

Portland State University

PDXScholar

Economics Faculty Publications and
Presentations

Economics

8-2023

Changing the Paradigm for Pesticide Resistance Management

David R. Shaw

Mississippi State University

Amy Asmus

RMS-Asmus Farm Supply, Inc.

Jill Schroeder

New Mexico State University

David Ervin

Portland State University, ervin@pdx.edu

Follow this and additional works at: https://pdxscholar.library.pdx.edu/econ_fac



Part of the [Economics Commons](#), and the [Environmental Studies Commons](#)

Let us know how access to this document benefits you.

Citation Details

Published as: Shaw, D. R., Asmus, A. B., Schroeder, J., & Ervin, D. E. Changing the Paradigm for Pesticide Resistance Management. *Pest Management Science*.

This Post-Print is brought to you for free and open access. It has been accepted for inclusion in Economics Faculty Publications and Presentations by an authorized administrator of PDXScholar. Please contact us if we can make this document more accessible: pdxscholar@pdx.edu.

Shaw David R. (Orcid ID: 0009-0000-2081-8385)

Changing the Paradigm for Pesticide Resistance Management

Running Title: Resistance Management

Authors: David R. Shaw*, Amy B. Asmus, Jill Schroeder, and David E. Ervin

Accepted Article

* David.shaw@msstate.edu Mississippi State University, USA, Office of the Provost and Executive Vice President, Mississippi State, MS 39762

Asmus Farm Supply, Inc., USA, Agricultural Retailer, Principal owner, Certified Crop Adviser with Resistance Management Specialty, Rake, IA 50465

New Mexico State University, USA, Department of Entomology, Plant Pathology, and Weed Science, Las Cruces, NM 88003

Portland State University, Departments of Environmental Management and Economics, 1825 SW Broadway, Portland, OR 97201

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process which may lead to differences between this version and the [Version of Record](#). Please cite this article as doi: [10.1002/ps.7709](https://doi.org/10.1002/ps.7709)

Abstract:

Collaborative action on the part of all stakeholders in pest management is essential to effectively address the challenges of pesticide resistance. The US Environmental Protection Agency, through its Pesticide Program Dialogue Committee, recently posted a report on pesticide resistance management and the role the Agency can play in these efforts. In this perspectives piece, we commend the Agency for acknowledging these needs, and encourage implementation of the recommendations. We urge all stakeholders to follow the example set by EPA to engage openly, listen to other stakeholders, and determine their role as part of the broader community that is needed to address the challenges of resistance. Our contention is that pesticide resistance will continue to escalate until all stakeholders evaluate their roles in resistance management and work together as a community to influence effective management.

Key Words: Pesticide resistance; wicked problem, resistance management, stakeholder engagement.

Introduction

Albert Einstein once said “Learn from yesterday, live for today, hope for tomorrow. The important thing is not to stop questioning.” This Perspectives paper attempts to do just that in the context of pesticide resistance – recognize how this wicked problem developed, why it persists, assess where we stand in proactive and reactive management efforts, and project our ideas for altering the upward trajectory in the future.

Resistance to pesticides (fungicides, insecticides, and herbicides) is a classic example of a “wicked” problem: an extraordinarily complex problem with a myriad of underlying causes, no clear solutions, and unintended negative consequences with many if not all of the mitigating actions that can be taken¹. Recent articles have probed the causes, consequences and potential solution approaches to addressing the wickedness of pesticide resistance²⁻⁶. Wicked problems almost always stem from the interactions of biological, social/human, engineering and other processes. As such, they defy simple technological remedies and require experimentation, learning and adaptive management strategies that mesh with varying socio-ecological conditions over space and time⁴.

