Proceedings of the Integrated Crop Management Conference

Proceedings of the 24th Annual Integrated Crop Management Conference

Nov 28th, 12:00 AM

Weed management update: 2013

Micheal D. K. Owen
Iowa State University, mdowen@iastate.edu

Weed management update: 2013

Micheal D. K. Owen, associate chair, professor and Extension weed specialist, Agronomy, Iowa State University

Introduction

The success of weed management programs, more specifically herbicide programs, varied considerably during 2012 reflecting the importance of environmental conditions on all aspects of crop production. Variability of success was seen not only in the postemergence herbicide applications that continue to dominate herbicide use but also in the soil-applied residual herbicides; all herbicide applications were strongly influenced by tillage system, crop planting date, timing and amount of rainfall, and resulting weed emergence timing. While more soil-applied herbicides were used in Iowa during 2012, there are still too many acres of corn and soybean that are treated only with glyphosate thus moving the evolution of glyphosate resistant weed biotypes forward (Figure 1). Importantly, the trend of no new herbicide sites of action continues and while new herbicides will be available in 2013, they have old sites of action, many of which have existing resistant weed populations. The new products and changes in herbicides will be described in this paper. The implications of the 2012 drought on herbicide degradation and the potential for herbicide carryover will be addressed. Furthermore, an update on the development of new herbicide resistant crops and the anticipated implications of these technologies when deregulated and available commercially will be discussed. Finally, preliminary data from a research project supported by the Iowa Soybean Association to assess the extent of evolved resistance to herbicides in Iowa and a brief discussion about Palmer pigweed (Amaranthus palmeri) will be provided.

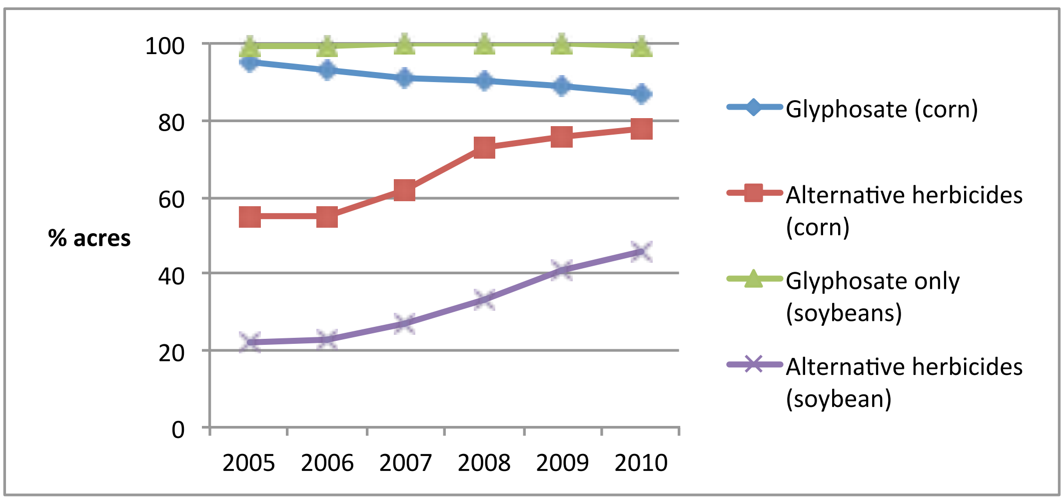

Figure 1. Use of glyphosate and alternative herbicides in Roundup Ready® corn and soybean. (Adapted from Sortes (2012) WSSA annual meeting)

New products and company updates

While a number of new products and premixtures are available or anticipated to be available in 2013, none of these products represent new herbicide sites of action. Given the existing resistances to available herbicide sites of action, this lack of discovery and development of new products will be increasingly problematic for weed management in Iowa agriculture and reinforces the need for a better understanding about how to best use the available herbicides to steward their continued performance. The following update includes companies that provided information about their proprietary products; inclusion in this paper does not signify endorsement nor does exclusion constitute a lack of support of the products.

