Evaluation of the Curriculum of a Department of Plant and Soil Sciences

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Abstract

In 1993-94, as part of an effort to evaluate undergraduate curricula, the Department of Plant and Soil Sciences at the University of Delaware (UD) sent questionnaires to alumni and potential employers in the disciplines of agronomy and soils, ornamental horticulture, and plant pathology. The undergraduate questionnaire, mailed to graduates of the years 1984 to 1993, was designed to assess the graduates' perceptions of the level of competency required for employment in their profession, and the level of competency provided in their undergraduate education. The employer questionnaire, mailed to current and potential employers in both industry and government, was designed to elicit their perception of the level of competency required to meet employees' job responsibilities. The objective of these surveys was to provide quantitative data for the faculty to use in further developing the undergraduate teaching programs in the Department of Plant and Soil Sciences.

While the core curriculum was rated as highly valued, alumni respondents indicated a need for better training in communications (written and oral), time management, and personnel management. A need for greater emphasis on environmental issues also was expressed. The data from employers supported the alumni recommendations, and expressed basic satisfaction with the quality of education in the department. Employers also recommended additional training in professional development skills, and strongly supported the expansion of the internship program.

Introduction

Academic departments throughout the U.S. have begun to conduct intensive reviews of their curricula in recent years **(Davis et al., 1991; Nichols, 1991)**. This has occurred in response to changing societal needs, shifts in academic programs in other departments or colleges (particularly in the "environmental" sciences), and questions from entering students about the application of an educational background to contemporary issues and career opportunities. Strengthening and updating existing curricula are necessary to provide students with the academic preparation both to compete for employment in a tight job market and to successfully address many of the complex issues that will be facing them once they are employed. Modifying curricula in a sensible manner, however, requires that we have an understanding of how alumni and employers perceive current academic programs. What strengths and weaknesses exist, not only in traditional course work but in areas that are becoming increasingly important, such as the practical experiences obtained by students outside the classroom?

The University of Delaware is a medium size state-related university with about 15,000 undergraduate students and 5,000 graduate and continuing education students. The undergraduate population is drawn predominately from Delaware and surrounding states. The student population is diversified in respect to ethnicity, race, and gender. The male-female ratio is 1.8:1. The Department of Plant and Soil Sciences is housed within the College of Agricultural Sciences, which has the 7th smallest undergraduate enrollment (569) of eight colleges within the University. Nearly all of these students (95%) originate from urban backgrounds.

The Plant Science Department was formed in 1968 by combining the departments of agronomy, horticulture, and plant pathology. The challenge from the early days has been to remain unified while maintaining the integrity of individual disciplines. Initially, the undergraduate curriculum featured general plant science, and the graduate degrees emphasized more specific individual disciplines. In 1972, a core curriculum was added that included required courses in botany, genetics, plant physiology, soils, plant pathology, and plant nutrition. In 1984, additional flexibility was introduced by offering four areas of concentration: General Plant Science, Ornamental Horticulture, Agronomy, and Plant Pathology. In 1990, the Plant Science Department became the Department of Plant and Soil Sciences. The core curricula of the Department of Plant and Soil Sciences now lead to a degree of Bachelor of Science in Agriculture, with majors in Plant Science or Environmental Soil Science. The Plant Science major is still subdivided into the same four concentrations: General Plant Science, Ornamental Horticulture, Agronomy, and Plant Pathology.

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In 1991, the College of Agricultural Sciences at the University of Delaware initiated a strategic planning process to direct its future development in the areas of teaching, research, and service to the agricultural industries and residents of the State of Delaware. Concurrent with the college strategic planning process, the Department of Plant and Soil Sciences began a period of self-evaluation with an eye toward updating and improving its programs in teaching, research, and service.

In 1993-94, questionnaires were sent to recent graduates and potential employers in industry and government. The surveys focused on alumni and potential employers in the disciplines of agronomy and soils, ornamental horticulture, and plant pathology. The objective of the questionnaires was to provide quantitative data for the faculty to use in further developing the undergraduate teaching programs in the Department of Plant and Soil Sciences.

Materials and Methods

The survey questionnaires were modeled after those used by the School of Environmental Design at the University of Georgia (**Nichols, 1991**). Questionnaires were sent to 210 departmental graduates from the years 1984-1993, and to 192 industry and government representatives. Self-addressed, stamped return envelopes were included with the questionnaires. Reminder post cards were mailed two weeks later.

