

Our. mission



The mission of the Illinois Council on Food and Agricultural Research (C-FAR) is to secure additional resources to adequately fund relevant and high-quality research and related outreach programs that lead to profitable, consumer-sensitive, and environmentally sound food and agricultural systems in Illinois and the nation.

C-FAR will foster public confidence in food and agricultural research through public participation in planning and evaluating the process and impact of research activities.

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Dear Friends,

We are pleased to provide you with this 1998 annual report of the Illinois Council on Food and Agricultural Research (C-FAR). We believe this report will provide you with a comprehensive review of the research projects being funded by C-FAR.

In FY 98, the C-FAR appropriation was \$9 million. These funds were allocated to a variety of research needs led by scientists at the University of Illinois at Urbana-Champaign, Southern Illinois University-Carbondale, Illinois State University, Western Illinois University and other non-profit research entities throughout the state.

C-FAR-funded research projects cover a wide range of issues that affect the food and agriculture industry and consumers. Generally, they:

- 1) develop/advance technologies to expand markets for agricultural products and employment in Illinois;
- 2) promote the economic development and management of agricultural and food systems in Illinois communities;
- 3) increase the capacity of Illinois crop and animal systems to respond to changing world food and agricultural demands;
- 4) improve consumers' nutrition, food quality and safety and health; and
- 5) provide for sustainable development and use of natural and human resources.

Development of the five Strategic Research Initiatives (SRI) was an emphasis in FY 98. This required a tremendous amount of time and effort during the last year. The SRIs help organize and direct researchers' and C-FAR members' attention to resolving major issues in Illinois—food safety and functional foods; information systems and technology; rural community development; swine odor and waste management; and water quality. Researchers at the four universities and several other entities are coordinating their efforts to solve problems in these areas. We're grateful to the hundreds of people who contributed their time and expertise to this effort.

When C-FAR received its first appropriation in FY 96, Illinois ranked number 29 in the United States for its financial support of food and agriculture research; in FY 98, Illinois was approximately 20th in the nation. While definite improvement is being made, we have a goal to push Illinois into the top 10

1998 Board of Directors

Illinois Council on Food and Agricultural Research

within the next few years. We believe this is an important ambition for a state that typically ranks nationally in the top five in gross agricultural production.

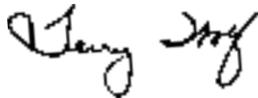
In FY 98, C-FAR had 55 organizational members, 15 affiliate members and more than 100 individual members. These numbers have consistently increased each year. A solid and diversified membership provides a strong foundation for any organization.

All C-FAR members are invited—and encouraged—to participate in C-FAR activities, visit with legislators about funding needs for food and agriculture research and attend our semi-annual meetings. Please call the C-FAR office if you or someone you know is interested in supporting Illinois food and agriculture research.

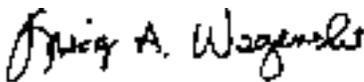
C-FAR is still a relatively new organization, and it takes some time for new initiatives and concepts to develop. We have devoted a lot of time and energy the past year to organizing and staffing the C-FAR office. Permanent office space and staff leadership have and will continue to provide C-FAR members, university partners and others with the support necessary for C-FAR to continue making a difference.

C-FAR is truly a unique, innovative organization. It is one of the only organizations in the United States that brings such a diverse group of people together for a common cause. Scientists and the private sector working together is a model we can be proud of.

Thanks to all C-FAR members, university researchers and the State of Illinois for support during the past year. Together, we will target and define research that will benefit all of society.



Terry Wolf,
C-FAR Chair



Kraig A. Wagenecht,
*C-FAR Executive
Administrator*



Terry Wolf
Chair, Homer



Carol Keiser
Membership Chair, Carlinville



Jeff Brooks
Vice Chair, Prophetstown



W. Lyle Roberts, Jr.
Legislative Chair, Bloomington



Constance Locher Bussard
Secretary-Treasurer, Springfield



Jack Erisman
Research Chair, Pana



Kraig A. Wagenecht
Executive Administrator

Staff

Kraig A. Wagenecht, Executive Administrator

Myra Kuhn, Communications Director

Susan Warsaw, Office Manager

Barb Haegele, Secretary

Amara Kennedy, Secretary

1998 Working Group Leadership

Working Group 1 — Expanding Markets for Agricultural Products

1 Len Corzine, Assumption, Chair

Harold Wilken, Danforth, Vice Chair

Working Group 2 — Promote Economic Development in Illinois

2 Steve Jurgens, Arthur, Chair

Renee Hunt, Rochester, Vice Chair

Working Group 3 — Increase Agriculture's Capacity to Meet Changing World Food Demands

3 Steve Kasten, Centralia, Chair

Frank Thorp, Clinton, Vice Chair

Working Group 4 — Improve Human Nutrition, Food Quality and Food Safety

4 Theresa Stretch, Ashmore, Chair

Carol Meyer, Steeleville, Vice Chair

Working Group 5 — Advance Sustainable Use of Natural and Human Resources

5 Susan Adams, Atlanta, Chair

Ed Weilbacher, Mascoutah, Vice Chair

C-FAR members

Organizational Members

Association of Illinois Soil and Water Conservation Districts
 Audubon Council of Illinois
 Central Illinois Agricultural Research Farms, Inc.
 Champaign County Farm Bureau
 Equipment Manufacturers Institute
 Farm Credit Services of Illinois
 Grain & Feed Association of Illinois
 Horsemen's Council of Illinois
 Illinois Agri-Women
 Illinois Association of Drainage Districts
 Illinois Beef Association - Checkoff Division
 Illinois Beef Association - Dues Division
 Illinois Chapter of the American Ostrich Association
 Illinois Corn Growers Association
 Illinois Corn Marketing Board

Illinois Crop Improvement Association, Inc.
 Illinois Dietetic Association
 Illinois Farm Bureau
 Illinois Farm Business Farm Management Association
 Illinois Farmers Union
 Illinois Fertilizer and Chemical Association, Inc.
 Illinois Forage and Grassland Council
 Illinois Grape Growers and Vintners' Association
 Illinois Horseradish Growers
 Illinois Lamb & Wool Producers, Inc.
 Illinois Milk Producer's Association
 Illinois Pork Producers Association
 Illinois Restaurant Association
 Illinois Seed Trade Association, Inc.
 Illinois Society of Professional Farm Managers & Rural Appraisers

Illinois Soil Testing Association
 Illinois Soybean Association
 Illinois Soybean Program Operating Board
 Illinois Specialty Growers Association
 Illinois State Beekeepers' Association
 Illinois State Horticultural Society
 Illinois State University Agriculture Alumni Association
 Illinois State Veterinary Medical Association
 Illinois Stewardship Alliance
 Illinois Sustainable Agriculture Society
 Illinois Thoroughbred Horsemen's Association
 Illinois Turfgrass Foundation
 Illinois Wheat Association
 Institute of Food Technologists
 Macoupin County Farm Bureau
 Madison County Farm Bureau
 Mason County Farm Bureau

Mercer County Farm Bureau
 Orr Research Center Corporation
 Rural Partners
 Safer Pest Control Project
 Southeastern Illinois Sustainable Agriculture Association
 Southern Illinois University Agriculture Alumni Society
 The Chicago Farmers
 University of Illinois at Urbana-Champaign College of Agricultural, Consumer and Environmental Sciences Alumni Association

Affiliate Members

Illinois Farm Development Authority
 Illinois Institute for Rural Affairs
 Illinois State University Department of Agriculture
 Illinois State Water Survey
 Macoupin County Soil and Water Conservation District
 National Center for Food Safety and Technology

Southern Illinois University at Carbondale College of Agriculture
 University of Illinois at Chicago College of Pharmacy
 University of Illinois at Springfield Institute for Public Affairs
 University of Illinois at Urbana-Champaign College of Agricultural, Consumer and Environmental Sciences
 University of Illinois at Urbana-Champaign College of Veterinary Medicine

University of Illinois at Urbana-Champaign Department of Agricultural and Consumer Economics
 University of Illinois at Urbana-Champaign Department of Natural Resources & Environmental Sciences
 Western Illinois University Department of Agriculture
 Western Illinois University Department of Family and Consumer Services

Individual Members

In 1998, C-FAR had about 125 individual members.



research directors

at Illinois' Public Agricultural Research Institutions

“During the relatively short life of C-FAR, approximately 160 projects and programs have been funded at the University of Illinois. Many of these efforts are of a cooperative nature. Also, as a result of the Strategic Research Initiative (SRI) program, many U of I scientists are working in cooperation with faculty and staff from the other agricultural universities in Illinois, state agencies and other organizations. This is what C-FAR is about—research and outreach teams solving problems of importance to the Illinois food and agricultural sector using an outcome-based approach.”

George C. Fahey, Jr., Assistant Dean
Research Leadership, C-FAR
College of Agricultural, Consumer and Environmental
Sciences
University of Illinois at Urbana-Champaign

“If not for C-FAR, we wouldn't have new research opportunities at Western Illinois University. The C-FAR funds support faculty research, but equally important is C-FAR's presence on our campus and the members' involvement in our competitive grants program. C-FAR's commitment impresses upon campus administrators the importance of food and agricultural research and the need to be responsive to citizens of Illinois.”

Danny E. Terry, Chair
Department of Agriculture
Western Illinois University

“C-FAR has dramatically strengthened the research efforts at Illinois State University. Virtually every faculty member of the department is involved, either directly or indirectly, in research targeting C-FAR objectives. The broad objectives of C-FAR have encouraged faculty to consider multi-disciplinary approaches to solving problems. Consequently, we now have teams of researchers collaborating to find solutions. In addition, C-FAR has enabled us to address critical equipment needs and renovate facilities to strengthen our research programs. These investments will pay dividends to the citizens of Illinois for years to come.”

J. Randy Winter, Chair
Department of Agriculture
Illinois State University

“During FY 98, the College of Agriculture was second only to the School of Medicine in Springfield in obtaining external research dollars at Southern Illinois University-Carbondale. The C-FAR dollars are providing us with extra leveraging power, thereby strengthening our ability to attract outside funding. Also, C-FAR dollars have enabled SIUC to become extremely competitive in attracting top research faculty to our College, because we now have a firm research base.”

Anthony W. Young
Associate Dean for Research
College of Agriculture
Southern Illinois University-Carbondale

C-FAR Launches Strategic Research Initiatives

SRI

The Illinois Council on Food and Agricultural Research (C-FAR) has allocated \$5 million to support research aimed at five Strategic Research Initiatives (SRI). The SRIs represent areas identified as important to Illinois consumers and the food and agriculture industry: food safety and functional foods (\$1 million); information systems and technology (\$900,000); rural community development (\$900,000); swine odor and waste management (\$1.2 million); and water quality (\$1 million). Food and agriculture researchers at the University of Illinois at Urbana-Champaign, Southern Illinois University-Carbondale, Illinois State University, Western Illinois University and other research entities in Illinois are coordinating their efforts to address the SRIs. Funding was based on the individual projects within each SRI.

Food Safety and Functional Foods. The FS/FF SRI was developed through a strategic planning process involving members of C-FAR Working Group 4, academic researchers, consumers and representatives from industry and government.

The FS/FF SRI mission is to promote multidisciplinary research that leads to safe and healthful foods.

Several food safety outcomes of the FS/FF SRI center on strategies for educating children, consumers, retailers and others on food-handling practices that will prevent food-borne illnesses. Other outcomes focus on strategies for ensuring safety of food products, such as tests and tools that small producers and processors can use to detect food-borne pathogens, or techniques that producers can use to detect and control salmonella. Researchers also will partner with state agencies, assist with updating the American Dietetic Association position paper on food safety and provide the dietetics community with current information from research within the SRI.

Functional foods, those foods or food ingredients which provide health benefits beyond basic nutritional needs and may reduce chronic disease risk and promote health, is a leading trend in the food industry today. The FS/FF SRI will focus on three foods or food ingredients which have significant potential to improve public health as well as have a positive economic impact on Illinois: soy, grapes and conjugated linoleic acid (CLA)

from beef. Consumption of these foods or food ingredients has been linked to reduction of breast cancer risk, the second leading cause of death in women. This C-FAR SRI will position Illinois as the leader in functional foods research. No other statewide effort is ongoing in this area.

Information about food safety and functional foods will be disseminated through outreach programs, enabling the public to make informed choices about foods for optimal health. The vision for this SRI includes increasing consumer confidence that the foods they eat will be safe and provide health-promoting benefits. Jan Endres, professor and associate director for the SIUC College of Agriculture Soy Center, and Clare Hasler, executive director of the U of I Functional Foods for Health Program, serve as co-leaders for the SRI, working closely with Theresa Stretch, chair for C-FAR Working Group 4.

Information Systems and Technology. The IST SRI brought members of the research and outreach community together with C-FAR Working Group 1 to identify needs and design a process for selecting funded activities.

The IST SRI will support research and outreach programs to enhance the availability, integration, delivery and use of information throughout the global food and agricultural systems, with a special focus on Illinois. The IST SRI emphasizes interaction among information and communication technologists, content and educa-

tion specialists, and farmers and other practitioners who use information technology.

This effort will put Illinois at the forefront of farm agribusiness and natural resource management tools. Several projects are aimed at organizing and delivering new information to farmers. Others will make food and agricultural information more easily accessible and useable. Many projects will build interactive decision-support tools on the World Wide Web. All projects are intended to enhance the competitiveness and profitability of the food and agricultural sector in Illinois, improve the management of natural resources in Illinois and improve the well-being of Illinois citizens. Sarahelen (Sally) Thompson, UIUC agricultural economist, serves as leader of the IST SRI, working closely with Len Corzine, chair for C-FAR Working Group 1.

Rural Community Development. The Illinois Farming Alternative and Rural Revitalization Methods (I-FARRM) project is a C-FAR initiative in rural community and economic development with a special focus on alternative and value-added agricultural development.

It consists of four component projects: Rural Development Opportunities (RDO); Improving Farm Income and Rural Communities through Value-Added Commodities (VALUE); Rural Enterprise and Alternative Agricultural Development (REDI) and the Rural Economic Development Tool Box (ED TOOL BOX).

These projects combine highly-applied action research models with an aggressive outreach and technical assistance approach. Researchers will identify alterna-

tive and value-added agricultural opportunities in Illinois. In addition, they will assist in enterprise development and expansion. Researchers also will explore farm-community linkage applications.

The I-FARRM project will produce concrete benefits and outcomes in the form of new and expanded rural agricultural businesses and enterprises in such areas as new grain products, value-added grains and processing, aquaculture, the grape and wine industry, agritourism, rural community foundations, community farmers' markets and other community farm-linkage enterprises and projects.

Significant public and private partnerships already are in place to support I-FARRM's proposed objectives and outcomes, and substantial matching dollars and economic impact will be leveraged. Raymond Lenzi, director for the SIUC Office of Economic and Regional Development, serves as leader for the SRI, working closely with Steve Jurgens, chair for C-FAR Working Group 2.

Swine Odor and Waste Management. The specific objective of this SRI is to support the continued development of an environmentally sustainable, socially acceptable and economically viable swine industry in Illinois through a broadly based, integrated program of research addressing issues relating to swine odor and waste management.

The research program addresses five areas: odor control and management; animal nutrition; manure processing and handling; systems design and management; and community and legal issues.

Within these areas, 27 different research projects are being carried out to develop approaches to minimize odor emissions and nutrient output from swine operations. The research program includes on-farm studies aimed at rapidly evaluating the most promising approaches and technologies under commercial conditions. Mike Ellis, UIUC animal scientist, serves as leader of this SRI, working closely with C-FAR Working Group 3 chair Steve Kasten.

Water Quality. The WQ SRI is focused on reducing contaminants in Illinois waters.

The initial year of the SRI concentrates on determining priority research to conduct, based on problem identification and a thorough review of past and current research. Once research priorities have been established and the most pressing needs identified, research initiatives to solve those critical needs will be developed and funded.

During the first year of this SRI, efforts will focus on nutrients utilizing a watershed model. The WQ SRI has partnered with the IST SRI to fund initiatives to accumulate, organize and distribute spatially varied data critical to determining priority areas for water quality protection and tracking progress in water quality improvement. The WQ SRI is also funding a new publication series to highlight past and current water quality research in Illinois and to expand public knowledge of water quality issues and protection techniques. Michael C. Hirschi, UIUC agricultural engineer, serves as leader of the WQ SRI, working closely with C-FAR Working Group 5 chair Susan Adams.

Fiscal Year 1998:

project updates

The Illinois Legislature passed the Food and Agriculture Research Act in 1995. The legislation supports the food and agriculture research initiative developed by the Illinois Council on Food and Agricultural Research (C-FAR). In FY 98, the C-FAR appropriation was \$9 million.

Funds were allocated to the University of Illinois at Urbana-Champaign, Southern Illinois University-Carbondale, Illinois State University, Western Illinois University and other non-profit research entities. Each university sponsored an internal competitive grants program to solicit creative, innovative, high-quality research that addressed C-FAR priorities. Progress reports from researchers follow, sorted by the five C-FAR research focus areas:

- **Expand markets for agricultural products.**
- **Promote economic development in Illinois.**
- **Increase agriculture's capacity to meet changing world food demands.**
- **Improve human nutrition, food quality and food safety.**
- **Advance sustainable use of natural and human resources.**

As stipulated in the legislation, 15 percent of the allocation was used to fund an external competitive grants program open to qualified researchers at non-profit institutions, organizations or agencies in Illinois. The C-FAR Working Groups assisted in evaluating and selecting the proposals for funding. Following is a list of C-FAR External Competitive Grants Program research projects, with progress reports included in the five Project Update sections.

Fiscal Year 1998: C-FAR External Competitive Grants Program

'98

FY 98 Projects **Principal Investigator** **pg.**

Research Focus:

Expanding Markets for Agricultural Products

Novel Process for Soy Oil Hydrogenation	Shashi B. Lalvani, SIUC	16
High Linolenic Acid Specialty Corn	David F. Weber, ISU	17
Conversion of Corn By-products into High-value Activated Carbon	Anthony A. Lizzio Illinois State Geological Survey	18
Gray Leaf Spot Resistance	Donald G. White, UIUC	18
Enhancement of Nutritional Composition of Corn	Torbert Rocheford, UIUC	19
Expanding the Grape, Wine Industry	R.M. Skirvin, UIUC	21
Improving Beef Quality	Larry L. Berger, UIUC	22

Research Focus:

Promote Economic Development in Illinois

Evaluation of Swine Waste Uses	Paul M. Walker, ISU	28
New Foundation for Sustainable Apple Orchards	Bradley Taylor, SIUC	29

Research Focus:

Increase Agriculture's Capacity to Meet Changing World Food Demands

Improving Quality, Consistency of Cattle	Douglas F. Parrett, UIUC	40
Automated Disease Diagnosis in Food Crops	David A. Lightfoot, SIUC	45

Research Focus:

Improve Human Nutrition, Food Quality and Food Safety

Effect of Soy on Breast Cancer	Keith Singletary, UIUC	53
Soy Protein Dose for Lowering Blood Cholesterol	S. Anderson, SIUC	54
Soy Phytoestrogens, Cardiovascular Health: Friend or Foe?	W.J. Banz, SIUC	55

FY 98 Projects	Principal Investigator	pg.
Development of Vegetable Products that Prevent Cancer	Elizabeth Jeffery, UIUC	57
Improving the Quality, Safety of Foods	Shelly J. Schmidt, UIUC	58
Safety During High Isostatic Pressure Processing	V. M. Balasubramaniam Illinois Institute of Technology	59
New Method to Calculate Antibiotic Milk Discard Times	Ted Whittem, UIUC	59
HACCP in Small Meat Processing Facilities	M. Susan Brewer, UIUC	60
HACCP Training of Food Services in Illinois	Hea-Ran Ashraf, SIUC	60
Salmonella Transmission on Farms	Peter B. Bahnson, UIUC	61
Creating Dietary Changes	Carol Boushey, SIUC	63

Research Focus:

Advance Sustainable Use of Natural and Human Resources

Sustainable Development: Decision Model for Planning	Richard L. Farnsworth, UIUC	66
Reducing N Runoff in Corn	David A. Lightfoot, SIUC	69
Water Quality in Alternative Cropping Systems	G.F. McIsaac, UIUC	68
Effects of Livestock Facilities on Groundwater Quality	I.G. Krapac Illinois State Geological Survey	70
Effects of Rotation, Fertilization Practices on Soil	Michelle Wander, UIUC	72
Sustainability, Efficiency of Agriculture	David Onstad, UIUC	74
Biofilters to Control Swine Odor	Roderick Mackie, UIUC	76

project updates

Research focus: Develop and advance technologies to expand markets for agricultural products and employment in the agricultural and food sector in Illinois.

Cancer Cell Inhibition Effects of Extruded Isoflavone

Breakfast cereals and snacks are good candidates for incorporating soy into mainstream products to deliver health benefits associated with soy.

To that end, researchers studied the changes in isoflavone profile and bioactivity during extrusion processing of corn/soy blends. Concentrations of the four genistein derivatives (genistin, malonylgenistin, acetylgenistin and genistein) and the four daidzein derivatives (daidzin, malonyldaidzin, acetyldaidzin and daidzein) were measured before and after extrusion in four different samples: promax70 (high isoflavone content) and procon2000 (low isoflavone content) with and without corn meal (0% or 80% corn). After extrusion, total isoflavones and all derivatives except acetyl decreased. Acetyl-derivatives increased after extrusion.

Biological activity was measured in three human cell lines: BT-20 [estrogen receptor (ER)-negative breast cancer cell], MCF-7 (ER-positive breast cancer cell) and MCF-10F (non-cancer breast cell). The samples with higher total isoflavone or genistein showed higher inhibition on growth. As a

result, samples after extrusion had a higher IC50 and procon2000 samples had a higher IC50 than promax70 samples. The presence of corn dramatically increased inhibition even though isoflavone levels were lower, while extrusion of corn-containing samples had greater increases in IC50 values than pure soy samples. ER-positive cells had lower IC50 values than the ER-negative cells, but the IC50 values for the cancer and normal cells were similar.

Overall, extrusion only slightly decreased isoflavone levels and biologic activity. Therefore, extruded breakfast cereals and snacks containing soy should maintain any health benefits associated with soy.

James Faller, Keith Singletary,
Jiyuan Li, Symon Mahungu
Food Science and Human Nutrition
College of Agricultural, Consumer
and Environmental Sciences
University of Illinois at Urbana-
Champaign

Effect of Soy on the Intestine

Intake of soy protein reduces blood cholesterol levels in animals and humans.

The mechanism responsible for this effect is not clearly known. If understood, the component in soy responsible for this effect could be better utilized or manipulated. Currently, it is hypothesized that

one or more components of soy has an effect within the bloodstream and/or the liver and on the intestine, perhaps lowering cholesterol or fat absorption.

For this project, we are studying the effect of soy and soy components on the function of the intestine. This includes the production of the “B48” form of the apolipoprotein B (apoB) molecule. The intestine produces the B-48 form of apoB, and B-48 may help determine how lipids are cleared from the bloodstream. We are measuring the levels of ApoB 48 produced by human Caco-2 intestinal cells. We have treated Caco-2 cells with the soy isoflavone, genistein.

Preliminary data indicated that genistein increased ApoB-48 production. This data also indicated that soy isoflavones may lower blood lipid levels by producing a higher ratio of B-48/B-100, stimulating clearance of lipoproteins from the bloodstream. We are also conducting permeability studies using monolayers of intestinal cells to measure the passage or absorption of lipids through intestinal cells when cultured with different components of soy. This C-FAR project is helping us understand the action of soy protein intake on the function of the body.

Neil Shay, Randall Frey
Food Science and Human Nutrition
College of Agricultural, Consumer
and Environmental Sciences
University of Illinois at Urbana-
Champaign



Transformation of Sterols from Soybeans

Researchers established conditions for growth of a cholesterol-reducing bacterium on solid and liquid media containing soybean sterols and lecithin.

Chemical hydrogenation in the presence of a palladium catalyst was used to show that crude soybean sterols are an efficient source of beta-sitosterol for conversion to beta-sitostanol. Gas chromatography was used to develop a method for detection of beta-sitostanol in media containing low levels of the compound.

The major anticipated impacts of the project will be an improvement in health and an increase in economic status of Illinois citizens. Individuals with elevated risk of coronary heart disease due to high serum cholesterol levels will benefit from the research. Consumption of beta-sitostanol will lower serum cholesterol levels, a major risk factor of coronary heart disease. Expansion of facilities will lead to increased employment in the grain and food processing industries to satisfy the demand for beta-sitostanol. Increased demand for soybeans and corn will produce higher prices for farmers' crops.

The next step of the research will optimize the production of beta-sitostanol from soybeans and show that the product is as effective at lowering serum cholesterol levels as the product derived from other sources. Commercialization of the process is expected to be performed by grain processors, such as Archer Daniels Midland, Decatur, Illinois, and companies that produce consumer products via microbial fermentation, such as Genentech, Cedar Rapids, Iowa. SIUC is performing this research

to improve the state's economy and health of citizens.

John D. Haddock
Microbiology
Brian Klubek
Plant, Soil and General Agriculture
College of Agriculture
Southern Illinois University-
Carbondale

Thin Film/Pan Frying with Soy Oil

Thin films of low linolenic soybean oil (LL-SBO) and partially hydrogenated soybean oil (PH-SBO) were heated without food on a surface area of 676 cm² at about 200°C.

Samples weighing about 2.5g were heated and collected every minute and analyzed by high performance size exclusion chromatography (HPSEC) until a polymer content greater than 20% was reached. Heated samples were also analyzed with static headspace GC and supercritical fluid chromatography (SFC).

HPSEC analysis of the heated LL-SBO and PH-SBO indicated a substantial increase in polymeric triacylglycerols (>20%) after six minutes and 10 minutes of heating, respectively. The major flavor volatiles, detected in both heated samples, were hexanal, heptanal, trans-2-heptenal, trans-2-octenal and trans,trans-2,4-decadienal.

SFC determined the percentage of unmodified monomeric triacylglycerol (TAG) substrate remaining after each heat treatment (an apparent first order reaction). The percentage of unaltered LL-SBO triacylglycerols after six minutes of heating was 24%. In comparison, the percentage of unaltered PH-SBO triacylglycerols after 10 minutes of heating was 17%.

Little research has been done

on thin film/pan frying, since retail establishments cannot afford the research and large companies use deep fat frying for their products. Hydrogenation, which is done to make the oil more stable and the flavor acceptable for storage and frying, can produce *trans* isomers that may have undesirable toxicological effects. Genetically modified oils are gaining popularity, since they require no hydrogenation. The genetically modified oils (LL-SBO) are comparable to hydrogenated oils (PH-SBO) in terms of stability and the fried food flavor compounds produced during frying.

Kambiz C. Soheili, Preeyanooch Tippyawat, Symon M. Mahungu, William E. Artz

Food Science and Human Nutrition
College of Agricultural, Consumer and Environmental Sciences
University of Illinois at Urbana-Champaign

Novel Process for Soy Oil Hydrogenation

The aim of this research is to investigate a novel process for hydrogenation of soybean oil at low temperatures so that the production of undesirable *trans* isomers and cyclic aromatic fatty acids is minimized.

The process involves reduction of soybean oil in the presence of water and an emulsifier by atomic hydrogen produced *in-situ* due to water dissociation by electrolysis.

In this study, two types of emulsifiers, didoceyl dimethyl ammonium bromide (DDAB) and lecithin, were employed. DDAB needs to be removed and recovered from the reaction mixture, while lecithin need not be removed as it is a natural emulsifier obtained from



soybean itself. In addition, lecithin is inexpensive, readily available and compatible with soybean oil. Experiments were conducted at low temperatures (not greater than 45°C) using a stirred reactor to which an electrical current was impressed. The reaction mixture also contained nickel powder that acted as a catalyst for hydrogen transfer. After the passage of electricity for the desired time (six to 24 hours), the reaction mixture was homogenized and soybean oil was recovered. Subsequently, the oil was saponified and esterified prior to analysis by gas chromatography.

The results obtained so far have clearly indicated that when DDAB was used as an emulsifier, an increase in 16:0, 18:0, 18:1 and 20:0 with a simultaneous decrease in 18:2 and 18:3 fatty acids as function of time was observed. Similar results were also obtained when lecithin was used as an emulsifier.

