Approved January 24, 1990
Date

MINUTES OF THE Senate COMMITTEE ON Agriculture.

The meeting was called to order by Senator Jim Allen (Chairperson) at

10:09 a.m./~~p.m.~~ on January 23, 1990 in room 423-S of the Capitol.

All members were present except: Senator Montgomery (excused)
Senator Francisco (excused)
Senator Karr (excused)

Committee staff present: Raney Gilliland, Legislative Research Department
Lynne Holt, Legislative Research Department
Jill Wolters, Revisor of Statutes Department

Conferees appearing before the committee: Dean Walter R. Woods, Director, Kansas Agricultural Experiment Station, Kansas State University
Dr. George E. Ham, Associate Director, Kansas Agricultural Experiment Station, Kansas State University
Dr. Hyde S. Jacobs, Assistant to the Dean of Agriculture, Director, Kansas Water Resources Research Institute, Kansas State University
Dr. A. Paul Schwab, Soil Chemist, Department of Agronomy, Kansas State University
Dr. David A. Whitney, Soil Fertility Scientist, Department of Agronomy, Kansas State University

Senator Allen called the Committee to order and called on Dean Woods.

Dean Woods explained that only information about one part of the Experiment Stations' work would be discussed and that would be on water quality. Copies of information concerning water quality research were given to the Committee (attachment 1) which included information as presented by the following:

Dr. Hamm explained that research is done cooperatively with regional states and that research is being conducted to find ways to minimize the impact of agriculture on our environment.

Dr. Jacobs explained that KSU and KU work cooperatively on some water research projects and that water research subjects are selected because of state, regional and national research needs.

In answer to Committee questions, Dr. Jacobs answered that the Kansas Water Resources Research Institute does not put out an annual report but that summaries of research projects are usually completed in 1 or 2 years.

Dr. Schwab explained that research is being done on the quality of ground water to determine how contamination has occurred and also research on leaching in different types of soil. Information from the research is made available through publications, public forums and through the media.

Dr. Whitney explained about research that is being done on efficient use of fertilizer so that the right amount of fertilizer is used to prevent leaching.

The Chairman thanked Dean Woods and staff for their presentations and then called for action on Committee minutes.

Senator Doyen made a motion that the Committee minutes of January 17 be approved. Senator Frahm seconded the motion. Motion carried.

Senator Allen adjourned the Committee at 10:50 a.m.

GUEST LIST

COMMITTEE: Senate Agriculture DATE: January 23, 1990

NAME	ADDRESS	ORGANIZATION
Alex Hawkins	Topeka	KSBA
Robert Collins	Topeka	KSBA
Kenneth M. Wilke	Topeka	KSBA
Paul Schwab	Manhattan	KSU
Hyde Jacobs	Manhattan	KSU
George E Ham	Manhattan	KSU
David Whitney	Manhattan	KSU
Howard W. Tice	Hutchinson	KAWG
Walter Woods	Manhattan	KSU

WATER QUALITY RESEARCH Developments

A Report
to the
Kansas Legislature

by the
Kansas Agricultural Experiment Station
Kansas State University

Senate Agriculture Committee
1-23-90
attachment 1

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KSU
KANSAS STATE UNIVERSITY

Director of Agricultural Experiment Station

Waters Hall
Manhattan, Kansas 66506
913-532-6147
FAX: 913-532-6563

January 22, 1990

To Members of the Kansas Legislature

Dear Friends:

In Kansas, water is the lifeblood of agricultural, municipal, and industrial growth. This report highlights selected water quality research programs and facilities in the Kansas Agricultural Experiment Station (KAES) at Kansas State University.

Although most groundwater in Kansas meets drinking water quality standards, detectible amounts of pesticides are found in some surface waters and farmstead wells. I'm convinced that vigorous water quality research and technology transfer programs are crucial to future agricultural, municipal and industrial growth in Kansas.

The safe use of fertilizers, pesticides, and agricultural chemicals is an important and continuing KAES research thrust. Because protection and efficient use of water is crucial to economic stability, water and environmental quality are prime considerations.

To advance that research, specialized facilities have been installed to expedite rapid sampling and testing of soil and water samples. Lysimeter facilities (specially instrumented soil columns) have been constructed to provide for precise measurements of water and chemical movement in soil.

We invite comment about these or any other Experiment Station research program. We want to provide research programs that assure environmental quality and support economic growth.

Sincerely,

Walt Woods

Walter R. Woods
Director

EXECUTIVE SUMMARY

Research facilities: Specialized water and environmental quality research facilities in the Kansas Agricultural Experiment Station include the State Soil Testing Laboratory; monolithic weighing lysimeters for quantifying water and chemical movement; field plots dedicated to safe, efficient, and profitable use of fertilizers, pesticides and agricultural chemicals at four branch stations and 11 experimental fields; livestock feeding and waste treatment facilities and pesticide extraction and analytical facilities.

Faculty: Faculty expertise in water and environmental quality is concentrated in the Colleges of Agriculture, Engineering, Arts and Sciences, Veterinary Medicine, and Human Ecology. Associated K.S.U. research centers include the Kansas Water Resources Research Institute, Center for Hazardous Substance Research, Kansas Evapotranspiration Laboratory, USDA Wind Erosion Laboratory, Konza Prairie Natural Research Area, and University Analytical Laboratory.

Irrigation: Water use efficiency is an important KAES research thrust because agriculture is the largest withdrawal user of water in the state. Research is directed at irrigation scheduling, low energy precision application and drip irrigation on vegetables and field crops. The experimental data show that effective irrigation and application methods can be used to conserve water and energy and to reduce nutrient loss due to overwatering.

Hazardous waste: Significant research has been implemented in managing hazardous wastes, including stabilization, biodegradation, airstripping and thermochemical, and adsorption methods. Identifying essential functions of proposed processing schemes and obtaining essential experimental data which lead to improved process and plant design is an important interest.