BASF

BASF has received registration for Zidua herbicide in corn including popcorn and sweetcorn. This product has the active ingredient pyroxasulfone which is the herbicide KIH-485 on which Iowa State University Weed Science conducted research for a number of years however the rate of pyroxasulfone used was higher than what is currently registered. Pyroxasulfone is a group 15 herbicide and inhibits very long chain fatty acid (VLCFA) synthesis; this is the same mode of action for other commercially available products such as metolachlor (e.g. Dual) and acetochlor (e.g. Warrant) (Tanetani et al., 2009). The specific molecular site of action has not been confirmed. Group 15 herbicides do not inhibit germination but rather inhibit shoot elongation of germinated susceptible seedling weeds. These herbicides control many annual grasses and some small-seeded annual broadleaf weeds. Zidua is formulated as an 85% water dispersible granule (WG) and the 0.212 lbs A.I. can be applied early preplant (up to 45 days before planting), preplant incorporated, preemergence, early postemergence and in the fall. Fall application is not the best application timing for residual weed control in the spring and early post emergence applications must be timed prior to weed emergence. Do not apply Zidua through irrigation systems nor aerially. Only one application is allowed to corn each spring.

BASF is also developing a new formulation of dicamba for application on dicamba-resistant soybean cultivars. The new formulation will be called Engenia by BASF and is suggested to have a lower potential for volatilization than current dicamba formulations. The weed spectrum and relative efficacy is similar to available dicamba formulations. This formulation has been evaluated in more than 300 soybean field trials in 2011 and 2012 according to a recent BASF announcement and will be targeted to help control herbicide resistant weeds such as common waterhemp (Amaranthus tuberculatus). Iowa State University has evaluated this product and has observed off target movement to susceptible soybean cultivars. While the risk of volatilization drift may be reduced compared to current dicamba formulations, it is not zero. Furthermore, physical drift will require the same considerations that impact all herbicides. The potential for tank contamination resulting in injury to susceptible crops is also an important management consideration.

Bayer Crop Science

While Bayer Crop Science did not provide any specific update information, they are moving forward their stewardship efforts by holding "Respect the Rotation" field days and promoting the use of Liberty Link corn and soybeans and Liberty herbicide. The inclusion of the trait and the herbicide as part of a more diverse weed management program makes good sense. Bayer Crop Science has also developed a very good brochure describing herbicide resistance, current herbicide resistant weeds, management tactics for herbicide resistant weeds, and herbicide modes of action. This brochure is available at http://www.bayercropscience.us/news/2012_RTR/2013WeedResistanceManagementBrochure.pdf.

Dow AgroSciences

Dow AgroSciences continues to develop 2,4-D resistant traits in soybeans and corn under the name Enlist™ Weed Control System. There is a chance that the corn may be deregulated for a limited commercial launch in 2013 while the earliest deregulation of the soybean cultivars is in 2015. Enlist Duo will be the Dow AgroSciences proprietary premixture of glyphosate and 2,4-D choline. This new formulation of 2,4-D is suggested to have lower volatility, less physical drift potential and other favorable characteristics compared to current 2,4-D formulations. Drift reducing agents are included in the formulation. Weed control is similar to other 2,4-D products. Dow AgroSciences is developing a strong stewardship program and to minimize off-target issues with Enlist Duo, this program must be followed closely.

DuPont

DuPont has registered a new premixture of rimsulfuron (4.17%) and mesotrione (41.67%) and have named this product Instigate™ which is formulated as a water dispersible blend. DuPont is suggesting that this mixture provides burndown activity as well as residual activity in corn. There is some confusion with regard to the Herbicide Group number that is included on the Instigate label; DuPont indicates that this product has an Herbicide Group 2 product (rimsulfuron) and an Herbicide Group 28 product (mesotrione). However, Syngenta suggests that mesotrione is a member of Herbicide Group 27. The confusion reflects differences in designation comparing the Weed Science Society of America and the Herbicide Resistance Action Committee. Regardless, Instigate has one ALS inhibitor herbicide and one HPPD inhibitor herbicide. Instigate can be applied 14 days prior to planting up to V2 corn.

This product is restricted for application only on corn and seed corn, popcorn, ornamental corn and sweet corn should not be treated with Instigate. Do not make an application of another HPPD inhibitor herbicide (e.g. Callisto) following an application of Instigate. Other restrictions on the label need to be followed.

