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Introduction

Pest resistance to chemical, genetic, and agronomic management practices is a widespread and increasing problem in Iowa. Evolution of pest resistance to current management technologies is occurring at a faster rate than new technologies are being developed. Though many resistance management practices (RMPs) are well described and validated, their adoption has been slow. This project aims to bridge the gap between knowledge and adoption by engaging all sectors of Iowa agriculture utilizing a community-based approach, a tactical imperative when dealing with mobile pests that cross field boundaries. By increasing adoption of RMPs, valuable pest management tools will be preserved and long-term farm profitability will be protected.

Background

In January 2015, a meeting led by the Iowa Department of Agriculture and Land Stewardship (IDALS) and Iowa State University (ISU) College of Agriculture and Life Sciences (CALS) led to the call for the development of a statewide, voluntary pest resistance management plan, which would be coordinated by IDALS and involve participation from all sectors of Iowa agriculture. A framework for a plan was developed by a taskforce made up of representatives from Agribusiness Association of Iowa (AAI), Agricultural Biotechnology Stewardship Technical Committee (ABSTC), Iowa Corn Growers Association (ICGA), Iowa Soybean Association (ISA), the Iowa Chapter of the American Society of Farm Managers and Rural Appraisers (ASFMRA), Iowa Farm Bureau Federation (IFBF), Iowa Independent Crop Consultants Association, Iowa Institute for Cooperatives (IIC), Pesticide Resistance Action Committees (RACs), Practical Farmers of Iowa (PFI), and the Soil and Water Conservation Society. This framework (https://www.ipm.iastate.edu/files/iprmp/resistance-management-conceptual-framework.pdf), approved in December 2015, provided a structure for Version 1.0 of the Iowa Pest Resistance Management Plan (IPRMP). The first version of the IPRMP (https://www.ipm.iastate.edu/files/iprmp/iprmp.pdf) contains chapters regarding governance, state of the science, communication and outreach, and pilot projects, and was approved in December 2016.

Overview of the IPRMP

The Iowa Pest Resistance Management Plan is a statewide effort to slow the development of pest resistance, to foster methods of early resistance detection, and to mitigate resistance when it arises. The IPRMP involves broad participation from all sectors of Iowa agriculture to promote voluntary adoption of RMPs. Through successful implementation of voluntary efforts, we hope to minimize the need for additional regulatory intervention. In order to maximize adoption of RMPs, the IPRMP needs to be based on the most current, up-to-date science while also acknowledging the socio-economic realities farmers are facing. By engaging communities and including all sectors of agriculture, cohesion and consistency can be improved, maximizing the likelihood for success. While there are similarities in the general principles of resistance management for weeds, insects, and pathogens, each pest complex possesses unique challenges. Differences between pests in biology, mobility, current resistance profile, and diversity of available management tactics all have to be taken into consideration. For mobile pests with the ability to cross field borders, cooperation between neighboring farmers will be needed to manage resistance effectively.

Communication and outreach

Communication and outreach is key to this project's success. Clear, consistent messaging from all stakeholders is crucial to raising awareness and increasing understanding of pest resistance and the factors that contribute to its development. Certified Crop Advisers (CCAs), independent crop consultants (ICCs), agriculture retailers and other agronomic and farm advisers are key collaborators in this effort. Partnering organizations, including commodity groups and coops, will utilize existing partnerships and networks to reach out to farmers and landowners about adopting resistance management practices on their farms. Knowledge will be disseminated through press releases, blog posts, field days, and local-community events. The IPRMP website, www.ProtectIowaCrops.org, serves as a central hub for news, progress, information, announcements, and other relevant resources.

Pilot projects

Community-based projects are being implemented across the state of Iowa, each focused on an insect or weed resistance issue. Through discussions with a broad cross-section of stakeholders, a refined understanding of local perceptions, level of awareness, and current management practices is being gathered. As we identify barriers to implementation of recommended practices, solutions to overcoming these barriers can be developed. Barriers may include gaps in knowledge, time constraints, lack of necessary equipment, unavailability of necessary tools, and economic constraints, either real or perceived.

Four projects are being developed—two address insect pests and two address weed issues. One project targets western corn rootworm resistance to Bt (Bacillus thuringiensis) traits in corn and takes place in north central and northeastern Iowa. A second project focuses on soybean aphid resistance to pyrethroids and will take place in northwest Iowa. The third project concerns herbicide-resistant waterhemp in central Iowa. The fourth project is focused on Palmer amaranth and other resistant weeds and is taking place in Harrison County in southwest Iowa.

For each pilot project, we are assembling teams with representation from all sectors of agriculture, including farmers, crop advisers, commodity groups, agricultural retailers, seed dealers, lenders, university research and extension, and representatives from seed and chemical companies. Identifying and engaging key influencers is crucial in order to maximize visibility and credibility within communities. In addition to creating new connections within communities, tapping into existing networks is instrumental. Project plans are being developed from the "ground-up," with extensive input and guidance from farmers and other local stakeholders. A broad cross-section of stakeholders is vital as each brings unique viewpoints and valuable insights into barriers to adoption of RMPs and potential solutions.