Future work will involve the study of important process variables (electrode potential, temperature) on the product quality. In addition, key experiments will be repeated and product characterization carried out which will also include determination of cis and trans fatty acids.

The research has shown that hydrogenation of soybean oil can be carried out at low temperatures, which should result in substantial savings over the commercial processes. The commercial hydrogenation processes are carried out under high pressure and high temperature conditions that require use of expensive construction materials and result in operational difficulties. In addition, it is known that trans fatty acids are produced during hydrogenation at high temperatures.

Thus, the low temperature process for soybean oil hydrogenation described here will result in lowering of materials and operational costs, while the hydrogenated

product will contain reduced amounts of trans fatty acids which are known to be harmful to human health.

A C-FAR External Competitive Grants project.

Shashi B. Lalvani, Hea-Ran L. Ashraf, Bruce N. Jacobson
Mechanical Engineering and Energy Processes
College of Agriculture
Southern Illinois University-Carbondale

Corn-based Biodegradable Shrink Wrap

The domestic market uses more than 8 billion pounds of flexible packaging annually.

Plastic waste accounts for 20% by volume of the more than 100 million metric tons of waste handled annually. Waste disposal problems have driven the development of biodegradable plastics, mainly from starch and polylactic acid. However, performance (flexibility, toughness, water resistance) and cost remain major challenges. Corn zein was proposed in this project as a starting material for production of bioplastics.

In laboratory-scale experiments, zein was plasticized with oleic acid to produce biodegradable sheets and films. Scaling-up required the formation of dry and stable resins to be used in plastic manufacturing. Extrusion processes were developed to produce resin pellets from zein-oleic acid compounds. Original concerns about the feasibility of extrusion processing of resins, due to their high fatty acids content, were cleared by effective pre-processing. Pellets were obtained from both single-screw and twin-screw types of extruders. Special high-pressure feeders were employed to facilitate extrusion flow in single screws. Twin-screw extruders required the addition of

aqueous ethanol to reduce melt viscosity and facilitate flow.

Resin pellets from both processes were formed into flexible and tough sheets. Tensile properties of resin sheets were comparable to those of low-density polyethylene. Water absorption was measured at 1% to 10% (24hs). Low water absorption samples were comparable to Nylon 6.

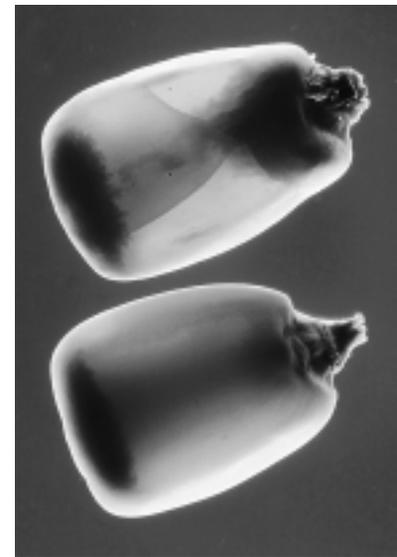
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High Linolenic Acid Specialty Corn

The objective of this research is to identify QTLs for fatty acid biosynthesis in maize so that breeders can use the information to produce a specialty crop with higher levels of essential omega-3 fatty acids.

Specialty crops such as this would not only benefit Illinois farmers (additional premiums), but also consumers (improved health attributes).

For this project, the team purchased and learned to use Pharmacia AKTA explorer 10, a fully automated liquid chromatography system with capacity to analyze 96 samples during one run. Samples represent the fatty acid profiles found in dissected embryos from corn kernels that are genetically distinct. Specific pairs of recombinant inbred lines were grown and selfed to produce seed for analysis in addition to the seed of a IHO X Mo17 cross. These parental lines already have been used to produce populations and RFLP



maps. The fatty acid composition from each recombinant inbred pair will be compared for a significant difference. If a difference exists, then a population produced from these parents will be analyzed and the data entered into a mapping program for an estimation of linkage to a particular chromosome.

DNA was extracted from leaves harvested and freeze dried from the IHO X Mo17 cross where a significant difference between oil content exists. These DNA were prepared for RFLP analysis and will be placed in association with radioactive pieces of mapped DNA for more precise localization of genes affecting fatty acid production.

A C-FAR External Competitive Grants project.

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Converting Corn By-products to High Value Carbon

The objective of this study is to develop high-value activated carbon (AC) from corn stillage (CS), a by-product of the corn-to-ethanol conversion process.

Producing commercial grade AC from CS would improve the overall economics of ethanol production in our state. Illinois ethanol producers generate about 1.7 million tons of CS per year. The conversion of this stillage, currently selling for 10 to 20 cents per pound, into AC, which typically sells for \$2 to \$5 per pound, would enable ethanol producers to offset some of their production costs. To the best of our knowledge, no one has attempted to produce AC from CS. One high volume application for

AC is its use in automobiles for gasoline vapor emissions control. Each car built in the United States requires up to 2 pounds of carbon.

The CS used in this study was a by-product of the ethanol dry milling process commonly referred to as distillers dried grains with solubles. AC was produced from CS having surface areas exceeding those of commercial ACs. The gasoline vapor adsorption capacity of one CS carbon was 30% greater than that of the best automotive carbon. According to the Ford Motor Co., this was a promising result.

The goal of second year work will be to further optimize the properties of this carbon and to work with Scientific Ag Industries (SAI) in Blakely, Georgia to scale up production of high quality AC from CS. Large quantities (300 to 500 pounds) of CS will be obtained from Archer Daniels Midland in Peoria and processed in their rotary kiln under conditions established in our laboratory.

A C-FAR External Competitive Grants project.

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Corn Starch Yield Calibration with NIR

Corn starch yield is affected by variety, environmental growing conditions and drying conditions.

Corn starch yield typically varies from 58% to 72% dry basis and is important for wet millers who process corn for starch production, for conversion to fructose or for ethanol production. One hundred gram starch yield tests that predict actual wet milling starch yield were used as a reference method for developing an extract-

able starch calibration on a NIR Systems Model 6500 spectrophotometer.

A corn starch yield calibration was developed from 791 samples with a standard error of cross validation (SECV) of 1.023%. This indicates about 95% of similar samples could have starch yield predicted by NIR within about ± 2 percentage points. With a wider range of samples in the calibration set and by adding repeatability files, the SECV is capable of being improved to about 0.65 to 0.90 based on the standard error of the laboratory reference method.

The calibration is expected to be successful in segregating corn lots for high and low starch yield percentages. A relatively small improvement of only 2 percentage points in starch yield is estimated to be valued at 4 to 6 cents per bushel.

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Gray Leaf Spot Resistance

Gray leaf spot has been a serious leaf disease of corn since the late 1980s, mostly because of increased use of conservation tillage.

With conservation tillage, previously diseased leaf debris remains on the soil surface. Previously diseased leaf tissue is the place where causal fungus successfully survives the winter and in the spring, produces spores that start the gray leaf spot epidemic. The disease was not a problem when tillage practices

buried crop debris. Conservation tillage was adopted to reduce erosion of soil and its use should be continued.

Unfortunately, most widely used Corn Belt germplasm is susceptible to gray leaf spot. In previous research, we identified sources of resistance to gray leaf spot. We have crossed resistance into commercially used inbred lines, while selecting for both yield and disease resistance. Several of our inbred lines have 50% to 80% less disease than inbreds currently used in commercial hybrids.

We are now using molecular technology to identify the areas on the corn chromosomes where genes for resistance are located. The location of genes for resistance will allow for the use of marker-assisted selection in crossing genes for resistance into commercially used inbred lines. Marker-assisted selection greatly increases the efficiency and precision of backcrossing the resistance genes while preserving the favorable agronomic characteristics of the commercial line.

The eventual outcome of this research will be the control of a serious corn disease in an environmentally friendly manner that will allow for the continued use, and possibly the expanded use, of conservation tillage.

A C-FAR External Competitive Grants project.

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Enhancement of Nutritional Composition of Corn

Improved levels of tocols, carotenoids and fatty acids will add value to Illinois grain,

improve food safety since there will be higher levels of antioxidants that inhibit spoilage of food, improve nutritional value and may help to expand markets for Illinois corn grain.

We have successfully used molecular markers to map chromosomal regions controlling levels and forms of tocopherols (vitamin E), carotenoids (pro vitamin A) and fatty acids (saturated, mono- and polyunsaturated fats) in corn grain.

We have mapped chromosomal regions controlling levels of alpha and gamma tocopherol in a cross of W64A x A632. The major regions are on chromosome bins 6.06, 8.04, 2.04, 4.04, 5.04, 9.02 and 1.08. In this same cross, we have mapped chromosomal regions that control specific carotenoid forms: alpha and beta carotene, lutein and cryptoxanthin. The major regions are on chromosome bins 7.02, 1.09, 6.02 and 2.03. We have mapped chromosomal regions controlling levels of stearate, oleic, linoleic and linolenic fatty acids in a backcross-derived population of Illinois High Oil x B73. The major regions controlling fatty acids are chromosome bins 6.01-6.05, 3.03 and 2.08.

We have begun assessing the tocol, carotenoid and fatty acid composition of corn grain grown in Illinois. In 1997, a number of maize hybrids were grown in Champaign and other locations. We have identified variation in corn grown in Illinois and have experimental lines that will enhance this germplasm.

A C-FAR External Competitive Grants project.

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Increasing Trp in Corn, Soybeans; New Selectable Marker

The coding sequence and promoter for the tryptophan (Trp) biosynthetic control enzyme, anthranilate synthase (AS), have been cloned and sequenced.

The amino acids that make the enzyme feedback-insensitive have been identified and this form was used to transform bacteria to impart resistance to the Trp analog, 5-methyltryptophan (5MT). *Astragalus sinicus* hairy roots transformed with AS were also resistant to 5MT and contained much higher than normal levels of Trp.

The team produced corn plants that should contain AS driven by a seed specific promoter with the purpose of increasing the Trp content. The AS promoter was shown to be tissue culture specific with some species by transient expression using *gus* as the reporter gene. Good constitutive expression was found in several cases when the promoter was truncated. Progress is being made in cloning the gene for the factor that stimulates AS transcription in 5MT resistant tobacco cells.

This progress toward the goals of increasing Trp in corn and soybeans to increase their value and of developing a new selectable marker and a tissue culture specific promoter to expedite genetic engineering has led to scientific publications and presentations, a patent application and funding from the Consortium for Plant Biotechnological Research.

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Propagation for Nursery Productivity

The objective of this project is to develop a propagation technique that has the potential to increase both efficiency and productivity of Illinois nurserymen.

This technique allows softwood shoots to be forced from dormant stem sections so that propagation, via stem cuttings, may be initiated several months earlier than typically possible. As a result, production time of certain species may be reduced and nursery operations may increase profitability.

Considerable progress has been made toward meeting research objectives during the first two years of this project. Several studies have been directed toward quantifying species/clonal variability when using this method with maple and 10 additional species. Other studies have investigated the manner in which stem section diameter, stem section length and environmental parameters (shade, intermittent mist) affect the number of shoots produced. Recent studies have investigated the way in which different media (six types) affect this propagation technique.

Technology transfer is an important part of this project, and researchers are currently developing techniques (in cooperation with local nurseries) that allow propagators to generate softwood shoots from small caliper pruning material collected at their own nurseries. It is expected that continued research in this area, along with enhanced rooting studies, will be a primary focus of next year's work.

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Improving Market Channels for Value-added Soybeans

The long-term objective of this project is to increase the utilization of soybeans in the edible oil market by developing a cost-effective marketing channel that will maintain product quality.

To meet this objective, research on the production, marketing and genetic components of value-added soybeans was conducted.

A subset of the 7,000 Illinois FBFM (Farm Business, Farm Management) records was used to statistically compare, across and within regions, differences in corn and soybean yields from 1983 to 1995. Historical cost and return information indicated a potential competitive advantage of soybean production in three of the five regions of Illinois. Returns were also evaluated to see if the new lines have a comparative advantage in specific regions of the state.

The marketing component involved development of a database of edible oil supply, demand and price data, a survey of specialty grain handlers and a survey of edible oil processors. Information from the survey of 84 specialty grain firms is being analyzed to compare traditional and alternative market channels used by firms handling specialty grains and how costs differ across the various market channels.

The 32 respondents who completed the edible oil processors' survey represented processors of soybean, corn, cottonseed and sunflower oil. Although survey responses indicated that there is little, if any, use of value-added oilseeds in current production of edible oils, several respondents stated that the

trend would be in that direction.

The genetic component includes developing soybeans with higher oil content through mutagenesis techniques.

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Expanding the Horseradish Market

Illinois ranks first in U.S. horseradish production. The bulk of the crop is used as an additive in different types of foods.

Demand for horseradish by the food industry has not changed in the last 50 years. Recent use of an enzyme extracted from horseradish (horseradish peroxidase, EC 1.11.1.7, donor:hydrogen-peroxide oxidoreductase) in medical research and in waste water decontamination offers new marketing opportunities for horseradish growers. Industry experts predict that demand for horseradish peroxidase (HRP) will nearly double in the next decade. The main objectives of the proposal are to evaluate horseradish peroxidase distribution in different parts of the horseradish plant; to screen a germplasm collection housed at the U of I Cruise Farm for HRP activity; and to identify optimum cultural practices that will stimulate the enzyme activity.

Evaluation of HRP activity in horseradish plants showed that 86% of the activity is localized in the



Research Focus:

Develop and advance technologies to expand markets for agricultural products and employment in the agricultural and food sector in Illinois.

rootsystem and 14% is localized in the leaf petiole, while the leaf blade contained 0% activity. Among the 130 horseradish numbered selections, nine have very poor root systems and therefore were not included in the analysis. The remaining 121 selections were evaluated for HRP activity in the roots only. Results showed that three selections have specific activity greater than $5.0 \mu\text{mole} \cdot \text{mg}^{-1} \text{protein} \cdot \text{min}^{-1}$; 10 selections have specific activity between 4 to $5 \mu\text{mole} \cdot \text{mg}^{-1} \text{protein} \cdot \text{min}^{-1}$; 36 selections have specific activity between 3 and $4 \mu\text{mole} \cdot \text{mg}^{-1} \text{protein} \cdot \text{min}^{-1}$; 58 selections have specific activity between 2 and $3 \mu\text{mole} \cdot \text{mg}^{-1} \text{protein} \cdot \text{min}^{-1}$; and 14 selections have specific activity less than $2 \mu\text{mole} \cdot \text{mg}^{-1} \text{protein} \cdot \text{min}^{-1}$. None of the present commercial cultivars contained higher than $3 \mu\text{mole} \cdot \text{mg}^{-1} \text{protein} \cdot \text{min}^{-1}$, specific activity.

A field-scale plot of the selections with the highest horseradish peroxidase activity were tested under varying nitrogen : phosphorus : potassium ratios and application timing for the enzyme activity. Results show that the enzyme activity is slightly higher under high phosphorus and significantly lower under high nitrogen. We have also found that leaf injury enhanced the enzyme activity.

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Expanding the Grape, Wine Industry

To assess and quantify the size of the grape and wine industry in Illinois, researchers prepared a questionnaire and

made on-site visits to several grape growers and most of the wineries in the state.

Additional site visits were made during the summer of 1998. The questionnaire was designed to survey grape growers and wine-makers concerning the status of their industry and their future plans.

Based on the tabulations of 140 questionnaires, 47 growers were confirmed to have vineyards. There are approximately 120 acres of producing vineyards in Illinois and 60 acres of non-yielding grapes. Geographically, the majority of the yielding plants (53.1 acres) are found in Zone 2 (the area between Interstate 70 in the south and Interstate 80 in the north). Zone 1 (north of Interstate 80) has 25 acres of vines; Zone 3 (south of Interstate 70) has 32 acres. However, the majority of the new plantings are being made in the south (Zone 3), where 63 acres of non-bearing plants are reported. Of the grapes grown in Illinois, 94% are used to make wine, 5% are sold fresh and 1% are processed into juice. This research (reported on the Web at <http://w3.aces.uiuc.edu/NRES/faculty/Skirvin/CFAR/>) is being used by the Illinois Grape and Wine Resources Council to encourage the development of the Illinois grape and wine industries.

Cultivar trials have been established at four regional sites in the state: St. Charles (north), Urbana (central), New Salem (west central) and Dixon Springs (south). Each location has about 25 cultivars planted in a replicated design. These plants will be grown for a minimum of five years to assess their hardiness, adaptability, fruit production and wine quality. To study the role of grape rootstocks in winter hardiness, we will establish a planting of selected cultivars grafted onto selected rootstocks

which may impart improved winter hardiness.

To test the survivability and yield potential of several wine grapes, including the European wine grape *Vitis vinifera*, members of the Illinois Grape Growers and Vintners' Association (IGGVA) have been invited to join in participatory research projects with the UIUC. They will follow specific procedures for growing and caring for plants that we plan to provide.

A C-FAR External Competitive Grants project.

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Technology for Embryo Handling, Analysis

Almost all commercial cattle breeding is performed using fertilization techniques.

For example, bovine embryos are individually handled with mouth-pipettes and large, expensive manipulators as they are fertilized *in vitro* at a cost of up to \$2,000 per procedure to the farmer. Potentially, this research will provide a reliable and inexpensive instrument to facilitate rapid embryo manipulation and improved measures of viability. The primary objectives are to develop prototype micro-scale systems for the handling and evaluation of individual embryos and to demonstrate the use of these systems using mouse embryos.

To date, we have designed, built and tested a micro fluidic system capable of transporting individual, pre-implantation mouse



embryos through a network of channels to selected locations. In addition, we have preliminary results showing changes in lactate for different embryo and ova preparations. This project directly addresses the C-FAR priority to improve the productivity, profitability and competitiveness of Illinois livestock enterprises. Further, it may reduce production costs for livestock and livestock products.

The long-term impact of this work may be profound. Specifically, it will allow research to increase our understanding of factors affecting embryo viability and identify which are natural components of normal healthy embryos. This may ultimately allow for the formulation of strategies to ensure viability of embryos being transferred and allow us to screen for damaged embryos.

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Illinois Animal Disease Reporting System

Researchers created a database to receive animal disease information from the veterinary diagnostic laboratories in Illinois and developed methods of importing data.

Data collection is in an early stage of testing. Software will allow collected data to be plotted on a map of Illinois. In addition, this animal disease data will be plotted on maps that interactively display other information, such as animal population densities, streams, rivers, lakes, wetlands, highways, public water sources, soil types, rainfall and ambient temperatures.

A uniform nomenclature system for reporting laboratory diagnoses and procedures has been developed by linking a modified system of "diagnosis codes" currently in use by a number of Midwest veterinary diagnostic laboratories to the massive and powerful nomenclature system developed for human and veterinary medicine called SNOMED. Presentations of this nomenclature system have been given by the principal investigator at regional and national meetings of veterinary diagnostic laboratory workers and information specialists in June 1998. The system of nomenclature is now being evaluated by collaborators at other diagnostic laboratories in South Dakota, Illinois, Iowa and Washington.

Once completed, this system will allow animal health professionals to monitor more closely the presence of disease in Illinois animal populations and to develop more effective strategies for control and eradication.

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Improving Beef Quality

Data collected from this research project will help the beef industry see the relationship between the increased cost of production and the consumer's ability to differentiate between steaks of different marbling levels.

The first half of the cattle in this project were harvested in 1998. We have been successful in producing high-quality beef in that more

than 50% of the cattle graded USDA Prime. The national average is less than 2%.

We are now in the process of developing regression equations for each animal relating the marbling development to the amount of feed required per unit of gain. We know that breed and age affect the relationship between marbling and subcutaneous fat development. The yearling cattle had more than 40% yield grade 4 carcasses while the calves only had 20%, with equal marbling development. The Wagyu-cross cattle were also leaner at the same marbling level than the Angus.

These data will allow us to calculate how much premium the cattle producer must receive to justify feeding the cattle for longer periods to achieve a higher quality grade. Taste panel evaluations of steaks from all cattle will help determine the relationship between marbling levels and consumer acceptance.

A C-FAR External Competitive Grants project.

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Electronic Information for Food, Agriculture

The primary goal of this project is to enhance our basic understanding of adoption and use of electronic information systems within farm and agribusiness firms.

The effort combines novel conceptual and modeling techniques to explore this issue.

Research Focus:

Develop and advance technologies to expand markets for agricultural products and employment in the agricultural and food sector in Illinois.

A significant case study analysis has been performed in conjunction with the efforts of a group of east-central Illinois farmers and local agribusiness managers, the CCNETag project. This group's learning activities have been monitored since the group's inception in the mid-1990s. Findings include: Electronic communications (the Internet) are of great potential interest and value because they provide communication access, not because they provide more information. Relative to business communications, agricultural decision makers desire to employ the technology to enhance business-to-

business communications with their suppliers and customers. Infrastructure issues are impediments, however, many hardware and software constraints can be overcome. Lack of a community of "similar users" is a more critical constraint in many rural areas. The learning process is continual.

A second outcome of the project has been development of a dynamic model of the adoption process for yield monitors. This model successfully integrates both qualitative and quantitative factors that affect adoption decisions.

The conceptual foundations of this approach are distinctive in

that they uniquely combine system dynamic principles and technology adoption literature to a precision agriculture technology. Field implementation of the model will allow producers and other decision makers to better anticipate the evolution of this and similar technologies.

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Research focus: Promote the economic development and management of agricultural and food systems in rural and urban communities in Illinois.

project updates

Geostatistical, Econometric Analysis of Site-Specific Agriculture

We evaluated the influence of soil sampling and subsequent interpolation methods on accuracy of soil nutrient maps for representative central Illinois farms.

The relative accuracy of nutrient maps was then used to perform an economic analysis of site-specific management relative to whole field management. We found that the method of sample collection greatly influences map accuracy. For instance, the traditional method of collecting a laboratory soil sample is to obtain a composite of five to nine soil samples collected within a 2-meter diameter area. We compared this to a composite sample collected in various ways, such as a composite of five to nine samples collected along a 50-meter transect. Map accuracy was strongly dependent on the spatial arrangement chosen for the composite samples.

In addition, we examined the influence of interpolation methods (ordinary kriging, log-normal kriging and inverse distance weighting) on map accuracy. We found that kriging methods provided more accurate phosphorus and potassium nutrient maps than did inverse distance weighting in most of the 30 fields studied. We

have systematically examined the potential economic benefits of variable rate application of nitrogen, phosphorus and potassium on representative central Illinois farms.

Results indicate that returns above a fertilizer cost of \$5 to \$12 per acre can be achieved. However, these economic benefits can only be achieved by adopting more precise variable rate application criteria than currently used. Our research has also quantified the value of alternative intensity levels of site-specific information. The optimal level of soil sampling may be more intensive than current practice, but we are also quantifying the benefits from alternative strategies for collecting the information which can lower the per acre annual cost.

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Site-specific Management for Crop Production

The aim and long-term objective of this project is to enhance the economic and environmental benefits attainable from site-specific crop management systems in Illinois.

For two large-scale research farms, we developed multiple geo-referenced information layers and implemented variable rate application of fertilizers. This included variable rate application of nitrogen fertilizer on corn utilizing economic criteria and the multiple information layers. Results indicate that returns above fertilizer cost of \$5 to \$12 per acre can be achieved and detrimental environmental impacts can be reduced by perhaps 40% to 60%. However, these economic and environmental benefits can only be achieved by adopting more precise variable rate application criteria than currently used in the industry.

Research in developing a near-real-time aerial imaging system has included collecting digital aerial images approximately every two weeks during the 1997 and 1998 growing season. Spatial yield maps are highly correlated (above 0.8) with red reflectance 75 days after corn planting. These results show great promise for early detection of crop stress conditions. As a result of this research, a commercial company in central Illinois is using the aerial imaging system.

Our survey results indicate that around 10% to 15% of farmers surveyed in Illinois, Iowa, Wisconsin and Indiana have adopted some form of site-specific management technology. Moreover, approximately 40% surveyed expect to adopt the technology by the year 2001.



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Uncertainty, Investment in Precision Agriculture

Precision technologies, such as variable rate applicators and yield monitors, can simultaneously increase farm profitability and reduce negative environmental impacts associated with over-application of agro-chemicals.

This research is an attempt to understand how farm size, soil characteristics and uncertainty about prices influence the adoption of precision agriculture technologies.

The analysis uses a simulation model that measures the implicit cost of uncertainty in the returns to the investment using an option pricing approach. To apply this method, price trends for inputs and outputs have been analyzed. The price information has been combined with information on the production and pollution resulting from conventional and site-specific production methods, to indicate the profitability of adoption under baseline conditions. In the next stage of the project, greater detail in the farm conditions will be built into the simulation model.

The model reveals that soil homogeneity and small scale of

operation can make the technologies inappropriate for Illinois farms. After the model has been fully developed and its results confirmed through discussions with farmers, the research should provide guidance for targeting these new technologies where they are most useful, modifying them to widen their usefulness and highlighting the need for alternative technologies for farms that cannot adopt precision technology profitably.

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VRT Effects on Corn Yield, Fertilizer Use

The goal of this project is to evaluate changes in yield and fertilizer use that may result from the adoption of variable rate application of fertilizers for corn production.

This goal will be accomplished using the computer model CERES-Maize and historic weather data from Peoria; soil data from McLean County; and fertilizer and crop husbandry inputs that are typical for central Illinois.

Preliminary findings indicate that comparisons between conventional fertilizer application and variable rate technology (VRT) fertilizer application can be made using the yield estimate differences. Computations can be made concerning the differences in the amount of fertilizer used in each situation.

Application of findings will be limited to regions that have similar weather and soils as central Illinois.

However, by supplying the appropriate weather, soil and crop husbandry data, the model could be used to generate results for any area where corn is grown.

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Impact of Precision Ag for Farmers, Retailers

The goal of this research was to ascertain the potential profitability of adoption of precision farming services for farmers and dealers of the services.

Part of the research included developing models of the investment and operating costs, capacities and prices charged and paid for such services as variable rate fertilizer application. The most recent surveys of farmers and dealers were designed to help estimate the amount of precision farming services used in selected Illinois areas. One survey was designed and mailed to farmers in three Illinois counties (McLean, Stephenson and McDonough), and a more recent survey was mailed to fertilizer dealers in Illinois.

Preliminary analysis of data from the 1998 farm operator survey in McLean County indicated that larger acreage farm operators were more likely to be using precision farming practices than were smaller acreage farm operators. Larger acreage farm operators, 500 acres or more, accounted for the vast majority of acreage to which most precision farming practices were applied. Also, a greater percentage of large farm operator respondents than small farm operator respondents reported using precision farming practices.

Among farmers responding to



Research Focus:

Promote the economic development and management of agricultural and food systems in rural and urban communities in Illinois.

the survey, those farming more than 500 acres represented 94% of acreage on which yield monitoring and yield mapping were used and 79% of the acreage on which variable rate application of dry fertilizers was used. A full report is anticipated by early 1999.

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Economic Performance of Market Advisory Services

Producers view market advisory services as a significant source of market information and advice in their quest to manage price risks associated with marketing corn, soybeans and wheat.

While the advisory service industry has existed for more than 20 years, very little is known about the risk management performance of the services. As a result, Illinois producers have little basis for evaluating and selecting advisory services.

Research in the last year examined advisory service pricing performance in 1996 for corn and soybeans. Specifically, the average price received by a subscriber to an advisory service was calculated for corn and soybean crops harvested in 1996.

Of the marketing programs for corn, five achieved a net price that is within (plus or minus) 10 cents of the harvest cash price of \$2.81 per bushel. Two of the advisory programs achieved a net price more than 10 cents higher than the harvest price, while 19 programs achieved a net price that is more than 10 cents per bushel below the harvest price.

For soybeans, only one of the

advisory programs was within (plus or minus) 10 cents per bushel of the harvest cash price of \$6.95 per bushel. However, 21 of the 24 programs achieved a net price that is more than 10 cents per bushel above the harvest price, with only two services more than 10 cents per bushel below the harvest price.

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Financial Performance of Farms, Agribusiness Firms

The main objective of this project is to develop integrated firm-level financial performance models that can be used to evaluate current public policies and programs that impact the financial well-being of Illinois agriculture.

The "IFARM" model has been developed and applied to issues including property tax reform in Illinois and changes in cash rental practices. Publications on these issues have been prepared and disseminated. The model is also being used to evaluate proposed federal tax reforms, including a flat tax and a national sales tax. This work is part of a Ph.D. dissertation that is nearing completion.