Questionnaires

The questionnaires were divided into three sections: 1) **respondent characteristics**, 2) **general education** questions, and 3) **specific education** questions concerned with individual concentrations within the department.

Alumni questionnaire

Respondent-characteristic questions included year of graduation, highest degree earned, gender, area of concentration (agronomy and soils, ornamental horticulture, pathology, or general plant science), current job title, current employer, income range, and courses taken since graduation. **General-education** questions included educational preparedness for post-graduation job, course accessibility while at Delaware, need for a professional development course, desire for an alumni newsletter, and need for an internship program. There was an opportunity to respond in length to open-ended questions concerned with: 1) reasons for not working in their area of education, 2) comments on curriculum, 3) competitiveness with cohorts, and 4) also to provide additional comments about the education provided by the department.

Specific-education questions (169) associated with the individual concentrations were divided into the following sections: general section, crop management (agronomy), soil science, ornamental horticulture, and pathology. Each concentration was further divided into areas of emphases (i.e., soil science subdivided into soil taxonomy, soil physical properties, etc.). Respondents were asked: 1) to indicate the level of knowledge/skill that they felt was required to meet the responsibility of their current position, and 2) to indicate the level of knowledge/skill that they felt the department provided them in each of these areas. A four point scale (1 = very high, 2 = high, 3 = average, 4 = low) was used to indicate the level of knowledge/skill (Table 1).

Employer questionnaire

Respondent-characteristic questions included name of company/agency, respondent's position or title, a brief description of the nature of the business or agency, responsibilities of the respondent, whether the respondent was self-employed, whether the respondent has employed departmental graduates, and if so, how well were they prepared for employment compared to graduates from other institutions.

General-education questions addressed issues including whether the department should offer a professional development course, whether internship experience improves employment potential, and what skills an internship should provide. Respondents were encouraged to provide additional comments.

Specific-education questions were identical to those in the alumni survey (see above); however, respondents were asked: 1) to indicate the level of knowledge/skill that was required in their profession, and 2) to indicate the level of knowledge/skill that was observed in their entry level employees (Table 1).

Table 1

Alumni were asked to indicate using a four point scale (1 = very high, 2 = high, 3 = average, 4 = low) the level of knowledge/skill 1) that is required in the profession compared to 2) that provided by the Department and the University of Delaware. Employers were asked to indicate the level of knowledge skill 1) that is required in their profession compared to 2) that observed in their entry-level employees.

Required in the profession	Provided by the Department and the University of Delaware OR Observed in entry-level employees
Very high (high knowledge of the facts and principles, and ability to apply them immediately), **High** (general knowledge of the facts and principles, and be able to use texts or other sources to clarify specific points), **Average** (awareness of the basic concepts or theories), and **Low** (knowledge/skill not needed).	**Very high** (program provided a broad knowledge base of facts and principles and the ability to apply them immediately), **High** (program provided a knowledge of the facts and principles, and the ability to use texts or other sources to clarify specific points), **Average** (program provided a brief exposure to the concepts or theories), and **Low** (program did not address this knowledge/skill).

Statistics

For alumni, means of differences between required-by-the-profession minus provided-by-UD-education responses were analyzed using a paired t-test. A positive value indicates that the departmental courses provided more than what is required by the profession. A negative value indicates that the departmental courses did not provide what is required by the profession.

For employers data from the questionnaires were analyzed two ways; 1) means of differences between required-by-the-profession minus observed-in-entry-level-employees responses were analyzed using a paired t-test; and 2) means of "what is required in the profession" by the total-employer-respondent pool. Means of "what is required in the profession" at the 2.5 mean point (Table 4) were chosen as a midpoint between the highest and lowest mean responses.

For a full listing of the survey questions, contact the corresponding author.

Results

Alumni questionnaire

Respondent characteristics: Eighty-four alumni (40%) or an average of about 10% from each of the ten classes returned questionnaires. Study concentrations within the plant science major included: agronomy 13%, ornamental horticulture 50%, plant pathology 10%, and general plant science, 27%. The male:female ratio of respondents was 1.2:1. Graduate degrees were earned by 13% of the respondents, and 58% indicated that they had taken some form of continuing education since graduation. Most of the respondents were employed by private industry (47%), 24% by federal, state (including colleges and universities) or local governments; 8% were self employed, 11% were employed in fields other than plant or soil sciences, 2% were unemployed, and 7% did not respond to the question. A majority (87%) reported their annual income. One-third noted annual incomes of less than $21,000, 44% had incomes between $21,000 and $36,000, 18% $36,000-50,000, and 6% above $50,000.

