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My View: Automated weed control in organic cropping systems

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In 2005, for the first time, all 50 states in the United States had some certified organic farmland (USDA 2007). Producers in the United States dedicated over 1.62 million hectares of farmland to organic production systems in 2005. The increase in the number of hectares of crops being grown organically has brought with it a growing need for more labor and nonconventional inputs for weed control. Currently, weed control is ranked as the number one production cost by organic and many conventional growers. Over the past 10 yr, development of machine-guided technologies for site-specific (precision) weed control has advanced rapidly, but emphasis in the weed science societies (e.g., WSSA, WSWS) has lagged behind, not to mention being absent in the area of precision weed control in organic systems.

In 2006, Michigan State University, University of Florida, Washington State University, and Colorado State University were the first to offer degree programs in organic agriculture. Purdue University (and probably others) is considering establishing a major in organic farming, anticipating that in 5 to 6 yr, organic crops will be between 5 to 10% of food production. The creation of specific university programs to address organic agriculture indicates that organic agriculture is beginning to receive more attention from academia.

The terms ''precision'' and ''organic'' usually are not included in the same sentence when it comes to agricultural production systems because of the stereotypical idea that precision relates to modern technology and organic is basically dropping seed in the soil and letting nature do the rest. Deryckx (2001) describes weed control in organic farming as more than cultivation and hand hoeing and includes many interacting techniques, such as crop rotation, cover crops, crop variety selection, employment of stale seed beds, flaming, tine weeding and harrowing, weeder geese, etc. Further, the constant goal of the organic farmer is to continuously regenerate the highest level of soil health and provide relative freedom from weeds and soil-borne pathogens. This goal is probably true for many conventional farmers, once the economical bottom line has been met.

Currently, weed control in organic farming is expensive. Gianessi and Reigner (2007) report time required to hand hoe a wide range of crops to be from 17 h ha^{-1} (almond) to 408 h ha^{-1} (peanut). Earthbound Farm®, one of the largest organic producers in the United States, spends up to $1,000 per acre ($405 ha^{-1}) in weeding costs, according to their website (http://www.ebfarm.com). They say that the common misconception of organic farming is that it lacks sophistication or science, which they address by noting that organic farming requires a mastery of ecology and soil science. They are forgetting that technology could and should be a part of organic farming, just as it is in conventional farming. Most organic farmers are using diesel-powered tractors, which are an obvious product of technology. Why is technology not viewed as organic?

Organic crop production has much to do with precision applications, particularly because there is rarely a quick solution to a pest outbreak, plant nutrient deficiency, or an underfertilized soil. Weed control in organic crop production does not mean the continued use of primitive tools and techniques for field operations. Technologies and machines might not fit the traditional concept that embodies organic agriculture, but their application and use can be just as organic as the farming operation in which human labor is employed for weed control.

Organic weed control programs at Michigan State University, Cornell, Washington State University, University of California (Davis), and University of Florida emphasize similar concepts as Deryckx (2001), but fail to provide any research information on vision systems or machine-guided technologies. Unfortunately, a big disconnect exists between organic farming and technology, from basic to applied weed control at the university, industry, and commercial production levels.

Site-specific weed control in organic crop production would benefit greatly from automated weed control systems. In the United Kingdom, a weeding robot and integrated band steaming were shown by Sorensen et al. (2005) to potentially reduce labor demand by up to 85% in sugar beet and 60% in carrots. Machine vision and RTK GPS guidance systems are the latest technologies being researched for use in weed detection and identification. Other technologies include guidance, precision in-row weed control, and mapping. A simple search on recent (2002 to 2009) published research on automation and weed control resulted in more than 30 hits in engineering and technology journals (e.g., *Biosystems Engineering*, *Computers, and Electronics in Agriculture*) and two hits in the most common weed science journals (e.g., *Weed Science*, *Weed Technology*; S. L. Young, personal observation).

The growing interest in organic systems, both by universities and in the marketplace, and the large discrepancy between traditional research in weed science and advances in agricultural engineering, should be a cause of concern among weed science professionals. In the near future, weed control in organic systems could stimulate the demand for development of automation and machine-guided systems, simply because of the high cost and low availability of human labor. In current conventional systems, human labor for weed control is not an issue, so the demand for automation is driven more by environmental concerns, which are rarely on par with economic concerns. A greater awareness and promotion of automation for weed control in organic farming systems is needed in the broad field of weed science.

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