Other models are also under development. A 10-year optimization model with uncertainty is nearing completion. It is being used to evaluate tenure relationships with differing time and risk attitudes. A 10-year hog simulation model is also being completed to investigate performance differences across Illinois contract growers and independent producers based on

different lending costs.

A hog module is being added to the 10-year farm-level stochastic model. This model is being used to develop and investigate the applicability of neural networks as a tool to develop a credit-scoring model. The 10-year farm-level stochastic model will also be the initial basis of a new C-FAR project, "A Financial Evaluation of Entry Barriers for Illinois Farmers."

David Lins
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The Illinois Resource Allocation Model

The IRAM project offers the capability to assess and predict the economic benefits and costs realized by Illinois agriculture under different political, economic and environmental conditions.

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Swine Industry Technology Transfer Program

The objectives of this program were to support a series of applied swine research projects of direct relevance to the Illinois pork sector and to rapidly communicate the



results of this and other relevant research to the industry using a variety of mechanisms.

These have included presentations at conferences, meetings and seminars; papers and articles in scientific and industry meetings; and PORKNET (the home page that was developed under this project (<http://www.ansci.uiuc.edu/porknet>)).

Research projects supported during the second year of the project included nutritional manipulation of pork eating quality; the effect of dietary vitamin D3 on pork quality; the link between sickness, immune response and nutrient requirements; the identification and evaluation of genes associated with body composition; and the relationship between stress and pig performance. Activities of a student group (Illini Pork Link) that acts as a liaison between the U of I and the swine industry continued to be integrated into this project.

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Ultrasound to Detect Sow Ovulation

A significant accomplishment of this research was characterization of factors which influence the timing of ovulation in the post-weaned sow.

This will facilitate prediction or control of ovulation and allow development of improved breeding techniques and reproductive performance. Over the last 18 months, we have developed the ultrasound technique to quickly de-

termine the ovarian status of the female and the occurrence of ovulation with little or no observed animal stress. We have identified the leading factors that influence time of ovulation after onset of standing estrus in the post-weaned sow. Other factors that also influence time of ovulation include duration of post-partum interval, interval from weaning to estrus and follicle size at estrus.

The strongest relationship to time of ovulation was follicle size on the second day of estrus. We also observed a significant spread in the timing of ovulation after onset of estrus with sows ovulating as early as 24 hours and as late as 120 hours after onset of estrus. Our ultrasound data, in conjunction with the timing of artificial insemination, have indicated that the timing of the last insemination dose prior to or after ovulation can affect both farrowing rate and litter size. The optimum time of insemination appears to be 24 to 12 hours prior to ovulation for maximum reproductive performance.

In light of the fact that the time of ovulation can be unpredictable, we believe that the ultrasound technique offers swine producers a tool to increase economic returns through improved herd reproductive performance.

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Illinois State University

Economic Analysis of Aquaculture Industry

The number of aquaculture producers in Illinois has expanded considerably.

In 1988, 29 individuals held permits, compared to 100 in 1996. Aquaculture production is dis-

persed throughout the state. It was estimated in 1992 that 5 million pounds of aquaculture products were produced or held in Illinois. Production systems include ponds, raceways, cages and tanks. End uses include food fish, fingerlings, bait and ornamentals. Three individual business plans show feasibility and profitability for raising hybrid striped bass and catfish in ponds and floating raceways in southern Illinois.

The need for handicapped accessibility in outdoor recreation has been increasingly appreciated. Although 34 fishing sites are available for the general public, only five are handicapped accessible. Anderson Sunfish Farm is an operational fee fishing enterprise desiring to modify the facility to be handicapped accessible. Regulations were researched and recommendations made on property modifications and equipment needs. The farm is in the process of obtaining financing.

Research data on agricultural cooperatives indicate that cooperatives have a place in aquaculture. Traditional forms of cooperative efforts which were identified included service, purchasing, marketing and processing. The team also evaluated a relatively new form of integrated cooperatives. A role for aquaculture cooperatives in Illinois is feasible but will be challenged by determination of demand, supply and other related issues.

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Swine Waste Uses

This interdisciplinary research project was designed by the



Research Focus:

Promote the economic development and management of agricultural and food systems in rural and urban communities in Illinois.

Illinois State University and University of Illinois Livestock and Urban Waste Recycling Research Team (LUW Team).

Two of the major objectives are to create value-added by-products using livestock waste and to develop environmentally acceptable processing methods for handling livestock waste which can be used by small-, medium- and large-scale operations.

Solid and liquid fractions of livestock waste have been successfully used in combination with landscape waste (leaves, grass clippings, wood chips) to produce Class B agronomic and Class A designer compost. Amending soil with compost at rates up to 60 tons per acre has resulted in corn grain yields similar to those produced with inorganic nitrogen fertilizer. The team found no evidence of transfer of indicator microorganisms detected in livestock waste to agronomic crop samples analyzed.

These results, to date, indicate that substantial bacterial concentration reduction in finished compost results in limited potential for transfer of harmful bacteria to soil and agronomic crops. Monitoring wells have been established in one of three agronomic plots dedicated to this project. These wells will be used to monitor the effects of unprocessed liquid swine manure and processed effluent produced from liquid swine manure on ground and soil water.

A C-FAR External Competitive Grants project.

Paul Walker, Ken Smiciklas, Tim Kelley
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Illinois State Water Survey

New Foundation for Sustainable Apple Orchards

We have identified 19 (out of 30 tested) rootstocks and interstem/rootstock combinations that after two years in the orchard produce trees at least 30% smaller (canopy volume $< 1.93 \text{ m}^3$) than the industry standard, MM.111.

Identifying rootstocks which induce dwarfing of mature tree size is essential to hastening returns on investment in new orchards because dwarf trees can be planted at closer orchard spacing. This shortens the period required for trees to fully occupy allotted space in the orchard. The flowering data collected in spring 1998 identify 19 rootstocks and interstem/rootstock combinations that induce at least twice the precocity (early cropping) of the industry standard, MM.111. The 19 new rootstocks induced two to four times higher flower cluster density (flower clusters per m^3 tree canopy volume) than did the MM.111 industry standard.

The potential of these precocity inducing rootstocks to increase horticultural efficiency of new Illinois apple orchards of the future can be extrapolated from flower cluster density values, theoretical fruit set ratio (30%) and average fruit size at harvest. The projected third-year yields of seven of the new rootstocks ranged from five to 10 times greater than the industry standard (MM.111) yield of 5.4 metric tons per hectare. Visual assessment of fruit set suggested the new rootstocks will produce even greater yield advantage at harvest in 1998.

The projected yield advantages of the new rootstocks could be reduced or eliminated by poor set and growth of fruits under typi-

cal Illinois stress. Additional empirical testing of yield efficiency and stress tolerance is needed before commercially feasible rootstocks can be identified.

A C-FAR External Competitive Grants project.

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project updates

Research focus: Increase the capacity of Illinois crop and animal systems to respond to changing world food and agricultural demands.

Societal Perceptions of Illinois Agriculture

Researchers surveyed Illinois residents about their perceptions of the role of agriculture in the environment, economy and community.

Resulting information will be invaluable to policy makers charged with representing the values of their constituents and to individuals, firms and groups involved in or impacted by the level and type of production agriculture in Illinois. Specific, well-targeted information is being disseminated through both academic journals and the popular press and during formal and informal meetings with interested parties. The nature of the University's mission ensures that collection, analysis and dissemination of this information is unbiased and transparent.

Key findings about the perceptions of Illinois residents have been identified. First, overall, agriculture is considered the industry with the greatest economic impact in Illinois; however, this perception is not consistent across counties. Second, agriculture is perceived as a single industry; residents do not perceive important differences between crop and livestock farmers or farms in motivation, activities or performance.

Perceptions of family (versus corporate) farms are much more positive; however, residents differ in how they distinguish one type of

farm from the other. Third, in general, residents of largely rural Illinois counties perceive a decline in the quality of life over the past five years and expect this trend to continue.

Cheryl J. Wachenheim
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Illinois State University

Genetics of *E. coli*

Enterotoxigenic E. coli (ETEC) are non-invasive pathogens that cause acute diarrhea in neonatal pigs, lambs and calves.

ETEC colonize the intestinal epithelium by means of fimbrial adhesins such as 987P that constitute a major virulence factor. We have shown that two copies of the genes encoding the 987P fimbriae are present in cells: one is on a plasmid and a second copy on the chromosome.

We previously showed that expression of these genes was regulated via phase variation. Strain I36, a 987P- mutant resulting from a spontaneous loss of the 987P plasmid, was found to be completely avirulent when fed to piglets, but a rare reversion to 987P+ phenotype was observed when feces from these piglets were plated on blood agar. Based on a genetic analysis, it was concluded that activation of the previously silent chromosomal copy of 987P genes in vivo results in the production of 987P fimbriae.

We are continuing to determine the mechanism of phase variation that regulates the plasmid-borne 987P genes, and the mechanism of silencing/activation of the chromosomal copy of 987P genes. PCR amplification and restriction digestion analysis of a promoter region did not detect any gross rearrangements or deletions which were thought to cause variable expression of 987P.

We showed that the chromosomal 987P genes contain all of the genes necessary to produce 987P. The presence of the 987P genes was further confirmed by PCR amplification using primers specific to these regions.

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Swinepox Virus Vected Vaccines for PRRS

Porcine respiratory and reproductive disease syndrome (PRRS) virus is responsible for significant economic losses to the swine industry.

Although commercial vaccines are available, these consist of attenuated PRRS viruses which may revert to more virulent strains and contribute to virus persistence in swine herds. Thus, the retention of only those parts of the PRRS virus which afford protection, that



is, the products of open reading frames (ORFs) 4 and 5, in alternative vaccines, must be considered.

Toward this end, we intend to create swinepox virus (SPV) which will express the two ORFs separately and then measure the vaccine potential of the two recombinant viruses. So far, we have inserted both ORFs and pox virus promoters required for their expression into the genome of SPV. This feat was accomplished by generating plasmids which would direct the insertion to occur within a non-essential region of the SPV DNA, its thymidine kinase gene. These plasmids, containing either ORF 4 or 5 together with an adjacent bacterial gene, were separately introduced into pig kidney cells infected with SPV. Homology between the plasmids and replicating virus genomes enabled the insertion of the foreign DNA into the SPV genome.

Recombinants in the progeny (< 0.02%) were identified based on their ability to produce the bacterial enzyme. Putative recombinant SPV have been shown to retain either ORF 4 or 5 at the predicted location. Currently, their expression of the two PRRS virus proteins is being assayed.

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Swine Health Monitoring, Decision Making System

A herd health monitoring system consisting of serological testing and slaughter evaluation was effective in detecting subclinical infection of the herd at an early stage.

Serological testing was a better tool for evaluating the economic impact of subclinical infection than slaughter evaluation. Infection of the herd with porcine reproductive and respiratory syndrome virus, swine influenza virus, transmissible gastroenteritis virus, pseudorabies virus or *Mycoplasma hyopneumoniae* without clinical disease signs reduced average daily weight gain between 18 and 116 grams per day on seven farms that were monitored in 1996 and 1997.

Sows infected subclinically with porcine reproductive and respiratory syndrome virus had, on average, between 0.5 and 0.9 still-born piglets per litter more than seronegative animals. The average interfarrowing interval was three to 10 days longer for seropositive than seronegative animals.

The magnitude of the economic effect of subclinical infection with a pathogen differed among farms. However, all of the monitored farms had substantial production losses due to subclinical infection.

The herd health monitoring system developed in this study enables producers and veterinarians to estimate the economic impact of subclinical infection on the farm. Thus, decisions on intervention measures, such as management changes, vaccination or treatment, can be based on an analysis of production costs and benefits.

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Symbiotic Therapy to Reduce Dependence on Antibiotic Prophylaxis for Weaning Pigs

Probiotics are of interest as alternatives to antibiotics

currently used as growth promotants.

Future applications of probiotics are dependent upon an adequate monitoring system for introduced organisms. Four-week-old piglets weaned on an antibiotic-free diet were inoculated with antibiotic resistant (400 µg/ml streptomycin and 40 µg/ml rifampicin) *Lactobacillus reuteri* strain MM53 (2.5×10^{10} cells/dose). There were two regimes of inoculation. The first consisted of daily dosage and the second consisted of dosage every fourth day. Fecal samples were collected daily for three weeks and analyzed for the presence of the resistant strain.

Background levels of antibiotic-resistant *L. reuteri* were below detectable limits (1×10^3 CFU / g feces). Daily-dosed piglets maintained 1×10^5 to 1.5×10^6 CFUs / g feces compared to total Lactobacilli at a level of 1×10^9 CFUs / g feces. For piglets dosed once every fourth day, CFUs became undetectable two days post-inoculation.

Currently, we are comparing this conventional mode of probiotic tracking to more specific molecular approaches, such as 16S rRNA probe hybridization and denaturant gradient gel electrophoresis utilizing both the V3 and the V1 region of the 16S rDNA.

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Fumonisin Suppression of Bacterial Resistance in Pigs

We investigated the cell-mediated and humoral immune responses, and



Research Focus:

Increase the capacity of Illinois crop and animal systems to respond to changing world food and agricultural demands.

alterations in sphingolipids, in pigs exposed to sublethal doses of fumonisins (FB).

In study one (low dose), pigs were fed 0 (control) or 2 mg fumonisin B₁ (FB₁)/kg/day of FB-contaminated culture material for five weeks. Pigs were vaccinated with a killed pseudorabies virus (PrV) vaccine (SyntroVet) on weeks one and three. The cell-mediated response was determined by the blastogenic response of peripheral mononuclear cells (PBMC) after 72 hr of stimulation with phytohemagglutinin (PHA) or PrV. There were no significant differences in the PrV stimulation index, response to PHA, PrV antibody titers, total lymphocyte numbers or numbers of CD3⁺, CD4⁺, CD8⁺ or CD4⁺/8⁺ subpopulations by flow cytometry.

In study two (high dose), we examined the effects of fumonisins on macrophage phagocytosis. Cells from a murine monocyte/macrophage (RAW 264) cell line were incubated with FB₁ followed by FITC-labeled Salmonella for 0 to 60 min with analysis by flow cytometry. There was a significant dose-dependent decrease in phagocytosis for cells treated with 25 to 1000 mM FB₁ for ≥3 min as compared to controls. Similar results were obtained *in vivo* in pigs fed FB₁-containing culture material at 15 mg FB₁/kg BW for three days with decreased phagocytosis by pulmonary alveolar macrophages (PAMs) when incubated with FITC-labeled Salmonella for 10 and 30 min. Sphinganine (Sa) and sphingosine (So) concentrations were increased in RAW cells exposed to FB₁ (Sa:So max 38.67) as compared to control (0.06), and in PAMs from treated pigs (Sa:So 2.74) as compared to controls (0.34). Sa and So were also increased in lymph nodes and thymus.

Thus, FB₁ did not affect humoral immune responses, but inhibited macrophage phagocytosis and sphingolipid biosynthesis in immune cells and tissues. Therefore, FB₁ can cause immune suppression in pigs which may increase susceptibility to infectious diseases.

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Transgenic Alteration of Sow Milk

Transgenic gilts (n=5) were matched with non-transgenic gilts (n=8) of the same breed, age and farrowing season.

Gilts were bred, allowed to farrow, and litter sizes were adjusted to 10 piglets. Milk samples were collected from each animal on days zero (after the completion of farrowing), five, 10, 15 and 20 of lactation. Milk was analyzed for the presence of bovine a-Lac using an ELISA specific for bovine a-Lac. Transgenic sows produced bovine a-Lac in their milk at concentrations ranging from 300 to 900 mg.

The concentration of a-Lac was highest on days zero and five of lactation and decreased as lactation progressed. Secretion of bovine a-Lac increased the total a-Lac (bovine + porcine) concentration in milk about 50% throughout a lactation. As expected by the critical role of a-Lac in mammary lactose synthesis, milk lactose concentration in transgenic sows was 46% higher in transgenic (3.8%) than non-transgenic sows (2.6%) on day 0 of lactation (p<0.01).

Higher lactose concentrations were also observed in second lactation milk from transgenic sows (n=4) containing 3.7% lactose versus 2.6% in non-transgenic sow

milk (n=5) (p<0.01). These data are important because they show that our gene construct drives the secretion of high concentrations of a desired protein into the milk of transgenic swine.

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Gaining Growth Potential in Pigs

The hypothesis is that cytokines secreted by immune cells induce fat cells to secrete leptin, which subsequently acts in the brain to decrease food intake and increase energy expenditure.

Therefore, increased production of leptin may explain why pigs subjected to infectious and noninfectious pathogens neither eat nor grow well.

Studies conducted this past year showed that immune stimulation by lipopolysaccharide increased plasma leptin in fasted animals. Moreover, it was demonstrated that production of inflammatory cytokines is a prerequisite for leptin secretion after immune stimulation by lipopolysaccharide, and that cytokines act directly on fat cells to trigger this response.

These results support the idea that leptin is involved in food intake regulation in sick or immune-challenged animals. Therefore, leptin is a candidate molecule for regulating food intake in pigs.

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Post-weaning Estrus in Pigs

Profitability in the swine industry is based on prolificacy.

To optimize prolificacy and profits, it is essential that sows are re-bred immediately after weaning. An extended post-weaning anestrus decreases overall productivity and increases production costs. Nutritional status of the sow influences the length of post-weaning anestrus. Insufficient feed intake, inadequate dietary energy and heavy milk production cause depletion of body fat during the post-partum period. Animals with low body fat have low conception rates.

The overall goal of this project is to identify and characterize the metabolic signal which regulates the length of weaning-to-estrous interval. Our work centers around the hormone leptin. Leptin is a good candidate as the mediator of reproductive function in response to body composition because it is synthesized by fat, and concentrations in blood are dependent upon body fat composition. Our specific goals for this project are to determine if ovaries of sows contain leptin receptors and to determine if plasma leptin concentrations in pigs are correlated with body fat, stage of lactation and dietary protein or energy.

Characterization of this hormone will enhance our understanding of the mechanisms which control post-partum reproductive function. A better understanding of these mechanisms will enable researchers to develop management strategies, nutritional regimens and/or drug therapies which will improve prolificacy and profitability in the swine industry.

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Reproductive Efficiency in Swine

Reproductive efficiency is of considerable economic importance to swine producers.

Factors affecting reproductive efficiency include, but are not limited to, conception rate, number of pigs born alive, number weaned and 21-day weaning weight. We have established that as the incidence of males in a litter increases, distance between anus and vulva on female littermates increases. Also, we have shown that there is a significant relationship between the proportion of males in a sow's birth litter and the likelihood that she will have problems with conception.

Females from litters with a large percentage of males (70% or more) are likely to experience conception failure. Swine producers need to consider the sex ratio of litters when making their selection of which gilts to retain for breeding stock. Recently, we determined that three factors significantly affect the number of teats on female swine: proportion of males in the litter, number of teats on the sow (genetics) and birth weight of the gilts. When there are more males in a litter, the average number of teats on gilts in that litter is lower. These effects likely reflect the intrauterine position phenomenon which occurs in a number of mammals. Female fetuses positioned between two males in utero are masculinized.

Currently, we are conducting studies to determine if variation in piglet survival and growth rates to weaning may be affected by the intrauterine position effect. There may be differences in females from litters with different proportions of males in their birth litters.

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T.L. Rosenthal
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Soy Phytoestrogens and Swine Reproduction

Soybean meal contains estrogenic compounds called phytoestrogens that have been shown to affect reproductive function in animals.

Soybean meal makes up a significant percentage (about 20%) of most swine diets. This research focuses on the effects of these compounds on swine reproduction. *In vitro* studies with swine ovarian granulosa cells indicate that phytoestrogens have the ability to decrease follicular cell atresia, potentially leading to more follicle recruitment and ovulations, thus potentially increasing litter size. A swine feeding study is under way.

Prepubertal gilts were assigned to two diet treatment groups, standard soybean meal and low phytoestrogen soy protein concentrate. Parameters under examination are body weight, feed consumption, backfat, serum reproductive hormones, vulva diameters, first estrus, estrous cycle length, success of breeding and litter size. Body weight, crown-rump length and anogenital distance will be measured on offspring within 24 hours of farrowing.

Breeding success and litter size will then be examined for two subsequent gestations to determine if the possible effects of phytoestrogens are permanent or only occur when the animals are fed these soy compounds. Reproductive performance of offspring will also be tracked over the following year.



Since swine also have a great potential for being a model for human cardiovascular health studies, the team is measuring plasma HDL, LDL, total cholesterol, triglycerides, glucose and insulin. First-trial gilts are just reaching breeding age. Preliminary results show increases in frame (length, $p < 0.05$; girth $p < 0.10$), as well as an increase ($p < 0.05$) in blood glucose for the soybean meal-fed animals, suggesting a phytoestrogen effect on growth and metabolism. Information is reported on the Web at <http://www.siu.edu/~tw3a/soyepro.htm>.

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Somatotropin: Effects on Ovarian Function

Our long-term objectives are to understand the actions of somatotropin (ST) on reproductive functions in domestic animals.

Our primary objective is to further elucidate the role of ST as a molecular modulator of sterol metabolism and follicle survival in the ovaries of swine and a bST-transgenic mouse model. *In situ* hybridization (ISH) experiments were performed to determine the cellular mechanisms of the effects of IGF-I and FSH, alone and in combination, on the expression of P450scc mRNA in single porcine granulosa cells. IGF-I is a mediator of ST action and P450scc is the rate limiting enzyme for steroidogenesis in the ovary.

Results suggest that the accumulation of P450scc mRNA after

treatment with IGF-I and FSH is due in part to an increase in the number of target ovarian cells expressing more P450scc. Expression of three ovarian steroidogenic enzyme genes was examined using ISH in two lines of transgenic mice expressing bovine ST and their non-transgenic littermates. Steroidogenic expression was higher in both lines of bST transgenics, indicating increased follicle health. Apoptosis is the underlying mechanism for ovarian follicle atresia in mammals. A decrease in follicle apoptosis could result in an increase in ovulation rate. Follicle apoptosis was decreased in the bST-transgenic lines, indicating that chronic ST exposure significantly decreases follicle apoptosis, and thus atresia in murine ovarian follicles.

These findings strongly suggest that ST treatment could contribute to an increased ovulation rate, and therefore litter size in litter-bearing species (swine). Additional information is on the Web at <http://www.siu.edu/~tw3a/cfargh.htm>.

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Soy Phytoestrogens and Animal Reproduction

Soy products contain estrogenic compounds called phytoestrogens that have been shown to affect reproductive function in animals.

Our overall objectives are to chemically and genetically characterize phytoestrogen production in different varieties of soybeans and to determine the effects of soy-

related phytoestrogens on animal reproductive function.

We have chemically and genetically analyzed soybean samples from recombinant inbred line populations derived from two popular soybean cultivars, 'Essex' and 'Forrest'. We found consistent differences between the lines: Forrest accumulated more total phytoestrogen, daidzein and genistein, but Essex accumulated more glycitin. The recombinant inbred lines showed transgressive segregation for phytoestrogen content. Broad sense heritability estimates indicated that 48% to 90% of this variability was genetic. We have shown that the 81% of the variability of total genistein content is associated with a marker called BLT65.

Using DNA markers in breeding selection, we can potentially reduce detrimental phytoestrogens and enhance beneficial phytoestrogens. Rat feeding studies have shown that dietary soy protein affects histological reproductive parameters in female rats. Uterine epithelium and larger follicle numbers were dependent on soy phytoestrogens. *In vitro* studies with swine ovarian granulosa cells indicate that phytoestrogens, especially daidzein, have the ability to decrease follicular cell atresia.

Increased use of phytoestrogens in the swine diets could lead to more follicle recruitment and ovulations, thus potentially increasing litter size. Additional information is on the Web at <http://www.siu.edu/~tw3a/cfarsoy.htm>.

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Ovarian Granulosa Cell Health: Trigger for Subfertility in Cattle

Subfertility is a problem that occurs in older animals of all species of mammals.

Reduced reproductive efficiency has a dramatic impact on the economics of the cattle industry. Beef cattle weaning weight per calf increases in dams up to 5 years of age. This peaks, then plateaus through age 9 or 10 years, decreasing from there on. The most productive years for dairy cows are between the ages of 2 and 8. Input/output costs are best when terminal culling is done at 8 or 9 years. And yet, the average culling due to reproduction is around the ages of 6 or 7, and infertility is the major reason for culling beyond 2 and 3 years of age.

We hypothesize that the functional health of the ovarian follicle and its cells may be a factor in the subfertility of older animals. In this proposal, we are studying the granulosa cells of the ovarian follicles of aged cows and determining if these cells react differently to hormonal stimuli than younger animals. This would potentially lead to hormonal treatment regimes that would extend the reproductive life of cows, and therefore make the production of cattle more efficient. Experiments for this project are under way.

Granulosa cells are being processed for *in vitro* culture from slaughterhouse cows. Cattle are aged by examining teeth. Preliminary age groupings are 2 to 5 years; (ii) 5 to 10 years; and (iii) greater than 10 years of age. Cells are treated with: control, (ii) FSH, (iii) IGF-I, (iv) IGF-I + FSH. Subsequently, the cells are being processed for apoptosis assays indicat-

ing the potential ovulatory propensity of the ovaries from the different age groups. *In situ* hybridization and other histological analyses are planned to further indicate ovarian endocrinology and health.

Additional information is on the Web at <http://www.siu.edu/~tw3a/cowovary.htm>.

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New Male Fertility Test

Reproductive infertility and subfertility have an enormous cost to animal agriculture.

Many reproductive problems are linked to males. In many cases, these problems are not identified until the males are used for breeding purposes (too late). Unfortunately, the laboratory assays of male fertility most often used are not accurate predictors of fertility.

We have developed an assay for bull sperm that measures the ability of sperm to bind to eggs. We use a red or a green fluorescent dye to label sperm from different donors, mix the sperm together and allow them to bind to eggs. Because of the competitive nature of this assay, we have found that it measures the ability of sperm to bind to eggs more accurately than previous assays. Using this assay, we are determining if egg binding ability is related to actual fertility of bulls and boars. We have tested sperm from two different groups of bulls with accurate fertility information. One group includes bulls used for artificial insemination and we are comparing egg binding ability to conception rate estimates. A second

group includes bulls whose fertility was ranked by inseminating semen from many pairs of bulls and we are determining the parentage of the offspring. We are analyzing the results.

We have also found that the optimal labeling conditions for bull sperm will label boar sperm. We will determine if egg binding ability is related to boar fertility. This assay could be an important technique used to estimate male fertility accurately.

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Spermatogonial Transplantation in Livestock

Spermatogonial transplantation in livestock promises a new means to market the genetic potential of breeding livestock.

It also is a promising technique to produce transgenic livestock, allowing insertion of desired genes directly into the genome of the germ cells where the gene can be passed on to offspring. Cattle and swine breeders in Illinois would benefit economically from this technology.

The objectives of our study are to define procedures to separate germ cells from the testis, infuse these cells into recipient testis and destroy native spermatogonia in those animals destined to be transplant recipients. We have developed cell separation procedures that include spermatogonia from testis of the bull and boar. Furthermore, electron microscopy of the isolated



cells demonstrates the presence of type A spermatogonia (or perhaps gonocytes) that serve as stem cells and which will establish spermatogenesis upon transplantation.

Proof of viability of these isolated cells must await success in actual transplantation procedures. This continues to be a future objective. Transplantation requires us to inject isolated cells into the tubular structures of the testes. Using dye injections, we have shown penetration of dye into a small percentage of the seminiferous tubules. We continue to search for injection techniques that will maximize penetration of the cells into a large portion of the tubules. Experiments demonstrate that the chemical busulfan will destroy endogenous spermatogonia in potential recipient boars. Young boars treated with busulfan have smaller testes and fewer spermatogonia than untreated controls. Further studies are under way to determine optimal dosage and timing of busulfan treatments.

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Improving Pregnancy Rates in Cows

This project to improve pregnancy rates in beef cows is under way, but some preliminary results are available.

A total of 538 suckling calves were administered Syncro-Mate B (SMB). About one-half of the cows

received melengestrol acetate (MGA) 10 days before SMB treatment. Based on blood samples collected before treatment, cows were divided into four groups: untreated anestrous cows, MGA treated anestrous cows, untreated estrus-cycling cows and MGA treated estrus-cycling cows.