Tillage systems: Conservation tillage systems are widely used to retain surface residue, minimize erosion and reduce nutrient loss in runoff and below the root zone. Overall objectives are to maximize farm profitability, minimize chemical and energy inputs and protect the resource base. For example, in ridge tillage experiments herbicide applications are reduced by as much as 50 percent.

Chemical movement: Specialized field and laboratory facilities monitor pesticide, nutrient and water movement through or below the root zone. Early studies focused on movement of nitrate and atrazine and later expanded to other chemicals used in cropping systems.

Plant genetics: KSU plant breeding programs increase the genetic resistance to attack by insects and diseases by the state's major food, feed grain and forage crops and for alternate crops like pearl millet and sunflowers. Incorporating genetic resistance is cost-effective, specific to target pests, compatible with non-target organisms and leaves no harmful residues.

INTRODUCTION

Mission: As the state's land grant university, Kansas State University is committed to meeting the priority research, education and technology transfer needs of its citizens. Thus, basic and applied research in agriculture and related areas to help ensure an adequate supply of wholesome food and fiber products, preserve the resource base, and assure water and environmental quality are integral to the mission of the Kansas Agricultural Experiment Station (KAES).

Scope: KAES directs significant effort to research in water and environmental quality and to developing, testing, and promoting environmentally safe agricultural systems. This report focuses on KAES research efforts in water and environmental quality.

Water in Kansas: Water is the lifeblood of agricultural, municipal and industrial growth, and the state's history is replete with efforts to develop, manage and conserve this essential resource. Although more than 60 percent of the state's residents use groundwater for drinking water, more than 50 cities use small impoundments, more than 50 use streams, and more than 30 use a major reservoir. About 90 percent of the irrigation water and about 75 percent of the self-supplied industrial water used in the state is groundwater. Over 500 public water-supply systems use groundwater sources.

Most groundwater in Kansas meets the state's drinking water standards. However, water quality is a growing concern. Detectible amounts of pesticides are found in several Kansas reservoirs and lakes, and in some farmstead wells.

The protection and efficient use of our water resources are crucial to economic stability and to agricultural and industrial production in Kansas.

Research thrusts: KAES is the major research arm of Kansas State University. Some of the research thrusts in water and environmental quality include: safe use of fertilizers, pesticides, and agricultural chemicals; fate and effect of agricultural chemicals; integrated pest management; physical, chemical, and biological processes and their environmental consequences; erosion and sediment control; profitable, sustainable agriculture; best management practices; groundwater contamination, chemical movement and remediation; waste treatment; weed and pest control investigations; soil and water management; and soil and cropping systems.

KAES recently initiated, on a trial basis, an in-house grants program, whose priority concerns included water quality and sustainable agriculture. The objective was to capitalize on the special interests of KAES faculty in preventing contamination, abating pollution, reducing chemical inputs, conserving natural resources, and enhancing social well-being.

Research expertise: Significant research expertise in water and environmental quality exists among faculty in agricultural economics, agronomy, animal sciences and industry, biochemistry, biology, chemistry, agricultural engineering, chemical engineering, civil engineering, nuclear engineering, entomology, forestry, grain science and industry, horticulture, human ecology, plant pathology, and veterinary medicine.

Cooperative research in water quality and water resources is conducted with the University of Kansas through the Kansas Water Resources Research Institute at KSU and the Water Resources Institute at KU. Cooperative efforts are also underway with the Kansas Geological Survey, U.S. Geological Survey, Soil Conservation Service, and other state and federal agencies.

Specialized facilities: Specialized KAES facilities for water and environmental quality research include:

- Monolithic weighing lysimeters
- Pesticide extraction and analytical facilities
- Field plots dedicated to pesticide runoff and leaching studies
- Pesticide leaching columns in greenhouse facilities
- Neutron activation analysis
- Experimental plots devoted to safe, efficient and profitable use of fertilizers, pesticides and other agricultural chemicals.
- Livestock feeding and waste treatment facilities
- Waste Water Analytical Laboratory
- Granulated activated carbon removal of pesticides
- Field research at four branch stations and 11 experiment fields, with irrigation research conducted at five of those sites
- State Soil Testing Laboratory
- University Analytical Laboratory
- Center for Hazardous Substance Research
- Kansas Water Resources Research Institute
- Kansas Evapotranspiration Laboratory
- Konza Prairie Natural Research Area
- USDA Grain Marketing Research Laboratory
- USDA Wind Erosion Laboratory

OVERVIEW

Walter R. Woods
Director, Kansas Agricultural Experiment Station

Introduction

Although most ground and surface water in the state meets the state's drinking water standards, water quality is a growing concern. We are committed to the thesis that protection and efficient use of water are crucial to economic stability and to agricultural and industrial production in Kansas.

Strengthening Research Capability

The Kansas Agricultural Experiment Station has, over time, systematically strengthened its capability to conduct research related to water and environmental quality. This has been accomplished by internal reallocation, by cooperation with other agencies such as the Kansas Department of Health and Environment, Environmental Protection Agency, and U.S. Geological Survey, and by focusing faculty assignments, particularly when replacement faculty are recruited. In recent years new faculty have been employed in soil microbiology, soil physical chemistry, soil fertility and soil physics. All have been directed to increase research effort in areas related to water and environmental quality. In addition, faculty in agricultural engineering, civil engineering and biology have increased their research emphasis in water and environmental quality.

Research Facilities

Traditional research facilities at Kansas State University include the Kansas Water Resources Research Institute, Kansas Evapotranspiration Laboratory, Konza Prairie Natural Research Area, USDA Wind Erosion Laboratory and field research facilities at Manhattan, four branch stations and 11 experiment fields. Recently, EPA established a Center for Hazardous Substance Research at Kansas State University.

