THE KENTUCKY AGRICULTURAL EXPERIMENT STATION

107th Annual Report

1994

COLLEGE OF AGRICULTURE UNIVERSITY OF KENTUCKY LEXINGTON, KENTUCKY
40546

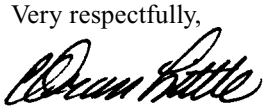
TO HIS EXCELLENCY,

HON. BRERETON JONES

GOVERNOR OF KENTUCKY

I herewith submit the one hundred and seventh annual report of the Kentucky Agricultural Experiment Station for the period ending December 31, 1994. This is done in accordance with an act of Congress, approved March 2, 1887, entitled, "An act to establish Agricultural Experiment Stations, in connection with the Agricultural Colleges established in the several states under the provisions of an act approved July 2, 1862, and under the acts supplementary thereto," and also the act of Kentucky State Legislature, approved February 20, 1888, accepting the provisions of the act of Congress.

Very respectfully,



C. Oran Little, Director
Lexington, Kentucky
June 30, 1995

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PURPOSE

As a Land Grant institution, the University of Kentucky is responsible for serving the people of the Commonwealth of Kentucky. The College of Agriculture, with its research, teaching, and Extension activities, has developed a structure and organization to provide the mandated Land Grant services in agriculture and related areas.

The Kentucky Agricultural Experiment Station has been providing research results to farmers for more than 100 years. The continued growth of Kentucky agriculture attests to the benefits of applying new knowledge and technology to the agricultural production process. Much of the research leading to increased quantity and improved quality of Kentucky's agricultural output was performed by the Experiment Station. Also, College researchers address problems of agribusiness, consumers, international trade, food processing, nutrition, community development, soil and water resources, and the environment.

Although much Experiment Station research has immediate application to agricultural problems, scientists are also involved in basic research, generating new information to help solve present and potential problems. The ability of Kentucky producers to be competitive in domestic and world markets requires an expanded base of knowledge in emerging areas of research applicable to agriculture.

This Annual Report summarizes Experiment Station research highlights for 1994. Lists of the faculty, research projects, and publications completed during the year are also provided.

The research programs of the Kentucky Agricultural Experiment Station have benefitted Kentucky's agriculture over the past century, and the results of present and future research will continue to serve Kentucky's primary industry.

AGRICULTURAL ECONOMICS

Research in agricultural economics involves such diverse subjects as improving the profitability of Kentucky agriculture and agribusinesses, enhancing U.S. competitiveness in international trade of food and fiber products, and assisting in the revitalization of the Commonwealth's rural communities.

Enhancing Agricultural Profitability

Analysis of the 525 farms participating in the Kentucky Farm Business Analysis program revealed that 1993 was another good year financially. Returns varied around the state and by enterprises on specific farms. However, net returns were positive for all areas of the Kentucky Farm Business Management Groups. While returns were down from 1992 levels, it should be recognized that 1992 financially was the most profitable year since the early 1970s. Central Kentucky farms, in particular, showed improved returns, whereas only Ohio Valley livestock farms improved returns in 1993 in Western Kentucky. Hog and beef farmers experienced positive net returns, but dairy farmer returns were down statewide.

The University of Kentucky is the leading research institution examining the role of crop insurance in agricultural production. In 1994, eight crops became eligible for coverage under the Group Risk Plan (GRP) pilot program for crop insurance: corn, wheat, soybeans, grain sorghum, cotton, barley, peanuts, and forage. Research continued on how farmers accept GRP insurance (measuring participation rates) and how well GRP meets the insurance needs of farmers.

Kentucky beef producers and cattle buyers were surveyed to analyze beef risk management practices in feeder calf backgrounding programs. Grazing contracts with conventional weight-gain payment terms were found to be low-risk for pasture owners, but were of little benefit to cattle owners. Risk management for cattle owners required price risk management through futures hedging or put options purchases. Analyses compared different seasonal backgrounding operations on fescue pasture and supplemental feeding, with and without grazing contracts.

A study of the adoption and use of bovine somatotropin (bST) in dairy found that use will likely be determined mostly by sociological factors. Potential adopters of bST are characterized as being young, having more education, having larger herds, and operating with relatively low net worth.

Research showed that trade liberalization was found to increase the demand for U.S. meat in different regions of the world. However, export demand increases are realized primarily through income effects in the importing countries. For households which consumed meats, the own-price elasticity was

found to be elastic at -1.8. All meats expenditure was found to fall with rising education levels as well.

Two studies evaluated the U.S. burley tobacco program and the effect of possible higher excise taxes on cigarette consumption. The first study evaluated the Tobacco Improvement Act of 1985 and its impact on quota, stocks, prices, exports, leasing, grading, and other alternative programs. The second study reported that a 75 cent per pack excise tax would reduce U.S. cigarette consumption by 15%, reduce burley use by $84 million, and net the federal government $50 billion over a five-year period, while reducing state tobacco tax receipts by more than $1 billion.

Several models were developed to appraise greenhouse enterprises. In particular, the case of different size greenhouses is being analyzed from an investment perspective given the irreversibility of the greenhouse investment.

Additional research activity focused on: how financial futures might be used as a hedging strategy for smaller banks that tend to be concentrated in rural areas; examining the impact of the Community Reinvestment Act on rural banks; examining how farm family household motivation influences the financial performance of U.S. agriculture; and assessing sustainable livestock production and investment in livestock where the interaction of grass growth, grazing, and wind erosion are evaluated.

Competitiveness Through International Trade

An analysis of the major external factors that might drive or explain trade patterns in food and fiber products found that the U.S. tends to export bulk agricultural products because of religious differences, low levels of urbanization, unfamiliarity with the distribution system, and a general lack of awareness of cultural differences. These non-economic forces were found to be more important in explaining where the U.S. exported processed food than economic variables such as GDP, income, or the level of foreign exchange reserves. The study concluded that the U.S. has been slow to adjust to a world economy where processed foods are traded, rather than bulk commodities.

Research revealed that multinational food processing firms located their facilities in countries were growth rates were high, where market size was large, and where English was the spoken language. Results also showed that there are many niches for processed foods from the U.S. such as wines, snack foods, breakfast cereals, dietetic foods, microwavable products and pet foods.

Revitalizing Rural Communities

Research is being conducted to understand not only how investments in education affect economic development, but also how economic development affects investments in education. One aspect of the study statistically explained student test scores in Kentucky. One argument was that factors not under the influence of school administrators, especially the socioeconomic background

of the student or the level of economic development in the community, have to be controlled to arrive at accurate assessment of performance.

A study identified strategic policy levers, including improvements in educational attainment, which states may use to increase the number of biotechnology firms locating within their borders. Biotechnology has been viewed both as a means of increasing value-added from agriculture, and stimulating economic development and employment. Another study examined how educational attainment of the population affects a rural county's ability to attract medical doctors.

Research Projects

An Analysis of Finance Efficiency and Socioeconomic Influences in Urban and Rural Public Schools—S.J. Goetz

Analysis of Selected Economic Factors Affecting the Long Run Viability of the Northern Dairy Industry—R.L. Beck

Analyzing the Future International Competitiveness of the U.S. Food Industry—M.R. Reed

Benefits and Costs in Natural Resource Planning—R.C. Ready

Changing Patterns of Food Demand and Consumption Behavior—B.W. Bobst

Development of Multiobjective Decision Criteria Models for Agricultural Investment Appraisal—A. Pagoulatos

Economic Analysis of Southern Regional Adjustments to a Dynamic Livestock-Meat Sector—B.W. Bobst

Exportation of Agricultural Products from the Southern States—M.R. Reed

International Trade Research on Commodities Important to the Southern Region—M.A. Marchant and M.R. Reed

Quantifying Long Run Agricultural Risks and Evaluating Farmer Responses to Risk—H.H. Hall

Regulatory, Efficiency and Management Issues Affecting Rural Financial Markets —D. Freshwater

Rural Development: Alternatives in the New Competitive Environment—S.J. Goetz

AGRICULTURAL ENGINEERING

Agricultural Engineering research is directed toward solving existing and emerging engineering-related problems found on Kentucky's farms and forests, as well as developing methods of protecting foods and other farm products which are consumed or utilized by the public. Five broad areas of interest are pursued.

Machine Systems design involves development and evaluation of basic machine systems through the application of theoretical and applied mechanics. A fully-automated burley tobacco harvesting and curing system is being tested on Experiment Station farms. A mechanical spearing machine has been demonstrated to farmers. A commercial version of the wire-strung portable frame system was used on a limited number of farms throughout the burley producing area. A two-row mechanical tobacco topper was shown to significantly reduce labor. An electric powered tobacco stripping aid is undergoing on-farm evaluations.

Techniques for targeted herbicide application using GIS/GPS and reflectance sensors are being researched. A significant effort is in the area of robotics and machine vision as a support technology for machine systems for harvesting, grading, and automated control of field machinery. The effects of soil compaction created by heavy machinery on water infiltration, ground water movement, and plant growth are being studied.

Bioenvironmental engineering involves applying sound engineering, agricultural, and ecological principles to solving problems dealing with the management and care of our natural resources. Research efforts include better methods of controlling and managing soil erosion through the development of better mathematical models to be used as design tools by engineers. A 4,000-acre watershed is being used to investigate the fate and transport of agricultural chemicals on a karst watershed. Research efforts are directed toward protecting ground water resources and rebuilding land disturbed by surface mining activities and landfills.

Structures and Environment involves the design of farm structures and environmental control systems for plant and animal production, feed storage and processing centers, residences, and utility buildings. Research efforts are directed toward reducing infiltration into residences, better management of animal waste, improved design of grain storage systems and structures, improved environmental control within poultry and swine growing facilities, computer-aided design methods for dairy facility design, and the development of alternative structures for curing burley and dark tobacco. Evaluation of a low-cost field curing structure for dark air-cured tobacco showed satisfactory curing during the 1994 season.

Crop Processing research involves applying basic engineering sciences, particularly heat and moisture transfer processes, to the processing, storage, and handling of farm products. Management protocol has been developed for curing burley tobacco in wire-strung portable frames over sod for dry, wet and normal curing seasons. In each type of year, the tobacco cured on the portable frames was shown to be equivalent to conventional barn cured burley.

Food Engineering involves applying engineering principles to achieve efficient production and high standards of quality during processing, packaging, storage, and distribution of food products. A milk coagulation sensor has been developed using fiber optics and light reflectance that improves the control of cheese making. The sensor is being evaluated in this country and several foreign countries. Research shows the applicability of using light reflectance as an aid in making cottage cheese.

Other on-going research which has basic implications in more than one of the areas mentioned above includes developing a profitable beef-forage production system through computer modeling, and modeling growing swine. Meteorological research will improve the understanding and use of weather-related agricultural management models in the southern region. Research is underway to identify ways of reducing the health and accident risk for farm workers and youth.

Research Projects

Agricultural BMP's and Surface Water Ground Water Interaction in Karst Terrain—J.L. Taraba

Agricultural Pesticide Handling and Application Technology Demonstrations —S.G. McNeill

Analysis and Management of Misting Systems for Tunnel Ventilated Broiler Housing—R.S. Gates

Assessment of the Hydrologic Response of Surface Mined Lands in the Appalachian Coal Region—R.C. Warner

Calibration of STOWME: Computer Model to Estimate the Inventory of Grain Facilities—S.G. McNeill

Comparison of Integrated Electronic Controllers to Conventional Staged Thermostatic Control in Large Broiler Houses—R.S. Gates

Design Data for the 1, 2½, and 5% Occurrences of Extreme Dewpoint Temperature with Mean Coincident Dry-Bulb Temperature—D.G. Colliver

Design of a Passive Greenhouse Irrigation System Using Geotextiles and Geomembranes—R.C. Warner

Design and Demonstration of a Low-Pressure Low-Flow Irrigation System for Nurseries' Containerized and Ball and Burlap Areas—R.C. Warner

Development and Evaluation of a Model for an Active Gas Collection System at Municipal Landfills—R.C. Warner

Development of a 3-Axis Manipulator for Harvesting of Fruit and Vegetable Crops —S.A. Shearer

Development of the AutoCAD-SEDCAD Interface—R.C. Warner

Development of a Computer-Aided Method for Determining Minimum Ventilation Timer Settings in Kentucky Broiler and Pullet Houses—R.S. Gates

Development of Geographical Information Systems (GIS) in the UK College of Agriculture—K.T. Priddy

Development of Near-Real Time Weather Station at Woodford County Research Farm—K.T. Priddy

Development of Profitable Beef-Forage Systems for the Southern Region—L.W. Turner

Development of the SEDCAD+ (Sediment, Erosion, Discharge by Computer Aided Design) Model: Version 4—R.C. Warner

Development of Soil Temperature Climatology of Southeast U.S.—K.T. Priddy

Development of a Trickle Irrigation Design and Specification Program—R.C. Warner

Development of Weather-Related Insect Forecast Model Output in Geographical Information System (GIS) Format—K.T. Priddy

Dynamic, Probabilistic Modeling of Respiratory Disease in Livestock—L.W. Turner

Effect of Construction and Quality Assurance on the Leachate Migration from Agricultural Waste Lagoons -- R.C. Warner

Effect of Ozone on the Storage Life of Refrigerated Fruits and Vegetables—F.A. Payne

Energy Savings from Combined Natural-Forced Ventilation Systems for Greenhouse Retrofits—R.S. Gates

Engineering Principles for Conservation Cropping Systems—S.A. Shearer

Facility Design and Testing for Closed System Plant Micropropagation—R.S. Gates

Farm Family Health and Hazard Surveillance Projec—L.R. Piercy

Fluid Power Drives for Agricultural Field Machinery—S.A. Shearer

Ground Water Study of the Toyota Plant Site, Scott County, Kentucky—G.K. Felton

Hydrograph Separation Analysis of Karst Flow Systems—G.K. Felton

The Impact of Agricultural Systems on Surface and Ground Water Quality—G.K. Felton

Improved Curing of Burley Tobacco—L.R. Walton

Improved Information Delivery by Developing Internet Gopher/Web Server in the UK College of Agriculture—K.T. Priddy

Improving Quality and Efficiency of Burley Tobacco Market Preparation—L.G. Wells

Infiltration Energy Losses in Residential Structures—D.G. Colliver

Integrated Grazing System Decision Support for Improved Sustainability and Environmental Quality—L.W. Turner

Interior Environment and Energy Use in Poultry and Livestock Facilities—R.S. Gates

Knowledge-Based System for Single Stem Greenhouse Rose Production—R.S. Gates

Laboratory Assessment of the Influence of Construction Quality Control in Dairy Waste Lagoons—R.C. Warner

Maximum Daily and Annual Nutrient and Pesticide Loads from Turfgrass Management Areas—G.K. Felton

Mechanical Systems for Improving the Labor Efficiency of Burley Tobacco—L.G. Wells

Mechanics of Granular Solids—I.J. Ross

Milk Coagulation Sensor Development—F.A. Payne

Model Development and Verification of a Tubular Trickle Irrigation System to Increase Water Application Efficiency—R.C. Warner

Modeling Responses of Growing Pigs—L.W. Turner

Nighttime Ventilation Strategies for Summer Heat Stress Relief in Broilers—R.S. Gates

Physical and Bioremediation of Hazardous Waste Contained Soils through Incorporation of Coal Fines and in situ *Environmental Management—R.C. Warner*

Preliminary Assessment of Construction Equipment, Moisture Content and Moisture Incorporation Method on the Performance of Dairy Waste Lagoons—R.C. Warner

Reducing Heat Stress in Swine Through Sprinkler and Fan Cooling—L.W. Turner

Reducing Nitrogen and Phosphorus in Swine Waste Through Diet Manipulation—L.W. Turner

The Role of Sediment in Nutrient Transport in a Karst Ground Water Catchment—G.K. Felton

Sensor Development for Cottage Cheese and Yogurt Culture—F.A. Payne

Sequences of Extreme Temperature and Humidity for Design Conditions—D.G. Colliver

Site-Specific Management of Nutrients on Agricultural Lands—S.A. Shearer

Stress-Strain Modeling of Wheel Compaction Incurred During Restoration of Prime Farmland—L.G. Wells

Systems for Providing and Controlling Interior Environments for Poultry and Livestock Housing—R.S. Gates

Targeted Herbicide Application Using GIS/GPS and Reflectance Sensors—S.A. Shearer

Time Integrated Variable Control Strategies for Animal and Plant Environments—R.S. Gates

Utilization of Commercially Composted Waste to Reduce the Transport of Herbicides to Surface and Ground Water—R.C. Warner

Variable Rate Seeding in Conservation Tillage and No-Till Cropping Parameters for Surface Mining in the Appalachian Coal Region—R.C. Warner

Wetting and Drying Rates of Soybeans in the Pod Under Simulated Field Conditions—S.G. McNeill

AGRONOMY

The research objectives of the Department of Agronomy include: improving productivity and quality of crops, sustaining soil and water resources, and revealing fundamental properties and processes of plants and soils.

