recover injured *Listeria* cells and other potential pathogens. Fung's Double Tube system, a K-State method, enhanced the recovery of heat injured cells. The results were obtained 19 days sooner than with the Hungate system. Oxyrase™ additions created environments preferred by the heat injured cells.

Most Probable Numbers of *Listeria*: Direct plating methods and the most probable number technique (using the Fung-Yu tube system) were compared for enumerating *Listeria* bacteria in raw meat. Significant differences in percentage of positive results between the two isolation techniques were found. Only 17 percent of positive samples were detected by direct plating, whereas 31 percent were detected by the most probable number (Fung-Yu tube) method. Direct plating lacked sensitivity for detecting low numbers of *Listeria*. Use of the Fung-Yu process and selective motility enrichment helped overcome that difficulty.

Identification and Quantitative Analysis of Fumonisins In Beef: Fumonisins are central nervous system carcinogenic toxins produced by molds and appear to be tumor-initiating and tumor-promoting. The health effects are just beginning to be compiled. The thermospray mass spectral analysis being developed at K-State gives sensitivities in the parts per billion range, minimal matrix effects, minimum cleanup, and about 60 percent recovery. The method detected fumonisins from corn and feed extracts and from spiked meat and rumen fluids. Fumonisins are not hydrolyzed by rumen fluid even after 4 hours of incubation. Extraction procedures are being modified to increase recovery from meat.

Isolating *Yersinia* Microorganisms: The presence of *Yersinia* organisms in cooked products may be due to inadequate heat treatment, poor hygiene, or cross contamination. Although the virulent plasmid of *Yersinia* can be readily recognized by dye binding, a simple indicator of the microorganism is needed. In this research, combinations of enrichment and plating medias were evaluated for their ability to recover the virulent strains. A combination of sorbitol bile broth and congo red-magnesium oxalate gave the highest recovery of *Yersinia* in contaminsted pork.

Membrane Fractions (Oxyrase™) and Food Safety: KSU microbiologists discovered that Oxyrase™, a membrane fraction of *E. coli*, stimulates the growth of food pathogens,and a U.S. patent has been granted. The membrane fraction significantly stimulates strains of *Listeria, E. coli, Salmonella, Yersinia, Clostridium, Campylobacter jejuni*, and *Campylobacter coli*. The organisms started growing earlier with shorter lag phase and grew faster than those without the membrane fraction. This characteristic significantly lowered the detection limit by increasing cell growth to the detectable level.

Oxyrase™ in and Rapid Detection of Microorganisms: *Campylobacter jejuni* and *Escherichia coli* 0157:H7 are potentially devastating pathogens and require selective enrichment for detection. For 5 strains of *C. jejuni* and one strain of *E. coli*, growth was significantly higher and generation times significantly shorter in the Oxyrase™ treated samples. Although *Campylobacter* was not detected in 100 meat samples using three enrichment broths, 60 percent of 53 chicken samples were *Campylobacter* positive using brucella Oxyrase™ with Doyle and Roman antibiotics, higher than any other treatment.

Rapid Detection Methods Based on Motility Enrichment: Preventing recontamination of processed products from raw materials often depends on the use of rapid detection methods. Many meat samples tested negative for *Listeria* by conventional direct plating methods but tested positive as determined by a motility enrichment method developed at K-State. The superiority of the motility enrichment procedure for detecting *Listeria* in raw meats (beef, pork, turkey, and lamb) was conclusively demonstrated.

Yeast and Mold Isolation from Meat: K-State scientists previously developed an organic dye media selective for the growth of *Aspergillus* and *Penicillium*. Those media (BV1 and BV3) were then studied to determine their ability to grow aflatoxin-producing strains of *Aspergillus*. The BV1 and BV3 dyes are selective for *Aspergillus* and *Penicillium* and allow for the production of aflatoxin. Miniaturized inoculation techniques were developed to provide for increased efficiency and mass studies as was an aniline blue medium for rapid detection of *Candida albicans*.

Liver Flukes: A capture enzyme-linked immunosorbent assay (ELISA) to detect *Fasciola hepatica* antigens in sheep and cattle provides a needed step in developing a simple, specific, rapid, inexpensive test to screen liver fluke infestations in cattle. Procedures have been developed using cotton rats as a host for maintaining the pathogen in the laboratory. This host can be easily infected and may serve to perpetuate liver flukes in snails and other hosts.

Residue Protection

Testing for Organophosphate Residues: Significant use of organophosphate pesticides occurs worldwide. To ensure a safe food supply, methods for determining organophosphate residues and their metabolites are required. K-State researchers are testing the analytical capability of high performance liquid chromatography coupled with mass spectroscopy in lean and fat beef treated with organophosphates and their metabolites. The detection procedure proved linear over the concentrations studied and the procedure promises to be an effective analytical tool.

Thermal Decomposition of Organophosphates: The thermostability of organophosphate pesticides and selected primary and secondary metabolites was investigated. Water and meat

samples containing mixtures of organophosphates and their metabolites were heated for 1 to 2 hours at 70 and 80°C and analyzed. Despite heat-induced degradation (hydrolysis and oxidation), over 50 percent (and more) of many of the organophosphate residues still remained. Heating or cooking did not eliminate most organophosphate residues.

Detecting Viruses

Detecting Bacterial Viruses: Viruses are common food contaminants, but detection methods are complex, and attempts have been made to use bacteriophages as viral indicators. Phages specific to *Bacteroides fragillis* have shown excellent potential. Researchers are using the Fung Double Tube method to detect bacteriophages. In the system, *B. fragillis* grows well and produces typical colonies. Although plaque forming units were not observed, host colony counts were lower and more diffuse in the presence of phages. This may lead to simple, rapid method for a presumptive measure of fecal contamination of viruses. Confirmation will require more study.