Administration of MGA 10 days before SMB treatment improved ($P = .02$) the synchronization rate in estrus-cycling cows, but not anestrous cows. Although pregnancy rate was not affected by MGA treatment, the non-statistical improvement was proportional to the improvement in synchronization rate.

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Swine Odor Control in Lagoons

Starting new pork production facilities has become more and more difficult, due to public objection to odors.

A major source of the odors is from the surface of anaerobic waste treatment lagoons. The goal of this research is to develop a system to eliminate these odors. The system, located at the SIUC Swine Center, consists of a baffle grid that covers the first stage of the three-stage lagoon system, a pump and piping to deliver a clean water flow from the third stage lagoon across the surface of the first stage. An overland flow recycle system maintains good quality water in the third stage. The duckweed will be harvested to provide a high protein

feed supplement. Calculations indicate that odor reductions of 90% or more should be attainable by the system.

Laboratory studies showed about a 10-fold dilution of the swine waste, which provides ammonia levels in the 50 to 80 mg/l range, is required to support a good growth rate of the duckweed. Ammonia levels above 200 mg/l kill the duckweed.

It was also found that when the duckweed was exposed to ammonia concentrations of 470 mg/l for up to 24 hours and then returned to the normal strength solution, the duckweed would recover. Thus, some system downtime due to power failure or other causes could be tolerated without having to re-inoculate the pond with duckweed.

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Mechanical Engineering and Energy
Processes
Richard Steffen
Plant, Soil and General Agriculture
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Enhancing ISU Capacity for Swine, Ruminant Research

We have designed a new building model for estrus detection and ultrasound in female swine for maximum practical ease and efficiency.

The design will allow a single individual to detect estrus in up to 18 females at one time without any loss in boar exposure or detection efficiency. The facility is well designed to accommodate the use of



ultrasound on females to detect optimum time of breeding or pregnancy status.

Additional components of the building include a dedicated swine surgery suite that conforms to approved animal care and use protocols, a small prep and research lab and a waste handling system that will be incorporated into the waste composting trials at ISU.

The building is expected to be fully operational by the end of 1998.

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Reducing Cost, Nitrogen Excretion in Calf Diet

Our hypothesis is that protein content of milk replacers for young calves can be decreased from current industry standards of 20% to 22%, which would decrease cost to dairy producers and decrease nitrogen excretion into the environment while maintaining adequate growth and health of calves.

We have completed the animal portion of an experiment to measure the effects of protein content (16%, 19%, 24%, 27%) in milk replacers on growth and body composition of calves. Laboratory analyses are in progress.

Preliminary results show that average daily gain of body weight increased as dietary protein content increased. Gain of protein in the body was maximized, and excretion of nitrogen (as a percentage of nitrogen intake) was minimized, by

24% protein. Body fat content decreased as milk replacer protein content increased.

A second experiment is testing the hypothesis that a milk replacer protein content of 18% (lower than current industry standard), coupled with a starter (dry feed) protein content of 22% (greater than current industry standard), will result in lower cost to farmers, more efficient use of dietary protein by calves and less nitrogen excretion by calves. Fourteen of 60 calves have been placed on experiment. No data are available yet.

When completed, these experiments will enable dairy producers to make informed decisions about protein content in milk replacers that should improve their profitability while minimizing impact on the environment.

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Repartitioning Maintenance for Efficiency

Previous C-FAR-funded research has demonstrated an improvement of beef quality when cattle are weaned at an early age.

The current C-FAR-funded research is designed to try to understand the mechanism of repartitioning of maintenance requirements through programmed feeding of the animal, which allows it to be more efficient in feed conversion and thus, allows more nutrients to be used for growth and finishing. This research is ongoing.

Cattle from the first year have completed the study. Laboratory and statistical analysis of the samples collected is being processed. A computer model of the early weaning portion of the project has been completed by working with the UIUC agricultural economists. Preliminary data show that there may be an effect on internal organ weight with a programmed feeding regimen. This effect demonstrates that we may be able to repartition the maintenance requirements of the growing animal since the internal organs account for the largest percentage of maintenance.

Preliminary data from the developing heifer portion of the research demonstrated that feeding developing replacement heifers a restricted amount of intake affected the total voluntary intake during a readjustment period at the conclusion of the trial. This may allow Illinois producers to raise replacement heifers that require a reduced level of intake to satisfy maintenance requirements in the pasture.

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Early Weaning Systems Improve Quality

Beef quality and consistency has been identified as one of the major problems facing the beef industry by the National Cattlemen's Beef Association.

Breeding and management programs that produce high-quality beef with optimal fat thickness are essential. This research was de-

signed to evaluate the effects of weaning management systems on calf performance, the quality of beef produced, cow performance and subsequent reproductive performance of the dam. Three breed types with different sires were used throughout the studies.

These studies indicate that early weaning of steers, before the traditional time of 205 days, will increase overall gain, decrease daily intake, increase total concentrate consumed, improve feed efficiency and improve quality grades of steers. British-bred steers have lower gain, lower daily intake, reduce days finishing and consume less total concentrate than steers of Continental breed type when harvested at a constant fat endpoint. Wagyu cross-bred steers have lower gain, lower intake, more undesirable efficiencies, more days finishing, lighter carcass weights and improved quality grades compared to steers of British breeding when harvested at a constant fat endpoint.

Early weaning systems benefit cows by removing the requirements for lactation. This will allow cows to cycle more readily and improve reproductive performance. Early weaning appears to be an optimum beef production system to complement structural changes in the industry. Early weaning systems are well-suited to Illinois because of the large number of producers who finish their own calves and the abundance of corn that is available.

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Forage Protein Use by Grazing Cattle

We collected samples of common Illinois forages (bromegrass, tall fescue, alfalfa) throughout the spring growing season (mid-April to early June) and learned that all of those forages contained very high proportions of non-protein nitrogen (N) and soluble N in the protein fraction.

The result of this compositional characteristic is that the rate of breakdown of protein in the rumen is very rapid and protein losses to the animal are high.

The important outcome of this finding is that even though these forages are very high in protein, that protein is very inefficiently used by grazing cattle. We evaluated whether supplementation strategies could be developed that would improve the use of this forage protein. Supplementation of steers grazing the spring growth of tall fescue increased the average daily gain of those animals, but this improvement seemed to be due to an increase in energy intake rather than to an improvement in protein utilization. We supplemented steers fed fresh alfalfa with different levels of cracked corn and found that energy supplementation improved utilization of the alfalfa protein in the rumen; the improvements were detected at low levels of supplementation (.4% of body weight per day).

Supplementing cattle grazing on high-quality legumes or grasses in early spring with low levels of an energy source may be an effec-

tive means of improving the utilization of the forage protein by the cattle.

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Grazing Strategy Reduces Costs

Western Illinois is the largest area of cow-calf production in Illinois, contributing millions of agricultural dollars to rural areas.

However, Illinois beef producers spend \$113 per cow more than Iowa producers. Nearly 60% of these cow costs are feed related. Producers must find more economical ways to feed cows, and one way is to use non-harvested forages to reduce labor and feed costs. By reducing costs, Illinois beef producers will increase profit levels.

Because wintering feed costs are the single largest expense in cow-calf production, managing winter feed resources to minimize these costs is the key to profitable production. The least expensive feed resource on most Illinois farms is grazed corn crop residue. Many farms, however, have inadequate quantities of corn crop residues to meet the forage demands of the over-winter grazing season and must resort to other, more expensive winter feed alternatives. Typically, cow-calf producers use hay as their supplemental winter feed, but there is some evidence to indicate that this may not be the most cost effective means of over-wintering their cow herd.



This study will give producers the information necessary to determine the best use of alternative forages as an integral part of their over-winter beef forage feeding program by evaluating the costs, nutritional value and feed utilized per cow from four alternative forage systems compared to two traditional controls: annual seeding of brassicas (forage turnips) seeded following wheat or oat production; winter rye aerial seeded into standing corn and grazed with crop residue; grazing maize (strip grazed forage type corn) used for winter forage or summer “slump” forage to allow extension of other forage for winter grazing; permanent seeding of cool season grasses (fescue) stockpiled for winter strip or rotational grazing; and controls (either or both) of corn crop residue grazing with supplemental hay and no crop residue with all over-winter forage provided by hay.

For the summer 1998 through winter 1999 grazing year, three different cooperators have been identified for each of the four alternative forage systems. Each cooperator is also using other areas of their land or adjoining land as the crop residue and/or hay feeding control. Grazing of these alternative forages will begin this summer as pastures decline and extend into the winter months. Having each cooperator also provide a control will allow maximum assessment of the economic benefits of each of the alternative forage systems in reducing over-winter feeding costs. Cow body condition scores will also be measured in conjunction with transition from pasture grazing to the various alternative forage systems so that any effects on cow nutrition can also be assessed.

Teresa North
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Investigations in Efficiency, Meat Quality

Trauma or disease results in specific loss of muscle protein compared to other proteins in the body.

This loss of muscle has significant economic consequences for livestock producers because of the feed and time needed for animals to recover lost lean tissue. In the worst case, severely weakened animals may not be economically salvageable even if the disease causing the problem is controllable. Muscle protein turnover is also a significant component of growth efficiency. However, our understanding of myosin degradation has remained unclear despite the fact that myosin is the most abundant muscle protein.

The overall purpose of this project in to find a new proteolytic enzyme that is important in protein degradation of muscle. During the past year, we made progress toward isolating two distinct proteases from muscle. First, we have completely purified a serine protease that degrades myosin. This protease had not been previously described until April of this year, when it was reported in mice.

We are currently comparing the sequence of our pig myosin protease with that reported for the mouse “myonase.” Second, we have further purified another distinct protease that also degrades myosin. This protease is calcium dependent, and has not been previously described in the scientific literature. In addition, we have also completed sequencing of myosin proteolytic fragments using pure chicken myosin, which is the only myosin from

an agricultural species for which the gene sequence is known.

Our work indicates that myosin in pigs is considerably different than chicken myosin. This unrecognized difference invalidates the assumption that meat animal myosins are all very similar to chicken.

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Improving Quality, Consistency of Cattle

“Beef 2000” programs were held in January and June 1998.

More than 100 Illinois beef industry leaders participated in this in-depth program to learn more about beef as a meat product. The program provides training on market cattle evaluation, grading and carcass fabrication to enhance the development of strategies to address the quality and consistency shortfalls of the Illinois beef industry. Participants included producers, processors and meat purveyors so that all segments of the beef production industry could interact to discover how to produce better beef products.

Participants developed key strategies to share with other beef industry clientele: 1) More communication between producers, feeders, packers, retailers and consumers to address the problems and needs of each segment and lead to problem-solving strategies. 2) Form working relationships among beef production sectors involving education of each sector as to their responsibilities in the system of qual-

ity, consistent beef production. 3) Purebred breeders and cow/calf producers need to document the carcass characteristics of the cattle they raise. Selection programs should include emphasis on improving the beef product that reaches consumers, particularly with increased pressure on superior sire selection.

Key areas to change in future sessions included adding more information on food safety issues and marketing strategies for high-quality beef products. Program evaluations showed that 100% of the participants found the program “very rewarding” and 75% stated that all segments of the beef industry should participate in this program.

A C-FAR External Competitive Grants project.

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MRI for Evaluation of Fat/Muscle Ratios

In this project, we have developed several techniques which hold excellent promise for the evaluation of interstitial fat in the tissues of meat samples as well as in live animals.

The approach relies upon differences between the nuclear spin relaxation of protons chemically bound to fat (lipids) and those in adjacent molecules, usually water. All measurements are made with magnetic resonance imaging (MRI) and are non-invasive.

We began by assuming that the measurement of the longitudinal spin relaxation time (T_1) would provide a route to analyze for fat in muscle. We have discovered that measuring the transverse relaxation time (T_2) provides an even more sensitive assay for fat and can be measured much more rapidly than T_1 , thus, shortening the time required for a determination. We determined that MRI image contrast between fatty tissue and non-fatty tissue can be used to assess the fraction of tissue which is high in fat. We have applied this method to assess the effects of growth hormone on the secretory tissue volume in the udders of young heifers. The MRI method is as precise as chemical techniques and is non-destructive.

Analysis of the data (T_2 or T_1) has been accomplished with several mathematical techniques. We have succeeded in finishing a numerical method for obtaining the inverse Laplace transform of the relaxation data, providing us with data on the distribution of $T_{1,2}$ values in a sample. We have seen that these distributions reflect the fat/muscle ratios in samples.

We have discovered that the accuracy of the method depends upon the signal-to-noise ratio of the data. Thus, to use this approach, we must spend time acquiring data. An alternate method, modeling the data using an explicit dual Gaussian distribution of relaxation times, seems to be less affected by noisy data.

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Central Laboratory Animal Care Facility

This award was made to a program development proposal that requested support for purchase of equipment needed in the ACES Laboratory Animal Care Facility.

The new equipment will be used to provide low-cost and efficient service to ACES faculty who use laboratory animals in their research. A number of research projects related to improving efficiency of animal production and improving nutritional status of humans.

Items purchased with the FY 98 allocation included: 1) bedding dump station to reduce exposure of animal care staff to airborne particulate matter, a leading cause of laboratory animal allergies; 2) rodent gas anesthesia machine and hot bead sterilizer, which benefit all faculty conducting survival surgery in rodents; 3) caging and accessories for 400 microisolation units for mice to support research with transgenic animals; 4) a countertop refrigerator, stainless steel carts and caging shelf units for housing rodents; and 5) miscellaneous smaller accessories needed for rodent care and housing.

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Rotational Grazing for Sheep

Sheep producers typically graze their animals over an entire pasture at one time, rather than using rotational grazing to maximize the available forage.

While research is available regarding rotational grazing of cattle, none is available regarding rotational grazing for sheep in the Midwest. This project evaluates the forage efficiency of rotational grazing for sheep.

The pasture at WIU has been divided into four small pastures, each of approximately two acres. Of these four, one is undivided for grazing by 10 Suffolk ewes, another has been subdivided into seven separate paddocks for grazing by 10 Suffolk ewes, one is undivided for grazing by five Suffolk and five whiteface lambs, and one has been subdivided into seven separate paddocks for grazing by five Suffolk and five whiteface lambs. The efficiency of each grazing system will be determined by condition scores for the ewes, and by average daily gains in lambs. Analysis of the forage for nutrient value will also be a part of the trial.

Data on cattle indicated that the stocking rate of a pasture can be increased by 30% to 50% if rotational grazing practices are followed as opposed to traditional grazing. If similar results are found in this trial, a sheep producer would be able to stock 30% to 50% more animals on an acre of pasture with little, if any, additional cost. This would greatly reduce his fixed pasture cost per head and improve profitability.



John Carlson
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Evaluation of Ram Testing Records

Because of the lack of technology, sheep producers were unable to know what environmental factors are associated with feed consumption, average daily gain and feed efficiency until recently.

If the exact effects of environmental conditions were known, producers could make the necessary adjustments in livestock buildings to maintain efficient performance of the animals. This technology, while too expensive for the average producer, is now available and working at the WIU Ram Test Facility. The equipment there records individual daily consumption of feed. Data on daily temperatures, rainfall and humidity have been obtained and will be correlated with data from the Illinois Ram Test labs.

From these results, producers will be able to tell the critical points at which additional cooling is needed to provide comfort for the lambs and to maintain good feed consumption, resulting in efficient growth.

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Program in Agrigenomics

C-FAR funds were used to develop high throughput genotyping techniques in the DNA facility of the Biotechnology Center.

These techniques, amplified fragment length polymorphism (AFLP) and simple sequence repeat (SSR) typing, are used in research aimed at improving agriculture in the Midwest. Soybean cyst nematode races that are reducing crop yields can be identified using these methods. Soybean breeders can use this information to develop effective breeding programs leading to improved soybean cyst nematode resistant hybrids. Some of the most troublesome weeds to corn and soybean growers are related plant species belonging to the Amaranth family.

Two factors that contribute to the success of this weed complex are hybridization between species and development of herbicide resistance within some species. Genotyping techniques are used to understand the relatedness of these weed species to determine the potential for herbicide resistance to be transferred between species. The gene sugary enhancer 1 gene (se1) in sweet corn produces an endosperm mutation that increases the sugar content of the kernel.

Finding new markers closely linked to this gene will improve the efficiency with which breeders can develop new se1 hybrids for commercial production. Oat cultivars have been developed that tolerate infection by the barley yellow dwarf viruses (BYDV). Mapping the genes contributing to BYDV tolerance will aid in determining the mechanisms by which plants are

Research Focus:

Increase the capacity of Illinois crop and animal systems to respond to changing world food and agricultural demands.

able to tolerate infections.

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Molecular Approaches for High Oil, High Oleic Corn Hybrids

Genetic progenies segregating for oil and oleic acid concentration in the maize kernel were developed in summer 1998.

This involved a set of back-cross-derived lines and their test crosses. These materials were planted on the South Farm in Spring 1998 for field evaluation. Rocheford began the transgenic aspect of the project during the winter while on sabbatical. Constructs with the fatty acid desaturase 2 clone were developed in sense and anti-sense orientations and successfully bombarded into callus cultures.

The objective is to develop high oleic oil through antisense or cosuppression technologies. The marker genotyping aspect of the project began with the purpose of identifying chromosomal regions controlling levels of oil and oleic acid that can be introgressed into maize hybrids through molecular marker-assisted selection.

This C-FAR support was used as a formal matching support for the Illinois Missouri Biotechnology Alliance (IMBA) proposal ("Development of High Oil, High Oleic Maize Hybrids," Rocheford et al.) that was awarded in March 1998 for \$423,000. The C-FAR and IMBA awards were used as matching support for a National Science Foundation Plant Genome proposal ("Genomic Analysis of Seed Quality Traits in Corn") awarded in September 1998. This NSF project involves the University of Delaware (lead institution), Massachusetts General Hospital/Harvard, and the UIUC. The total award is \$2.2 million, and the UIUC portion is \$420,520.

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Nutritional Quality of Transgenic Corn

A gene isolated from *E. coli* (gdhA) has been successfully added to the corn genome.

This gene enables the corn plant to increase nitrogen uptake from soil and convert it to amino acids. The economic impact of higher amino acid or other changes in nutrient content of corn would be significant to the corn and livestock producers of Illinois, since more than 80% of corn production in the United States is used for livestock feed. The gene increases nitrogen metabolism in an energy independent manner, enabling the corn plant to store conserved energy in starch, lipid or other energy storage nutrients. Five

germplasm samples with (+) or without (-) the transgene for nitrogen uptake have been analyzed for dry matter (DM), ash, acid detergent fiber (ADF), neutral detergent fiber (NDF), lignin content, crude protein (CP), CP digestibility (CPDIG) and percent starch. The five germplasms used were A+/-, B+/-, C+, D- and E+/-.

Our initial data indicate gene effects within certain germplasms on DM and NDF content. Although there were no significant gene effects upon CP and CPDIG, this does not rule out possible effects on protein concentration and quality. Measurement of true protein content may show differing effects, as it will allow quantification of actual protein present, and not only protein containing and non-protein nitrogen. Further measures of starch content, starch digestibility and fatty acid content will help define the gene effects with respect to energy re-partitioning within the corn grain.

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Pathogen Resistance in Soybean Germplasm

The overall goal of this project was to determine the potential usefulness of the wild annual species, *Glycine soja*, for broadening the germplasm base of the cultivated soybean, *G. max*.



The major objectives of the project were to screen plants from the USDA *G. soja* collection (about 1,102 accessions) for sources of resistance to three economically important pathogens: *Sclerotinia sclerotiorum* (causes Sclerotinia stem rot), *Septoria glycines* (causes brown spot) and *Fusarium solani* (causes sudden death syndrome).

The entire collection was screened for resistance to sudden death syndrome and 9% of the *G. soja* accessions were classified as resistant. About 20% of the accessions exhibited some form of resistance to Septoria brown spot, for which there are no good sources of resistance in the soybean germplasm collection. No sources of resistance were found for Sclerotinia stem rot.

In addition, the *G. soja* collection was screened for resistance to race 3 of *Phytophthora sojae*, the causal agent of Phytophthora root rot. Almost 20% of the collection had some resistance to race 3 of *P. sojae*.

Currently, we are studying the genetic nature of the above sources of resistance within the *G. soja* collection. In the future, we hope these sources of resistance will be incorporated into commercial soybean breeding programs and will provide soybean growers in the state with resistance cultivars that will subsequently allow for reduced losses and higher soybean yields due to the control of these diseases.

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Benefits of Fungal Endophytes in Soybean

Soybean endophytes are fungi that reside in soybean plants but do not cause any detrimental effect on the host plant.

Although endophytes of grasses and other plants have been extensively studied, little is known about soybean endophytes. This research is aimed at exploring the benefits of endophytes in soybean.

Extensive efforts were made to collect soybean fungal endophytes in Illinois and in adjacent states. Two hundred sixty-seven isolations were made during the growing seasons of 1996 and 1997. All the isolates were characterized by their growth rates, colony morphology on three different growth media and variations in the nuclear rDNA. The distribution of soybean fungal endophytes is widespread. Fungal endophytes were isolated from nearly every soybean field that was sampled in 1996 and 1997. Fungal endophytes were isolated from soybean plants collected from Illinois, Iowa, Wisconsin and Virginia.

Soybean endophytes can be divided into four tentative groups. The effect of the soybean endophytes on soybean plants varied in greenhouse tests. A majority of the fungal endophyte isolates did not cause any detectable detrimental effects on soybean plants, as measured by plant appearance, height and weight. A three-component bioassay was developed for selecting fungal endophytes that can improve soybean health and increase soybean resistance to brown stem rot. Selected strains of fungal endophytes significantly reduced brown stem rot severity as mea-

sured by the number of stem nodes showing disease symptoms.

These findings provide the base information for further exploitation of the fungal endophytes to improve soybean health and productivity.

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Greenhouse Evaluation of SDS Resistance

Soybean sudden death syndrome (SDS) is an increasingly important disease causing significant yield loss in Illinois.

Application of resistance, a potential strategy for disease control, requires an efficient method for resistance identification. This study has established a stable method for greenhouse screening.

Using 5,000 to 7,000 spores/g soil inoculated on 15-day-old plants by estimating disease 30 days after inoculation, resistant cultivars were significantly distinguished from susceptible ones. Resistant cultivars took longer incubation periods than susceptible cultivars. However, lower inoculum concentrations significantly prolonged incubation periods on both resistant and susceptible cultivars. Proper inoculum concentration was a critical factor in greenhouse screening.

Greenhouse observations for cultivar reaction to SDS were significantly correlated with that of multi-year field tests. Temperature

Research Focus:

Increase the capacity of Illinois crop and animal systems to respond to changing world food and agricultural demands.

was also an important factor in greenhouse screening. We will combine its effect on our standard approach in the next step of the research. We will focus on testing activities of enzymes involving toxin detoxification in further research.

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Mapping Soybean SDS

The objectives of this project were to evaluate the impact of soybean sudden death syndrome (SDS) on soybean yield, to compare selected soil and environmental factors collected from the SDS symptomatic and non-symptomatic areas, and to identify the specific factors that cause the spread of the disease.

Preliminary results indicate that the SDS disease is inversely related to soil macroporosity and proportionally related to moisture content at field capacity. Areas with high moisture retention capacity and/or compaction were more vulnerable to the occurrence of the disease. Results also indicate that for every 10% increase in the SDS disease index (incidence x severity) there will be approximately a 10% soybean yield decrease.

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Enhancement of SDS, SCN Research

Soybean sudden death syndrome (SDS) causes significant yield loss and has become an important disease in Illinois.

Information about SDS epidemiology and yield loss is required for resistance selection, disease control and soybean production. Supported by C-FAR, we have conducted two-year field experiments to investigate development of root infection on different cultivars.

Initial root infection and disease development were significantly reduced on resistant Pharaoh and Ripley compared with susceptible P3981 and CM497. These resistant cultivars also showed slow development of root infection. Field studies showed that SDS disease index at growth stage R6 was significantly negatively correlated with seed weight, yield per pod, number of pods per plant, yield per plant and 1-m-row yield in the field.

To improve the greenhouse facility, a water circulation system (water baths) has been established for conducting research on temperature effects on SDS and soybean cyst nematode development and resistance screening. We will combine the effect on our standard disease screening approach in future research. Mechanisms of SDS resistance, especially in enzyme activity on cultivars, will be intensively studied with C-FAR support.

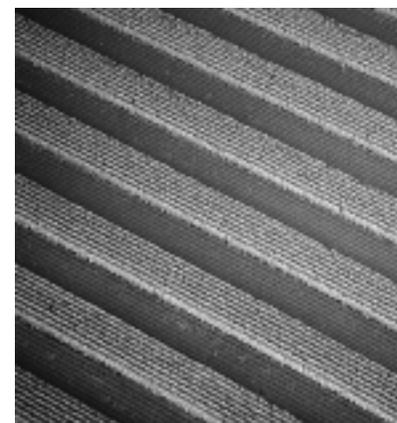
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Automated Disease Diagnosis in Food Crops

This project has several objectives: to purchase an upgrade to a PCR-fluorimeter to facilitate marker-assisted selection for disease resistance by PCR and disease organism detection in roots by PCR; to screen thousands of plant lines with molecular markers within a single season; and to rapidly detect and quantify root pathogens in field samples.

We purchased a PCR fluorimeter, a PE7200, from Perkin Elmer and installed it in the laboratory. The detection of the major gene for soybean cyst nematode resistance *Rhg1* has been shown to be possible using the fluorimeter. We have screened 15,000 plant lines for the major gene for soybean cyst nematode resistance *Rhg1*, most by the conventional microsattelite markers. The gels have doubled the cost of marker selection; the fluorimeter will reduce the cost. Selections were made for the SIUC breeding program, DeKalb genetics and Limagrain. With the commercial lines, the companies bore the full cost.

Selection for *Rfs1*, the major gene for SDS resistance, has been shown to be possible using a new



marker SIUC-SATT122. The marker correlates 97% of the time with SDS resistance. We will use it to combine high yield potential with resistance to SDS and SCN by the selection of rare recombinants. The marker SIUC-SATT122 is being adapted for use with the fluorimeter.

Samples of infected roots are being collected. We will duplicate aliquots used for plate quantification and DNA extraction. The DNA will be used to test the fluorometric probe to be derived from the ITS sequence produced in a separate project.

A C-FAR External Competitive Grants project.

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Wheat Scab Resistance Research

The long-term objective for this project is the development of soft red winter wheat genotypes with excellent resistance to scab (*Fusarium head blight*) combined with resistance to other diseases, high yield potential and acceptable winter hardiness and milling and baking quality.

Our short-term objectives are: 1) to combine genes for resistance to scab from diverse sources; 2) to evaluate the genotypes produced from crosses and identify those with resistance to scab; 3) to identify molecular markers associated with genes for resistance to scab; and 4) to work toward using molecular markers to assist in breeding for scab resistance.

In 1998, we evaluated about 750 experimental breeding lines and varieties in the inoculated, misted field nursery. Based on field symptoms and evaluation of kernels, we identified new scab resistant lines. We collected agronomic data on previously identified scab resistant lines, and putatively scab resistant plants were selected from seven segregating F_4 populations.

Using a population of lines from a cross of resistant and susceptible cultivars, we conducted research on identification of molecular markers linked to scab resistance. About 300 combinations of AFLP (amplified fragment length polymorphism) primers were screened, and 11 AFLP markers showed significant association with scab resistance. Most of these molecular markers were located in one chromosome region.

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Cucumber Mosaic Virus in Peppers

Yield losses of peppers due to cucumber mosaic virus (CMV) have been severe in southern Illinois.

To determine if weed hosts are sources of CMV for aphid transmission to peppers, plants of local weed species were collected and tested in ELISA. Samples tested in fall 1996 included 1,296 plants of 18 species. Only nightshade

(*Solanum sp.*) plants (17 of 101) and ground cherry (*Physalis spp.*) plants (12 of 30) tested positive for CMV.

In 1997, researchers tested 2,632 plants of 40 species. Only *Solanum sp.* (15 of 408 plants) and *Physalis spp.* (2 of 58 plants) were infected with CMV. The nightshade appears to be *Solanum americanum* or a closely related species. Most of the virus-infected plants were detected early in the spring, before pepper planting, and could be serving as virus acquisition sources for crop infection.

