The Department of Agronomy is one of the largest units— and probably the most diverse department—at the University of Kentucky. The Department strives to balance, and excel in, all three mission areas of a Land Grant institution: research, teaching and extension. The subject matter being addressed by the Department Faculty is enormously broad; including the chemistry, physics and biology of both plant and soil systems; ranging from the molecular, to the whole plant, to the ecosystem level.

The fundamental objective and vision of the Department is to integrate the most sophisticated fundamental research, with applied research and development, and with extension and education programs; in order to address the problems of crop production and agricultural land use in the Commonwealth and in the World.

Department personnel and programs (and this document) are organized by: 1) mission areas—teaching, research and extension; 2) discipline areas—plant physiology, plant breeding/genetics, crop ecology/physiology/management, and soil science; and 3) commodity/resource areas—corn, forages, seeds, small grains, soils, soybean, tobacco, turf, and weeds.

Approximate distribution of faculty effort:

by appointment:
32 research/teaching (approx. 4 FTE teaching total)
15 extension
6 adjunct

by discipline:
9.5 plant physiology/biochemistry
14.5 soils
20 crop ecology/physiology/management
9 plant breeding/genetics

by commodity/resource:
7 grain crops
7 forages
1 seeds
13 soils
9 tobacco
1 turf
4 weeds
11 no specific area
Summary of Personnel, July 1991

<table>
<thead>
<tr>
<th>Classification</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Faculty</strong></td>
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<tr>
<td>Professor</td>
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<tr>
<td>Associate Professor</td>
<td>12</td>
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<tr>
<td>Assistant Professor</td>
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</tr>
<tr>
<td>Extension Professor</td>
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<td>Associate Extension Professor</td>
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</tr>
<tr>
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<td>3</td>
</tr>
<tr>
<td>Professor (Adjunct)</td>
<td>0</td>
</tr>
<tr>
<td>Associate Professor (Adjunct)</td>
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</tr>
<tr>
<td>Assistant Professor (Adjunct)</td>
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<tr>
<td>Vacancy</td>
<td>1</td>
</tr>
<tr>
<td>Research Specialist</td>
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<td><strong>- Subtotal</strong></td>
<td>65</td>
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<tr>
<td>Postdoctoral Scholars</td>
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</tr>
<tr>
<td>Visiting Scientists</td>
<td>8</td>
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<td><strong>Staff</strong></td>
<td></td>
</tr>
<tr>
<td>Administrative Secretaries</td>
<td>3</td>
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<tr>
<td>Clerical</td>
<td>8</td>
</tr>
<tr>
<td>Technical</td>
<td>55</td>
</tr>
<tr>
<td>Administrative (USDA)</td>
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</tr>
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<td>Clerical (USDA)</td>
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<tr>
<td>Technical (USDA)</td>
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<tr>
<td>Temporary labor</td>
<td>Up to 45</td>
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<td><strong>Graduate Students</strong></td>
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<tr>
<td>Soil Science MS</td>
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</tr>
<tr>
<td>Ph.D.</td>
<td>9</td>
</tr>
<tr>
<td>Crop Science MS</td>
<td>8</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>11</td>
</tr>
<tr>
<td>Plant Physiology</td>
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</table>
EXTENSION PROGRAMS

At the current time, 17 faculty hold extension specialist appointments. Of these, 14 are full-time, and 3 are split (see Table 1). Total FTE's in extension agronomy programs are 15.3. All extension agronomy specialists hold Ph.D. degrees in appropriate specialty areas. Extension specialists are administered by the departmental chairman and are integrated into other departmental affairs in research and teaching. Likewise, research/teaching faculty make important contributions to the extension program. Extension faculty are academically grouped with the departmental disciplinary area appropriate to their training, and with the commodity and/or resource group associated with their subject matter assignment. Several specialists are associate members of the graduate faculty and sometimes serve as graduate student advisors (M.S. degrees) or on graduate advisory committees.

Crops specialists are assigned responsibility for all major including tobacco (burley and dark), corn, soybeans, small grains, forage legumes and forage grasses. Minor field crops also covered are grain sorghum, sweet sorghum, and canola. Turf management and maintenance is also a major program area. In addition to these crops responsibilities, weed control in agronomic crops is a major program area, as well as soils, from the standpoint of crop fertilization practices, land use, water quality, and waste product application.

Activities in the various subject matter areas are developed to support county, area, and statewide programs. Emphasis at any given time is placed on topics of timely concern to the various programs. Input from county agricultural agents, producers, farm supply dealers, area and state extension councils, and researchers is taken into account in determining program emphasis. Currently, agronomy specialist programs are emphasizing technology for production of burley and dark tobacco, corn, soybeans, wheat, forages, canola, and sweet sorghum. This includes major emphasis on variety selection, tillage practices, fertilizer and lime practices, soil compaction, weed control, and least-cost production practices. Additionally, forage programs are emphasizing hay quality and hay marketing. Quite a bit of support is being provided to the various commodity and farm supply dealer associations in the state.

As a result of the general public's increased environmental concerns, programs relating to the effect of agricultural practices on groundwater quality and waste disposal (municipal wastes and animal manures) are now underway. Also, programs have been initiated to evaluate the usefulness of constructed wetlands in the treatment of liquid wastes. As a means of generating practical information specific to the varying soil and climatic differences in the state, specialists are involved to varying degrees in conducting on-farm field trials. In addition to providing useful production information, field trials are often used as the focal point of county and area field days. Approximately 150 of these trials are conducted each year in 50 to 60 different counties.
Specialists are using technology transfer methods such as county, area, and state meetings; field days; seminars and short courses; in-service training; print media and electronic media; extension publications and newsletters. Several specialists have developed videotaped programs on important topics, for use by county agricultural agents in local activities.

Future agronomy extension programs will continue to emphasize current agricultural production needs and environmental issues. A wide mix of information transfer techniques will be used to best target such information to intended audiences. Major efforts will continue to provide technical assistance to county extension agents, the farm supply industry, and farmers and consumers on topics of interest and concern.
Assignment and Location of Extension Agronomy Specialists

<table>
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<tr>
<th>Specialty Area</th>
<th>Lexington</th>
<th>Princeton</th>
<th>Quicksand</th>
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<tr>
<td>Tobacco</td>
<td>J.H. Smiley</td>
<td>Bill Maksymowicz</td>
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<tr>
<td></td>
<td>G.K. Palmer</td>
<td></td>
<td></td>
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<tr>
<td>Grains</td>
<td>M.J. Bitzer</td>
<td>J.H. Herbek</td>
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<tr>
<td>Forages</td>
<td>J.C. Henning</td>
<td>G.D. Lacefield</td>
<td>--</td>
</tr>
<tr>
<td>Turf</td>
<td>A.J. Powell</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>Weed Control</td>
<td>J.D. Green</td>
<td>J.R. Martin</td>
<td>--</td>
</tr>
<tr>
<td>Soils</td>
<td>K.L. Wells</td>
<td>L.W. Murdock</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>W.O. Thom ¹/</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G.W. Thomas²/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reclamation</td>
<td>V.P. Evangelou³/</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>Agronomy</td>
<td>--</td>
<td>M. Rasnake</td>
<td>H.B. Rice</td>
</tr>
</tbody>
</table>

¹/0.75 FTE, ²/0.30 FTE, ³/0.25 FTE
AGRONY Teaching

The Department strives to give teaching the priority our students deserve. Declining undergraduate enrollment in the traditional departmental major, Agronomy, and in Production Agriculture was a cause of concern throughout the 1980's. This was a nation-wide trend. However, the Department teaching faculty have more recently found ways to reach and serve additional new students. Curriculum change as well as modification of existing courses for broader appeal have led to a significant increase in student contact hours over the last five years.

Goals and Objectives:
The major goals of the Department's teaching program are to train students who (1) have the most up-to-date knowledge about plant and soil science, (2) understand the scientific method of investigation and can use it to solve problems, (3) can effectively communicate their knowledge to others, (4) work effectively in groups, and (5) are motivated to continue their education throughout their lives. These goals and objectives are common to both our undergraduate and graduate programs.

Undergraduate Programs

Organization:
The teaching program in the Department of Agronomy is divided into two segments—the undergraduate teaching program and the graduate teaching program. The undergraduate program comprises two curricula, the Agronomy curriculum and the Production Agriculture curriculum. The Agronomy curriculum is the disciplinary curriculum of the department while the Production Agriculture curriculum is a college-wide, interdisciplinary curriculum. Established in 1972 by the College of Agriculture to provide a broadly based program related to agricultural production, the curriculum has no courses in its own right, but is composed of courses from most departments in the college.

Each program has a separate committee charged with planning, fostering, improving, and coordinating the respective programs. A Coordinator of Undergraduate Instruction is appointed by the Chairman of the Department. The Coordinator of Undergraduate Instruction provides immediate oversight for the undergraduate education programs in Agronomy and Production Agriculture. He serves as chairman of the Undergraduate Program Steering Committee and the Production Agriculture Committee, serves on the Departmental Advisory Committee, coordinates all undergraduate program committees (e.g., Scholarship Committee, Student Activities Committee), and coordinates the Department's undergraduate student advising program. He appoints special or ad hoc committees as necessary to improve and promote undergraduate education. He performs the routine administrative duties associate with the undergraduate program, such as: schedule listings, textbook order notices, catalog changes, class rolls, grade reports, and course lists and objectives. In
addition, he serves as liaison with the Associate Dean of Instruction and the staff and programs of this office.

The Undergraduate Program Steering Committee is composed of eight Agronomy faculty members, the president of the Agronomy Club as undergraduate student representative, the Chairman of the Department as ex-officio member, and the Coordinator of Undergraduate Instruction as chairman of the committee. The committee members are appointed annually by the Chairman of the Department. The committee has primary responsibility for the overall undergraduate education program of the Department. It continually reviews the B.S. degree program in Agronomy to insure that courses and course objectives, content, sequence and frequency, and instruction meet the department's objectives and the students' education needs. It considers new courses and curriculum changes proposed by any faculty member and recommends to the chairman and faculty changes in courses, curriculum, and scheduling. The committee provides leadership in the development of programs and activities to improve teaching competency of the faculty.

The Production Agriculture Committee consists of the Undergraduate Program Steering Committee along with two additional faculty members appointed by the Associate Dean for Instruction, one each from the Departments of Agricultural Economics and Animal Sciences. The responsibilities of this committee generally parallel the responsibilities of the Undergraduate Program Steering Committee.

A Scholarship Committee is appointed by the Chairman of the Department. The Coordinator of Undergraduate Instruction is responsible for coordinating the work of this committee. The chairman of the committee serves as the Department's representative on the Scholarship Committee of the College of Agriculture. The responsibilities of the committee are (1) to recommend to the College of Agriculture Scholarship Committee prospective recipients of the scholarships for which Agronomy has responsibility, (2) represent the Department on the college's scholarship committee, (3) promote additional undergraduate scholarships for Agronomy.

Scope of Program:
Courses: The Department offers 57 courses (see Table). Fifty of these offer classroom or laboratory instruction. All but one of the courses is supervised through our Department. AGR/FOR 564 is taught by a forestry faculty member. Of the 57 courses, 14 are offered each semester, and 16 more are offered once each academic year.

