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Micheal D. K. Owen

Iowa State University, mdowen@iastate.edu

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Weed management for 2017 and beyond
Micheal D.K. Owen, University Professor, associate chair, and Extension weed specialist, Agronomy, Iowa State University

Introduction
It has been approximately 30 years since the last new herbicide mechanism of action (MOA) was introduced and it is unlikely that a new MOA will be introduced in the near future. Furthermore, weed management issues continue to escalate, particularly the increasing number of herbicide-resistant weed populations and the increasing population densities in fields with herbicide-resistant weeds. For example, in Iowa, multiple resistance in waterhemp is the norm rather than the exception and the rate of spread is accelerating. The recent wide spread introduction of Palmer amaranth in Iowa further contributes to future weed problems. Regardless, farmers in Iowa remain “techno-optimistic” that new herbicide solutions to the weed management problems will be soon introduced (Dentzman et al. 2016). This “techno-optimism” is contrasted by the “techno-skepticism” of farmers in the south. Interestingly, Iowa farmers also express concerns that new resistances in weeds are inevitable with the anticipated new herbicides but that the future new herbicides are essentially the only option for effective weed control. A number of current and future issues will be considered and perspectives provided in this paper.

Industry update

**BASF** – Engenia herbicide (HG4) is a new N,N-Bis(3-aminopropyl)methylamine [BAPMA] salt of dicamba that significantly reduces volatility of the active ingredient dicamba when compared to other currently available formulations. Engenia treatments will not require additional additives to further reduce the potential for volatilization. Engenia is a 5 lb ai/gal formulation. It will be registered for over-the-top applications on dicamba-resistant soybean as well as preplant treatments without planting restrictions, but registration by the EPA is still pending.

Zidua Pro contains pyroxasulfone (HG15), imazethapyr (HG2), and saflufenacil (HG14). It is labeled for burndown and preemergence uses in soybean at rates of 4.5 to 6.0 fl oz/A. Optimum burndown of emerged weeds requires the use of MSO and a nitrogen source. No planting interval restriction is listed for Zidua Pro except when applications are made on coarse textured soils with < 2% organic matter where a 30 day interval between application and planting is required.

Preemergence applications were added to the Armezon Pro (HG27 and HG15) label for corn.

The Zidua (HR15) postemergence application window in soybean has been expanded to allow treatment from emergence to 3rd trifoliate stage.

**Bayer CropScience** – DiFlexx Duo was registered for field, white, seed and popcorn last spring. It is a combination of tembotrione (HG27), dicamba (HG4), and the safener cyprosulfamide. DiFlexx Duo is registered for preemergence and postemergence (up to V10 corn stage) applications. Use rates range from 24 to 40 oz/A. Adjuvants that are needed for POST DiFlexx Duo applications include HSOC, COC or MSO and a nitrogen source.

Balance GT soybean launch date is targeted for 2017 pending Japan and China approval of the trait.

**Dow AgroSciences** – Resicore was approved in 2016 for application in field corn, seed corn, silage corn and yellow popcorn for preemergence application and contains acetochlor (HG15), mesotrione (HG27), and clopyralid (HG4). Resicore may be applied postemergence to field corn, seed corn and silage corn but not yellow popcorn. Postemergence applications must be made before the corn is 11 inches in height.
Enlist Duo (HG4 and 9) is registered and available for non-Enlist corn and soybean as preplant burndown and preemergence (corn) and preplant burndown (soybeans) but not available for postemergence use until the Enlist crops are approved by China. No adjuvants are described on the Enlist Duo label. It is anticipated that China may approve of the Enlist crops in 2017. Enlist Duo has less potential for volatilization than other HG4 formulations but care should be taken regardless to avoid conditions that may cause off-target movement of the herbicide. The Enlist Duo label describes appropriate nozzles for application, buffer requirements and specific application techniques. Herbicide-resistant weed management requirements are also included in the Enlist Duo label.

**DuPont** – Realm Q (HG2 and 27) is now registered for aerial application, and dicamba (HG 4) has been added as a tank mix partner. Aerial application of HG27 and HG4 herbicides represents a potentially serious risk for off-target herbicide movement.

Afforia can be applied either preplant or preemergence to any soybean at 2.5 oz/A. Preemergence applications must be made within 3 days after planting and prior to emergence. When used with BOLT soybean varieties, the Afforia rate can be increased to 2.5 to 3.75 oz/A for either preplant or preemergence applications. The BOLT technology provides enhanced tolerance to sulfonylurea herbicides (HG2).