Food Borne Viruses: Food is a potential vehicle for transmitting viruses. Some have used high temperatures (79°C) to inactivate viruses while others propose using lower temperatures for longer periods. The inactivation of bovine rotavirus, bovine enterovirus, and bovine herpesvirus were monitored at low temperatures. The viruses persisted in meat samples stored at -20°C for a least 15 weeks. At higher temperatures, rotavirus was readily inactivated at 60°C, but inactivating bovine enterovirus required cooking at 70°C for 10 minutes. Thus, ground beef needs to be cooked for at least 10 minutes at high temperatures to destroy enteroviruses.

FOOD SAFETY EDUCATION

The Kansas Cooperative Extension Service maintains core programs in nutrition, diet, and health. Food quality and safety have been identified as a system-wide issue. Cooperative Extension organizes food safety programs related to food borne diseases, quality assurance, hazard analysis, and production and post-harvest technology. Programs are adapted to local needs in consultation with elected councils, government agencies, and local and industry representatives. The educational agenda is directed to new and established processors; the consuming public and child care, health care, and food service management and employees; and those who produce, market, and consume Kansas products.

Kansas food safety specialists are recognized as state and national leaders and have been asked to assist in organizing and producing educational materials and pilot programs for regional and national use.

Food Safety on the Farm

Food Safety in Dairy Enterprises: A committee of veterinarians, regulatory personnel, and Extension specialists organized the Kansas Milk and Dairy Beef Quality Assurance Educational Program. Since January 1992, the 10-point residue-avoidance guidelines have been presented at 34 Kansas Dairy Herd Improvement Association annual meetings. Besides producers, the 1,340 individuals in attendance included 80 veterinarians, 16 marketing field representatives, and 8 regulatory personnel. Participants represented 556 dairy herds or 46 percent of the state's total.

Beef Quality Assurance: To assure wholesomeness and maintain consumer confidence in beef products, Kansas State University is promoting three quality assurance initiatives:

Drug Usage: Specialists have surveyed and summarized current systems used by feedlots to monitor drug usage.

Permanent Identification: Specialists are exploring the use of electronic implants to permanently identify cattle from birth to consumer. The pilot program was expanded to include a ranch, commercial feedlot, and 150 steer calves implanted at birth.

Cow-Calf Quality Assurance Manual: The manual being developed by Extension specialists and veterinarians will become the national reference guide for cow-calf safety assurance programs.

Swine Quality Assurance: In 1992, pork quality assurance was a priority focus at KSU Extension swine programs. Extension specialists cooperated with the Kansas Pork Producers Council to heighten awareness about food safety. Certification is achieved only if producers review the 10 critical control points for drug residues prevention. With 200 producers certified, Kansas leads the nation in producers who have completed the Pork Quality Assurance Program. A similar program also is an initiative of the National Pork Producers Council.

Pesticide Applicator Training: Extension specialists cooperating with the State Board of Agriculture train agricultural producers in the best techniques to protect the food supply when applying general and restricted-use pesticides. During the 1992 reporting period, 2,909 private and 2,109 commercial applicators received training on chemical application and were licensed to apply chemicals in Kansas.

Food Safety for Processors

Hazard Analysis for Critical Control Point (HACCP): HACCP analysis identifies critical control points in the processing cycle and their associated hazards. The program is designed to help small processors develop individualized food safety programs. The HACCP project was expanded to include two additional meat plants selling products to national food service chains. This helped to increase sales and improve safety procedures. Other processors were assisted with training and certification in processing low acid and acidified foods.

Hazard Analysis Training Outline:

Line employees are trained to handle food safely in a production environment.

Management personnel are trained in HACCP concepts, program implementation, total quality management, plant and equipment sanitation, microbial sampling, documentation, and verification.

Managers are helped with plan implementation and technical advice in selecting microbial and residue detection kits, incubators, sanitizing agents, and operational changes.

Verification—the adequacy of the HACCP plan is confirmed by collecting environmental samples, meat products, and performing appropriate food safety tests.

Participation is encouraged by awarding certificates for completing HACCP training and sharing test results.

Food Safety Programs for Small Entrepreneurs: In this program, new or beginning processors are assisted with laboratory analyses for water activity, pH, aerobic plate count, and head space to assess product shelf-life. Other topics include food plant sanitation, risk assessment, and consumer perceptions of food safety. The goal is to help processors manufacture safe, high-quality food. Achieving those goals is critical for the survival of an emerging business and for the health of the consuming public.

Coordinated Food Quality Programs: An interdisciplinary, multi-agency team is used to provide individuals and agencies with technical support, marketing assistance, plant layout design, product development, and business planning. The coordinated effort involves Extension specialists from foods and nutrition, agricultural engineering, animal sciences, horticulture, and agricultural economics and individuals from the Kansas Value-Added Center, Kansas Agricultural Experiment Station, and State Board of Agriculture.

Food Safety for Consumers

Public Policy Educational Forums: Kansas has approximately 22,011 licensed or registered eating establishments (commercial, institutional, health care, and child care). Kansas food service employees are not required to complete food safety training or undergo health examinations.

In 1992, Cooperative Extension conducted 16 public policy educational forums on food safety in food service. The forums, part of an Extension food safety initiative, identified a need for food safety training of sanitarians, industry personnel, and consumers, for mandatory manager certification and local food safety training programs. Policy options studied included 1. maintaining the status quo, 2. regulatory options, 3. food service industry initiatives, and 4. consumer options. The 627 participants included managers, dietitians, cooks, teachers, consumers, and community leaders.