Majors: Agronomy majors peaked in 1979, while production agriculture majors peaked in 1977 (see Table). Enrollments in both undergraduate majors have steadily declined since that time. Recent evidence indicates that agronomy numbers have stabilized.

In 1990, after extensive faculty discussions, we installed a revised undergraduate program designed to attract more students to our department. This program includes three options: 1) plant
Agronomy Department Course Offerings, January 1991

<table>
<thead>
<tr>
<th>AGR Cross List</th>
<th>Title</th>
<th>Credits</th>
<th>Offered*</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>360 (ASC)</td>
<td>Genetics</td>
<td>3</td>
<td>F</td>
<td>Pfeiffer</td>
</tr>
<tr>
<td>366</td>
<td>Fundamentals of Soil Science</td>
<td>3</td>
<td>F,S</td>
<td>Frye</td>
</tr>
<tr>
<td>367</td>
<td>Laboratory in Soil Science</td>
<td>2</td>
<td>F</td>
<td>Frye</td>
</tr>
<tr>
<td>370</td>
<td>Environ., Food Prod., and Soc. in U.S.</td>
<td>3</td>
<td>S</td>
<td>Bush</td>
</tr>
<tr>
<td>386</td>
<td>Principles of Field Crop Prod.</td>
<td>3</td>
<td>F</td>
<td>Grabau</td>
</tr>
<tr>
<td>395</td>
<td>Special Problems in Agronomy</td>
<td>1-4</td>
<td>F,S,Su</td>
<td>Staff</td>
</tr>
<tr>
<td>399</td>
<td>Experiential Learning in Agron.</td>
<td>1-6</td>
<td>F,S,Su</td>
<td>Staff</td>
</tr>
<tr>
<td>404</td>
<td>Integrated Weed Management</td>
<td>4</td>
<td>F</td>
<td>Witt/Slack</td>
</tr>
<tr>
<td>406</td>
<td>Plant Breeding</td>
<td>3</td>
<td>S</td>
<td>Nielsen</td>
</tr>
<tr>
<td>408</td>
<td>Tobacco</td>
<td>3</td>
<td>F even yr.</td>
<td>Palmer/Smiley</td>
</tr>
<tr>
<td>412</td>
<td>Grain Crops</td>
<td>3</td>
<td>S even yr.</td>
<td>Egli (coordinator)</td>
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<tr>
<td>460G</td>
<td>Soil Use &amp; Management</td>
<td>3</td>
<td>F</td>
<td>Blevins</td>
</tr>
<tr>
<td>470G</td>
<td>Fertilizers and Soil Fertility</td>
<td>3</td>
<td>S</td>
<td>Thomas</td>
</tr>
<tr>
<td>501</td>
<td>Reclamation of Disturbed Land</td>
<td>3</td>
<td>F</td>
<td>Barnhisel</td>
</tr>
<tr>
<td>502</td>
<td>Ecology of Economic Plants</td>
<td>3</td>
<td>F odd yr.</td>
<td>Egli</td>
</tr>
<tr>
<td>510</td>
<td>Ecology &amp; Util. of Grasslands</td>
<td>4</td>
<td>S</td>
<td>Dougherty/Collins</td>
</tr>
<tr>
<td>515 (HOR)</td>
<td>Turf Management</td>
<td>3</td>
<td>F</td>
<td>Powell</td>
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<tr>
<td>556</td>
<td>Seed Technology</td>
<td>3</td>
<td>S even yr.</td>
<td>Tekrony</td>
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<td>557</td>
<td>Seed Biology</td>
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<td>S odd yr.</td>
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<tr>
<td>560</td>
<td>Soil-Plant Relationships</td>
<td>3</td>
<td>F even yr.</td>
<td>Sims</td>
</tr>
<tr>
<td>564 (FOR)</td>
<td>Forest Soils</td>
<td>3</td>
<td>F</td>
<td>Kalisz</td>
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<tr>
<td>566</td>
<td>Soil Microbiology</td>
<td>3</td>
<td>S</td>
<td>Coyne</td>
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<tr>
<td>573</td>
<td>Soil Morphology and Classification</td>
<td>3</td>
<td>F</td>
<td>Karathanasis</td>
</tr>
<tr>
<td>575</td>
<td>Soil Physics</td>
<td>2</td>
<td>Every 3rd Sem.</td>
<td>Phillips</td>
</tr>
<tr>
<td>576</td>
<td>Lab in Soil Physics</td>
<td>1</td>
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</tr>
<tr>
<td>581</td>
<td>Chemical Anal. of Soils &amp; Plants</td>
<td>4</td>
<td>S</td>
<td>Barnhisel</td>
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<tr>
<td>597</td>
<td>Spec. Topics in Agron. (Subtitle Reg.)</td>
<td>1-3</td>
<td>on demand</td>
<td>Staff</td>
</tr>
<tr>
<td>599</td>
<td>Special Problems in Agronomy</td>
<td>1-4</td>
<td>F,S,Su</td>
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<tr>
<td>601 (BIO)</td>
<td>Spec. Top. Molec. &amp; Cell Genetics</td>
<td>1</td>
<td>S</td>
<td>Chappell</td>
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<tr>
<td>602</td>
<td>Principles of Yield Physiology</td>
<td>3</td>
<td>S even yr.</td>
<td>Egli</td>
</tr>
<tr>
<td>619 (BIO)</td>
<td>Cytoengineering</td>
<td>4</td>
<td>S even yr.</td>
<td>Eizenga</td>
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<tr>
<td>622 (BIO)</td>
<td>Physiology of Plants I</td>
<td>3</td>
<td>F</td>
<td>Wagner et al.</td>
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<tr>
<td>623 (BIO)</td>
<td>Physiology of Plants II</td>
<td>3</td>
<td>S</td>
<td>Wagner et al.</td>
</tr>
<tr>
<td>630 (BIO)</td>
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<td>3</td>
<td>Su 4-wk.</td>
<td>Wagner et al.</td>
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<tr>
<td>658</td>
<td>Advanced Weed Science</td>
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<td>F odd yr.</td>
<td>Witt/Barrett</td>
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<td>660</td>
<td>Advanced Soil Biology</td>
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<tr>
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<td>Plant Breeding I</td>
<td>3</td>
<td>S odd yr.</td>
<td>Poneleit</td>
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<tr>
<td>666</td>
<td>Advanced Plant Breeding</td>
<td>3</td>
<td>F even yr.</td>
<td>Poneleit</td>
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<td>671</td>
<td>Soil Chemistry</td>
<td>4</td>
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<td>Advanced Soil Physics</td>
<td>3</td>
<td>F odd yr.</td>
<td>Phillips</td>
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<td>676 (STA)</td>
<td>Quant. Inherit. in Plant Pop.</td>
<td>3</td>
<td>S even yr.</td>
<td>VanSanford</td>
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<td>678 (BIO,STA)</td>
<td>Statistical Genetics</td>
<td>3</td>
<td>on demand</td>
<td>Cornelius</td>
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<tr>
<td>681 (GLY)</td>
<td>Mineral. &amp; Chem. Anal. of Soils</td>
<td>4</td>
<td>S even yr.</td>
<td>Barnhisel</td>
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<td>697</td>
<td>Spec. Topics in Agron. (Subtitle Reg.)</td>
<td>1-3</td>
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<td>712</td>
<td>Advanced Soil Fertility</td>
<td>3</td>
<td>S odd yr.</td>
<td>Grove</td>
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<tr>
<td>721</td>
<td>Pedogenesis and Soil Taxonomy</td>
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<td>S odd yr.</td>
<td>Karathanasis</td>
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<tr>
<td>732 (BIO,HOR)</td>
<td>Mineral Nutrition of Plants</td>
<td>3</td>
<td>F odd yr.</td>
<td>MacKown</td>
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<td>741</td>
<td>Clay Mineralogy</td>
<td>3</td>
<td>S even yr.</td>
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<td>749</td>
<td>Dissertation Research</td>
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<td>F,S,Su</td>
<td>Staff</td>
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<tr>
<td>768</td>
<td>Residence Credit for M.S.</td>
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<td>F,S,Su</td>
<td>Staff</td>
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<td>769</td>
<td>Residence Credit for Ph.D.</td>
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<td>770-001</td>
<td>Agronomy Seminar: Crops</td>
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<td>770-002</td>
<td>Agronomy Seminar: Soils</td>
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<td>773 (BIO)</td>
<td>Seminar in Plant Physiology</td>
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<td>F,S</td>
<td>Staff</td>
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<td>799</td>
<td>Research in Agronomy</td>
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<td>F,S,Su</td>
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<td>GEN 104</td>
<td>Plants &amp; Man: A World View</td>
<td>3</td>
<td>F,S</td>
<td>Grabau</td>
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</tbody>
</table>

* F = Fall Semester; S = Spring Semester; Su = Summer Semester (both 4-week and 8-week, unless otherwise indicated). Offered every year unless otherwise indicated.
Summary of Courses, Student Numbers, Student Contact Hours (SCH), and Majors, Fall Semesters 1975-1990.

<table>
<thead>
<tr>
<th>Fall Semester</th>
<th>No. of Students</th>
<th>SCH</th>
<th>Undergraduate</th>
<th>Graduate&lt;sup&gt;3&lt;/sup&gt;</th>
<th>B.S. Degrees</th>
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<td>694</td>
<td>2251</td>
<td>72</td>
<td>87</td>
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<td>1976</td>
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<td>2493</td>
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<tr>
<td>1977</td>
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<td>2859</td>
<td>103</td>
<td>108</td>
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<td>1978</td>
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<td>1979</td>
<td>706</td>
<td>2207</td>
<td>123</td>
<td>74</td>
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<td>1980</td>
<td>608</td>
<td>1953</td>
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<sup>1</sup> Production Agriculture majors are advised in the Agronomy Department.

<sup>2</sup> Biotechnology majors are primarily advised in the Agronomy Department.

<sup>3</sup> Graduate students include those pursuing advanced degrees in Crop Science, Soil Science, and Plant Physiology/Biochemistry/Molecular Biology programs.
and soil management, 2) plant science, and 3) soil science. The first program appeals to many of our students, including those interested in turf science. The latter two programs are intended to prepare students for advanced degrees. It is probably too early to tell whether this revision has made our program more attractive to prospective students.

Faculty in our department also developed and continue to supervise an individualized program in biotechnology. Many of the outstanding students in this program are not from traditional agricultural backgrounds, and thus provide an outreach to a greater audience. As shown in the following table, growth has been rapid. For the fall semester of 1991, we will have approximately 65 biotechnology majors.

Another recent individualized program in natural resource conservation, started by the Department of Forestry, is attracting a number of students to the College. Our Department is investigating means by which we can become involved in this new program.

Degrees granted: While production agriculture reached a low but apparently stable number of graduates in the late 1980's, agronomy undergraduate numbers have continued to decline.

Number of students and student contact hours: (see Table) Both student numbers and student contact hours peaked in 1977, declined steadily through 1987, then recovered gradually since that time. Since the number of students majoring in agronomy and production agriculture have continued to decline since 1987, it is clear that at least some of our courses have been functioning in a "service" capacity, providing technical training in agronomic areas for students in other majors.