In pest control, the benefits of synthetic pesticides are accompanied by a long-term risk – evolving resistance. There is a continuing escalation in pest resistance, notwithstanding laudable private and public efforts to implement best management practices for resistance management (RM), which are based in research that should slow down the evolution of resistance⁷. This failed trend, which is to address pest management and pesticide resistance discipline by discipline, grower by grower, field by field, is the current paradigm that we contend needs to be changed. In this perspective article, we argue that this current approach does not exploit the **collective** knowledge and wisdom of farmers, crop advisors, other industry groups, government agencies, pest management scientists, social scientists and other professionals to innovate more effective and sustainable RM approaches.

When the authors began working together on the issues related to herbicide resistance, we were steeped in the habits, and the language, in which we were trained and continually practiced (or

only those perspectives our experiences permitted us to see as applicable). That resulted in deep-seated perspectives, talking past each other rather than with each other and understanding unfamiliar or conflicting viewpoints.

David – a weed scientist lens. Why don't "they" see how urgent this crisis is, and why don't "they" listen to what I'm telling them to do. We've done the research and developed the educational materials. "They" just aren't doing what we tell them to do.

Amy – a producer and crop consultant lens. Why don't "they" pay attention to hurdles and priorities in production and understand how everything is interconnected. How can "they" think we can just easily implement best management practices (BMPs) to create the perfect, simple solution? Whose responsibility is it to bear the costs (agronomic, economic, environmental and social) of resistance and its aftermath? Why don't "they" understand that "I" am trying, but resistance is in my fields anyway? Does it matter what my practices are if not everyone is doing the right practices... or they are doing the right practices and it is not holding off the development of resistance? How can I "rescue" an outbreak with tillage when that is against my USDA conservation practices/contracts, or in conflict with an Endangered Species Act required mitigation? Can I implement practices like cover crops when short term cost outweighs immediate benefits?

Jill – an agency staff lens – "My" agency's work is driven by the policies set by our leadership and the rules set out by legislative actions. Our approach to managing pests is

often different from our sister agencies because of the constraints set through our agency goals, objectives, and mandates.

Dave – an economist and social scientist lens – Social scientists, mostly economists, have studied the monetary causes and consequences of pest resistance for decades. As a rule, other social scientists and pest management scientists and professionals were not engaged. That pattern has begun to change with more interdisciplinary/transdisciplinary investigations that tap the knowledge of producers who make pest management decisions. However, those efforts are the exception not the rule. The broader social science community has not seen engagement in pest resistance management research as a priority. Until that changes we will not understand the full set of human behaviors that fuel resistance growth to innovate effective management programs.

Making the transition to RM using the full complement of knowledge sources will not be easy or fast as evidenced by the fact that, after over ten years of working together, we have a great deal of work ahead^{3,8}. To appreciate why, think back to the complex and time-consuming days of pest control before the existence of synthetic pesticides. Thus the adoption of pesticides was relatively quick and broad for compelling reasons. A large body of science documented that farmers found these “new innovations” easier to use, more cost-effective and more precise in their scope of pests³. Moving away from such popular tools will involve using costly practices that are more labor and management intensive and less immediately effective. BUT, it’s a challenge that all stakeholders need to accept if we want sustainable and resilient pest management. To do so, we need to disrupt the trend of practitioners relying on individual “silver

bullet” practices and the prospect of more to come⁹. Instead, we need to exploit the collective knowledge and wisdom of all stakeholders in pest management to innovate more holistic approaches¹⁰.

Crop production includes a large variety of stakeholders including farmers, consultants, agriculture businesses, bankers, input supply chains, processors and buyers, government agencies, and university educators. Each of these stakeholders often look at their priorities as stand-alone protocols and often do not realize or cannot address the interconnectivity of practices in overall production. As a grower considers recommendations of each group, conflicting choices often emerge and difficult decisions have to be made. One example that often is cited is the use of tillage in weed management. The ongoing pressure to increase conservation practices that benefit soil health such as reduced tillage, cover crops, and other management changes often include economic incentives through USDA and other public programs; this may effectively remove tillage from consideration for weed control unless there is no other option left¹⁰. Once early choices are made in any production system, the “unwinding” of the consequences of those decisions are often difficult if not impossible. The agronomic, social and economic damage done by allowing resistance to develop is not any different. Allowing a resistant pest to be ingrained into a production system will make them more difficult to manage.