Soils

Soil mineralogy research focused this year on evaluation of water dispersible colloid particles and their potential to facilitate transport of herbicides to the groundwater. Preliminary experiments with intact soil columns have indicted that up to 20% more atrazine and up to 100% more metolachlor can be leached through the rooting zone and into the groundwater in the presence of water dispersible colloids.

A long-term research study designed to evaluate no-tillage versus moldboard plow tillage system for corn production is in its 25th year. Corn yield and soil property measurements strongly support our hypothesis that no-tillage is a sustainable farming system. The most noticeable change observed in soil properties includes the stratification of nutrients in the soil surface layer of no-till. Organic matter, nitrogen, calcium, and potassium all tend to accumulate at the surface of no-till.

Research in the soil microbiology laboratory is addressing non-point source pollution by fecal bacteria and nitrate in agricultural systems. We are investigating: the movement of fecal bacteria from poultry wastes through surface runoff and infiltration; the management of runoff by grass filter strips; and the effect of animal wastes on stimulation of denitrification in tillage systems.

Another project deals with pyrite oxidation and acid mine drainage production, the most costly environmental pollutant in Kentucky. A breakthrough was made in a new technology by which pyrite is inactivated through a coating process employing metasilicate. The silica coating technology is environmentally friendly and protects pyrite more effectively than phosphate coating.

Crop Ecology and Management

Results of a long-term field study in no-till wheat indicated that fall applications of herbicides resulted in fewer broadleaf weeds compared to spring applications. Weed control appeared to have a greater impact on the yield of no-till wheat in 1994 than in 1993. The difference in impact of weeds on wheat yield may be attributed to the fact that no-till plots tended to have more problems with weedy annual grasses in 1993.

Research in the field and laboratory demonstrated that leaf senescence in soybean, a yield limiting factor, is not caused by the high N demand of the

seed. Seeds do not "demand" N from the leaf; rather, the accumulation of N by seeds is totally dependent upon the N supplied by the leaf. Our work contradicts the popular senescence theory based on the idea that seed N demand caused the removal of N from the leaf and leaf senescence.

No-till tobacco production has been shown to be a feasible alternative to conventional production, but several problems remain. Research is being conducted to identify options for weed control.

On-farm testing of early maturing MG II soybean cultivars revealed continued strong yield performance under full season planting conditions. Early planting of cultivars from Maturity Groups (MG) 00 to IV consistently reduced linolenic acid content of the grain. Perhaps there is a place for production of newly emerging, early maturing soybean cultivars with genetically reduced linolenic acid levels in southern latitudes.

Several parameters affecting seed germination for tobacco transplant production were evaluated in the float system. Based on the data, light to medium tray filling, dome-shaped dibble with 3/4 in. depth, media with better gas exchange and melt-coat pelleted seed are important for good transplant production.

MH residues continue to be a cause for concern for burley manufacturers and especially for burley exporters. Studies over the past several years were geared toward residue reduction. No adjuvant or booster has shown consistent favorable results. However, tank mixes of sucker control chemicals which have other modes of action have successfully controlled sucker growth when combined with reduced application rates of MH.

Kenaf (*Hibiscus cannabinus* L.), a non-wood fiber producing plant, was evaluated for its potential as a crop in Kentucky for producing pulp for making paper. It is a relative of cotton and okra and is not related to marijuana (*Cannabis sativa* L.) even though some varieties have palmate leaves that resemble marijuana. The Kenaf ranged from 9.5 to 12.0 feet tall and yielded from 2.6 to 6.8 tons per acre. Yields of 6 to 10 tons per acre are needed for economic production of Kenaf. The potential for Kenaf production in Kentucky is dependent on the construction of a processing plant.

Plant Physiology and Genetics

Two major advances in understanding plant-pathogen interactions were accomplished. The regulatory elements within a plant defense gene were mapped using molecular genetic techniques, and a new signal molecule thought to regulate the activation of plant defense responses was characterized.

Two clover cultivars are nearing the testing stage to determine suitability for release: Kura clover (first season blooming, and high seedling vigor) and Red clover (non-pubescent selected for faster drying and less dustiness).

The plant trichome may be viewed as a factory for producing certain plant secondary compounds of commercial value. We are targeting trichome enzymes involved in terpene and sugar ester synthesis with the goal of opti-

mizing production of certain compounds and modifying existing trichome metabolism to produce novel compounds.

We have purified and characterized novel poly(A)polymerases from several plant species. These enzymes differ in significant ways from mammalian and yeast enzymes; most interesting is the involvement of multiple components in the non-specific reaction catalyzed by the plant enzymes. One component is a ribonucleoprotein that may be involved in RNA processing and transport in the nucleus.

The investigation and manipulation of fatty acid biosynthesis and peroxidative metabolism is continuing. We have transformed plants including soybeans with a desaturase targeted to endoplasmic reticulum in cells. This research will provide important insights in improving plant pest resistance and crop quality.

We have introduced genes into tobacco which conferred resistance to tomato spotted wilt, alfalfa mosaic, vein mottling, potato virus Y, and etch viruses. We have successfully introduced the bean pod mottle virus coat protein gene into soybean and have produced second generation transgenic progeny. All these materials are currently being evaluated.

New statistical methodology is being developed to analyze, identify and exploit yield response patterns in multisite crop variety trials.

As interest in growing earlier maturity soybean as a hedge against weather uncertainty increased, it became necessary to determine if soybean genotypes adapted to full season conditions in the upper midwest are also the most suitable for Kentucky. Random maturity group I lines were tested in MN and KY. Results indicated that early maturity group soybean varieties could be transferred from north to south with adequate predictability.

Research Projects

Alkaloid Accumulation in Acremonium coenophialum *Infected Tall Fescue—L.P. Bush*

Analysis of MRNA Polyadenylation and Metabolism in Plants— A.G. Hunt

Assessment of Constructed Wetlands for Animal Waste Treatmen—W.O. Thom, Y. Wang and J. Dinger

Bacterial Dissimilation of Nitrate to Ammonium in Batch and Chemostat Culture—M.S. Coyne

Behavior, Fate and Bioactivity of Acetolactate (ALS)-Inhibiting Herbicides —M. Barrett

Biomass Production by Fescue and Switchgrass Alone and in Mixed Swards with Legumes—M. Collins

Breeding and Genetics of Trifolium Species—N.L. Taylor

Breeding Burley Tobacco for Improved Pest Resistance and Productivity—M.T. Nielsen

Breeding Improved Wheat, Oats, Barley for KY—D. VanSanford

Cellular and Molecular Biology Initiative in Dark Tobacco—G.B. Collins

Characterization and Modifications of Metabolism Leading to Sucrose Ester Acyl Constituents Important to Natural Insect Resistance in Tobacco—G.J. Wagner

Characterization of Phytoalexin and Sterol Biosynthetic Genes in Tobacco—J. Chappell

Classification and Characterization of Kentucky Soils through Soil Surveys—A.D. Karathanasis

Classification Soils for Solute Transport as Affected by Soil Properties and Landscape Position—R.E. Phillips

A Comprehensive Corn Weed Management System for Kentucky—W.W. Witt

Cooperative Agreement Relative to Classification and Characterization of Kentucky Soils Through Soil Surveys—A.D. Karathanasis

Corn Breeding and Genetics: White Endosperm, Food Quality Inheritance, and Hybrid Performance—C.G. Poneleit

Correlation and Calibration of Crop Yields with Soil Test Levels of Major Nutrients—W.O. Thom

Dark Tobacco Breeding Genetics and Management—P.D. Legg

Determine if Chlorophyll Measurements can Predict Nitrogen Needs of Wheat—L.W. Murdock, Jr.

Development of a Soybean Tissue Culture and Genetic Engineering Center—G.B. Collins and P. Moore

Development of Efficient Tissue Culture Systems for Introducing Useful Foreign Genes into Soybeans via Genetic Engineering—G.B. Collins

Development of an Efficient Transformation Regeneration System for Soybean (Glycine max)*—G.B. Collins*

Distribution of Constituents Within Tobacco Leaf—H.R. Burton

The Effect of Face and Stable Flies on Pasture Utilization by Grazing Cattle—C.T. Dougherty, F.W. Knapp and N.W. Bradley

Effects of Ambient Environment on the Storage of Switchgrass for Biomass to Ethanol and Thermochemical Fuels Project—M. Collins

Effects of Suckering Practices on Growth Characteristics—J. Calvert

Enhancement of High School Science Curriculums: DNA Science Workshops for Science Teachers—J. Chappell

Environmental and Genotypic Control of Assimilate Allocation in Grain Crops—D.B. Egli

Environmental and Morphological Determinants of Field Curing Rates of Legume Hay—M. Collins

Evaluation of the Best Management Practices to Improve Water Quality in Karst Drainage Systems—J.H. Grove and W.O. Thom

Evaluation of Burley Tobacco Varieties—M. Nielsen

Evaluation of Nitrogen Fertilizer Materials—K.L. Wells and W.O. Thom

Evaluation of Small Grains on Mine Soils—R.I. Barnhisel

Evaluation for Soybean Variety and Breeding Lines for Use in KY—T.T. Pfeiffer

Evaluation of the Effects of Different Tobacco Vein Mottling Virus Genes on the Susceptibility of Burley Tobacco to Potyviruses—A.G. Hunt, M.T. Nielsen and W.C. Nesmith

Field Application of Pyrite Micro-encapsulation Technologies for Controlling Pyrite Oxidation and Acid Mine Drainage Production—V.P. Evangelou and R.E. Phillips

Formation/Stabilization of the Water Oxidizing Complex: Polypeptide/Secondary Donor Requirements—G.M. Cheniae

Genetic Engineering of Dark Tobaccos: A Sub-project of Cellular and Molecular

Biology Initiative in Dark Tobacco—J. Chappell

Genetic Control of a Putative Multiple Pesticide Metabolizing Cytochrome P450—M. Barrett

Genetic Manipulation of Alkaloids and Polyamines in Burley Tobacco—G.B. Collins and P. Moore

Genetically Engineered Protection of Burley Tobacco Against Potyviruses—A.G. Hunt

Green River Food Corn Total Quality Management Program—G. Henson, J.H. Herbek and M.C. Smith

HHMI Initiative Teacher Research—M.E. Salvucci

Improved Fertilizer Use Efficiency and Environmental Soundness in Burley Tobacco Production—J.L. Sims

Improved Management of Legume Cover Crops for Sustainable Grain Crop Production—W.W. Frye

Improving Soybean Technology Transfer in Kentucky—J.H. Herbek and M.J. Bitzer

Improving Switchgrass Productivity as a Biofuel Crop—M. Rasnake

Improving the Magnesium Nutrition of Burley Tobacco to Enhance Plant Growth and Usefulness of Cured Leaf—J.L. Sims and J.H. Grove

Increased Desaturation of Soybean Triacylglycerol—D.D. Hildebrand

In Vitro *and* In Vivo *Studies of mRNA 3' End Formation in Plants—A.G. Hunt*

Kinetics and Thermodynamics of Adsorption-Desorption in Binary and Ternary Soil Colloid Systems—V.P. Evangelou

Maintenance of Seed of Trifolium Species —N.L. Taylor

Management of Weedy Vines in Corn—W.W. Witt and C. Slack

Manipulation of Linolenate and Other Fatty Acids in Soybean Oil—D. Hildebrand and G.B. Collins

Manure Applied to Shallow, Well Drained Soils Improving Groundwater Quality—J.H. Grove

Mechanisms of Transport Leading to Vacuolar Storage Sequestration of Zn, Cd and MN—G.J. Wagner

Mineralogy and Charge Properties of Readily-Dispersible Fractions from Selected Soils and Sediments—A.D. Karathanasis

Modifying Recombination Rates in Soybean and Assessing the Effect on Breeding Progress—T. Pfeiffer

Molecular Dissection of Metabolic Channels for Sterol and Sesquiterpene Metabolism in Tobacco—J. Chappell

Multiplicative Models for Genotype X Environment Interaction—P.L. Cornelius

Mutagenicity of Genetic Engineered Tobaccos Having Altered Levels of Isoprenoids—J. Chappell

On-Farm Research Using Farming Systems Methodology—G.W. Thomas

Phenology, Population Dynamics, and Interference: A Basis for Understanding Weed Biology and Ecology—W.W. Witt

Plant, Animal and Environmental Factors Limiting Intake of Grazing Beef Cattle —C.T. Dougherty

Plant Exploration in Western United States to Collect Annual and Perennial Native Trifolium Germplasm for Crop Improvement—N.L. Taylor

Plant Genetic Rsource Conservation and Utilization—N.L. Taylor

Population Improvement and Line Development of White Endosperm Maize —C.G. Poneleit

Protein Analyses of Commercial Corn Hybrids—C.G. Poneleit

Quality Evaluations of Corn Grain for Food and Industry Uses—C.G. Poneleit and A. Kwaku

Regulation and Manipulation of Sesquiterpenoid Metabolism in Tobacco —J. Chappell

Refining Components of an Early-Planted, Early-Maturing Soybean Cropping System—L.J. Grabau

Remediation of Acid Drainage through Surface Coating of Fe Sulfide—V.P. Evangelou

Restoration of Altered Lands—R.I. Barnhisel

Restoration of the Productivity of Prime Farmland Following Surface Mining—R.I. Barnhisel

The Role of Lipoxygenase and Lipoxygenase Mediated Products—D. Hildebrand and J. Kuc

Seed Biology and Technology Investigations—D.M. TeKrony

Soft Red Winter Wheat Breeding and Variety Development for Kentucky—D.A. Van Sanford

Soil Nitrate Testing to Improve Use Efficiency and Reduce Residual Nitrate Under Corn and Wheat—J.H. Grove

Somatic Cell Genetics of Crop Plants—G.B. Collins

Soil Classification System for Southern Region Based on Water and Chemical Flow—R.E. Phillips

Soil Survey Characterization and Environmental Impact Assessment of Daniel Boone National Forest Ecosystems—A.D. Karathanasis

Soybean Genetic Engineering for Increasing Monounsaturated Fatty Acid Ratios—D. Hildebrand and G.B. Collins

Targeting of the Cd-Chelator Metallothinein to the Plant Cell Wall and Root Tissue using Recombinant DNA Methodology—G.J. Wagner

Tobacco and Forage Research—S.J. Crafts-Brandner

Transgenic Resistance to Bean Pod Mottle Virus and Soybean Mosaic Virus in Soybeans—S.A. Ghabrial and G.B. Collins

Understanding and Manipulation of Lipid Biosyntheses in Plants—D. Hildebrand

Update of Best Management Practices Manual for Surface Coal Mining Kentucky Nonpoint Source Management Program—R.I. Barnhisel

Use of Productivity Indices to Estimate the Yield Potential of Disturbed Soils—R.I. Barnhisel

Utilizing Seed Vigor as a Component of Seed Quality—D.M. TeKrony

Variability of Soil Properties and Its Effect on Water Quality and Soil Management—R.E. Phillips

Varying Corn Populations According to Soil Type and Depth of Topsoil—M.J. Bitzer, R.I. Barnhisel and J.H. Grove

Viral Gene Expression in Potyvirus Infections—A.G. Hunt

Wheat Management Research Interactions Resulting from Decisions about the Season N, Disease N, Planting Date, Varieties, Tillage Manure, and Lodging Control—J.H. Grove

Winter Annual Root Development and the Scavenging of Residual Soil Nitrate —J.H. Grove, R.L. Blevins and D. Zourarakis

Yield Evaluation of Alfalfa Varieties— L. Lauriault

Yield Potential and Long Term Effects of No Tillage on Wheat Production—L.W. Murdock, Jr.