In response to questions on curriculum, former students found that our curriculum provided adequate preparation both for graduate education (83%) and employment (98%) (62% of the latter indicated that they were very well to extremely well prepared). Almost 94% reported that in their present situation they were competitive with colleagues who had trained at other institutions.

General-education questions: Responding to questions on courses, 96% found that the foundation courses were adequate and that the availability and range of upper level courses were adequate (73% and 69%), respectively. Most felt they had ample opportunity to select elective (92%) and independent study (84%) courses.

A majority (93%) of the respondents favored adding to the curriculum a formal course on professional development, and 93% noted the department should develop an alumni newsletter. Of the 41% respondents with internship experience, 86% found that the experience was beneficial to their career. In addition, 72% of the respondents thought that internship experience would be helpful to career development and 67% noted that it would justify an additional semester on the undergraduate degree program. Slightly more than half (53%) felt that an internship should be part of the degree program.

Alumni repeatedly stated that practical experience (internships, independent projects, hourly employment in research) was invaluable. As stated by two respondents, "Although I believe I had a solid background in my course work, more practical experience is essential to be competitive," and "an internship program would put you leaps and bounds above the competition."

There was some concern that plant pathology and soil science courses are too slanted toward agronomic crops and that plant identification courses are too slanted toward local species (which is perceived as a problem for people that relocate).

A strong need was expressed for the development of non-technical skills such as oral communication and writing skills. Alumni expressed a need for "more oral presentations" or "require students to take courses in public speaking." Although one alumnus understood the importance of writing, they stated "I doubt if anyone could have convinced me of that when I was in school, though."

Also addressed as important in the non-technical skills area were personnel management and business skills. Generally speaking, alumni felt "that people management is the biggest thing everyone feels unprepared for" and that "students would benefit from courses involving development of management skills and/or human relations."

Specific-education questions: Fifty percent of the alumni respondents were from horticulture majors. A comparison of the total-alumni-respondent pool with the horticulture-alumni-respondent pool indicated that the two groups responded similarly overall. The following issues emerged as important based on the questionnaire (Tables 2 and 3).

General education • Major areas that need to be addressed in our curricula were identified as communication skills, personal development, business skills, interpersonal skills, time management, oral communication, and personnel management (Table 2). Many respondents felt that the "hands on" training offered by our department was too dependent on laboratory experience thus resulting in inadequate field experience. There was some sentiment expressed that the basic sciences (physics, organic chemistry, chemistry, laboratory skills) were not as important as other aspects of the curriculum (Table 3).

Soil science and management • Alumni felt that a Plant and Soil Sciences' degree provided them with adequate information on soil science and management (No item had a difference value less than -0.1) (Table 2). Topics that alumni seemed interested in learning more about (but were not necessarily "required" on the job) included areas of soil science related to environmental aspects of soil management (e.g. leaching of nutrients and organics, soil conservation, and

remediation of contaminated soils) and applications of soil testing to field situations.

Plant pathology • No major areas were identified as requiring more training for students enrolled in the plant pathology curricula (Table 2); however, many alumni felt that they got more preparation than was required in laboratory protocols (e.g., media preparation, inoculum increase) and in areas not associated with ornamental horticulture (e.g., diagnosis of diseases of agronomic crops, fruits, and vegetables (Table 3).

Alumni felt that information on soil microbiology was not required in their positions. This may reflect the fact that they were not exposed to the practical aspects of this area of soil science during their undergraduate careers because our department does not teach an undergraduate course in soil microbiology.

Ornamental horticulture • Current environmental issues are reflected in the job requirements of the alumni and should be better addressed in the curricula (including social, technical and regulatory aspects) (Table 2). Small business skills need to be emphasized more in the present courses. Alumni felt that there should be less emphasis in the basic sciences (Table 3).

Crop management • Weed control/pesticides was the only major deficiency noted in our current curriculum that could be corrected with a traditional course (Table 2). Also, a need was expressed for more emphasis on environmental issues related to pesticide use.