We assert that a paradigm of voluntary cooperation among stakeholder groups has the best chance to tailor diverse chemical and non-chemical RM practices that fit local socio-ecological conditions. Notable pest eradication programs (e.g. boll weevil) provide lessons for designing and executing successful cooperative approaches^{11,12}. However, adapting these lessons

will require consideration of similarities and differences in end goals for RM compared to eradication programs, time, experimentation, new resources and, above all, a spirit of listening first followed by negotiation and collective, adaptive action¹³. It is amazing how willing we are to openly discuss and defend our position in a community of stakeholders, yet how difficult it is to truly listen to all perspectives and make accommodations in our individual goals to reach common ground and move forward together. Therein lies the challenge – creating new habits of openness, trust, cooperation, co-learning, and implementation.

In an attempt to address the roles of each stakeholder in production, Coble and Schroeder (2016)¹⁴ summarized a call to action from the second Herbicide Resistance Summit that was hosted by the National Academies of Science. They called for specific actions from every stakeholder group. But, those groups must not only understand the perspectives of the other, they also must work in tandem. If not, little or no progress can be made in slowing resistance evolution. In fact, remaining locked into our individual or group paradigm that does not consider the complexities of pest biology, corporate profitability requirements, and farm management is what has led to the dramatic increase in resistance to pesticides. ***Each relevant stakeholder group can be successful in contributing to solutions only if the first goal of every group is to work at listening to the perspectives of each other and incorporating those understandings into the scope and reach of their influence and actions moving forward.***

Our perspective is that we need to expand and accelerate transdisciplinary research and action studies of the complex dynamics of voluntary collaboration programs for pesticide resistance. Moving forward as a community will require a knowledge of hurdles holding us back, and

Accepted Article

establishing trust between stakeholders so that each can take appropriate actions to achieve community goals. Failing that crucial effort will almost certainly guarantee the continued rise in resistance and a shorter useful life for many pesticides that are economical, effective and safe for humans and the environment if used properly. Ostrom¹⁵⁻¹⁷ in her Nobel prize speech pinpointed the root cause of societies over-drafting common pool resources (CPR) – the central role of trust in coping with social dilemmas. CPR are resource systems that are depletable with use and for which access to the resource is difficult and costly to regulate. Ocean fishing grounds and large underground aquifers are common examples. In essence, users do not take into account the cost of depleting the resource on other potential users. The susceptibility of weeds to certain herbicides can be a depletable CPR if resistant weeds migrate across farm boundaries¹⁸. Recent science indicates that weed mobility can occur for natural and human reasons. Without private cooperation (as Ostrom documented) or public regulation, the susceptibility of weeds to certain herbicides in CPR situations will be diminished.

We contend that the combination of private and public efforts will be superior to relying only on private or public approaches, as both contain important stakeholders in turning the tide on pest resistance.

Building on the call to action from the Herbicide Resistance Summit¹⁴ and subsequent work, the authors were participants in a successful community building workshop on resistance in Iowa attended by a diverse group of stakeholders¹⁹. The workshop focused on establishing shared values, developing trust, and identifying key commonalities among the participants regarding pest resistance. Representatives from EPA and other local, state and federal agencies joined

farmers and representatives from industry, agricultural retailers, commodity groups, NGOs, and academia in this two-day workshop. Attendees identified three elements that made the experience successful 1) inclusion of a diversity of stakeholders, 2) networking opportunities that provided an opportunity to build relationships and trust, and 3) the group included community leaders and discussions were led by expert facilitators. This workshop experience helped build the foundation for EPA to take the next steps to reconsider their key role in resistance management.