ANIMAL SCIENCES

Livestock and livestock product sales account for more than half of the total farm cash receipts in Kentucky. Although poultry is growing at the most rapid rate, the potential for large growth exists in all of our farm animal commodities.

The Department of Animal Sciences is committed to fostering the growth of livestock commodities in Kentucky by making scientific discoveries and providing educational services geared to promoting profitable production of animals and animal products. The Kentucky livestock industry is an extremely important economic force that must continue to grow. However, we must see that this growth is environmentally friendly and accepted by the consumer and public. To support this growth we will need basic and applied research as well as educational programs designed to effectively disseminate information.

Non-Ruminant Nutrition

Increasing dietary calcium from 2.8 to 3.5% improved egg production and egg shell quality and increased body weight without affecting bone strength. Replacing half of the ground limestone with oyster shell particles as the main source of dietary calcium improved egg shell quality and the strength of the humerus without affecting the strength of the tibia.

Supplementing a low protein, corn based diet with lysine, tryptophan, threonine, and methionein resulted in optimal growth in pigs and resulted in a marked decrease in the nitrogen and phosphorus excretion which, environmentally, is very significant. Spray-dried porcine plasma was equal in nutritional value to dried skim milk in starter diets for pigs. The immunoglobulin fraction appeared to be responsible for the improvement in pig performance resulting from porcine plasma. Porcine somatotropin injections dramatically increased the lean tissue and decreased the fat deposition in finishing pigs, but it reduced the bone mineralization.

Other studies showed that highly productive sows nursing large litters require at least 16% crude protein (.80% lysine) in their diet to maximize milk yield and minimize body weight losses during lactation.

Food Science

Desirable flavor and extended shelf life are two of the most important attributes of beef. Unfortunately, beef from cattle finished on grass alone does not possess these characteristics. An antioxidant and a commercial flavoring agent were added to restructured steaks manufactured from grass fed beef. The results of two years of data reveal that much of the grassy “off” flavor

normally associated with this product can be masked by the flavoring agent while the frozen shelf life can be extended up to 60 days with the addition of the antioxidant.

Rheological properties of muscle myofibrillar protein gels formed in processed meats are critically dictated by heating procedures. Linear heating and slow heating favor formation of more elastic gel networks, thereby allowing meat to be more tightly bound. White muscle proteins (e.g., from chicken breast) were capable of forming more rigid gels and more viscous suspensions than red muscle proteins (e.g., from chicken thigh). Based on the results, different cooking schedules should be adopted for processing of white and red meat.

Microbiology

The metabolic activities of microorganisms in the digestive tract supply ruminant animals with most of the nutrients needed for growth, milk production and maintenance. One of the initial steps in the metabolism of pentose sugars, an important energy source for bacteria, is transport. This is also a potential site for metabolic regulation. The ruminal cellulolytic species *Ruminococcus albus* and *Butryivibrio fibrisolvens* both utilized ATP-dependent transport systems for xylose and arabinose uptake. It appeared that a common permease was used for the uptake of glucose and xylose by *R. albus*. In both *R. albus* and *B. fibrisolvens,* arabinose utilization was severely inhibited by most other sugars and this appeared to be related to transport and internal metabolic steps. This knowledge will be useful in designing rational schemes for manipulating ruminal fermentation and influencing animal performance.

A study examined the effects of dietary mannanoligosaccharide (MOS) on the prevalence of antibiotic resistance in fecal coliforms in swine not exposed to antimicrobials for 22 years. Prevalence of antibiotic resistance in lactose-positive isolates was not influenced by MOS; however, percentage of lactose-negative isolates that carried the resistance pattern streptomycin + sulfisoxazole + tetracycline decreased ($P<.01$) over time.

Physiology and Genetics

Studies with prepubertal gilts showed that estrogen injections 10 to 12 days after estrus will extend luteal lifespan and estrous cycle length of gonadotropin-induced cycles. Such extended cycles were terminated with prostaglandins. The combined treatment appears to be an effective method of estrus synchronization in gilts.

Pregnancy and estrogen injection suppressed prostaglandin secretion in response to oxytocin. Estrogen appeared to suppress response more than did pregnancy. However, concentration of progesterone (which supports preg-

nancy) after day 15 was less in estrogen-treated sows than in pregnant sows. This suggests that the conceptus may supply signals in addition to estrogen to maintain pregnancy.

Data collected on 11,084 stocker cattle processed through one Central Kentucky stockyards indicated that 26.6, 32.5 and 44.8%, respectively, of slick-shed, partial-shed and non-shed cattle expressed elevated body temperature.

Ruminant Nutrition

In steers, analyzing both zinc and metallothionein in serum made it possible to differentiate between stress and dietary deficiency as causes of low serum zinc. In another study, when dolomite was included in the protein supplement fed with corn silage in a growth trial it was as effective as magnesium oxide and limestone in maintaining blood levels of both magnesium and calcium.

Experiments have demonstrated that pancreatic secretion of a-amylase may be diminished in the presence of increased small intestinal carbohydrate in beef cattle. This situation is detrimental to digestive efficiency.

Copper toxicity has been reported on five Jersey farms when feeding copper at a level which is considered safe. A trial comparing Jersey and Holstein cattle showed a more rapid accumulation of copper in the liver of Jersey cattle as well as a higher plasma copper level. The results indicate that Jersey cattle have a markedly different copper metabolism than Holstein cattle. The safe upper limit for Jersey cattle is probably less than one half of the 100 ppm as recommended by the National Research Council.

Research Projects

Acid-Base Balance and Mineral Requirements of Dairy Cattle—R.W. Hemken

Amino Acid Sources and Concentrations for Swine—G.L. Cromwell

Antimicrobial Resistance and Plasmid-Mediated Virulence Attributes of Fecal Colonic Bacteria from Pigs—B.E. Langlois

Bioenergetics of Nutrient Transport and Growth of Gram-Negative Ruminal Microorganisms—H.J. Strobel

Comparison of Forage Finishing Systems, Carcass Traits and Processing Technologies—W.G. Moody

Effect of Additives and Processing Methods on Culture Agglutination and Cheese Yield—C.L. Hicks

Endocrine Regulation of Prostaglandin F_2a Secretion in Sows—L.A. Edgerton

Endocrine Mechanisms Contributing to Establishment of Pregnancy in Ruminants—W.J. Silvia

Evaluation of Beef Cattle Germplasm Resources Involving Additive and Nonadditive Genetic Effects—F.A. Thrift

Evaluation of Tall Fescue in Dairy Cattle —J.A. Jackson

Functional Properties of Food Proteins —Y.L. Xiong

Genetic and Phenotypic Aspects of Cow Productivity Using Field Records Collected on Angus Cattle—D.K. Aaron

Growth and Reproductive Performance in Angus and Brangus Cattle as Affected by Endophyte-Infected Tall Fescue and Breed Type—K.K. Schillo

Hydrolyzed Feather Meal as a Supplement for Lambs Consuming High Concentrate or High Roughage Diets—D.G. Ely

Improving Harvested Forages for Ruminants—G.E. Mitchell, Jr.

Increased Efficiency of Sheep Production —D.G. Ely

Maximizing Efficient Use of Forage Dry Matter by Beef Cattle Grazing Tall Fescue—D.G. Ely

Metabolic Relationships in Supply of Nutrients for Lactating Cows—D.L. Harmon

Nutrition and Exercise on Development of Horse Skeletal and Muscular Tissue and Subsequent Performance—L. Lawrence

Nutritional Systems for Swine to Increase Reproductive Efficiency—G.L. Cromwell

Optimizing Digestion and Absorption in the Ruminant Small Intestine—D.L. Harmon

Requirements and Bioavailabiltiy of Phosphorus for Swine—G.L. Cromwell

Resistance to Mastitis in Dairy Cattle—R.J. Harmon

Synergistic Microbial Interactions for Stimulating Cellulolytic Activities and Ruminant Production—K.A. Dawson

Skeletal Problems in Poultry—A.H. Cantor

Synchronization of Estrus in Gilts—L.A. Edgerton

ENTOMOLOGY

Research in Entomology continues to be directed toward understanding insects and related arthropods and their interactions with plants and animals. The ultimate goal is the development of more effective and environmentally benign management tactics and strategies for pest species.

Physiology, Biochemistry, and Molecular Biology

Progress has been made in the purification and characterization of a polypeptide secreted by cells derived from the extraembryonic serosal membrane (teratocytes) of an egg from a braconid parasite, *Microplitis croceipes*, of the tobacco budworm. The mechanism by which this polypeptide inhibits protein synthesis in certain host tissues is under investigation. Proteins inhibited include synthesis of storage proteins needed for successful pupation and adult development as well as certain enzymes essential to regulation of hormone titers. Regulations of these proteins have important implications for application in pest management.

Research is underway to elucidate the molecular basis of one type (*kdr*-type) of insect resistance to pyrethroid insecticides, which act on the insect nervous system.

Ecology, Behavior, and Evolution

Other than through enzymatic regulation of pheromone biosynthesis, the cabbage looper moth does not have an active means of regulating the ratio of pheromone components that are emitted. It was discovered that genetically based difference between individuals does affect the biosynthesis of pheromone components, and the response of males to pheromone blends.

Research in insect genetics focused on evolutionary and genetic aspects of interactions between male and female insects, including: studying pheromonal and acoustic communication by cockroaches; documenting how male-produced signals can be used by females to assess the potential genetic contribution of males to their offspring; and investigating how genetic correlations and gene flow may limit behavioral plasticity and behavioral responses to stress in cockroaches and grasshoppers.

Laboratory experiments revealed that young stages of the wolf spider *Schizocosa*, an abundant forest-floor predator, are readily preyed upon by centipedes and other species of spiders. However, reducing densities of these enemies of *Schizocosa* in fenced field plots did not increase numbers of young *Schizocosa* compared to fenced or open control areas. Mortality within the predator-reduction plots over the 2-mo. experiment was high (68%) and was

due largely to cannibalism. A laboratory experiment revealed that an increase in the abundance of insect prey decreases cannibalism and increases the number of spiders that remain in an area. The results of these studies will help us understand the role of spiders in controlling insect populations.

Field experiments showed clear evidence of competitive exclusion between a ladybeetle and a tobacco aphid pathogen; the first biocontrol agent to establish in the field excludes the other one. However, only the pathogen can provide economically significant control of these aphids. The study has shown that, at least in some instances, lady beetles can actually interfere with aphid control.

Lady beetle larvae were found to be attracted to tobacco plants which had recent aphid feeding damage. The attraction was duplicated with green leaf volatiles known to be released by the plant in response to aphid feeding. This previously unknown response is likely an important aspect in determining how lady beetle larvae find their aphid prey.

The within-plant distribution of potato leafhopper nymphs decreased on the middle and bottom sections of the alfalfa plant as it matured. The density of adult leafhoppers rapidly decreased in the second growth alfalfa after it reached 100% bloom. Yellow pan traps were used to detect adult leafhopper migration to and from second growth alfalfa.

A statewide survey for the Asian tiger mosquito, *Aedes albopictus* (Skuse), was initiated in 1993 and completed in 1994. Of Kentucky's 120 counties, 59 are infested with this mosquito.

Spectral reflectance curves were obtained from tires and a wide range of background coverages (such as water, soil, roads). Custom video camera lenses were ground and will be evaluated in 1995 to determine their effectiveness in spectrally isolating tire piles in both rural and urban environments.

Two years of field data confirmed the emergence and activity of two cohorts of adult American dog ticks in central Kentucky. Overwintering cohorts are active from mid-April to mid-June and summer cohorts (derived from overwintering larvae) are active from early June to early August. Host-seeking adults are found randomly distributed along paths used by hikers. Percentage survival of field-collected adult ticks maintained under constant laboratory conditions may indicate the intensity of spring tick host-seeking activity.

Three forms of trypsin were identified from horn flies based on soybean trypsin inhibitor sensitivity. The Michaelis constants were 0.34, 0.45, and 0.70 mM using a-Nbenzoyl-DL-arginine-p-nitroanilide as a substrate. Bovine serum strongly inhibited horn fly trypsin activity *in vitro*.

Tree leaves damaged by Japanese beetles were found to emit a complex blend of volatiles that attracts additional beetles. This work helps to explain the aggregative behavior of this important pest on particular plants.

Research on the ecology of black cutworms on golf courses revealed that most eggs laid on putting greens are removed by mowing. Combined use of

resistant grasses, clipping removal, and sand top dressing may reduce insecticide use and associated hazards to wildlife and water quality on golf courses.

Pest Management

A U.S. Patent was issued for a method and apparatus for deploying entomopathogens targeted against insect pests using an autodissemination technique.

Basic research on the simultaneous infection of the corn earworm, *Helicoverpa zea*, with two baculoviruses has demonstrated that dual infections significantly reduced the median lethal dose. Similar reductions in median lethal times of host response were also noted. An optimal mixture of 65% HzSNPV and 35% AcMNPV was most lethal and resulted in the most rapid host mortality response. Addition of the ultraviolet brightening agent, Tinopal, further enhanced median lethal dose and time response.

A cytoplasmic polyhidrosis virus infectious to the fall webworm, *Hyphantria cunea*, was shown to be transmitted both horizontally and vertically. Larval cohorts effectively disseminated virus intra-colonially. Sublethally infected adults passed the virus onto the next generation although we have not determined whether it is through transovum or transovarial transmission routes.

Results of a study on the season-long impact of insecticide applications on beneficial invertebrates in turf suggest that populations of earthworms and smaller predators such as rove beetles and spiders may not recover for many months after use of certain insecticides.

Completion of a three-year study correlating seasonal occurrence of key insect pests with flowering phenology of trees and shrubs provided a calendar which greatly simplifies the problem of proper timing of pest control decisions by homeowners and landscape managers.

Damsel bugs, which are important predators of soybean insect pests, probe plants for moisture. A test of resistant and susceptible soybean lines showed that damsel bug predation on caterpillars which had fed on resistant plants adversely affected growth and reproduction of these predators, but the predators were not seriously affected by probing resistant plants. Field tests showed that row spacing and planting date had little effect on the amount of predation inflicted on known densities of soybean podworm eggs. Field studies of predation on soybean podworm (=corn earworm) eggs corroborated evidence from 1993, with the dominant predators being damsel bugs in soybean and a lady beetle (*Coleomegilla maculata*) in corn; each accounted for about 50% of the total observed predation in the respective crops.

Research Projects

Biological Control of Arthropod Pests (NCR 125)—G.C. Brown

Biological Control of Selected Arthropods and Weeds Through Introduction of Natural Enemies (S-238) —B.C. Pass

Biology and Management of Insects Attacking Urban Landscape Plants—D.A. Potter

Biology, Ecology, Economics and Population Management Strategies for Muscoid Flies Affecting Cattle (NC 154) —F.W. Knapp

Characterization of Biologically Active Secretory Products From Teratocytes of Microplitis croceipes, *an Endoparasite of the Tobacco Budworm—D.L. Dahlman*

Control Processes in a Terrestrial Food Web: Trophic Intractions of a Generalist Predator—D.H. Wise

Damage Thresholds Risk Assessment and Environmentally-Compatable Management Tactics for White Grub Pests of Turfgrass—D.A. Potter

Determinants of Resistance of Woody Landscape Plants to the Japanese Beetle —D.A. Potter

Development of Entomopathogens as Control Agents for Insect Pests (S-240)—G.L. Nordin and G.C. Brown

Development of Sustainable IPM Strategies for Soybean Arthropod Pests (S-255)—K.V. Yeargan

Effect of Groundcovers and Mulching Materials on Weed and Japanese Beetle Grub Infestation in Woody Ornamental Production Systems—D.A. Potter

Empirical Evaluation of Dynamic Systems Theory in Entomological Laboratory Systems—G.C. Brown

Epidemiology and Insecticidal Control of Barley Yellow Dwarf of Wheat—D. Johnson

Evaluation of the Southern Region IPM Program—B.C. Pass

The Genetics and Evolution of Behavioral Plasticity in Reproductive and Social Behavior of the Cockroach, Nauphoeta cinerea*—A.J. Moore*

The Genetics of Sexual Selection in Nauphoeta cinerea*—A.J. Moore and K.F. Haynes*

Gypsy Moth Survey—B.C. Pass

Impacts of Spiders in Food Webs of Crop and Forest-Floor Ecosystems—D.H. Wise

Indigenous Biological Control: Assessing Predator Impact on Pest Populations and Factors Affecting Predator Abundance—K.V. Yeargan

Insect Stress: Multitrophic Interactions Between Parasites, Pathogens and Allelochemicals—D.L. Dahlman

Interactions Between Non-Insecticidal Control Techniques for Tobacco Aphid Management—G.C. Brown, G.L. Nordin and D. Hildebrand

Isolation of Biologically Active Secretory Products From an Endoparasite—D.L. Dahlman

Mechanism and Regulation of Polydnavirus Replication—B.A. Webb

Molecular Characterization of the KDR type Mutation in the German Cockroach —K. Dong

A New Approach to Understanding Food Webs of the Forest-Floor Arthropod Community—D.H. Wise

Nursery Inspections—J.T. Collins and B.C. Pass

Pathogenicity, Transmission and Introduction of a Cytoplasmic Polyhedrosis Virus to Fall Webworm, Hyphantria cunea *(Drury) Populations in Kentucky—G.L. Nordin*

Pesticide Impact Research and Data Analysis—B.C. Pass

Physiological and Ecological Relationships Affecting Biting Flies and Ticks on Pastured Cattle (S-242)—F.W. Knapp

Plant Pest Survey Detection Cooperative Agriculture Pest Survey—P.M. Dillon.