Employer questionnaire

Respondent characteristics: Seventy (36%) completed questionnaires were returned, representing a broad cross section of employment opportunities available to graduates of our department. The number and nature of employers responding to the survey were as follows: private nurseries and landscaping companies (22), public parks, gardens, clubs and arboreta (13), chemical corporations (11), private institutions, arboreta, and gardens (10), private companies and laboratories (10), and public research organizations (4). The number and job title of respondents include the following: manager (15), scientists/researcher and staff (13), director (10), president (9), owner (7), superintendent (4), vice president (3), superintendent (3), project leader (2), department head (1), and not stated (1). Answers to the question on respondent job responsibilities indicated that 96% were responsible for hiring personnel. Twenty percent of the respondents were self employed. In their capacity as an employer, 50% of the respondents noted that they had hired UD graduates in the past, and 36% reported UD graduates among current employees.

When asked how well UD graduates were prepared for employment, compared with other employees, 31% said UD graduates were better prepared, 66% said they were the same as employees from other institutions, and 3% indicated that their preparation fell short of graduates trained at other institutions.

General-education questions: Nearly all (94%) of the employers would recommend the inclusion of a professional development course (covering resume and cover letter preparation, job interview skills, time management, and interpersonal relations).

All of the employers agree (76% strongly agree) that practical or field experience for course credit (such as an internship) improves a student's chance for gaining employment in their company or agency. Sixty-one percent of the employers agree that an internship is necessary as background and training for employment with their company or agency.

Skills listed by employer respondents (skills that specifically pertained to their company or agency) that an internship should provide included: interpersonal skills, whether dealing with customers, managing people, or working as a member of a team; communication (oral or written) skills; hands on (practical) experience; equipment operation; time management; independent work ability; and plant identification (highest ranking for any "traditional" education question).

Generally speaking, employers described internships as being an "excellent opportunity for employer/intern to evaluate each other" as long as the internship involved learning and challenges and was not just "easy labor." Internships provide an opportunity for students to get to know potential employers and evaluate career options. Internships were viewed as especially valuable for students lacking hands-on-experience and one respondent said that internships are "essential for a non-farm background person."

Additional general comments clearly indicated that employers are seeking graduates with a broad education (i.e., more than just technical training). Interpersonal (especially communication) skills were viewed as critical areas for success and advancement after employment. Internships may be one way to address this need.

Specific education questions: A number of issues emerged as important based on "what the employers viewed as required in the profession" (Table 4).

General education • Ranked as average to very high in importance by employers were non-technical skills that promote professional success (ability to learn on own, problem solving skills, time management, ethical standards, high personal values, ability to speak and write clearly and effectively, appreciation of different cultural perspectives), practical experience (such as an internship), financial management skills, and other topics such as environmental awareness, data collection and recording, biology, and familiarity with computers (Table 4).

Ranked of average to low importance by employers were the need to have business management skills (securing supplies/equipment, personnel management, determining costs, marketing/sales/advertising, accounting and starting a business) and knowledge or skills in the basic sciences (mathematics, chemistry, laboratory skills, statistics, organic chemistry, geology, and physics) (data not shown).

Soil science and management • Employers seemed to feel that a broad knowledge of soil science and management was important (Table 4). (There were no items rated higher than ~3.0 or less than 2.3). Knowledge of basic chemical reactions

Table 2. Survey results indicating where alumni needed more preparation prior to employment.