Model Food Safety Training Program: The focus of the Model Training Program was to educate food handlers (management and employees) to reduce the risk of food-borne illness. The program incorporated planned sequential learning experiences and pre, interim, and post observations in selected food service operations and included both managers and employees. Employees participated in four training sessions about personal hygiene, proper storage and serving temperatures, cross-contamination, cleaning and sanitizing, and modifying work habits to improve food safety.

Extension Agent and Sanitarian Training: A two-day, train-the-trainer approach was used with Extension agents and state sanitarians employed by the Kansas Department of Health and Environment (KDHE) to enhance their capability to deliver food service sanitation programs. The goals were to provide a food safety review, emphasize HACCP based inspections, and become certified. Sixteen Extension agents and 25 sanitarians participated. All agents and sanitarians were certified through a testing procedure. Written evaluations demonstrated that agents and sanitarians felt the training would help them educate the public and other operators about food safety. The training of Extension agents in conjunction with KDHE is continuing.

Food Safety for Family Child Care Providers: "Safe Food for Children" lessons have been completed and pilot tested for family child care providers. Each lesson includes a leader's guide, a brochure for parents, and "extras" such as stickers, shopping lists, magnets, and food storage charts. Each lesson is accompanied by a short animated video starring "Mike the Microbe." An advisory group of food and nutrition specialists, child care specialists, registered dieticians, a county agent, and a county health nurse assisted in developing the lessons.

Food Safety for Children

Safe Food for Children: Extension specialists, with help from a USDA grant, conducted a nationwide satellite training session using "Safe Food for Children" and "Food Safety Express" educational materials developed at Kansas State University and the University of Missouri. The training was targeted to professionals who teach, license, or administer child care providers in state and federal agencies and state associations. Participants viewed the program at 179 sites in 48 states, Guam, and Germany. There was a known audience of over 1,500 participants.

Taking a Risk on Food—Curricula for Youth and Adults: The goals of this USDA special project have been to increase consumer understanding of food related risks and facilitate informed decision making on food safety issues. Under KSU leadership, four states are participating on the project team. The project is being implemented through model programs, development of curriculum guidelines, and review of existing curricula for risk education. An Internet accessible database was established at Michigan State University. In the second year of funding, four regional workshops will train Extension staff across the United States in building localized programs using the database and other tools to enhance food safety programming nationwide.

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AGRICULTURE, WATER, AND ENVIRONMENT

Adequate water and quality environment are of preeminent importance to the economy of Kansas. For crop production agriculture, inadequate moisture is likely the most limiting environmental stress and nitrogen the most deficient nutrient. Pollution of surface and groundwater by sediment, nutrients, pesticides, and other organic and inorganic materials is increasingly recognized. Because water is a limited or depleting resource in many areas, there is increased emphasis on resource conservation and water quality and environmental protection. This concern is evident in research, teaching, and Extension thrusts at Kansas State University.

AGRICULTURAL RESEARCH

Water conservation and environmental quality components are incorporated into a significant number of crop and soil management, nutrient efficiency, and cropping systems research projects at K-State. Researchers, through design and data gathering protocols, are addressing priority water conservation and environmental quality issues. The protection of surface and groundwater quality is a paramount consideration.

Crop and Soil Management

Mapping Yields While Harvesting the Crop: Mapping grain yields while harvesting the crop is technically feasible. Yield maps provide data with which to locate problems and evaluate cropping practices. Significant variations in grain yield were observed in a single field. This supports the need to apply fertilizer at variable rates in accord with field location and condition. Potentially, this could reduce chemical input, increase efficiency, and reduce environmental hazards.

Crop Rotations: The use of crop rotations is an effective management strategy to enhance yield and reduce cost. Researchers in northeast Kansas (1982-1992) determined that grain sorghum rotated with soybeans outyielded continuously cropped grain sorghum by 18 bu/a. In a continuous grain sorghum system, yields increased with increasing N rate up to 90 lb/a. In the rotated system, however, maximum yield was achieved with only 40 lb/a of N. Grain sorghum grown in rotation with soybeans produces higher yields with lower input costs.

Composting Manure: Manure disposal from cattle feedlots is a major concern. In western Kansas, manure compost applied at 1 tn/a annually maintains soil P levels, while higher rate of application increases soil P, K, and organic matter levels. The application of manure compost at rates up to 7 tn/a annually is environmentally safe. (No increase in NO_3 levels in the lower soil profile were observed after four years of compost applications). For maximum crop production, manure compost should be applied in combination with N fertilizer.

Rotation Benefits in the Great Bend Prairie: Rotating corn with soybeans or a wheat-soybean double-crop increased corn yields 20 percent on irrigated Farnum fine sandy loam when compared to a continuous corn system. Less nitrogen fertilizer was necessary to maximize yields with the rotation. This suggests that producers on irrigated sandy soils in the Great Bend Prairie can significantly increase yields and decrease nitrogen fertilizer input through crop rotations as short as two years.

Nutrient Efficiency

Nitrogen Soil Tests in Eastern Kansas: Preplant nitrogen soil tests are a valuable management tool to determine nitrogen fertilizer application rates. Use of this test improves producer efficiency and reduces the potential for environmental problems. Applying excess nitrogen is an environmental hazard and an economic liability cost that can be avoided by use of this test.

Mineralization: After harvest, crop residues decompose and release nitrogen for subsequent crops in a process called mineralization. Field studies show that only 0.5 to 2.5 percent of the nitrogen in sorghum residue was mineralized in 110 days. This suggests that nitrogen release by the previous crop contributes little to the nitrogen needs of the current crop. Thus, management of applied fertilizer is a critical part of the crop production process.

