1862 Agricultural Experiment Station Research
University of Missouri-Columbia
Annual Report

Goal 1. An agricultural system that is highly competitive in the global economy

Overview:

Increased animal production with reduced plant and human resources will be necessary to provide a safe, adequate food supply for increasing world populations. MU has a strong reproductive physiology group striving to improve the efficiency of animal production through increased reproductive performance and improved reproductive technologies. The main thrust is to understand physiological mechanisms associated with increased fertility in domestic farm species. Emphasis is on ovarian function, *in vitro* fertilization, early embryonic development, maternal recognition of pregnancy and development of transgenic offspring. Identification of gene products linked to improved reproductive and productive traits will be used to develop new reproductive treatment regimens to improve reproductive performance and labor efficiency of farm animal operations.

Consumer concern about food cost, quality, and safety as well as farm animal welfare encourages development of genomic technology for efficiently producing high quality animal protein at low cost and with less reliance on growth promotants and antibiotics. MOAES is working to improve efficiency of production of animal protein through identification of specific genes influencing growth, disease resistance, reproductive rate, and meat quality. Our program is geared towards: (1) identifying genetic markers associated with variation in reproductive performance, growth, meat quality, and disease resistance; (2) identifying the timing of gene expression during the reproductive process; and (3) studying the function of gene products expressed during the reproductive process.

Missouri forage and livestock producers and their associated industries will require improved information and technologies to produce and market their products. MOAES thrusts are improved grazing systems, supplementation strategies, value-added strategies, and improved forages.

There is a need for additional scientific information concerning the role of environmental factors, nutrition and infectious agents to make recommendations related to animal health. Our animal health program goals are: characterize health and disease status of swine production systems; survey blood micronutrient status in feeder cattle; study genetic basis of melanoma in swine and cystic ovaries in dairy cattle; examine immune system and infectious diseases; and characterize cellular receptors.

Crop production in Missouri is faced with a wide range of environmental problems that include drought, flooding, cold and hot weather, insects, and microbial pathogen damage. Research is

needed to determine best practices for growing crops under these abiotic and biotic stress conditions. To develop plant strategies to produce high quality forages, grains, and special products, MOAES scientists are: improving our knowledge of how plants respond to stresses such as drought nutrient deficient soils, acid soils, and aluminum toxic soils; improving value-added traits; and improving cropping system practices based on new knowledge of crop physiological processes.

Insects, pathogens and weeds reduce the quantity and quality of agricultural crops. The use of pesticides to control these agents has ecological and economic impacts on agricultural production. New strategies for controlling pests, including biopesticides, transgenic crops and alternative practices can reduce pest damage and the pesticide used needed for their control. The MOAES goal is to improve the quality and quantity of agricultural production and develop environmentally compatible crop management strategies that reduce the impact of biotic agents while minimizing environmental impacts associated with their control.

The agricultural sector is in economic crisis, which is most pronounced in production agriculture, with some financial problems in marketing and processing. From an economic perspective, these problems resolve into the need to reduce costs of production per unit and enhance revenues. The objective of the MOAES research program is to determine the uses for resources in the agricultural sector that will generate at least as high returns as those obtained by the application of similar resources to comparable uses elsewhere in the economy. Although the focus will be on Missouri farms, some of the issues have no geographic boundaries.

Adding value to renewable natural resources is a way to increase economic activity. MOAES scientists are working on new ways to convert raw materials into consumer products; information transfer of new technologies; and organizational alternatives that foster business development.

Missouri's forage/livestock system will face both increased competition and enhanced market opportunities. Producers and their associated industries will require improve information and technologies to produce and market their products competitively. MOAES programs are working toward improved grazing systems; supplementation strategies; value-added strategies; and improved forages for ruminant production.

Animal health is dependent upon factors such as proper management, nutrition and absence of infectious diseases. Diseases of particular importance involve those affecting the respiratory, enteric, and reproductive systems. Additional information is needed concerning the role of environmental factors, nutrition, and infectious agents. MOAES animal health programs are keying on characterization of health and disease status of swine production systems; surveys of blood micronutrient status in feeder cattle; genetic basis of melanoma in swine and cystic ovaries in cattle; research on the bovine immune system; and cellular receptors in cattle related to immune responses.

Increasing economic and environmental pressures are requiring producers to become more efficient in their use of crop production inputs. Precision agriculture systems and technologies

hold promise for improving returns and reducing environmental risks. MOAES scientists are characterizing soil, landscape, crop pest and crop production variability. The development of sensors and control systems and evaluating variable-rate input are key areas of our program.

Key Theme: Animal Production Efficiency

Description/Impact:

Swine:

- Used daily ultrasonography to determine onset of estrus in sows to determine the time for insemination. A technique was developed for ovarian ultrasound of gilts and sows.
- Modeled livestock breeding programs using reproductive technologies. Breeding for maximized reproductive performance in swine did not result in maximum return to producers. Evaluation of biological characteristics may be necessary.
- Studied cellular events associated with fertilization and early embryo development. Understanding the cellular events will aid in methods to decrease the 30% loss of conceptuses in the first month of development.
- An alternative method of selection to improve litter size may be identified that requires neither expensive equipment or facilities to implement.