Survey area	Alumni		Employers	
	Mean of Difference[a]	T Test and Significance	Mean of Difference[a]	T Test and Significance
General education				
Time management	–1.4	–12.7***	–1.2	–9.5***
Ability to speak clearly and effectively	–1.3	-11.0***	-0.8	-6.1***
Able to listen effectively	-1.0	-8.7***	-	-
Ability to learn on your own	-0.8	-8.7***	-1.0	-8.8***
Personnel management	-1.2	-8.6***	-0.8	-5.3***
Securing supplies and equipment	-1.1	-8.1***	-0.4	-3.3**
Ability to write clearly and effectively	-1.0	-7.9***	-1.0	-6.9***
Environmental awareness	-0.8	-7.8***	-0.4	-4.5***
High personal values	-0.8	-7.1***	-0.6	-6.2***
Determining costs	-1.0	-6.9***	-0.6	-4.6***
Ethical standards	-0.8	-6.3***	-0.6	-5.4***
Financial management	-0.6	-5.0***	-1.3	-8.1***
Knowledge of marketing, sales, advertising	-0.6	-5.0***	-0.5	-3.4***
Practical, field experience	-0.6	-5.0***	-0.4	-2.9**
Computer skills	-0.8	-4.9***	-0.6	-4.4***
Problem solving skills	-0.5	-4.4***	-1.0	-7.8***
Awareness of different cultural perspectives	-0.6	-4.3***	-0.7	-6.8***
Statistics	-0.6	-4.2***	-0.2	ns
Data collection skills	-0.5	-3.9***	-0.6	-5.6***
Accounting	-0.3	-2.6*	-0.3	-3.2*
Starting a business	-0.3	-2.2*	-0.2	ns
Soil science and management				
Leaching of nutrients and organics in soils	0.2	ns	-0.9	-5.2***
Irrigation practices	-0.1	ns	-0.8	-5.0***
Controlling harmful soil microorganisms	0.3	ns	-0.8	-4.9***
Soil conservation practices	-0.1	ns	-0.6	-4.5***
Chemical reactions of organics with soils	0.2	ns	-0.8	-4.5***
Subsurface transport of chemicals	0.2	ns	-0.7	-4.5***
Soil erosion and runoff control practices	-0.1	ns	-0.7	-4.5***
Conditions for optimal soil microbial activity	0.6	ns	-0.8	-4.5***
Plant pathology				
Chemical control methods for plant diseases	0.0	ns	-1.0	-6.0***
Diagnosis of plant diseases affecting ornamental plants	0.0	ns	-1.0	-5.7***
Fundamental concepts of plant disease	0.3	ns	-0.9	-5.6***

Table 3. Survey results indicating where alumni received more preparation than required prior to employment.

Survey area	Alumni		Employers	
	Mean of Difference[a]	T Test and Significance	Mean of Difference[a]	T Test and Significance
General education				
Laboratory skills	0.8	4.8***[y]	-0.1	ns
Chemistry	0.5	4.1***	-0.2	ns
Organic chemistry	0.4	3.4***	-0.2	ns
Physics	0.2	2.1*	-0.1	ns
Soil science and management				
Soil classification	0.7	3.4**	-0.3	ns
Land-use planning	0.6	4.9***	-0.1	ns
Soil texture and structure	0.6	3.4***	-0.6	-3.9***
Types of soil microorganisms	0.6	4.1***	-0.7	-4.2***
Conditions for optimal microbial growth	0.6	4.9***	-0.8	-4.5***
Practices to enhance microbial activity	0.6	3.6***	-0.8	-4.5***
Soil identification	0.5	2.7**	-0.4	-2.9**
Soil temperature relations	0.5	2.5**	-0.5	-3.2**
Infilitration and permeability	0.5	2.6**	-0.7	-3.9***
Soil moisture relations	0.4	2.6**	-0.6	-3.8***
Soil compaction	0.4	2.4*	-0.7	-4.4***
Types of microbial reactions	0.4	3.1**	-0.5	-3.3**
Managing saline soils	0.4	2.6**	-0.1	ns
Controlling harmful soil microbes	0.3	2.5*	-0.8	-4.9***
Plant pathology				
History	1.0	6.1***	-0.1	ns
Diseases caused by mycoplasma	0.9	5.4***	-0.5	-2.9**
Diagnosis of diseases of agronomic crops	0.9	5.1***	-0.3	-2.4*
Disinfection and sterilization	0.9	4.9***	-0.1	ns
Media preparation	0.9	4.4***	-0.0	ns
Diseases caused by viruses	0.8	4.2***	-0.5	-3.4**
Inoculum increase	0.8	3.9***	-0.3	ns
Establishment of diseases	0.8	4.3***	-0.3	ns
Microscope use	0.8	3.9***	-0.3	ns
Diseases caused by nematodes	0.7	4.2***	-0.5	-2.7*
Diagnosis of diseases of fruits	0.7	3.5***	-0.4	ns
Diagnosis of diseases of vegetables 0.7	4.0***	-0.4	ns	
Classification of plant diseases	0.6	4.3***	-0.6	-3.5***
Development of disease in plants	0.6	3.9***	-0.6	-4.2***
Stages of disease development	0.6	4.1***	-0.8	-4.3***