Fertilizer Management Technology: Ammonium volatilization losses from urea applied to calcareous soils can approximate 25 percent. Studies show that ammonia loss was reduced 22 percent in calcareous soils and 48 percent in noncalcareous soils when ammonium thiosulfate (ATS) was added to urea ammonium nitrate (UAN) fertilizer. Urea hydrolysis inhibition was greatest for soils low in clay and organic matter and increased with increasing soil pH and with band application of the fertilizer.

Fertilizer Effects on Soil Properties: Soils treated for twenty years with ammonia, ammonium nitrate, urea, and a urea-ammonium nitrate solution were sampled to determine the status of selected physical and chemical properties. There was no significant differences among the four nitrogen source treatments. The 20 years of treatment reduced soil pH (5.2 v. 6.2) in the surface; increased micronutrients (Fe, Cu, and Mn), and decreased available phosphorous and exchangeable bases (Ca, Mg, and Na). There was no significant difference in maximum bulk density or optimum water content for compaction. When properly applied, all sources of nitrogen are agronomically equal.

Nitrate/Ammonium Ratio Management on Corn: Field experiments in northeastern Kansas show that preplant application of urea ammonium nitrate (UAN) solution or ammonium nitrate (AN) plus a nitrate inhibitor (NI) result in both ammonium and nitrate being available for plant uptake. Without the nitrate inhibitor, the ammonium nitrogen is converted rapidly to nitrate nitrogen. Mixed nitrogen nutrition (ammonium and nitrate) increased growth and nitrogen uptake by corn 4 to 7 percent compared to nitrate nutrition. Using the NI inhibitor increased returns ranging from $7.40 to $18.90 per acre.

Phosphorus Availability in Soil: Investigators at K-State are researching the ability of plants to obtain phosphorus without the addition of fertilizer. Certain plants like prairie big bluestem cooperate with soil fungi, called mycorrhiza, to obtain nutrients that would otherwise be unavailable. The fungi transport nutrients from one plant to another, making it possible for one plant to share its nutrients with a neighbor. The research objective is to decrease the demand for fertilizers by agronomic crops.

Surface Acidification: High rates of nitrogen applied to the surface of no-till areas acidified the uppermost soil layers. Lime may be needed to correct this problem. As the nitrogen rate increased, the organic matter content of the uppermost soil layer also increased. This suggests that the higher nitrogen rates not only increased grain yields but also improved the overall fertility of the soil. In south central Kansas, research has demonstrated that one-quarter the recommended rate of lime application is sufficient to achieve optimum yields on acid soils that have subsoils that are only moderately acid.

Nutrient Efficiency in Dryland Cropping Systems

Fertilizer Rate: In Ellis county, nitrogen fertilizer applied at half rates (20 lb of N/a with the grain sorghum seed at planting time) gave yields comparable to a full nitrogen fertilizer application (40 lb of N/a top-dressed). The 20 lb rate resulted in a 11.5 bu/a increase over the unfertilized control in a low fertility, no-till tillage system in a wheat-sorghum-fallow rotation during 1986 to 1992. Applying half the normal rate and achieving nearly the same yield response is significant because it increased production efficiency, water-use efficiency, and return on investment.

Western Kansas: The effect of fertilizer placement on the recovery of nitrogen (N) was evaluated in western Kansas. About 60-70 percent of the N was recovered from subsurface applications but only 40-45 percent was recovered from broadcast N. This left an extra 25-50 lb/a of N in the broadcast treated soil depending on the treatment rate. The extra nitrogen represents an environmental hazard and an added cost. Clearly, the proper management of N fertilizer can significantly reduce the potential for leaching N below the root zone.

Eastern Kansas: In eastern Kansas, data also suggest that at lower rates, 30 lb N/a nitrogen is used less efficiently when broadcast as compared to incorporation in a conventionally tilled system. Subsurface placement (knifing) also improves efficiency at the low N rate. At high nitrogen rates, 120 lb N/a, there was no difference in efficiency due to tillage, nitrogen source, or nitrogen placement.

Nitrogen Placement in Conservation Tillage Systems: Nitrogen placement in conservation tillage management systems (high residue) is a critical factor to maximize efficiency. Placing nitrogen below the residue (knifing) increased grain yields and protein compared to surface broadcast nitrogen. Knifeless or point injection was comparable to knifed applications. Urease inhibitors, ATS and NBPT, were evaluated and NBPT proved a viable nitrogen management tool for high residue surface broadcast applications.

Alternative Agriculture

Alternative Agricultural Systems: Researchers are examining the economic and environmental implications of alternative agricultural systems. Data were collected from 15 farms and from experiments using conventional or alternative farming systems. Preliminary results suggest that without government participation several alternative rotations may be more profitable than conventional rotations. The alternative systems should reduce environmental impacts, including contamination from agrichemicals and soil erosion.

WATER RESOURCES RESEARCH

Water conservation and water quality are growing concerns. In Kansas, irrigators withdraw 80 percent of the state's water, and there is a concerted need to use water efficiently, extend aquifer life, and protect surface and groundwater from contamination.

Irrigation

Drip Irrigation: The net irrigation requirements for producing 200 bushel corn yields were reduced 25 percent using subsurface driplines spaced 60-inches apart. This translates to a 40-50 percent water savings compared to sprinkler and furrow systems, which typically operate with a 65-75 percent efficiency. Lateral dripline lengths up to 660 feet were acceptable on slopes up to 0.5 percent. Although installation costs decrease with increased dripline spacing, the practical maximum spacing is about 60 inches.