Redundancy in Chemical Communication: Evolution of Sex Pheromone Blends—K.F. Haynes and A.J. Moore

Semiochemical Mediation of Reproductive Behaviors in Moths—K.F. Haynes

Simple Dynamic Models for Incorporating Biological Control Agents into IPM Decision Making—G.C. Brown

Surveillance of Aedes albopictus *in Kentucky—G.M. Beavers*

Spatial Dynamics of Leafhopper Pests and Their Management on Alfalfa (NC-193)—B.C. Pass

A Systematic Study of the Kentucky Conopidae (Diptera)—P.H. Freytag

Yield Potential and Long-Term Effects of No Tillage on Wheat Production—D. Johnson

FORESTRY

Kentucky contains 12.7 million acres of forest land (50% of its total land area) which support two important industries in forest products and recreation/tourism, as well as community water supplies and habitat for a wide array of species. Expanding economic markets and rising timber values are placing increasing emphasis on the forest resources of Kentucky.

The research objectives of the Department of Forestry are to achieve sustained utilization of the Commonwealth's renewable forest products and support wise stewardship of Kentucky's forest lands. In support of these objectives, research is conducted in Forest Management and Forest Biology, including ecology, soil processes, wildlife biology, and genetics.

Forest Management

Alternative silvicultural practices are being studied to determine their effectiveness for producing high quality timber while providing for other resource needs such as maintaining biodiversity, wildlife habitat and forage, and aesthetic beauty. Two-aged forests, containing potentially valuable older trees surrounded by young regenerating trees, provide for multiple age-classes thereby increasing the long-term biodiversity of the forest.

Evaluation of the growth and quality of small sawtimber white oak stands released to different residual canopy tree densities producing two-aged stands having differing numbers of older trees is underway at Robinson Forest in eastern Kentucky. Results of 10 years of growth in these stands indicate that the stands are regenerating a vigorous understory while maintaining or increasing the value of the older crop trees. Results of this evaluation will aid in determining the feasibility of using two-aged silvicultural practices for the production of high valued timber.

A computer simulation model using a dynamic programming network search has been developed to evaluate the value of management information in determining optimal timber rotations for various species and forest cover types throughout the central and eastern United States. Initial results investigating shortleaf pine indicate that the financial returns are sensitive to the precision of state variables, particularly stand density, and to the interval in which management decisions are considered. Basal area per acre, both as a single measure of stand density and in combination with stand average diameter, was the most efficient state variable in determining high value rotation schemes.

Future investigations will examine combinations of more state variables, investigate other species and cover types, and also look at "expert system" rules that might be applied to low-precision data in order to improve its usefulness in finding high value rotation schemes.

A reclamation study was initiated in western Kentucky to establish herbaceous vegetation and black locust on an extremely acid (pH 1.8), 80 year-old abandoned coal washing site. In addition to lime and fertilizer, soil amendments included: hardwood bark; straw and manure; bark, sawdust, and manure; and a mixture of sewage sludge and kiln dust. Terra-Sorb™, a water holding synthetic polymer, was also tested. After three growing seasons, all treatments produced similar amounts of woody biomass, except the sludge, which produced none. The sludge, however, produced significantly higher vegetative cover. Vegetation and biomass production was not improved with Terra-Sorb.

The northern bobwhite has experienced population declines through much of its range, possibly amplified by extensive plantings of Kentucky-31 fescue, which limits availability of bare ground and represses growth of preferred food species. Research has been conducted to determine the effectiveness of burning, disking, and or herbiciding in converting fescue fields to bobwhite habitat supporting native species such as ragweed and foxtail. Evaluation of seven combinations of treatments indicated that herbicide application was most effective in eliminating tall fescue. Controlled burning was the most ineffective treatment, while the effectiveness of fall and spring disking waned with time. Bobwhite winter feeding habitat was improved on fall disk, spring disk, and herbicide plots. Fall disk plots provided the highest nutritional quality foods. Nesting habitat was improved only on herbicide plots, but brood rearing habitat structure and invertebrate food populations were improved on both herbicide plots and fall disk plots.

Forest Biology

A single-tree physiological model, TREGRO, was used to examine the effects of ozone exposure on the growth of mature trees and seedlings of northern red oak *(Quercus rubra)*. Results point to carbon storage in coarse roots as the primary point of stress resulting from ozone exposure. Long-term cumulative effects of ozone on perennial tissues were implicated by reductions in growth increment with increasing ozone exposure. Further modeling research on red oak mature trees and seedlings elucidated physiological differences between mature trees and seedlings that explain differences in their abilities to withstand ozone exposure. Specifically, seedlings had a smaller ozone response because of lower leaf conductances, lower ozone uptake, and recurrent flushing of leaves.

Decline in calcium concentration and content in the forest floor of the northern hardwood forest has been documented at the Hubbard Brook Experimental Forest, New Hampshire. Such a decline in calcium could have a significant impact on the long-term productivity of the northern hardwood forest and could signal future concerns for hardwood forests throughout eastern North America. Research has been initiated to determine: 1) whether the decline has had any impact on other components of the ecosystem; and 2)

whether the decline is common throughout the northern hardwood forest, as the result of broad reaching anthropogenic influences, such as acid precipitation.

Preliminary investigations examined the Ca and Mg concentrations in sapwood in the three dominant tree species, yellow birch *(Betula allegheniensis)*, sugar maple *(Acer saccharum)*, and American beech *(Fagus grandifolia)*, and the relationship of wood chemistry to soil chemistry, drainage, and elevation. Dilute acid extractable Ca and Mg in the upper mineral soil under sugar maple and yellow birch were greater than under beech, suggesting Ca and Mg "loading" under these species. Beech showed significantly greater concentrations of both Ca and Mg in trees on wet sites than on dry sites, but sugar maple and yellow birch were insensitive to soil drainage class.

For all three species, Ca and Mg concentrations decreased with increasing elevation. Content of these elements in forest floor horizons collected from five stands declined during 1979 to 1994. The average decrease in forest floor Ca content was 22%. Magnesium contents declined by 14% over the same period.

Studies of the genetics of red oak have been conducted in a 30 year-old and a 19 year-old provenance test to determine: 1) the geographic patterns of phenotypic variation; 2) the genetic control of phenotypic variation; 3) correlations among phenotypic traits; and 4) an estimation of the magnitude of interaction between genotypes and environment in expression of phenotypic variation.

Preliminary analyses of growth and stem quality indicate that when making phenotypic selections in natural stands, there is no benefit to be gained by identifying the single best phenotype in a stand. A sample of a number of the better dominant and codominant individuals in a stand is sufficient to characterize the entire stand. This understanding will benefit seed collectors who must contend with the vagaries of year-to-year seed production in northern red oak.

Research Projects

Characterization of Fluid Flow Pathways in Hardwoods—J.M. Ringe

Development of Conservation Strategies for Forest Dwelling Wildlife Dependent upon Topographic Habitat Features—M.J. Lacki

Economic Assessment of Surface Mine Reclamation—J.M. Ringe

The Effects of Forest Management Practices on Forest Nutrient Status—M.A. Arthur

Effects of State Interval Size and Number of Predictors on Dynamic Programming Solutions in Forestry—M.H. Pelkki

Evaluation of Differential GPS Positioning Accuracies in Forestry Applications—C.J. Liu

Indicators of Ecosystem "Quality" in the Mixed Mesophytic Forest—P.J. Kalisz

HORTICULTURE AND LANDSCAPE ARCHITECTURE

Integrated Crop Management

A new concept of irrigation for commercial greenhouses as well as the home owner was developed. Water and nutrients are supplied to plants from a constant water table (CWT) system consisting of a capillary mat placed on a level surface with one end suspended in a trough. The system automatically maintains a constant water/air ratio in the growing medium as determined by plant requirements and eliminates nutrient and water runoff and waste. The number and total length of marigold seedling roots increased over a 16-day growing period on the CWT irrigation system.

Herbicides as weed management tools are under evaluation for use in vegetables and herbaceous and woody ornamentals. More than eight acres of studies evaluated both pre and postemergence herbicides for efficacy in weed control and crop tolerance. Both labeled and newly developed herbicide chemistries were evaluated.

No-tillage systems were evaluated for commercial vegetable production in 1993 and 1994. Killed rye cover provided considerable weed suppressive potential over an 8-week period. Clover covers were also highly weed suppressive, but regrew after glyphosate application to control growth and later interfered with further crop growth. Killed hairy vetch covers stimulated crop and weed growth. Sweet corn yields similar to those in conventional tillage systems were produced in killed rye or hairy vetch covers. Pumpkin yields were not affected by treatments but those produced in rye residues or conventional production exhibited superior quality.

Sorgoleone, a potent phytoinhibitor produced by *Sorghum spp*., selectively inhibited the growth of several weed species and was particularly inhibitory to *Digitaria sanguinalis*, *Abutilon theophrasti*, and *Echinochloa crus-galli*. Sorgoleone had no effect on the growth of *Ipomoeae hederacea*. Sorgoleone had limited, if any, effect on germination of over 20 different crop and weed seedlings. Sorgoleone was found to be a potent inhibitor of electron flow in photosystem II between Qa and Qb binding sites.

Vegetable production/marketing systems research is generating information to help growers obtain higher net returns per acre. This research has included: fertigation systems for tomatoes and peppers, cultivar trials, sequential planting of tobacco and vegetable crops, and fall vegetable greenhouse production.

As part of a national S-103 survey of the nursery industry, surveys were distributed to 160 of Kentucky's wholesale production nurseries during 1994.

Results indicate that the average size nursery in the state was 87 acres. Almost 75% of the firms have been started since 1970. Balled and burlapped products were the most common marketed unit. Deciduous shade/flowering trees and evergreen trees were the most common plant types produced. Landscape firms accounted for 70% of the buyers from Kentucky's wholesale nurseries. States which most frequently receive Kentucky products include Kentucky, Ohio, Indiana, Illinois and Michigan. The average 1993 gross sales for the respondents was $446,512.

Crop Improvement

Sorbitol dehydrogenase (SDH) is a key enzyme in sorbitol metabolism in apple. While cultivar differences in SDH activity was not found, comparison of 'Golden Delicious' fruit in clusters or located singly indicated that crop load may have an effect on the activity of SDH. Differences in SDH activity may be a result of available sorbitol, as girdling and defoliation, which eliminated sorbitol import into fruit, stopped fruit growth and resulted in SDH activity declining to nondetectable levels. Re-establishment of vascular continuity across the girdled zone and of sorbitol import into fruit resulted in a significant increase in SDH activity and the resumption of fruit growth. Apple fruit growth and quality may be sensitive to ever transient changing SDH availability.

Characterization of *Fragaria* (strawberry) drought stress responses indicated that a root-derived drought stress signal is produced in response to declining soil water content. In split root studies, a droughted half of the root system produced a drought signal which reached the foliage and reduced stomatal conductance and transpiration rate while the watered half of the root system kept all leaf water potential components the same throughout the plant. Xylem exudate ABA content increased in response to drought stress, although it was not consistently higher at all sampling times. Thus, other factors may also be involved in signalling drought in *Fragaria*.

Horticulture faculty cooperate in a national project evaluating fruit rootstocks under various environmental conditions and production systems in an effort to find better adapted fruit rootstocks for Kentucky. A semi-dwarf apple rootstock planting with 6 rootstocks (100% survival) and a peach rootstock planting with 12 rootstocks were established in 1994.

Ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) is a rate-limiting enzyme in carbon assimilation in plants. The species and site-specific post-translational methylation of Lys-14 in the large subunit (LS) of Rubisco was shown to be catalyzed by S-adenosylmethionine (AdoMet):Rubisco LS (lysine) N-methyltransferase (Rubisco LSMT). A full-length cDNA of Rubisco LSMT was obtained. All five of the peptic polypeptide sequences from the Rubisco LSMT were found in the deduced amino acid sequence of the Rubisco LSMT full-length cDNA clone. The Rubisco LSMT gene was expressed in an organ-specific manner and was modulated by light.

Studies on natural compounds may lead to the development of alternatives to use of synthetic pesticides for control of pathogens on plants and plant derived foods. Volatile compounds derived from the phenylpropanoid metabolic pathway were effective growth inhibitors of pathogenic fungus, *Botrytis cinerea*, on strawberry fruit and exhibited the lowest phytotoxicity of the compounds tested. Lipoxygenase-lyase derived compounds strongly inhibited the fungus but also extensively damaged the fruit. The terpene hydrocarbons evaluated were not significantly active against the pathogen. Volatile compounds emitted by rose flowers cause anomalous hyphal development in *Botrytis cinerea.*

Insect repellency is an appealing mechanism of host resistance, especially for high value crops such as vegetables that have a low threshold for insect injury. However, repellency is not well understood. In wild species of tomatoes, plant hairs and chemicals associated with the hairs are responsible for repellency of whiteflies and spider mites. The compounds produced depend on the genetic makeup of a plant. Long-term exposure reveals more differences among compounds than short-term exposure. Sesquiterpene acids appear the most effective repellents. Intermediate chain length ketones and hydrocarbons appear to be less effective. Inheritance of sesquiterpene acids is controlled by a few genes, and thus transfer of chemical-based repellency from the wild species to the cultivated tomato appears possible.

Environmental Regulation of Plant Growth and Development

Supplementary lighting (long-day treatments) of corn flower or bachelor's button (*Centaurea cyanus*) in a greenhouse system for single-stem cutflower production decreased days to flower and number of nodes on each stem and increased stem length and marketable quality. Floral initiation from long days occurred on seedlings five days old. Incandescent and HPS lamps produced similar responses.

Landscape Architecture

Development of a basic Geographic Information System of surface mined areas has positioned our program to provide planners with data that will guide them through various tasks. The basic conceptual framework includes physical, economic, and socio-cultural factors for utilizing devastated land on both local and regional bases.

Increasing financial and physical stress in downtowns of Kentucky's small towns are causing a loss of environmental quality and community vitality. Vocal planning and design knowledge that can be focused on these problems is usually minimal. An assessment of urban design problems and opportunities in a selected group of towns was developed for the Kentucky Main Street Program to provide better downtown planning assistance.