In addition, water quality laboratories in the departments of agronomy, agricultural engineering, and civil engineering have been modernized to facilitate rapid extraction and analysis of soil and water samples. Two lysimeter facilities, one at Manhattan and one at the Kansas River Experiment Field, have been equipped with lysimeters to expedite the measurement of chemical and water movement in relatively undisturbed soil. The lysimeter facilities at the Kansas River site involve cooperative work with EPA and USGS.

Early work at the newly established lysimeter sites involved atrazine and nitrate movement through soil. That work has been expanded to include other herbicides commonly used in cropping systems in the area.

Scope of Reports

Our reports today involve:

- Experiment Station research thrusts
- The Kansas Water Resources Research Institute
- Chemical movement in soil
- Safe use of agricultural chemicals

We intend to maintain strong research efforts in areas such as water use efficiency, conservation tillage systems, non-point source pollution and best management practices. Concurrently, however, we wish to respond to the emerging areas of remediation, treatment of hazardous waste and the fate and effect of pesticides and nutrients in the environment. We also intend to maintain strong plant breeding programs with emphasis on minimizing the use of fertilizers and pesticides by incorporating genetic insect and disease resistance.

EXPERIMENT STATION THRUSTS

George E. Ham
Associate Director, Kansas Agricultural Experiment Station

Introduction

The Kansas Agricultural Experiment Station supports several research projects which deal directly and indirectly with water quality. These projects entail Kansas-focused projects as well as regional research projects. Cooperation with other agencies also enhances our capability to investigate the impact of agricultural systems on water quality.

Water and Environmental Quality

Fate of chemicals: Physical, chemical and biological processes act jointly to determine the fate of nutrient elements and chemicals in soil. Within the last 18 months, a multidisciplinary water quality research team has been organized by reorienting faculty positions as retirements and resignations occurred. The team includes a soil microbiologist to examine carbon and nitrogen dynamics in soil; and a soil chemist to study nutrient cycling, transport and efficient fertilizer use, especially nitrogen; and a soil physicist to investigate

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water and solute transport in soil. Their research will help clarify processes like chemical and biological degradation, transport and leaching and volatilization, immobilization and nutrient and chemical uptake in plants.

Conservation systems: Other researchers are examining existing management practices to minimize the impact of agriculture on the environment. This includes such management practices as conservation tillage (including ridge-till), accurate fertilizer and pesticide placement, minimal chemical use, improved water management, precision fertilizer recommendations, improved soil and plant tests and biological control of pests.

Chemical movement: An ongoing KAES project concerns the leaching of atrazine and nitrate in sandy and finer-textured soils at five field locations. This research involves soil and water sampling, monitoring tracer movement, and determining water and chemical movement through the soil profile. Closely related water quality research activities are funded by the Kansas Water Resources Research Insitiute and U.S. Geological Survey. KAES scientists also participate in three Western Regional projects which are investigating the water quality degradation potential of agricultural systems. Those projects include: 1) W- 155 (Characterization and Management of Soil Water and Solutes in Field Soils) and 2) W-170 (Chemistry and Bioavailability of Waste Constituents in Soils); 3) W-82 (Pesticides and Other Organics in Soil and Their Potential for Groundwater Contamination). KAES scientists have participated for many years in North Central Regional Project NC-98 (Nutrient Management in Conservation Tillage to Improve Productivity and Environmental Quality).

Enhancing Water Quality Research

Chemical transport research facilities: A multi-disciplinary study of transport of agricultural chemicals through soil is a result of the in-house grants program for FY 1989. Project leaders include an agricultural engineer, a civil engineer and an agronomist. This project will facilitate the establishment of a long-term research site to study the movement of potential contaminants like nitrate, atrazine and alachlor in and through soil. Minimizing the potential for groundwater contamination is of critical concern.

Minimizing chemical use: Another funded project deals with low, moderate and conventional use of herbicides for five tillage systems for soybeans and grain sorghum grain in a two-year rotation. Ridge till is a cropping system that appears to have great potential for reducing herbicide use. The allelopathic effect of oats is also included in the study as a potential method to reduce herbicide use.

Experiment Station Goals

The long-term goals of KAES research thrusts are to improve our understanding of the basic processes that control the fate and transport of fertilizers, pesticides and other chemicals, and to develop crop production systems that minimize adverse environmental impacts.

THE KANSAS WATER RESOURCES RESEARCH INSTITUTE (KWRRI)

Hyde S. Jacobs
Assistant to the Dean of Agriculture; Director, KWRRI

Introduction

The Kansas Water Resources Research Institute is a state- and federally-funded research institute headquartered at Kansas State University. It supports research and educational programs at both K-State and the University of Kansas (KU). The mission is threefold — research, student training, and information dissemination. The KWRRI policy committee is composed of representatives from K-State and KU. Coordination is achieved through KWRRI at K-State and the Water Resources Institute at KU. Working relations between the two universities are excellent.

Before the institute can expend federal funds made available through the Water Resources Research Act of 1984, a 2:1 match is required; that is, every federal dollar expended must be matched by two state dollars.

Research Program

From 1984 to 1989, 47 percent of the institute's research projects were directed to water quality problems, 32 percent to aquifer and river system analysis, 16 percent to water and resource management and 5 percent to water law. The results of each research project are summarized in project completion reports. However, publication in professional journals is a most important way to disseminate research results. Publication in professional journals is also an important measure of the quality of the research program. From 1984 to 1989, KWRRI scientists completed 38 research projects. During that time, those principal investigators published 54 research reports on directly related topics in professional journals. There is a multiplier effect because projects started with KWRRI funds are often extended by other funding agencies.