**Monsanto** - Soybean cultivars with dicamba (HG4) resistance are globally deregulated and recently the herbicide developed for the crop, XtendiMax with VaporGrip technology (dicamba, HG4) was registered by the EPA.

**Nufarm** – Cheetah contains glufosinate ammonium (HG10) and is registered for non-selective postemergence application in corn and soybean with the LibertyLink trait.

Panther SC is 4 lb ai/gal formulation of flumioxazin (HG14) and is registered for preplant burndown application in corn 3 to 30 days prior to planting. Panther SC can be applied prior to soybean planting or preemergence within 3 days after planting and prior to soybean emergence.

Scorch is a premixture of dicamba, 2,4-D and fluroxypyr, all HG4 herbicides that can be applied preplant, preemergence and postemergence in field corn. Fluroxypyr improves activity on kochia. Postemergence applications of Scorch can be applied broadcast to V5 or 8” corn and applications from V6 to 36” corn (or 15 days prior to tasseling) must be made with directed drop nozzles.

**Syngenta** – Acuron Flexi is a premixture of bicyclopyrone (HG27), mesotrione (HG27) and S-metolachlor (HG15) registered for preplant, preemergence and postemergence application in field corn, seed corn, silage corn; sweet corn and yellow popcorn cannot be treated with Acuron Flexi postemergence.

There are numerous other modifications on the labels of existing Syngenta proprietary products (i.e., the addition of HRAC code and resistance management language in the Bicep II Magnum label). These changes pertinent for Iowa can be found on the Acuron, Bicep II Magnum, Callisto, Dual II Magnum, Dual Magnum, Evik DF, Flexstar GT 3.5, Fusilade DX, Gramoxone SL, Halex GT, Prefix, and Sequence labels.

**Winfield** – Winfield and United Suppliers are merging and thus the herbicide product lines are somewhat in flux. Information about the Winfield product line can be found at http://www.winfield.com/Farmer/Products/ProductCategory/default.aspx?Cat=Herbicides&Seg=For%20Farmers while the United Suppliers product line can be found at http://www.unitedsuppliers.com/products/productlistings/tabid/269/default.aspx.

**Other companies** - There do not appear to be significant changes in the proprietary products from FMC and Valent although Valent reports the development and pending registration of a liquid flumioxazin formulation (Valor EZ). DuPont and Monsanto have an agreement that will allow DuPont to sell, when EPA registration is approved, FeXapan plus VaporGrip (HG4). This formulation of dicamba which is suggested to reduce the potential for volatilization. The product, when registered will be available for weed management in the Roundup Ready Xtend Crop System. Monsanto and Sumitoma have signed an
agreement to develop new PPO (HG14) technologies, presumably new HG14 herbicides and crops with resistance to HG14 herbicides. This agreement is unlikely to bring new tools for weed management within the next 10 years.

Herbicide resistance

The three most common herbicide resistant weeds in Iowa are waterhemp, giant ragweed, and horseweed/marestail. We continue to evaluate populations of these weeds for herbicide resistance by treating with Group 2, 5, 9, 14 and 27 herbicides to characterize their resistance profiles. Herbicide resistance in waterhemp continues to be a major problem in Iowa and waterhemp populations with multiple resistances increasing. A population of giant ragweed was recently discovered that is resistant to both HG2 and HG9, and initial results support putative resistance to HG27.

The recent discovery of Palmer amaranth across Iowa brings in the possibility that this “new” weed problem will further contribute to the herbicide resistance issues. Considering that Palmer amaranth populations in Missouri, Illinois, Kansas and Nebraska have evolved resistance to HG2, HG9 and HG27, it should come as no great surprise that the new Iowa populations will also have similar resistance profiles. Recently, Palmer amaranth populations in the mid-South have also evolved resistance to HG14. Efforts in Iowa are underway to understand the levels and types of herbicide resistances in the introduced Iowa Palmer amaranth populations. Importantly, efforts will be initiated at several levels to contain and eliminate the newly discovered Palmer amaranth populations.