More than 1,000 pepper and 500 tomato transplants tested negative for CMV in ELISA. To determine the aphid vectors responsible for CMV transmission, aphids were captured in spring and summer of 1997 using net and suction traps placed in pepper fields. To determine if they could transmit the virus, aphids were placed on young pepper plants and placed in alcohol for later identification. More than 2,500 aphids were trapped, representing more than 80 species, 16 of which have been recorded as vectors of CMV. Among the most common species collected were *Rhopalosiphum padi*, *R. maidis*, *Lipaphis erysimi* and *Schizaphis graminum*. Only two of 1,800 live-trapped aphids transmitted CMV to pepper seedlings.

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UIUC Plant Care Facility

C-FAR funds provided for the Plant Care Facility (PCF) are used to provide general labor and equipment in support of many researchers in the greenhouse.

These funds have allowed the PCF staff to provide increases in the quantity and quality of services offered to PCF users. Research projects in the PCF greenhouses include studies on plant breeding, plant-microbe interactions, plant insect interactions, disease screening, basic molecular biology, soils and plant nutrition, water quality, weed control and herbicide development and related topics. Most of these studies are done through the departments of Crop Sciences and Natural Resources and Environmental Sciences.

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Rapid Assay for Western Corn Rootworm

The major hypothesis that we are testing is that there are genetic differences between a population of the western corn rootworm (WCR) that oviposits in soybean fields (or perhaps indiscriminately in any planted field) and another population that prefers cornfields.

The way we tested this hypothesis was to 1) sequence two genes, one of which included a variable region, from a limited number of individuals from each population, and 2) systematically seek differences between the populations by absence or presence of DNA fragments amplified with arbitrary primers (Random Amplified Polymorphic DNA analysis).

Two populations of beetles were available: those that were collected as larvae from first-year cornfields and then reared to adulthood, and those collected from cornfields outside the affected areas. The nucleic acids were extracted from one beetle of each population, and two DNA segments from each sample were amplified by the polymerase chain reaction. The reaction products were then purified and sequenced (for both strands). One segment consists of 450 base-pairs (bp) of the cytoplasmic ribosomal (r)DNA and includes the variable spacer region. However, no differences were detected between the samples out of 398 unambiguous bp read. (This same sequence differed in 115/390 bp from the closest published homologous sequence from the alfalfa weevil.) The other segment, from the mitochondrial rDNA locus, yielded 423 bp of unambiguous sequence, but again without any differences. (This same sequence differed in 66/423 bp from the closest published homologous sequence from the clover leaf weevil.)

Nucleic acids were extracted from a panel of 12 beetles, divided evenly between the populations and the sexes. Analysis of the DNA from the panel amplified with a set of 16 arbitrary, decameric primers (RAPD) revealed many polymorphisms among individual samples. Clustering analysis of allelic fre-

quencies supported the hypothesis of two populations.

Although no individual RAPD fragment was monomorphic in one population and absent in the other, the status of four out of the 100 fragments analyzed was highly informative for the population of WCR (Table 1). Because two of the fragments are amplified by the same primer and have similar molecular weights, they may be allelic.

Three of the fragments have been cloned and sequenced. (Because the same RAPD primer flanks both ends of the fragment, cloning was essentially a prerequisite for the sequencing.) Two of the RAPD products, specified by the same primer, show homology to overlapping, but different regions of the reverse transcriptase of the LINE 1 family of retrotransposons. On one side of the WCR open reading frame the first 10 nucleotides, which primed the amplified fragment, were identical at 7/10 sites to those of the homologous *C. elegans* reverse transcriptase. The two sites in the WCR DNA which are occupied by the reverse transcriptase are not related in terms of nucleotide sequence homology.

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Keeping Rotation for Rootworm Control

Over the past half-dozen years, western corn rootworm (WCR) beetles in east central Illinois and northwest Indiana have changed their behavior and are now laying eggs in soybean fields in addition to cornfields.

This has resulted in serious root injury to corn planted after soybeans in affected areas and has undermined crop rotation as a management tool for this pest.

Intensive sampling for WCR in Illinois soybean fields has shown that the problem is only slowly spreading west. However, it is rapidly spreading north and east, aided by summer winds and storms. Our computer simulation model forecasts that “problem” WCR will be laying eggs in soybean fields in much of Ohio, lower Michigan, and southern Wisconsin during the next five years, while “problem” WCR should reach Iowa within the next 10 years. WCR beetles in “problem areas” have also changed their feeding behavior, broadening their diet beyond just corn to include soybean flowers and foliage as well as a number of different weed species. We detected no significant effect of feeding on soybean blossoms or foliage by WCR on soybean yield.

A preliminary economic threshold to help farmers determine if WCR beetle densities were sufficiently high in their soybean fields to warrant the use of a soil insecticide in first-year corn the next year was also developed. We determined that capturing seven WCR beetles per yellow sticky trap per day could lead to economic

root injury (one node of roots destroyed) to corn the following year.

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Monitoring Corn Borer Resistance to *Bt* Corn

In field surveys of more than 200 acres of transgenic *Bt* cornfields in the summer of 1998, we found only one surviving corn borer on a *Bt*-positive plant.

This level of survivorship, similar to that observed in 1997, suggests that a baseline early-season effective level of *Bt* resistance is present in less than one in a million corn borers.

These data are valuable in two ways for Illinois corn producers. First, they indicate that any corn borer infestations and crop losses in *Bt* corn currently are likely to be the result of too-low concentrations of *Bt* toxins in particular hybrids, not from pest resistance. Second, they provide the bulk of the Midwest’s real-world field data on the susceptibility or resistance of European corn borer to *Bt* corn. These data will be used by researchers and regulators to determine the amount of non-*Bt* “refuge” acres that will be needed to delay pest resistance to transgenic *Bt*-corn hybrids. Our data will help to make these regulations provide for maximum short-term and long-term economic benefits from transgenic *Bt* hybrids.

Laboratory bioassays of healthy and *Nosema*-infected laboratory colonies of European corn borer populations from Illinois have provided baseline susceptibility information that can be used in comparisons with future bioassays to identify the development of *Bt* resistance in this target pest.

Nosema is a naturally occurring pathogen that helps to regulate corn borer populations. Our data do not yet tell producers how to manage *Bt* corn, but they are essential for recognizing and responding to the development of resistance to *Bt* in this pest in the future.

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Low Input, Non-chemical Weed Control System

We successfully developed the second prototype “smart sprayer II,” a computer-vision controlled selective sprayer.

The real-time plant-sensing system on the prototype can be used for detection of crop plants (corn and soybean), weeds and weed density in fields. Last summer’s field experiment results showed that the system can be used in real-time for field operation controls. Special field test plots have been prepared at the Agricultural Engineering Farm for field evaluation of system performance and new weed control methodologies.

Three journal papers, two conference papers and two patent disclosures have been filed on the second period of this research. A total of \$260,000 of external fund-



ing and research support was received to continue the project.

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Weed Management Systems for Pumpkin

The Illinois Fruit and Vegetable Industry Research Advisory Board identified weed management in pumpkins as a top research priority.

Current weed management systems rely on clomazone (Command) herbicide. Clomazone does not control pigweeds and nightshades, two very common weeds in Illinois production areas, necessitating cultivation and hand removal. Our research has taken two approaches to solve weed management problems and reduce labor costs.

New herbicides, such as sulfentrazone (Authority), SAN 582H (Frontier) and imazumox (Raptor), were evaluated in both research farm and on-farm studies. Sulfentrazone and imazumox controlled problem weeds with only minor injury to the pumpkins. Both herbicides have been entered into the IR-4 project which develops herbicide registrations for vegetables. Once these herbicides are available, they will improve the profitability of pumpkin production by reducing labor costs and improving yields.

Our second approach was to modify pumpkin cropping systems to control pigweed and nightshade. During the summer of 1998, cropping systems using banded applications of clomazone and

ethylfluralin (Curbit), plastic mulch and rye cover crops with strip tillage were evaluated.

These systems can be immediately adopted by farmers because they do not rely on new herbicide registrations. They will control pigweeds and nightshade while reducing inputs and improve profitability. We will continue research on modified pumpkin cropping systems in the summer of 1999.

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Automatic, Autonomous Vehicle for Ag

The program for the development of automatic and autonomous vehicles has addressed several basic and applied issues of agricultural equipment automation.

Basic analyses have included the dynamics of steering systems and posture sensors for guidance. Applied issues have evaluated the potential of several commercial sensing systems and a commercial mechanical guidance system.

Two-wheel drive and front-wheel assisted platforms have been developed based on agricultural tractors (115kW) for this research. The steering systems of both research platforms were characterized and used to develop a controller appropriate for agricultural vehicle guidance. A steering system simulator was constructed to allow for advanced model development.

Posture sensing methods were developed using GPS, geomagnetic direction sensors (GDS), inertial

and machine vision sensing systems. A kinematic DGPS system with 20 cm accuracy provided relatively accurate tracking control. Superior performance was achieved using a survey quality system with 2 cm accuracy. GDS provided sufficient accuracy for tracking vehicle heading, but suffered from directional effects and drift.

Vision guidance methods were developed for row crops using the convergence of rows observed on a camera tilted from horizontal. They provided excellent performance in following crop row variations. A vision guidance system was developed that was capable of guidance on row crops in tests up to 11 mph in corn up to 60 cm tall. On severely curved rows, the system was capable of speeds up to 7 mph. Sensor fusion of GPS-inertial-machine vision and GPS-GDS-machine vision provided the most flexible and accurate guidance and capability for operation under dynamically changing field conditions.

GPS and machine vision were used to map agricultural crop characteristics while a vehicle moved through the field. Precision maps were recorded of weed infestation and could be separated from crop canopy in real-time. Additionally, the stage of crop development could be mapped simultaneously. It is feasible that guidance and mapping operations could occur simultaneously.

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Nutrient Sensors for Precision Application

The economic importance of soil macronutrients and the potential environmental problems associated with excess fertilization are important reasons for investigating nutrient sensors.

A real-time soil nutrient sensor used in conjunction with established nutrient test recommendations could have a significant impact on fertilizer application. There is potential for reduction in fertilizer inputs with negligible reductions in yield, resulting in economic benefits for Illinois grain producers and reduced impact of agricultural production on the environment.

Collection and processing of soil samples to develop maps of soil nutrients is time consuming and costly. In addition, correct assessment of spatial variation of nutrients may require a sample density that is cost prohibitive. Our project is focused on developing and testing a sampling system utilizing nutrient sensors to measure the nutrient supply in the soil, so that added nutrients can be limited to not exceed crop needs.

Tests have measured the sensor's response to changes in nutrient level, showing that the sensor might analyze up to four samples in five seconds. Bench-top experiments are used to measure the effect of sample size, shape, density, soil type, texture and other factors on nutrient extraction speed.

Current tests will lead to optimization of a real-time soil sampler and extraction system. The use of microelectromechanical systems (MEMS) might improve nutrient

detection limits and increase sampling rates. Miniaturization of the system should minimize the amount of extractant used and make simultaneous sampling at multiple depths possible. With the development of a prototype system, we can assess the importance of high-density sampling and its benefits to Illinois producers and consumers.

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Reliable Soil Test for Potassium

Satellite global positioning systems (GPS) greatly enhance the potential for precision farming, but their success depends heavily on soil tests.

Potassium (K) is a major nutrient required for plant growth, but the use of GPS to manage K fertility of soils is jeopardized because tests for K are often unreliable. In spite of much effort, this problem persists.

The purpose of this study is to devise a reliable soil test for K. It is divided into three phases: 1) distinguish between plant available and non-available K by rigorous thermodynamic and empirical methods; 2) identify the effect of iron (Fe) charge (oxidation state) on K forms in soils; and 3) establish the role of soil bacteria in altering the Fe oxidation state. A specially designed chemical apparatus

is being used to measure thermodynamic properties of K under various levels of depletion from soils.

This method is being combined with results from greenhouse cropping studies in which K is depleted from the soil, then critical levels for crop productivity are measured empirically with two extracting chemicals (NaBPh_4 and NH_4OAc). Both extractants gave good estimates, but NaBPh_4 was somewhat better than NH_4OAc . Native bacteria in soils alter the oxidation state of Fe in clay minerals, which in turn changes the amount of K in the plant-available pool.

This process is being quantified, in part, by identifying the soil bacteria that are responsible for such changes in Fe. Thirty-two different Fe-reducing bacteria were enriched and purified from four Indiana soils and one Chinese rice paddy soil. The latter contained an average of 100 times more Fe-reducing bacteria than the former. DNA studies are in progress to identify the Fe-reducing bacteria. This is the first study to comprehensively characterize Fe-reducing bacteria in soils.

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Fertilizer Management to Optimize Water Quality

The overall objective of this project is to determine the influence of fertilizer nitrogen (N) management upon water quality.



A 30-acre site has been selected (Hoffman farm, Hudson, Illinois). The site has been subdivided into six equal parcels of approximately five acres. Within each five-acre parcel, 4-inch tile was installed in April 1997 on a 75-foot grid with interceptor access to collect tile water on a weekly basis for NO₃-N concentration. After the tile was installed, the parcels were planted into soybean in early May. The first year of this study (1997) provided a “baseline” to evaluate the uniformity of the six parcels. In 1998, six agricultural fertilizer N practices for corn were evaluated: 0 lb N/acre N (control); 175 lb/N acre fall-applied anhydrous ammonia (AA); 175 lb/N acre fall-applied AA + N-Serve; 125 lb/N acre spring-applied AA + N-Serve; 175 lb/N acre pre-plant spring-applied AA; and 140 lb/N acre sidedressed AA (applied after planting).

We are installing automated flow meters (with weirs) and autosamplers to more precisely estimate total NO₃-N loading throughout the growing season. The knowledge gained from this study will aid in developing recommendations that deal with fertility and cultural practices which promote the safe stewardship of Illinois farmland.

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Optimizing Crop Production of No-till Corn

Researchers started a project in 1995 to improve the transition from conventional tillage to no-till, which reduces both wind and water erosion.

They discovered that it was difficult to obtain consistent corn stands under no-till, thus yields were lower from no-till than from conventional tillage. This was partially the result of cool, wet soils, which favor *Pythium*, a soil-borne fungal plant pathogen. This pathogen can rot the seed before it emerges, cause seedlings to die and may cause stalk rot at later stages of growth. It is favored by cool, wet soils, commonly associated with no-till in the spring.

A new management system that combined the benefits of no-till with warmer and drier soils at planting, normally associated with conventional tillage, was needed. Strip-till is a cropping system that tills a strip only 6 to 7 inches wide and creates a ridge about 3 to 4 inches high. In this study, we used a modified anhydrous applicator to make the strips.

Results from 1996, 1997 and 1998 demonstrated that fall strip-till is superior to no-till and spring strip-till and equal to mulch-till. Soil in the ridge was 6° to 8° warmer than in the no-till, and plant stands from the fall strip-till exceeded 90% in all three years. Yields were equal to or greater than mulch-till in all years. Both plant stands and yields from spring strip-till were better than no-till, but were not as high as fall strip-till or mulch-till.

The initial goal of the research was to improve the transition from conventional tillage to no-till. While this was successful, the effectiveness of fall strip-till has provided farmers with a new alternative to crop management.

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Research focus: Improve the nutrition, food quality, food safety and health of humans.

project updates

Increasing Appeal of Soy Protein Products

If health benefits are to be realized, sufficient amounts of soy protein (25 to 50 g/day) should be incorporated into the diet, but there are few mainstream products that contain 5 to 10 g soy protein per serving.

Our goal is to develop prototype soy foods that meet the criteria of acceptability, functionality and protein content.

Soy yogurt made from INTSOY processed soy milk was well liked. Varying the bacterial culture resulted in some differences in flavor and texture, and those containing probiotic producing bacteria (acidophilus and bifidus) had improved sensory characteristics. By using a combination of dough improvers and oxidants, we developed a formula for high soy protein white bread with good volume, moisture content and density. Dough improvers (potassium bromate or sodium stearoyl lactylate), an oxidant (ascorbic acid) and vital wheat gluten were added to a straight dough formulation containing about 16% soy protein. Consumer tests indicated that the product was well liked.

Successful preparation of an extruded cereal with soy protein isolate and corn was dependent on the sugar and moisture content. Off-flavor development could be

avoided by use of less heat and mechanical force during processing. Extruded soy/corn snacks had good acceptability, which was related to consumers' attitudes toward soy foods and prior information about their beneficial health effects.

Studies with populations of seniors suggested that education by lecture or computer-based programs about health, nutrition and soy's role in the diet increased liking for and intent to buy soy products. Incorporation of soy ingredients into foods that are well-liked by American consumers is a continuing challenge to the food industry.

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Effect of Soy on Breast Cancer

Breast cancer is a leading cause of cancer-related death among American women.

The capacity of the soy isoflavone genistein to potentially reduce breast cancer risk by inhibiting the multiplication of cancerous (MCF-7, BT-20) and precancerous (MCF-10F) human breast cells was examined. It was determined that precancerous human breast cells were more sensitive to

the antiproliferative action of genistein than were cancerous breast cells. At physiologically relevant concentrations of genistein, the precancerous cells were blocked at a specific phase of cell division, while the cancerous cells were unaffected. This different sensitivity to genistein was due to differences in responses of critical cell division control proteins (cyclins) to genistein between the two breast cell lines.

These findings suggest that genistein may be more effective in stopping breast cancer at its earliest stages and consequently, may have considerable importance in the prevention of breast cancer. A better understanding of this action of genistein is needed so that sound public health recommendations can be made to American women.

A C-FAR External Competitive Grants project.

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Soy Protein Dose for Lowering Blood Cholesterol

This was a clinical intervention trial designed to determine the optimal dose of soy protein required to lower blood cholesterol in men with moderately elevated cholesterol levels (220 to 300 mg/dL).



Although the effect of soy protein on blood cholesterol has been investigated in more than 45 human clinical studies, no dose-response study has been conducted to date to determine how much soy protein one needs to eat to favorably influence cholesterol levels.

The study consisted of a three-week lead-in period during which 81 subjects (divided into three cohorts) consumed a low-cholesterol (< 300 mg/day), low-fat (\leq 30% total kcal) National Cholesterol Education Program (NCEP) Step I diet. After three weeks, total cholesterol was measured and subjects were randomly divided into five experimental groups, each receiving 50g/day of a different isolated soy protein (ISP):casein mixture (50g:0g; 40g:10g; 30g:20g; 20g:40g; and 0g:50g) for six additional weeks. The test protein was delivered in a variety of baked products (muffins and breads) and ready-to-mix beverages. The subjects received the intervention diet at breakfast daily, five days/week, in the Bevier Hall Spice Box. Blood samples were collected at the end of the lead-in period and at weeks three and six of the intervention period.

Compared with the control group, statistically significant reductions were seen for total- and non-high density lipoprotein cholesterol and apolipoprotein B for all doses at six weeks and for the higher doses (40 and 50 g) at three weeks. Thus, as little as 20 grams of soy protein per day was effective in lowering cholesterol in these subjects.

This observation is significant as the American Soybean Association (ASA) has submitted a petition to the Food and Drug Administration requesting a health claim on food labels regarding the relationship between soy protein consumption and reduction of coronary heart disease risk. The ASA will be identifying 25 grams per day

as the effective level of soy protein in this regard. This C-FAR-funded project is the only direct dose-response data confirming that this level of soy protein will effectively lower cholesterol.

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Soy Protein Isolate for Peritoneal Dialysis Patients

More than 700,000 individuals in Illinois have kidney and urinary disease.

When an individual's kidneys fail to work, the condition is called end-stage renal disease (ESRD). Persons suffering with ESRD must rely on dietary management and dialysis or kidney transplantation for survival. Compromised protein status is well recognized as a complication of ESRD. As kidney function declines, many body processes become unbalanced and contribute to impaired nutrient utilization, which often leads to a decrease in food intake and malnutrition.

Researchers at SIUC are conducting an intervention study at two dialysis units. A projected 100 participants with ESRD treated with hemodialysis will participate to study the efficiency of isolated soy protein as a method of reducing protein malnutrition. Participants will receive either food products made with soy protein or identical products without soy protein to test the effectiveness of soy in improving protein nutritional status. The dialysis patients and the researchers do not know which products they (the participants) are re-

ceiving (a double blind study). Health parameters will be checked monthly to monitor response to the soy protein intervention.

Positive findings from this study will result in an additional dietary management tool for individuals receiving dialysis, thus, improving their quality of life. Isolated soy protein is a readily available source of high biological value protein that can be easily incorporated into dietary patterns.

A C-FAR External Competitive Grants project.

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Phytoestrogens and Cardio- vascular Health

Phytoestrogens are found in high concentrations in soybeans and have been shown to affect many physiological parameters.

The overall objective of this study was to determine the *in vivo* (animal) and *in vitro* (cell) effects of the phytoestrogens on actions of insulin and gross cardiovascular physiological parameters. Stable insulin-sensitive cell lines are being cultured and subjected to varying doses of genistein, daidzein or estradiol with and without insulin.

In addition, several animal studies have been executed. Findings show that in the male animals, soy protein and soy phytoestrogens are cardioprotective in several respects. Briefly, in the initial animal study when casein was substituted with soy protein containing 3.5 mg of phytoestrogens/g of protein, decreases in body weight, intra-abdominal fat, food efficiency ratio, insulin and insulin/glucose ratio were observed in male rats.



Additionally, we performed similar experiments injecting soy phytoestrogens (genistein and daidzein) in rats and found similar results. These data, along with existing literature on the cardioprotective effects of soy protein and/or soy phytoestrogens, suggest a cumulative cardio-protective effect of soy protein containing natural isoflavones. Future research will address the independent mechanisms with regard to each specific cardioprotective effect.

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Soy Phytoestrogens: Friend or Foe?

The phytoestrogens genistein and daidzein are found in high concentrations in soybeans, and have been shown to affect reproductive and metabolic parameters.

The overall objective of this study was to examine the effects of soy protein and soy phytoestrogens on key cardiovascular risk factors. Male and female rats were randomly assigned to one of three treatment groups: high isoflavone protein (HI); isoflavone-free soy protein (IF); non-soy (Casein) protein (C).

During the six weeks on the respective diets, body weight and diet intake were measured and feed efficiency ratio (FER) was calculated. Following sacrifice, blood was collected for insulin, glucose and cholesterol measurements. The abdominal fat pads, soleus muscle and reproductive organs were removed and weighed. In the male rats fed IF and HI, there was a marked

($p < 0.05$) reduction in body and intra-abdominal fat weight when compared to C. In addition, the male HI rats had a reduction in FER, insulin and insulin to glucose ratios (I/G) ratio vs. C. These gross physiological and metabolic effects in the male rats were not manifested in the female rats.

In the male animals, soy protein (IF and HG) benefitted cardiovascular health via a decrease in body weight and intra-abdominal fat. Further beneficial effects (decreased FER, insulin and I/G ratio) were conferred in male rats by consuming high phytoestrogen soy protein (HG) and the decrease in I/G ratios suggests an improvement in insulin-sensitivity. We have also performed similar experiments injecting soy phytoestrogens (genistein and daidzein) and found similar results. These data suggest a cumulative cardioprotective effect of soy protein containing natural isoflavones.

A C-FAR External Competitive Grants project.

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Stimulating Functional Foods Research, Education

Functional foods was recently recognized as the leading trend in the food industry today (Food Processing Magazine's Top 100 R&D® Survey, August 1998).

The Functional Foods for Health Program at the University of Illinois, largely due to the outreach efforts of the executive director, continues to be recognized, both nationally and internationally, as the leading academic research

and education program on functional foods. Two years of C-FAR funding has helped support the infrastructure of the FFH Program. In particular, these funds were used to help support the salary of Clare M. Hasler, executive director, who has a 75% Extension/25% research appointment. As part of U of I Extension activities, Hasler is an expert on the "ask the expert" service of the StratSoy database. She also presented 35 invited lectures at local, national and international meetings in FY 97/98.

During the last fiscal year, the FFH Program expanded its roster to 23 corporate members, including ADM, Bayer, the California Almond Board, the California Prune Board, Cargill, ConAgra, General Mills, Hershey Foods, Kellogg*, Kraft*, Mead Johnson*, McCormick*, McNeil Specialty Products*, Monsanto, Nestle*, Ocean Spray, Protein Technologies, Intl.*, Pulsar/Seminis Vegetable Seed Co., ReLiv*, Sunstar, Tropicana, Warner Lambert, and Welch's* (*new this year). Because of the expanding Industrial Affiliates Program, nearly \$75,000 in seed grants was awarded in FY 98, a 50% increase from last year.

FFH Program faculty membership expanded to 92 members, an increase of eight over last year. The FFH Program has recently established an "affiliate" faculty category, whereby outstanding researchers at other academic institutions can become members of the FFH Program. Two researchers are affiliate members: Bahram Arjmandi, Oklahoma State University, and John Folts, University of Wisconsin-Madison.

The most significant accomplishment related to this project was the establishment of a Strategic Research Initiative (SRI) on Food Safety and Functional Foods (FS/FF). Hasler was selected as co-leader of this SRI. (See p. 10)



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Biosensor for Food Estrogen Research

Breast cancer incidence in North America increased alarmingly during the 1980s.

Although the increased diagnosis in middle-aged women can be attributed to effective screening programs and the use of mammography, it does not explain the rise in older women. Studies now show that environmental factors, in combination with genetic predisposition, play a role in the etiology of breast cancer.

Recent studies suggest that dietary and environmental estrogens may play an important role in the etiology of breast cancer. Compounds with estrogenic activity may be detrimental to women with estrogen-dependent breast cancer, whereas those with anti-estrogenic activity may be beneficial. In other cases, estrogens may be beneficial to women by reducing the risk of cardiovascular disease and bone loss.

We have developed a biosensor assay to identify biologically active compounds in food with either estrogen agonistic or antagonistic activity. This bioassay can be used to measure estrogenic/anti-estrogenic activity in complex mixtures. Additionally, we have evaluated some of the compounds with estrogenic/anti-estrogenic activity using a whole animal model.

We have demonstrated the estrogenic activity of genistein using the biosensor assay and have validated these results in a whole animal model. Such data will assist health providers in making recommendations concerning diets con-

taining potentially beneficial or detrimental estrogenic or anti-estrogenic profiles.

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Investigations in Plasma Lipoproteins

Phospholipid transfer protein (PLTP) is present in human plasma and serves as a carrier of phospholipids and cholesterol.

It plays very important roles in the metabolism of plasma lipoproteins, especially high-density lipoproteins (HDL).

I. To provide information on how PLTP is produced and secreted by human cells, we used Hep G2 cells, which are derived from a cancerous human liver cell line showing many functions of normal human liver cells. When Hep G2 cells were grown and kept in nutrient medium, the activity of PLTP increased with time. To make sure that this activity was caused by secretion of PLTP having the same properties and characteristics of human plasma PLTP, we added a solution of antibody produced in rabbits against human plasma PLTP. The addition completely prevented PLTP activity in the medium.

This told us that human liver cells possibly secrete PLTP, like Hep G2 cells. We confirmed that the size of Hep G2 PLTP was exactly the same as that of purified human plasma PLTP. Also, the secreted PLTP showed exactly the same heat sensitivity as human plasma PLTP. Furthermore, it had an HDL conversion activity similar to human plasma PLTP. The conversion activity is responsible, in part, for making larger HDL. These larger

HDL are present in higher amounts in premenopausal women who are more resistant to coronary heart disease. Because of the potential importance of PLTP in human health, we are continuing the investigation of the relationship between PLTP and HDL with various other human cell lines.

II. Because of its potential importance in human health, we investigated the synthesis and secretion of PLTP using Hep G2 cells. Phospholipid transfer activity was found to increase in the cell conditioned media with time. The transfer activity in the media was inhibited by rabbit anti-human PLTP IgG and by heating at 58°C. The molecular weight of Hep G2 PLTP was about 78 kDa by Western blot analysis, in agreement with the molecular weight obtained for purified human plasma PLTP. The PLTP secreted by Hep G2 also possessed an HDL conversion activity similar to human plasma PLTP. Incubation of HDL with the culture media resulted in its enlargement. Upon treating the cells with 4 mM sodium butyrate, the PLTP secretion increased by 200%.

Ribonuclease protection assay showed a much higher level of PLTP mRNA in the cells treated with sodium butyrate. The increase in PLTP secretion by butyrate treatment was accompanied by an increase in the amount of secreted HDL which gave a higher hydrated density than the HDL obtained without butyrate.