The following table shows the frequency of our course offerings over the last 16 years, as well as the numbers of students taught in each course. Course sizes are generally small, with no more than 80 students in a given section, and usually somewhere between 10 and 25 students in a given classroom.

Teaching Loads: Thirty three of our faculty have at least some involvement in teaching at either the undergraduate or graduate level. In general, teaching loads are relatively low, reflecting the heavy research/extension emphasis of the department. For the 1990-91 academic year, five faculty devote more than 30% of their official effort to teaching. Of the remaining non-extension faculty, 14 are between 10 and 20% teaching, and 14 are less than 10% teaching.

Teaching Facilities:
Classrooms: The department has no exclusively assigned classroom space, but does have use of two teaching laboratories. Classrooms are assigned to all departments in the College of Agriculture by the Associate Dean for Instruction. The college has first claim on the classrooms in its buildings, but if not occupied by agriculture classes, the space may be assigned to other academic units of the university.
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Classrooms assigned to the department are generally adequate in size, but are deficient in almost every other way. In some, light control is so poor that slides and overhead transparencies are difficult to use. In others, ventilation equipment is so loud that teachers cannot be heard, or temperature control is out of the instructors' hands. Perhaps more important, new technologies which are already in use at other state institutions and in the community college system are not available for use by our instructors. A recent grant from the UK Agricultural Alumni Association has provided some relief in the form of a large screen television and video cassette recorder dedicated to use in one of the rooms our courses often use.

Laboratories: The two undergraduate teaching laboratories are adequate to provide laboratory space for some courses. However, cramped facilities have resulted in sharing one of those laboratories with other agriculture programs, and thus make it difficult to add laboratories for courses not currently having them. A good deal of graduate laboratory course instruction takes place in research labs, compromising our important research function. Two of our 1990 undergraduate program options require both an internship and an independent research project. Most of these independent research projects take place in research laboratories, placing further pressure on this space.

Library Facilities: The Agriculture Library located in the Agricultural Science Center-North, is recognized as one of the best satellite libraries at the University. It is staffed by well-trained, professional librarians and assistants. It has excellent holdings for most levels of courses. In addition, it is equipped with modern facilities for interlibrary loan service. The hours of operation are convenient and adequate in length. The library staff operate a reserve desk as a service to instructors and students for short-term check-out of references, slides, tapes and other teaching materials that are used intensively by students. In short, the library services available to the teaching program are excellent.

Independent Study Opportunities:
The most used independent study opportunities are the Department's two special problem courses (AGR 395 and AGR 599) and AGR 799 Research in Agronomy. The first two courses provide credit for various kinds of learning activities, but most frequently involve a 1-to 4-credit research project. AGR 799 extends credit for research projects not directly connected to the student's thesis research. A student arranges a project with a faculty member with interest and expertise in the appropriate area. A written report in the style of scientific writing is usually required.

AGR 399 Experiential Education allows students to earn up to 6 hours credit (on a pass/fail basis), for work experience related to agronomy and contributing to the overall learning objectives of the curriculum. On-campus and off-campus advisors are required and a learning contract must be prepared and approved before registration. Generally, students find the work
experience, often with the help of faculty members, and arrange to work with a faculty member to earn credit. Summer internships and trainee programs with agricultural chemical companies, Soil Conservation Service, tobacco internships, and training at the Epcot Center have been the most common forms of experiential education.

Teaching Quality and Improvement:
The teachers in the Department are usually rated higher than the average for the College in student evaluations. Most of the teaching faculty of the department are recognized by students as being highly competent teachers, knowledgeable in subject matter, and interested in the students' academic and personal development. The Kentucky Chapter of Gamma Sigma Delta, a national agricultural honorary, has selected several Agronomy teachers for its Master Teacher Award, and one Agronomy teacher received the Great Teacher award from the University of Kentucky Alumni Association. Nonetheless, teaching improvement is always needed.

The Department has no formal teaching improvement program. Generally, it is left to the initiative and resources of each faculty member. The Chairman counsels with the teachers when student evaluations indicate problems. Occasional teaching improvement programs are sponsored by the College and University, and faculty of the Department have participated.

Graduate Programs

The Department of Agronomy was organized in 1913. During the next 37 years (1913–1950) 40 M.S. degrees were awarded. In the 1950's the size of the faculty increased, as did graduate training. The Department awarded 91 M.S. degrees during the 1956–65 period. A doctoral program in Agronomy was proposed in 1964. The proposal was rejected by the Graduate School with the recommendation to strengthen faculty in selected areas and develop programs along disciplinary lines. The Soil Science doctoral program was approved in 1967. The Agronomy Department took leadership in developing an interdepartmental Plant Physiology doctoral program, approved in 1967. The Crop Science doctoral program was approved in 1971. Thus, the Agronomy Department has three graduate programs that offer doctoral degrees based on disciplinary subdivisions. The Crop Science program includes faculty from the Horticulture and Forestry Departments. The Plant Physiology program also involves graduate faculty from several departments.

During the period of 1969 to 1980 the Department of Agronomy awarded 41 doctoral degrees and 81 M.S. degrees. From 1980 to 1991, the department has awarded 67 doctoral and 127 M.S. degrees. For the 1990 fall semester the Crop Science program had 24 graduate students enrolled, Plant Physiology had 9 and Soil Science had 27, respectively. The distribution of doctoral and M.S. degree candidates for the Department (3 disciplinary programs combined) was 36 doctoral and 24 M.S. students. Some of the Ph.D. students are associated with other departments, for
example 3 are in Forestry and 5 in Horticulture, with advisors from these departments who are members of the Crop Science and Soil Science graduate faculty.

Our graduate program enrollment has shown remarkable stability since 1977. A shrinking U.S. pool of graduate school applicants has caused enrollment declines in some other agronomy departments, and has caused all crops and soils departments to question if enrollments can be maintained. In this competitive situation it is critical that stipends be held at reasonable levels and that the Department provide an atmosphere and environment conducive to learning, productive graduate research and professional development.

The three graduate programs are coordinated by a four-member Graduate Committee consisting of the Chairman of the Department and the three Directors of Graduate Studies. This committee coordinates the overall graduate program activities, evaluates applications for admission to the programs and for graduate assistantships and fellowships. This committee as a group, and as individuals representing their graduate program, assume the leadership in recruiting graduate students. The Directors of Graduate Studies are the local representatives of each graduate program, provide the program's administration, and act as official liaison with the Graduate School.

Virtually all graduate students in the Department receive graduate research assistantships. No continuing teaching assistantships are awarded, though some students receive a T.A. for one to two semesters while teaching laboratories for the introductory crops and soils classes.

A non-thesis M.S. option is offered but has rarely been used. Almost all students participate fully in, and make important contributions to, the Department's research program, and subsequently prepare a research thesis based on their work. An increasing demand for non-thesis graduate training is expected to result from new incentives for county agents and other agronomic professionals to seek advanced training.
DISCIPLINARY RESEARCH PROGRAMS

The Department is nationally and internationally recognized for excellence in agronomic research. During 1989 faculty published 149 scientific papers and book chapters, among the most productive records in the U.S. Twenty faculty currently hold editorial board appointments on leading scientific journals. Thirteen hold current grants from open competition at the national level. Thirteen have been elected Fellows of the American Society of Agronomy.

While no formal barriers exist within the Department's research program, and interdisciplinary collaboration is the norm, it is divided into the following sections for purposes of organization and discussion:

- Plant Physiology and Biochemistry
- Plant Breeding and Genetics
- Crop Ecology, Physiology and Management
- Soil Science

Plant Physiology/Biochemistry

Current projects:
- Determine the mechanism of photoactivation to form the catalytically active water-oxidizing complex of photosynthesis.
- Determine the biochemical events of photoinhibition within photosystem II reaction center of photosynthesis.
- Identification of the specific photosystem II polypeptides required for O₂ production from water.
- Elucidation of the physiological and biochemical components of the senescence process in crop plants.
- Develop fundamental knowledge about the regulation of crop nitrogen use efficiency by understanding the plant physiological processes controlling nitrogen transport, assimilation and partitioning.
- Evaluate the relationship between source and sink organs of small grains to identify physiological traits that may allow selection of superior yielding genotypes.
- Modification of enzyme systems that exert regulatory control over photosynthetic carbon metabolism and partitioning.
- Regulation of biosynthesis and accumulation of alkaloids and their utilization in secondary reactions within the crop.
- Mutation analysis of major carbon fixing enzymes of higher plants.
- Isolation of regulatory genes involved in sucrose metabolism.
- Genetic manipulation of fatty acid biosynthesis and peroxidative metabolism.

- Elucidation and modification of plant chemistry to enhance natural pest resistance.

- Accumulation and distribution of cadmium in plants to lower human exposure from diet.

- Molecular interactions of plant and pathogens.

- Determination of transcriptional control of gene expression.

- Characterization of polyadenylation signals of plant genes.

- Design and application of expression and transformation vehicles for molecular biology approaches to plant modification.

- Isolation, identification and characterization of chemicals associated with crop quality.

Research opportunities and potential:
The plant physiology/biochemistry/molecular biology faculty represents the most modern and current fundamental plant science research and teaching activities available. This research continues to support agricultural crops important to Kentucky. Faculty interests range from the whole plant to how a few molecules affect the whole plant. Extensive interactions exist among these faculty as well as with plant breeding, crop management and soil science personnel. These interactions exploit the diversity of scientific expertise which exists within the faculty to design and package the most powerful and modern approaches to improved quality and quantity of crop production.

Within the discipline, emphasis for the future will be on nitrogen metabolism and utilization, photosynthesis, natural product metabolism and accumulation, and pest/crop interactions. Each of these areas will require expertise in plant biochemistry, enzymology, molecular biology, transgenic plant manipulation and genetic engineering.

Available fossil fuel for the production of nitrogen fertilizers will decrease in the future making it more difficult to maintain crop yields. Identification of physiological traits associated with nitrogen use efficiency and the effective use of photoassimilates for yield can be used to dissect the molecular basis for the control of these processes affecting plant productivity. Manipulating the molecular controls of these processes will then give an alternate means of developing superior germplasm.

Two important aspects of photosynthesis are the understanding of the photosystem II reaction center for oxidation of water and the carbon partitioning within the plant following carbon dioxide fixation. The mechanism of photoactivation, assembly of the catalytically active center from polypeptides and divalent ions,
the biochemical events of photoinhibition, and identification of ligands for cations for the reaction center are all questions which, with correct answers, may lead to greater efficiency of production in normal or altered environments.

Understanding mechanistic aspects of carbohydrate partitioning at both the whole plant and biochemical level will allow greater economic yield of crop plants. Characterization of these processes will be conducted to determine how these processes and their regulatory components change during plant ontogeny. Detailed biochemical investigations designed to elucidate the active- and effector- sites of key enzymes in the pathway will be necessary.

Many chemicals produced by plants alter pest/crop interactions. Long-range goals are to understand and exploit the metabolic potential of different plant tissues. Alkaloids, fatty acids and terpenoids are groups of compounds that alter pest/crop or even crop/animal interactions. Isolation of the precursors, characterization of enzymes responsible, identification of the genetic material, and alteration of expression of this genetic information will improve crop quality. Many of these studies will involve also genetic alteration of the pest as well as the crop.

