Weed Science

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Critical Next Steps in Combating Herbicide Resistance: Our View

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My View

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We face a wicked challenge. Awareness, communication, and concern about herbicide resistance (HR) have all substantially increased among farmers, their advisers, agrichemical industry representatives, and staff of some key government agencies. However, in spite of this awareness, HR is no less a crisis today than antibiotic resistance.

The Herbicide Resistance Education Committee of the Weed Science Society of America (WSSA), with the help of local weed scientists and professional facilitators, held listening sessions in seven agricultural regions in 2016 to 2017 to gather information from invited participants in an effort to understand the grassroots concerns and challenges of these stakeholders, including cropping systems, environmental conditions, and economic, social, and regulatory constraints. Six key themes emerged from the listening sessions. Participants:

1. wanted new herbicides, especially those with new mechanisms of action (MOAs);
2. believed there is no need for more government regulation of herbicides;
3. stated that crop rotation options, as well as diverse integrated weed management options, are necessary for herbicide resistance management (HRM), but achieving such diversity in weed management and cropping systems is difficult at best;
4. said that the current agricultural economy makes it difficult to implement best management practices; and
5. were aware of HR but were managing it and were panicking.

In light of what we heard, we propose the actions outlined in the following sections.

Awareness of the Challenge

First, it is widely recognized within the weed science community that any new herbicide is, at best, a number of years away. Thus, we must initiate a clearly articulated national educational effort to explain the scientific, economic, and regulatory challenges to discovery of a new herbicide, as well as the length of time it takes to bring a new discovery to the market. This effort could help growers and others better understand why weed science professionals are so concerned with maintaining the utility of our present herbicide tools. We must also recognize that seed technology will allow us to use existing herbicides in new ways or in new cropping systems that can help manage difficult weeds, but these developments will also bring the possibility of increased selection pressure and resistance development. These new technologies are *not* new chemistries and therefore must be properly stewarded so they do not suffer the same fate as other widely used MOAs.

This educational campaign must arise from and involve all who influence weed management decisions, and especially those close to the growers: crop advisors, retailers, and industry salespeople, as well as university weed scientists and other relevant scientists. The U.S. Environmental Protection Agency (EPA) should also play a role by providing publicly available information on requests for registration and required testing procedures, as well as details on how to easily find this information.

WSSA can play a major role by crafting educational materials, similar to those produced earlier on HR by the Herbicide Resistance Education Committee (HRAC), and by adapting and endorsing materials produced by organizations like the United Soybean Board and its Take Action materials. However, this effort must have the complete participation of and buy-in and support from stakeholders, particularly the herbicide industry and commodity groups, if it is to be successful. Once the educational materials are ready, the WSSA Public Awareness

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Committee and all stakeholder groups should adapt them for release through various agricultural press and social media outlets. This information must also be adapted and delivered through the trusted adviser network by agricultural retailers and certified consultants as they work with their customers.

Barriers to Herbicide Discovery

We believe that a thorough evaluation of the barriers to new herbicide development should be conducted. This could include whether there are specific public policy issues that are part of the problem, or whether public policy changes could promote herbicide discovery and commercialization. The WSSA director of science policy, working with the WSSA Science Policy Committee, should have frank discussions with industry, perhaps represented by CropLife America and HRAC, and the EPA to assess the perceived and actual barriers to new herbicide discovery and development. The overall cost of bringing a new herbicide to market and an uncertain regulatory environment have been cited as reasons that companies are reluctant to proceed with the investment. Are there changes in rules regarding patents or data exclusivity in registration that can help? If the WSSA, industry, and regulatory agencies can develop a plan to address real barriers, then stakeholder groups can be enlisted to advocate for change.

Regulations

We are certainly hesitant to suggest that new regulations are needed to address HR issues, but we are also well aware that the threat of regulation, whether from private or public entities, can be a powerful motivator for behavioral change. We propose that the WSSA Herbicide Resistance Committee develop a hypothetical set of measures, perhaps modeled on fungicide-label resistance management guidelines, that could be used for HRM. These might include mandatory restrictions on in-season and across-season use of a herbicide or herbicide MOA, mandatory combinations of effective MOAs in any one application, and mandatory training for resistance management. Any expression of interest in such regulations by regulatory agencies would send a clear message to the agricultural community that voluntary change is much more desirable than provoking regulation.