Research Projects

All American Selection Trial Garden—S. Bale

Blackberry and Raspberry Cultivar Evaluation—G.R. Brown and D. Wolfe

Daylily Cultivar and Production System Evaluation—W. Dunwell

Densities and Secretions of Trichomes on Lycopersicon*—J.C. Snyder*

Developmental and Environmental Influences on Carbohydrate Partitioning in Fruit Crops—D.D. Archbold

Drainage Systems for Orchards—G.R. Brown, D. Wolfe, and M. Rasnake

Evaluation of Cut Flower Species for Adaptability to Improved Greenhouse Production Practices and Extended Postharvest Life —R.G. Anderson

Fall Vegetable Greenhouse Production—D. Spalding, R. Anderson, B. Rowell

Fertilization Systems for Field-Grown Nursery Crops—D.L. Ingram

Herbicide Evaluations in Vegetable Crops and Woody and Herbaceous Ornamentals—L.A. Weston and R.E. McNiel

Integrated Crop Management Program for Apples—J. Hartman, G.R. Brown, D. Wolfe, and R. Bessin

Interaction Between Ethylene and Polyamines During Seed Germination and Early Seedling Growth—R.L. Geneve

Knowledge-Based Manufacturing System for Optimization of Greenhouse Rose Production—R.G. Anderson and R.S. Gates

The Landscape of Main Street: An Assessment of the Urban Landscapes of Kentucky's Main Street Towns—N. Crankshaw

Light, Temperature and CO_2 Effects on Carbohydrate Metabolism in Bedding Plant Seedlings—J.W. Buxton

Nitrogen Cycling in Strawberry—D. Archbold, C.T. MacKown

Planning Model for the Development of Mountaintop Removal-Valley Fill Mining Sites—T.J. Nieman

Plant Emitted Volatile Compounds and Their Role in Host Plant Parasite Interactions—T.R. Kemp

Plant Interactions in Minimum Tillage Vegetable Production Systems—L.A. Weston

Post-Translational Modifications in Ribulose Biosphosphate Carboxylase/Oxygenase—R.L. Houtz

Rootstock and Interstem Effects on Pome and Stone Fruit Trees—G.R. Brown

Seedless Table Grape Cultivar and Training System Evaluation—G.R. Brown and D. Wolfe

Southeast Tree Fruit Cultivar Evaluation —G.R. Brown, D. Wolfe, J. Strang, and R.T. Jones

Sustainable N Management: Intensive Crop Production and Improved Water Quality—D.C. Ditsch, R.T. Jones, R.C. Pearce, and J.H. Grove

Technical and Economical Efficiencies of Producing and Marketing Landscape Plants—R.E. McNiel

Thornless Blackberry Training System Evaluation—G.R. Brown and D. Wolfe

Use of Natural Volatile Compounds for Control of Microbial Spoilage and Quality of Strawberry During Modified Atmosphere Storage—D. Archbold, T.R. Kemp, B. Langlois, and M. Barth

NUTRITION AND FOOD SCIENCE

(COLLEGE OF HUMAN ENVIRONMENTAL SCIENCES)

The Department of Nutrition and Food Science is supported by the Kentucky Agricultural Experiment Station at the University of Kentucky through research activities and salary of four regular title faculty and one chairperson, with joint appointments and projects in the KAES. Their research focuses on nutrition in relation to eating disorders, cardiovascular disease, cancer, nutrient-drug interactions and aging.

Cardiovascular Disease

Kentuckians are experiencing a high incidence of nutrition-related health problems, which may be due to overconsumption of fat. The vascular endothelium plays an active role in physiological processes such as hemostasis, regulation of vessel tone and vascular permeability. Because of its constant exposure to blood components, including prooxidants, diet-derived fats and their derivatives, the endothelium is susceptible to oxidative stress and to injury mediated by blood lipid components. Data suggest that certain nutrients, which have antioxidant and/or membrane stabilizing properties, protect endothelial cells by interfering with the mechanisms of endothelial cell dysfunction.

Cancer

The main goal of our research is to determine the mechanisms by which peroxisome proliferators induce hepatic tumors in rodents. We hypothesized that the peroxisome proliferator perfluorodecanoic acid (PFDA), which inhibits peroxisomal beta-oxidation and lacks promoting activity, unlike other peroxisome proliferators, would increase hepatic cell proliferation and oxidative DNA damage less than the conventional peroxisome proliferator ciprofibrate. In another study, we examined if polycyclic aromatic hydrocarbons (PAH) could alter tissue levels of vitamin A. Carcinogenic PAH, such as benzo(a)pyrene and 3-methylcholanthrene, decreased hepatic vitamin A concentrations but increased renal vitamin A concentrations.

The effect of dietary fat and iron on oxidative damage was studied in mice. As expected, vitamin E supplemented groups had markedly higher hepatic vitamin E content. However, animal groups receiving fish oil had significantly lower vitamin E content than those receiving lard or hydrogenated lard. The results obtained provide experimental evidence on the prooxidant effect of fish oil and iron *in vivo*.

Aging

The effects of chronic alcohol (ETOH) feeding on antioxidant defenses in mice fed AIN-76 liquid diets were investigated. The results suggest that chronic ETOH administration decreases liver antioxidant defense capacity; however, the mice fed AIN-76 ETOH liquid diet can maintain a higher antioxidant defense capacity than those fed Lieber-DeCarli ETOH liquid diet.

Eating Disorders

Research is examining relationships between central nervous- system histamine, histaminergic receptors (H1), histaminergic-associated physiologic symptoms, anorexia and dietary treatment. Results suggest that increased histamine and/or H1 receptor concentrations are potential mechanisms for elevated central histaminergic activity in dietary induced pathophysiological states. Additionally, this study indicates a means of influencing the histaminergic symptoms of physical activity, food intake and/or effciency of weight gain associated with food restricted or low protein diets.

Research Projects

Dietary Vitamin E/Fat Oxidative Damage —C.K. Chow

The Histaminergic System and Eating Disorders—L.P. Mercer

Lipid Mediated Endothelial Injury—B. Hennig

Mechanism of Hepatocarcinogenesis by Peroxisome Proliferators and Influence of Dietary Antioxidants—H.P. Glauert

Nutrient-Alcohol/Oxidative Drug Interaction—L.H. Chen

PLANT PATHOLOGY

Fundamental and applied research endeavors concerning plants infected with bacteria, fungi, nematodes and viruses were pursued with the intent to achieve improved disease management strategies having minimal environmental impact.

Plant-Bacteria Interactions

Studies were undertaken to resolve the role of bacterial extracellular proteins in pathogenesis and elicitation of the hypersensitive resistance response (HR) in plants. Of five proteins detected in the culture supernatant of *Pseudomonas syringae* pv. *tomato*[1], three were produced only under conditions that induce the expression of bacterial *hrp* genes, which are required for bacteria to initiate pathogenesis or to elicit the HR.

The *Pseudomonas syringae* pv. *syringae hrpZ* gene product, harpin$_{Pss}$, previously shown to elicit the HR, induced systemic acquired resistance (SAR) in cucumbers to different pathogens, including the angular leaf spot bacterium *(Pseudomanas syringae* pv. *lachrymans)*, the anthracnose fungus *(Colletotrichum lagenarium)* and tobacco necrosis virus.

A rapid screening procedure for *Arabidopsis thaliana* mutants impaired in the expression of HR was established. Two tobacco genes expressed specifically during the development of the HR were identified. One showed high similarity with the *msr* gene, which has previously been shown to be induced by a variety of environmental stimuli, including auxin and pathogens. The other gene is unique in amino acid sequence.

In surveys of landscape trees from 1989 to 1994, bacterial leaf scorch *(Xylella fastidiosa)* was found in 16 Kentucky cities and towns distributed statewide. Bacterial leaf scorch was observed in bur, pin, red, shingle and white oak, as well as in red maple and sycamore.

Plant-Fungus Interactions

A continuing dogwood anthracnose survey confirmed the disease in three new counties in 1994, bringing the incidence of *Discula* anthracnose on dogwoods to 54 of Kentucky's 120 counties. Austrian pines on the University of Kentucky campus were monitored for tip blight *(Sphaeropsis sapinea)*, disease severity ranging from zero to trees near death. Infected cones are a probable

[1]*Pseudomonas syringae* pv. *tomato* is the primary causal agent of bacterial speck of tomato and not bacterial leaf spot of tomato, as was incorrectly stated in the 1993 Annual Report. *Xanthomonas campestris* pv. *vesicatoria* is the primary causal agent of bacterial leaf spot of tomato.

source of inoculum. Juniper and flowering dogwood cultivars were assessed for their reactions to various diseases. There were significant cultivar differences.

A purified polygalacturonase (PG) produced by *Cryphonectria parasitica* (chestnut blight) caused browning of the inner bark of American chestnut and hydrolyzed isolated cell wall materials from both American and Chinese chestnut bark. PG activity was detected in infected chestnut bark. Lower PG activity was detected in cankers on resistant Chinese chestnut as compared to those on susceptible American chestnut. A protein extract from Chinese chestnut bark was more inhibitory to the *C. parasitica* PG than a similar extract from American chestnut.

The foliage of transgenic tobacco overexpressing ß-1,3-glucanase was highly resistant to black shank *(Phytophthora parasitica* var. *nicotiana)*. The foliage of some overexpressing lines was also resistant to blue mold *(Peronospora tabacina)*. Inoculation of lower leaves with tobacco mosaic virus (TMV) induced SAR to black shank and blue mold and increased the activities of ß-1,3-glucanase. High levels of ß-1,3-glucanase may contribute to resistance and SAR of tobacco to pathogens which have glucan cell walls.

Using tobacco cell suspension cultures and tobacco plants, data were collected which support the existence of multiple mechanisms for inducing systemic resistance and increasing biosynthesis of pathogenesis-related proteins. Salicylic acid may function in relevant signal transduction.

Acremonium coenophialum is an *Epichloë* type fungal endophyte and important agent of biological protection for tall fescue. However, the endophyte produces ergot alkaloids which are toxic to grazing livestock. With the long-term aim of modifying the endophyte to reduce or eliminate its toxicity, cloning of the gene, *dmaW*, for the first step in ergot alkaloid biosynthesis in the related fungus, *Claviceps purpurea*, was accomplished. A new endophyte species, *Epichloë festucae*, important for the biological protection of fine fescue was characterized.

Plant-Nematode Interactions

Research focused on the soybean cyst nematode (SCN). A six-year project was initiated to determine the effect of seven different cropping sequences on SCN reproductive ability and race structure. Too frequent use of SCN-resistant soybean cultivars may result in SCN race shifts, complicating management of the nematode. Preliminary results from the two study sites confirm that one is infested with race 1 and the other with race 3. For both locations, base populations of the nematode were similar between treatments. It is premature to draw any conclusions about the effect of a single year in different crops on SCN reproductive ability or race shift potential.

Plant-Virus Interactions

Study of mechanisms involved in the earliest stages of infection of a plant cell by a RNA virus of helical structure (TMV) revealed that coat protein

molecules are removed from the virus particles very rapidly and in a bi-directional manner. Some 30-40 minutes after inoculation of the cells, the production of progeny virus particles has commenced.

In the conduct of a mutational analysis of the potyvirus tobacco vein mottling virus, mutant viruses with impaired abilities to be replicated or to undergo polyprotein processing in inoculated plant cells or that produce altered patterns of disease symptoms in plants were isolated. One mutant, which contains four additional copies of a short sequence motif in the 3, untranslated region of the genome, was able to infect and spread in plants but did not produce symptoms.

The interaction between potyvirus particles and the helper component protein required for transmission of these viruses by aphids was visualized by electron microscopy. Ultrathin sections of aphid mouthparts were labelled with specific antibodies conjugated to gold particles.

A gene present on caulimoviruses was used to stimulate the expression of internal genes of a polycistronic messenger RNA in transformed tobacco. This may represent a useful system for improving transformation technology for tobacco and other higher plants.

Transgenic soybean plants that express the precursor to the coat proteins of bean pod mottle virus (BPMV) were produced. These transgenic soybean plants provide the only known source of resistance to BPMV, since all commercially available cultivars lack resistance to BPMV.

Full length cDNA clones representing the genomes (RNA 1,2 and 3) of two strains of peanut stunt virus (PSV) were constructed. Satellite RNA symptom-attenuating properties of PSV-associated satellite RNAs are being investigated for the purpose of developing satRNA-mediated transgenic protection against PSV in forage legumes.

The complete nucleotide sequence (5,178 bp), organization and expression of the dsRNA genome of the mycovirus Helminthosporium victoriae 190S virus have been determined. The dsRNA has two large open reading frames (ORFs); ORF 1 codes for the viral capsid protein and ORF 2 codes for the RNA-dependent RNA polymerase.

Disease Management

Electronic weather monitors were used in two apple orchards to test whether accumulated leaf wetness could be used to establish a threshold for timing fungicide sprays for sooty blotch and flyspeck diseases. Preliminary results suggested that disease symptoms appear at 200 hours (sum of all leaf wetness time periods beginning 10 days after petal fall) and that fungicide sprays need to be applied at 175 hours. Two and three fungicide applications were saved at the two locations.

Wheat research addressed evaluation of new generation fungicides as well as the development of fungicide use decision guides and economic damage thresholds for foliar diseases. Studies were ongoing concerning the epidemi-

ology and control of barley yellow dwarf virus. Efforts were also focused on two corn diseases associated with expanding use of conservation tillage; gray leaf spot and Diplodia ear rot. Hybrid reactions to disease were evaluated.

Field experiments indicated that mycorrhizal fungal communities respond more to crop species in the cropping system than to any other factor. In the case of mycorrhizal stunt of tobacco, cropping systems can be devised which will control the stunt pathogen. Management of mycorrhizal fungal communities should be considered in development of low input, sustainable cropping systems.

Research to identify agronomically acceptable turf varieties with disease resistance were continued. Field studies on cultural control of spring dead spot of bermudagrass were conducted, as well as ongoing evaluations of commercial fungicides.

Additional testing was pursued to determine which management strategies were most likely to enhance or curtail disease development in transplant production in greenhouse and float-bed systems. Experimental verification of optimal disease control protocols in these increasingly common production systems is critical because of the different disease possibilities they present. Metalaxyl-insensitive strains of the blue mold fungus and *Pythium* spp. were often recovered from these systems.

Research Projects

Assessment of Yield Losses Due to Gray Leaf Spot of Corn—P. Vincelli

Biological Improvement of Chestnut and Management of the Chestnut Blight Fungus—L. Shain

Characterization of Potyvirus Mutants Non-pathogenic to Tobacco—T.P. Pirone

Characterization of Viral Genes and Gene Products Which Mediate Aphid Transmission and Cell to Cell Movement —T.P. Pirone

Chemical Controls for Tobacco Diseases in Float/Greenhouse Systems—W.C. Nesmith

Consequences of the Ten-Year, Conservation Reserve Program on Disease Development in Corn, Soybean and Wheat—D.E. Hershman

Cultural Practices for Managing Spring Dead Spot of Bermudagrass—P.Vincelli

Defining and Mapping the Genes of Caulimoviruses—R.J. Shepherd

Determination of Economic Damage Thresholds for Wheat Fungal Diseases —D.E. Hershman

Disassembly and Early Gene Expression of RNA Plant Viruses—J.G. Shaw

Distribution of Bacterial Leaf Scorch in Kentucky—J.R. Hartman

Effect of Cropping Sequence on Soybean Cyst Nematode Reproductive Ability and Soybean Yield—D.E. Hershman

Effect of Reduced Tillage on Disease Development in Wheat—D.E. Hershman

Epidemiology and Insecticidal Control of Barley Yellow Dwarf Virus in Wheat —D.E. Hershman

Evaluation of Disease Management Strategies for Tobacco and Vegetables— W.C. Nesmith

Evaluation of Fungicides and Other Commercial Products for Control of Turfgrass Diseases—P. Vincelli

Evaluation of Landscape Austrian Pines for Pine Tip Blight Disease—J.R. Hartman

Expression of Latent Mechanisms as a Means for Plant Disease Control—J. Kuc

Forage Legume Viruses: Identification and Genetic Resistance for Improved Productivity—S.A. Ghabrial

Genetic and Biochemical Analysis of the Hypersensitive Response in Higher Plants—S.Y. He

Genetic and Biochemical Analysis of the Hypersensitive Response in Plants— S.Y. He

Identification of Disease Resistant Cultivars of Turfgrasses and Corn—P. Vincelli

Interactions between Castanea *sp. and Strains of the Chestnut Blight Fungus—L. Shain*

Introduction of Acremonium *Endophytes into Grasses for Crop Improvement—M.R. Siegel*

Management of Rhizosphere Dynamics to Control Soilborne Pathogens and Promote Plant Productivity—J.W. Hendrix

Modulation of Virus Symptoms and Down Regulation of Gene Expression in Tobacco via Viral Satellite RNA—S.A. Ghabrial

National Dogwood Anthracnose Survey —J.R. Hartman

Natural and Modified Grass Endophytes as Agents for Biological Protection—C.L. Schardl

Pest Predictive Technology for Apple Disease Management—J.R. Hartman

Plant-Fungal Endophyte Interactions: Potential for Cultivar Improvement in Species of Festuca *and* Lolium*—M.R. Siegel*

Phylogenetics of Epichloë *Species and Related Grass Mycosymbionts—C.L. Schardl*

Potyvirus Replication and Pathogenicity —J.G. Shaw

Production of Transgenic Soybeans with Resistance to Soybean Mosaic Virus—S.A. Ghabrial

Regulation of Gene Expression in Tobacco for Disease Resistance by the Use of Sense and Antisense Transformation and Chemical Agents which Release Immunity Signals—J. Kuc

Role of Coat Protein and Helper Component in Aphid Transmission of Potyviruses—T.P. Pirone

Structure and Function of the Viral dsRNAs of the Plant Pathogenic Fungus Helminthosporium victoriae*—S.A. Ghabrial*

The Relationship between Boxwood and Mycorrhizal Fungi—J.W. Hendrix

The Relationship between Holly and Mycorrhizal Fungi—J.W. Hendrix

The Role of Specific Viral Genes and Gene Products in Potyviral Pathogenicity, Host Range and Aphid Transmission—J.G. Shaw and T.P. Pirone

Transformation of Plant Pathogenic and Plant Mutualistic Fungi—C.L. Schardl

Transgenic Resistance to Bean Pod Mottle Virus and Soybean Mosaic Virus in Soybeans—S.A. Ghabrial

Urban Tree and Ornamental Plantings Disease Evaluations—J.R. Hartman

Wheat Seed Treatment and Foliar Fungicide Screening—D.E. Hershman

REGULATORY SERVICES

The Division of Regulatory Services administers state laws pertaining to the manufacturing, processing, labeling, and marketing of commercial feed, fertilizer, seed, tobacco seedlings, and raw milk. Its purpose is to protect farmers and other consumers from poor quality, mislabeled, or misrepresented products and to protect agricultural businesses from unfair competition from those who might take short cuts in the quality of their products.