Beef/Dairy Cattle:

- Studied gene expression during the earliest phases of follicular growth when follicles may be irreversibly imprinted to disease. Diseases, infections, and disorders can cause reproductive failure.
- Showed that the corpus luteum secretes progesterone which regulates estrous cycle length and maintenance of pregnancy in cattle. The precise nature of the effect of progesterone on the corpus luteum needs further investigation.
- Investigated the family of enzymes that affect the cyclical change in the ovary to increase understanding about ovarian development and regression.
- Examined GH (growth hormone) and GH receptor in reproduction and growth of animals to find methods to improve animal reproduction and growth by manipulating GH and GH receptor.
- Defined interferon-tau (IFN-t) fertility hormones in cattle. Study showed it is possible to identify IFN-t proteins with superior ability to extend estrous cycle length. IFN-t research should identify products that are likely to be useful fertility agents and possibly therapeutic agents in human medicine.
- Developed a software model system to provide researchers and producers with a simulation model for systems based research and management decision support.
- Treatment of ovarian cysts with progesterone may form the basis of a new therapy causing fewer cows to be culled for reproductive failure.

- Identified antigens for an improved pregnancy test in cows. In collaboration with Monsanto, a pregnancy kit is being refined for on-farm use for accurate and early pregnancy diagnosis. The kit will be ready to market soon.
- Cloned and sequenced a novel new estrogen receptor and localized its expression in granulosa cells of follicles.
- Discovered a progestin treatment prior to estrous synchronization protocol that effectively synchronizes estrus with resulting high fertility.
- Developed a new estrous synchronization treatment (7-11 Synch). This protocol will aid in estrous synchronization and timed AI programs.
- Conducted studies to investigate the effect of polyunsaturated fatty acids supplied from raw soybeans on milk production and reproduction. Cows fed cracked soybeans during the summer were found to maintain higher feed intake and milk production without any harm to reproductive processes.
- Studied interaction of diet components on bacterial growth in the rumen by identifying and enumerating bacteria. Determined requirements of nitrogen by rumenal bacteria and amino acid needs. An increased understanding the bacterial needs of the rumen should lead to growth efficiency and significant reduction in nitrogen excretion.

Key Theme: Animal Health

Description/Impact:

Sheep:

- Showed that leptin is the nutritional signal regulating multiple functions in ruminants, including the neuroendocrine activity. Growth and reproduction are affected by the nutritional status.
- Studied mechanisms of interaction between nutrition and reproduction. Insulin is the most recognized of the metabolic messengers. Treating well nourished ewes with insulin did not increase reproductive efficiency and may have interfered with the ewes at maximum nutritional and reproductive stages.

Swine:

- Investigated ways to produce swine embryos *in vitro* that minimize the transfer of contagious diseases among animals at different locations.
- Showed an injection of progesterone at weaning was unable to delay estrus in sows weaned at 14 days or less of lactation. This is significant because of the trend to wean younger piglets to improve health even at the cost of subsequent reproductive performance.

Beef/Dairy Cattle:

- Showed that night cooling is superior to cooling during the hottest time of the day in reducing body heat content and maintaining productivity. Responses of cattle to heat stress have been able to quantify the benefit of shade for better productivity.

- Investigated blood markers of sensitivity to fescue toxicosis and summer heat. Identification of these markers will allow the removal of animals that are severely affected by these toxins and ultimately breed for animals that are resistant.
- Conducted survey of blood copper status in Missouri feeder calves. Geographic regions deficient in copper and selenium will be identified and recommendations will be made for intervention strategies individual producers.
- Conducted laboratory feeding studies of fumonisin in cattle, poultry, ducks, mink, swine and catfish. Results are being used by FDA to establish levels for fumonisin in animal feeds. Absorbents and/or crude enzyme preparations may provide an economical means of safely feeding highly contaminated feedstuffs to livestock.
- Bovine-type tuberculosis has re-emerged in the US as a threat to the livestock industry and to human health. Demonstrated that the CD8+T cell populations is essential for protection and that gamma-delta T cell receptor populations bearing the WC1 molecule regulate trafficking to sites of infection.
- Identified a novel factor which regulates the production of IgA by B cells in cattle. IgA is the most predominant immunoglobulin present in the nasal, oral and gut tissues. These sites are the predominant portals of entry for most pathogens. Neutralizing or blocking IgA antibodies is an important part of disease prevention.

Poultry:

Evaluated several absorbents to lessen the toxic effects of aflatoxin and ochratoxin. Results demonstrate that not all absorbents are equally effective and several have been shown to impair nutrient use.

- Determined the amino acid requirements of turkeys from hatch to market. These results should lead to a fundamental change in the feeding practices of the turkey industry.
- Enteric disease causes significant production losses in the turkey industry. Turkeys with diarrhea are commonly infected with the protozoa, *Cochlosoma anatis*. Determined the resistance of this protozoa to commonly used disinfectants and drying.

Key Theme: Animal Genomics

Description/Impact

- Identified a possible genetic modifier controlling male germ cell numbers. Efforts have been made to further map and clone this modifier. The new findings will help design research strategies for cutting-edge male reproduction studies.

Key Theme: Adding Value to New and Old Agricultural Products

Description/Impact:

- Studied the best milling process to decrease variability and improve quality of co-products. There is considerable variation in nutrient concentrations in corn gluten and distillers grain. Marketing co-products as animal foods has a direct impact on feasibility of processing corn into ethanol.

- Developed a conceptual model for relating costs of quality to transaction and production costs. Identified key components of successful value-adding food supply chains and the role that public entities can play in development of such chains.
- A new method of reducing fat content in pork was developed. The fat-reduced pork could be used to make fat-reduced sausages with physical properties similar to control high-fat sausages.

Key Theme: Grazing

Description/Impact:

- Showed that birdsfoot trefoil interseeded with tall fescue produced greater average daily gain and greater gain per acre in cattle than did tall fescue in a continuous grazing system.