New herbicide resistance traits and weed management

While the Roundup Ready2 Xtend (dicamba resistant) soybean cultivars have been deregulated and are approved by important international markets, the herbicides developed for these cultivars have not been accepted by the EPA. Enlist (2,4-D resistant) soybean is not widely available due to a decision by Dow AgroSciences to curtail availability until the crop is deregulated globally. However, the 2,4-D and glyphosate herbicide combination (Enlist Duo) specifically formulated and registered for the new trait is approved by EPA, albeit not widely applied by farmers at this time.

A primary concern for these new herbicide-resistant crops and the new HG4 herbicide formulations is the issue of off-target movement and injury. The three avenues for off-target injury include movement by herbicide volatilization, movement by the drift of the spray droplets during application, and the movement onto sensitive crops via the contamination of sprayers and support equipment.

Research conducted by Iowa State University characterized the impact of the two HG4 herbicides applied to susceptible soybean at the V3 stage of development with quantities of 1/10 to 1/5000 of the anticipated label rates that mimic the amount of the HG4 herbicides in a drift situation (Figures 1 and 2)(McGregor and Owen 2014).
Clearly, non-dicamba soybeans are more sensitive to dicamba than 2,4-D. Dicamba caused greater yield reduction at lower relative rates than 2,4-D. Foliar injury was observed at herbicide rates that did not cause a reduction in yield. Importantly, the HG4 herbicides in these experiments were applied uniformly to the soybean and thus may not mimic the effects of herbicide drift whether from volatilization or physical drift. Also, drift that occurs during the reproductive development of sensitive soybeans has a greater negative impact on soybean yield (Bradley 2016). Given the issues that have developed during the past two years when the dicamba-resistant soybeans were available to farmers, the focus of the following discussion will be on dicamba. However the basic concepts of off-target movement are also applicable to the 2,4-D formulations for the 2,4-D resistant soybeans.

Roundup Ready2 Xtend soybean have been widely planted despite the unavailability of the dicamba formulations labeled for application to the dicamba-resistant soybean cultivars. Unfortunately, decisions to use available, non-registered dicamba formulations for over-the-top applications has been common, particularly in the mid-south where more than 100,000 acres of non-dicamba resistant soybean and other crops were negatively impacted. The question is whether the use of the new dicamba products which were developed to reduce the potential for volatilization would have caused similar wide spread problems.

There are three dicamba formulations that may be registered for use in Roundup Ready2 Xtend soybean. BASF has developed Engenia, a new salt of dicamba, which is described as having 70% lower relative volatility when compared to Clarity. Monsanto has developed Roundup Xtend (glyphosate + dicamba) and Xtendimax (dicamba) with VaporGrip; these formulations use the same salt of dicamba as Clarity, but include an additive (Vapor Grip) that reduces volatilization. DuPont will market its own brand of dicamba with Vapor Grip technology, FeXapan, through an arrangement with Monsanto.
Figure 2. Effect of dicamba and 2,4-D applied to V3 soybeans. Data averaged for 6 experiments conducted in 2013 and 2014.

The potential for volatilization for these new dicamba formulations was determined from laboratory and growth cabinet experiments, as well as field evaluations. The question becomes whether the volatilization data derived from experiments that represent a relatively small area is valid when farmers adopt the technology and spray the new dicamba formulations over the landscape and under variable environmental conditions.

The companies have developed stewardship programs for farmers and applicators intended to minimize off-target movement of dicamba and 2,4-D. The goals of the programs are to increase awareness of application parameters and environmental conditions that contribute to particle and vapor drift. The labels for the new formulations take a different approach to off-target movement than seen previously. Only nozzle types specified on the label (manufacturer, type, and size) can be used to apply the new formulations. Only products that have been tested to determine their effects on spray droplet size can be tank-mixed with these herbicides. Non-treated buffer zones are specified when spraying adjacent to sensitive vegetation.

Given the wide spread illegal use of dicamba on the dicamba-resistant soybean, it is suggested that the programs were less than successful at describing the needed stewardship concepts and gaining acceptance of the importance of these concepts. Again the question becomes how farmer adoption of the new dicamba formulations will fare when there is considerable more area treated across the landscape during widely variable environmental conditions. Will farmers and applicators use the appropriate spray tips and observe the environmental criteria described on the labels?
Lastly, the other potential problem for the new dicamba herbicides is sprayer and nurse tank contamination. Again, the herbicide labels describe the criteria to clean dicamba residues from tanks and sprayers. Research conducted at Iowa State University evaluating cleanout procedures demonstrates clearly that when specified procedures are followed, tank contamination can be significantly reduced and should minimize off-target issues (McGregor and Owen 2015). However, the studies did not assess the potential for contamination in spray lines, booms and reservoirs where herbicide residues result in serious off-target problems if these are not appropriately cleaned (Bradley 2016). It will be crucial for farmers and applicators to observe the equipment cleanout processes.