That being said, EPA must recognize that herbicide use restrictions incorporated on labels of recently registered herbicides such as XtendiMax®, FeXapan™, and Engenia® limit their use and utility for resistance management. Any label amendments and/or registration requirements cannot be so specific that the certified agronomists on the ground cannot use tools effectively as circumstances change. Advisers and growers need to be able to adapt tools based on different soil types, cropping systems, weed spectrums, environmental conditions, and other seasonal production variables as they arise throughout the growing season, and not wait for a regulatory exemption or emergency label to be issued for use.

We also foresee an issue with registrants being the primary partner to implement these restrictions. Registrants are key partners in requesting and adding information on the labels, and checks and balances are minimal if they are also the chief enforcers. A manufacturer serving in the role of enforcer of situations that may limit its ability to sell its product poses a clear conflict of interest.

EPA must resolve the issue of synergism between chemistries so mixtures of effective herbicide MOAs, considered the most efficacious herbicide use tactic for resistance management, are not restricted from use. There also must be a system wherein approval of one chemistry formulation is followed by approval of all identical formulations to avoid the perception that a manufacturer can exempt a safe product sold in an unowned portfolio on the basis of exclusion of a competitor in a marketplace.

While additional regulations were generally not supported in the sessions, there was one interesting exception. That was the use of state noxious weed laws as models for herbicide-resistant weeds, in conjunction with state inspectors, to limit the introduction of new and herbicide-resistant weed species into a state. A specific example mentioned was Palmer amaranth (*Amaranthus palmeri* S. Watson) movement into northeastern states. One action could be to document the cost-effectiveness and acceptance of noxious weed programs through interviews and other means to assess their usefulness in controlling herbicide-resistant weeds. The WSSA Herbicide Resistance Education Committee, working with appropriate extension specialists in the states with these laws, could undertake this evaluation. They could also work with the National Association of State Departments of Agriculture to publicize how these programs are effectively structured. The recent Chinese threat of trade barriers to soybean imports because of herbicide-resistant weeds highlights the need for regulations in this area.

Diversity Is Hard

There were fewer "success" stories of HRM in the listening sessions than we hoped. Their absence illustrates the wickedness of the challenge confronting us. We recognize that one problem with how we organized the listening sessions was a lack of diversity in our participant selection. But there were also instances of growers stating they did not have an HR problem and had been practicing appropriate HRM tactics for some time. We need to showcase these individuals and highlight their success, because they demonstrate that it is possible to practically and economically incorporate more diversity into weed management. These people can be spokespersons and show that what the individual does on his or her own farm can make a difference. A fully developed media campaign using all available avenues must be developed around these success stories. These individuals could be identified on regional and state levels by the WSSA and regional weed science society Extension committees. Industry, agricultural retailers, commodity groups, and consultants could also help to identify successful individuals, for example, Syngenta's Resistance Fighter profiles. The stories should be captured in video, print, and various social media and offered for use across multiple platforms.

Perhaps it is also time to revisit how we are spreading the word that proactive resistance management can be economically advantageous. We have new studies that demonstrate this positive outcome, and we need to more effectively communicate that message. WSSA should partner with industry and commodity groups to disseminate that information in all possible venues to spur innovative integrated weed management.

A subcommittee of the WSSA Herbicide Resistance Education Committee has developed a draft template for developing an integrated weed management plan. We must move this from draft into final form and disseminate that template to all interested and affected parties. However, the template also highlights how little we know about many weed species and HRM in many cropping systems. We would challenge the WSSA and the regional weed science societies' extension committees and herbicide resistance

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committees to develop a list of priority species, identify data gaps, and suggest needed research. They should also produce educational materials based around these informational needs.