Key Theme: Plant Genomics

Description/Impact

- Studied the identification of *Arabidopsis* RNA polymerse II. An increased understanding of the basic transcriptional machinery in plants is crucial to advance knowledge on gene regulation.
- Isolated and characterized *Arabidopsis* proteins. Decoding genetic information is essential for the full exploit of the potential of plants to provide food and fiber.
- Discovered HDAC mutations in *Arabidopsis* which provides a unique opportunity to study the role of the enzymes in plants. A thorough understanding of transcriptional regulation will allow for an improved manipulation of the expression of useful genes in crop plants.
- Showed that alanine is the nitrogen exchange product in the soybean symbiotic system. This means that the process is under genetic control and can be manipulated to improve crop yields.
- Examined the regulation of auxin response genes. This research should lead to designing genes that modify the growth and development of crops and trees to improve yield, stature, and quality.
- Showed that protein catalysts, known as matrix metalloproteinases (MMPs), regulate the tissue remodeling in reproduction. Research is revealing 3D atom-resolution structural details of how tissue inhibitor of metalloproteinases (TIMP) and MMPs interact. These findings should enable molecular engineering of useful properties into TIMPs.
- Showed that light dependent inactivation is most likely due to the action of a specific protein kinase. The recombinant PDC kinase from maize has been cloned, sequenced, and expressed. This finding will allow for a determination of the extent to which this enzyme controls respiration and contributes to oil synthesis.
- Examined the processes for nickel incorporation into urease. This research has potential application in recycling urea from industrial and biological sources.

- Examine alpha ketoacid dehydrogenase complexes and focused on the components which form the core to which other components bind. This research should be crucial to enhancing oil synthesis in oil seeds.
- Constructed a mutation in the gene encoding cytochrome c3 in the sulfate-reducing bacterium, *Desulfovibrio desulfuricans.* This research should have practical application on the sulfate-reducing bacteria to bioremediation of uranium.
- Developed a method to increase the quality of lysine in proteins that is superior to others that have been attempted. The resulting plants will not express new or novel proteins which might diminish their value for animal or human consumption.
- Identified new components in the mitogen-activated protein kinase (MAPK) cascades and increased understanding about the role of pathogen-activated MAPK signaling pathways. This research should provide useful targets for manipulating plant disease resistance.
- Manipulating host genetics to sustain high levels of pathogen repressors to eliminate production of viruses. Producing genetic tools and biological resources to control insect pests in a reproducible manner.
- Developed several varieties of soybean cyst nematode (SCN) resistant soybeans and management practices which have cut losses due to soybean cyst nematode.
- Used RFLP probes to fingerprint different soybean lines having resistance to soybean cyst nematode for breeding studies.

Key Theme: Plant Germplasm

Description/Impact

- An increased understanding about the molecular basis for pollen recognition will support plant breeding strategies for engineering, sterility or moving agronomic traits from wild species into crop plants.
- Studied custom-made *Rhizobium* soybean cultivars to enhance nitrogen fixation.
- Characterized high-lysine mutants of rice to aid in increasing nutritional quality of cereals.
- Identified new population of birdsfoot trefoil with increased persistence. Identified two fungal/plant combinations in fescue which exhibit limited toxic effects in animal feeding.

Key Theme: Plant Production Efficiency

Description/Impact

- Discovered that an interaction between abscisic acid and ethylene in root and shoot growth regulation is a step toward identifying processes which regulate plant growth in drought-prone environments.
- Showed that densities of waterhemp need to be kept below 6 plants per meter to prevent yield losses. Using narrow rows helps prevent weed emergence.
- Showed that herbicide-resistant corn varieties can sustain up to five weeks of grass competition before yields are reduced.

- Showed that the use of reduced rates of soil-applied broadleaf herbicides followed by reduced rates of glyphosate result in less weed control and economic return than do weed control programs relying on glyphosate alone.

Key Theme: Plant Health

Description/Impact

- Providing new fundamental information about how plants resist infection by pathogens. Information can be used to develop new strategies for resistance.
- Identified and genetically characterized new sources of scab resistance in wheat.
- Showed that foliar applications of boron to soybean are not effective in counteracting soybean cyst nematode effects.
- Evaluated peach rootstocks for cold susceptibility. This information is useful to nurserymen and growers.
- Established a new model for soybean cyst nematode race determination. Current methods of detecting race shift do not account for variability.
- Identified chitinolytic isoforms that improve disease resistence in tall fescue.

Key Theme: Precision Agriculture

Description/Impact

- Studied techniques for measuring and analyzing granular materials in an airstream to develop methods to measure granular fertilizer on a fertilizer applicator. A real-time granular fertilizer sensor will allow for increased accuracy in monitoring and controlling f variable granular rates of crop inputs.
- Designed a portable system to monitor and document field operation data. The system will facilitate the collection and processing of applicator travel speed, application width, and position data to permit the creation of readable log files. A practical monitoring systems will enhance machine use, maximize nutrient use by crops, and minimize the environmental impacts of crop-livestock production.
- Missouri Precision Agriculture Center (MPAC) is coordinating extension, research, and teaching efforts in precision agriculture. Low crop returns have limited incentive for adoption of precision agriculture technology. To reduce costs, farmers should use existing information such as yield maps to identify areas for soil sampling rather than sampling entire fields. Economic analysis can determine more profitable use of fertilizer without variable rate technology.

Key Theme: Rangeland/Pasture Management

Description/Impact

- Showed that low levels of grass herbicide suppress stem and seed formation in tall fescue, thereby improving forage quality, and eliminating the need for clipping pastures. These procedures should reduce effects of endophyte-infected fescue.