Feed, fertilizer, seed, and tobacco seedlings are monitored in the manufacturing or retail channels for reasonable and acceptable compliance with state laws through label review, product inspection, and sampling and analyzing of products. Raw milk is monitored during marketing to assure an accurate and equitable exchange between producers and processors and to ensure the integrity of milk from farm to processor.

Ten regulatory inspectors and one auditor travel throughout the state, collecting samples, inspecting facilities, and auditing records. Additionally, three full-time, temporary inspectors cover the state to inspect labels, records, and visual quality of tobacco seedlings in the marketplace. The Division also offers seed testing, soil testing, and poultry litter and animal manure testing to growers and homeowners.

Auditing Program

H.S. Spencer

Audits of sales and fee payments were made on 332 of 677 milk, seed, feed, and fertilizer businesses in Kentucky to verify check-off and tonnage fees. Fees assessed to help defray the costs of inspecting, sampling, and analyzing commodities in accordance with Kentucky laws are: fertilizer, 50 cents per ton; feed, 35 cents per ton; seed, 4 to 24 cents per unit. During May, raw milk is assessed a check-off fee of 3 cents per 100 pounds.

Income from fees in 1994:

Feed account	$663,152
Fertilizer account	587,482
Creamery license account	61,607
Soil testing	120,121
Seed tags, testing and tonnage	163,094
TOTAL	$1,595,456

These cash receivables were substantiated on 2,899 fertilizer tonnage reports, 3,369 feed tonnage reports, 1,163 seed reports, and 23 milk reports. These reports were checked for accuracy and compared with field audits of the firms submitting them. An additional $8,000 was realized through auditing and correcting inaccurate reports.

Milk Regulatory Program

R.H. Hatton

The milk regulatory program administers the Kentucky Creamery License Law, which establishes regulations for ensuring that dairy farmers are accurately paid for the milk they produce and that the integrity of milk is maintained from the farm to the processor. The program is conducted by a program coordinator and one inspector who covers the state. In 1994 the program:

• Reviewed and issued licenses to 13 milk buyers, 52 testers, 464 sampler-weighers, and 9 raw milk transfer stations.

• Analyzed and administered action on 9,500 official samples and checked 3,000 producer pay records.

• Conducted 75 inspections at 18 milk laboratories.

• Analyzed 1,100 exchange samples from commercial laboratories.

• Trained and examined 76 sampler-weighers and nine testers.

• Conducted 516 inspections of 262 sampler-weighers.

Feed Regulatory Program

C.E. Miller

The feed regulatory program provides consumer protection for the purchasers of commercial feed, maintains a marketplace environment that promotes fair and equitable competition for the feed industry, and helps ensure the safety and wholesomeness of animal products for human consumption. In 1994 the program:

• Administered actions on 3,819 official samples of commercial feed involving 21,361 official tests to monitor the distribution of about 3 million tons of commercial mixed feed and feed ingredients.

• Administered a cooperative program with FDA on eight feed mills that mix restricted drugs in feed. An additional 57 state inspections were conducted on mills that mix non-MFA drugs in feed to ensure compliance with medicated feed regulations. Forty-one mills that mix no drugs were inspected to ensure compliance with labeling, manufacturing, and storage practices.

• Conducted 7,500 label reviews and maintained product registration for about 15,000 products from 875 companies.

• Cooperated with the Association of American Feed Control Officials in con-

ducting the twenty-ninth Annual Feed Management Seminar at Shakertown, Kentucky. Forty-six professionals from 26 states and the FDA attended.

Fertilizer Regulatory Program

D.L. Terry

The Kentucky Fertilizer Law ensures that fertilizers sold in Kentucky are clearly and accurately labeled so that consumers can make informed purchases of fertilizer and be assured of its quality. The law also protects the legitimate fertilizer industry from unfair competition. In 1994 the program:

• Administered actions on 5,198 official and 65 unofficial samples of fertilizer involving 9,247 tests of the 935,000 tons of fertilizer distributed in Kentucky.

• Reviewed labels and registered 3,756 products from 480 firms, including 238 who manufactured custom blends of fertilizers.

Inspection Program

F. Herald

The inspection program aims to achieve industry compliance with the consumer protection laws that the Division is charged with administering. This responsibility is carried out by inspectors strategically located throughout the state, each with an assigned area to cover. They inspect manufacturing plants, processing facilities, storage warehouses, and retail stores; collect official samples of feed, pet food, fertilizer, and seed; review records; and offer advice and assistance to clientele in improving their operations to achieve compliance.

In 1994:

• A team of nine inspectors performed 5,370 inspections of the processing, manufacturing, and marketing of feed, fertilizer, and seed. In addition, three temporary inspectors traveled throughout the state during April and May to implement the 1994 Tobacco Seedling Law and one full-time milk inspector covered the state to enforce the Creamery License Law.

• Inspectors collected the following official samples for laboratory verification of appropriate constituents and quality:

Feed 3,720
Fertilizer 3,198
Seed 2,409
Milk 9,500

Seed and Tobacco Seedlings Regulatory Program

D.T. Buckingham

The seed regulatory program assures Kentucky farmers of quality seed and tobacco seedlings of known varieties and promotes fair and equitable competition

among seed dealers and tobacco seedling distributors. In 1994 the program:

- *Collected and tested 2,409 official seed samples.*
- *Issued stop sale orders on 341 official seed samples and 209 violative seed lots at seed dealer locations.*
- *Conducted a cooperative program with USDA, AMS on trueness-to-variety testing and on interstate shipments of seed.*
- *Inspected tobacco seedlings at 152 locations in Kentucky.*

Seed Testing Program

E.E. Fabrizius

The seed testing program provides the seed industry and seed growers of Kentucky with competent, reliable, and timely analyses of their seeds for labeling requirements and quality assurance. In 1994 the seed laboratory tested 5,909 seed samples as a service to the Kentucky seed industry.

Soil Testing Program

V.W. Case (Lexington)
D.L. Kirkland (UKREC, Princeton)

Soil testing provides the citizens of the Commonwealth with scientific information about the fertility status of their soils, and in cooperation with the Cooperative Extension Service, provides them with lime and fertilizer recommendations based on soil tests. The program also offers non-routine, optional soil tests for UK researchers and analyses of poultry litter and animal wastes for farmers and farm advisors.

In 1994 the program analyzed the following number of samples:

Agriculture	31,515
Home lawn and garden	6,521
Strip-mine reclamation	149
Commercial horticulture	574
Greenhouse	71
Research	6,386
TOTAL	45,216

The Lexington lab also analyzed 126 soil samples for triazine residue.

ROBINSON SUBSTATION

Research and demonstration trials at Quicksand are primarily conducted by the departments of Agronomy, Horticulture and Plant Pathology. Horticulture research consists of trials with fruit and vegetable cultivars for both commercial and home gardens. Agronomy research activities include forage management, no-till corn production, tobacco nitrogen management, and variety trials for sweet sorghum, kenaf and corn. Plant Pathology trials deal primarily with evaluating cultivar resistance in tobacco and field corn.

Horticulture

Forty sugar enhanced (se) sweet corn cultivars were evaluated for commercial yield and ear quality. Several promising new yellow, white and bicolor cultivars were identified.

A pumpkin, Jack O'Lantern, cultivar trial was conducted for the second year. Twenty three cultivars were examined for yield, fruit quality and disease resistance. Market demand for other fall decorations, ornamental corn and gourds, resulted in cultivar trials for both crops. Results from these trials have been used to help expand sales of Kentucky's pumpkin acreage by providing a more diverse sales package.

A plastic mulch-double cropping trial involving green peppers and fall cauliflower was evaluated for suitability under Kentucky conditions. The use of a white on black polyethylene mulch resulted in superior overall yields when both crops were considered part of a production system. Such a production system allows growers to obtain multiple crops using the same set of resources.

A study involving fall cole crops as scavengers of residual fertilizer nitrogen was jointly conducted by Agronomy and Horticulture faculty to evaluate the use of fall cole crops (cabbage and/or broccoli) to recover residual fertilizer N following high-value summer annual cash crops. No cabbage yield response to fertilizer N was measured in 1993. A cabbage yield response to 50 lb N/ac was measured in 1994. Residual N following sweet corn and tobacco was slightly lower in 1994 than 1993 indicating that a yield response to fertilizer N could be expected when residual soil NO_3-N levels fell below 20 ppm. Soil nitrate-N and plant total N uptake were also measured to determine the usefulness of cabbage (compared to winter rye and fallow) to recover residual N and minimize the potential for N loss to the environment. Fall cabbage was found to be as effective as rye in capturing nitrogen that would normally be lost due to leaching.

Work on field diagnostic tools for estimating nitrogen needs for fresh market tomatoes is another on-going cooperative project between Agronomy and Horticulture. Hand-held Cardy meters were found to be effective for rapidly measuring fresh petiole sap nitrate levels in fertigated tomatoes. Work is underway to determine if a reliable correlation between instrument reading and plant N needs exist. The role that residual soil nitrogen plays in predicting tomato N response is also being studied.

A summer annual flower cultivar evaluation was conducted as part of a state-wide effort to determine which plants and cultivars would develop well and produce attractive bloom and foliage for Kentucky's commercial and home landscapes. Twelve different genera of flowering plants, 29 impatiens, 15 geranium and 11 petunia cultivars were evaluated. Results were compared with similar trials in Lexington and Princeton.

Agronomy

As part of long-term no-till plots, wheat was tested as a winter cover crop to determine how much carryover soil N it would take up from the preceding no-till corn crop and make available to the following no-till corn crop. The increased N content of the killed wheat cover crop did not increase N uptake or yields of no-till corn.

A study to test the importance of the endophyte fungus in tall fescue for survival in stressful environments was established in 1993 on a surface mine site in Breathitt County and on an undisturbed (less stressful) site at the UK Robinson Substation and UK Spindletop Research Farm. A second planting for this study was established in the fall of 1994. Eight pairs of isogenetic tall fescue varieties with and without the endophyte will be evaluated for plant stands, insect and disease incidence and dry matter accumulation. A companion study was also initiated in 1993 at the same mine site to evaluate a wide range of tall fescue plant material collected from around the world.

Tall fescue and orchardgrass variety trials were established at the UK Robinson Substation in the fall of 1994 to assist forage producers in eastern Kentucky with the selection of forage species and varieties evaluated under more site specific growing conditions. This project is managed by the UK Forage Variety Testing Program.

A study evaluating the influence of soil acidity on nitrification of ammonium fertilizer applied to no-till corn was continued. The intent of this trial is to determine how much nitrification is slowed by soil acidity and whether this reduction affects the ability of the pre-sidedress soil nitrate test to predict the corn crop's need for additional fertilizer N at topdressing time. A large yield response to N was observed. There was a small, positive yield response to the lime. Nitrification was not reduced at the lower lime rate and the level of nitrate found was strongly related to corn yield.

Another study, evaluating the long-term effects of phosphorus (P) and potassium (K) fertilization to no-till corn and soybean, was grown to corn. This was the ninth year in this trial. Responses to low rates of both P and K were observed.

Evaluation continued of newly-released burley tobacco varieties (private and public lines) for their tolerance to diseases common in eastern Kentucky. A site on the UK Robinson Substation has been selected and is being managed without rotation (similar to most commercial sites of production in the region) to encourage disease build up. It is now regularly providing strong pressure from tobacco etch virus and tobacco vein mottling virus, but low pressure to potato virus Y. The site also provides strong pressure from tobacco blue mold during seasons appropriate for the disease. In addition, the site has become infested naturally with the fungal pathogens causing black shank and black root rot, increasing its value for evaluation of burley tobaccos for use in eastern Kentucky.

Thirty sweet sorghum varieties were grown to compare their maturity in Kentucky with their maturity in Wisconsin. This was a joint experiment with a producer in Wisconsin who provided some of the varieties. Some varieties appeared to be more daylight sensitive and matured quicker in Wisconsin than in Kentucky. More sweet sorghum is being grown further north each year and additional varieties are needed for this production.

In 1994 at Quicksand the Maize Dwarf Mosaic virus transmitted from johnsongrass was very severe in this plot. The recently released sorghum varieties Dale, Della, M81E and Theis plus the older varieties Keller, Hoti, and Cowlcy from Texas all showed good MDM resistance. One very old variety, Ames Amber, also had good MDM resistance. Some of the older varieties which are still being grown, such as Sugar Drip, Umbrella, Orange and Waconia Orange, were completely killed by MDM.

Kenaf *(Hibiscus cannabinus* L.), a non-wood fiber producing plant, was evaluated for its potential as a crop in Kentucky for producing pulp for making paper. It is a relative of cotton and okra and is not related to marijuana *(Cannabis sativa* L.) even though some varieties have palmate leaves that resemble marijuana. The Kenaf ranged from 9.5 to 11.0 feet tall and yielded from 2.6 to 6.8 tons per acre. Kenaf should be planted in early May at 6 to 8 seeds per foot of row to obtain the highest yields. This plot was not seeded until June 7 and due to limited seed supplies, most of the stands were too thin resulting in low yields. Yields of 6 to 10 tons per acre are needed for economic production of Kenaf.

Research Projects

Annual Flower Cultivar Evaluations—S. Bale and R.T. Jones

Bramble Cultivar Evaluation Trial—R.T. Jones

Comparing Maturity and Disease Resistance of Sweet Sorghum Varieties—M.J. Bitzer and M. Morrison

Double Cropping Systems: Green Bell Pepper-Cauliflower Mulch Evaluation—R.T. Jones and J. Strang

Evaluating Burley Tobacco Varieties for Use in Eastern Kentucky—W.C. Nesmith, M. Morrison

Evaluating Kenaf Varieties for Kentucky—M.J. Bitzer

Fall Cole Crops as Scavengers of Residual Fertilizer Nitrogen—D.C. Ditsch, R.T. Jones and R.C. Pearce

Fall Pumpkin Production Evaluation—R.T. Jones and J. Strang

Long-Term Phosphorus and Potassium Needs for N-Till Corn and Soybean on a Highly Productive Soil—J.H. Grove and D.C. Ditsch

Ornamental Corn and Gourd Cultivar Evaluations—R.T. Jones and M. Witt

Response of No-Till Corn to Nitrogen Source—K.L. Wells, W.O. Thom, D.C. Ditsch and M. Morrison

Southeast Region Asian Pear Cultivar Evaluation—R.T. Jones, J. Strang and J. Brown

Tall Fescue Adaptability as Affected by Endophyte Fungus Infection—D.C. Ditsch, T.D. Phillips, L.M. Lauriault, M. Collins and J.C. Henning

Tall Fescue and Orchardgrass Variety Trials—L.M. Lauriault, J.C. Henning and D.C. Ditsch

RURAL SOCIOLOGY

The Rural Sociology research program is designed to advance the development and application of an understanding of social structure and social processes in the changing rural society. Through an integrated program of research, Extension programs, and instruction, the faculty focus on initiatives which are organized around two major areas: sociology of agriculture and community and human resource development. Within each major area, several substantive areas of specialized activity exist.