The results suggest that Hep G2 cells can be used as models of hepatocytes to study the regulation of PLTP synthesis and secretion, as well as HDL formation. We are using various other human cell lines to further study the relationship between PLTP and HDL.

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Vegetable Products that Prevent Cancer

An interdisciplinary UIUC research team has performed a survey of 66 cruciferous vegetables, including 51 broccoli, three cauliflower, five Brussels sprouts, five cabbage and two kale varieties.

The survey evaluates the variation in content of antioxidant vitamins (including vitamin A and other carotenoids, vitamin E and other tocopherols, and vitamin C) and of glucosinolates, complex glucose-containing molecules relatively specific to cruciferous plants. Both antioxidant vitamins and glucosinolates have been associated with cancer prevention.

The survey showed variation in vitamin and glucosinolate content between vegetable varieties, such that some varieties may offer considerably less health benefit than others. In broccoli, the content of glucoraphanin, the glucosinolate precursor for the chemopreventive agent sulforaphane, varied over 200-fold, with the variety Brigadier having the highest content. Brigadier had close to median levels for antioxidant vitamins in broccoli; broccoli varieties as a group had higher vitamin levels than Brussels sprouts, cabbage or cauliflower.

Both growers and consumers will benefit directly from this information. The information generated here will be useful in marketing varieties high in health-promoting components. At present, varieties are not identified in the supermarket. Therefore, an expected outcome of this research is that cruciferous vegetable varieties will be identified in the market, to enhance sales. In addition, local Illinois crucifer growers will benefit from this information by choosing

to grow the varieties with the greatest content of health-promoting components.

A C-FAR External Competitive Grants project.

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Resistant Starch as a Functional Food

Undigested protein that reaches the colon is fermented by the colonic bacteria to end-products that may have adverse effects on colonic health.

Resistant starch is a carbohydrate fraction that escapes digestion by enzymes in the small intestine and becomes available for bacterial fermentation in the large intestine. Resistant starch has a potential role in improving colonic health similar to that of dietary fiber.

The objective of this project was to provide a complete assessment of the potential role of resistant starch, as a functional food, to improve human health. Experiments focus on quantifying starch fractions in the most common starchy foods, determining fermentation characteristics of resistant starch and determining *in vivo* fermentation characteristics of resistant starch and its subsequent effects on colonic health.

A wide range of starchy food ingredients were procured and analyzed for different fractions of starch. The ingredients included beans, grains, flours, pasta products, and prepared grain products. Starch

in cereal grains and flours were comprised mostly of rapidly digestible starch and the beans contained high proportions of resistant starch. Selected grains and flours were cooked at different temperatures with or without inclusion of fat during cooking.

Results indicated that cooking starchy foods without fat caused an increase in rapidly digestible fraction of starch. However, when starchy foods were cooked in the presence of fat, more resistant starch was present. Currently, we are studying *in vitro* fermentation characteristics of starchy foods. In the next phase, *in vivo* studies will be conducted.

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Novel Oat Varieties for Managing Celiac Disease

A major focus of the project has been on the evaluation of various oat cultivars to attempt to identify lines which may have reduced or no capacity for the induction of human celiac disease.

Our screening assay has been based upon examining immunological cross-reaction of avenins with either human antibodies generated from the celiac disease response or with antibodies generated against wheat g-gliadin (a strong celiac disease inducer).

From this approach, it was apparent that oat avenins display extensive polymorphism with respect to reactive proteins present, their quantity and their migration on electrophoretic gels. Moreover, two



oat lines (“Potaroo” from Australia and “Whitestone” from North Dakota) were found which display little or no cross-reaction in the screening assay.

We are currently attempting to more quantitatively evaluate the cross-reaction of avenins from these oat lines and have initiated crosses to examine the extent of immunological cross-reaction of avenins from F2 progeny. We are also now examining the extent of transglutaminase reaction with oat avenins as this process has been suggested to also play a role in the induction of human celiac disease *in vivo*.

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Manipulation of Seed Oil Content, Composition

Dramatic differences exist in the relative proportions of lipid, protein and carbohydrate in oilseeds.

A fundamental question that remains unanswered is: What determines the ultimate composition of seed storage reserves? The fatty acid composition of the oil is as important as the quantity of oil present in an oilseed. Characteristics of vegetable oils are determined by their fatty acid composition. Genetic manipulations of acyl carrier protein (ACP), a key component of the fatty acid biosynthetic pathway in oilseeds, are being done to investigate the role of ACP in determining oil content and fatty acid composition.

Arabidopsis thaliana is being used for genetic manipulation of oilseed ACP levels. This plant serves

as a model for oilseed metabolism, as it contains 20% oil and can be easily manipulated genetically. There are several forms of ACP in plants (and within one plant). One of the goals is to obtain an understanding of why there are so many forms. Various manipulations have been performed and several transgenic plants have been generated. These include plants with both increased and reduced levels of at least one form of ACP. One significant finding is that over-expression of a seed form of ACP in leaf tissue has resulted in alteration of leaf fatty acid composition. This is one of the first reports that ACP forms have fatty acid specificity.

A basic understanding of the role of ACP in plant fatty acid/oil biosynthesis will contribute to the ability to tailor oilseeds for enhanced fatty acid composition and for optimal levels of the storage components of oil, protein and carbohydrates. This will enhance the agronomic value, nutritional quality and processing quality of oilseeds.

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C-FAR Fellows in Food Safety

The C-FAR Fellows in Food Safety program was developed in part because of the growing importance of food safety for the health and well-being of society.

Not only does the research performed by the C-FAR Fellows make important contributions to public health by ensuring a safe and wholesome supply of meat prod-

ucts, but it will enable livestock producers to increase productivity by enhancing animal health and well-being.

The overall strategy of this program is to use the C-FAR Fellows as the cornerstone of the programmatic initiative in food safety from which specific research proposals are developed. The financial request of the proposal is for support of graduate students and to provide modest support for other programmatic expenses, including the costs of travel to attend national meetings, the costs of publications and the cost for outside speakers in a seminar series. The cost of research, however, is provided by the Fellow's laboratory.

To promote interdisciplinary research that will result in synergistic activities among faculty and students and to ensure the training of new leaders in food safety research, a central mechanism that brings faculty together rather than isolating them was required. By placing graduate students in laboratories that have or are initiating multidisciplinary research projects, we are able to fulfill both objectives.

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Improving the Quality, Safety of Foods

Physical aging is a process that can occur in the lifetime of solid food materials (hard candies and low moisture foods, for instance).

It alters physical properties, such as density, volume and hardness, and decreases shelf life. If food manufacturers had a greater under-



standing of the mechanism that causes physical aging, its effects could be minimized. Thus, understanding the process of physical aging has the potential to be a valuable predictive tool to more accurately assure the quality, safety and stability of foods.

The two objectives of our research are: 1) to probe the molecular level behavior of simple carbohydrate materials as they undergo physical aging and 2) to examine the changes in the physical properties of aged carbohydrate materials. The molecular level behavior of maltose glasses, aged from 5 minutes to 10 days at two different temperatures below the glass transition temperature, were examined using two different measuring techniques, standard differential scanning calorimetry (SDSC) and modulated differential scanning calorimetry (MDSC).

It was found that SDSC was the best technique to use and that the physical aging process was best modeled using the Cowie and Ferguson model. The mechanism of physical aging is a decrease in the enthalpy of the material below the glass transition temperature. Manufacturers can decrease the amount of physical aging which occurs in low-moisture food products by selecting food ingredients that have a high-glass transition temperature compared to the typical storage temperature of the food product (usual room temperature). Additional research is being conducted to examine the changes in the physical properties of aged carbohydrate materials.

A new instrument has been developed by TA Instruments (Newcastle, Delaware) that combines DSC and Atomic Force Microscopy. To further our understanding of the textural changes which occur during physical aging, we are currently arranging with TA Instruments to assist us in conducting preliminary structure-function

experiments on our aged carbohydrate materials.

A C-FAR External Competitive Grants project.

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Safety During High Isostatic Pressure Processing

Consumer demand for minimally processed, additive-free, high-quality products with natural taste prompted the food industry to investigate non-thermal processing methods such as high isostatic pressure processing (HPP).

During HPP, the food is subjected to elevated pressures (up to 9000 atmospheres) to inactivate the microorganisms normally present in the food and extend the keeping quality of the food. HPP treated foods generally have better flavor, texture, nutrient retention and color compared to those of thermally processed foods. The goal of this research program is to evaluate the safety issues associated with processing foods by HPP.

The adiabatic heating characteristics of different pressure transmitting fluids during high-pressure processing of foods was investigated. Studies were conducted with three different concentrations (25%, 50% and 75% in de-ionized water) of water glycol hydraulic fluid solution. Pouches containing 50 ml water were used as the model test packages. Experiments were conducted using a pilot scale high-pressure food processor (model-QFP6, ABB Autoclave Systems Inc., Columbus, Ohio). The samples were subjected to a pressure (759 Mpa)

and process temperature (30°C) combination up to 10 minutes. Temperatures of the pressure transmitting fluid during different process runs were recorded using a Hewlett Packard data-acquisition system.

Adiabatic temperature rise during pressurization was greatest (27°C above the target process temperature) in the case of 75:25 glycol:water mix. The temperature rise was in the order of 25°C and 22°C for 50:50 and 25:75 glycol:water mixes, respectively. The difference in temperature could be attributed to the difference in the viscosities and thermal heating characteristics of the fluids. The effect of adiabatic heating occurring during pressurization was found to be minimized by lowering the initial temperature of the sample by 12°C (for the chosen experimental condition). For a 10-minute processing time, the rate of temperature fall ranged from 0.79 (for 75:25 mix) to 1.3°C/min (25:75 mix). Adiabatic heating effects on microbial population inactivation is under investigation.

A C-FAR External Competitive Grants project.

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Calculating Antibiotic Milk Discard Times

This project began in January 1997 with the following objectives: 1) to apply population pharmacokinetic methods to examine the disappearance of antimicrobial drugs from milk obtained from cows with naturally occurring mastitis;



2) to determine the minimum numbers of cases and samples per case necessary to define milk discard periods; 3) to identify the power of this new procedure to identify factors (covariates) which may affect the disappearance of antimicrobial drugs from milk, using the example of pirlimycin; and 4) to compare milk discard calculations based on milk drug concentration and excreted drug mass.

Initial data analysis shows that milk production is a major covariate which influences clearance of pirlimycin in milk. A new method has been developed to estimate milk discard times. This method achieved similar results as the current FDA Center for Veterinary Medicine's prescribed protocol. However, this new method does not require a specific residue study, thereby reducing the number of research animals necessary for drug development.

Our identification of covariates for clearance, such as milk production, allows farmers to predict which cows may cause violative drug residues in bulk tank milk and how many extra milkings should be discarded. Pharmaceutical sponsors and farmers benefit directly from this research. Indirect benefit to the consumer is achieved through higher confidence of an uncontaminated food supply (milk).

A C-FAR External Competitive Grants project.

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HACCP in Small Meat Processing Facilities

We developed a model HACCP Program at Thrushwood Farms Quality Meats.

Employees were trained in the use of the HACCP Plan, and it has been in operation since February 1998. Microbiological data are being collected weekly to assess whether the use of the HACCP Plan reduces microbial load and presence of pathogens. We are evaluating the microbiological data.

Based on materials developed for Thrushwood Farms, the HACCP Training Manual was developed to use for training small meat processing facilities personnel. The manual was pilot tested at the University of Wisconsin, Madison, in conjunction with their HACCP Training course. To date, 38 meat plant managers and employees have been trained at workshops in the use of the HACCP Manual in the preparation of HACCP Plans for their own plants. Two more workshops were conducted last fall with an enrollment of 80 participants; three workshops are scheduled for 1999.

A C-FAR External Competitive Grants project.

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HACCP Training of Food Services in Illinois

Academicians and regulatory officials collaborated in developing HACCP training materials that are suitable for the front-line food service workers.

The research team modified seven HACCP principles into a two-step procedure for easy adaptation in everyday practice. A training packet, including a 55-minute

video, a workbook with recipe exercises and several job aids, was produced.

The efficacy of these materials was evaluated by pre- and post-HACCP behavioral observations for a sample of food service workers using an instrument monitoring the trainees' food handling procedures. The result showed a significant reduction ($p < .001$) in HACCP violations eight weeks after the training session. Motivating and retaining the employees seemed to be major obstacles for the success of the sanitation management. In this study, out of 60 workers invited, 37 participated in the training and 28 workers took part in post-training observations after eight weeks.

This study has produced effective HACCP training materials that are suitable for food handlers. Continuous training seems to be a main factor in successful HACCP programs in the food service industry.

A C-FAR External Competitive Grants project.

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Food Practices, Food Safety Training Materials

More than 80% of the food-borne illness cases occur in the home.

Safe food handling practices of high-risk population groups, such as children under age 5, pregnant and/or lactating women, senior citizens, low-income families and people with debilitating diseases,



are essential to the maintenance and/or improvement of their health.

Home food handling practices and food safety concerns of high-risk population groups are being investigated. Surveys have been collected from a range of groups: over 800 children between third and tenth grades; over 100 senior citizens; over 100 Women, Infant, and Children (WIC) and low-income residents; and over 100 people with debilitating diseases. Two public service announcements based upon the tentative results of the survey are in progress. An Internet Web site is under construction.

Food handling practices of high-risk population groups will be assessed. Unsafe food handling practices or areas where consumers lack information about safe food handling will be addressed via multimedia resources to reach these high-risk population groups.

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Nutrition and the Elderly Conference

The Nutrition and the Elderly Conference was held in May 1998.

More than 30 participants attended, representing seven Illinois universities, four Illinois state departments, six area agencies on aging and six professional or public organizations. Each participant submitted and presented an abstract which reported what their view of the needs of the elderly in Illinois were, how they or their organization addressed those needs, and where they felt the gaps were. The abstracts were posted on a Web page: <http://w3.aces.uiuc.edu/FSHN/NAC/>. Breakout sessions

and discussion periods focused on physiological and psychological changes associated with aging, nutrition education needs and food security issues.

A proceedings was distributed to participants and will be posted on the Web page. Important conclusions drawn at the conference were identified: the need for a steering committee relative to nutrition and aging in Illinois; more education for health care providers and the elderly; and additional collaboration among service providers, as well as researchers in Illinois.

Although a Partnership Illinois grant was submitted to initiate this steering committee and a newsletter, the grant was not funded. Plans are to proceed with the steering committee, however. The process and conclusions drawn from this conference were presented in Atlanta at a June 1998 conference, *Awakening to Aging: Educating Leaders for an Aging Society*, American Association of Family and Consumer Sciences.

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Novel Gc-MS-Based Assay for Zinc Status

Researchers measured urinary markers as an indicator of nutritional status of the body.

The project utilized gas-chromatography/mass spectrometry (GC-MS) as the means to measure relative levels of urinary metabolites. The GC-MS method is the same as that used in drug screening and diagnosis of genetic metabolic diseases. (It can identify hundreds of different compounds in a single urine sample.) The nutritional condition studied was zinc

deficiency, a condition that may be common for many individuals, especially at the 'marginal' level of deficiency. The field of nutrition has yet to identify a reliable method for measuring zinc status in humans.

Our project involved two sets of studies. First, rats were fed zinc deficient diets and urinary metabolite levels were measured. Secondly, human subjects were recruited to participate in a seven-week study during which C-FAR investigators provided all of their food to them. Subjects were provided a zinc-deficient diet for five weeks and then a zinc-supplemented diet for two weeks. Urine samples were collected twice each week from subjects. Significant changes occurring in metabolism may have led to the differences we measured in the concentration of some urinary metabolites in both animals and humans.

By conducting this project, we have demonstrated the feasibility of this method. We are currently preparing manuscripts for nutrition journals so that nutrition scientists and physicians may become aware of this result.

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Salmonella Transmission on Farms

More than 3,000 samples were collected from animal and environmental sources on six swine farms in Illinois from March to August 1998.

On each farm, a cohort of at least 30 pigs was monitored with



collection of blood and fecal samples from 2 to 23 weeks of age. Cross-sectional groups of swine were also tested at each visit to each farm. These samples were tested for salmonella by culturing the organism. Blood samples were taken from every mammal sampled. These will be tested for antibodies to salmonella by a mixed-antigen ELISA. Reservoirs identified by positive culture to date include water, feed, boot scrapings, pen floor scrapings, flying and crawling insects, cats, mice and swine from every stage of production. Preparations are under way for sample collection from a new group of farms.

This research lays the foundation for accurate identification of reservoirs for salmonella and their relative importance. This is crucial to the implementation of effective control measures against salmonella. Veterinarians and swine producers will benefit as this information helps them to reduce salmonella-induced disease in swine. Consumers will benefit as reduced exposure to salmonella reservoirs reduces the risk of salmonella contamination of food sources. Ultimately, everyone will benefit from the economic and public health benefits of salmonella reduction.

A C-FAR External Competitive Grants project.

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Reducing Salmonella Infection on Farms

The USDA-FSIS now requires pork processors to meet standards for allowable salmonella occurrence on

carcasses.

The purpose of these projects is to identify and prioritize potential points of intervention on farms that would reduce the occurrence of salmonella among slaughtered pigs. We are accomplishing this by comparing and contrasting the salmonella status of pigs from 150 Illinois pig farms, looking for farm or management characteristics that are associated with low salmonella shedding. The study is divided into three stages, with repeat sampling of farms at each stage. Preliminary analysis of samples collected in stages I and II show that while more than 50% of farms have detectable salmonella by our methods, only a small percentage of farms account for the majority of salmonella-positive pigs.

Review of the extensive farm survey shows that a broad cross-section of members of the Illinois Pork Producers Association has participated in the project. Analysis of the relationship between herd characteristics and salmonella level are pending.

Concentrated salmonella shedding suggests that changes at a limited number of high-risk farms should reduce overall salmonella levels in slaughtered pigs. This approach should also be the most cost effective, since the changes can be targeted at a small subgroup of farms.

Assessment of risk factors should help researchers to focus on factors with the highest potential for success. Identifying production practices that safeguard the food supply should help Illinois farmers retain their market access and improve the value and safety of their product. This can enhance the safety of pork provided to consumers and allow Illinois pork to compete in the national and international marketplace.

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Inhibiting Uterine Bacterial Attachment

Bacteria must attach to tissue surfaces to establish infection.

This research investigates a method to prevent bacterial attachment through the use of benign compounds (sugars) designed to interfere with bacterial attachment sites. Uteri (n=5) from cows of unknown history were obtained from an abattoir. Endometrial samples harvested from these uteri were incubated with *Escherichia coli* with or without five different sugars. Homogenized tissues were diluted and plated onto *E. coli* selective media plates. Number of *E. coli* colony forming units (CFU) were counted and results expressed as CFU/mg tissue.

E. coli binding to bovine tissues was variable between animals and nonuniform between different sites in the same uterus. Several techniques were investigated to overcome this variability and a split sample design was adopted. Binding of *E. coli* was significantly enhanced through the addition of a number of sugars. Sugar concentration appeared to play a role in this phenomenon. Results suggest that glucose and glucosamine stimulate the greatest binding enhancement.

These results are relevant to the cattle breeding industry since



most of the semen extending compounds commercially employed for the artificial insemination of cattle contain glucose as an energy source. This research suggests that this practice may be creating a uterine environment conducive to bacterial infection.

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Alternatives to Antibiotics to Prevent Infections

This research tests the ability of different sugars to prevent adherence of bacteria to mucosal tissues, therefore preventing infection.

Horse uterine tissue is being used as a model since it is easy to obtain and work with in the laboratory. Five sugars (mannose, glucose, galactose, N-acetyl-D-glucosamine and N-acetyl-D-galactosamine) were tested for their ability to prevent the adhesion of *Escherichia coli* (*E. coli*) bacteria to uterine tissues. Mannose was identified as the most efficient sugar in preventing bacterial attachment.

In the laboratory, *E. coli* attachment can be significantly decreased with 25 mg/ml mannose added at the time of bacterial assault. Limited field testing resulted in negative bacterial cultures after 24 hours of mannose plus *E. coli* treatment, whereas *E. coli* alone resulted in positive cultures in two of three test subjects.

Although a useful tool to determine presence or absence of infection, uterine bacterial culture could not assess the degree of infection present. Several methods were tested to find an accurate and simple method to count bacterial

attachment to tissues. Although accurate, counting the number of bacteria attached to tissues under the microscope was not practical for field implementation.

A new method of growing bacteria by traditional culture methods from ground tissue samples shows promise. Further experimentation to test other bacteria with sugars is planned for the next year, as well as studies involving introduction of various treatments into the mares' uteri.

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Creating Dietary Changes

Emerging behavior theories indicate that individuals pass through a specific series of stages (for example, precontemplation, contemplation, preparation, action and maintenance) on their way to achieving and maintaining behavioral changes.

Interventions are more successful when they relate to the specific stage that the individual is in. This project focused on identifying specific eating practices and characteristics that reflect an individual's readiness to make dietary changes with regard to fat, fruit and vegetable intake.

Researchers have collected information from a projected 500 women and men, ages 20 to 80, representing diverse backgrounds. Volunteers complete a comprehensive nutrition assessment. Information collected so far shows that 14% are in the precontemplation stage for eating five servings of fruits and vegetables every day, 17% are in

contemplation, 27% are in preparation, 10% are in the action stage and 32% are in the maintenance stage.

People are doing more about fat intake than improving fruit and vegetable intake: 53% are in the maintenance stage for avoiding high-fat foods and 6% are precontemplators. The proportion of people in these stages is substantially different by gender, income and education.

The results from this study will provide a tool to classify individuals to their appropriate stage of change with regard to diet. Thus, nutrition educators can refine their educational messages to consumers.

A C-FAR External Competitive Grants project.

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Research focus: Provide for sustainable development and use of natural and human resources in Illinois.

project updates

Farming on the Rural/Urban Fringe

Farmers on the rural/urban fringe are commonly assumed by planners to sell out solely for profit motives.

Our findings in a Kane County town experiencing rapid farmland conversion indicate a more complex reality. Farm families and newcomer residents reveal starkly contrasting priorities for land use. Two-thirds of farmers oppose the county plan that established an agricultural zone to discourage premature conversion, while two-thirds of newcomers favor the plan, although they did not know of it.

Newcomers and farmers overwhelmingly agree, however, that farmland should have development restrictions. The groups also favor preserving a middle landscape that retains open spaces now farmland, and allows some mixed residential, recreational and other development. Farmers, however, are pessimistic about future farming in Kane County. They expect to be pushed west by higher land prices, newcomer hostility, field invasions and equipment vandalism. Farmers' awareness that about one-third of local farmland has undergone a "hidden transfer" (determined from tax rolls) to developers also shifts the momentum toward suburbanization.

These factors gradually transform farmers' meaning of farmland to that held by newcomers. Once the rural landscape is defined as suburban, farming no longer seems viable.

Planners grappling with farmland preservation must understand that how farmland is defined, as much as financial gain, appears to shape decision-making about farmers staying on the fringe. Planners should also avoid splitting a community as did Kane County with its "Critical Growth" zone. Such a split increased Elburn's vulnerability to development. Similarly, not gaining farmers' support for the plan doomed it by appearing more attuned to urban than rural priorities.

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Public Perception of Animal Suffering

The project objective is to identify and characterize perceptions concerning animal suffering among key publics within Illinois.

Preliminary work conducted in 1998 involved the development and subsequent pilot testing of in-

terview instruments on various segments of the population, including a sample of approved humane investigators. The survey addressed common practices, environmental conditions and hypothetical scenarios concerning animal welfare. Humane investigators were also asked to comment on the effectiveness of the Illinois Humane Care for Animals Act.

Preliminary data suggest that the perceived psychological state ("feelings") of an animal is an important factor influencing the assessment of its welfare. In addition, there are numerous demographic factors that influence attitudes concerning animal suffering. Humane investigators maintained that the Illinois Humane Care for Animals Act allowed them to adequately address two forms of animal cruelty: abuse and neglect. However, humane investigators indicated that there are a significant number of complaints involving behavioral deprivation that existing humane laws do not address. These complaints most commonly involved a perceived lack of social interaction in dogs and a perceived lack of freedom of movement (for instance, exercise) in stalled horses.

This research will lead to an improved awareness and understanding of society's quest for acceptable standards of animal welfare.

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Integrating Wildlife in Ag Conservation

This project considers the population ecology and management of upland game species, such as pheasant and quail, and Neotropical migrant species currently experiencing pronounced declines.

Most of the work to date has been conducted on or near the Prairie Ridge Natural Area (PRNA) in Jasper County. The PRNA is a network of grassland tracts in a farmland mosaic near Bogota, Illinois. Emphasis was given to evaluating wildlife responses to grassland management practices that are of potential importance in farming systems (for example, vegetation appropriate for grazing systems, set-aside farmland and filter strips).

Over 750 nests have been found to date. Reproductive and survival parameters of birds have been documented relative to habitat features and other environmental conditions. The preliminary findings confirm the high variation in reproduction and survival between species, management practices and other temporal and spatial factors, and potential for improving wildlife habitat while achieving the broader goals of farm policies and programs in Illinois.

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College of Agricultural, Consumer and Environmental Sciences
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Development: Decision Model for Planning

The project focused on wrapping up work with the Otter Lake Resource Planning Committee, observing and participating in activities of the Otter Lake Planning Committee and developing new techniques for improving the planning process.

The effort included participation in two watershed planning efforts: Otter Lake and Blackberry Creek.

One accomplishment was development of techniques and practices to improve the planning process. These included development and use of Rapid Resource Appraisal (RRA). This addition to the planning process consists of four elements: targeted resource education, a tour of the watershed, meetings with stakeholders and meetings with government officials. The purpose of the RRA is to broaden the views of committee members and build consensus among committee members regarding the committee's objectives.

Another important activity was identification of the elements of a core data set for developing sustainable plans and use of the data in the Blackberry Creek Watershed planning effort. Many committees waste valuable time deciding which resource, economic and social data should be collected. The core data set identifies the most commonly used data in planning and tells committee members where to obtain it in electronic and hard copy forms.

Jody A. Rendziak, Sonya Salamon and Richard L. Farnsworth collaborated on an article, "Is Locally Led Conservation Planning Working? A Farm Town

Case Study." (*Rural Sociology* 63 (2), pp. 214-234.) In addition, three U of I Extension publications were written for planning committee members or facilitators.

The RRA is likely to become a part of watershed planning efforts across the nation. The Natural Resources Conservation Service supports its use in planning. More importantly, RRA is well received among committees. Given the choice, committees have voted almost every time to conduct an RRA.

A C-FAR External Competitive Grants project.

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Watershed Lessons From the Cache River

Driven by ongoing problems of non-point source pollution, watershed managers increasingly must respond to regulation.

To develop basin-specific plans would be a daunting task given the time, data and financial investment needed to construct individual watershed models. If solutions to non-point pollution are to be investigated, the judicious use of existing watershed models is necessary.

In the first year of this project, representative farms using linear programming (LP) were developed to reflect farming practices in the Cache River Watershed of southern Illinois. We are currently enhancing the interface between this model, GIS and hydrological model (AGNPS) to develop a decision-support tool for watershed manag-



ers. This decision support tool will enable targeting of non-point source pollution to remedial policy initiatives or management practices. Using a clustering routine available in GIS ARC/INFO, the Big Creek landscape was allocated into farming units. The optimized LP resulting land coverages served as input to AGNPS.

The land-use changes that result from policy are demonstrated to have an economic impact (such as farm income and crop sales) and an ecological impact (such as sediment loss and sediment yield). For example, a policy directive constraining soil loss to T would result in an average decline of over \$1,100 per farm, while reducing sediment yield by 22% at the mouth of Big Creek.

Further enhancements will recognize that producers do not solely base their acreage decisions on soil series mapping units. Producers farm fields. Additionally, in southern Illinois, pest management is a crucial part of the acreage decision. These as well as other concerns are being addressed as a base scenario is developed.

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Watershed Sustainable Development

Researchers designed this project to critically examine and provide guidance on watershed performance criteria (physical, biological and socio-economic) that stakeholder groups might use in their watershed planning efforts.

Essential to the study is an understanding of the institutional framework within which watershed planning is done. This understanding is needed to clarify the nature and limits of authority available to grassroots planning groups. The diffuse decision-making inherent in Illinois watersheds with many independent landowners alters or constrains a number of elements of conventional planning, such as centralized decision-making, command and control implementation and ongoing management that would monitor and react to performance criteria.