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The 1990 Research Program

Over time, water quality problems have grown in complexity and importance, and in 1990, KWRRI will fund seven new projects — all involving water quality. The following water quality problems will be addressed:

- Waterborne pathogens
- Pesticide movement in soil
- Denitrification
- Atrazine biodegradation
- Atrazine degradation products
- Hydrogeology of hazardous waste sites
- Surface water quality trends

Subject matter disciplines for the 1990 program include bacteriology, soil chemistry, soil microbiology, sanitary engineering, civil engineering and geology.

Project Selection

Research priorities are based on state, regional and national water resources research needs. Water resource scientists on each campus are informed of KWRRI project priorities, selection criteria and deadlines. Before final approval, projects are subject to both peer and user review.

Response to State Needs

KWRRI is committed to respond to priority water resources research needs, particularly priority research needs in Kansas. In 1989, KWRRI responded to a request by the Kansas Water Office to identify factors that should be included in any study of water transfer in the state. The report, prepared jointly by KWRRI faculty at K-State and KU, provides a summary of pertinent water law, a review of research reports, and recommends areas of needed research.

Subsequently, KWRRI contracted with the Kansas Water Office to complete: (1) a legal review of the operational aspects of the water transfer law, (2) guidelines for parties seeking water transfer, and (3) guidelines for use by the water transfer hearing panel. This report will also be prepared jointly by faculty at K-State and KU and is scheduled for completion in July, 1990.

CHEMICAL MOVEMENT IN SOIL

A. Paul Schwab
Soil Chemist, Department of Agronomy

Introduction

Kansas State University has responded to concerns about groundwater quality by initiating several innovative projects. Contamination of water by agricultural chemicals — pesticides, herbicides, and nitrates — has prompted research to determine how chemicals reach water supplies and how contamination can be avoided. The movement of pesticides and herbicides in soil is being studied in the laboratory, greenhouse, and the field to determine the effects of tillage, precipitation, and soil type on chemical migration. Special emphasis is placed on regions with susceptible aquifers like the Great Bend Aquifer in central Kansas and the Equus Beds near Wichita. Specialized facilities are being instrumented in Manhattan to thoroughly quantify the movement of chemicals in water under normal agricultural conditions. The Agricultural Experiment Station has invested in equipment and field facilities that promise to place Kansas State University among the leaders in research in chemical movement in soil.

Nitrates

Nitrate movement in soil is being examined because of the widespread use of nitrogen fertilizer. Nitrate contamination in ground and surface waters is also common. However, there are many potential sources of nitrate in water other than agriculture, so all studies examining chemical movement in soil must be carefully planned and executed. On-going projects are examining the effects of manure, long-term fertilization, tillage and irrigation on nitrate movement in soil. The concentration of nitrate expected to arise from natural processes is being studied on the Konza Prairie, an important pristine site adjacent to the university.

Cooperative Efforts

The movement of chemicals through soil is dependent on climate, rainfall, soil properties and management practices. A multidisciplinary approach is being practiced at Kansas State University, with projects involving researchers from many departments including agronomy, geology, civil engineering, agricultural engineering, biology, and plant pathology. Formal research agreements have been executed with the Kansas Department of Health and Environment, Kansas Geological Survey, the U.S. Geological Survey, and the Soil Conservation Service. Research results are disseminated through scientific publications, the popular press, extension special-

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ists, and university publications. New courses are being developed for graduate and undergraduate students using the latest research and technology.

Research Results

The results from K-State water quality research have direct applicability to the general public and the agricultural community. Previously it was thought that sandy soils would be subject to leaching but, perhaps, finer-textured soils would not. However, all soils appear susceptible to nitrate leaching; and, if excess nitrogen is applied, it is likely to move as water percolates through the soil. To prevent contamination, the application of all forms of nitrogen, including fertilizers and manure, must be managed properly. Atrazine movement is limited to sandy soils and very low concentrations have been detected at depths as great as 15 feet. Heavy-textured soils do not appear to allow much atrazine migration. In those soils, the decomposition of atrazine is rapid enough to limit the threat to groundwater contamination. Alachlor does not appear to move through soil and also tends to degrade rapidly.

Application

The results of our research should be useful to farmers and ranchers, regulatory agencies, and the general public. We hope to continue to study the characteristics of susceptible chemicals, develop best management practices and provide data with which informed management and regulatory decisions can be made.

SAFE USE OF AGRICULTURAL CHEMICALS

David A. Whitney
Soil Fertility Scientist, Department of Agronomy

Water Protection

At Kansas State University, surface and groundwater protection is an integral research objective in projects dealing with the use of fertilizers and agricultural chemicals. A water and environmental quality protection objective is always implied even where it is not directly stated.

Soluble Nutrients

With fertilizer application, the primary concern for groundwater quality protection is proper management of soluble or leachable nutrients like nitrate-nitrogen. The level of soluble nutrients in the soil should be minimized whenever the soil is not supporting an actively growing crop. Nutrient management is especially important on soils subject to ready movement of water through the soil. In this discussion, nitrate-nitrogen is used as the primary example of research with soluble nutrients.

Research Thrusts in Nitrate Management include:

Nutrient management: A key component of nitrogen management is to add only that amount of fertilizer which will optimize crop yield. Any excess is regarded as an environmental hazard. Because environmental conditions vary widely, it is difficult to project optimum nutrient needs in Kansas under non-irrigated conditions. Consequently, numerous nitrogen rate and source studies are conducted at research fields and experiment stations across the state. The objective is to enhance our understanding of nutrient-environment interaction, make precise fertilizer recommendations, and protect soil and water resources.