One area in which there is plenty of information is the relative efficacy of various herbicide chemistries on individual weed species. However, it would take considerable research and cross-checking to compare the relative effectiveness for HRM of a specific weed species using any one prepackaged or custom herbicide mixture versus another. A computer app would address this need. This is an obvious application for a computer app. Who should take the lead developing the app? The Extension committees would have the data on effectiveness, but computer expertise is needed as well. We propose that WSSA appoint a special committee to work with the Extension Committee to develop this app.

Removing Disincentives

We must identify and reduce or eliminate public and private sector disincentives and build public and private incentives to incorporate more HRM into farming operations. Here, we particularly task the USDA Natural Resources Conservation Service (NRCS) to build more flexibility into its programs so as to allow timely and periodic use of tillage if it is useful as a component of HRM. We heard a number of comments from participants that they were constrained on using tillage by NRCS programs. NRCS must realize that, just as in economics, a judicious short-term use of tillage (cost) can lead to long-term soil-saving benefits if more extensive tillage is avoided later. As far as incentives, we call upon both NRCS and the Risk Management Agency to give more consideration to HRM in their farm programs.

We must also address this issue from a research and educational standpoint. It is not just the incentives of NRCS programs that cause growers to object to tillage; with many soils there are distinct benefits from no-till or reduced-till systems. If tillage is essential to HRM, we need research and education on how to minimize damage to soil structure and how to best return to reduced-tillage systems as soon as the HRM emergency is managed. Additionally, research and education programs are needed to help farmers who practice conservation tillage diversify their weed management practices in the absence of tillage.

Extending and Expanding the Conversation

In the listening sessions there were many statements asking for all parties—industry, academia, government, commodity groups, retailers, consultants, financial institutions, and others—to work together more to address HR and to deliver a consistent message. This is probably the most challenging yet most important recommendation that we have, since those who have not been engaged up to this point do not see a need to engage or do not have the time or resources to be able to engage. To that end, we propose the Herbicide Resistance Education Committee work with U.S. HRAC to convene an in-depth and paradigm-challenging forum that would bring relevant stakeholders together, especially those we have not reached in the past, to address this need. We propose a multiday facilitated retreat with natural and social scientists to determine a path forward to more effectively and collectively address HR.

There were also many pointed comments from participants that "others," particularly those who did not take advantage of educational programs such as those offered by Cooperative Extensions, were a big part of the reason that more progress has not been made in addressing resistance. These comments reflect the need to view HR weed issues in their full scope. While this implication could be challenged and may not be appropriate in certain settings, it is nevertheless important that we reach and engage all who have a role in causing and controlling this problem. Certainly, this issue of who Extension reaches and does not reach, how to overcome this disparity, and how to engage all relevant parties in structuring effective approaches must have been considered and studied in the past. We suggest, at least as a first step, that the Herbicide Resistance Education Committee conduct a literature search on this issue to determine whether there are lessons that have been learned in other areas of common pool resource management that can be applied to HRM.

A Community-based Approach

Many of our assumptions about the more limited mobility of weeds compared with other pests have been disproved by recent scientific studies. The spread of HR has demonstrated that the concerns expressed in the listening sessions about probable movement of resistance from others, both neighbors and those farther away, are quite valid. Since this is the case, it is critical that we start a discussion now on how we can create various forms of community-based cooperative efforts to limit this spread. Community-based efforts to deal with other agricultural problems (crises) have had some successes: for example, both boll weevil and pink bollworm in cotton and water management districts in the western United States. We need to study the successes and failures of programs such as these and design cost-effective efforts for cooperative weed management programs that are region and commodity specific. We also need to explore how we can incorporate communication tools that allow participants to compare notes and share successes and failures. To accomplish this will require engagement and patience from every one of the entities mentioned earlier, as the challenge is formidable. However, a large body of science and experience shows that what we suggest is feasible.

Albert Einstein is often quoted as saying "the definition of insanity is doing the same thing again, and expecting a different outcome." It is time to do something different; this "Our View" paper is our attempt to suggest what we can and must do differently. Business as usual will not suffice. We also invite others to engage in the conversation, challenge our ideas, and put forward other approaches to address this very wicked problem.

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