- Evaluated species of legumes for flood tolerance, herbage yield and quality. Legumes fix atmospheric nitrogen and are excellent feed for livestock and wildlife.
- Showed that rotational grazing can increase forage productivity and quality while maintaining a higher level of ground cover compared with continuous grazing. Increased vegetative cover means less runoff and improved water quality. Increased legumes means less nitrogen fertilizer needed.
- Alfalfa, the most produced and cheapest hay crop in Missouri, is limited by potassium deficiency in the soil. As a useful service to producers, we are developing a device they can use to detect potassium deficiency in fields.
- Studied different stocking rates and grazing methods of cattle to improve the profitability of forage and forage-based livestock enterprises.

Key Theme: Biofuels

Description/Impact

- Showed that engine life can be extended using fuel with 1-2% biodiesel blend. Fuel economy may also be positively impacted.

Key Theme: Aquaculture

Description/Impact

- Studied fish-habitat relationships and restoration of river-floodplain interactions. Results were used to evaluate several alternative flow regulation scenarios proposed for the Missouri River. Results are also being used by state and federal natural resource agencies to manage fish populations in large rivers.
- Developed model to predict growth rates of crappie based on food consumption and temperatures.

Key Theme: Ornamental/Green Agriculture

Description/Impact

- Used differential thermal analysis to investigate freezing of woody plants. Study provides information on the winter survival mechanisms and hardiness of native and commercial plants. Data are useful to nurseries for selection of winter hardy materials.

Key Theme: Innovative Farming Techniques

Description/Impact

- Showed that deep tillage is a profitable practice under all tillage methods in cotton production.

Key Theme: Diversified/Alternative Agriculture

Description/Impact

- Carried out farm trials of alternative crops in five states in cooperation with 6 universities and one non-profit organization. Farmers are expanding their acreages of alternative crops as a result of these activities.

Key Theme: Biobased Products

Description/Impact

- Evaluated the technical and economic feasibility of converting feedstocks into ethanol and higher value chemicals. It is technically possible, but not economically feasible to make ethanol alone. However it can be profitable if ethanol is produced with high value co-products.

Key Theme: Agricultural Competitiveness

Description/Impact

- Examined concentration of ownership and control in the international food systems continues. A new methodological approach suggests a very small number of dominant food chain clusters are emerging. If the food system is not composed of autonomous firms competing with each other, major management decisions are made by a small core of firm executives. This study highlights the need for public debate on the social, economic, and environmental consequences of the changing global food systems.

Source of Federal Funds: Hatch, Grants

Scope of Impact: Multi State

Goal 2. A safe and secure food and fiber system

Overview:

An increased understanding is needed about the various factors required to assure food safety from production to consumption. The interrelationships of production, processing, distribution and storage on chemical, biological, and physical hazards found in food products are being studied. Consumers need this information to make informed decisions about food safety issues. Scientists study ways to prevent the growth of pathogenic bacteria in raw and lightly processed food products, microbial ecology and pathogen suppression in food products, and new technologies and their application to eliminate food-borne hazards.

Key Theme: Food Quality

Description/Impact

- Evaluated meat quality using a computer-based meat image segmentation program. Color and marbling were used to predict USDA quality grades. A computerized system

can improve the objectivity and consistency of beef grading, and provide the meat industry with a valuable tool for quality assurance.

- Studied flavor of fat and fat replacers on lower fat ice cream and found that milk fat is an important carrier and modifier of flavor in ice cream. Certain fat replacers selectively bind or enhance components of flavor. These studies provide research and development personnel in the ice cream industry with useful information.
- Designed several new algorithms and applied them in food extrusion control. Image processing was found useful in predicting beef quality, texture features and to classify certain wood grain patterns. This research should lead to new automation technology that improves performance of food processing efficiency, consistency and product quality.
- Developed a new correlation using the group contribution methods. Data about thermal conductivity of liquids as a function of temperature are essential in the design of heat and mass transfer equipment. This research is useful for the production of liquid thermal conductivity and the Prandtl number as a function of temperature for vegetable oils on food processing.
- Showed that consumers could receive quality venison products, formulated with both carbohydrate and protein binders, instead of ground pork with its inherent levels of added lipids. Venison is a highly nutritious meat, which is under-commercialized and under-used in the U.S.
- Showed that human sensory perceptions of vanilla and chocolate flavors in ice cream containing varying concentrations of fat and fat replacers were matched. These observations on effects on flavor volatiles were made using gas chromatography and mass spectrometry. The findings provide manufacturers of ice creams with scientifically-based guidance the in formulation of low fat vanilla and chocolate ice creams.
- Studied new meat processing technologies and evaluated analytical techniques and interactions of meat and nonmeat ingredients in processed muscle food. These findings will enable processors to manufacture higher quality products and meet requirements of consumers for safe, palatable and economical meat products.
- Evaluated solid phase microextraction as an analytical extraction methods for flavor compounds. This technique can be used for flavor analysis, but causes loss of stability of the fibers. Large coefficients of variation indicate considerable fiber-to-fiber variation and unacceptable lot-to-lot variation.

Key Theme: Food Safety

Description/Impact

- Improved the quality of lactic acid used in the food industry for acidification and control of microorganisms. A patent has been obtained. The safety and shelf life of beef will be enhanced using a product that will be readily accepted by the consumer.
- Achieved expression of green fluorescence protein (GFP). GFP can be used in a variety of applications including screening of polypeptide libraries, development of live vaccines, construction of biosensors, and protein secretion studies.

Source of Federal Funds: Hatch, Grants

Scope of Impact: Multi State

Goal 3. A healthy, well-nourished population

Overview:

Dietary nutrients have two critical roles to pay: prevention of nutritional deficiency, and promotion of optimal health. Consumers need additional scientific information concerning the relationship between dietary components and health. MOAES scientists are researching the nutritional habits and practices of various populations, and the roles of nutrients and cellular components in regulation of metabolic processes.