Fertilizer application rates: Depending on the crop rotation and amount of applied manure, nitrogen rate adjustments are key components in effective nitrogen management. Research has clearly shown that corn or grain sorghum following soybeans or other legumes need less fertilizer to obtain equivalent yields than do crops grown without a legume in the rotation. Additional research is needed, however, to quantify the release rate and absolute amount of nitrogen supplied by legumes. Research is also focused on nitrogen cycling in cultivated versus native plant systems. The objective is to determine just when nitrogen is released from the legume so cropping systems can be optimally matched to nitrogen release. That project is a cooperative effort involving personnel from agronomy, biology, the Kansas Rural Center, and the Land Institute.

Residual nitrates: Residual nitrates in the soil profile can be substantial when drought or other environmental hazards result in sharp yield declines. We are working to refine nitrate testing procedures. A North Central Regional Research Project (NC-98) is evaluating a pre-sidedress soil nitrate test as a tool for identifying sidedress nitrogen needs. Results from those studies will be compared with data from other states to ascertain the usefulness of the pre-sidedress nitrate test.

Contamination of surface waters is closely tied to erosion and sedimentation. No-till, conservation tillage systems and other conservation practices are being researched and recommended to control soil erosion. Those tillage systems, however, may create potential problems because the fertilizer is not incorporated into the soil and may dissolve into run-off water.

Immobilization of fertilizer nitrogen in surface residues is another potential problem. Researchers are exploring ways to minimize these problems by injecting plant nutrients below the soil surface. Results have shown a consistent advantage to injecting rather than broadcasting liquid nitrogen fertilizer on no-till grain sorghum. Yield advantages of 10 to 15 bushels per acre more than cover the expense of knifing liquid nitrogen into the soil.

Our research demonstrates that whenever nitrogen use efficiency is improved, economic return is enhanced and environmental quality is improved.

WATER QUALITY RESEARCH FACILITIES AND RESEARCH THRUSTS

Water Use Efficiency

Irrigation scheduling: Effective irrigation scheduling conserves water and energy and enhances water quality by reducing nutrient loss due to overwatering. Precision soil moisture measurements are costly and time-consuming, so researchers in North Central Kansas simplified the process. After extensive comparisons, they recommend irrigation scheduling by stage of growth rather than by soil moisture measurements. Based on 8-year averages, corn irrigated three times — at 8 weeks, 9 weeks and 10 weeks after emergence — yielded within 11 bushels (94 percent) of the fully irrigated treatment which required as many as five or six irrigations. Similarly, soybeans irrigated twice at pre-selected stages of growth yielded within 1 bushel (94 percent) of the fully irrigated treatment while saving up to two irrigations annually.

Irrigation scheduling and surge irrigation research is being conducted at the Southwest and Northwest Research-Extension Centers at Garden City and Colby cooperatively with agricultural engineering.

Low energy precision application (LEPA): A LEPA system is being used at the Southwest Research-Extension Center to study crop water use and crop performance under sprinklers. The low pressure spray head installed 1 to 2 feet above the ground has three modes of operation. The chemigate mode is capable of spraying both water and pesticides on the crop canopy with ability to control insects at pesticide application rates much lower than conventional rates. The chemigate mode offers considerable potential for reducing environmental risk.

Drip irrigation: Research to determine the feasibility of drip irrigation with field corn is being conducted at Garden City and Colby. Although expensive, drip irrigation systems can increase irrigation efficiency to 75 to 95 percent. This minimizes deep percolation of water and nutrient loss. Researchers are studying drainage patterns in the root zone where design variables are lateral spacing, lateral length and time of water application. The effect of nitrogen management with respect to corn yield, water use, nitrogen uptake, loss of nitrate is also being determined. Cooperating departments include agronomy, agricultural engineering, agricultural economics and the Northwest and Southwest Research-Extension Centers.

Drip irrigation for vegetables, fruits and ornamentals: The use of plastic mulches during intensive vegetable production reduces water loss and controls weeds, and reflective mulches repel some insects. With trickle irrigation, the amount of water and chemicals applied can be rigorously controlled. The use of trickle irrigation and plastic mulches are being studied to determine how water and nutrients can be applied most effectively to enhance production, provide for timely harvest and preserve soil and water quality. Research with sweet potatoes, fruit production and ornamentals is also underway.

Horticultural and landscape crops are usually irrigated and heavily fertilized. These high-value crops require timely operations and skilled management. Research by K-State horticulturists is designed to help home and commercial horticulturists apply technological innovations which enhance profitability and maintain environmental quality

Off-season irrigation: Research at the Southwest Research-Extension Center, in cooperation with the Department of Agronomy shows that off-season irrigation for corn is less efficient than in-season irrigation. Water applied in the growing season is more likely to be used for plant growth, less subject to loss by drainage and evaporation and less likely to carry nutrients below the root zone. Additional research to improve water use efficiency is also underway with many of the state's important crops.

Managing Hazardous Wastes

Stabilizing solid waste: Factors affecting the stabilization or solidification of hazardous wastes include the type and amount of pozzolanic materials, kind of solidifying agents and properties of the waste materials. Those characteristics are being studied in order to experimentally determine the feasibility of solidification/stabilization processes for typical hazardous wastes. Establishing the necessary data bases for optimally treating such wastes is a related objective.

Biodegradation technology: Although bioremediation has many potential applications, a better understanding of the technology is needed for many field applications. Microcosm studies are being conducted to study the effects of soil moisture and oxygen transfer on biodegradation in the vadose zone. Mathematical models for bioremediation in the three-phase environment of the vadose zone will be formulated.

Air stripping: When properly designed, air injection or air venting procedures can be used to remove many volatile contaminants. This research will provide preliminary design protocols for using air stripping as a remedial measure. Simple computer codes are being developed to calculate gas flow patterns using various venting arrangements. Numerical simulation is being used to investigate the effect of injection and withdrawal well placement.