Diagnosis of plant diseases affecting trees	0.0	ns	-0.9	-5.3***
Biological control methods for plant diseases	0.0	ns	-1.0	-5.0***
Influence of environment on plant disease	0.4	ns	-0.9	-5.0***
Preparation of written reports	-0.1	ns	-0.9	-4.6***
Stages of plant disease development	0.6	ns	-0.8	-4.3***
Development of disease in plants	0.6	ns	-0.6	-4.2***
Dissemination of plant disesases	0.5	ns	-0.7	-4.1***
Preparation of oral reports	-0.2	ns	-0.7	-4.0***
Ornamental horticulture				
Knowledge of environmental regulations	-0.9	-6.7***	-1.2	-7.4***
Personnel management	-1.1	-5.9***	-1.0	-6.1***
Environmental ethics	-0.8	-5.8***	-0.8	-5.7***
Environmental management skills	-0.7	-5.0***	-0.8	-5.1***
Contracts and bidding	-0.6	-4.0***	-0.5	-3.2**
Equipment use and maintenance	-0.7	-3.9***	-1.0	-6.7***
Knowledge of plant and animal habitats	-0.4	-3.1**	-0.6	-4.4***
Native plant identification	-0.5	-3.0**	-0.8	-5.6***
Integrated pest management strategies	-0.5	-2.7**	-1.3	-8.4***
Irrigation systems	-0.4	-2.4*	-0.4	-2.5
Weed control	-0.4	-2.3*	-1.0	-7.3***
Basic knowledge of ecosystems	-0.4	-2.3*	-0.6	-4.1***
Crop management				
Pesticide use: environmental effects	-0.8	-3.9***	-1.1	-5.6***
Agricultural equipment: safety	-0.6	-3.3**	-1.1	-6.4***
Pesticide use: safety	-0.5	-2.6*	-1.1	-6.5***
Agricultural equipement: operation	-0.5	-2.5*	-0.8	-5.1***
Pesticide use: selection of pesticides	-0.4	-2.0*	-1.1	-6.9***
Agricultural equipment: maintenance	-0.4	-2.0*	-0.8	-4.7***
Pesticide use: application	-0.4	-1.9*	-0.9	-5.6***

[z]A negative difference for alumni indicates more preparation is needed in the area prior to employment.
A negative difference for employers indicates students have enough preparation prior to the employment.
A positive difference for alumni indicates they think they got more than they needed.
A positive difference for employers indicates students need more preparation prior to employment.

Plant disease epidemiology	0.6	3.0**	-0.6	-3.6***
Diseases caused by bacteria	0.6	4.4***	-0.6	-3.5**
Plant inspection and quarantine	0.6	3.7***	-0.5	-2.8**
Identification of pathogens	0.6	3.1**	-0.1	ns
Reports on the literature of plant pathology	0.6	3.3**	-0.2	ns
Dissemination of plant disease	0.5	3.3**	-0.7	-4.1***
Diseases caused by abiotic factors	0.5	3.2**	-0.7	ns
Environmental effects on disease	0.4	2.3*	-0.9	-5.0***
Host and pathogen genetics	0.4	2.2*	-0.2	ns
Concept of plant disease	0.3	2.5*	-0.9	-5.6***
Ornamental horticulture				
Plant cell structure and function	1.1	7.9***	-0.3	ns
Plant genetics	0.9	6.4***	-0.2	ns
Plant anatomy and morphology	0.9	6.5***	-0.3	ns
Basic plant physiology processes	0.8	5.7***	-0.6	-4.1***
Plant propagation	0.7	4.4***	-0.7	-4.3***
Plant classification	0.6	4.5***	-0.4	-2.6**
Plant pathology	0.5	3.7***	-0.2	ns
Greenhouse management	0.4	2.6**	-0.6	-3.7***
Land surveying and topographic mapping	0.4	3.2**	-0.1	ns
Design graphics and drafting	0.4	3.1**	-0.1	ns
Soil science	0.4	2.7**	-0.7	-4.4***
Landscape design	0.3	2.5**	-0.5	-2.6**
Crop management				
Crop rotations	0.6	3.4**	-0.3	ns
Taxonomy of agronomic crops	0.5	2.4*	-0.1	ns
Production practices of grain crops	0.5	2.5*	-0.1	ns
Tillage practices	0.5	2.3*	-0.5	-3.0**
Taxonomy of cover crops	0.4	2.0*	-0.2	ns
Production practices of vegetables	0.4	2.1*	-0.0	ns
Production practices of turfgrasses	0.4	2.2*	-0.3	-2.4*

[z]A negative difference for alumni indicates more preparation is needed in the area prior to employment.
A negative difference for employers indicates they think students have enough preparation prior to employment.
A positive difference for alumni indicates they think they got more preparation than they needed.
A positive difference for employers indicates they think students need more preparation prior to employment.
[y]***=.001, **=.01, *=.05 significance levels.