Preseason Irrigation: The five-foot soil profile was at 69 percent of field capacity after harvest for the 82 sprinkler and surface irrigated fields sampled. Consequently, preseason irrigation is generally not necessary for irrigated corn. The water content measurements were more variable for surface-irrigated systems than for sprinkler systems. This suggests that more careful management of surface-irrigated systems is warranted. Leaving the soil drier at

harvest increases the possibility of effective storage of winter precipitation and decreases the possibility for deep percolation loss.

Irrigation Management: The timing and quantity of an irrigation greatly influences the amount of water that drains from the soil. Modeling studies show that the drainage loss with four, 6-inch irrigations can be nearly 15 acre inches. This is a cost without benefit because yields produced with three properly timed irrigations are nearly as great as those produced with four irrigations. The net income from the more efficient water regime is greater.

Resource Allocation For Irrigated Corn: An examination of nine resource allocation schemes revealed that fully irrigated corn was most profitable using standard fertilization and seeding rates. This resource allocation maximized mean net income and minimized the standard deviation. Irrigators wishing to grow corn when irrigation is constrained should seriously consider reducing the irrigated area to match the severity of the water constraint.

Water Quality

Groundwater Quality: K-State has developed a major effort in researching translocation of agricultural chemicals through soils throughout the state. Field studies of nitrate and atrazine leaching have been conducted at St. John, Great Bend, Bentley, and Ashland. Laboratory column, adsorption, and dissipation experiments have accompanied each of these studies. Biotic and abiotic degradation of atrazine and alachlor have been examined in soils and groundwater. Ongoing efforts include non-equilibrium adsorption transport of atrazine, construction of a weighing lysimeter, and laboratory monitoring of atrazine degradation.

Fate of Nitrogen: Significant research is directed toward determining the source, movement, and fate of nitrogen under different management practices because it impacts nitrogen use efficiency and water quality. Information is being collected on mineralization of nitrogen from legumes and manures for crop production under different tillage systems. Once nitrogen is converted to NO_3 then movement is affected by tillage, rotations, and soil morphology. This impacts NO_3-loss and the potential for remediating NO_3-contaminated soils and groundwater.

Estimating Atrazine Loss to Surface Water: A geographic information system (GIS) has been developed to estimate potential impact of atrazine loss to surface water. Soils, hydrology, and land cover comprise the data layers needed to make the estimate. The GIS procedure will be expanded to smaller watersheds in the Delaware River Pesticide Management Area. With proper correlation, the procedure could reduce the amount of monitoring needed to identify areas with high atrazine loss potential.

Atrazine and Nitrate Leaching from Soil: When application exceeds crop demand, nitrate, a common contaminant in Kansas groundwater, can leach through clay, loam, and sandy soil into groundwater. Applying only the amount of nitrogen needed for growth significantly reduces contamination. Conversely, atrazine moves readily in sandy soils but much less readily in soils high in clay or organic matter. Preventing contamination is more practical than remediation because it takes over a year to reduce the concentration by one-half once atrazine reaches the aquifer.

Water Quality Protection Strategies for Wells: Where nitrates, pesticides, and volatile organic compounds are found in well water, identifiable sources within 200 feet of the wells are the most probable cause. The use of pesticides at labeled rates in the vicinity of the well is not generally a factor related to pesticide occurrence in the well. The use of fertilizer near the well is a factor in high nitrate content in about 30 percent of the wells. Livestock feeding sites were a factor in the nitrate content of about 50 percent of the wells, septic tanks in 15 percent, and bulk fertilizer storage in 5 percent. Testing is the only reliable way to determine if nitrate is less than the maximum contaminant level.

Using Iodinated Resins to Disinfect Water: Large-scale systems containing pentaiodide resin capable of treating surface and groundwater and producing microbiologically pure, disinfected, potable water have been developed. A zirconium peroxide resin uses iodide ions to disinfect the water and then removes the iodide ions from treated water. A silver-chelex resin disinfects water but removes the iodide ion by precipitation in the resin bed. The pentaiodide resin may also be useful in disinfecting air in environments where sterile air is required.

Managing Soil Water and Solutes: Experiments at KSU demonstrate that accurate predictions of herbicide movement require a more detailed description of the adsorption process. Researchers are characterizing the appearance and movement of deethylatrazine and deiospropylatrazine, which are atrazine degradation products. However, groundwater quality evaluations have typically not included tests for atrazine degradation products in Kansas.

Crayfish Culture

Crayfish Aquaculture: Studies have been conducted to evaluate the potential of crayfish aquaculture in Kansas. The experimental species, *Orconectes nais*, is commonly found in farm ponds in Kansas. It is hardy and prolific, but it readily overpopulates and growth is stunted. When subjected to a heavy harvest, the population was thinned and rapid growth was achieved. Annual harvests of 150 to 900 pounds per acre of mixed sizes (bait and food sizes) were achieved. Results in farm ponds were variable depending on water quality, population density, and nutrition.

ENVIRONMENTAL QUALITY RESEARCH

There is a growing concern about environmental quality on a local, national, and global scale. Researchers at Kansas State University are addressing environmental issues in natural resource management, climatic change, biological control, and remediation of contaminated soil. Those efforts are in addition to work in water conservation and water quality.

Natural Resource Management

Konza Prairie Research: The Konza Prairie Natural Area (8,616 acres of native prairie) is an ecological and educational research center at K-State. The site serves as a natural laboratory for analyzing native and domestic populations and communities and ecosystem processes. Much of the research involves watershed-scale fire regimes and grazing cattle and bison. Kings Creek originates on Konza, serves as a benchmark water quality site, and is the most pristine stream in Kansas.