Human health is largely controlled by the action of various chemicals within the cell. A significant step toward health promotion and disease prevention should be achieved through an increased understanding of how specific nutrients modulate metabolic processes within the cell. In working toward understanding the role of specific mineral nutrients on cellular processes and metabolism, MOAES scientists are examining selenium sensitive, zinc-responsive genes and the accumulation of zinc in cells, and applying the data generated to other mineral nutrients.

Key Theme: Human Health

Description/Impact:

- Showed that human consumption of a diet rich in polyunsaturated fatty acids from fish oils does not appear to compromise vitamin E status of the immune system.
- Determined whether individuals at risk have a higher rate of seroconversion to hepatitis E than the general population. Hepatitis E has recently been found to infect both humans and swine.
- Showed that the protein, P2Y2 nucleotide receptor, found in blood vessels, immune cells, respiratory tract and brain appears on tissue damage associated with various diseases including diabetes, atherosclerosis, Alzheimer's disease and cystic fibrosis. Knowledge gained from an increased understanding of P2Y2 receptor functions should lead to new treatments for human diseases.

- Clarified the process by which the liver secretes lipoproteins into blood. The studies are contributing to the development of drugs to control the concentration of cholesterol in blood. Apolipoprotein B is the structural protein for very low density protein (VLDL) and low density lipoproteins (LDL) in blood.
- Established that IGF-I signaling is impaired in the zinc deficient state. Dietary zinc deficiency is associated with growth failure in humans and animals, and reduce food intake in animals. The specific cellular defects induced by zinc depletion that causes the symptoms remain unidentified.

- Identified cellular metabolic responses to specific dietary factors and correlated these with disease risk, specifically cancer risk. Through identification of specific changes in cellular metabolism, dietary recommendations to reduce the risk of cancer may be made to consumers.
- Showed that fetal exposure of mice to low doses of the pesticide methosychlor can disrupt normal development of the reproductive tract, which can lead to enlargement of the prostate and reduced sperm production in adult mice. Also, hypermethylation of a tumor suppressor gene accompanies development of human breast cancer when compared to normal mammary tissue from the same patient. The work on mechanisms of natural estrogen and environmental estrogen action in human breast cancer cells and in mice during fetal development should lead to an increased understanding about the impact of exposures to environmental estrogens on human and domestic animal reproduction.

Key Theme: Human Nutrition:

Description/Impact

- Examined the molecular basis for dietary selenium requirements, and showed that expression of GXP1 activity and mRNA levels are the most sensitive markers for changes in selenium status. Using the hypotheses that changes in status of one antioxidant will elicit protective changes in levels of other antioxidants, the study shows that selenium status is not changed by variation in the status of Vitamin E.
- Examined dietary guidelines, frequency of a particular message, and subjective evaluation of the quality of the message to ascertain the type of quality of nutritional messages in food advertisements.
- Characterized human zinc transporter, hZIP2, which provides one of the first molecular tools to study the metabolism of this essential mineral. The analysis of zinc metabolism in yeast provides a paradigm for understanding metal ion homeostasis is all eukaryotes. Studies of plant metal ion transporters may ultimately lead to the production of genetically modified crop plants with improved yields or nutritional quality and better methods of phytoremediation.

Source of Federal Funds: Hatch, Grants

Scope of Impact: Multi State

Goal 4. Greater harmony between agriculture and environment

Overview:

The expanding residential and urban use of agricultural and forest lands is putting pressure on aquatic and terrestrial habitats. The loss and fragmentation of habitats is causing declines in terrestrial populations and several fish species are threatened. Of particular concern is the reduction are areas of large forest tracts, loss of glades and stream riparian areas, degradation of

recharge regions for springs and groundwater, loss of wetlands in floodplains that support waterfowl, species diversity, and water quality. To enhance the state's natural resources, MOAES research and education activities will focus on: developing management approaches to reverse decline in fish and wildlife; determining factors affecting the decline at the landscape level; determining how land use and cover affect wildlife populations and diversity; documenting reproductive ecology of fish and wildlife species to determine what conditions are necessary for breeding; determining importance of limited food and predation in regulation of fish and wildlife populations; and determining how land use and cover affect water quality in lakes and streams.

As domestic agriculture and human populations expand, natural resource professionals must have the latest spatial data analysis to understand the impact on natural resources at the landscape scale to effectively plan and manage the problems created. Geographic information systems (GIS) and other computer based spatial analysis technologies provide important new tools for dealing with landscape scale problems. The MOAES program is expanding research on the application of GIS to natural resource management and agricultural/land use planning, developing education programs in landscape analysis and GIS application, and developing new spatial data analysis and software.

Due to long-term environmental consequences of current land-use practices (soil erosion, chemical pollution of waterways, etc.), MOAES scientists are conducting research on the benefits of intentionally combining trees and/or shrubs with crops and/or livestock. The financial and conservation benefits to small family farms using increased application of agroforestry technology are being studied. In our Center for Agroforestry, we are identifying species and selections for us in agroforestry practices; developing a scientific basis for designing agroforestry practices; evaluating and demonstrating the environmental, ecological and economic benefits of properly designed agroforestry practices; evaluating and demonstrating the production benefits; and identifying and quantifying the economic and social factors that facilitate or constrain the adoption of agroforestry.

Growth of animal agriculture will be limited unless more environmentally friendly and socially acceptable methods of managing animal waste are developed. The recent USDA-EPA United National Strategy for Animal Feeding Operations provides that comprehensive nutrient management plans be developed and implement for all animal feeding operations by the year 2008. A critical component if development of these plans is the estimation of nutrients which will b excreted in an animal feeding operation. MOAES scientists are working toward understanding the various factors that influence manure nutrient variability and developing databases and models to predict manure nutrient excretion based on modern animal genotypes, feed ingredients, and feeding practices. Research projects focus on: the role of feeding programs on the animal nutrients excreted; influence of feed ingredients on nutrients excreted and odor; genotype of the animal and state of growth on nutrients excreted; and development databases, models and educational programs for regulatory and waste management professionals.