This project is creating educational materials describing the context within which watershed planning occurs in Illinois, assessing the implications of that context on outcomes that can be expected and commenting on the usefulness of performance criteria in the watershed planning and management process. The intended audiences include grassroots planners and agency personnel and researchers who work with and advise these planning efforts.

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Economics
Greg McIsaac, Karyn McDermaid
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Illinois State Natural History Survey

Nitrate Data from Watersheds

We have compiled data from the Illinois Environmental Protection Agency, the U.S. Geological Survey, the Illinois

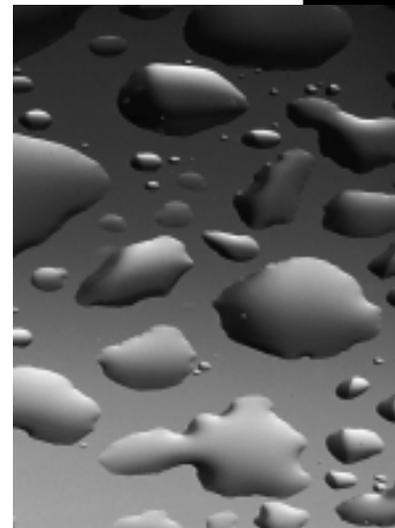
Department of Agriculture and the Illinois State Water Survey on nitrate concentration, stream flow, crop yields, livestock numbers, fertilizer sales, precipitation, evapotranspiration and soils for five watersheds in central Illinois for the period 1979 to 1996.

Watersheds were selected on the basis of the quality of data available and the severity of the nitrate problem.

Statistical analyses of these data indicate a strong positive correlation between stream flow and nitrate concentration in the stream. There is also a significant negative correlation between stream nitrate concentration and nitrogen removed in the previous year's crop harvest, indicating high nitrate concentrations typically follow a year when crop yields are low. We have identified multiple linear regression models that can account for approximately 70% of the variation in stream nitrate concentration.

We will further refine these models and use them to estimate the mass of nitrate nitrogen leaving these watersheds in stream flow. These models will also be useful for identifying conditions under which nitrate-N concentrations are likely to be problematic, which may be useful for watershed management and the management and regulation of drinking water supply reservoirs.

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Identifying, Reducing Nitrate in Water

Nitrate levels in excess of the public health standard of 10 mg N/l in public water supplies, along with concern about hypoxia in the Gulf of Mexico, have drawn renewed interest to improving fertilizer N use efficiency.

Prior research has indicated that some farmers may be unknowingly contributing to these problems.

The objectives of this research were to determine the effect of rate and time of N applications on nitrate-N concentrations in water from tile lines and to evaluate the effect of previous N rate on current N needs and on recovery of fertilizer N by plants. Tile-line monitoring systems that record water flow rates and collect water samples on a predetermined schedule were installed at 11 experimental sites. At each site, N-rate studies were conducted when the field was planted to corn.

There appeared to be no relationship between previous N rate and current response to applied N. However, the relative yield response was higher for spring and sidedress treatments than for fall-applied N. Efficiency of fertilizer use was greater for spring-applied N than for fall-applied or sidedress N. Nitrate loss in tile-line effluent was generally highest from those fields where corn was grown that year and from those fields that had a previous history of excess rates of N application.

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Management Effects on Nitrate-N Concentrations

Over the course of the project, nitrate concentrations in the Little Vermilion River have ranged from 0 to 17 mg NO_3^- -N/L, with the highest concentrations generally occurring in late spring and the lowest generally occurring at the end of the growing season.

This seasonal trend corresponds with the agricultural cycle. The purpose of this project is to quantify the impacts of change in agricultural practice on water quality. The overall goal is to improve regional water quality using management practices that make sense, both economically and environmentally.

Subsurface drainage from eight fields is monitored for nitrate and pesticides. Average nitrate-nitrogen concentrations are lower for fields where nitrogen is applied to emerged corn, as compared with fields where nitrogen is applied prior to planting (9.8 mg/L vs. 16.8 mg/L). Nitrate-nitrogen concentrations from a field in continuous meadow averaged 1.1 mg/L.

Financial incentives were provided to those farming the monitored fields to apply the amount of nitrogen fertilizer recommended in the University of Illinois Agronomy Handbook. Monitoring tile nitrate concentrations for two to three years after the change in management will provide evidence as to the effectiveness of the practice in improving water quality. The result-

ing data set will be used to develop models for predicting the effects of such practices at the watershed scale.

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Water Quality in Alternative Cropping Systems

Water flow and water quality in subsurface drainage has been monitored since August 1996 in three fields, each under different crop management systems: no-till, conventional till and certified organic.

The tiles are part of tile-outlet terraces that occasionally collect surface runoff in addition to subsurface flow. The tile outlet terrace was installed on the organic system in fall 1997. (Data prior to that time is only subsurface flow for that system.)

Mean nitrate-N concentrations to date are 8.6, 9.2 and 2.6 mg N/L for the no-till, conventional-till and organic systems, respectively. Thirty-five percent of the samples from the no-till and 47% of the samples from the conventional system exceed 10 mg N/L. No samples from the organic system (out of 65 analyzed) have exceeded this level.

There is considerable variation in nitrate concentrations over time. Nitrate concentrations for the no-till and conventional systems decrease significantly when surface flow enters the tiles. Nitrate concentrations in the organic system have tended to increase somewhat



during the 1998 growing season (up to 8 mg N/L so far), after corn was planted following a leguminous green manure crop that was grown the previous season.

A C-FAR External Competitive Grants project.

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Reducing N Runoff in Corn

Differences in herbicide resistance, nitrogen use efficiency, nitrogen content, plant growth and composition and grain yield of GDH-transgenic corn under field conditions are being evaluated in five locations with three rates of N application.

Field evaluations in 1997 were conducted at two selected sites. Corn inbreds and hybrids are being evaluated. (Originally, one site and only inbreds were proposed.)

Fifty transgenic events were evaluated to find the best six to nine for further testing. For B73xH99 hybrid corn, the GDH-transgenic corn was taller and produced 10% higher kernel yield and 10% more plant biomass yield. Partitioning between kernel and plant was not altered, nor were test weight, kernel size or nitrogen content. Therefore, 10% more nitrogen was harvested from the transgenic crop. Maturity dates were three to five days later for GDH-transgenics than non-transgenics, but this was sufficient to explain only about 2% of the yield and harvested nitrogen gain. The 1998 results for all hy-

brids and locations will be analyzed during 1999. Studies will be extended in 1999.

In the greenhouse, differences in vegetative shoot and root growth as represented by herbicide resistance, fresh weight, dry weight and nitrogen content will be evaluated, along with residual mineral N remaining in the soil.

To study herbicide resistance, transgenic corn inbreds containing *pat::gdhA* and *pat* alone were planted (*pat* is the gene used in Liberty-Link™). Leaves were painted four weeks after plant emergence with one, two, three and four times the normal rate of Liberty. Plant injury was not observed with *pat::gdhA* even at four times the normal rate. In contrast, *pat* alone provided resistance only up to twice the normal rate.

Greenhouse studies were used to evaluate transgenic corn growth improvements consequent on *gdhA*. Early growth was evaluated. Root mass, shoot mass, plant height, nitrogen (N) content and free amino acid composition were increased by *gdhA* expression. Therefore, crop yield, N content and efficiency of N utilization are expected to improve under field conditions. Residual mineral N in the soil leachate was determined to be lower in *gdhA* transgenic plants than the controls.

Another series of experiments is aimed at determining the effect of the transgene expression on the pool sizes of amino acids of importance to N transport within the plant. It will contribute information needed to design rational expression patterns for the transgene in agronomically elite corn hybrids.

A C-FAR External Competitive Grants project.

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Nitrogen Fertilizer Alternative for Corn

Resource & Agricultural Management, Inc. (RAM) has developed a process for scrubbing power plant smoke stacks to recover sulfur that is produced while burning Illinois high-sulfur coal.

Currently, the majority of this waste is being vented into the atmosphere. This project is designed to recycle the sulfur and other mineral elements and reclaim them for use as a fertilizer product. The product that is being produced is an ammonium sulfate solution fertilizer of high quality, with an analysis of 16-6-0-8.

RAM has established a pilot plant for scrubbing the smoke stack on the power plant at WIU. In cooperation with Brad Hunt, a farmer, the fertilizer that is generated is applied to 10-acre replicated field plots using large equipment. Anhydrous ammonia and 32% urea ammonium nitrate (UAN) are also applied to corn for comparison in a corn-soybean rotation utilizing no-till. Corn yield is measured with a yield monitor. Comparisons are made from yield maps.

Corn yields using the ammonium sulfate by-product were equal to corn yields using anhydrous ammonia or 32% UAN solution as a nitrogen fertilizer in no-till corn after soybeans in a corn-soybean rotation and in no-till corn after corn on a commercial scale using large equipment after two years of testing. This technology offers a nitrogen source that produces high corn yields while protecting the air we breathe in Illinois.

Gordon Roskamp
Agriculture
Western Illinois University
Brad Hunt, Farmer
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Constructed Wetlands Remove Nitrogen

Three treatment wetlands were constructed to test their effectiveness in removing nitrogen (N) and phosphorus (P) from agricultural tile drainage water.

The wetlands were located between upland crops (corn/soybean) and an adjacent stream. Each wetland was continuously monitored for three water years from October 1, 1994 through September 30, 1997, allowing input/output budgets and removal efficiencies to be determined under a wide range of weather conditions. Most of the N (95% nitrate) entered the wetlands from tiles during winter (30% of all N) and spring (65%). Annual N removal rates varied from 26% to 47% of tile inputs to the three wetlands for the three water years, averaging 36%.

Overall wetland N removal efficiencies were lowered when high tile flow events occurred during cold temperatures in the winter and early spring. When wetlands were combined with the 17 m buffer strip between the berm and the river, as much as 45% of the N may have been removed. Wetlands reduced outlet nitrate concentrations by an average of 42%, and decreased concentrations below the EPA drinking water standard of 10 mg L⁻¹ in all but one of the four wetland/water year combinations where the standard was exceeded. Wetlands did not remove P.

Treatment wetlands can effectively reduce agricultural N loading to surface waters. These wetland systems may provide a simple low-cost method to meet drinking water standards in municipalities of the agricultural Midwest and

to reduce agricultural N loading to the Mississippi River.

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Mercury Export from Constructed Wetlands

Artificial wetlands can effectively consume nitrates in drainage water from Illinois farms, but using them to improve a watershed's water quality would require that many be built.

Before doing so, we need to determine if artificial wetlands have any unintended negative environmental effects.

Wetlands often export more mercury (Hg) to rivers and lakes than upland soils. This Hg comes primarily from waste incineration and coal burning, reaching soils everywhere by rainfall. Our research, conducted at the UIUC constructed wetlands on the Embarras River, suggests that Hg in rain is >95% stripped by soils as the water drains from the fields. But the wetlands do not efficiently retain Hg in rain falling onto them, so they lead to an increase in Hg entering the river. Although wetlands also support anaerobic bacteria that transform part of this Hg into methylmercury (meHg), the artificial wetlands produced little meHg during periods of peak flow.

Although Hg and meHg levels in the wetland waters were far below drinking water standards, fish can accumulate meHg to levels up to 10-million fold over those in the water. In order to avoid harming wildlife and humans that consume fish, planners can use the results of this study to predict the export of Hg to Illinois surface waters from watersheds where the construction of numerous wetlands may be considered.

Robert Hudson
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Livestock Facilities and Groundwater Quality

We have been investigating groundwater quality for nearly two years at two livestock waste lagoons.

The local geology at the sites indicate that groundwater at site A is more vulnerable to contamination than at site C. We have collected 338 groundwater and lagoon samples. More than 25 different bacterial species or strains of species were identified in the samples. Many of the species detected are commonly found in the environment and are not indicators of fecal contamination. Lagoon samples contained fecal coliform, fecal streptococcus and indicator organisms (such as *E. coli*, *Streptococcus faecium* and *Streptococcus faecalis*) used to determine the safety of potable water. *E. coli* was more often detected in groundwater samples at site C (28% of samples) while *S. faecium* and *S. faecalis* were detected more often (38% and 46% of samples) at site A.



Chloride, ammonia, potassium, phosphate and sodium were the predominant constituents in the lagoon samples. Except for phosphate, these constituent concentrations were greater in samples that had been impacted by seepage from the lagoon when compared with background concentrations. Phosphate-P concentrations did not exceed 0.3 mg/L in the groundwater samples even though lagoon concentrations were about 82 mg/L. Site A groundwater samples contained greater concentrations of waste constituents than site C. Contaminants at site A have been detected up to 100 m from the lagoon. At site C, migration has been detected less than 30 m.

Results of this study show the need for regulations to protect groundwater near livestock waste lagoons. The significance of the long-term environmental fate of the bacteria and inorganic contaminants as they move with the groundwater is being evaluated.

A C-FAR External Competitive Grants project.

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Atrazine, Pelletized Limestone for Weed Control

Atrazine is used on 70% to 80% of the 11,000,000 corn acres in Illinois.

The soil pH affects the availability of atrazine in the soil for plant (weed) absorption and microbial breakdown. Limestone must be added to field crops in Illinois because of nitrogen applications and removal of essential nutrients by the growing crop. Pelletized limestone is simply finely ground limestone that can be accurately spread with

commercial equipment. In no-till, both the limestone and the atrazine are left on the surface of the soil where weed control could be enhanced.

In cooperation with Brad Hunt, a farmer, pelletized limestone was applied to the soil at 0, 200 and 400 lb/acre prior to planting corn in a corn-soybean crop rotation on 10-acre plots utilizing commercial application equipment in three replications. Atrazine was applied at recommended rates depending on soil organic matter and clay content. Weed control was evaluated and corn yield was measured.

Weed control was greater in the plots with 200 and 400 lb/acre of pelletized limestone in the first two years of this three-year no-till study. Atrazine is an inexpensive herbicide that provides excellent weed control at recommended rates without the addition of other herbicides that have greater cost to the farmer.

Gordon Roskamp
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Western Illinois University
Brad Hunt, Farmer
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Atrazine Removal by Aquatic Plants

Phytoremediation has been proposed as a method for diminishing the environmental impact of pesticides and herbicides.

In this project, we examined native Illinois aquatic plants, in particular those that grow in a flowing, shallow water environment and form the so-called drainage channel plants. Our approach was to determine the rate of uptake of herbicides by several plant species

under greenhouse conditions. In our studies this year, we grew aquatic plant specimens (either collected from nature or purchased commercially) in the presence of various concentrations of the herbicide atrazine, which is a groundwater and drinking water contaminant of major concern.

To date, we have performed experiments with several species: *Ceratophyllum demersum* (hornwort), *Cyperus strigosus* (sedge), *Eleocharis obtusa* (spikerush), *Elodea canadensis*, *Juncus spp.* (rush), *Jussiaea repens* (water primrose), *Polygonum hydropiper* (smartweed) and *Sagittaria latifolia* (arrowhead). Of the eight species, the most effective by a wide margin was *Ceratophyllum*. This bushy, floating plant is an inhabitant of ponds and slow-flowing streams throughout Illinois.

In contrast to earlier model stream experiments that show a half-life of eight to 14 days for atrazine, our studies with *Ceratophyllum demersum* indicated uptake of 50-ppb atrazine with a half-life of three to five days. Similarly, *Jussiaea repens* took up atrazine with a half-life of six to seven days. (Substrate materials, gravel and pressed clay also adsorbed some atrazine, but at significantly slower rates.)

Hornwort has a very large leaf area per gram of biomass, a characteristic similar to that of a subtropical aquatic species, parrotfeather (*Myriophyllum aquatica*), that has been studied by Jeffers and Wolfe at the USEPA Athens laboratory. The results suggest that hornwort could be used as part of an overall management strategy for reducing the impact of herbicide exposure.

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Herbicide Fate in Saturated Soils

Herbicide behavior in anaerobic environments is important to crop production strategies and environmental stewardship.

Illinois cropland receives seasonally large amounts of rainfall which lead to soil flooding. Saturated soils are oxygen-free (anaerobic). We studied degradation of the commonly-used herbicides atrazine, dimethenamid and trifluralin in flooded soil microcosms. The microcosms represented conditions a herbicide would encounter in flooded soils as well as in drainage ditches and freshwater sediments. The design of our study was compared with the design of the anaerobic study required by the Environmental Protection Agency (EPA) for herbicide registration.

We found that the EPA design created a very different microbial environment than exists in nature, which confounds herbicide fate predictions. Since microbiology is very important to herbicide fate, we feel that the EPA protocol should be modified to represent environmental conditions.

Results of herbicide degradation showed that more than 90% of applied herbicides were unrecoverable after six months, and most had degraded to metabolites in less than one month.

The metabolites were not very soluble in water and would not be expected to pose a threat to water quality. The time required for 50% of herbicide degradation was three weeks for atrazine; two weeks for dimethenamid; and one week for trifluralin. Anaerobic microbial metabolism accelerated herbicide degradation, but chemical degradation of herbicides also occurred. More than 50% of the applied herbicides

became irreversibly attached or "bound" to the soil.

Our findings, that herbicides degrade to nonbioactive levels in anaerobic flooded soils, contradict the popular belief that herbicides persist in anaerobic environments.

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Effects of Rotation, Fertilization Practices on Soil

The objectives of this project are to identify the general effects of crop rotation and fertilization practices on soil microbiology and labile organic matter and the relationship between these properties and soil biological and physical condition.

Management of soil organic matter may be the only way that we can maintain or even increase the productive capacity and environmental integrity of our agricultural systems for the long-term. Research suggests that the organic matter that contributes most to soil productivity is relatively young in age; this means that organic matter quality could be managed on a reasonable time scale.

Soil samples were collected from the Morrow plots in 1997 and from individual farm fields (1997 and 1998) during the year corn was grown. We sampled 28 farm fields that have had a history of conventional or no-tillage practices and

that use either two-year or multi-year crop rotations. A variety of direct and indirect measures of the total and active microbial community and soil organic matter are being used to assess the validity of proposed microbial indices of soil quality. To date, simple bacterial to fungal ratios have not provided conclusive information about soil condition. Measures of substrate utilization are sensitive to field management and tillage history but are difficult to relate to soil condition in a predictive manner.

These and yet-to-be completed measures of labile soil organic matter will be correlated with soil properties (quantified in 1997 and 1998) and measures of soil performance (to be assessed in 1999). This strategy will contribute to the identification and development of soil quality assessment tools adapted for individual and/or commercial use.

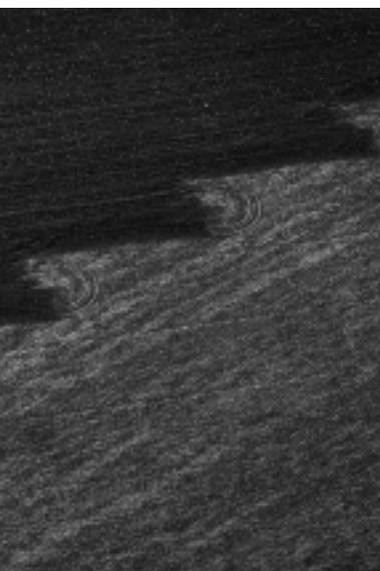
A C-FAR External Competitive Grants project.

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Surface Chemistry of Soil Clay Minerals

The electrical charge of iron in clay minerals potentially exerts a dominant influence on soil behavior with respect to water-holding capacity, plant-availability of potassium fertilizers, pesticide degradation and fate of heavy metals.

How iron does this is still poorly understood. A better under-



standing would enable the design of soil management practices to deal more successfully with many problems in agriculture and the environment. Clay minerals assert their influence because of their large, chemically-active surfaces. So, iron undoubtedly must affect the surface in some manner. The purpose of this study was to discover how.

Clays are comprised of individual layers, each consisting of four parallel planes of negatively-charged oxygen ions. These ions are neutralized mostly by much smaller and positively-charged silicon, aluminum and iron ions occupying the gaps between oxygens within the layer. Except iron, these ions have a fixed charge which can change between 3+ and 2+. In the soil, this happens by natural bacterial activity.

In this study, application of highly sophisticated X-ray and infrared spectroscopic techniques revealed that if the charge on iron is reduced from 3+ to 2+, the iron changes its location, water molecules become tightly bound and distances between metal and oxygen ions change within the clay layer. These alterations in chemical structure drastically change the bond angles and energies that tie the clay layer together, which in turn modify the factors that control surface chemistry, namely, electronic orbitals in and the geometric configuration of surface oxygens.

These results and methods will now be used to test a variety of common clays to discover patterns and general principles that can be converted to practical use.

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Soil Factors Influencing Yields

The objective of this research is to evaluate soil characteristics that affect crop yields in nearly level southern Illinois fields that have a claypan.

The one soil property that most consistently correlates with yield is soil thickness above the claypan. Generally, the thicker the soil above the claypan the higher the yield. The greater soil thickness allows root systems of crops to expand into larger soil volumes for water and nutrient uptake.

Higher and lower yields were less related to fertility differences in the field. Soil moisture for crops, either a deficiency during droughts or an excess during wet years, appeared to be the major limiting factor to final yields. There was an inverse relationship of electrical conductance (EM38 meter readings) with depth to the claypan at this study site, but the relationship did not hold at other southern Illinois field sites.

The impact of these results to producers will be the necessity to expand the rooting depth of crops by deep tillage or the removal of excess water by improving land drainage. Future research will focus on management practices (which may be different) that will increase the production potential of historically higher yielding and lower yielding portions of fields.

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Landscape Waste Application

Researchers have uncovered evidence that leaf waste from municipalities can be applied to fields of corn with beneficial side effects for the soil.

Leaves collected from Normal, Illinois, were applied to 24 experimental corn plots at the Illinois State University farm for three consecutive years. Leaf depth ranged from 0 to 9 inches, with each depth being replicated six times per year.

Yields did not differ among treatments in 1996 or 1997, but percent moisture of corn was greater for 9-inch plots than for 0- or 3-inch plots in 1997. Based upon soil analysis, there were significant differences in Bray P1 phosphorous, Bray P2 phosphorous, calcium, cationic exchange capacity, magnesium, organic matter and soil pH among treatments in 1997. Significant changes from 1995 to 1997 were observed for magnesium and organic matter.

In June and July 1997, soil samples were collected at 1-foot intervals to a maximum depth of 5 feet, and percent moisture was computed and compared across treatments. Figures for June showed significant differences in percent moisture among treatments at depths of 1 foot and 5 feet. Figures for July showed significant differences in percent moisture at depths of 1 foot, 3 feet and 4 feet. The results suggested that leaf application can enhance soil moisture retention, even at depths of 5 feet.

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Agriculture
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Vegetable Production Sustainability

The objectives of our project were to improve communication between researchers and the vegetable industry, increase on-farm research and improve a reduced-tillage rye cover crop mulch system for producing vegetables.

During the winter 1997-98, the Fruit and Vegetable Industry Research Advisory Board met three times and discussed research priorities, research during the summer of 1997 and research for summer 1998. Plans are to continue the Advisory Board next year.

In the summer of 1998, we established on-farm research plots in Collinsville (horseradish), Havana (snapbeans and pumpkins), Morton (pumpkins) and Cissna Park (sweet corn). Each of these on-farm experiments was planned with U of I Extension and growers from the area. The on-farm portion of our project will make the vegetable industry more competitive and could increase the opportunities for Illinois agriculture to diversify.

In the third portion of our project, we evaluated strip tillage as a technique to improve snapbean and processing pumpkin yields in a rye cover crop mulch system. On average, yield loss was 63% in rye mulch without strips and 20% in rye mulch with strips, compared to conventional tillage with a pre-emergent herbicide (CT). Soil bulk density was higher, leaf nitrogen content lower and potato leafhopper populations reduced in the rye treatments compared to the CT. The soil compaction and nitrogen tie-up may have reduced plant growth.



The strip tillage, where a rye cover crop is planted in the fall and killed in the spring, will reduce the need for pesticides and protect the soil. Further research is continuing to develop better yielding strip-tillage strategies for snapbeans.

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Sustainability, Efficiency of Agriculture

The Sustainability and Efficiency of Agriculture in Central Illinois (SEACIL) project began in late 1997.

We developed collaborations with seven central Illinois farmers with a wide range of experiences and approaches to farming. We are also analyzing three years of Stewardship Farm data to study nutrients, energy and dollars in the system. We created a computer database, selected the questions that needed to be asked, met with the collaborators and started collecting data.

Through our collaborator interview process, we have documented the framework of fields, livestock groups, tillage practices and rotations, equipment and structures that each farmer works within. We are using the database of farmer-supplied information and maps to schedule soil sampling. Intensive soil sampling will measure total nutrient stocks (N, P, K, bulk density), which are not measured in typical sampling performed by farmers.

We held three study circle meetings in Taylorville. They were well attended by our research team,

farmers, U of I Extension, Natural Resources Conservation Service and Soil and Water Conservation District representatives, and citizens. The study circle activities will continue for the purposes of sharing new points of view and educating our research team.

We have developed the groundwork for data collection and analysis that will allow society to view agricultural systems and farms in new ways that focus on sustainability and conservation of resources.

A C-FAR External Competitive Grants project.

David Onstad
Natural Resources and Environmental Sciences
College of Agricultural, Consumer and Environmental Sciences
University of Illinois at Urbana-Champaign

Pesticide-free Production on the Allison Farm

The public wants water to be free of pesticides and fertilizers and food to be pure.

The viability of agriculture in western Illinois depends on the economical production of crops and livestock with minimal threat to the environment. The practical importance of this research lies in the development of farming options that implement cropping systems that do not rely on pesticides. If this objective can be accomplished, it will enhance farmer income by reducing their capital inputs while helping them to preserve productivity of the soil and protect the environment. Furthermore, markets for organic and/or pesticide-free foods are expanding; Illinois farmers should be empowered to benefit from these economic opportunities. Several Illinois grain

elevators are contracting for “maintained identity” specialty crop markets.

The WIU Agriculture Department initiated research on a pesticide-free, limited-fertilizer farm near campus. Our strategies are to keep it pesticide-free, find ways to control weeds and other crop pests, evaluate cropping and tillage practices and determine the economic feasibility of pesticide-free or “organic” crops in western Illinois.

We are preserving a “benchmark” field laboratory for fundamental evaluation of soil health. We have maintained a unique pesticide-free farm as a laboratory for future research into the fundamental properties and relationships of cropping and tillage practices to soil health. We have begun to compare ridge-till and conventional tillage in two different cropping systems.

In 1997, we demonstrated that weed control of giant foxtail, velvetleaf and Pennsylvania smartweed was improved in ridge-tilled soybeans. Volunteer corn was a serious problem in conventional-tilled soybeans, but was eliminated in ridge-tilled plots. The first year of a soybean planting-date study, weed control was easier at later planting dates; however, the highest yields occurred with the two earliest planting dates.

Since 1996, this project has been supported with a grant from C-FAR, augmented by a Conservation 2000 grant (1996–98), Illinois Soybean Program Operating Board discretionary funds (1997–98) and supported from several regional and local private businesses. We have involved local farmers and members of the agricultural industry in identifying research needs, planning, conducting and supporting the research. Local farmers have participated through lending or leasing equipment and donation of time. Seed and machinery compa-

nies have provided resources gratis or at reduced rates.

Gerald Vigue, Tim Howe
Agriculture
Western Illinois University

Global Warming: Changes in Carbon Dioxide Levels

Over 12 weeks, tall fescue yield increased 10% to 62% under elevated CO₂, depending on the level of nitrogen (N) supplied to the plants.

The plants had an average 22% less crude protein (CP) and that CP was 13% less digestible under elevated CO₂. Adding more N made matters worse rather than better. The CP was 23% less digestible under elevated CO₂ in the high N treatment. The endophytic fungus had little or no effect on tall fescue growth, but the fungus did alter the plants’ N metabolism.

The changes in CP reported above are still evident in fungus-infected plants, but the response is muted. We found no changes in the levels of plant alkaloids produced by the fungus under elevated CO₂. Aphids feeding on tall fescue grown in elevated CO₂ had a 300% higher transmission rate for barley yellow dwarf virus when compared to aphids feeding on tall fescue grown under ambient CO₂.