Energy Balance Studies: In energy balance studies of sorghum and sunflower, it was determined that sunflower depleted more water (about 7.1 in) from the soil than sorghum. If the global climate becomes drier in the northern mid-latitudes, as predicted, the lower soil-water use and lower latent heat flux of sorghum compared to sunflower suggest that sorghum will be better adapted to the climate change.

Remediation

Heavy metal mining activities in southeast Kansas have produced heavy metal contaminated soils. The soils have a limited productive capacity because of trace element toxicities.

Bioremediation of Mine Tailings: Because mine tailings in southeast Kansas contaminated with heavy metals pose a significant health risk, research was conducted to determine if mycorrhizal fungi or a mixture of microbes could stimulate plant growth in the tailings. (Establishing vegetation would reduce risk and limit wind and water erosion). When tailings were fertilized and amended with mycorrhizal fungi or an expanded clay product, plants did survive on the tailings. Experiments to compare other expanded clay products and methods of application are in progress.

Remediating Soils Contaminated with Heavy Metals: Isolated areas in southeast Kansas have experienced contamination from lead and zinc mining activities. Research demonstrates that heavy applications of lime, manure, or mixtures of sewage sludge and cement kiln dust decrease zinc phytotoxicity and increase plant growth. Preliminary studies suggest that there is little uptake of lead, cadmium, zinc, or copper by grain sorghum growing in soils amended with municipal solid waste.

Denitrifier Ecology in Stratified Soil Profiles: Denitrification is important in the vadose zone because denitrifying microorganisms reduce nitrate to nitrogen gas, degrade pesticides, and survive in a nutrient-poor environment. Research demonstrates that the microbial population and activity were greater in nutrient-enriched zones relative to other subsurface layers. This enhances the likelihood for agrichemicals to undergo biological transformation before they reach the groundwater. Such transformations can convert agrichemicals to less toxic and less persistent forms.

Biological Control

Managing Livestock Insects: Entomologists at the Southwest Research-Extension Center in Garden City developed mass production methods for rearing a native fly parasite. Mass release of parasites in 18 cattle feedlots reduced stable fly numbers nearly 50 percent (below the economic threshold) in the cleaner feedlots and reduced the need for pesticides. In Kansas, economic benefits would approximate $7 million even if only half the fly irritation loss were prevented.

Bacteria as Selective Weed Control Agents: Over 200 bacterial isolates have been identified that selectively inhibit root elongation of downy brome, Japanese brome, or jointed goatgrass without affecting wheat growth. Thirteen isolates retained their inhibitory capacity when inoculated on downy brome or jointed goatgrass grown in soil under controlled conditions. This may become a promising alternative weed control method; however, microbial weed control agents are unlikely to replace the use of herbicides.

Climatic Change

Air Quality/Climatic Change: Global atmospheric carbon dioxide concentration is increasing at an unprecedented rate, and the consequences of that increase are subject to speculation. Because rangelands occupy 47 percent of the earth's land surfaces and 54 percent of the conterminous United States, responses of rangeland to this environmental change are potentially significant to the global carbon budget. The ecosystem-level research at K-State is the only truly terrestrial natural ecosystem research with respect to elevated CO_2 in the world.

Elevated CO_2 Research: Agronomists have been studying the effects of elevated carbon dioxide (twice ambient) on a tallgrass prairie ecosystem. Results indicate that because of water conserving effects of elevated CO_2, tallgrass prairie ecosystems will have increased production. However, forage quality may be reduced by lowering crude protein and increasing fiber components. It was concluded that even with reduced rainfall and increased temperatures, tallgrass prairie productivity will not decline as much as previously expected.

High Temperature Injury: Major accomplishments:
1. Photosystem II was identified as the major site of high temperature injury to photosynthesis in wheat. A growth regulator (cytokinin) from roots was implicated in the rapid

senescence and early maturity of wheat under high temperatures. 2. High temperature was demonstrated to interact with photoinhibition injury in wheat by exacerbating injury to Photosystem II and demonstrated to interact with drought injury by preventing osmotic adjustment to water deficits. 3. Resistance to high temperatures during maturation was identified in wheat genotypes from Australia and China and shown to have high heritability. Other work showed that heat-resistant somaclones could be developed in tissue culture and resulted in release of resistant wheat germplasm.

Protective Clothing: To reduce pesticide exposure by applicators, K-State is conducting research on coveralls to determine optimal fit, enhance acceptance, and maintain maximum mobility. The addition of starch is also being investigated as a protective procedure. The use of laundry starch may be a feasible strategy because the thermal insulation and permeability of fabrics were not substantially altered by the addition of starch.

Genetic Improvement

Wheat: Germplasms have been released that have resistance, alone or in various combinations, to leaf rust, soilborne and spindle-streak mosaic viruses, powdery mildew, and Hessian fly. Those releases included eight disease-resistant germplasms from crosses between hard red winter wheat and goatgrass. Germplasms under development will also have resistances to Septoria leaf and glume blotches, tan spot, stripe rust, and Russian wheat aphid. Genes have also been identified that confer female fertility of hybrids of hexaploid wheat while hybrids of other accessions are female-sterile.

Sorghum: Genetic improvement is an environmentally friendly way to increase sorghum yield, enhance pest resistance, and improve functional properties. Sorghum breeders emphasize population improvement schemes and the use of new germplasm to introduce desirable, quantitatively inherited traits. This includes protection against greenbugs, chinch bugs, spider mites, and stalk rot; tolerance to drought, saline conditions, and low nitrogen soils; and improved feeding quality.