Sociology of Agriculture

Comparative Sociology of Agriculture. Research in East Asia is providing faculty, working with other scholars in Japan, Korea, and Taiwan, a comparative understanding of the domestic social forces that facilitated land reform in the region, the impact of the land reform on subsequent national development patterns, and the importance of the land reform legacy for East Asian agricultural adjustment. A study is under way of the issue of the potential for agricultural-environmental policy linkages in the internationally uncompetitive, yet domestically central, rice subsectors of Japanese, Taiwanese, and South Korean agricultures. Also being studied are current obstacles to the recruitment of a new generation of farmers in East Asia, which will provide a basis to look comparatively across North America, Western Europe, and East Asia at the future of farming as an occupation.

Intergenerational Changes in Farm Family Perspectives of the Environment. Environmental and natural resource issues are critical components of rural development policy. Program focus is on natural resource utilization and economic development, impacts of natural resource production, and relationships among environment and quality of life. Findings have led to the development of a conceptual framework of how cultural groups transform the nonhuman environment symbolically and thereby mesh the social, cultural, and nonhuman environments into structures of symbols and beliefs that are shared among members of the group.

Trends in Agriculture. As an example of changing agriculture, research results have shown that Kentucky's dairy industry is confronting both a changing market place and changing conditions of production. Consolidation among dairy processors and the loss of dairy farms continue. Kentucky lags behind the rest of the U.S. in average herd production. In some Kentucky counties, dairy farmers have decided to organize local dairy groups to strengthen the voice of dairy interests and to provide organizational support for individual members. Sociologists at the University of Kentucky are also cooperating with

colleagues in eight other states to examine organizational and structural changes in the dairy industry from the perspective of enterprise operators.

The Transformation of Agriculture: Resources, Technologies and Policies. Environmental and natural resource problems continue to affect farms, families, communities, and societies. Research results have been applied to policy situations of rural communities adapting to the changing positions of agriculture and natural resources in small communities, and for government programs to address local planning for the development of rural communities.

Community and Human Resource Development

Household and Labor Market Dynamics. Studies in this area address a wide range of issues involving individuals, families, communities, and labor market areas. This research examines family financial stability and the importance of economic factors for internal family interaction and community development.

Research is examining local economic adaptations to changes in the service sector in rural areas. This research is observing the range of structural and cultural adjustments from the informalization practices of firms to the small scale entrepreneurial activities of households. Another project explores how home-based economic activities affect resource flows in rural households and families and influence the resources available to women in their later years.

Social and Economic Factors Affecting Family Well-Being. Rural society's prospects for growth and development ultimately rest with the capacities of people. Human resources refer to the skills, abilities, and understanding required for people to function effectively in families, the work place, organizations, and communities. Specific areas of study are rural health, youth, family dynamics and functioning, aging, leadership development, and the role of social organizations in encouraging or inhibiting human resource development.

Several projects have investigated the structural, economic, and cultural characteristics of rural residence on family functioning as well as the social/psychological factors influencing family well-being. Intra-family dynamics such as distribution of power and authority, division of labor, and implementation of coping strategies are important variables.

Research has discovered spatially-based inequalities in the organization and delivery of health services. The relationship between farm safety and health is being studied as an example of community health characteristics, considering how environmental health hazards are perceived and defined by residents and evaluating different approaches to incorporating citizen perspectives into the health planning process. Interviews with women from three different communities located in three different regions of Kentucky are being conducted

to understand how public policies and broader social, economic, political, and cultural forces intersect in conditioning the everyday experiences of rural women with work and health care and welfare systems.

Community Resource Development. Communities are the settings in which people interact with the larger society to provide basic human services, employment, and solutions for local problems. Within the sphere of rural development policy, the local community is currently seen as the initiator of economic and social development. The Rural Sociology Program seeks to enhance rural communities' abilities to develop by focusing on issues of growth and change, availability and quality of community services, infrastructure, employment and manpower, and community decision making. Several Extension programs have been developed based upon these research findings.

Research has led to policy proposals based upon the concept that programs can gain local legitimacy by sharing policy authority with local boards. Local rural development efforts would be led by local boards which involve a broad base of local citizens but with federal funding to facilitate implementation of local plans.

Research Projects

Empowering Farm Women to Reduce Hazards to Family Health and Safety on the Farm—T. Greider

Garrard County Child Care Program—P. Dyk

Harlan Youth Employability Program—P. Dyk

Household, Labor Markets, and Human Resource Development in Rural Kentucky—L. Burmeister

Intergenerational Changes in Farm Family Perspectives on the Environment—T. Greider

Kentucky Kids Count—L. Garkovich and G. Hansen

Land Policy Issues in East Asia—L. Burmeister

Ohio River Valley Project—L. Swanson

Organization and Structural Changes in the Dairy Industry—L. Garkovich

Planning Grant for the Family Preservation and Support Services Act—P. Dyk and L. Garkovich

Rural Labor Markets in the Global Economy—A. Tickamyer

Rural Policy Mandates and Black Land Grant Research—R. Harris

Social and Economic Factors Affecting the Well-Being of Kentucky Rural Families—P. Dyk

The Transformation of Agriculture: Resources, Technologies, and Policies—L. Burmeister

Women and Persistent Rural Poverty—R. Harris

Women, Poverty, and Health in Rural America—R. Harris

VETERINARY SCIENCE

Among the research, service and Extension programs provided by the Department of Veterinary Science to Kentucky's animal industry, the greatest expansion occurred in 1994 in the range and comprehensiveness of the diagnostic services provided by the department's Livestock Disease Diagnostic Center. Aided significantly by the renovation and expansion of facilities at the laboratory, the Diagnostic Center has made considerable progress towards becoming a nationally accredited full-service laboratory. There has been increased growth and diversity in the various research programs not only in the Maxwell H. Gluck Equine Research Center but also in the Equine Blood Typing and Research Laboratory and the Livestock Disease Diagnostic Center.

Gluck Equine Research Center

Achievements have served to reaffirm the reputation of the Gluck Center as one of the outstanding equine research institutions in the world. Aside from the major commitment to research on infectious diseases, the Center strives to promote and strengthen its programs in other important areas of specialization: experimental pharmacology and therapeutics, epidemiology, immunogenetics, parasitology and reproductive physiology. Increased competitive extramural support garnered by these programs during this past year attests to their success.

Biomechanics and Locomotion. Though limited by down-sizing in the number of faculty involved, considerable progress was achieved in electronic solids modelling of the lower limb of the horse in both normal and abnormal locomotion states. Collaborative studies with researchers in the Department of Animal Sciences on the effect of diet on electrolyte changes in exercising horses and on the nature and extent of muscle damage generated in horses subjected to high intensity exercise continue to be productive.

Immunogenetics. These are among the more significant accomplishments of this program: cloning of the Mx gene, which may play a role in resistance to influenza virus, and its tentative mapping to equine chromosome 27; characterization of more than 35 microsatellite DNA gene markers and their chromosomal relationships; and demonstration of polymorphism in the major histocompatibility gene, DRA, which in other species is invariant. One of the major long-term goals of this program, constructing a gene map of the horse, got off to a successful start.

Infectious Diseases. In light of the traditional importance of infectious diseases for the horse industry worldwide, this program continues to focus major attention on those diseases of greatest economic and veterinary medical significance.

Considerable progress has been achieved in research on **equine herpesvirus 1**, a ubiquitous and economically damaging pathogen of the horse. An assay for the detection of virus-specific cellular immunity in the horse has been developed and a major viral antigen responsible for evoking cell-mediated immunity in the horse after herpesvirus infection has been identified. Current studies are aimed at developing improved vaccine strategies for the prevention and control of herpesvirus diseases in the horse.

The research program on **equine influenza** continues to be productive over a diversity of aspects of this infection. The more significant accomplishments included: validation of the Directigen Flu-A test as a very rapid, sensitive and specific diagnostic test for equine influenza; molecular analysis and characterization of the virus responsible for the equine influenza epidemic in Hong Kong in 1992; and genomic analysis of the different equine influenza viruses in circulation in the USA since 1987.

Research on **equine infectious anemia** continues to focus on several major areas critical to the pathogenesis of this infection, including: defining the critical viral determinants that make certain strains of EIA virus virulent; establishing which antigenic determinants of the virus stimulate an immune response in the horse critical for protection against this infection; and developing tests that will improve existing diagnostic accuracy for this disease.

On-going research on **equine arteritis virus** has confirmed the immunogenicity and safety of the existing modified live virus vaccine for use in weanling or yearling colts. It is hoped by recommending a strategy of vaccinating colts against this infection to obviate the risk of establishment of the long-term carrier state when they are adults. In collaboration with researchers in Canada and Sweden, the nested PCR assay has been confirmed as a highly sensitive and specific diagnostic test for cases of acute or chronic equine arteritis virus infection.

A large-scale field trial involving 320 mares on 9 farms in central Kentucky confirmed the safety and efficacy of a new inactivated vaccine for the prevention and control of **rotavirus** diarrhea in foals. Additional studies with this product and further investigation into the etiology of neonatal diarrhea in foals and improved methods for restricting the spread of infection on affected farms are planned.

The major thrust of microbiological research in the department continues to be focused on equine **streptococcal** diseases and **leptospirosis**. Among the objectives of the studies on equine streptococci are: to characterize the opsonic and mucosally active epitopes of the M protein of *S. equi*; to study the M protein genes of the equine group C streptococci; to determine the protective humoral immune responses of the horse to *S. equi*; and to elucidate the pathogenesis of *S. zooepidemicus* pneumonia in the horse.

Research on equine leptospirosis at the LDDC has established the serovars most frequently implicated in leptospiral abortion in mares. On-going studies are aimed at determing whether certain wildlife species can serve as long-

term resevoirs of the organism on affected farms and in establishing the immunodominant proteins of *L. kennewicki* for the horse.

Parasitology. Studies were completed on the transmission of benzimidazole-resistant small strongyles in the horse, the prevalence of *Anoplocephala perfoliata* infection in horses in Kentucky and on the transmission and pathogenesis of larval cyathostomiasis. Long-term studies into the prevalence of certain internal parasites of ruminants are continuing.

Significant progress has been achieved in developing several specific immunologic and DNA assays to study *S. neurona* infection in the horse and to determine the life cycle of the parasite. Several collaborative studies are aimed at better defining the prevalence of infection and incidence of the disease, equine protozoal myeloencephalitis (EPM), in various states besides Kentucky.

Pharmacology and Experimental Therapeutics. One of the major areas of research interest in this section was highlighted by the First International Workshop on Testing for Therapeutic Medications, Environmental and Dietary Substances in Racing Horses held at the Gluck Center in August. This highly successful program has taken a leadership position nationally in this critically important field. Other areas of significant research involvement include musculoskeletal injuries in Kentucky racehorses and the value of amantadine/rifamantadine for the prophylaxis of equine influenza.

Reproductive Physiology. The research program in reproductive physiology continues to be focused in two major areas, neuroendocrinological control of seasonal breeding in the mare and the basis of early embryonic loss in mares.

Among the more significant accomplishments was the finding that mares which exhibit estrous cycles during the winter months in one year may not do so in subsequent years. This phenomenon of winter cycling has been observed in the absence of any alteration in the nocturnal rise of the hormone, melatonin.

Research activity on early embryonic loss in mares includes: studying differential gene expression by the endometrium in pregnant and non-pregnant mares; determining the changes in prostaglandin synthase mRNA in the endometrium of cycling and pregnant mares; and establishing the control of gene expresion for retinol binding protein in equine endometrium, embryos and extra-embryonic membranes.

Livestock Disease Diagnostic Center

The service and Extension programs offered by the Livestock Disease Diagnostic Center continue to provide a major resource for the state's animal industry. The expansion and renovation of the laboratory facilities was completed in June and the Center is on course for accreditation as a full service laboratory. In addition to handling an increasing accession caseload, faculty in the laboratory continue to expand their respective research interests in a diversity of fields including microbiology, pathology, toxicology and virology.

Equine Blood Typing and Research Laboratory

The typing laboratory provided parentage testing for more than 24,000 samples involving 22 breed registries. A wide variety of studies is in progress addressing different aspects of genetic diversity among equids and evolution of the domestic horse. In addition, there is involvement in the equine gene mapping initiative using horse-mouse somatic cell hybrids and in establishing the genetic basis of *Epitheliogenesis imperfecta* in the American Saddlebred breed. Another area of current interest in to determine the gene responsible for juvenile cataracts in the Boston Terrier breed.

Research Projects

Amantadine/Rimantadine Prophylaxis of Equine Influenza—T. Tobin

Analysis of Equine Respiratory Tract Mucosal Antibody Production in Response to Influenza Infection or Vaccination—T.M. Chambers

Antigenic Relatedness of Geographic and Temporally Disparate Isolates of Equine Arteritis Virus as Compared by the Microneutralization Test—W.H. McCollum

Application of New Technology for the Diagnosis of Equine Infectious Anemia—C.J. Issel

Cell Culture Models for Analysis of Equine Influenza Viral Host Discrimination—T.M. Chambers

Changes in Prostaglandin Synthesis mRNA in Endometrium of Cycling and Pregnant Mares—K.J. McDowell

Characterization and Sequence Determination of Opsonic and Mucosally Active Epitopes of M Protein of Streptococcus equi*—J.F. Timoney*

Characterization of Proteins in Stallion Seminal Plasma—K.J. McDowell

Chemotherapeutic Control and Prevalence of Natural Infections of Internal Parasites of Equids—E.T. Lyons

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Control of Gene Expression for Retinol Binding Protein in Equine Endometrium, Embryos and Extra-Embryonic Membranes—K.J. McDowell

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Diagnostics for Equine Infectious Anemia—C.J. Issel

Differential Gene Expression by Endometrium of Pregnant and Nonpregnant Mares—K.J. McDowell

The Efficacy of an Inactivated Rotavirus Vaccine—D.G. Powell

Equine Protozoal Myeloencephalitis: Development of an Antemortem Diagnostic Probe and Epizootiologic Analysis—D.E. Granstrom

Equine Protozoal Myeloencephalitis: Isolation and Characterization of the Etiological Agen—D.E. Granstrom

Equine Protozoal Myeloencephalitis Prevention and Control—D.E. Granstrom

Equine Rotavirus Vaccine Study on 300 Mares and 300 Foals—R. Dwyer

Gene Map of the Horse—E.F. Bailey

Genetic and Mechanistic Analysis of the Equine Mx Antiviral Gene—E.F. Bailey, T.M. Chambers

Genetic Aspects of Captivity: Management of Genetic Polymorphism in Small Populations—E.G. Cothran

Genetic Nasis of Epitheliogenisis imperfecta *in American Saddlebred Horses—E.G. Cothran*

Genetic Relationships among Domestic Horse Breeds—E.G. Cothran

Gonadotropin-Releasing Hormone in Mares: Development of Methods for Measurement and Factors Affecting Secretion During Anestrus—B.P. Fitzgerald

Hemagglutinin Antigen of Equine-2 Influenza Virus:
a) Equine Influenza Diagnosis and Surveillance, and Molecular Characterization of Isolated Virus Strains
b) Epitope Mapping of Equine Influenza Virus Hemagglutinin from the Standpoint of the Equine Immune System
c) Genetic Analysis of Host Specification of Equine Influenza A Viruses—T.M. Chambers

Hereditary Basis of Equine Congenital Defects—E.G. Cothran

Identification of the Equine Herpesvirus-1 Proteins and their Respective Subregions that Elicit Cytotoxic T-Lymphocyte Immune Responses in the Horse—G.P. Allen

Immune Enhancement of EIAV Replication and Disease—C.J. Issel

Immunobiology of Sarcocystis neurona *Infection in the Horse—D.E. Granstrom*

Immunologic Management of Lentivirus Infections: EIAV—C.J. Issel

International Equine Infectious Disease Surveillance—D.G. Powell

Investigation into Outbreaks of Equine Infectous Diseases in Central Kentucky —R. Dwyer

The Investigation of Acute Outbreaks of Infectious Respiratory Disease—D.G. Powell

In vivo *Evaluation of Infectivity, Pathogenicity, and Immunogenicity of Different Novel Candidate Live Equine Influenza Virus Vaccines—T.M. Chambers*

Mapping of the Horse Genome Using Horse-Mouse Somatic Cell Hybrids—K.T. Graves

Mechanisms of Placenta-Specific Gene Expression—K.J. McDowell

Melatonin and Seasonal Breeding in Mares—B.P. Fitzgerald

Molecular Cloning and Sequencing of Transferrin and Alpha Fetoprotein cDNA's—K.J. McDowell

Musculoskeletal Injuries in Racing Horses—T. Tobin

Pathogenesis of Pneumonia due to Streptococcus zooepidemicus *in the Horse—J.F. Timoney*

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Pregnancy Associated Glycoproteins of the Horse—K.J. McDowell

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Proteins of Leptospira kennewickii *Immunodominant for the Horse—J.F. Timoney*

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Sequence Analysis of MHC Class I and Class II Genes of Equidae—E.F. Bailey

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Williams, D.M., B.J. Smith, J.M. Donahue and K.B. Poonacha. Serologic and microbiologic findings on three farms with leptospiral abortions. Equine Vet. J., 26:105-108.