Table 4. Knowledge/skills that employers feel are important to the occupational success of their employees.

Survey area	Required level of knowledge required by the profession (Mean ± S.E.)[z]
General education	
Ability to speak clearly and effectively	1.9 ± 0.1
Ability to write clearly and effectively	1.9 ± 0.1
Computer skills	2.3 ± 0.1
Financial management	1.9 ± 0.1
High personal values	1.9 ± 0.1
Ethical standards	1.8 ± 0.1
Ability to learn on your own	1.6 ± 0.1
Environmental awareness	1.9 ± 0.1
Time management	1.7 ± 0.1
Problem solving skills	1.7 ± 0.1
Data collection skills	2.1 ± 0.1
Biology	2.2 ± 0.1
Practical field experience	2.4 ± 0.1
Awareness of different cultural perspectives	2.2 ± 0.1
[Least important (3.4±0.1): physics, starting business, accounting]	
Soil science and management	
Soil physical properties: texture	2.5 ± 0.1
Soil physical properties: moisture	2.4 ± 0.1
Soil physical properties: compaction	2.3 ± 0.1
Soil physical properties: infiltration	2.4 ± 0.2
Soil chemical properties: acidity	2.3 ± 0.1
Soil chemical properties: inorganics	2.5 ± 0.1
Soil chemical properties: leaching	2.3 ± 0.1
Soil chemical properties: organics	2.5 ± 0.1
Soil management: erosion	2.4 ± 0.1
Soil management: conservation	2.5 ± 0.1
Soil management: irrigation	2.4 ± 0.2
Soil microbiology: growth	2.5 ± 0.1
Soil microbiology: enhance activity	2.5 ± 0.2
[Least important (3.3±0.1): forest management, saline soil management]	
Plant pathology	
Concepts of plant disease	2.0 ± 0.1
Development of disease in plants	2.2 ± 0.1
Dissemination of disease in plants	2.2 ± -.1
Stages of disease development	2.2 ± 0.1
Plant disease epidemiology	2.4 ± 0.1
Influence of environment on disease	2.1 ± 0.1
Diseases caused by fungi	2.2 ± 0.1
Diagnosis of plant diseases caused by ornamentals	2.1 ± 0.2
Diagnosis of plant diseases caused by trees	2.2 ± 0.2
Chemical control methods	2.0 ± 0.1
Biological control methods	2.1 ± 0.1
Presentation of oral reports	2.4 ± 0.2
Presentation of written reports	2.2 ± 0.2
[Least important (3.3±0.1) history, (3.3±0.3) identification]	
Ornamental Horticulture	
Turfgrass identification	2.5 ± 0.1
Woody plant identification	1.9 ± 0.1
Herbaceous plant identification	1.8 ± 0.1
Weed identification	1.9 ± 0.1
Native plant knowledge	2.2 ± 0.1
Plant propagation	2.5 ± 0.1
Planting techniques	1.8 ± 0.1
Pruning and training techniques	1.9 ± 0.1
Diagnosis of plant diseases and other problems	1.9 ± 0.1
Insect identification	2.0 ± 0.1
Insect control	2.1 ± 0.1
Disease control	2.1 ± 0.1
Weed control	2.0 ± 0.1
Landscape design	2.5 ± 0.2
IPM strategies	1.9 ± 0.1
General landscape maintenance	2.0 ± 0.2
Equipment use and maintenance	2.1 ± 0.1
Personnel management	2.4 ± 0.2
Knowledge of plant and animal habitats	2.5 ± 0.1
Basic knowledge of ecosystems	2.4 ± 0.1
Environmental management skills	2.5 ± 0.1
Environmental ethics	2.0 ± 0.1
Knowledge of environmental regulations	2.2 ± 0.1
Plant nutrition	2.2 ± 0.1
Basic soils	2.3 ± 0.1
Basic plant physiology processes	2.5 ± 0.1
[Least important (3.3±0.1) surveying]	
Crop management	
Cropping systems: fertilizer	2.4 ± 0.2
Cropping systems: diagnosing	2.2 ± 0.2
Pests: insects	2.0 ± 0.1
Pests: weeds	2.1 ± 0.1
Pests: diseases	2.0 ± 0.1
Pests: scouting	2.2 ± 0.1
Pesticide use: types	2.0 ± 0.1
Pesticide use: application	2.0 ± 0.1
Pesticide use: selection	2.0 ± 0.1
Pesticide use: safety	1.8 ± 0.1
Pesticides: environmental	1.9 ± 0.1
Agricultural equipment: operation	2.4 ± 0.1
Agricultural equipment: safety	2.1 ± 0.1
Agricultural equipment: maintenance	2.5 ± 0.1
[Least important (3.3±0.2): agronomic production practices]	