Soybeans: A recent soybean release, KS5292, is a group 5 line resistant to race 3, soybean cyst nematode. The new variety has a 6 percent yield advantage over Essex in Kansas and regional trials. Another release, KS430, is a group IV K-line with a 6 percent yield advantage over the varieties Sparks and Spencer. Several yield-competitive, cyst-resistant varieties have been also identified. This will be especially useful since researchers have consistently observed a 10 to 20 percent yield reduction on infected soils.

Alfalfa: Research is directed at developing methods for utilizing molecular marker technology in alfalfa improvement, genetic control of post-harvest protein stability, and producing germplasms with favorable traits using molecular marker technology. Researchers have developed an efficient method of identifying and cloning species-specific repeated DNA elements; an analysis of protein degradability and buffer capacity in ancestral lines of alfalfa; and registration and release of germplasm KS219, with multiple resistance to eight pests. Two germplasms are in the release process.

EDUCATIONAL PROGRAMS

Agriculture, Water, and Environment

Cooperative Extension is focusing educational efforts on critical social, economic, and environmental issues including resource, energy, and environmental stewardship. Educational efforts are led by interdisciplinary teams of specialists and agents and are coordinated with cooperating citizens groups and with state and federal agencies. The objective is to integrate production, protection, and conservation programs and help agriculture, industry, and communities be sustainable, profitable, and environmentally friendly.

Extension programs in resource conservation and protection are organized for local, regional, and statewide delivery.

Nutrient Management

Soil Testing: Soil testing is promoted through mass media, meetings, on-farm demonstrations, and in-depth schools as an aid in making sound nutrient and lime use decisions and in preventing contamination. The volume of samples tested has increased 20 percent in three years. A survey (State Board of Agriculture) showed that an average producer uses less than a pound of nitrogen per bushel of grain produced. Thus, less nitrogen is applied to the soil than is removed in the grain. It is estimated that soil testing in Kansas, public and private, improves net returns by $700,000 annually.

Testing Soils for Nitrate: An aggressive demonstration/applied research program was begun in 1991. In 1992, demonstration studies were conducted at 40 sites. This allowed KSU to further refine the soil profile nitrate test and provide information on the validity of pre-sidedress nitrogen soil testing. The sites have been located on farmer fields and KSU experiment fields and often serve as demonstration sites for tours and field days. Use of recommended nitrogen rates, appropriate yield goals, preplant soil tests, and crediting previous legumes and manure are essential to proper application and reducing potential contamination.

Pest Management

Best Management Manual: Cooperative Extension is developing a Best Management Practice Manual for Kansas because existing materials are not well adapted to Kansas. The soil pollution potential section has been completed and presented in professional meetings and adopted in the Soil Conservation Service Field Office Technical Guide. A system ranking pesticides has been developed for review by

Extension and other agencies. The objective is to help local planners in their efforts to reduce contamination.

Pesticide Management Area: A Pesticide Management Area was established in 1992 for controlling atrazine in runoff in the Delaware River Watershed. Extension established demonstrations and held grower meetings. Those efforts focused on regulatory requirements (rate reductions, set-backs from wells and water bodies, and curtailing non-cropland use of atrazine); and voluntary provisions (rate reductions, best management practices, method and timing of applications, riparian and conservation practices, and integrated weed management). Atrazine runoff has been notably decreased.

Atrazine Use: A limited survey of farmers in the Delaware River Watershed indicated that 92 percent of corn and grain sorghum acres received atrazine at an average rate of 1.35 lb/a. Of the respondents, 78 percent are using less atrazine or have changed practices because of environmental concerns, and 14 percent are shifting to preplant incorporation to reduce runoff hazards. Based on computer simulation (GLEAMS model), it is estimated that atrazine runoff loss could be reduced 38 percent for corn and 50 percent for sorghum because of these changes.

Atrazine Alternatives: Extension specialists have placed great emphasis on the safe and effective use of atrazine and other herbicides. Atrazine use alternatives were presented statewide to farmers, dealers, crop consultants, agricultural writers, integrated weed management meetings, ridge-till and other conservation tillage meetings, regulatory agencies, wildlife and parks personnel, noxious weed groups, state extension advisory council, State Board of Agriculture, and others.

Priority Practices in Herbicide Management: There are 208,155 acres of grain sorghum in the five county area comprising the Pesticide Management Area. Surveys indicate that 88 percent or 183,150 acres receive annual applications of atrazine. Priority practices for producer adoption established by specialists in the pest management area include:

1. Use of foliar applications (post-planting) of atrazine premixes as an alternative to higher soil applied rates.
2. Soil incorporation of atrazine on pre-planting applications on clean tilled soils and sites able to meet residue requirements of the 1985 farm bill.
3. Use of early applications (before April 15) of atrazine to avoid high potential runoff period.

Soil and Crop Management

On-Farm Action Research for Extension Programs: An adaptive research concept (plant populations, planting date, hybrid maturity, irrigation, fertility, row spacing) is now being widely utilized. This research supports 1. drilling early corn utilizing specific plant population and hybrids, 2. reducing seeding rates of corn and sorghum by 30 percent (yields will still be maintained), 3. planting soybeans in 30-inch rows rather than drilled plantings (in low yielding environments), and 4. planting large wheat seed (the yield advantage is 2.5 to 3 bu/a).

Residue Management, Tillage, and Runoff: Rainfall-runoff demonstrations were conducted at 18 sites. Best management practices and their effect on soil erosion, runoff, and infiltration were graphically illustrated for over 1,000 individuals. As a result, 40 percent of the participants indicated that they would change their farming practice to reduce erosion and runoff and enhance water quality; 60 percent wanted to see the demonstration repeated; and 95 percent indicated they learned valuable principles.