Williams, N.M. and P.J. Timoney. Variation in susceptibility to disease among A/J, AKR/NCr1BR, BALB/cAnNhsd, C3H/HeJ, C3H/HcNHsd, C57BL/6J, C57BL/10SnJ, CBA/J, CF1, and 1CR mouse strains infected with *Ehrlichia risticii.* J. Comp. Path., 110:137-143.

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(In addition, members of the department published 25 abstracts.)

Ph.D. Dissertations
(Unpublished)

Agricultural Economics

Gallacher, Guillermo Marcos. Time allocation and production efficiency: The U.S. corn belt.

Harrison, Robert W. Risk sharing through contractural arrangement: An application to the feeder cattle industry.

Mawampanga, Mwana N. An application of the analytic hierarchy process to the farmer's decision to adopt sustainable agriculture.

Nourbakhsh, Tahereh. Impact of socioeconomic characteristics of U.S. households on the demand for beef, pork, poultry, and all meats.

Trabelsi, Brahim. External debt of African and Latin American countries: Resource allocation implications.

Agronomy

Baerg, Roger J. Basis of imazethapyr selectivity in cowpea *(Vigna senensis)*, interactions between insecticides and cytochrome P450 activities, and cytochrome P450 monooxygenase metabolism of imazethapyr.

Hayati, Renih. Carbon and N supply during seed filling and leaf senescence in soybean.

Jacobson, Brent D. Relationship of herbicide fate in agricultural soils to water contamination.

Animal Sciences

Du, Zengyu. Bioavailabilities of copper in copper proteinate, copper lysine and cupric sulfate, and copper tolerances of Holstein and Jersey cattle.

Jazi, Saeed H. Effects of zinc supplement on animal performance and measurement of serum metallothionein as an alternative method in assessment of zinc deficiency in ruminants.

Entomology

Clark, Deborah Campero. Genetic and behavioral aspects of acoustic signaling during society interactions in a Madagascar hissing cockroach (*Gromphadorhina portentosa*) (Dictyoptea: Blaberidae).

Crutchfield, Berry A. Feeding ecology and damage thresholds for Japanese beetle and southern masked chafer (Coleoptera: Scarabacidae) grubs in cool-season turfgrasses.

Plant Pathology

Dalisay, Rodelio F. Persistence of induced systemic resistance and enhanced peroxidase and chitinase activities in cucumber plants.

Edskes, Herman K. Regulatory elements involved in caulimoviral gene expression.

Gao, Shaojian. Characterization of an endopolygalacturonase produced by *Cryphonectria parasitica*.

Mucharromah. The effect of sterols on the resistance of potato tuber discs and foliage to *Phytophthora infestans*: Compatibility/incompatibility and metabolic responses in the potato-fungus interaction.

Rural Sociology

Buchanan-Moore, Mary. Early childbearing in Kentucky communities: An ecological approach.

Herzenni, Ahmed. The cultural economy of technical innovation in semi-arid rural Morocco.

Veterinary Science

Whitfield, J. Morphological and functional significance of cartilage canals of

epiphyseal cartilage and neovascularization as related to the pathogenesis of osteochnodrosis dissecans.

M.S. Theses
(Unpublished)

Agricultural Economics

Fordham, Miriam A. The import demand for U.S. hardwood lumber in Japan.

Henken, Kim Bunch. Analyzing agricultural contamination of groundwater wells in Kentucky: Economic decision making for the individual well-owner.

McLendon, Louis L. Community influences on food stamp redemption rates and food sales in food stores.

Peters, D. Bart. Analysis of corn and soybean basis patterns for selected Kentucky markets.

Agricultural Engineering

Bowden, Ruth J. Air leakage characteristics of wall joints in residential construction.

Hootkany, Ali. Hydraulic conductivity behavior of soil liners in agricultural waste containment facilities.

Stepanek, Paul J. Electrohydraulic control of a prismatic joint for use in automated cole crop harvesting.

Zhang, Xiao Xing. Image analysis of two-dimensional soil grid systems.

Agronomy

Basheeruddin, Ayesha T. An evaluation of best management practices on nitrate-N leaching losses.

Cui, Mingwu. Seed germination and seedling development of burley tobacco in a greenhouse float system.

Fabrizius, E.E. Predicting changes in soybean seed germination during storage under warehouse conditions.

Fortuna, Ann-Marie. Tillage, nitrogen rate, and legume crops in determining nitrogen availability in corn

Gilfillen, Rebecca A. Fecal bacteria trapping in two lengths of grass filter strip.

Howell, James M. Fecal bacteria in two agricultural watersheds in Kentucky and their movement through intact soil columns.

Pearce, William L. Powdery mildew and associated yield loss in soft red winter wheat.

Animal Sciences

Curry, N.W., II. Evaluation of sire by breed of dam interactions for preweaning beef cattle in the Southern Region.

Healy, H.P. The effects of concentrate form on humoral, hormonal and gastric parameters in mature horses.

Holman, Carol P. Long-term availability of magnesium in dolomitic limestone fed to yearling steers.

Kaminski, Michael A. Effect of progesterone withdrawal on uterine secretion of prostaglandin F_2a in response to oxytocin.

Keeney, S.M. Influence of calf genetic type and other factors on body temperature of stocker cattle.

Entomology

Lemire, Robert A. Pathogenicity and transmission of a cytoplasmic polyhedrosis virus isolated from the black swallowtail, *Papilio polyxenes asterius* stoll to fall webworm, *Hyphantria cunea* (Drury).

Willis, Darcy C. The effects of varying densities of *Amblyomma americanum* (L.) on measured physiological responses of beef cattle.

Zhao, Jing Zhang. Impact of head ex-

tracts and PBAN of chemical communications in the cabbage looper moth, *Trichoplusia ni* (Hübner) (Lepidoptera: Nocutuidae).

Forestry

Evans, J.W. Magnetic resonance imaging of two hardwoods below fiber saturation point using the bound water signal.

Mauro, R.J. Survival, movements, and habitat use of a translocated population of ruffed grouse in western Kentucky.

Shoemaker, L.G. Diet preference of the endangered Virginia big-eared bat, *Plecotus townsendii virginianus,* in the Daniel Booned National Forest, Kentucky.

Horticulture*

Fang, Hui. Studies on the mechanism of specificity of rubisco large subunit N-methyltransferase for the larget subunit of rubisco.

Jones, Rodney O. Propagation of gas plant (*Dictamnus albus*).

Wang, Pinger. Development and characterization of an affinity purification technique for rubisco large subunit N-methyltransferase.

Rural Sociology

Chung, Wei-keung. The economic dynamism of Hong Kong: Partnership of state and capitalists.

Wusananingsih, Kodar Tri. Development programs for women in Indonesia: A review and recommendation.

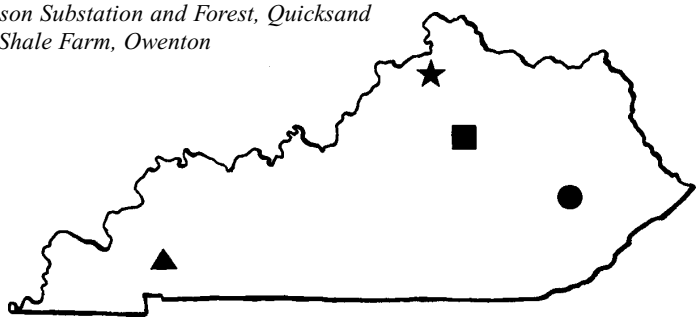
Veterinary Science

Costa, L.R.R. Evaluation of an enriched p26 vaccine in protecting ponies against equine infectious anemia.

** Theses incorrectly listed in 1993 Experiment Station Annual Report under the department of Entomology. We regret the error.*

STATEWIDE RESEARCH

■ *University of Kentucky, Lexington*
▲ *Research and Education Center and West Kentucky Substation Farm, Princeton*
● *Robinson Substation and Forest, Quicksand*
★ *Eden Shale Farm, Owenton*



Research activities of the Kentucky Agricultural Experiment Station were conducted at Lexington, Princeton, Quicksand and Owenton and in counties throughout the state in 1994.

Efforts are constantly made to ensure that the research studies have application to the problems of all Kentucky farmers and other clientele groups. Locations of the experimental facilities provide conditions representative of most sections of the state.

Campus — Laboratories and specialized equipment for all research program areas.

Coldstream — Maine Chance — Spindletop Farms — Beef and dairy cattle, poultry, horses, sheep and swine, forages and grain crops, tobacco and turf.

South Farm — Fruits and vegetables, ornamentals.

Woodford County Farm — This farm was purchased in late 1991 as a future location for development of state-of-the-art food animal research programs. The farm is in the initial phase of development as a research facility.

At Princeton (Caldwell county) the **Research and Education Center** facilities and the **West Kentucky Substation Farm** are devoted to research on grain crops, beef cattle, swine, fruits and vegetables, forages, and tobacco.

At Quicksand (Breathitt county) the **Robinson Substation** is the location of research on fruits and vegetables, ornamentals, forages, grain crops, tobacco, and wood utilization. Quicksand is also the headquarters of **Robinson Forest**, which spreads over parts of Breathitt, Perry, and Knott counties and is the site of forestry and watershed management research.

The **Eden Shale Farm**, located in Owen county near Owenton, is where experimental and demonstration studies are conducted on forage crops, tobacco, fruits and vegetables, and beef management.

FINANCIAL STATEMENT

Statement of Current General Fund
Income and Expenditures
Fiscal Year 1994

INCOME

Federal Funds:	
Hatch Amended	$3,789,400.00
Regional Research	785,676.00
McIntire-Stennis	400,877.00
Animal Health	82,032.00
Total Federal Funds	**$5,057,985.00**
Non-Federal Funds	**19,648,988.09**
Total Funds	**$24,706,973.09**

EXPENDITURES

	Federal	Non-Federal	Total
Personal Services	$4,205,377.67	$12,682,790.94	$16,888,168.61
Travel	89,058.22	104,771.28	193,829.50
Equipment	220,452.42	625,491.61	845,944.03
Other Operating Expenses	543,096.69	6,235,934.26	6,779,030.95
Total Expenditures	**$5,057,985.00**	**$19,648,988.09**	**$24,706,973.09**

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Agricultural Experiment Station

October 1, 1993 — September 30, 1994

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Weckman, Randy D., Assistant Professor
Witham, D.B., Associate Professor

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Swetnam, L.D., Research Specialist
Taraba, J.L., Associate Professor
Turner, G.M., Research Specialist
Turner, L.W., Professor
Walton, L.R., Professor
Warner, R.C., Associate Professor
Wells, L.G., Professor

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Bush, L.P., Professor
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Collins, G.B., Professor
Collins, M., Professor
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Tomes, L.J., Research Specialist
Tutt, C.R., Research Specialist
Van Sanford, D.A., Professor
Wagner, G., Professor
Witt, W.W., Professor
Wood, J.M., Research Specialist

Animal Sciences
Kiracofe, G.H., Chairman & Professor
Aaron, D.K., Associate Professor
Button, F.S., Jr., Research Specialist
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Dawson, K.A., Professor
Deweese, W.P., Research Specialist
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Ely, D.G., Professor
Ford, M.J., Research Specialist
Harmon, D.L. Associate Professor
Harmon, R.J., Professor
Hemken, R.W., Professor
Hicks, C.L., Professor
Hightshoe, B., Research Specialist
Huckabay, J.D., Research Specialist
Jackson, J.A., Jr., Associate Professor
Langlois, B.E., Professor
Larson, B.T., Assistant Professor
Lawrence, L.M., Associate Professor
Lindemann, M.D., Associate Professor
Mitchell, G.E., Jr., Professor
Monegue, H.J., Research Specialist
Moody, W.G., Professor
O'Leary, J., Associate Professor
Parker, G.R., Professor
Randolph, J.H., Research Specialist
Schillo, K.K., Associate Professor
Silvia, W.J., Associate Professor
Straw, M.L., Research Specialist
Strobel, H.J., Assistant Professor
Thrift, F.A., Professor
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Xiong, Y., Assistant Professor
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Entomology
Pass, B.C., Chairman & Professor
Barney, R.J., Assistant Professor*
Brown, G.C., Associate Professor
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Collins, J.T., Nursery Inspector
Dahlman, D.L., Professor
Dong, K., Assistant Professor
Freytag, P.H., Professor
Haynes, K., Associate Professor*
Hunt, R., Assistant Professor*
Knapp, F.W., Professor
Moore, A.J., Assistant Professor
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Parr, J.C., Research Specialist
Potter, D.A., Professor
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Yeargan, K.V., Professor

Forestry
Muller, R.N., Chairman & Associate Professor
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Kalisz, P.J., Associate Professor
Kimmerer, T.W., Associate Professor
Lacki, M.J., Assistant Professor
Liu, C.J., Associate Professor

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Horticulture
Ingram, D.L., Chairman & Professor
Anderson, R.G., Professor
Archbold, D.D., Associate Professor
Brown, G.R., Professor
Buxton, J.W., Associate Professor
Crankshaw, N.M., Assistant Professor
Geneve, R.L., Associate Professor
Houtz, R.L., Associate Professor
Kemp, T.R., Professor
Klein, P., Assistant Professor
McNiel, R.E., Professor
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Snyder, J.C., Associate Professor
Weston, L.A., Associate Professor
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Nutrition and Food Science
Mercer, L.P., Chairman & Professor
Chen, L.H., Professor
Chow, C.K., Professor
Glauert, H.P., Associate Professor
Hennig, B., Associate Professor

Plant Pathology
Smith, D.A., Chairman & Professor
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He, S.Y., Assistant Professor
Hendrix, J.W., Professor
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Kuc, J.A., Professor
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Shaw, J.G., Professor
Shepherd, R.J., Professor
Siegel, M.R., Professor
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Wu, X., Research Specialist

Regulatory Services
Frye, W.W., Director & Professor
Beine, R.L., Laboratory Coordinator
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Case, V.W., Specialist
Coffey, D.S., Specialist
Cox, B.W., Specialist
Fabrizius, E.E., Research Specialist
Flood, J.S., Specialist
Gibson, G.L., Research Specialist
Gopalou, S., Research Specialist
Hatton, R., Milk Coordinator
Herald, F., Field Coordinator
Johnston, N.T., Specialist
Kirkland, D.L., Specialist
Lichtenberg, D., Specialist
Mason, D.W., Specialist
Miller, E., Feed Coordinator
Niffenegger, D.A., Seed Coordinator
Prather, T.G., Research Specialist
Spencer, H.S., Auditor
Terry, D.L., Fertilizer Coordinator & Assistant Director
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Robinson Substation
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Rural Sociology
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