# Herbicide-resistant weeds: An evolving problem of importance in Iowa crop production

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## Introduction

The changes in Iowa agriculture over the last three decades have been monumental and the implications of these changes often overlooked during the course of developing the plans for next year. Consider that in the 1970's, aggressive tillage predominated the production systems in Iowa, conservation tillage was an interesting but not generally practiced idea and herbicides had to be mechanically incorporated into the soil. In the 1980's, the acetolactate synthase (ALS) inhibiting herbicide families were introduced. The imidazolinone and sulfonyl urea herbicide families were applied to an estimated 90% of the soybean acres and more than 65% of the corn acres. In many instances, these herbicides were applied repeatedly on fields during the year and certainly recurrently from year to year. Despite warnings that this production practice would result in significant problems (e.g. evolved ALS-resistant weed biotypes), commercial agriculture continued with the unsustainable practice of using one type of herbicide exclusively and the inevitable resistant weed problem evolved as predicted. By the time glyphosate-resistant (GR) crops were introduced, ALS resistance was widespread and much of the utility of these important products had been lost. However, the GR crop technologies and concomitant use of glyphosate became available and adoption in global agriculture was unprecedented. Importantly, the trends toward conservation tillage practices were strongly supported by the "new" system.

Usage of glyphosate rose to the point that there were no other herbicides used on more than 10% of the soybean acres and only atrazine continued to demonstrate a strong presence in corn (Young, 2006). Once again, naysayers suggested that because the GR-based crop production systems were essentially devoid of diversity for weed management, glyphosate-resistant weeds would evolve (Owen, 1997). These warnings were again unheeded and the inevitable resistant weeds did indeed evolve to the extent that the GR technologies are threatened. Unfortunately, this time, given the unprecedented adoption of GR-based crop systems and glyphosate utilization, the industry had essentially withdrawn from herbicide discovery and development such that no new answers would come forward. Given the dire straits that currently exist in weed management, now is the time to objectively review the sustainability of the system and determine if perhaps it is time to change perspectives on a more diverse management plan for weeds.

## What are the options?

In Iowa corn and soybean production, there are a number of effective, but sparingly utilized, tools and tactics available to manage the ever increasing herbicide resistant weed problem. This is unlike the situation in the Mississippi Delta and Southeastern states where cotton production is threatened (Culpepper and York, 2007). The rhetorical question as to why the plethora of tools and tactics available to Iowa agriculture have not been used, even when it was correctly suggested that the evolution of GR weeds was inevitable, is a function of demographic changes in agriculture (i.e. size of farms and time availability) as well as a desire for the convenience and simplicity that the GR crop-based systems provided (Owen et al., 2009; Owen et al., 2010). Growers continued to maintain a position of denial that these ever increasing problems would ever impact their farms; it should now be clear that the problems are here and changes must occur now or potentially Iowa agriculture will experience the same severe consequences that growers in Georgia are now facing.

### *Herbicide options*

There are numerous "alternate" herbicides that can help resolve the glyphosate resistance in weeds. "Alternate" is another way of saying "old" and these established herbicides are indeed useful if properly included in a longer-term weed management plan. The list of herbicides currently registered for corn and soybean is long and represented by a number of herbicide families and mechanisms of action (MOA). Generally, the more herbicide diversity that is included in a long term weed management plan, the better. However, many of these herbicides have already been improperly used and thus have selected for resistant weed biotypes. Thus, the simple inclusion of other herbicides

will not necessarily resolve weed management problems. A partial list of available "alternate" herbicides is presented in Table 1.

**Table 1.**

| Corn | Soybean |
|---|---|
| Atrazine | Sencor |
| Prowl (and others) | Prowl (and others) |
| Balance Flexx | Authority (and others) |
| Callisto (and others) | Pursuit |
| Sharpen | Valor (and others) |
| Basis | Cobra (and others) |
| Dual (and others) | Warrant (and others) |
| Banvel, Clarity | Basagran |
| 2,4-D | Select (and others) |
| Ignite | Ignite |

The point is not to list all the available "alternate" herbicides but rather to provide an indication of the number and diversity of products available for weed control in corn and soybean. There are also a number of premixtures available and often these products are advertised as effective strategies to manage herbicide resistant weeds. Be advised however, that many of these products contain herbicides for which weeds have already evolved resistance (i.e. ALS herbicides and common waterhemp). Thus it is critically important to identify the preexisting weed resistances in the field and also to know the specific MOA of the herbicides under consideration.

## *Herbicide use concepts*

The concept of herbicide rotation of MOA has gained considerable traction in Iowa agriculture. While rotation of herbicide MOA is a tactic that can help mitigate the evolution of herbicide resistance, it has, over time, limited utility. Consider the recent identification of HPPD-resistant common waterhemp in a seed corn production field; the company rotated herbicide MOA but still selected for resistance (McMullan and Green, 2011). Again, the more diversity in herbicide use, the better the weed management in the longer-term.