Soil Fertility/Soil Management: These Extension programs stress efficient use of nutrients, including proper fertilizer rates, sources, placement, and application, and use of legume rotational crops and animal waste products. Water quality and proper nutrient management are underlying themes. Educational programs in this area have been covered at over 350 county Extension schools, in-depth workshops, field days and tours, in-field training sessions, and farm visits with total attendance of over 25,000 people, including 2,000 dealers, fieldmen, and consultants.

Conservation Reserve Program: This educational effort is cooperative with other USDA agencies and private organizations. The four-phase program includes 1. cover crop and seedbed preparation, 2. seeding and establishment, 3. cover crop and seedbed preparation, and 4. preparing for contract completion. Phases 1 and 2 have been completed, and phases 3 and 4 are ongoing. Ninety-nine percent of all seeded acres were established with a reseeding rate of less than 7 percent—likely the best program in the nation.

Agricultural Sustainability: Agents and specialists implemented 77 sustainable agriculture demonstrations including 1. use of stable fly predators and sanitation at 25 feedlots and 12 dairies as a replacement for chemical treatments, 2. improved no-till alfalfa seedings at three locations, and 3. the benefits of crop residue in increasing water infiltration and decreasing sediment movement on highly erodible cropland at 37 sites. Over 200 producers adopted these and other sustainable agriculture practices.

Pollution Abatement

Livestock Waste Management: Extension specialists were active in the multi-agency Herington Lake Demonstration Program with the Kansas Department of Health and Environment, State Conservation Commission, Dickinson County Conservation District, Soil Conservation Service, and Environmental Protection Agency. Extension specialists designed 9 livestock waste systems as demonstrations. A separate project

will evaluate the systems as best management practices for runoff control for the 3,000 cattle they serve.

Waste Management In Riparian Areas: Engineering extension specialists visited 150 farms to assist with livestock waste management. Many sites were in riparian areas and may be subject to future regulatory action. Specialists indicate that about half of the visits have resulted or soon will result in improvements in livestock waste management and will impact 26,000 cattle. The visits provided valuable data for preparing design specifications, publications, and other educational materials.

On-Site Waste Water: Extension specialists have conducted training sessions for professionals in health and environment, Extension, resource conservation, and citizen groups who manage on-site waste water. They developed an Environmental Health Handbook cooperatively with the Kansas Association of Sanitarians and Kansas Department of Health and Environment. They also addressed the need for waste water lagoons for private homes in a specially designed bulletin. The publication provides introductory material for the homeowner and addresses how lagoons work, lagoon design, construction, and permitting.

Septic System Maintenance: Cooperative Extension has an active program in septic system maintenance conducted in cooperation with the Kansas Department of Health and Environment. Specialists hold in-depth training schools for local health department personnel, sanitarians, and septic tank installers. Counties participating in the Local Environmental Protection program are developing sanitary codes for sanitary waste water systems. The training program is supported by a series of Extension educational publications.

Wellhead Protection

Farmstead Assessment: Farm*A*Syst is an Extension program adapted to Kansas to help rural residents evaluate and protect groundwater resources. The program consists of 10 worksheets that allow farmers to evaluate farmstead structures, practices, and site vulnerability to groundwater contamination. The program was piloted in the Webster Creek Hydrologic Unit, and agent and multi-agency training sessions have been held. A project involving FFA and 4-H Youth to complete Farm*A*Syst was completed in Finney County and is ongoing in Marion County. Kansas specialists were part of the national staff for training held in Ft. Worth, Denver, and Portland.

Well Plugging: In 1992, 47 well-plugging demonstrations were held with over 2,000 in attendance. When coupled with previous efforts, 40,000 well-plugging bulletins were distributed, numerous well-plugging exhibits were displayed at county fairs, and several civic and service groups planned to plug abandoned wells as community service projects. In 1991/1992, 1,012 wells were plugged according to records submitted to the state. To date, 50 counties have written nonpoint source pollution management plans that include well-plugging activities.

Publications: In support of its water quality and environmental quality initiative, Cooperative Extension published over 25 educational bulletins and a video on plugging abandoned wells. The bulletins were distributed to interested citizens not only by Extension but also by cooperating state and county agencies. Selected titles include Plugging Abandoned Wells, Using Pesticides Safely, Safe Domestic Wells, Activated Carbon Filters, Suggested Water Tests for Private Systems, and Shock Chlorination for Disinfecting Water Systems.

Water Quality: Over the past four years, 80 county Extension offices have conducted at least one county-wide media campaign to encourage people to have their water tested. At least 1,000 water samples were tested each year. Specialists conducted clinics explaining results of water tests and encouraging follow up action in 80 counties between 1988 and 1992. Since then, program delivery has been conducted by county staff.

Coordination with other Agencies: Extension environmental quality programs are often coordinated with other agencies and groups. For example, Kansas has received USDA funding for five Agricultural Conservation Programs and a Hydrologic Unit project. An interagency water quality newsletter is published quarterly. Information on pesticides in groundwater and surface water have been merged into training sessions for commercial pesticide applicators. A pollution rating system for soils was incorporated into a Soil Conservation Service technical guide.

Environmental Awareness: Three hundred seventy-nine teachers and educators, who reach a potential of 12,000 youth, attended Extension-conducted environmental education programs designed to create environmental awareness and enhance the development of an environmental ethic.

Drought

Drought: Over 300 articles on drought and drought effects have been published on a CD-ROM as part of an agriculture and Life Science series. Copies were placed in each area Extension office and in each county office equipped with a CD-ROM drive. In addition, over 50 new-articles related to drought and water conservation were released to news services and area Extension offices. A video titled "Maintenance Landscaping" was also produced and aired over public broadcasting systems.

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