Future research will lead to isolation of genes involved in plant metabolism and the genetic dissection of these genes in an effort to improve or modify plant performance. Keys to this work will include mutation analysis of these genes, determination of transcriptional control of gene expression, design and application of expression and transformation vehicles, and the generation of transgenic plants to examine the effect of mutagenesis on the plant phenotype. Application and evaluation of transgenic plants and genotypes will require the interaction of researchers with very different expertise.

**Plant Breeding and Genetics**

**Current Projects:**

**Cellular Genetics:**
- Develop efficient cellular systems for in vitro manipulation of all agronomic crops for Kentucky.
- Develop coupled cellular regeneration/transformation systems for using recombinant DNA methods to transfer foreign genes into agronomic crops.

**Statistical Genetics:**
- Investigation of shifted multiplicative model analysis of crop yield trials as a tool for identifying environments and genotypes with no genotype rank-change interactions.

- Development of statistical procedures for evaluation of the predictive value of various multiplicative model forms in genotype x environment analysis with application to Kentucky crop yield trial data.
Tall Fescue Genetics:
- Development of tall fescue haploids and characterization of the monosomic chromosomes in the tall fescue aneuploid lines.
- Utilization of isozyme markers, in situ hybridization, RFLP mapping, C- and N- banding to identify individual chromosomes and hybrids.
- Interspecific and intergeneric hybridization to increase the variability for forage quality in tall fescue.
- Elucidation of the interactions between endophytic fungi and Festuca species, Lolium species and their hybrid derivatives.

Biochemical Genetics:
- Investigation of the role of fatty acid metabolites in plant growth and development and pest resistance.
- Genetic alteration of plants for improved food quality and as more attractive industrial chemical feedstuffs.

Dark Tobacco Breeding and Genetics:
- Development of disease-resistant cultivars, and population improvement through recurrent selection.
- Breeding for reduced levels of compounds suspected to be human health hazards.

Burley Tobacco Breeding and Genetics:
- Develop burley tobacco varieties with increased disease and insect resistance.
- Initiating a new tobacco type with enhanced flavor and aroma attributes.

Soybean Breeding and Genetics:
- Overcoming soybean mosaic virus-induced yield reductions in double-cropped soybean by incorporating genetic resistance.
- Increase the recovery of recombinant genotypes by using genetic control of recombination.

Corn Breeding and Genetics:
- Investigate improved yield potential by studying the rate and duration of grain fill.
- Continue breeding program for white endosperm corn and release germplasm for varietal improvement.

Clover Breeding and Genetics:
- Investigation of Kura/white clover hybrids for improved persistence that will reduce the need for frequent pasture renovation.
- A new red clover cultivar with improved virus and root rot resistance will offer distinct improvement over older cultivars.
Small Grains Breeding and Genetics:
- Utilization of high kernel growth rate in wheat to develop earlier maturing genotypes.

- Investigation of the role of minor genes in conferring durable powdery mildew resistance.

Research Opportunities and Potential:
The plant genetics and breeding programs for field crops will continue to serve agriculture primarily through the basic genetic studies and the development and release of new cultivars and germplasm. It will be essential that plant geneticists and breeders continue to develop and use new techniques such as those arising in cellular and molecular biology. Utilization of basic science methods will require that geneticists and breeders collaborate closely with laboratory scientists and these research efforts will require additional laboratory research space and controlled plant growth facilities. It does not appear that private companies will expand their breeding and cultivar development activities in the future and there are even examples where private breeding especially for speciality and minor crops, is being downsized or discontinued. There is a need for basic genetics, new breeding methods and germplasm development for all crops including major crops such as corn and soybeans where private breeding efforts are substantial.

Projections for scientist demand in the future suggests a continued need for training M.S. and Ph.D level geneticists and breeders to fill both private sector and University/USDA positions. The graduate students must be well trained in conventional plant breeding, genetics, cytogenetics and statistics, and have strong subject matter exposure in plant physiology, cellular and molecular biology, biochemistry, pathology and entomology.

More emphasis will be placed on crop plant composition and quality characteristics while maintaining good production characteristics such as disease and insect resistance in newly released cultivars and germplasm. In addition, increased attention will be given to developing genotypes amendable to conservation practices such as reduced tillage and lower input levels. Environmental concerns and demands will require that new cultivars be developed which possess biological control mechanisms for pest resistance. Cultivars compatible with no-till and minimum tillage management systems; cultivars fitting double-cropping and other cropping systems; and new and alternate crop plant cultivars will need to be developed.

Plant genetics and breeding in the future will involve greater team effort between breeders/geneticists, cytogeneticists, pathologists, entomologists, cellular/molecular biologists, physiologists, biochemists, engineers and statisticians. Attention must be given to having critical scientist input to the crops being pursued though breeding and genetics.
Every plant breeding program involves current and future use of biochemical and/or molecular markers, recombinant DNA gene transfer methods and the use of cellular in vitro system strategies in their efforts to characterize, manipulate, and develop genetic materials into new cultivars and germplasm. It is clear that a modern and viable plant genetics and breeding effort will require substantially expanded research laboratory techniques, facilities and scientific expertise to facilitate access to techniques in the basic sciences area.

**Crop Ecology, Physiology and Management**

**Current projects:**

**Crop management:**
- Development, evaluation and improvement of management practices for existing and new crops in Kentucky.
- Development of production systems and improved quality of corn and small grain silage.
- Management practices for soybean cropping systems.
- Evaluation of soybean cultivars in various cropping systems.
- Systems for management of production and quality of burley tobacco.
- Evaluation of existing and new crop species and cultivars for Kentucky agriculture.

**Crop physiology:**
- Physiology of wheat and soybean yield.

**Forage production and utilization:**
- Post-harvest physiology, yield and quality of forage crops.
- Evaluation of cultivars and forage species for Kentucky agriculture.
- Estimation of herbage intake of grazing livestock and investigation of the mechanisms that regulate intake.

**Turfgrass management:**
- Evaluation of turfgrass species and varieties for Kentucky.
- Development and evaluation of turfgrass management practices.

**Weed control:**
- Development of management strategies for specific crop weeds.
- Evaluation of weed control practices for conventional and conservation cropping systems.
- Dissipation of herbicides in soils under differing cropping systems.
- Mechanisms of herbicide selectivity and phytotoxicity in crop and weed species.

Seed technology and physiology:
- Evaluate the effect of seed production environment on seed quality.
- Physiology of seed growth and development as it related to maximum expression of seed vigor.

Research opportunities and potential:
Crop management: Cropping systems will be the primary focus of research in crop management with conservation tillage practices receiving high priority. Special emphasis will be placed on cropping systems that minimize economic and environmental risks to maximize profit and minimize negative environmental impacts.

Some part of our effort will be devoted to evaluation of new crops to answer the call for diversification of Kentucky agriculture. Evaluation of new cultivars of corn, soybeans, wheat, canola and tobacco will be more important than in the past as the fruits of genetic engineering and other biotechnology enter the marketplace.

Crop physiology: The primary emphasis of the crop physiology research program will be to further understand the processes that regulate yield and quality in existing and new crops of Kentucky. Factors in the soil-plant environment that limit yield and crop quality will be identified and quantified. This information will be used to develop the algorithms that can be used in simulation and expert systems models of agro-ecosystems for economic and environmental analyses and in other information services.

Stress physiology of major crops will receive special emphasis because of environmental concerns including ozone depletion, global warming and acid rain. All of these have potentially large impacts on both crop production and crop quality.

Post-harvest physiology will receive high priority in seeds research and in conserved forages because of its importance in storage and quality of agricultural products.

Forage production and utilization: The grassland resource is currently under-utilized. The main problem with under-utilized grasslands is the quality of herbage is such that herbage intake is reduced and livestock produce poorly. Consequently, much of the research effort will be directed toward herbage quality and the factors that affect it.

A considerable part of the research effort must be devoted to increasing the productivity of livestock per unit area of grassland and this will entail more intensively managed livestock operations. Intensive grazing systems are the primary way that Kentucky farmers can increase income from livestock on
grasslands. Research in these systems is expensive and, consequently, research should be directed towards the systems analysis and the development of the necessary tools: simulation and expert systems models.

Turfgrass Management: Research in the science and management of turfgrass will likely expand as the acreage of amenity grassland increases with changes in demography, population growth, urbanization and increasing time spent on leisure activities. Environmental issues, especially those concerning fertilizer and pesticides will also play an expanding role in our turfgrass research program.

Weed science: Concerns regarding the environmental impacts of weed management practices, particularly herbicide use, will dominate research objectives. Herbicides will continue, for the near future, to play a part in weed management systems, so evaluation of their efficacy, environmental impact and behavior in plant and soil systems will be necessary. Emphasis will be expanded on integrated pest management, biological control, reducing herbicide use and conversion to safer herbicides. Expert systems will assume a greater role for helping the farmer make appropriate weed management decisions. Evaluations of weed management technologies will be based on lowering costs and environmental impacts without sacrificing weed control efficacy. Evaluations of herbicide behavior in plant and soil systems will continue both to prevent environmental problems with currently used herbicides and to guide in the development of new, more environmentally safe herbicides.

Seed technology and physiology: Kentucky's crop and livestock industries will continue to be dependent on seed for production, expansion and growth. Major emphasis of the seed research program will be to determine the physiological and biochemical processes responsible for maximum expression for seed quality. This information will be used to identify traits that control seed vigor expression which can be manipulated by conventional plant breeding and genetic engineering. Research will continue to determine the processes responsible for seed deterioration and devise strategies for predicting when declines in seed vigor occur during storage.

Soils Research

Current projects:
No-Tillage Research:
- Influence of no-tillage and other conservation tillage systems on soil physical and chemical properties.

- Evaluation of soil mineralogy and solute chemistry changes imposed by conservation tillage practices.

- Agronomic and economic feasibility of legume cover crops and no-tillage/conservation tillage in sustainable grain crop production systems.
- Nutrient placement and N management for no-till corn, soybean and winter wheat.
- Production of burley tobacco using no-tillage practices in small grain cover crops.

Water Quality:
- Effect of rapid water movement through macropores on groundwater contamination.
- Effects of non-agricultural activities on surface and groundwater quality.
- Conservation tillage and soil management for soil erosion control and surface water quality protection.
- Effect of tillage systems and vegetative filter strips on soil erosion and runoff water quality.
- Influence of tillage and cropping systems on the transport of nitrates and herbicides through soils.
- Effect of microbial populations on groundwater quality.
- Evaluation of natural and constructed wetland systems for purification and treatment of wastewater.

Soil Fertility:
- Microbial nitrogen transformations and physiological mechanisms regulating nitrate loss in soils and sediments.
- Efficient use of industrial byproducts as soil amendments.
- Impact of cropping sequence on rotation performance, soil properties and input requirements.
- Elucidation of agronomic practices increasing Ca uptake during the early growth stage of tobacco.
- Comparisons of band and broadcast applications of P and K fertilizers on N, P, and K requirements of row crops.