A recent U.S. Environmental Protection Agency Pesticide Program Dialogue Committee (EPA PPDC)²⁰ exercise that engaged diverse stakeholders in exploring new RM policies and actions exemplifies such change. The thematic findings from that exercise are presented below. We applaud EPA for conducting this first step to help move us along a path to a new paradigm for RM.

The EPA Role in Pesticide Resistance Management

EPA is an important stakeholder in resistance management. Their actions affirm the importance of resistance management by using regulatory tools to address resistance²¹, including two important Pesticide Registration Notices (PRN)^{22,23}. These PRNs directly address pesticide labeling, education, training, and stewardship. In particular, PRN 2017-2 focuses on general labeling, education, training and stewardship strategies for addressing herbicide resistance and the guidelines presented are based on the 2012 review paper that discussed best management practices for reducing the risks of herbicide resistance²⁴.

The primary Federal Advisory Committee Act (FACA)²⁵ advisory committee for the EPA is the Pesticide Program Dialogue Committee²⁶. The FACA “governs the operation of federal advisory committees and emphasizes public involvement through open meetings and reporting.”²⁵ The PDDC “is a forum for a diverse group of stakeholders to provide feedback to EPA on various pesticide regulatory, policy, and program implementation issues.”²⁶ Two of the authors are appointed members of the PDDC (Amy and David) and led a proposal to create a working group that could develop recommendations to EPA on pesticide resistance. The working group was comprised of individuals representing a wide variety of stakeholders, including the other two co-authors, chosen to provide the diverse perspectives and wisdom of EPA stakeholders (see the acknowledgment section for working group members and the organizations they represented). The PDDC defined four primary questions to be addressed:

1. *Are there current EPA policies that positively or negatively affect conventional pesticide resistance management? What policies could be re-worked to more positively address resistance management?*
2. *Are there current industry programs that positively or negatively affect conventional pesticide resistance management? Would EPA have a role in those programs, and what might that be to positively influence industry?*
3. *Are there incentives (for registrants or pesticide users) that could be considered related to conventional pesticide regulation that might positively affect resistance management? Are*

there other ways in which the agency can work with stakeholders (e.g., growers, commodity groups, academics) to cooperatively address resistance management?

- 4. Are there elements from EPA's Bt PIP resistance management program that could be used in conventional pesticide resistance management?*

Recommendations from the PPDC Resistance Management Working Group are listed below.

Rationales for each are given in the complete report²⁰:

- 1. EPA should explore changes in pesticide labels to make them more uniform across manufacturers. Labels need to contain clear and concise language so all needed information to implement resistance management is easily found and understood by end users such as crop consultants, pesticide decision makers, and commercial and private pesticide applicators.*
- 2. EPA should conduct a thorough review of EPA policies and regulations that impact resistance management, and remove contradictions and situations that hinder effective resistance management to the maximum extent possible.*
- 3. EPA should expand collaboration and outreach efforts with other federal agencies and convene panels of relevant stakeholders to address specific priority issues and questions associated with resistance and resistance management.*

4. *EPA should explore how it can encourage proactive pesticide resistance management and prevention programs in cooperation with industries and universities through cooperative agreements, updated training materials, and grant programs.*
5. *EPA should explore the creation of incentive programs for assistance in overcoming the hurdles associated with resistance management, in particular incentives to researchers, users and suppliers for accurate early detection and timely adoption of regionally specific resistance management actions.*

Conclusions -- Moving Forward

Changing the paradigm of pest resistance management from stakeholders acting on their own to one of collaboration in sharing knowledge and experience is an imposing challenge. Yet, staying the present course of uncoordinated and often conflicting actions promises to continue the trend of increasing pest resistance in the U.S. and abroad⁷. Private and public costs will continue to rise and impinge on efficiency and competitiveness. Sound theory and evidence from commons resource management suggest an alternative path of multi-stakeholder collaboration can innovate more sustainable resistance management. Excellent examples of this can be found in the pink bollworm and boll weevil management programs^{11,12}. The major task in realizing this fundamental shift is securing and sustaining full stakeholder participation. A supportive task is securing funding for social scientists to work with natural scientists and practitioners to better understand how such collaborative action can move the needle on resistance management.

