Nov 18th, 12:00 AM

Using Precision Agriculture as a Tool to Enhance Weed Management

Gregg A. Johnson
University of Minnesota

Follow this and additional works at: https://lib.dr.iastate.edu/icm

Part of the Agriculture Commons, and the Agronomy and Crop Sciences Commons

https://lib.dr.iastate.edu/icm/1998/proceedings/16

This Event is brought to you for free and open access by the Conferences and Symposia at Iowa State University Digital Repository. It has been accepted for inclusion in Proceedings of the Integrated Crop Management Conference by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
USING PRECISION AGRICULTURE AS A TOOL TO ENHANCE WEED MANAGEMENT

Gregg A. Johnson
Assistant Professor
Department of Agronomy and Plant Genetics
University of Minnesota

Historically, the goal of agronomic research and associated technologies is to advance crop management strategies that maximize grain production and reduce economic risk on a field scale. We all realize and appreciated the impact that weeds have on our ability to meet these goals. It is, therefore, critical to have an effective short and long-term management plan to deal with weeds. Weed management decision-making is a complex endeavor requiring integration of weed biology, environmental risks, labor needs, crop yield potential, efficacy of a given control measure, and economics (Buhler et al., 1996). Because of this complexity, we often choose risk-averse management strategies that rely on full-rate uniform application(s) of herbicide(s) to reduce risk of yield loss due to weeds. Some have argued that we are missing the opportunities presented by a more holistic vision using integrated strategies that increase the short and long-term efficiency of the entire crop production system (Drazkowski, 1997). In other words, we need to trade the comfort and security of maximization for optimization.

We have seen an increase in weed species diversity over the last century, despite the use of highly effective herbicides (Cousens and Mortimer, 1995; Ghersa and Roush, 1993; Wyse, 1994). This is because current crop/pest management systems lead to the presence of highly adapted weed species that exploit a given set of cultural, chemical, and environmental conditions (Wyse, 1994; Navas, 1991). For example, weed control achieved almost exclusively by chemical methods can lead to changes in weed species composition and density over time. Moreover, the cost of herbicides has risen significantly over the last decade, increasing variable costs when profit margins are already small. This has lead to renewed interest in integrated weed management strategies (IWM) that prevent establishment of weed species that are highly adapted to a given management strategy as well a reduce cost of control (Cousens and Mortimer, 1995). The challenge for IWM is to harness the conceptual and technological tools necessary to develop and implement integrated strategies that do not lead to the evolution of weed species which are well adapted to a specific control strategy. Precision farming is a tremendous platform on which to design and implement IWM strategies that increase overall system efficiency.

The ability to selectively apply herbicides using precision farming techniques is intuitively appealing, especially considering weed populations where there is obvious and distinct spatial aggregation. Precision weed management is currently focused on the use of new technologies to apply herbicide to certain areas of the field based on some predetermined criteria, such as the location or density of a given weed species. However, the emphasis on technology, rather than the development of new crop and pest management systems that integrate and optimize the use of these new technologies, limits our abilities to realize the full potential and promise of precision management. The ability to implement a systems-based integrated strategy both spatially and temporally through precision agriculture strategies represents a significant breakthrough in weed management. Clearly, the ability to harness new advances in technology allows us to explore new ideas and act on those ideas in way never before imagined. Moreover, the ability to accurately obtain and analyze spatial information on crop, pest, and landscape elements creates new opportunities for enhanced dialogue, learning, and decision building. However, the technology must not be at the center of our thinking; it must be peripheral to the philosophy.
The success of new crop and weed management strategies is dependent on our ability to manage risk associated with these strategies, be it perceived or real. Risk in the conventional systems is managed conservatively by applying higher inputs to manage for a mean field condition. Mortensen et al. (1998) suggests that an alternative method of managing risk is to characterize the spatial diversity existing in a field and manage with rather than overcome it. Precision weed management can help manage risk by providing information needed to optimize correct timing of inputs, determine and optimize relationships between biotic and abiotic variables, and accurately monitor management successes and failures (Wallace, 1994). Dynamic spatial and temporal information about fields will ultimately reduce the risk involved with changing current weed management practices in favor of more economically and environmentally sustainable approaches. This aspect of precision farming receives little attention due, in part, to a lack of understanding of spatial and temporal interactions between landscape characteristics (e.g., soil biophysical properties, slope, and aspect), weed populations, and management strategies. Precision weed management can improve our knowledge of the factors driving weed presence/absence, whether they are management, biological, or environmental. An understanding of these factors will help in the selection of appropriate integrated weed/crop management strategies that inhibit or slow the establishment, growth, and dispersion of weeds across the landscape.