Water quality is the most frequently voiced concern of citizens. Expansion of residential use of agricultural lands and increasing intensification of agricultural operations make the water quality scenario more complex. MOAES scientists are seeking ways to improve the quality of drinking

water in Missouri by: monitoring seasonal patterns in the reservoirs and streams; understanding the sources and pathways of microbes and nutrients in watershed; identifying the effects of alternative land use/management activities on farm income, soil erosion, surface water quality, and fish characteristics; developing alternative management strategies; and gaining effective public involvement at the watershed level to address water quality-related issues.

Ways must be found to enhance the efficiency of agricultural production to improve soil health and minimize effects of applied nutrients. MOAES scientists are working to improve the management of crop nutrients, increase understanding about how soil management practices impact microbial activities in soil, increase knowledge of soil formation and sustainability, and investigate the bioavailability, fate and transport of chemicals in soils. Our scientists are doing basic and applied research on: precision application of fertilizer and lime; how to increase efficiency of fertilizer use by plants; management of crop nutrients in soils; fate and transport of chemicals in soils; and improved soil-test-based recommendations.

Climate change and the mechanisms leading to climate change on both global and regional scales have been of great interest to the agricultural community and the general public. Various mechanisms are being studied to explain long and short-term global climate variations, such as El Nino and flooding, including the effect of increasing carbon dioxide concentrations. Climate fluctuations due to natural variability in the climate system have also been examined, particularly midwestern climates linked to coupled ocean-atmosphere phenomena. MOAES scientists are seeking to understand climate variables (temperature, precipitation, and length of growing season) that impact the local economy and agricultural community by studying large-scale atmospheric flow regimes, particularly those forced by sea surface temperature variations in the Pacific Ocean basin. The program components are: global climatological and dynamic characteristics of blocking flows; effects of climate change on large-scale flow regimes, including the increase of atmospheric carbon dioxide; local climatological character of heavy precipitation; and local climatological character of the growing season.

Improved forecasting can come with an increased understanding about the atmospheric evolutionary processes. The interaction of various atmospheric circulation systems is being studied, particularly the role of short wave-long wave interaction and frontal development in mid-latitude cyclone formation. MOAES scientists are using computerized simulation models to produce idealized atmospheric data, construct and use a trajectory model to follow individual air parcels, and use various computer programs to analyze and display data.

Key Theme: Agricultural Waste Management

Description/Impact:

- Showed that feeding low phytate corn and barley mutants reduces phosphorus excretion by poultry, and reduces environmental problems with phosphorus pollution from poultry manure applied to pastures and cropland.

Key Theme: Water Quality

Description/Impact

- Installed five onsite sewage treatment systems (3 drip irrigation, 2 low pressure pipe) on private lots in a karst terrain and monitored them for one year. Data showed that the systems are treating sewage effluent to a high degree, protecting public health and maintaining the quality of the environmentally sensitive area.
- Developed a rainfall simulator that had 50% more range than commercial models that are used to predict water runoff volume, quality and sediment. Improved hydraulic and solids attenuation modeling offers a reliable design treatment for submerged flow constructed wetland systems.
- Showed that dispersal in the soil by pressure-dosing techniques such as low pressure pipe and drip irrigation systems provides improved treatment and greater evapotranspiration. Increasing use of on-site wastewater treatment systems require greater primary treatment.
- Used aquatic macroinvertebrates as indicators of water quality to assess the impact of land use practices on water quality.
- Used information on precision agriculture to improve methods for quantifying soil variability and assist farmers in using site-specific information. Economic analysis of riparian buffers strongly supports the current practice of constructing these buffers along streams and rivers in cropland areas.

Key Theme: Endangered Species

Description/Impact

- Characterized microclimatic habitat and population demographics of three locally rare plant species. This project provides critical information on rare plants for managers in the National Park Service.

Key Theme: Natural Resources Management

Description/Impact

- Conducted climate change research and inventory and monitoring of natural resources in the national parks of the Ozarks and Central Great Plains. Reports and publications are used by park managers to establish or modify resource management practices.

Key Theme: Forest Resource Management

Description/Impact

- Showed that controlling animal use pressure reduces the risk of damage and permits high quality timber to be grown.

Key Theme: Forest Crops

Description/Impact

- Identified several legumes that can be grown with hardwoods and pines without significantly inhibiting tree growth.

Key Theme: Soil Quality

Description/Impact

- Showed that severe soil compaction decreases tree growth, microbial activity, and earthworms. Earthworms can help overcome the severe effects of compaction relatively quick.
- Showed through soil organic carbon studies that the majority of sequestered C is in subsoils even in Mollisols.

Key Theme: Soil Erosion

Description/Impact

- Computed rainfall factor which will allow conservationists to develop economical conservation treatment. Results will be used for predicting erosiveness of surrounding land.

Key Theme: Drought Prevention and Mitigation

Description/Impact

- Studied drought physiological responses of major commercial timber species to guide geneticists and forest managers to make improved decisions in tree breeding and ecosystem management. These finding provide especially important information for managers coping with plant responses to changing global environments.