Another option is to incorporate other available crop technologies with the herbicide options. The inclusion of the glufosinate-resistant crops and glufosinate as a topically applied herbicide is an excellent option to manage many herbicide-resistant weed biotypes that are present in Iowa crop systems. Proper use of glufosinate is important; recognize that the application requirements are different than those for glyphosate and thus it is important to closely follow the requirements to optimize the weed control provided by the trait/herbicide combination in a diverse weed management system. However, the inclusion of the trait/herbicide combination will inevitably result in the same fate as glyphosate if it is the only adjustment towards a more diverse system made by growers. Consider that resistance to glufosinate has been identified (Heap, 2011).

An important herbicide use tactic that has benefits is the inclusion of different herbicide MOA each year. The doctrine of "start clean" reflects the importance of using a soil-applied herbicide that provides residual weed control. This application strategy is typically supplemented by another herbicide with a different MOA applied topically to the crop and weed. However, the relative importance of the soil-applied herbicide for the mitigation of herbicide resistance in weeds is overshadowed by the importance to deter the early season interference of weeds on the crop thus protecting potential yield.

No herbicide, despite the advertising rhetoric, will provide season-long weed control. Thus, when another herbicide MOA is applied to another cohort of recently-emerged weeds in the crop, it is that herbicide MOA that selects for resistance and the soil-applied herbicide MOA has limited resistance management value in this scenario. The best strategy for using multiple herbicide MOA is to make each application of herbicides redundant. Redundancy in this context suggests that more than one herbicide MOA should be included each time an herbicide application is made. Again, simplicity is not a consideration when choosing the candidate herbicides; an understanding of existing

resistances in the field, the specific MOA of the herbicides and the need to have diversity in MOA for the overall system must be a core principle of the choices. Furthermore, only considering year to year herbicide diversity is short-sighted. A longer-term herbicide use plan, focusing on a diversity of herbicide MOA and application tactics, must be developed. However, if a change in herbicides use is the only strategy that is included in an attempt to diversify crop production systems and weed management, weed management and thus the crop production system will inevitably fail (Owen, 2011).

### *Diverse strategies*

An objective assessment of weed management should make it very clear that herbicide-based systems are destined to ultimately fail. Simple and convenient is a mantra that must be forgotten and while time use considerations are a major factor that has guided agriculture to that which is simple and convenient, more diverse weed management must be included. As suggested, while the need of new "widgets" is important for the short-term, greater diversity in the Iowa crop production system must be established for the long term sustainability of weed management.

The primary objection to increasing diversity in weed management appears to be the inability of growers to fully appreciate the consequences of not diversifying the production system. This objection is closely followed by concerns for the time the diverse tactics require. Finally, according to the author, another important objection is the fact that the "institutional knowledge" on how to manage weeds without focusing solely on glyphosate is lacking.

Diversity includes, but is not limited to crop rotation, tillage, cover crops, other cultural strategies and mechanical control. A more complete list of tactics and a discussion on the need for diversity is available (Green, 2011; Green and Owen, 2011). The key to a diverse weed management program is a basic understanding of the biology of the system, the interactions of weeds and crops, and a truly objective assessment of the production system (Knezevic et al., 2002; Swanton and Weise, 1991). Integrated weed management (IWM) is crucial to the sustainability of agriculture and diversity of tactics is the basis of IWM.

A reasonable objection to the adoption of IWM is time availability. For example the inability to cultivate several thousand acres of row crops because of the time requirement is a real and rational objection. However, consider that growers do not typically use the same corn hybrid on all the acres under their management. Similarly, it is not a common practice to use the same fertility program on every field. The reasons for these examples of production diversity are intuitively obvious; the diversity exhibited by these production decisions minimize risks and maximize economic benefits. The same strategies of managing fields in the smallest unit should be included for IWM; cultivate only the fields that require this tactic and use a diversity of herbicides and crop technologies on individual fields. The greater the diversity in an IWM program, the greater the environmental, economic and ecological benefits.

## Conclusions

It should be clear to anyone who reviews the historic perspectives of weed control objectively that the system is not working. Weeds have evolved resistance to all of the available herbicide MOA. Many weeds have evolved multiple resistances; consider that common waterhemp populations have evolved resistance to glyphosate, ALS herbicides, triazine herbicides, PPO herbicides, HPPD herbicides and most recently, 2,4-D. Specific populations of common waterhemp in Illinois have multiple resistances to five herbicide MOA and in Iowa, all common waterhemp should be considered resistant to all ALS herbicides. While herbicides will continue to be the primary tactic to selectively control weeds in row crops, if only herbicides are used, weeds will inevitably adapt to the tactic and weed control will fail. There is a need to change the crop production systems and more specifically, how weeds are managed. Diversity is the key to economic, environmental and ecological sustainability in weed management and thus crop production, regardless of the lack of simplicity and convenience.

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