EPA is to be commended for taking a leadership role in this transition. It is important to understand that the recommendations we developed in the PPDC working group were focused on what the EPA could affect or influence; thus these recommendations are only one part of resistance management as a whole and are specific to EPA's sphere of influence. EPA's action to open themselves up to a public evaluation of their role and embracing the responsibility of follow up that comes with accepting recommendations provides an example for other stakeholder groups to follow. EPA has committed to providing updates on how they are addressing these recommendations at each of the upcoming PPDC semi-annual meetings. These minutes are public record, so they in essence also committed to keeping other key stakeholders updated as to their RM actions. Achieving reciprocal openness by other pest management stakeholders will help establish mutual trust, a crucial requirement for an effective collaboration.

The recommendations in the PPDC workgroup report to the EPA did not come easily – very diverse and often opposing perspectives repeatedly came forward. This effort certainly tested our collective ability to listen and learn from others. Each group represented had goals for their representation and priorities in pest management. Many of these viewpoints are articulated in the appendices of the workgroup report to the PPDC and EPA²⁰. For example, one of the most hotly discussed topics was early detection and rapid response to suspected resistance. On one hand, everyone acknowledged the need for this. However, many concerns were expressed on how to avoid an overwhelming number of false positives and inappropriate actions when pest management failures are not the result of resistance presence. There were also active discussions on who must bear the costs of change, roles and responsibilities of the various stakeholders, and unintended consequences arising from any action. In the end, however, the report was

unanimously supported by the working group, and the PPDC unanimously endorsed the report. Now it's important to engage EPA's administrative leaders in actualizing the changes needed to enhance pest management programs across all natural and social ecosystems.

How can pest management scientists and practitioners build off of the EPA PPDC exercise to enlarge the domain of collaboration in addressing resistance? A meta analysis of 137 cases of collaborative governance across a range of policy situations identifies several critical variables that influence whether consensus-oriented decision making process can be successful: (1) prior history of conflict or cooperation in the community; (2) incentives for stakeholders to participate; (3) power and resources imbalances; (4) leadership; (5) institutional design; (6) face-to-face dialogue; (7) trust building, and; (8) small "wins" that develop trust, commitment and shared understanding²⁷. The EPA PPDC exercise and our collaboration experiences support the importance of considering each variable in building successful pest resistance management.

Our experiences in this journey also included self-discovery of the personal perspectives we each have around RM. We have learned that none of us as representatives of an individual group can solve the problem of resistance alone nor can we tell others what they should or should not do to address resistance. We have learned we must truly learn to listen and talk to as well as build trust with all stakeholders regardless of their perspectives. We can and must serve to open doors for other stakeholders to do the same type of self-discovery and evaluation of their perspectives and how to work within a collaborative community to address their part of resistance management. A key ingredient for success is establishing full cross communication between all stakeholder groups. Open and effective communication is essential to address any potential for inconsistent

messaging surrounding the effectiveness of tools to manage resistance and to reduce redundancies or working at cross purposes.

It is impossible for any group, such as ours, to independently create a general plan for pest resistance management. Managing resistance is in the hands of the individuals who practice (make decisions for and apply) pest management measures. Those individuals customize, even within their own areas of practice, diverse pest management plans within various management zones. However, we know that individual decisions made with the best of intentions but without collaborative knowledge sharing have led to increasing pest resistance. To alter that trajectory, groups like ours can and should provide tools (e.g. education, training in diverse group facilitation, synthetic or natural chemistries, cultural practices, IPM tools and opportunities) to those individuals as well as coordinate the actions of each individual to the benefit of a large area (local, regional, national) or the environment. Key to all of this is to listen regularly and intently to those who must interpret and apply pest management tools to address pest problems in the field. Developing tools without understanding the constraints that pest management practitioners work under and integrating them into the collective knowledge base contributes to the lack of success in addressing resistance.