Key Theme: Integrated Pest Management

Description/Impact

- Showed that mechanical harvesting of alfalfa decreases the number of alfalfa weevil larvae over grazed alfalfa.. This information assists producers with non-chemical pest management.
- Studied four different glandular-haired cultivars of alfalfa on the feeding mortality, and plant part preferences of the potato leafhopper as well as symptom development of leafhopper. Concluded that the amount of feeding and mortality are inversely correlated, but that hopperburn symptoms are not correlated with either feeding or mortality and only partly with trichrome density.
- Showed that beneficial insects are attracted more to traps with daylight flourescent bulbs than other sources of light studied. This information can be used to modify trapping procedures for more efficient capture of selected insect groups.

Key Theme: Pesticide Application

Description/Impact

- Collected corn borers and tested them for potential to resistance to Bt toxin. Monitoring of both European and southwestern corn borer is essential for alerting growers to moth flights and timing of insecticide application.

Key Theme: Wildlife Management

- Established quantitatively the benefits of the CRP program on songbirds. Data will be useful for developing future natural resource management programs.
- Developed a multi-capture box to gain an understanding of the age, prebreeding behavior, and movements of nesting waterfowl not previously possible because only laying and incubating females could be captured. Adaptation of this technique to other cavity nesting birds opens new opportunities for study.

Key Theme: Weather and Climate

- Showed that interannual variation in global and local weather can be linked to natural variability. Mid-western weather and Atlantic Ocean hurricane activity are entering a new phase similar to that of the 1950-60's when El Nino was a less reliable predictor of mid-Western climate.

Key Theme: Nutrient Management

Description/Impact

- Used geographical positioning system (GPS) to determine the most economically productive nitrogen rate for each location in a field. Flyash is a good material for raising soil pH in acid soils, but it must be leached to remove boron and sodium.

Key Theme: Sustainable Agriculture

Description/Impact

- Supported 115 on-farm trial and demonstration projects in sustainable agriculture. Results from 63 of the trials have been published. Funding was increased last year to include more projects.

Key Theme: Forest Crops

Description/Impact

- Identified costs and returns associated with growing black walnut in an alley cropping system Nuts contributed little to the profitability of the total system. Timber provided 29%, traditional crops 65%. Benefit/costs relations in excess of 1:5 were calculated on the investment in a pecan cleaning and shelling plant.

Source of Federal Funds: Hatch, Grants

Scope of Impact: Multi State

Goal 5. Enhance economic opportunity and quality of life for Americans

Overview:

The 1996 Farm Bill created a radically different set of farm policies. Adjustments within the production agriculture and agribusiness sectors have already been significant. Policy makers at the local, state and federal levels need unbiased micro and macro policy analysis. Scientists at MU and Iowa State University are providing objective evaluations of major national policy options. The result of these analyses are being presented at regional meetings, statewide conferences and to national audiences. The multi-disciplinary team in Missouri is: evaluating farm program options and summarizing potential impacts; preparing baseline analysis that looks ten years ahead and gives projections for all major agricultural commodities; and evaluating potential implications of major policies on international trade and U.S. competitiveness.

The "food system" is going through a period of immense change. There is a great need for sound, fundamental social science research to provide analyses that empower Missouri decision makers to manage their portion of the global food and natural resource systems. Scientists are providing information to help rural communities address current and longer-term issues. Research projects address price and income risks; evaluate structural and organizational issues; develop feasible options for adapting to economic, social and environmental factors.

Rural communities are being impacted by the changing structure of agriculture, welfare reform and the restructuring of healthcare. Research at MU is aimed at helping the communities retain employment and economic activity, address infrastructure issues, and assess the benefits and costs of tourism.

Global competition and rapid changes have increased the complexity of marketing decisions. Research is producing analyses which help producers and agribusiness improve incomes and help decision makers better understand the multiple competitive forces and impacts. MU programs work toward optimal grain and oilseed marketing strategies; profit enhancing technologies that can be adopted by producers and agribusinesses; and risk management options and strategies that will enhance profitability.

Rural communities have changed dramatically in some areas during the '90s. The future of some communities is in doubt and others are struggling with the stresses of population growth and agricultural structural changes. Research is providing information useful for individuals and groups in local decision making and problem solving. Results facilitate informed decisions on issues like healthcare, community services, family services and community infrastructure.

Key Theme: Child Care/ Dependent Care

Description/Impact

- Developed an instrument and completed 10 pilot observations on child care arrangement. Previous research has indicated that the quality of relative and non-regulated child care arrangements was rated as "unacceptable". Methodology of previous studies has been questioned. The goal is to establish a reliable informal child care instrument to measure quality of child care in rural communities.

Key Theme: Children, Youth, and Families at Risk

Description/Impact

- Documented the sense of obligation of individuals older and younger adult generations post-divorce. Divorce is increasingly common for families. The findings inform policy makers, help professionals in family studies, sociology, psychology and gerontology with issues faced by post-divorce families.

Key Theme: Family Resource Management

Description/Impact

- Completed pilot interviews and processed them to analyze impacts of welfare reform on low income families.

Key Theme: Retirement Planning

Description/Impact

- Showed that single mothers making the transition from welfare to work were not likely to earn sufficient income to meet basic expenses and prepare for retirement. A study of elderly women show some aspects of poverty transcend culture. Rising health care costs also impair ability to save for retirement. Population aging creates a need to study the environmental factors in the family system that facilitate or constrain financial preparation for retirement.

Key Theme: Promoting Business Programs

Description/Impact

- Investigated private-private and private-public networks in the agrobiotechnology industry to provide evidence on how firm strategies and industry structure interact. Gathered evidence to support the hypothesis that agrobiotechnology firms are connected and networked with each other and that such connections have a determinant role on the choice of firm strategies and success of biotechnology firms.