Mineralogy-Chemistry-Pedology:
- Surface chemistry of soils and metal sulfides for predicting mechanisms and rates of inorganic and organic reactions.
- Surface chemistry of roots and predictions of nutrient availability to plants in soils.
- Using in situ soil solution composition to model pedogenic processes and nutrient transformations in natural, managed and disturbed soil systems.
- Quantitative evaluation of morphological, physicochemical and mineralogical relationships influencing the utilization potential and productivity of soils.
Mine Reclamation:
- Evaluation of physical, chemical and mineralogical properties affecting yield potential of reclaimed soils.

Research opportunities and potential:

There is great public concern about agriculture's effects on water quality. Studies have been initiated to assess the contribution of agricultural pesticides and fertilizers to pollution of groundwater. If indeed our present tillage management practices are causing water quality to deteriorate, we must identify the causative factors. Once these factors are identified, we can then conduct basic and applied research to minimize or eliminate the contribution of these factors.

Research is underway to better understand the nutritional requirements of plants for differing tillage, soil management, rotations and crops. The increasing dependence upon pesticides in crop production is of great concern with regard to economics and potential environmental degradation. Research is needed on soil management techniques, such as allelopathic effects of cover crop residues and limited cultivation, to reduce dependence on herbicides, especially in conservation tillage systems.

Basic research on microbial ecology is needed. Studying the ecology of fecal coliforms in groundwater, which originate from inadequate waste treatment and land application of waste products, will help identify the potential for water pollution from animal and human waste. A research program to better understand the ecology of denitrifying and ammonia dissimilating bacteria in terms of environmental parameters which regulate their activity and competition should result in more accurate estimates of nitrogen fertilizer fate in different agricultural locations.

As environmental concerns about water and soil pollution from mining, agricultural, and waste disposal activities increase, basic and applied research in soil and environmental chemistry, mineralogy, pedology and reclamation will continue to develop fundamental knowledge leading to prevention of adverse effects and better management of affected soils. The development of a complete soil characterization data base for major soils in Kentucky will be implemented in geographic information models (GIS) utilizing regional and local indicators. This will be a great asset in developing sound land resource and environmental policy and for improving soil use and management interpretations. More basic and applied research initiatives will be undertaken to demonstrate the utilization of this data base in solving problems associated with water and soil quality deterioration. Such research projects will include investigations of the solution and surface chemistry, the mineralogy of different soils and geologic materials, and their interactions with agricultural chemicals and industrial and municipal pollutants. The evaluation of constructed wetlands as less expensive alternatives in biochemical wastewater purification will continue in an effort to improve operating criteria and long term efficiency of these systems. Additionally, research efforts will concentrate on the utilization of industrial waste materials as fertilizer.
amendments to reconstructed and agricultural soils, and the development of realistic productivity indices for restored soils.

Soil science also has an important role to play in the future commercialization of genetically engineered plants. Soils research can identify growth- or compositional product- limiting soil factors, which could be used as a guide by genetic engineers in targeting plant processes to be altered. Examples of such applications include biochemical alterations of above or below ground plant parts, or external plant alterations associated with the physical and chemical characteristics of roots and leaves.
COMMODITY/RESOURCE AREAS

Commodity/resource groups provide a mechanism for focusing the Department's expertise and programs on the problems of Kentucky agriculture and on significant issues related to Kentucky land use. Research/teaching faculty and extension faculty, together, evaluate needs and limitations associated with a specific crop or activity area, providing guidance to applied research and extension programs. In addition, several of these groups have official, recurring functions, for example: review of germplasm and variety release by the Seeds Group, fertilizer recommendation review by the Soils Group.

Corn

Importance:
Corn is grown each year in Kentucky on about 1.0 to 1.5 million acres of prime row-crop farmland. Average acre yield has increased consistently since the 1930's and reached a high of 116 Bu Ac⁻¹ in 1989. Depending on yield and market price, the value of Kentucky's annual corn production may exceed 300 million dollars. Corn grain in Kentucky is produced for both feed and food uses. About 60% of the Kentucky corn crop is fed to livestock; primarily swine, cattle, and poultry. Corn silage use by livestock represents a significant feed source for the dairy industry. White endosperm corn is processed in the dry milling industry to produce grits, flour, and meal for various traditional food uses. A new food use for corn is in snack foods. Although still small, snack food processing represents a growing utilization base for both white and yellow food corn hybrids. Kentucky popcorn production, once a major source of the U.S. popcorn supply, is recovering lost acreage. Ethanol production from corn grain is also emerging as a significant use of Kentucky produced corn and may increase in importance as natural gas and oil reserves diminish or become more expensive. Although only a small part of the Kentucky corn crop is now used in industrial starch processing, the readily available waterways, rail system, and highways make Kentucky corn production available to national and international feed, food, and industrial grain processors.

Accomplishments:
- Corn yield acre⁻¹ has increased from less than 30 bu acre⁻¹ in 1917 to 116 bu acre⁻¹ in 1989, resulting in increased production of nearly 600% on about 60% fewer acres.

- Development of No-Tillage corn production; with major reductions of soil erosion, water contamination, and costs.

- Provided information on importance of crop rotations, use of cover crops, optimum row spacing, and plant density for no-till.

- Showed that no-till corn production on poorly drained soils is increased by a row cleaning planter device developed at KY, crop and tillage rotations, and by delayed planting.
- Expanded corn grain production in Central and Eastern KY using improved hybrids and production practices, such as no-till.

- Helped farmers identify and put in use improved management practices by conducting a corn production yield contest.

- Helped establish the Kentucky Corn Growers Association; which will provide commodity leadership for research and marketing.

- Showed that urease inhibitors increase nitrogen use efficiency.

- Recognized the problem of soil surface acidification and the value of residue management to conserve soil moisture.

- Defined necessary inputs and yield increases needed for profitable irrigation of corn in KY.

- Worked with the IPM program to develop corn growth stage description charts and stand count methods.

- Identified and made farmers aware that soil compaction is a major problem in many fields.

- Identified an application "window" for best growth, development, and yield response to the growth regulator ethephon.

- Demonstrated the value of using legumes to supplement commercial nitrogen fertilizer for corn.

- Developed breeding stocks resistant to Maize Dwarf Mosaic and Maize Chlorotic Dwarf viruses and new high yield white endosperm populations.

- Evaluated the performance of more than 150 commercial hybrids sold in KY; 12,000 reports are distributed each year.

- Evaluated hybrids for tolerance to diseases, insects, herbicides, for performance on reclaimed mine soil, and for protein percent.

- Described yield physiology in terms of kernel growth duration and rate; developed unique breeding populations for these traits.

- Tested performance of white and yellow endosperm food corn hybrids; initiated breeding to develop unique germplasms for KY.

**Future Issues and Direction:**
Corn research and extension activities at the Kentucky Agricultural Experiment Station should continue to provide the Kentucky agricultural community with the most up-to-date information and resources available. Kentucky corn production must be productive and profitable. In addition there are new challenges such as the privatization of research and resources, specialization of markets, and the public demand that contamination of water resources not be caused by agricultural practices.
Hybrid evaluation will continue. Diseases and insects adapt and continue to pressure current varieties. New end uses for corn will require specific genotypes. Most traditional varietal development will be done by private research companies that may not develop hybrids with adaptation to Kentucky conditions. The latter point will become more significant as varietal development becomes more concentrated in private organizations with major sales and research facilities in the central corn belt. Traditional specialty corns for Kentucky, white endosperm corn and popcorn, may need additional attention. Other specialty corn uses that can be developed for Kentucky are yellow and white endosperm corn hybrids for snack foods, plus hybrids with starch suited to production of ethanol, starch/polyvinyl biodegradable plastics, and Calcium Magnesium Acetate (CMA) deicer. Protein quantity and quality should be considered for both feed and food uses. Traditional breeding methods must be supplemented with the most recent and effective biotechnological methods. RFLP marker assisted selection plus movement of desirable genes from other varieties and related or non-related species by use of mechanical or biological vectors may improve the rate of varietal change. Kentucky researchers should participate in the derivation of such techniques.

Corn production management decisions will become more complex. Common pesticides, herbicides and insecticides, may be replaced by less effective ones or by those that may require more care in application. Cultural practices of the past occasionally create new problems such as soil compaction. Estimates of 30% compacted soils in some Kentucky counties suggest a strong need to verify such problems and determine remedies. Continued applied research on cropping systems and hybrid maturity interactions plus special management needed for specialty corn crops, including popcorn, will be needed. New use hybrids may require special management for optimum yield or product quality. Educational needs include: in-depth corn management training for growers, county agents and agribusiness; teaching aids such as training videos and computer programs, as well as a corn production handbook.

Concerns about soil and water contamination by fertilizers and pesticides used in corn management systems may influence the use of many current chemicals, may inhibit future product development, and will certainly influence the course of research and extension programs. Minimum tillage will be essential for maximum control of environmental pollution by soil and/or pesticide runoff. The strong position of Kentucky no-till research should be expanded with innovations of equipment, varietal inputs, herbicide and other pesticide inputs, and overall management. Research programs in herbicide evaluation should emphasize traditionally troublesome weed species such as johnsongrass. But new alternatives may be needed for triazines and other chemicals that may pose a threat to groundwater. Fertility research will address optimum utilization and minimum nutrient loss, as well as cost effectiveness.
Forages

Importance:
Grassland is a resource which, if developed to its potential, can greatly increase agricultural income of the Commonwealth. In Kentucky, there are about nine million acres of forages, divided into 5.5 million acres of hay and meadow, and about 3.5 million acres of permanent pasture. The forage crop in Kentucky is marketed primarily through a livestock enterprise (beef, dairy, sheep, or horse) and receipts cannot be directly documented. However, it has been estimated that approximately 46% of the annual livestock receipts can be directly attributed to forages. Using 1989 data, this amounts to $661 million, roughly equivalent to tobacco sales. Increasing amounts of high quality forage is being marketed directly as cash hay. In 1989, cash receipts from hay sales were $66 million. Forage crops also provide immeasurable value as aesthetic background, erosion control and water purification.

The future of forage crops is bright and promising. Forage agriculture is truly sustainable agriculture with a minimum of crop support subsidization. An assessment of agricultural potential for Kentucky indicated that hay and silage production from perennial forages could be doubled with no reduction in the acreage devoted to row crops. For hay alone, Kentucky could increase acreage of alfalfa to 2 million acres and all other hay to 3.6 million acres even with corn and soybean acreage increasing. Replacement of endophyte-infected tall fescue, increased yields of alfalfa, and improved grazing management of grass, grass-legume, and pure legume stands could result in further increases in agricultural income in Kentucky. As economic pressures dictate more efficient farming systems, farmers are turning to their forage enterprises to increase, maintain, or even restore profitability and sustainability of the overall farming operation.

Accomplishments:
- Defined the relationship between the presence of the endophyte in tall fescue and the accumulation of four different type(s) of alkaloids -lolines, ergots, peramine and loliteums.

- Demonstrated increased animal performance of tall fescue containing low endophyte levels.

- Developed callus culture methodologies to transfer endophytes to different host grasses.

- Demonstrated rumen function responses to diazaphenthrene and loline alkaloids in tall fescue.