Thermochemical treatment: A bench-scale incinerator has been designed and constructed to thermally destroy hazardous wastes like chlorinated compounds. Experimentally derived data will be used to develop models for the design and operation of hazardous waste incinerator systems.

Computer-aided design and control systems for treating and minimizing hazardous wastes: Because hazardous waste treatment systems are complex and non-linear, it is important to identify the essential functions of proposed processing schemes, design guidelines, safety regulations, cost and other factors. That information will then be organized into a set of rudimentary heuristics for the design and operation of hazardous waste treatment systems. To minimize waste and optimize design, object-orientated programming will be employed to encapsulate heuristics and other essential information in appropriate decision aiding systems. Potential systems will be studied using the knowledge engineering environment running on a XEROX 1108 Artificial Intelligence Workstation.

Adsorption of hazardous wastes: Although soil can be an important disposal medium, little information about adsorbate-absorbent interactions with hazardous organic compounds and soil constituent is available. In this study, Fourier transform infrared photoacoustic spectroscopy will be used as the detection scheme for the adsorbed species. Currently, the adsorption of naphthalene onto alumina is being investigated.

Remediation

Soil microbiology research: Because of the overriding importance of microorganisms in the nitrogen cycle, researchers have adopted multiple objectives: (1) to characterize the ecology of denitrifying organisms in the vadose zone, because denitrification is a potentially important decontamination mechanism; (2) to assess the availability of various forms of soil nitrogen in order to improve nitrogen use efficiency from both mineral and organic sources of nitrogen; and (3) to develop an improved soil nitrate test for Kansas and the surrounding region. This interdisciplinary research is being conducted cooperatively with the U.S. Geological Survey, a North Central regional committee, and Kansas State faculty.

Residue disposal: The feasibility of ensiling grass and newsprint clippings for disposal on land is being investigated. Such materials could improve soil moisture storage and infiltration and enhance forage or crop production.

Conservation Tillage

Conservation tillage systems: Conservation tillage systems are widely used to retain surface residue, minimize erosion and reduce nutrient loss in runoff. Residues retained on the soil surface slow evaporation, increase infiltration and moisture storage and enhance yield potential. Capturing the full potential of conservation tillage systems requires: (1) timely management, (2) effective weed control, (3) adequate soil fertility, and (4) crop rotation. Although conservation tillage systems may be best adapted in sub-humid areas, KAES scientists are working to develop improved farming systems for use throughout the state.

Wheat diseases: Conservation tillage practices that retain surface residue have been adopted in many regions of the state. However, wheat emerging through surface residues in central and south central Kansas may be subject to infection from pathogens like tan spot and cephalosporium stripe. Research shows that wheat in reduced tillage systems in this area benefit significantly by periodic rotation to another crop. Rotation out of wheat for just one year reduced early-season tan spot by 55 percent when compared with continuous wheat under no-till or chisel tillage systems.

Weed control on sandy soils: Sandy soils present special weed control problems. Sandy soils without crop or residue cover are highly susceptible to wind erosion. When tillage is used to control annual grasses, crop residues needed for wind erosion control may be destroyed. In addition, crops grown on sandy soil are often prone to herbicide injury. Researchers at the Sandyland Experiment Field recommend the use of crop rotations and selective herbicides to solve this problem. In this farming system, two years of wheat are followed by two years of grain sorghum. Prior to planting wheat, weeds (mainly annual grasses) are induced to germinate by tillage and the emerging weed crop is controlled with atrazine. Atrazine applications are carefully timed to prevent damage to the subsequent grain sorghum crop.

Studies are also in progress to: (1) replace wheat in the rotation with a crop that fixes nitrogen yet competes effectively with annual grasses, (2) develop safe and effective weed control and production practices for alternate crops like rapeseed or canola oil, Austrian peas and other promising crops, and (3) monitor atrazine and nutrient movement and prevent groundwater contamination. Specially instrumented plots have been established to monitor atrazine and nutrient movement.

Wheat-sorghum-fallow rotations: When comparing various cropping systems for dryland fallow areas of Kansas, the wheat-sorghum-fallow rotation has been the most risk-free in terms of consistent production, net return and optimum use of rainfall and stored soil moisture. This conservation tillage system integrates the use of crop rotations, tillage and herbicides to control weeds, reduce erosion and minimize runoff. Farm benefits are enhanced because water use efficiency (compared to clean till systems) is increased about 15 percent due to reduced tillage and by about 18 percent due to the use of fertilizers. Increasingly, researchers are instrumenting plots and implementing studies to determine the fate and effect of the agricultural chemicals used in the farming system.

Soil fertility and conservation tillage: The potential for reducing erosion with reduced tillage systems is well established. Many soil fertility questions remain, however, because of the influence of large amounts of residues retained in or on the soil surface. These questions involve environmental quality and the use of nitrogen fertilizer, in particular, how nitrogen use efficiency is impacted, not only by soil type and climate, but also by nitrogen source, rate and application method. K-State researchers are addressing those questions on several stations and fields using a variety of tillage methods, nitrogen sources, application methods and nitrogen rates. The objectives are to maximize profitability and to maintain and protect the resource base.

Ridge tillage: Ridge tillage is an example of such research. In ridge tillage, herbicide use is reduced 50 percent by growing the crop and banding the herbicide on narrow ridges. Savings in tillage costs approximate $20 per acre and savings in herbicide costs approximate $6 per acre. Corn grown in ridge tillage systems yields within 4 bushels (142 vs 146 bushels per acre) of that grown in conventional systems.

Field and Analytical Facilities

Water quality laboratories: Water quality laboratories in the agronomy, agricultural engineering, and civil engineering laboratories have been modernized to facilitate rapid extraction and rapid testing of soil and water samples for pesticides and other contaminants.