Insect resistance

Western corn rootworm (WCR, *Diabrotica virgifera virgifera* Leconte) is a serious insect pest of corn in the North Central United States. Western corn rootworm has been managed using conventional insecticides and rotation to non-host crops. In 2003, corn hybrids genetically modified to produce toxins derived from the soil bacterium Bacillus thuringiensis were commercialized and rapidly adopted in subsequent years. In 2009, severe feeding injury by western corn rootworm was observed in fields planted to single trait Cry3Bb1 corn in Iowa; subsequent laboratory analyses confirmed the presence of Bt resistance (Gassmann et al., 2011). Since then, cross-resistance between three of four Bt toxins targeting underground pests (Cry3Bb1, mCry3A, and eCry3.1Ab) has been observed (Gassmann et al., 2014). Practices that favor the development of Bt-resistance include a history of continuous corn, repeated use of the same Bt-trait, and high western corn rootworm pressure. If a WCR population in a field develops Bt-resistance, the resistant population can then spread to neighboring fields through the movement of resistant adult rootworms.

Northeast Iowa was chosen as the location for the WCR pilot project as continuous corn production is common, which contributes to high WCR populations and higher risk for Bt-resistance development.

In addition, there is an active Iowa Corn Growers Association membership, which helps facilitate community building and outreach. We are currently working with local stakeholders to ascertain current local management practices that may affect the development of Bt-resistance in WCR. Such practices include crop rotation, use of transgenic Bt-corn, rotation between Bt-traits, use of hybrids with pyramided traits, use of soil-applied insecticides, and extent of field scouting. As we continue to gather information regarding current management practices, barriers to adoption of RMPs can be identified. Reasons for differences between current and recommended management practices include misunderstanding of practices that lead to the development of resistance, a lack of necessary equipment to diversify management practices, socio-economic factors, and an overly optimistic view of the timeline for when new pest management technologies will become available.

Soybean aphid, first detected in the United States in 2000, is the most important insect pest of soybeans in the North Central United States. Soybean aphid feeding can reduce photosynthetic rate, plant growth, pod number, seed number, seed weight, and seed oil concentration (Beckendorf et al. 2008; Macedo et al. 2003; Ragsdale et al. 2011). Foliar insecticides, including pyrethroids and organophosphates, are used to manage soybean aphid infestations. Failures of pyrethroid applications to control soybean aphid have been reported in Minnesota since 2015 (Hanson et al. 2017). In 2016, a pyrethroid failure was documented in a field in northwest Iowa (E. Hodgson, unpublished data). Resistance to pyrethroids would restrict tools available to manage soybean aphid and could increase input costs.

The second pilot project addresses soybean aphid resistance to pyrethroids, and will take place in northwest Iowa. As pyrethroid resistance in soybean aphid is an emerging threat, this project is focused on educating farmers about the risk of pyrethroid resistance and adopting practices that limit the development and spread of insecticide resistant aphid populations. Recommendations are available that will effectively manage soybean aphid while reducing the likelihood of insecticide resistance developing (Hodgson et al., 2012). As populations fluctuate year-to-year and location-to-location, regular scouting is recommended and economically sound. Foliar insecticide applications can then be made based on populations reaching the economic threshold of 250 aphids per plant on 80% of plants with populations increasing. If multiple applications are required in a single season, rotating insecticide modes of action will reduce selection pressure of any single insecticide.

Weed resistance

Globally, there are at least 485 unique cases (species x site of action) of herbicide resistance in 252 weed species. In Iowa, populations of at least 10 weed species have been documented with herbicide resistance, some with resistance to multiple herbicide groups (Heap, 2017). In Iowa, the most common herbicide-resistant weeds are waterhemp, marestail, and giant ragweed (Owen, 2016). Waterhemp populations exhibiting multiple herbicide resistance are increasing (Owen, 2016), and populations with resistance to five herbicide groups have been documented (Owen et al., 2015). In addition to widespread resistance to group 2 (ALS inhibitors), group 5 (triazines), and group 9 (EPSP synthase inhibitors, i.e. glyphosate), resistance to group 14 (PPO inhibitors) and group 27 (HPPD inhibitors) is increasing and of considerable concern. Populations of marestail and giant ragweed resistant to group 2 and/or group 9 herbicides can be found in Iowa and neighboring states and further complicate management efforts (Heap, 2017; Owen, 2015).

Weed management has been dominated by herbicides for many years. However, as there has not been a new herbicide site of action commercialized in 30 years, proper stewardship of currently available herbicides in the face of increased herbicide resistance is vitally important. In addition to utilizing herbicides with multiple effective sites of action, it is important to diversify weed management to include strategies beyond the use of herbicides. Norsworthy et al. (2012) recommended 12 best management practices (BMPs) for herbicide resistance management, including ”Use a diversified approach toward weed management focused on preventing weed seed production and reducing the number of weed seed in the

soil seedbank," "Use multiple herbicide mechanisms of action (MOAs) that are effective against the most troublesome weeds or those most prone to herbicide resistance," and "Use mechanical and biological management practices where appropriate". Growers have adopted some of the recommended BMPs to varying degrees; unfortunately, adoption of many of these practices remains poor. From an optimistic viewpoint, this leaves many opportunities for improvement.