- Identified different host-endophyte combinations which produce different kinds and amounts of alkaloids.

- Use of isozymes to determine the parentage of tall fescue x giant fescue hybrids and amphiploids.
- Characterization of 21 monosomic tall fescue plants to locate genes for disease resistance and quality on specific chromosomes.

- Regeneration of normal plants from inflorescence cultures of tall fescue for use in molecular techniques of gene transfer.

- The first release of a meiotically stable, 56 chromosome tall fescue germplasm from hybridization.

- Demonstration of the beneficial effect of Acremonium coenophialum on seedling vigor and plant competitiveness of tall fescue.

- The release of 'Johnstone' tall fescue.

- The release of 'Rhizo' Kura clover.

- The release of 'Fergus' birdsfoot trefoil.

- Demonstrated that plant hairs on red clover stems are responsible for reduced hay curing rates under field conditions.

- Demonstrated that perennial ryegrass cultivars persist in this environment, producing higher quality forage than tall fescue.

- Demonstrated that ammonium propionate is an effective preservative of moist alfalfa hay.

- Demonstrated that the tall fescue endophyte has minimal impact on stand productivity and forage quality after establishment.

- Demonstrated that endophyte infection status does not affect in vitro digestion rate of tall fescue cell walls.

- Established a maximum rate of grazing intake of beef cattle on tall fescue and alfalfa swards differing in height and density.

- Demonstrated that increased sward density increases intake rate of cattle grazing grass swards.

- Disseminated information to agents, producers, and others on forage establishment, production, management, harvesting and utilization; thereby facilitating adoption of improved practices.

**Future Issues and Direction:**

1) Identification of the toxic entity(s) of the endophyte-tall fescue system.

2) Find endophyte-tall fescue combinations that contain the toxins responsible for the insect and disease resistance and enhanced plant growth but without the toxin for poor animal performance.

3) Develop tall fescue haploids and characterize the monosomic chromosomes in the tall fescue aneuploid lines.

4) Utilization of isozyme markers, in situ hybridization, RFLP mapping, C- and N-banding to identify individual chromosomes and hybrids of tall fescue.
5) Produce intergeneric hybrids to increase the variability in forage quality of tall fescue.
6) Elucidate the interactions between endophytic fungi and Festuca species, Lolium species and their hybrid derivatives.
7) Develop a white x Kura clover hybrid with improved persistence.
8) Develop a new red clover variety with greater virus and root rot resistance.
9) Development a less pubescent red clover variety to speed field hay drying and to reduce dustiness due to shattered trichomes.
10) Develop a model for the prediction of hay drying times for Kentucky environments by determining relationships between weather and plant variables and field drying rates.
11) Evaluate the potential for use of microwave heating as a means of sterilization of moist hay.
12) Elucidate factors limiting the rate, herbage quality and total amount of forage consumed by grazing cattle.
13) The forage extension program will continue to stress the delivery of applicable forage production information to all appropriate audiences using a variety of educational methods. Applied research, demonstrations, agent training, and the development of educational materials to be used by others will continue to be the focal points of future extension programs.

Seed

Importance:
Kentucky's crop and livestock industries have been and will continue to be dependent on the seed industry for the distribution of seed of improved varieties of small grain, soybean and hybrid corn. The Department of Agronomy Foundation Seed Project and Kentucky Seed Improvement Association have maintained a consistent supply of foundation and certified seed for grain, tobacco and forage production throughout the state. In 1990 over one and one half million certified seed tags were issued for twelve crops and 110 varieties with an estimated value exceeding 10 million dollars.

A research/teaching program in Seed Science and Technology was established in 1978. Since that time, 11 M.S. and Ph.D. students have completed their degrees and now hold key seed positions with public agencies or private companies throughout the U.S. The program has attracted graduate students and visiting scientists to the department and has been successful in gaining seed industry support and recognition.

Accomplishments:
Seed Multiplication and Extension: A coordinated seed program in close alignment with the seed industry and the foundation and certification programs has been in existence for several years. Excellent progress has been made toward increased production and use of certified seed of improved varieties, especially of soybean, small grains and tobacco. The organizational structure of the combined seed certification and foundation seed programs have been utilized as a model in several other states. Alan
Phillips has been recognized nationally as President of the Association of Official Seed Certifying Agencies. A good example of the success of these programs was the seed increase for a KAES release, Pernyri1e soybean, from one bushel of Breeders Seed in 1985 to 225,000 bushels of Certified Seed three years later.

Seed Research:
- Described indicators of seed physiological maturity for soybean, corn, wheat and canola; can be utilized by seed producers to time harvesting and maximize quality.

- Demonstrated that seed vigor was related to field emergence under adverse soil conditions for a wide range of crop species, but there was no relationship between vigor and final yield in grain crops if plant populations were adequate.

- Developed improved methods for measuring seed vigor in soybean, corn and wheat; these methods have been incorporated into standardized seed testing procedures within the U.S. and Canada.

- Identified seed infection by Phomopsis longicolla as the major factor responsible for reduced seed quality in soybean. Developed production systems which reduced seed infection and improved soybean seed quality.

- Developed a point system for predicting when to use a foliar fungicides to reduce Phomopsis seed infection in soybean seed fields.

- Determined the relationship between seed development and seed quality (germination and vigor) for corn, soybean, wheat and canola.

- Modified model for estimating declines in soybean seed germination and accurately predicted germination losses in a warehouse storage environment.

- Verified that the viability of Phomopsis longicolla declined to low levels during soybean seed storage, which resulted in increases in seed germination. The decline in P. longicolla could be modified by changes in the storage environment.

- Determined that the vigor of the soybean seed axes declined before whole seed vigor. The declines were related to declines in axes mitochondrial respiration and were associated with peroxidative changes in mitochondrial lipid fatty acids.

Future Issues and Direction:
Seed Multiplication and Extension: Plant variety protection has caused the number of privately developed varieties to increase rapidly during the last decade, while the certified seed volume of publicly developed cultivars has declined. This has resulted in changes in public cultivar release procedures including; exclusive releases, elimination of the registered seed class and royalty assessments. These changes will directly affect both the foundation seed and seed certification programs in future years. Seed certification will be required to provide a wider range
of services and seed quality assessments including seed health, varietal identity, seed composition and other information needed for national and international seed marketing. The acreage and volume of foundation seed produced will quadruple in the next five years as additional small grain and soybean cultivars are released without the registered seed class. This will require additional facilities and equipment for foundation seed conditioning, storage and distribution. It will require a modification of present production procedures to maintain seed quality at present levels.

Adult education programs for Kentucky farmers, county agents and seedsmen must be expanded to provide information on the many changes in cultivar release policy, privately developed cultivars and changes in plant variety protection.

Seed Research: A continuous supply of genetically pure seed of high viability and vigor will continue to be essential for crop production. Although the technology for evaluating seed vigor has improved, there are still many questions regarding the fundamental basis of seed vigor expression which are not well understood. Basic research is needed to identify those traits that control seed vigor and to provide information for manipulation of those traits using conventional plant breeding or genetic engineering. The seed provides a perfect model to study molecular changes that occur during development, maturation and deterioration which influence vigor. Research needs and opportunities will expand as established seed research programs in Mississippi and Oregon are reduced. Thus, with adequate faculty and space the potential exists for expansion of seed research and training programs at the regional, national and international levels.

Small Grains

Importance:
Small grains produced in Kentucky include wheat, barley, oats, rye, and triticale. Soft red winter wheat is by far the most important of these crops, and therefore, is the focus of most of our research and extension efforts. Although canola is not one of the small grains, canola research and extension projects fall within the purview of this committee and will be discussed below.

In general, winter annual grain crops such as wheat play a pivotal economic role in the rotation with corn and doublecrop soybeans. Because wheat is harvested early in the summer, it can provide critical cash flow to help pay corn and soybean production costs. Harvested acreage of wheat has fluctuated around 500,000 for the past 5 years. In 1989, when wheat yields averaged 50 bu/a and prices were $3.65/ bu, the wheat crop generated $ 82.1 million, 5% of cash receipts for all crops. Most of the barley produced in Kentucky is fed on the farm because there is not a consistent cash market for the crop. Canola has been produced in Kentucky for such a short time that its economic potential is difficult to assess.
Accomplishments:
- Released 'Schochoh', a winter hardy, 6-rowed winter feed barley.

- Released 'Verne', a high yielding, soft red winter wheat variety.

- Provided varietal performance data to farmers for wheat (7 locations), barley (4 locations), and canola (2 locations).

- Information on new small grain varieties has been rapidly introduced to farmers.

- Forage and silage yield and quality of triticale and rye varieties have been evaluated.

- Have become a key source of information on quality aspects of new rye varieties.

- Have demonstrated the capability of producing wheat yields of over 135 bu/a in research plots.

- Have shown that the highest wheat yields do not always return the greatest profit to the producer.

- Have effectively educated producers in the recognition and control of wheat diseases.

- In three of the past four years wheat yields have been at or near record levels.

- Have conducted some of the first no-till research on wheat, and have demonstrated acceptable stand establishment, increased N requirement (30-40 #/a), and yields equivalent to conventional tillage.

- Have improved understanding of N nutrition for winter wheat: fall N should not be credited against the spring N recommendations.

- Have demonstrated that yield of wheat varieties is related to their capacity to first store, and then later remobilize stem carbohydrates.

- Have shown that yield of wheat in Kentucky is sensitive to periods of reduced light as short as 5 to 7 days.

- Shown that both the spike and peduncle have a considerable capacity to assimilate nitrate immediately following anthesis.

- Negligible transfer of mobilized vegetative N occurs among tillers with developing grain, which implies limited cycling of N through the root system prior to delivery to the grain.

- Source limited and sink limited wheat cultivars have been identified for the purpose of determining physiological traits that may be selected and manipulated to enhance grain yields.
- Initiated a wheat yield contest for Kentucky, which has demonstrated that farmers can produce yields in excess of 100 bu/a.

- Helped to initiate and develop the Kentucky Small Grain Growers Association.

- Initiated a four-part, in-depth, Wheat Production and Management School.

- Developed wheat seeding calibration and planting guide, no-till wheat production and slide set, and freeze damage material and slide set.

- Through development of one of the first canola research and extension programs in the U.S., Kentucky has become a leading canola state.

- Have become a nationally recognized source for canola research and extension information.

**Future Issues and Directions:**
We anticipate that small grains research and extension programs in the future will be shaped, in part, by the growing concerns over environmental quality. For example, in the breeding program, there will be increased emphasis on identifying, characterizing, and utilizing new genes for disease and insect resistance, with the idea of reduced reliance, for environmental reasons, on fungicides and insecticides. Physiological studies will focus on identification of characters associated with high yields in warm environments, since we may be experiencing global warming, or are at least in a warming cycle. Management studies will attempt to refine the precise use of pesticides (for example; through timely application or reduced rates). We will also seek a greater understanding of wheat root development and its role in utilizing residual inorganic N, thereby reducing the potential for nitrate contamination of groundwater.