Macro-weighing lysimeter: A macro-weighing lysimeter facility is being constructed at Kansas State University to expedite the measurement of chemical and water movement through soil. The lysimeters will contain relatively undisturbed soil blocks representing soils from the Equus Beds and Great Bend Prairie Areas. The research installation will be used to obtain information on the effect of crop and soil management on chemical movement and the potential for groundwater contamination.

Open end lysimeters: Seventeen open end lysimeters were constructed on the Kansas River Experiment Field to monitor herbicide movement under irrigated and non-irrigated conditions. Agricultural herbicides tested included Atrazine, Dual, Treflan, Lasso and 2,4-D. Each lysimeter is instrumented with small suction lysimeters to obtain moisture samples after herbicide application. This project is a joint effort between Kansas State University, the U.S. Geological Survey and the Environmental Protection Agency.

Non-Point Source Pollution

Computer models: Research and extension agronomists and computer systems personnel have developed a computer management model for corn. The model projects the influence of hybrid maturity on growth stage, harvest date and crop water use. Use of the model will help increase water use efficiency primarily through improved use of rainfall and by reducing drainage and nutrient loss from the root zone. Similar models are being developed for grain sorghum and sunflowers.

Simulating agricultural non-point source pollution: The agricultural non-point pollution simulation model (AGNPS) was applied to five small agricultural watersheds to evaluate its use as a water quality planning tool for the Soil Conservation Service. The model simulates erosion losses with reasonable accuracy and can be used to evaluate the effect of changes in crop management practice and feedlot control systems. The model has limited ability to evaluate the effects of dams and ponds and does not consider groundwater pollution or pesticide effects.

Pesticide and Nutrient Movement in Soil

Atrazine: A field research site to monitor atrazine movement in soil was established at the Kansas River Valley Experiment Field cooperatively by the departments of agricultural engineering and agronomy and the U.S. Geological Survey. Data from this study are to be used to verify computer models for predicting pesticide movement and will assist EPA in outlining test procedures to register new products. The research data suggest the need to incorporate atrazine at application time to minimize pesticide loss in runoff water.

Atrazine and alachlor: This study examines the migration and degradation of atrazine and alachlor (a component of Lasso) using five experimental sites. Although soil properties differ at each site, each is managed using typical agricultural practices. The rates and mechanisms of pesticide movement are being examined as well as the potential for groundwater degradation. The research is a cooperative effort between the departments of agronomy, agricultural engineering, and the U.S. Geological Survey.

Long-term effects: Studies concerning the effects of fertilizer nitrogen, phosphorous and potassium on corn and sorghum production have been conducted at the same site at Garden City for 29 years. Similar long-term plots, with and without herbicide treatments, and where crop residues have been systematically removed or burned, also exist. These plots represent a valuable historical record of the long-term effect of fertilizers, herbicides and residue removal on soil properties.

Nitrification inhibitors: Research results show that anhydrous ammonia applied with a nitrification inhibitor were held in the non-leaching ammonium form for 4 to 6 weeks after application. This delay maintained preplant applied anhydrous ammonia in the root zone through the early, wet season until plant roots were actively growing and using the nitrogen.

Safe and Effective Use of Agricultural Chemicals

Starter fertilizer: Most fertilizer phosphorous entering lakes or streams is adsorbed and transported by eroding soil particles. Research at the East Central Kansas Experiment Field demonstrated that phosphorous knifed 4 to 6 inches deep was agronomically more effective than phosphorous applied in the seed furrow, broadcast or banded 2 inches to the side and 2 inches deeper than the seed. The deeper placement of phosphorous concentrates the nutrient in a zone where it is available to the crop but not susceptible to erosion.

High phosphorous soils: While generally not a problem in groundwater, elevated phosphorus levels in surface waters can lead to algal blooms and reduced water quality for fish, wildlife and recreation. Because the chemistry of high phosphorus soils is not well understood, the phosphorus fractions in soil are being characterized using electron microscopy, x-ray diffraction or infrared spectroscopy.

Fertilizer placement: Recent data suggest that fertilizer nitrogen recovery in grain sorghum can be substantially increased by proper nitrogen placement. Under no-till grain sorghum, nitrogen use efficiency was 35 percent with broadcast nitrogen compared to 70 percent with subsurface-banded nitrogen.

Phosphorus management can also increase the recovery of fertilizer nitrogen by the grain. In studies with wheat, phosphorus applied with the seed nearly doubled (25 to 48 percent) the nitrogen use efficiency compared to broadcast phosphorus. Field research projects have been implemented to further evaluate these management effects on the recovery of fertilizer nitrogen and phosphorus by sorghum and wheat.

Corn-soybean cropping sequences: Data taken in the Kansas river valley over a 10-year period show that corn following a previous soybean crop yields an average of 51 bushels per acre more than corn following corn when no nitrogen was applied. The data suggest that soybeans will supply to a subsequent corn crop the equivalent a pound of nitrogen for each bushel of soybeans produced. Thus, nitrogen applications to corn following soybeans should be significantly reduced to avoid over-fertilization and possible groundwater contamination.

Synchrony and legume nitrogen contributions: These studies are being conducted cooperatively with the Land Institute and the Kansas Rural Center. They are designed to quantify the synchrony between the mineralization of organic matter, legume supplied nitrogen and nitrogen uptake by wheat and grain sorghum. Test crops include continuous wheat, continuous grain sorghum and combinations of those crops in rotations that include forages and legumes in conventional and no-till systems.

Reducing herbicide rates on soybeans: Research is being conducted in southeast Kansas to determine if herbicide rates can be reduced without reducing yield or profitability. Because area soils contain dense subsoils, herbicides are more likely to be lost through runoff than by leaching. Weed control strategies include reduced rates of selected herbicides, tillage, cultivation and crop residues. The problem is a difficult one because both broadleaf and grassy weeds are troublesome.

