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My view

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Weed Science as an Academic Disclipline in the Era of Biotechnology

As we enter the 21st century, the major challenges of agriculture are to (1) provide an abundant, nutritious, and safe food supply; (2) protect and enhance the world's natural resources; and (3) apply cutting-edge science and technology to problems related to food and fiber production and environmental conservation.

Management of weeds and other pests is an important component of modern crop production and will continue to play a key role in helping agriculture meet these challenges. Weed science is a discipline focused on the understanding and management of weeds and has coevolved with the agrochemical industry since the late 1940s. Historically, weed science has emphasized the use of herbicide technology for the control of weeds. During the past two decades, however, alternative methods of weed control and integrated weed management approaches have been researched and incorporated into the production systems of major crops.

LeBaron (1987) foresaw that biotechnology would become an important component of weed technology. He predicted that within 5 yr, the first major crops would be genetically engineered with herbicide resistance. He further predicted that this technology would cause shifts towards the use of superior herbicides but would not replace any current weed control technology. Advances in plant biotechnology in the 1990s have been spectacular and will continue at a rapid pace in the next century. Indeed, during the past decade, weed scientists have played a key role in the development and field evaluation of herbicide-resistant transgenic crops, which have been adopted by American farmers. Ongoing efforts in transforming crops with agronomic or "input" traits, such as herbicide and insect resistance, are expected to level off in the next 2 to 3 yr. Future products of crop biotechnology will concentrate on "output" traits, such as food quality, the production of pharmaceuticals, and the production of specialty chemicals (e.g., plastics; Thayer 1999).

Although LeBaron's foresight was correct, no one could have predicted the tremendous shake-up in the agrochemical industry that has resulted from the success of crop biotechnology. The ongoing mergers, acquisitions, and strategic alliances in the agrochemical and seed industry have created a few dominant multinational companies, which control a significant share of advanced germplasm for the world's major crops and much of the cutting-edge technology in agricultural biotechnology. As a result of these consolidations, a vertical integration, or coordination of food production, processing, and marketing to the consumer, has become a growing trend in American agriculture. Furthermore, the aforementioned industry consolidations have had and will continue to have a tremendous affect on the status of weed science as an academic discipline.

Major issues and challenges facing weed science in the era of biotechnology include the following: (1) relationships with industry, (2) funding opportunities, (3) graduate education, (4) faculty issues, (5) visibility and status of weed science as an academic discipline, (6) networking with other academic disciplines, and (7) creative outreach programs.

Past funding and most of present funding for weed science research has centered around herbicide technology because this technology guaranteed short-term success; most of the funding was provided by the agrochemical industry (Duke 1992). In addition, herbicide-based research was requested by most of the agricultural community. This model of industry support provided weed scientists in academia with adequate funds for applied and some basic research. In turn, industry funds supported the studies of numerous graduate students, who upon graduation were hired by the agrochemical industry and played a pivotal role in the screening and development of many new classes of herbicides. The model worked extremely well, to the point that three-fourths of all members of the Weed Science Society of America (WSSA) are or were employed by the agrochemical industry (Messersmith 1998). The continuing consolidations in the agrochemical industry, however, have and will continue to affect not only the membership of WSSA, but also the level of funding and research opportunities in weed science. Looking into the future, industry funding for weed science research conducted at land-grant universities will continue but at significantly reduced levels. The void will have to be filled by support provided by commodity groups and federal or state agencies. Based on recent trends, formula (federal and state) funding for agricultural research, extension, and teaching will continue to be highly competitive and inadequate to meet all needs. Competitive federal funding for selected programs, such as the National Research Initiative program in Weed Science and Invasive Weeds, the Pesticide Impact Assessment program, and the Integrated Pest Management program, will continue to be major sources of federal funding for weed science research. Opportunities for international research collaborations are available through the U.S. Agency for International Development and other agencies. As weed scientists, we should become familiar with these funding agencies and their program priorities and submit competitive proposals to secure

funding for future research. We must also become more creative when we seek research funding and explore all weed-related topics, not just weed control. The old definition of weeds as plants whose virtues have not been discovered will serve us well in the era of biotechnology. Several weeds are already used either as sources of specialty genes for the production of transgenic crops [e.g., *Arabidopsis thaliana* (L.) Heynh. (mouse-ear cress)] or as sources and bioproduction systems for nutraceuticals [e.g., *Hypericum perforatum* L. (common St. Johnswort)], pharmaceuticals [e.g., *Lemna minor* L. (common duckweed)], and drugs [e.g., *Phytolaca americana* L. (common pokeweed)]. With the advent of structural bioinformatics, weed scientists will be able to deduce protein functions from genomic sequences. The incorporation of genes sequenced from a certain plant into the same or heterologous plant species and screening for various traits will be very useful to weed scientists in the future. With such advances, it will be possible to study, understand, and manipulate genes responsible for dormancy, germination, and dispersal of weed seeds; vegetative reproduction, flowering, and fruit and seed formation; and secondary metabolites, growth, and development.

Strong graduate programs, particularly at the doctoral level, are critical for the survival of weed science as an academic discipline in the era of biotechnology. As we look into the future, we need to address many important questions. How will the changing market affect the size and number of doctoral programs in weed science offered in the U.S. and around the world? What will motivate future students to pursue a doctoral degree in weed science? Has weed science matured as an academic discipline to support post-doctoral research associates? Do we have the critical mass of faculty to train current and future weed science students in biotechnology and other emerging technologies? Based on a recent analysis (Messersmith 1998), about 450 weed scientists are employed currently by American and Canadian universities as faculty with research, teaching, and extension responsibilities. The vast majority of such faculty are weed control specialists conducting extension and applied research for major commodities grown in each state. The number of weed biologists, weed ecologists, and herbicide physiologists is significantly smaller. There are also a few molecular weed scientists, hired recently by certain midwestern and southern land-grant universities.

Academicians, private practitioners, and commodity groups will carry the burden of maintaining weed science as a viable discipline in the era of biotechnology. At present, weed science programs are affiliated with crop production or crop protection departments. In the future, weed science programs may be affiliated with plant science or plant biology departments. Because of the lack of departmental status, networking with related and long-established academic disciplines (e.g., entomology, plant pathology, plant physiology, agronomy, and horticulture) is necessary for the future survival of weed science. American entomologists and plant pathologists meet jointly every 5 yr. I strongly believe that WSSA should initiate the process for joining these two major crop protection disciplines in their next common meeting, which will be held in the year 2003. Entomology and plant pathology are older, well-established academic disciplines. The role of the agrochemical industry in the development of these disciplines has not been as pronounced as in the development of weed science. The experiences of entomologists and plant pathologists will be invaluable to weed scientists as we position ourselves for survival in an era of diminishing support from the agrochemical industry. In terms of outreach, weed science must address the needs of the growing constituencies or stakeholders (e.g., urban population) of the land-grant university system. In addition to farmers, we must communicate better with consumers, environmentalists, and the general public. Although the management tools are changing, weed control will continue to be an integral part of crop production now and in the future. Weed science can have a promising future in the era of biotechnology. Our biggest challenge will be to convince the presidents of land-grant universities, state governors and legislators, and the federal government that weed science is a mature discipline that can stand on its own and is vital to the success of American agriculture.

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