We plan to explore the opportunities offered by biotechnology to the breeding program. These include wide hybridization with wild relatives of wheat, tagging agronomically important genes with molecular markers, and development of doubled haploid lines for rapid entry into the testing system. We will continue to explore diverse ways of selecting for early maturity in wheat, including use of exotic genes, selection for rapid grainfill, and use of molecular markers linked to genes affecting earliness. The overriding objective is the development of earlier maturing varieties for doublecropping.

Basic physiological studies will target the processes limiting effective use of N and photoassimilates for kernel growth, in an attempt to identify traits suitable for selection and manipulation to enhance grain filling. Polymerase chain reaction techniques will be used for development of markers for the selection of genotypes with superior N use efficiency characteristics.
Research efforts should continue on high yield wheat pest management to define the impact of various pests on wheat yield and evaluate cultural, biological and chemical management of these pests.

No-tillage small grain production eliminates an effective weed control technique and places more emphasis on herbicidal control of weeds. We need to evaluate preplant weed control options and determine the effect of various weeds on wheat yields and quality in no-till conditions.

There is a need for further study of wheat N nutrition as it affects lodging and disease pressure, crop growth and development. We will continue to conduct research on basic production practices in the context of maximizing production efficiency. The existing wheat yield contest will be modified on the basis of input efficiency. We plan to develop production guides for wheat and for canola, and will continue to provide management schools for both of these crops.

The future of canola in Kentucky, and the future of canola research and extension efforts depends on the development of a stable marketing and processing industry that suits the needs of Kentucky producers. Given this essential ingredient, we should continue to test canola varieties, evaluate pest management strategies for canola, develop rotational and cropping systems suitable for canola, and continue to promote canola as a viable crop for Kentucky.

Soils

Importance:
Kentucky's soil resources undergird every agricultural industry in the state and influence urban and economic development. Approximately 15 million of the 25 million land acres in Kentucky are suitable for agricultural use. Agricultural policies, changes in farm marketing, development of large machinery, urban expansion, and the cost-price squeeze have all contributed to new demands on Kentucky's soils in recent years.

Widespread public concern about agricultural chemicals and soil erosion have transformed the agenda for soils research and extension. It is only recently that we have learned to appreciate the role of soil in the protection of the environment. By its very nature, soil has the capacity to absorb and alter waste products that potentially pollute the environment. Thus it is imperative that strong programs in soil science be continued and expanded at the University of Kentucky in order to protect, maintain, and improve the productivity of our soil resources.

Accomplishments:
No-Tillage and Conservation Tillage Systems:
- Found that no-tillage reduced soil erosion by as much as 98%, improved soil structure, and increased levels of soil organic matter and nitrogen.
- Found that legume cover crops with conservation tillage provide substantial N for corn while enhancing soil and water conservation.

- Developed corn-small grain-soybean rotations, three crops in two years.

- Found that soils enriched with organic matter due to no-tillage adsorb less NH₄ but more K than conventional soils.

- Noted that yields and quality of tobacco and corn grown using no-tillage were equal or greater than when using conventional tillage.

- Observed that continuous no-till management slows down soil mineral weathering processes.

- Identified microbial immobilization of N as one of the most important factors limiting crop N recovery in no-tillage.

- Found no-tillage improved K fertility of loessial and limestone soils.

Characterization of the Soils Resource Base of KY:
- Provided physical, chemical, and mineralogical data for 360 pedons in support of the Cooperative Soil Survey.

- Assisted in the publication of soil surveys in 85 Kentucky counties with 15 more counties awaiting publication.

- Intensified efforts to expedite and improve the quality of soil surveys.

- Developed a soil mineralogy map for the state based on analyses of typical soils found in different regions.

Efficient Utilization of Nitrogen and Other Plant Nutrients:
- Demonstrated that urease and nitrification inhibitors increased N fertilizer efficiency to corn and/or tobacco.

- Developed instrumentation to evaluate ag lime quality.

- Found that fertilizer P and K banding are no more effective than surface broadcasting for no-till corn and soybean production.

- Developed a system of fertilizer recommendations which gives optimum yields at minimum costs to growers with minimum adverse effects on the environment.

- Found that P and K needs of double-crop soybeans can be met by fall application prior to small grain planting.

- Developed methods to control Mn toxicity in tobacco.

- Developed a recommendation for Mo application to tobacco.
- Developed an automated method for the determination of Mo in plants.

- Verified soil test procedures developed for agricultural soils could be used for predicting fertilizer needs of surface mined soils.

- Developed site specific combinations of mechanical, chemical, and biological methods for restoring the productivity of disturbed prime farm lands.

- Found that alterations in NO₃ transport processes in roots are the primary initial responses limiting synthesis of newly acquired N in young, P stressed plants.

- Developed extension education programs for applying animal manures and sewage sludge to soil.

Basic Soil Processes:
- In well-structured soils, 80 percent of water containing solutes (or microbes) moves through less than one percent of the soil volume of the rooting zone.

- Developed new methods for measuring denitrification; characterized soil populations of denitrifying microbes.

- Demonstrated soluble salts containing a divalent cation can reduce NH₃ volatilization from N fertilizers.

- Developed models that predict the rate of soil-fertilizer reactions.

- Demonstrated that fragipan formation is the result of irreversible induration of amorphous aluminosilicates produced by feldspar weathering.

Future Issues and Direction:
Basic and applied research must be continued to provide information that leads to improved soil resource conservation; more efficient fertilizer, tillage, crop rotation, and soil management systems; improved classification and characterization of Kentucky soils; and effective stripmine reclamation procedures. Education and extension programs for farmers and the general public will be continued. However, future directions must also include new areas and address new concerns and issues.

In the immediate future, soils programs will be more concerned with environmental issues. Research will emphasize amelioration of potential soil and water pollution from agricultural chemicals and other soil management and crop production practices. Several lysimeter studies have already been initiated on nitrate and herbicide movement through soil as affected by crop and tillage system. Other studies include assessment of agricultural practice effects on water quality (nitrate, herbicides, bacteria, pH, and conductivity) on a watershed scale; and evaluations of constructed wetlands for waste water treatment. Future studies
will include field tests of poultry litter on tall fescue and corn; microbial ecology studies of fecal coliforms in groundwater and soil denitrifiers; and studies of the mechanisms by which nutrients and pesticides are transported in soil and influenced by conservation tillage systems.

**Soybean**

**Importance:**
Soybean production in Kentucky in 1989 totaled 36.9 million bushels, produced on 1.17 million harvested acres. The average yield was 31.5 bushels per acre. The 1989 soybean crop was valued at 215.6 million dollars. Acreage in the state has increased 130% since 1970, and total production has increased 160%.

**Accomplishments:**
- Acreage expansion from 300,000 acres in 1965 to 1.2 million acres in 1990.
- State average yield increased 33% during this time.
- Defined planting date range for maintaining high yield.
- Identified narrow row production systems to reduce yield loss in double crop plantings.
- Variety evaluations provided yield potential comparisons.
- Since 1980, participated in 15 variety releases, including SCN resistant varieties, based on Uniform Test cooperative data.
- Pennyrile variety released with adaptation to double cropping, with 1989 production on 10% of Ky acreage.
- Defined the most efficient selection scheme, based on mean productivity, for selecting genotypes adapted to double cropping.
- Transformed soybean by Agrobacterium infection or microprojectile bombardment, allowing foreign gene transfer.
- Found that soybean seed lipoxygenases differ in biochemical properties and differentially impact flavor and aroma.
- Improved speed and efficiency of screening systems for isolating lipoxygenase genetic variants.
- Rapid, efficient, and accurate non-destructive techniques for determining fatty acid composition and content of soybean seed were put into practice.
- Identified "rotation effect" between soybean and corn for increasing yield of both crops.
- More accurate soil test calibration improved phosphorus, potassium, and lime use efficiency in production systems.
- Expanded production to Eastern Kentucky; over 125,000 acres in 1990.

- Used yield contest to publicize high yield production techniques with yields > 60 bu/acre achieved annually.

- Developed early-planted, early-maturing cropping system to spread production risks and reduce production constraints.

- Determined that the duration of seed growth is related to yield while seed growth rate is not.

- Assessed the soil moisture reserve required for successful double crop production.

- Recommended seed production systems which will maintain soybean seed quality with high germination and vigor.

Future Issues and Direction:
Soybean producers need research and extension programs which will help them improve production efficiency and expand soybean markets, so that soybean production remains an economically attractive enterprise.

In terms of cropping systems research, more emphasis will be placed on methods which increase production stability. Examples in this area include: production of pest resistant varieties, particularly SCN and SMV resistance; maximizing the rotation effect and reducing the impact of soybean cyst nematode; refining tillage/cropping systems for enhanced productivity and water quality; and increasing opportunities for including other crops in the system.

Improving soybean production efficiency will require research that integrates all aspects of the production system. As we know which management practices are most effective in general situations, we want to establish a better understanding of the fundamental basis of the response to various management systems so that effective practices can be recommended for specific situations. In particular we want to be able to predict how management practices interact. This will require a better understanding of the physiological basis for high yield production.

Computer simulation techniques are likely to play a major role in determining situation specific responses, interaction responses, and the average effect over environments of risk-reducing and productivity-maximizing options. Extension programs will use computer analysis of production constraints and the alleviating practices in making recommendations. More intensive training of extension and agribusiness personnel concerning application of this expanding knowledge on soybean production will occur. A yield contest based on maximum profit instead of maximum productivity will publicize techniques increasing production efficiency.
Soybean marketing options can be improved by the production of compositionally altered soybeans targeted to specific markets. Alterations may include altered amino acid composition, lower saturated fatty acids, or specific new fatty acid components for industrial compounds. Further investigation of the control and genetic manipulation of fatty acid biosynthesis and peroxidative metabolism will be needed. Our resources in biotechnology will directed to the construction of these altered specialty genotypes, and towards improving cellular and molecular systems for genetic modification of soybean.

In summary, genetic improvement, through traditional and molecular approaches, can improve productivity, reduce risk, and increase market options. Precision, site specific soybean management requires management-oriented computer models, and the research and extension to support their development.

Tobacco

Importance:
In most years cash receipts from tobacco comprise over 50% of the total from all crops marketed and nearly 25% of all farm marketings including livestock. In 1991 the value of tobacco grown in Kentucky is likely to exceed $800 million. This will be produced by over 100,000 growers on nearly 210,000 acres. Projections by FAO of a nearly 2% annual increase in worldwide demand for tobacco from 1990 to 2000 suggest a continued strong market for Kentucky tobacco. Given the unique production environment required for burley and dark tobaccos and the global trend towards blended tobacco products, tobacco is likely to continue as the dominant Kentucky crop.

Accomplishments:
- Developed tobacco bale marketing system that saves producers $20 to $25 million annually.

- Development and release of disease resistant varieties of burley and dark tobaccos have drastically reduced disease losses.

- Elucidated causes of manganese toxicity and associated yield reductions in burley tobacco.

- Described metabolic pathways for nicotine biosynthesis in tobacco.

- Found that maleic hydrazide application increased yield and decreased nicotine levels.

- Band application fertilizers increased dramatically the efficiency of fertilizer use.

- Increasing leaf number and altering leaf orientation in new dark tobacco varieties have increased yield.

- Identified factors affecting formation and accumulation of certain health-related compounds including nitrosamines.
- Developed new germplasm for use in tobacco improvement including virus resistance, nematode resistance, and 20-fold reduction in nicotine.