Fertilizer timing and placement for grass: Tall fescue and smooth bromegrass are grown on more than two million acres in eastern Kansas. Much of that acreage is fertilized with nitrogen to enhance the quantity and quality of the forage. However, less than half of the applied nitrogen is recovered in the forage. Research studies show that subsurface placement of nitrogen has increased its recovery by as much as 15 to 30 percent. Research to minimize the cost and enhance the response to subsurface nitrogen applications in cool season perennials is continuing.

Interseeding tall fescue with legumes: Research has demonstrated that animal gains on fescue pasture seeded with ladino clover have equaled or exceeded gains on fescue pastures fertilized with as much as 80 pounds per acre of nitrogen annually. Research to enhance stand longevity, find improved methods of seeding, and to test other legumes is underway.

Integrating Management Systems

Weed competition: Weeds compete with crops for moisture, nutrients, and light on nearly every crop acre and cause greater monetary loss than all other agricultural pests combined. Annual crop losses range from 10 to 30 percent under normal growing conditions and as high as 50 percent when resources, especially soil moisture, are limiting. Weed control research is part of the farming systems research at each branch station and experiment field throughout the state. The emphasis is on low- cost, effective systems that optimize crop production and assure environmental quality.

Mycorrhizal symbiosis: Mycorrhizal symbiosis is an association between certain fungi and most crop plants. In this relationship, the fungi adsorb water and nutrients and translocate them to plants. This relationship reduces the need for fertilizer and increases drought tolerance. Mycorrhizal plants also display greater tolerance to soilborne diseases. Recent discoveries suggest that the fungi bind soil into aggregates, thereby reducing wind and water erosion. The fungi are naturally occurring, but high-input agriculture has reduced their numbers and effectiveness. Researchers are studying the function of mycorrhizal fungi in prairie and range plants where the symbiotic relation is unimpaired by the use of fertilizers or herbicides. Developing cropping strategies to enhance mycorrhizal symbiosis is a long-term objective.

Alternatives for inorganic fertilizer: The use of animal manures is a possible alternative for inorganic fertilizers. A significant interaction between the use of composted manure and nitrogen fertilizer on fields at Tribune led to a laboratory study of the kinetics of nitrogen mineralization and nitrification. The results of the study could suggest more effective ways to use plant nutrients while maintaining environmentally sound practices.

Water Quality Protection

Farmstead wells: A farmstead well survey conducted in cooperation with the Kansas Department of Health and Environment showed that nearly half of the wells did not meet the criteria for safe drinking water. Nitrate was the most prominent pollutant although 10 percent of the wells contained detectible amounts of organic chemicals. The study has been extended to determine if contamination can be related to distance from feedlots, well age, well construction, depth to water and similar factors. There is little evidence to indicate that fertilizer and pesticides used on cropland are a contamination problem of rural wells. However, preliminary results suggest that the distance to feedlots or similar hazards should be at least twice as far as generally recommended.

Hydrologic studies at Konza Prairie: Long-term trials show that early-season burning controls encroachment by weeds, brush and trees and enhances the vigor and longevity of tallgrass prairie. Plots have been established in the Konza Prairie Research Natural Area to measure the effects of burning tallgrass prairie on infiltration and overland flow. The project uses solid-set rainfall and overland flow equipment to measure infiltration, overland flow velocity and the quality of surface runoff. Results show that the loss of sediment and nutrients from unburned prairie was extremely low.

Plant Breeding Programs

Insect and disease resistance in crops: Plant breeders work to improve the state's crops — wheat, grain sorghum, corn, soybeans, alfalfa, melons, dry beans, sunflowers and pearl millet. Each crop is subject to attack by a variety of plant pests. Incorporating genetic resistance to insect and disease pests has many advantages. Genetic resistance is cost-effective, specific to target pests, compatible with non-target organisms, and leaves no harmful residues.

For example, K-State recently developed two new alfalfas with resistance to nine diseases and pests. One population, KS71, has tolerance to alfalfa weevil; the other, KS153, has tolerance to frost damage. Each new wheat release — Newton, Arkan, Dodge, Norkan and Karl — carried important pest-resistant genes. Many of the first greenbug-resistant grain sorghum hybrids used germ plasm released by K-State. Such releases affect pesticide use significantly. For example, as much as 25 percent of the Kansas sorghum acreage is treated for greenbug control. Developing hybrids resistant to today's greenbug biotypes could eliminate the need for about 150 tons of insecticide annually.

Bush-type melons: Changing the growth habit of melons from vine to bush types has environmental advantages. Bush-type melons can be readily grown using reduced row and plant spacings and a plastic mulch. With proper management, bush-type melons produce greater yields, minimize exposed soil, reduce erosion, and can be fertilized precisely through trickle irrigation.

Drought-tolerant turfgrasses: Turfgrass is normally fertilized and watered heavily, especially in home lawns, golf courses and other recreational areas. Work is underway to determine the optimum and minimum water requirements of turf varieties and to minimize water and fertilizer applications. The mechanisms by which plants adapt to drought stress are being studied and, where possible, will be adapted to reduce residential use of water and fertilizer.

By-Product Utilization

The wet milling industry uses large quantities of water to wash flour dough, separate starch from protein and recover gluten. Large quantities of gluten are imported or obtained domestically. The wash water contains dissolved flour and has a high biological oxygen demand, so disposal is a problem. The wash water also contains significant amounts of dissolved gums or pentosans. The gums act as hydrocolloids and have a great capacity to bind water, retain moisture in baked goods and increase the viscosity of liquids.

Research has been initiated to recover these gums from the waste stream and characterize them chemically and functionally. Their potential in replacing synthetic and imported gums in baked foods, salad dressings and other food products will also be evaluated. Constituent recovery is expected to add value to the product and reduce the pollutant load.