Key Theme: Impact of Change on Rural Communities

Description/Impact

- Improved environmental policy and project implementation by refining public environmental protection efforts to make them more inclusionary and participatory, and raising awareness of government agencies and staff to the social and cultural factors that are constraining citizen participation and support.
- Compared farms under the current farm bill, passed in 1996, to farms in programs in place under the 1990 farm bill. Many producers have been under great financial stress this year and have blamed the farm bill. Results did not find this to be a dominant factor of farm financial stress.
- Showed that rapid changes in demographics of rural Missouri continue to occur. Immigration of Hispanics into 10 percent of Missouri counties has increased, with positive contributions to the communities, but with challenges in language training for both adults and children. Grants have been obtained for ethnographic studies in non-metropolitan communities for Hispanics and African American populations. A study of 10 counties revealed that regardless of location in the state, urban sprawl was increasing rapidly.
- The Food and Agricultural Policy Research Institute (FAPRI) answered many congressional requests to analyze hog production, changes in crop yields and exports, examined flexible fallow proposal, crop insurance, and reform of the federal milk marketing order. FAPRI personnel gave congressional testimony and presentations to congressional staff.
- The Rural Policy Research Institute (RUPRI) is a multi state, interdisciplinary research consortium to conduct research and public dialogue to assist policy makers understand impacts of public policy choices. Currently RUPRI has a team working on innovations to increase equity capital in rural communities.
- The Office of Social and Economic Data Analysis (OSEDA) provides Missouri citizens with up-to-date information and analysis about their county and region through newsletters, and a web site. OSEDA, under contract with MO Dept of Elementary and Secondary Education, is responsible for the design, management and analysis of data generated from students, parents, teachers and administrators of all school districts in Missouri. Data collected are part of the assessment of school districts to improve school processes and learning environment.

Key Theme: Agricultural Financial Management

Description/Impact

- Developed an extensive model of firm valuation to determine what types of investment in the food and fiber sector may create the most value in the future. The model will show implications for the flow of investment capital and shift in expected value generations across industries.

- Identified critical factors to consider during organizational stages as well as methods to correct organizational failure problems associated with traditional producers groups. A database and guidebook are being developed to assist in the formulation of new producer cooperatives.
- Identified ways to integrate economic and social adaptation of rural Russian households to emerging market economy. Identifying new ways to measure sources of social capital to enhance more efficient economic development in rural areas.

Source of Federal Funds: Hatch, Grants

Scope of Impact: Multi State

Stakeholder Input Process

The MOAES stakeholder input process continues to be the same as reported in the 1999 POW. We have several advisory committee representing all regions of the state and having members from industry, government, academics and producers. The Missouri Agricultural Land Management Resource Institute (MALMRI) consisting of several state and federal agencies continues to meet bi-monthly and discuss areas of mutual concern. The MOAES formalized this group in 1989 to identify and respond to trends in Missouri agriculture.

Program Review Process:

Our scientific peer review program continues as described in the original Plan of Work.

Evaluation of the Success of Multi and Joint Activities

MOAES scientists participate in several multi-state projects and committees. Missouri contributes to a six-state animal waste consortium which provides funding to collaborating scientists for research, demonstration, and outreach projects in animal waste management. Several research and extension grants have participants from several states.

Integrated Research and Extension Activities

Five areas of work have been identified as integrated activities between MOAES and University Outreach and Extension: integrated cropping systems, forage/livestock, animal waste management, water quality, and human nutrition. The following is a a description of findings and impacts for this reporting period:

Integrated Cropping Systems:

- Discovered that densities of waterhemp should be kept below 6 plants per meter to prevent yield losses. Using narrow rows helps prevent weed emergence. Weed science scientists and extension personnel disseminate this information at various producer meetings and in publications.
- Showed that reduced rates of soil-applied broadleaf herbicides followed by glyphosate result in less weed control and economic return than do weed control programs relying on glyphosate alone. This finding is used in publications and presentations.

Forage/Livestock

- Showed that mechanical harvesting of alfalfa reduces weevil larvae more effectively than grazing alfalfa.
- Discovered beneficial insects can be more easily trapped using daylight flourescent bulbs. This provides an improved way to identify the location of the beneficial insects and to move them to areas where they are needed.
- Showed that birdsfoot trefoil interseeded with tall fescue produced greater average daily gain and greater gain per acre in cattle than did tall fescue in a continuous grazing system.

Animal Waste Management

- Showed that feeding low phytate corn and barley mutants reduces phosphorus excretion by poultry and reduces environmental pollution. This integrated work is being done under the Six-state Animal Waste Consortium.
- Found that using soybean hulls and a reduced crude protein for swine diets assists in controlling odor. Ammonium nitrogen was lowered significantly.

Water Quality

- Installed five on-site sewage treatment systems on monitor flow. Workshops are held to teach methods of sewage treatment installations in rural areas. Population increases in rural areas make these systems an important component of water quality.

Human Nutrition

- Surveyed food advertisements to determine quality of nutritional information given to the public.

Appendix C

U.S. Department of Agriculture
Cooperative State Research, Education, and Extension Service
Supplement to the Annual Report of Accomplishments and Results
Multistate Extension Activities and Integrated Activities
(Attach Brief Summaries)

Institution____University of Missouri_____
State_____Missouri _____

Check one: ___ _ Multistate Extension Activities
_X__ Integrated Activities (Hatch Act Funds)
____ Integrated Activities (Smith-Lever Act Funds)

	Actual Expenditures				
Title of Planned Program/Activity	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Goal 1 Integrated Cropping Systems	$140,965				
Goal 1 Forages and Livestock	$140,684				
Goal 3 Human Nutrition and Health	$73,212				
Goal 4 Water Quality	$33,929				
Goal4 Animal Waste Management	$37,340				
Total	$426,130				

_____ _____
Director **Date**

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