Technology is becoming available to help manage information and to use our understanding of spatial weed distribution in the application of weed management strategies. However, there is a need to test these hypotheses and tools in real-world settings where the biology, economics, and sociological aspects of the whole-farm system can be put in perspective. Increasing our understanding of the role of precision weed management in the context of a crop production system will ultimately lead to more economically, environmentally, and sociologically sustainable systems. However, established principles of weed management and competition must now be applied in a more optimal fashion, with more attention to where management efforts are initiated as well as to when. For example, the ability to selectively spray weed patches makes the interaction of timing and placement of herbicides more critical. Timing remains important with respect to weed growth stage and herbicide efficacy, but also with respect to the timing of competition, as expressed in the critical weed free period and the critical duration of interference. Precision herbicide applications may be more important for early emerging weeds whose competition a crop can tolerate less than late emerging weeds. However, limiting weed seed dispersal may be a critical factor in the long-term management of weeds. Therefore, spot application of late emerging weeds may be justified based on long-term economics of weed management.

Producers and consultants must have appropriate information about weed populations in fields, as well as other crop production and landscape information, to effectively develop precision weed management strategies based on integrated weed management strategies. Sampling is not only a means of obtaining information necessary to make current and future weed management decisions but also a means of obtaining information on the success or failure of past weed management decisions. However, such information is collected using qualitative or quantitative sampling methods that lack known utility. The lack of clear and concise sampling plans designed to obtain accurate and timely data make the assessment, development, and use of precision weed management strategies significantly more difficult. With the advent of precision farming, many useful methods of data collection are emerging including more efficient field survey and sampling techniques, sensor technology, and remote sensing. Field scouting is the most common method of data collection for weed management. This method can, however, be very time consuming. To enhance the rapidity at which data is acquired, many are looking towards new technology to provide data collection tools. Remote sensing, for example, is being used to collect color images or infrared/red reflectance patterns of weeds (Lass, et al., 1996). The goal is to choose a sampling method that is cost-efficient and collects the required information with just enough sampling so that the cost of additional sampling would exceed the benefit from the information obtained. In addition, a sampling plan must be within the time and labor constraints of producers and consultants. Once fields are mapped, the ability to predict the distribution of those weeds that do occur in localized
patches offers the potential for easier weed monitoring in the future, and may allow reduced use of herbicides (Wilson and Brain, 1991).

Weed biology data also suggest that there is some stability in the pattern of weed aggregation over time, i.e., weed aggregates occur in the same location for a period of time (Cardina et al., 1995; Johnson et al., 1996). In general, long-lived seedbank species appear more stable than short-lived species (Johnson et al., 1996) and populations are more stable in no-till than in conventionally tilled fields (Cardina et al., 1995). If studies continue to support this finding, then the high cost of annual weed scouting would be significantly reduced; whereby scouting would be performed in targeted areas or spread out over time. Moreover, if real-time sensors with sufficient resolution become available, the need for scouting would be considerably less, depending on how one uses the technology. It is, however, important that information not be lost when using real-time detection technology. Information such as location, species composition, and density of individual patches is critical since this information can be used to monitor the success or failure of present management strategies. Maps indicating where weeds were sprayed early in the growing season can assist in decisions later in the season if the herbicide used has soil or foliar activity. If herbicides with foliar activity only are used, then removal of one group of weed species early in the season may provide an ideal environment for establishment of other species. Growers should also consider whether weeds are appearing in clumps or strips within a field because of misapplication of preemergence herbicides.

The relationship between agricultural production, economics, environment, and society is complex, having both spatial and temporal structure (Drazkowski, 1997). The complexity is so challenging and complex that we have chosen to look at components of the system on a relatively large scale. We need a new strategy, a new process that accepts system dynamics and allows us to work with stakeholders, customers, and farmers to learn, share and experiment (Drazkowski, 1997; Mortensen et al., 1998). We need to use information to increase our knowledge and most importantly our collective wisdom to better manage weed and crop production systems. Our challenge is to fully embrace the concepts of precision management, to promote a better understanding of sustainable systems, to work with managers and farmers to create new wisdom on how to sustain our agricultural systems.
References