We are currently considering whether aphid population sizes will be different under elevated CO₂ in response to the changes in the plant quality reported above. We are also investigating whether aphid feeding behavior differs in response to the changes in plant quality under elevated CO₂. We are examining whether the number of probes, feeding bouts and the duration of feeding bouts change under el-

evated CO₂. The results may have important consequences for crop damage and disease spread in the future.

J. A. Newman
Zoology
David Gibson
Plant Biology
R. Dado
Animal Science, Food and Nutrition
College of Agriculture
Southern Illinois University-
Carbondale

Manure Treatment Using Zebra Mussels

The objective of this research is to develop a flow-through biological filter using zebra mussels to remove solids and nutrients from the liquid portion of swine waste.

Experiments were conducted that confirmed previous findings: In small containers of dilute manure (<1%), mussels were able to improve turbidity by 95%, reduce COD by up to 87% and reduce total nitrogen (57%) and total phosphorus (59%) within 48 hours. Reductions in ammonia levels were also seen.

During large-container trials, slight reductions in the effectiveness of the mussels were observed due to the design of the containers. However, the mussels were still able to significantly reduce turbidity (75%). *E. coli* bacteria counts were also conducted in these trials, with the mussels removing 90% of the bacteria. In other trials, dilute manure was replaced daily. These indicated good survivability under constant manure loading.

Two types of flow-through chambers were designed and prototypes constructed. Initial trials



with the first of these prototypes showed good mussel survival and significant reductions in turbidity as the manure passed through the chambers (up to 95%). This research shows the use of zebra mussels as part of a biological filter has promise as a method of swine waste treatment. This would benefit the Illinois pork industry and help it to remain competitive.

Richard Steffen, R. Dado, Todd Winters, Bruce Jacobson
Plant, Soil and General Agriculture
College of Agriculture
Southern Illinois University-
Carbondale



Biofilters to Control Swine Odor

Previous researchers have identified over 200 compounds in swine odor.

Swine odor is found in two fractions: odors adsorbed to dust and odors in the gaseous phase. Previous research claims that 80% of odor is associated with the dust fraction. Effective operation of a biofilter requires gaseous adsorption followed by biodegradation by microbes. In order to evaluate a biofilter properly, efficient removal of the dust fraction is necessary. Presently, we are in the final stages of evaluating a wet scrubber for dust removal. After this testing, biofilter testing will begin.

The present design includes the use of large, slow-degrading wood chips for media. This media reduces the negative effects on existing fans that finer materials produce. Also, the lifetime of the material is substantially longer compared to other types of materials.

The testing of the biofilter will begin with the determination of the optimal retention time required

for effective odor removal. This test will involve three biofilters with different retention times (one, two and four seconds) treating the wet scrubber effluent from the same fan. If these short retention times do not reduce odor substantially, longer times will be evaluated. Odor samples will be compared by a simple sniff test.

A C-FAR External Competitive Grants project.

Roderick Mackie
Animal Sciences
College of Agricultural, Consumer
and Environmental Sciences
University of Illinois at Urbana-
Champaign
Raj Mirpuri
Braun Intertec Corp.

Microbial Removal of Hog Slurry Odor

Annual production of more than 5.6 million pigs can result in 2.044×10^{10} lbs of manure per year that requires disposal.

Odor control and disposal of swine waste has inhibited the expansion of production facilities and resulted in increased regulatory control. Swine slurry odor is caused by soluble branched and straight chain volatile fatty acids (VFAs), as well as sulfur-containing compounds released due to the hydrolytic activity of bacteria. The objective of our research is to develop an alternative strategy for the treatment of odors emanating from swine waste lagoons. Our research takes advantage of the unique metabolic characteristics of Fe(III)-reducing bacteria (FeRB).

FeRBs in samples freshly collected from the swine waste lagoons at an SIUC swine facility were enumerated by most probable number

techniques using two different media and four different carbon and energy sources to account for different metabolic capabilities of the organisms and reduce bias in the procedure. The results show that the FeRBs represent a significant population in the swine waste lagoons. From our initial studies, certain conclusions are indicated for year one of this study:

- Fe(III)-reducing bacteria are present in swine waste lagoons in significant quantities.
- A novel FeRB was isolated from the swine waste lagoon and partially characterized.
- Fe(III)-reducing bacteria can degrade many of the individual organic components known to cause the odor in swine wastes.
- Fe(III)-reducing bacteria can grow by the degradation of odor causing components of swine waste.
- The growth of the swine waste FeRBs and the degradation of the odor-causing agents is limited by the supply of Fe(III) to the indigenous populations.
- Fe(III)-reducing bacteria do not degrade thiols.

John D. Coates
Microbiology
Brian Klubek
Plant, Soil, and General Agriculture
College of Agriculture
Southern Illinois University-
Carbondale

Thermal Depolymerization of Swine Manure

A batch thermochemical conversion (TCC) reactor was developed in March 1998.

The reactor is capable of handling pressures up to 1900 psi and temperatures up to 350°C. We conducted several testing runs to examine the temperature and pressure responses of the TCC process. Data collection was scheduled from May 1998. Due to the difficulties in handling manure and sanitation of the experimental apparatus, the TCC reactor was relocated from South Farm Building 970 to the Animal Environment Laboratory Building 825. In late May, a lightning strike destroyed the building and the TCC reactor.

With the help of the department, College of ACES and the UIUC campus, we were able to modify the design and place an order of the fabrication of a new TCC reactor in early July, six weeks after the lightning incident. The full experiment and data collection resumed in the fall. The setback caused by the lightning strike is approximately four to six months, including a test run of the reactors.

Y. Zhang, T. Funk, G.L. Riskowski, L.L. Christianson

Agricultural Engineering

R. Mackie, M. Tumbleson

Animal Sciences

College of Agricultural, Consumer and Environmental Sciences

University of Illinois at Urbana-Champaign

Composting Swine Carcasses

Producers have begun composting swine carcasses as an alternative to having them rendered.

This research focuses on materials to compost these carcasses efficiently and economically.

Three composting materials have been evaluated: straw, wood

chips and shredded paper. Wood chips are the commonly recommended material, thus it is considered a base material. Straw is cheap and readily available to farmers. Shredded paper was used because it is recycled.

Preliminary analysis of three replications shows that while straw is poor in its composting ability, the shredded paper appears superior to wood chips. Since shredded paper is available at no cost from most hospitals and other facilities with large administrative departments, it would appear to be a cheap and efficient alternative to wood chips for swine producers to use as a composting material.

John Carlson
Agriculture
Western Illinois University

Rural Family Program

During 1996-98, researchers with the Rural Family Program (RFP) conducted practical, applied research that promoted the well-being of rural families and furthered the development of human and social capital in rural communities.

RFP research projects fostered rural human and family development by determining needs for rural child care and recommending policies to improve availability; identifying successful characteristics of adults working with rural youth groups and developing leadership recommendations; specifying the unique needs of rural families adopting children with special needs and recommending policies to assist these families; and assessing factors affecting

volunteerism in rural schools and offering strategies for the implementation of successful school-based programs.

RFP researchers developed programs specifically tailored to the unique contexts of rural communities. These included programs designed to increase the availability of non-professional sources of support in rural communities; teach coping strategies and non-violent conflict resolution to rural children growing up in violent families; increase parent involvement in rural schools; and help rural children cope with the grief of family loss.

RFP researchers also designed educational and training materials; used the materials to train more than 200 rural teachers, social workers and rural human service professionals; and provided direct experience in applied rural research to numerous graduate and undergraduate students. These research and training efforts increased the sustainability of rural communities by increasing their capacity to engage in practical, successful actions that foster the healthy development of rural children and families.

Joseph H. Pleck, Laurie Kramer
Human and Community Development

College of Agricultural, Consumer and Environmental Sciences
University of Illinois at Urbana-Champaign

Paternity and Welfare Reform in Rural Counties

The Personal Responsibility and Work Opportunity Reconciliation Act of 1996, a federal welfare reform measure, requires states to adopt several new provisions in child support enforcement.



This project considers various issues surrounding the cooperation of welfare applicants with the child support enforcement provisions about establishing paternity and obtaining child support awards for children born out of wedlock.

In the past year, through multiple meetings with representatives of the Illinois Department of Public Aid, we learned about the administrative procedures and databases of the state and how they differ between rural and urban offices. We conducted descriptive analyses of data on the welfare caseload as of June 1997, by race and marital status.

We found that the racial breakdown of the caseload in the state overall is approximately two-thirds black and 10% Hispanic. By contrast, in the 20 central Illinois counties in this study, the racial breakdown is nearly two-thirds white and less than 1% Hispanic. This differs by county, with the more urban counties, such as Champaign, Macon and Peoria, more closely approximating the overall racial breakdown of the state.

By marital status, about 60% of the overall caseload is unmarried (70% of blacks), whereas in central Illinois 50% is unmarried. Again, this differs between urban and rural counties, with a higher percentage unmarried in the more urban counties of Champaign, Macon, Peoria and Sangamon.

Andrea H. Beller
Agricultural and Consumer
Economics
College of Agricultural, Consumer
and Environmental Sciences
University of Illinois at Urbana-
Champaign



Barriers to Rural Prekindergarten At-risk Programs

A variety of barriers to the creation of family-school-community partnerships in rural prekindergarten at-risk programs have been identified from data collected during year one of the project.

Several common themes were identified from interviews with family members, school personnel and community stakeholders in terms of the perceived benefits from prekindergarten at-risk programs (such as socialization of children, getting families invested in the school system and improving attitudes towards schooling), yet several differences emerged when exploring barriers to partnerships in these programs.

Parents identified such issues as transportation, tension between schools and families, scheduling and child care problems as major barriers to creating partnerships. In contrast, school personnel identified such issues as poorly educated and informed parents, parents who do not care and a lack of cooperation from families as major barriers to partnerships being established.

Issues identified by community stakeholders paralleled those expressed by school personnel with one major difference: a general lack of awareness of the functions of prekindergarten at-risk programs in their communities and how community members can be involved in creating partnerships with these programs and family members being served. Differences also emerged in the barriers identified by parents, school personnel and community stakeholders based on rural community type (that is,

farming-dependent versus manufacturing-dependent).

Knowledge gleaned from year one data is being used to develop a set of recommendations for school personnel and community leaders on strategies for establishing partnerships in these rural prekindergarten at-risk programs.

Brent A. McBride
Human and Community Development
Joyce Allen-Smith
Agricultural and Consumer Economics
College of Agricultural, Consumer and Environmental Sciences
University of Illinois at Urbana-Champaign

Fiscal Year 1999: C-FAR Internal Competitive Grants Program

'99

Internal competitive grant programs at the University of Illinois at Urbana-Champaign (UIUC), Southern Illinois University-Carbondale (SIUC), Illinois State University (ISU) and Western Illinois University (WIU) support C-FAR research projects on the following topics in FY 99 (July 1, 1998-June 30, 1999):

FY 99 Projects

Principal Investigator

Research Focus:

Expanding Markets for Agricultural Products

Rendement Napole Gene Effects on Growth, Carcass, Meat	Floyd McKeith, UIUC
Food Packaging Research Program	Scott Morris, UIUC
Processing, Structural Characterization of Zein-based Films	Graciela Padua, UIUC
Enhancing Nutritional Value of Corn Wet Milling	Kent Rausch, UIUC
Developing a UIUC Food, Brand Research Laboratory	Steven Sonka, UIUC
Producing, Marketing Free-range Poultry	Randall Westgren, UIUC
Transformation of Sterols from Soybeans	John D. Haddock, SIUC
Improved Propagation Efficiency for Illinois Nurseries	Paul H. Henry, SIUC

Research Focus:

Promote Economic Development in Illinois

Farm Land Control, Agricultural Competitiveness	Peter Barry, UIUC
Financial Entry Barriers for Farmers	Paul Ellinger, UIUC
Managing the New Western Corn Rootworm Strain	Michael Gray, UIUC
Evaluating Performance of Market Advisory Services	Scott Irwin, UIUC
Rural Human, Family Development Research	Joseph Pleck, UIUC
Estimating, Calibrating Farm Risk Measures	Bruce Sherrick, UIUC
Food on the Internet	Michael Ward, UIUC
Improving Grape Propagation	John Preece, SIUC
Impact of Ag in the Classroom (AITC)	Jeff Wood, ISU
Evaluating the Illinois Horticulture Industry	Tina Cade, ISU

Research Focus:

Increase Agriculture's Capacity to Meet Changing World Food Demands

Neurochemistry of Growth and Leptin	J. Lee Beverly, UIUC
Equipment for Dairy Farm	Jimmy Clark, UIUC
Conference on New, Reemerging Infectious Diseases	Roberto Docampo, UIUC
Minimizing Protein in Transition Dairy Cow Diets	James Drackley, UIUC
100 Generations of Selection for Corn Oil, Protein	John Dudley, UIUC
Developing an Amino Acid Flow Model	Robert Easter, UIUC
Automated Animal Data System	Michael Ellis, UIUC
Improving Pig Pen Design Efficiency	Michael Ellis, UIUC
Data Acquisition, Analysis for Site-specific Management	Carroll Goering, UIUC
Gray Leaf Spot, Rust Resistance in Forages	Andrew Hamblin, UIUC
Impact of Weed Competition on Corn Yields	Stephen Hart, UIUC
Amino Acid Transport, Use in Porcine Mammary Gland	Walter Hurley, UIUC
Use of Parasitoids Against Muscoid Cattle Pests	Carl Jones, UIUC
Molecular Markers for Wheat Scab Resistance	Frederic Kolb, UIUC
Linkage Map for the Vf Gene for Scab Resistance	Schuyler Korban, UIUC
Manipulating Amino Acid Supply in Cattle	Neal Merchen, UIUC
Oocyte Penetration: An Indicator of Sperm Fertility	David Miller, UIUC
Economics of Control/Prevention of Enzootic Pneumonia	Gay Miller, UIUC
Improving Phosphorus Utilization in Poultry and Swine	Carl Parsons, UIUC
Control of Stewart's Wilt in Sweet Corn	Jerald Pataky, UIUC
Cooling Pads for Reducing Heat Stress in Sows	Gerald Riskowski, UIUC
Expert System for Site-specific Weed Management	Lei Tian, UIUC
Use of Transgenic Corn to Control Ear Rot, Mycotoxins	Donald White, UIUC
Study of Glyphosate Resistance Mechanisms	Jack Widholm, UIUC
Soil Properties and SDS in Soybeans	S.K. Chong, SIUC
No-till Summer Squash Production	Alan Walters, SIUC
Spray-dried Porcine Plasma in Weaning Pigs	Gary A. Apgar, SIUC

FY 99 Projects

Principal Investigator

Enhancing Soybean Inoculation to Maximize Yields	Brian P. Klubek, SIUC
Ovarian Granulosa Cell Health: Subfertility in Cattle	H.D. Woody, SIUC
Automated Disease Protection in Food Crops	David Lightfoot, SIUC
Soy Phytoestrogens and Swine Reproduction	Todd Winters, SIUC
Transplantation of Spermatozoa in Livestock	Carl Hausler, SIUC
Nutritional Quality of Transgenic Corn	Gary Apgar, SIUC
Female Swine: Factors Affecting Reproductive Efficiency	Robert D. Arthur, SIUC
Mapping SDS, Soil and Site Factors	S.K. Chong, SIUC
Swine Odor Control in Lagoons	Charles B. Muchmore, SIUC
Processing Swine Waste to Control Odor, Increase Value	Paul Walker, ISU
Enhancing Research Capacity	Rob Knox, ISU
Evaluating Yields, Fertilizer Use with Variable Rate Technology	Kevin Baker, ISU
Precision Farming Adoption Rates, Profit Impact	Pat O'Rourke, ISU
Costs of Extending the Beef Grazing Season	Teresa North, WIU
Rotational Grazing for Sheep	John Carlson, WIU
Evaluating Central Ram Testing Records	John Carlson, WIU
Plastic Mulch Effects on Fresh-market Tomatoes	Marietta Loehrlein, WIU
Investigation of Callipyge Lambs	John Carlson, WIU

Research Focus:

Improve Human Nutrition, Food Quality and Food Safety

Developing Salmonella Vaccines for Chickens	Janice Bahr, UIUC
Decreasing Body Fat with Conjugated Linoleic Milk Fat	Angela Beaulieu, UIUC
Improving Soybean Health Using Fungal Endophytes	Weidong Chen, UIUC
A Novel Rheometric Method for Extruded Food	James Faller, UIUC
Sequence, Genetic Analysis of Agrobac Plasmid	Stephen Farrand, UIUC
S-methylcysteine Effects on Estrogen-induced Tumors	Timothy Garrow, UIUC
Soy and Cardiovascular Health	David Gross, UIUC
Chemical Identification, Genetic Regulation of Broccoli Flavor	John Juvik, UIUC Barbara Klein, UIUC

Soy Isoflavones and Breast Cancer Prevention	Keith Singletary, UIUC
Neonatal Intestinal Function and Resistance to Diarrhea	Kelly Tappenden, UIUC
Soybeans and Cardiovascular Risk	William Banz, SIUC
Inhibiting Bacterial Attachment with Sugars	Sheryl S. King, SIUC
Alternatives to Antibiotics in Animals	Sheryl S. King, SIUC
Household Food Practices, Safety Concerns	Martha Barclay, WIU

Research Focus:

Advance Sustainable Use of Natural and Human Resources

Particle Image Velocimetry to Study Ventilation Patterns	Yuanhui Zhang, UIUC
Conference: Agriculture in the Global Ecosystem	Daniel Anderson, UIUC
Effectiveness of Controlled Drainage on Poorly Drained Soil	Richard Cooke, UIUC
Soil Nitrogen Sources in Corn, Soybean	Mark David, UIUC
Identifying, Reducing Sources of Nitrates in Water	Robert Hoeft, UIUC
Constructed Wetlands, Water Table Management Effects	Robert Hudson, UIUC
Conservation Reserve Enhancement Program	Madhu Khanna, UIUC
Nitrogen Management Effects in the Little Vermilion River	J. Kent Mitchell, UIUC
Integrating Wildlife Management as a Conservation Strategy	Richard Warner, UIUC
Microbial Removal of Swine Slurry Order	John D. Coates, SIUC
Zebra Mussels in Flow-through Waste System	Richard Steffen, SIUC
Evaluation of Site-specific Management	E.C. Varsa, SIUC
Reducing N Runoff in Corn	David Lightfoot, SIUC
Fertilizer Management to Optimize Water Quality	Ken Smiciklas, ISU
Impact of Landscape Waste Application to Corn	Rick Whitacre, ISU
Increasing Embryos and Litter Size in Swine	Robert Knox, ISU
Pesticide-free Crop Production	Gerald Vigue, WIU
Pesticide-free, Organic Row Crop Production Economics	Rick Hirschi, WIU

Fiscal Year 1999: C-FAR External Competitive Grants Program



The C-FAR External Competitive Grants Program supports projects on the following topics in FY 99 (July 1, 1998-June 30, 1999):

FY 99 Projects

Principal Investigator

Research Focus:

Expand Markets for Agricultural Products

“Quick Fiber” Process to Enhance Ethanol Profitability	Steven Eckhoff, UIUC
Corn Hybrids for Efficient Starch Processing	Kent Rausch, UIUC
Biodegradable Polymers from Soy Oil and Soy Molasses	Michael Madigan, SIUC
Added Value from Trait-specific Corn	Dennis Thompson, Illinois Crop Improvement Association

Research Focus:

Promote Economic Development in Illinois

Breeding Horseradish to Increase Yields, Resist Disease	Robert Gerstenecker, UIUC Andrew Hamblin, UIUC
Creation of a Branded Product in a Commoditized Industry	Richard Knipe, UIUC
Automatic Oil Sprinkling System for Swine Facilities	Yuanhui Zhang, UIUC
Pastured Feeder Lamb Competitiveness	Charles Cavaness, DeKalb County Lamb and Wool Producers
New Foundation for Sustainable Apple Growth	Bradley Taylor, SIUC

Research Focus:

Increase Agriculture’s Capacity to Meet Changing World Food Demands

Hoop Structures: Alternative Life Cycle Pork System	Gilbert Hollis, UIUC
Development of Added Value High Oil Corn Hybrids	Robert Lambert, UIUC
Automated Disease Diagnosis in Crops	David Lightfoot, SIUC
Mechanisms of Toxin Tolerance to SDS in Soybean	Oval Myers, SIUC
Transplantation of Spermatogonia in Livestock	Lonnie Russell, SIUC

Research Focus:

Improve Human Nutrition, Food Quality and Food Safety

Technology Assisted Intergenerational Nutrition Education	Jim Painter, UIUC
Soy Protein and Soy Phytoestrogens	Andrzej Bartke, SIUC
Producing Beta-sitosterol from Soybeans	John Haddock, SIUC
Controlling Listeria Monocytogens in Food	Brian Wilkinson, ISU
Genetic Mapping of Soybean Phytoestrogen	Todd Winters, SIUC

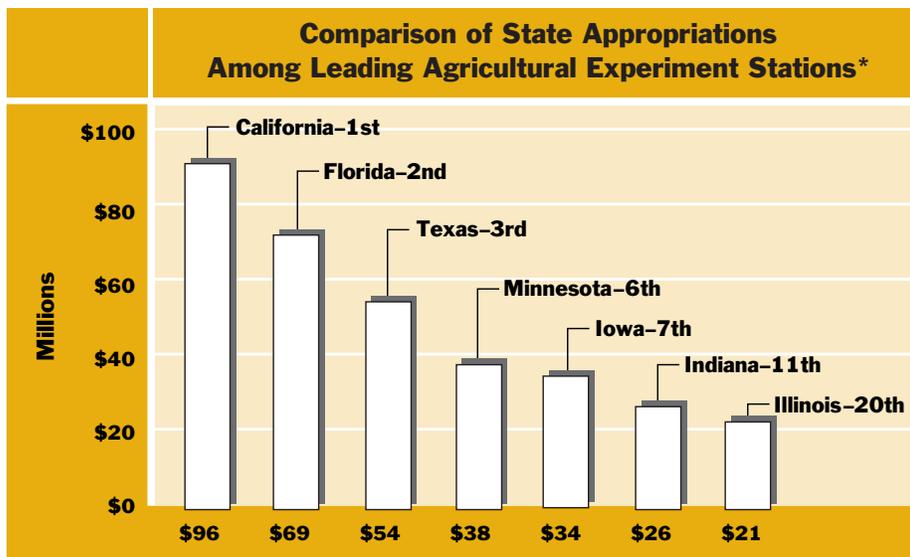
Research Focus:

Advance Sustainable Use of Natural and Human Resources

Edible Coverings to Protect Hay	Larry Berger, UIUC
Aerial Infrared Mapping of Subsurface Drainage Systems	Richard Cooke, UIUC
Groundwater Quality Near Livestock Waste Pits, Lagoons	Ivan Krapac, UIUC
Lake Springfield Watershed Management Practices	Troy Lively, Sangamon County Soil and Water Conservation District
Evaluation of Site-specific Management Practices	Edward Varsa, SIUC

How Illinois Compares

The Illinois food and agricultural sector formed C-FAR in late 1994 out of concern that Illinois ranked 29th in state support for food and agricultural research compared to other states. Through the efforts of C-FAR, state funding to research in fiscal year 1998 increased to \$12 million, moving Illinois to 20th place.



* Information in this illustration is based on anticipated FY 98 expenditure data. The current (FY 99) C-FAR appropriation of \$12 million could move Illinois to 15th in the nation in state government funding for food and agricultural research.

**Illinois Food and Agriculture Research Act: FY 98 Allocations
(July 1, 1997 - June 30, 1998)**

C-FAR Research Objectives	Internal Grant Program						External	Per Legislation	Total Allocations by Objective
	UIUC 82%	SIUC 11%	ISU 4%	WIU 3%	Total University Allocations	% Allocations to Research Universities	Competitive Grant Program		
Expand markets for agricultural products	985,680	86,000	0	0	1,071,680	14.22%	344,000		1,415,680
Promote economic development in Illinois	359,177	25,000	24,000	0	408,177	5.42%	82,500		490,677
Increase agriculture's capacity to meet changing world food demands	2,451,241	262,084	100,330	61,506	2,875,161	38.16%	263,000		3,138,161
Improve human nutrition, food quality and food safety	1,155,087	66,000	0	34,732	1,255,819	16.67%	410,770		1,666,589
Advance sustainable use of natural and human resources	1,073,958	216,500	132,798	118,934	1,542,190	20.47%	229,480		1,771,670
Research Support	85,000	28,658	0	0	113,658	1.50%			113,658
Research Discretionary	68,762	144,635	29,929	122	243,448	3.23%			243,448
Indirect Cost	0	0	14,353	10,764	25,117	0.33%			25,117
1% Member Expense								90,000	90,000
IDOA Fee								45,000	45,000
Total \$	6,178,905	828,877	301,410	226,058	7,535,250	100%	1,329,750	135,000	9,000,000

**FY 98 C-FAR Expenditure Summary Report by C-FAR Research Objective
(July 1, 1997 - June 30, 1998)**

Actual Fiscal Year Expenditures							
C-FAR Research Objectives	Internal				External	Per Legislation	Total
	UIUC	SIUC	ISU	WIU			
Expand markets for agricultural products	685,206	75,847	14,114	0	214,680		989,847
Promote economic development in Illinois	393,760	16,593	0	0	63,460		473,813
Increase agriculture's capacity to meet changing world food demands	1,685,003	212,885	95,582	61,506	181,408		2,236,384
Improve human nutrition, food quality and food safety	731,867	58,276	0	34,732	286,238		1,111,113
Advance sustainable use of natural and human resources	927,037	201,585	127,318	118,934	125,560		1,500,434
Subtotals	4,422,873	565,186	237,014	215,172	871,346	0	6,311,591
Indirect Cost	0	0	14,353	10,764			25,117
Research Support	144,496	28,658	0	122			173,276
C-FAR Administrative Office	172,656	N/A	N/A	N/A			172,656
1% Member Expense	N/A	N/A	N/A	N/A		25,794	25,794
IDOA Fee	N/A	N/A	N/A	N/A		45,000	45,000
Awards/Obligated Funds for FY 99 Research	1,438,880	235,033	50,043	0	522,610 (1)		2,246,566
Total FY 98 Expenditures \$	6,178,905	828,877	301,410	226,058	1,393,956	70,794	9,000,000

1. \$64,206 of this amount was re-directed to the FY 99 External Competitive Grants Program from the 1% Member Expense Account

**Illinois Food and Agriculture Research Act: FY 99 Allocations
(July 1, 1998 - June 30, 1999)**

C-FAR Research Objectives	Internal Grant Program						External	Per Legislation & SRIs	Total Allocations by Objective
	UIUC 82%	SIUC 11%	ISU 4%	WIU 3%	Total University Allocations	% Allocations to Research Universities	Competitive Grant Program		
Expand markets for agricultural products	238,536	86,000	0	0	324,536	6.42%	401,848		726,384
Promote economic development in Illinois	380,554	16,000	27,480	0	424,034	8.39%	279,220		703,254
Increase agriculture's capacity to meet changing world food demands	1,342,971	285,295	99,573	44,772	1,772,611	35.06%	375,451		2,148,062
Improve human nutrition, food quality and food safety	638,394	58,641	0	37,578	734,613	14.53%	410,958		1,145,571
Advance sustainable use of natural and human resources	602,545	159,000	108,109	102,005	971,659	19.22%	371,229		1,342,888
Strategic Research Init.								5,000,000	5,000,000
Research Support	107,000	32,000	6,060	0	145,060	2.87%			145,060
Research Discretionary	252,780	84,169	8,511	2,477	347,937	6.88%			347,937
Indirect Cost	0	0	12,487	9,833	22,320	0.44%			22,320
C-FAR Administrative Office	212,730	N/A	N/A	N/A	212,730	4.21%			212,730
FY 98 C-FAR Admin Expense	100,000	N/A	N/A	N/A	100,000	1.98%			100,000
1% Member Expense	N/A	N/A	N/A	N/A	N/A	N/A		120,000	120,000
IDOA Fee	N/A	N/A	N/A	N/A	N/A	N/A		50,000	50,000
Total \$	3,875,510	721,105	262,220	196,665	5,055,500	100%	1,838,706 (1)	5,170,000	12,064,206 (1)

1. An additional \$64,206 was allocated to the FY 99 External Program due to re-directing funds from the FY 98 1% Member Expense Fund

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