The third pilot project addresses herbicide-resistance in waterhemp in central Iowa. Herbicide resistant waterhemp is common and widespread in central Iowa. Stakeholders with significant presence in the region include major seed companies, Iowa State University, farm management companies, several coops, and commodity groups.

The first documented infestation of Palmer amaranth in Iowa occurred in 2013 in a field in Harrison County. Since then, Palmer has been found in conservation plantings and agricultural fields in at least 50 of Iowa's 99 counties (Hartzler, 2017). Palmer amaranth is aggressive and competitive, and poses a significant threat to Iowa agriculture. Palmer amaranth has exhibited a propensity to develop herbicide resistance, with populations in the United States resistant to herbicide groups 2, 5, 9, 14, and 27 (Heap, 2017).

A Harrison County pilot project is focused on Palmer amaranth and other problematic herbicide-resistant weed species. Slowing the spread of Palmer amaranth in Iowa is a high priority, and this corner of the state contains the longest established infestations of Palmer amaranth in the state. The Harrison County project is led by a dedicated farmer who provided leadership in the noxious weed effort and the 2016 educational forum.

Summary

Pest resistance poses a serious threat to Iowa agriculture. We are at a crucial point in the resistance timeline for many weed and insect resistance issues. Despite strong evidence for adopting RMPs, adoption of many such practices has been stubbornly low. The importance of integrating social and economic sciences into resistance management efforts has been suggested by other authors (e.g. Ervin and Jussaume, 2014). This project aims to understand the barriers to grower adoption of such practices and develop strategies and incentives to overcome them. By increasing adoption of resistance management practices, we hope to slow the development of resistance, protect management technologies, and preserve long-term farm profitability.

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References

Beckendorf, E. A., Catangui, M. A., and W. E. Riedell. 2008. Soybean aphid feeding injury and soybean yield, yield components, and seed composition. Agron J 100: 237–246.

Ervin, D., and R. Jussaume. 2014. Integrating social science into managing herbicide-resistant weeds and associated environmental impacts. Weed Sci 62: 1-12.

Gassmann, A. J. 2011. Field-evolved resistance to Bt mazie by western corn rootworm. PloS One 6(7): 1-7.

Gassmann, A. J., Petzold-Maxwell, J. L., Clifton, E. H., Dunbar, M. W., Hoffmann, A. M., Ingber, D. A., and R. S. Keweshan. 2014. Field-evolved resistance by western corn rootworm to multiple *Bacillus thuringiensis* toxins in transgenic maize. PNAS: 111(14): 5141-5146.

Hanson, A. A., Menger-Anderson, J., Silverstein, C., Potter, J. D., MacRae, I. V., Hodgson, E. W., and R. L. Koch. 2017. Evidence for soybean aphid (Hemiptera: Aphidae) resistance to pyrethroid insecticides in the upper Midwestern United States. J Econ Entomol 110(5): 2235-2246.

Hartzler, R. 2017. Add Osceola County to the map – Increased vigilance needed. ICM News. Iowa State University Extension and Outreach. August 16, 2017. https://crops.extension.iastate.edu/cropnews/2017/08/add-osceola-county-map-%E2%80%93-increased-vigilance-needed

Heap, I. 2017. The international Survey of Herbicide Resistant Weeds. [Online]. Available: www.weedscience.com. Accessed: October 25, 2017.

Hodgson, E. W., McCornack, B. P., Tilmon, K., and J. J. Knodel. 2012. Management recommendations for soybean aphid (Hempitera: Aphididae) in the United States. J Int Pest Man 3(1): 1-10.

Macedo, T. B., Bastos, C. S., Higley, L. G., Ostlie, K. R., and S. Madhavan. 2003. Photosynthetic responses of soybean to soybean aphid (Homoptera: Aphididae) injury. 2003. J. Econ. Entomol 96: 188-193.

Owen, M. D. K., Beckie, H. J., Leeson, J. Y., Norsworthy, J. K., and L. E. Steckel. 2015. Integrated pest management and weed management in the United States and Canada. Pest Man Sci 71: 357-376.

Owen, M. D. K. 2016. Weed management for 2017 and beyond. Pages 85-92 in Proceedings of the 2016 Integrated Crop Management Conference. Ames, IA: Iowa State University.

Norsworthy, J. K., Ward , S. M., Shaw , D. R., Llewellyn, R., Nichols, R. L., Webster, T. M., Bradley, K.W., Frisvold, G., Powles, S. B., Burgos, N. R., Witt, W., and M. Barrett. 2012. Reducing the risks of herbicide resistance: best management practices and recommendations. Weed Sci 60: 31–62.

Ragsdale, D. W., Landis, D. A., Brodeur, J., Heimpel, G. E., and N. Desneux. 2011. Ecology and management of the soybean aphid in North America. Annu Rev of Entomol 56: 375-399.

Resources

- www.protectiowacrops.org
- https://www.ipm.iastate.edu/files/iprmp/iprmp.pdf
- https://www.ipm.iastate.edu/files/iprmp/resistance-management-conceptual-framework.pdf