Acknowledgments

We appreciate and acknowledge the hard work and contributions to the PPDC report from the following: Jim Adaskaveg, University of California – Riverside; Chandra Aradhya, Bayer; Cameron Douglass, USDA/Office of Pesticide Management Programs; Jim Kerns, North Carolina State University; Kenny Seebold, Valent USA; Caydee Savinelli, Syngenta; Billy

Crow, University of Florida; Jim Fredericks, National Pest Management Association; George Frisvold, University of Arizona; Tim Lust, National Sorghum Producers; Janet McAllister, CDC - Division of Vector-Borne Diseases; Matthew Houser, Indiana University; Craig Kleppe, BASF; Dominic LaJoie, National Potato Council; Lauren Lurkins, Illinois Farm Bureau; Houston Wilson, Kearney Agr. Res. Ext. Center; Larry Dallas, Independent Grower; Katie Dentzman, Iowa State University; Steve Eskelsen, ADAMA; Patti Prasifka, Corteva; Gary Prescher, National Corn Growers Association. In addition, a number of individuals from a variety of stakeholders provided comments to the draft report.

Conflict of Interest

The authors claim no conflict of interest.

References

1. Rittel H, and Webber M, Dilemmas in a general theory of planning. *Policy Sci* **5**:155–169 (1973).
2. Ervin, DE and Jussaume, RA Jr., Herbicide resistance: Integrating social science into understanding and managing weed resistance and associated environmental impacts. *Weed Science* **62(2)**: 403-414 (2014).
3. Shaw, DR, The “wicked” nature of the herbicide resistance problem. *Weed Science* **64(Special Issue)**:552–558 (2016).
4. Jussaume RA Jr., and Ervin DE, Understanding weed resistance as a wicked problem to improve weed management decisions. *Weed Science* **64(Special Issue)**: 559-569 (2016).
5. Ervin DE, and Frisvold GB, Community-based approaches to herbicide-resistant weed

management: lessons from science and practice. *Weed Science* **64(Special Issue)**: 609-626 (2016).

6. Gould, F, Brown, ZS, and Kuzma, J, Wicked evolution: Can we address the sociobiological dilemma of pesticide resistance? *Science* **360(6390)**:728-732 (2018).
7. Heap, I, International Herbicide Resistant-Weed Database.
<https://www.weedscience.org/Pages/ChronologicalIncrease.aspx>. Accessed June 1, 2023.
8. McCauley, C, Legleiter, T, Herman, R, Rasoulpour, R, Schroeder, J, Pilcher, T, . . . Wright, T, Sustainable weed management – What is it and how are we doing? *Weed Technology* **36(6)**:768-776. doi:10.1017/wet.2022.103 (2022).
9. Dentzman, K, Gunderson R, and Jussaume R, Techno-optimism as a barrier to overcoming herbicide resistance: Comparing farmer perceptions of the future potential of herbicides. *Journal of Rural Studies* **48**: 22–32 (2016).
10. Shaw, D, Ervin D, Frisvold G, Jussaume R, and Sword G, Stewardship challenges for new pest management technologies in agriculture. Commentary. *Council for Agricultural Science and Technology (CAST)*, Ames, Iowa (2020).
11. Haney, PB, Lewis WJ, and Lambert WR, Cotton production and the boll weevil in Georgia: History, cost of control, and benefits of eradication. *Georgia Agriculture Experiment Stations Research Bulletin* No. 428. Athens, GA: University of Georgia (2009).
12. Walters, ML, Sequeira R , Staten R, El-Lissy O, Moses-Gonzales N, Radcliffe E, Hutchison W, and Cancelado R, Eradication: Strategies and tactics. in *Integrated Pest Management*, eds. E. B. Radcliffe, W. D. Hutchison, and R. E. Cancelado, 298–308. Cambridge: Cambridge University Press (2009).