[z]The lower the mean the more important the knowledge/skill is to the occupational success of employees based on the following scale: 1=very high, 2=high, 3=average, 4=low knowledge required by the profession. The 2.5 mean point was chosen as a midpoint between the highest and lowest mean responses.

in soils, soil moisture relations, and soil microbiology were clustered in the upper half of the ratings. Lowest rated items (highest means) were those that employers probably dealt with the least (forest soils, saline soils, soilless growth media, land-use planning, etc.).

Plant pathology • Ranked at very high to average importance by employers was knowledge associated with a) fundamentals (influence of environment on diseases, concepts of plant disease, stages of disease development, development of diseases in plants, dissemination of plant disease, plant disease epidemiology), b) diseases caused by fungi and abiotic factors , c) diagnosis of plant diseases affecting ornamentals and trees, d) management of plant disease using chemical and biological control methods, and f) the preparation of written and presentation of oral reports (Table 4).

Ranked average to low importance by employers were knowledge associated with; a) fundamentals (host and pathogen genetics, application of biotechnology, classification of plant diseases, and history of plant pathology), b) diseases caused by mycoplasma and spiroplasma, nematodes, viruses and viroids, and bacteria, c) diagnosis of plant diseases affecting fruits, vegetables, and agronomic crops, d) management of plant disease (plant inspection and quarantine, exclusion and eradication), e) laboratory skills (disinfection and sterilization, use of microscope, preparation of media, laboratory identification of pathogens, establishment of diseases, and inoculum increase); and, f) the literature of plant pathology *(data not shown).*

Ornamental horticulture • Plant identification skills emerged as high priorities (Table 4). Respondents rated the following plant groups in descending order of importance: herbaceous plants, weeds, woody plants, native plants, turfgrass, and indoor plants. Many basic plant culture skills were given high ratings (Table 4). Most important were planting, pruning and training techniques. Integrated pest management skills were also highly rated, along with disease and insect problem diagnosis and control. General landscape maintenance and equipment use were also rated as important (Table 4). All environmental issues were rated "above average" to "high" (Table 4). These included, in descending order: environmental ethics, knowledge of environmental regulations, basic ecosystem knowledge, environmental management skills, and knowledge of plant and animal habitats. Certain basic plant-related sciences were rated as highly important (Table 4). The highest rated were plant nutrition, basic soil science, and basic plant physiology.

Crop management • Employers place a premium on knowledge of pest control, including scouting, pest identification, and pesticide selection and use (Table 4).

Summary

Because most alumni felt that the department has provided a very good preparation for their careers, it is important that currently successful components of our curricula remain stable. No need for drastic change was indicated, but as stated below, several improvements were recommended that would strengthen our academic programs— such as the introduction of a required undergraduate course in professional development and the integration of communications-skills training in current courses. A course in professional development would provide students in the many current concentrations with additional backgrounds in areas such as technical writing, public speaking, and business skills. Revision of the current "Ornamental Horticulture Internship Program" to the "Plant and Soil Sciences Internship Program" would expand its activities to provide a greater diversity of opportunities that are applicable to all students in our department.

A course on weed biology and control is needed on a regular basis and at the same time include appropriate information on pesticides in existing courses. The use of adjunct faculty may allow for the expansion course offerings, or "short courses" in this area. More information on environmental issues (environmental ethics, environmental regulations, ecosystem knowledge, environmental management skills, plant/animal habitats) needs to be included in current courses.

Given the emergence of new issues (practical experience, environmental themes) and the reduced significance of the basic sciences as perceived by both the alumni and employer respondents, the core list of required courses should be re-evaluated.

Students who plan to have careers in industry or to be self employed, should be advised to include elective courses in public speaking, composition and marketing in their program of study.

It is quite clear that current employers are looking for graduates that are skilled in both oral and written communication (Anon., 1995). Alumni as well as potential employer respondents in the present survey agreed with Davis et al. (1991) in the importance of acquiring good communication skills prior to graduation.

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