Overall, the important considerations to reduce off-target movement of the new Group 4 herbicides are to follow the stewardship programs provided by the companies. Questions still exist with regard to the potential movement attributable to volatilization despite the new formulations, particularly when the area treated with the herbicides expands as anticipated. However, physical drift and injury attributable to sprayer and nurse tank contamination can be minimized by appropriate decisions by the applicator. These decisions and subsequent actions likely require time and procedures that are not simple or convenient. Importantly, these decisions and actions occur when there is limited time available for covering acres often contributing to poor decisions, especially during periods when unfavorable weather conditions limits time in the field. Furthermore, the expectations of the contributions that the new HG4 resistance soybeans will provide for the management of herbicide-resistant weeds need to be tempered by reality. While the HG4 herbicides can provide relatively good control of many important herbicide-resistant weeds, they do not represent the answer to this burgeoning problem. Unless these new tools are included in a more holistic approach to weed management, it is unlikely that the benefits they provide will offset the potential risks that exist.

Iowa Pest Resistance Management Plan

Iowa has experienced a rapid and widespread increase in evolved resistance in important pests. Weeds lead with most fields having infestations of waterhemp with evolved resistance to a number of herbicides (Owen 2013; Owen et al. 2015). More recently, populations of western corn rootworm evolved resistance to Bacillus thuringiensis (BT) and there are concerns about evolved resistance in soybean cyst nematode. National discussions and symposia on herbicide-resistant weeds and ISU faculty discussions about pest resistance in general resulted in an organized effort to determine what could be done to address the problems in Iowa. On January 30, 2015, a meeting was convened that included representatives from the Iowa State University College of Agriculture and Life Sciences, the Iowa Department of Agriculture and Land Stewardship, farmers, agriculture support groups, pesticide and biotechnology companies, ag retailers, land management firms, and commodity organizations. The meeting was convened in part because of growing concerns and the changing national regulatory framework to address pest resistance management that would impact Iowa agriculture. The meeting summary can be accessed at: http://www.ipm.iastate.edu/content/pesticide-resistance-workshop-2015.

The recommendations from the meeting included the need to develop a statewide voluntary pest resistance management plan, to establish a consistent message about pest resistance action, and to share outcomes of the meeting widely to all stakeholders. From that original meeting, a task force was charged to develop the conceptual framework for a state pest resistance management plan and to identify the roles that each stakeholder will play (Bradbury et al. 2016). The following stakeholders were identified as having important roles for the plan:
• Iowa agricultural organizations (i.e., Iowa Farm Bureau)
• Row-crop farmers, including land/farm owners and farm operators/renters
• Independent and certified crop advisers
• Seed, crop protection, technology/service, fertilizer providers, ag retailers
• Land owners, land managers
• Urban and rural community members
• EPA and USDA

Once the plan is accepted, the implementation of the ideas will be described. It will be critical that the plan is holistic and takes a long-term approach to pest resistance management. The economic impact of the plan must be addressed and the possibility of incentives considered. Individual approaches to pest management will be incorporated into the plan but community-based organizations to address the landscape implications of pest resistance will also be a factor of the plan. All of these considerations increase the complexity and difficulty in the successful implementation of the statewide plan. Monitoring results of the plan is critically important in the success as is developing an acceptable manner of governance of the voluntary plan. The Iowa pest resistance management plan will become public in the near future.

Conclusions

There are a number of changes and issues in play for weed management in 2017 and beyond. While it is anticipated that the dicamba herbicides developed to provide weed control in dicamba-resistant soybean will be registered in the near future, it is not known whether the products will be available for use in 2017. Given the issues of illegal applications of dicamba in the Midsouth, Iowa must not follow this path if the herbicides do not receive registration in time for application in 2017. Regardless, care must be taken using these products in order to avoid the risks associated with the herbicides. New herbicide resistances in weeds is also a consideration for 2017 and more diverse plans should be established to manage these problems. Similarly with Palmer amaranth populations being identified throughout Iowa, better weed management plans are needed. The Iowa Pest Resistance Management Plan will hopefully become the foundation of better weed management.

References