13. Schroeder, J, Barrett, M, Shaw, DR, Asmus, AB, Coble, H, Ervin, D, ... and Van Gessel, MJ, Managing herbicide resistance: Listening to the perspectives of practitioners. Procedures for conducting listening sessions and an evaluation of the process. *Weed Technology* **32(4)**:489-497(2018).
14. Coble HD and Schroeder J, A call to action on herbicide resistance. *Weed Science (Special Edition)* **64**:661-666 (2016).
15. Ostrom, E, A general framework for analyzing the sustainability of socio-ecological systems. *Science* **325**:419-422 (2009).
16. Ostrom, E, Beyond markets and states: Polycentric governance of complex economic systems. *American Economic Review* **100**, 641-672 (2010).
17. E. Ostrom, Background on the institutional analysis and development framework. *Policy Stud. J.* **39**, 7–27 (2011). 10.1111/j.1541-0072.2010.00394.x
18. Ervin, D, Breshears E, Frisvold G, Hurley T, Dentzman K, Gunsolus J, Jussaume R, Owen M, Norsworthy J, Al Mamun M, and Everman W, Farmer attitudes toward cooperative approaches to herbicide resistance management: A common pool ecosystem service challenge. *Ecological Economics* **157**: 237-245. <https://doi.org/10.1016/j.ecolecon.2018.11.023> (2019).
19. Dentzman K, Pilcher C, Bagavathiannan M, Barrett M, and Burke I, Lessons in building community capacity for managing agricultural pests: A science policy experience in Iowa. *Outlooks on Pest Management* **31(6)**:249-256 (2020).
20. Shaw D (editor), Report from the Resistance Management Work Group Pesticide Program Dialogue Committee, A. Reynolds, D. Shaw, B. Chism, co-chairs.

- <https://www.epa.gov/system/files/documents/2021-10/resistance-management-workgroup-report-and-recommendations-for-ppdc-review.pdf> (2021).
21. (EPA) Environmental Protection Agency, <https://www.epa.gov/pesticide-registration/slowing-and-combating-pest-resistance-pesticides>, accessed February 12, 2023.
22. (EPA) Environmental Protection Agency, <https://www.epa.gov/pesticide-registration/pm-2017-1-guidance-pesticide-registrants-pesticide-resistance-management> Accessed February 12, 2023.
23. (EPA) Environmental Protection Agency, <https://www.epa.gov/pesticide-registration/pm-2017-2-guidance-herbicide-resistance-management-labeling-education>, accessed February 12, 2023.
24. Norsworthy J, Ward S, Shaw D, Llewellyn R, Nichols R, Webster, T, . . . and Barrett M, Reducing the risks of herbicide resistance: Best management practices and recommendations. *Weed Science 60(Special Issue):31-62*. doi:10.1614/WS-D-11-00155.1 (2012).
25. (EPA) Environmental Protection Agency *Summary of the Federal Advisory Committee Act 5 U.S.C. 10*. <https://www.epa.gov/laws-regulations/summary-federal-advisory-committee-act>. Accessed 05/12/2023
26. (EPA) Environmental Protection Agency. Pesticide Program Dialogue Committee. <https://www.epa.gov/pesticide-advisory-committees-and-regulatory-partners/pesticide-program-dialogue-committee-ppdc#about>, Accessed June 4, 2023.

27. Ansell C and Gash A, Collaborative governance in theory and practice, *Journal of Public Administration Research and Theory*, **18**:543–571, <https://doi.org/10.1093/jopart/mum032> (2008).

Collaborative action on the part of all stakeholders in pest management is essential to effectively address the challenges of pesticide resistance. The US Environmental Protection Agency, through its Pesticide Program Dialogue Committee, recently posted a report on pesticide resistance management and the role the Agency can play in these efforts; we commend the Agency for acknowledging these needs, and encourage implementation of the recommendations.



Palmer Amaranth.jpg