- Characterized chemical changes in tobacco including formation of aroma constituents during senescence and curing.

- Through breeding created burley tobaccos with aromatic properties similar to Oriental tobacco.

- Developed and field-tested transgenic tobaccos expressing a metallothionein gene for reduced cadmium in leaves.

- Identified leaf trichomes as the sole site of biosynthesis of certain compounds affecting pest resistance and organoleptic properties.

- Developed a transgenic tobacco expressing genes for altered lipid metabolism.

- Elucidated nitrate uptake and assimilation processes.

- Found that adding molybdenum, an essential micronutrient, at transplanting increased tobacco growth and yield.

**Future Issues and Direction:**
Kentucky's tobacco growers will have a very real opportunity to increase returns in the coming decade. However, constraints on production, such as limited curing facilities and labor shortages, may threaten the ability to meet current and projected market demands. Many of these barriers can be countered by devising alternate production practices and by increasing production efficiency. Individual and collaborative research, development, and extension activities in a number of applied and basic areas can be directed to meet producers needs.

Immediate research goals should include improving the efficiency and reliability of tobacco transplant production, establishing alternate harvest schemes, improving fertilizer-use efficiency, enhancing environmental soundness of fertilization and pesticide use, reducing pesticide and growth regulator residues, and developing varieties that are more productive and pest resistant. These goals are directed to maintain or improve tobacco quality to meet domestic and international trade demands as well as improving production and enhancing production efficiency. While much of this entails more applied research, changes in production practices often have biochemical and physiological effects on tobacco growth and quality parameters. These effects must be characterized before any modifications in production practices can be recommended in complete confidence to growers.

Meeting applied research goals will be accompanied by more basic investigations into the physiology of tobacco growth and development and into health-related issues. These include: identifying mechanisms to reduce or eliminate nitrosamine formation; manipulation and characterization of fatty acid
metabolism to affect pest resistance; studying maleic hydrazide (MH) effects on photosynthesis and carbohydrate partitioning; developing improved methods to determine MH residues; and elaborating on the mechanisms of secondary plant product formation and accumulation. In addition, cellular selection and genetic engineering techniques will be employed in modifying leaf chemistry to affect leaf quality parameters and pest resistance.

A productive research effort is vital to maintaining and enhancing Kentucky's tobacco economy. This must include research directly applicable to enhancing production and quality as well as fundamental studies in genetics, physiology, biochemistry, molecular biology, and mineral nutrition.

**Turfgrass**

**Importance:**
An economic survey recently conducted by the Kentucky Agricultural Statistics service indicates that the turfgrass industry is of major economic importance to Kentucky, and its growth rate exceeds that of other agricultural industries. The survey determined that in 1989 there were 889,500 acres of turfgrass maintained at a cost of almost $350,000,000. At a labor cost of almost one hundred million dollars, 15,000 Kentuckians are employed in this industry, with approximately 50% of those employed full time. This does not include the labor of family members maintaining nearly 1.25 million home lawns in Kentucky. It is interesting to note that the turfgrass industry spends 20% as much for maintenance and equipment as does all of production agriculture in Kentucky. Because turfgrass acreage is so large when compared to important cash crops such as tobacco, it was found that 20% more was spent on turf than tobacco. The importance of the turfgrass industry in Kentucky is even further magnified when one considers that the expenditures for fertilizers, seed, pesticides, and labor, etc. have multiplier effects for associated Kentucky businesses.

**Accomplishments:**
- Determined that triclopyr effectively controls wild violets in turf. Product presently used throughout the United States.
- Conducted investigations to determine seed rate, nitrogen management and mowing regimes best for the new turf-type tall fescues.
- For increased winter hardiness, introduced Vamont bermudagrass for sports turf use.
- Conducted necessary research to submit RS-1 as an improved winter hardy bermudagrass for sports turf.
- Conducted field establishment research in several Kentucky counties to determine best procedures for sports turf renovation with perennial ryegrass or bermudagrass. These practices are presently used on at least one-half of the 2,733 athletic fields being maintained in Kentucky.
- Initiated research that concluded in the release of chlorsulfuron for the selective removal of tall fescue from Kentucky bluegrass turf.

- Initiated research that determined certain turf management practices that would maintain healthy earthworm populations.

- Extensive field testing has resulted in an annually updated list of best adapted cultivars of the following species: Poa pratensis, Festuca arundinacea, Lolium perenne, Festuca rubra, Festuca ovina and Cynodon dactylon.

- In cooperation with scientists in Entomology and Plant Pathology the best management and chemical control methods have been continually investigated for important diseases and pests of Kentucky turf.

- Conducted annual tests to determine best products and timing for both pre- and post-emergence control of smooth crabgrass, the most prevalent weed in Kentucky turf.

A research progress report is published annually to update professional turf growers and Extension Agents. Numerous other Extension Publications and timely articles are published concerning current topics.

- Turf conferences, short courses, field demonstrations and seminars are conducted annually to update professional turf growers and Extension Agents.

Future Issues and Direction:
The need for extensive turfgrass research is rapidly increasing as Kentucky becomes more urbanized, as outdoor sports such as soccer and golf expand, and as the entire population becomes more environmentally aware. Increased turf use always increases the demand for better quality; better quality often dictates the use of more pesticides, fertilizers and irrigation. This apparent paradox can be partially solved by developing demonstration research and education programs that enhance the environment and by basic research that develops better cultivars, management practices, biological controls, and safe pesticide use. Some specific research and education concerns relating to the environment are:

1) reduction of fungicide use on golf courses. At present, about 50% of all fungicides used in the United States is used for turf management - most of that on golf courses.

2) determining any groundwater risks related to turf maintenance.

3) research and education programs to support the recycling of lawn clippings and tree leaves in order to eliminate their disposal in landfills.
4) development of improved composting methods and proper use of the resulting compost in home lawns.

5) determining benefits of solid waste disposal on recreational sites.

6) improving player safety and needed wear tolerance of turf used for all outdoor sports.

7) reduction of water utilization in urban landscapes.

8) reduction of stream siltation in urban areas.

9) increase in college trained professionals employed to manage intensively used turf.

Weed Science

Importance:
Weedy plant species reduce the quality and quantity of agronomic crops. More money is spent by Kentucky farmers for weed control than on all other pests combined. Greater than 95% of the corn and soybeans grown in Kentucky are treated with at least one herbicide at a cost in excess of $30 million. Herbicides for weed control amounted to over 85% of all pesticides sold in Kentucky in 1990. Because of the importance of weeds in limiting crop production, the weed science program has focused on ways to reduce the impact of weeds. This has been accomplished by determining the effect of weeds on crops, developing weed management strategies for various cropping systems, identifying the ways in which herbicides kill weeds, developing safeners to reduce crop injury, evaluating new herbicides, determining the persistence of herbicides in soil and any effect on rotational crops, and distributing research results to growers through the weed science extension program.

Accomplishments:
- Developed a statistical analysis for examining the interaction of two or more herbicides when used in combination.

- Established that bentazon sensitivity in certain corn inbreds was due to an inability to convert bentazon to non-toxic metabolites and that the sensitivity was controlled by a single recessive gene.

- Identified effective safeners for decreasing imazaquin injury to corn and sorghum and imazethapyr injury to corn.

- Determined the mechanism of herbicide safener action for imazaquin and imazethapyr was due to an increase in herbicide metabolism.

- Established that mixtures of hormone herbicides (i.e., 2,4-D) and glyphosate provided greater control of some broadleaf weeds.
- Determined that hormone herbicides (i.e., 2,4-D) antagonized johnsongrass control from glyphosate or haloxyfop, and related compounds.

- Verified the presence in Kentucky of smooth pigweed resistant to triazine herbicides and developed management strategies.

- Evaluated and collected data for registration of a herbicide for wild garlic control in wheat; results in a potential saving to farmers of $1.3 million annually.

- Evaluated and collected data for registration of two herbicides for johnsongrass management in corn. This weed had resulted in about a $50 million annual loss prior to these new herbicides.

- Determined that the dissipation rate of imazaquin, imazethapyr, chlorimuron and clomazone was similar in conventional and conservation tillages.

- Determined that previous crop residue intercepted significant quantities of chlorimuron, imazaquin and imazethapyr; these herbicides were easily removed from the residue by rainfall and reached the soil surface.

- Determined that less than 0.5% of atrazine, cyanazine and simazine moved in run-off water in conventional and conservation tillages.

- Provided timely revisions of weed management recommendations for the agronomic crops and developed publications on specific weed and herbicide topics.

- Developed new publications and video tape on musk (nodding) thistle management in pastures.

- Developed and evaluated computer programs for economical and environmentally sound weed management in soybean.

**Future Issues and Direction:**
Weed management utilizing biological, cultural and chemical methods in an environmentally safe manner is the goal of the weed science program. Future goals include utilizing currently available technology more effectively, developing additional management strategies in many types of conservation tillages, and exploring new techniques for determining herbicide selectivity.

Selectivity mechanisms, particularly differential herbicide metabolism between plant species, are a major "black box" in the design of new herbicides. While it is increasingly possible to design herbicide molecules to act as specific inhibitors of enzymes, it is difficult to predict which chemicals will be tolerated (usually by metabolism to non-toxic derivatives) in crops but not weeds. We will study two of the major enzyme systems which detoxify herbicides in plants, cytochrome P-450 mixed function oxidase and glutathione transferase. Characterization and isolation of these enzymes will be a first step in the design of new selective herbicides. This knowledge
could allow the development of new "safer" herbicides which can be applied to the foliage of crops and weeds. This type of application is less of a threat to ground water contamination than soil applied herbicides and is ideally suited for reduced tillage agriculture which combats erosive losses of soil. Possession of the genes for these enzymes and knowledge of the control of their expression would allow development of new crop varieties more tolerant of applied herbicides and environmental pollutants. It may even be possible to develop "super-tolerant" plants which can be used to mine for pollutants in contaminated soil.

The development of resistant or tolerant crops to herbicides (to which they were previously susceptible) will potentially allow growers to use only one herbicide to control their weeds on corn and soybean. The integration of these herbicide resistant/tolerant crops into a crop/weed management program could lead to weeds resistant to those herbicides. Additionally, the successive use of one herbicide could lead to environmental contamination problems. A herbicide rotation program for the various tillages will have to be developed for the successful long-term use of these herbicide resistant/tolerant crops.

Emphasis will continue on utilizing cover crops and/or previous crop residues to provide initial suppression of weed emergence and growth. Also, in conservation tillage systems that utilize cover crops and/or previous crop residues, research will focus on methods to increase the use of herbicides applied to weed foliage instead of the soil. This is of importance because, in general, these foliarly applied herbicides are used at lower rates and are applied at times that will be less likely to cause contamination of ground and surface waters.

As results of the research program become available, the Weed Science extension program will develop appropriate publications, videos, slide sets or computer programs to disseminate and utilize the information. These various information delivery methods will target specific topics such as johnsongrass management in crop rotation systems, herbicide management to avoid ground and/or surface waters, herbicide management to avoid rapid buildup of herbicide resistant weeds and crop specific computer programs for economical weed management.