Realm™ Q was registered for corn by DuPont in July 2012 and is a postemergence premixture of rimsulfuron (Group 2) and mesotrione (Group 27 – see above) herbicides and isoxadifen, a potent safener that will minimize the potential for crop injury from the rimsulfuron. This product provides burndown activity as well as some residual control of some annual grasses and broadleaf weeds. The amounts of rimsulfuron and mesotrione are 7.5% and 31.25% respectively by weight in the water dispersible granule formulation. Apply 4 oz product per acre to corn up to 20" tall or exhibiting 7 leaf collars, whichever is more restrictive. Crop oil concentrate or nonionic surfactant and AMS must be included and atrazine is also recommended. Do not include Basagran or foliar-applied organophosphate insecticides with Realm™ Q. Realm™ Q should not be applied aerially or through irrigation systems. The soybean rotational interval is 10 months. DuPont cautions that a potential interaction with Realm™ Q and Counter and Lorsban soil-applied insecticides that can result in severe crop injury and yield loss.

DuPont has labeled Cinch® (82.4% s-metolachlor) (Group 15) for postemergence application in soybeans. Note that s-metolachlor does not demonstrate activity on weeds that have emerged prior to application.

FMC

FMC received registration for Anthem™ a premixture of pyroxasulfone (Group 15) and fluthiacet-methyl (Group 14) herbicides. Anthem™ is formulated as a suspoemulsion and contains 2.15 lb. active herbicide ingredient. This premixture can be applied fall or spring, preplant, preplant incorporated preemergence or postemergence. When applied postemergence to weeds, it is critical to note the weed type and size as Pyroxasulfone does not demonstrate activity on emerged weeds and fluthiacet-methyl has limited activity on some small broadleaf weeds although velvetleaf control is good. Do not apply Anthem™ aerially or by irrigation equipment. Observe harvest intervals as detailed on the label. Anthem™ applied at 13 oz/A will contain 0.212 lb a.i. of pyroxasulfone. Registration of Anthem ATZ (Groups 5, 14, and 15) is pending.

Monsanto

Monsanto has registered Warrant® herbicide (acetochlor, Group 15) is now registered for preplant, at-planting and preemergence surface application in soybeans. Incorporation of the encapsulated acetochlor is not recommended and up to 4 quarts of Warrant® can be applied per season. These additions to the label supplement the previously labeled post emergence application in soybean. Acetochlor does not demonstrate activity on emerged weeds.

Monsanto has also detailed their 2013 recommendations in Roundup Ready corn and soybeans. A number of application scenarios are described in several tillage systems if glyphosate resistant weeds are present or absent. Monsanto is providing incentives to use alternate herbicides in combination with glyphosate for all application timings. This effort to incentivize stewardship is laudable however it specifically provides stewardship for glyphosate. All herbicide sites of action should be stewarded and it is important to consider tactics for weed management other than additional herbicides. Importantly, given the herbicide resistances that have evolved in Iowa (see later in this paper), it is critical to make sure that the alternate herbicides are active on the target weeds to best utilize the Monsanto recommendations and incentives.

Monsanto continues to develop the dicamba-resistant soybean cultivars and it is anticipated that Roundup Ready Xtend may be commercially available in 2014. The available soybean cultivars demonstrate excellent tolerance to dicamba and weed control of selected broadleaf weed was also good. However in large-plot trials conducted by Iowa State University in 2012, off-target movement of the new dicamba formulation was observed and it is clear that the utilization of this technology will require focused attention in order to minimize issues of off-target and tank contamination.

Syngenta

Syngenta has changed the formulations of three of their proprietary products to allow better handling, mixing, compatibility with sulfur-containing fertilizers and cleanup. These products include Lumax® EZ, Lexar® EZ and a Camix replacement, Zemax™. The ratio of herbicides in Lumax EZ is also different such that the product amount applied has increased.

Valent

Valent has registered Fierce™ herbicide on corn for fall and spring burndown applications or preemergence in no tillage and minimum tillage systems. Conventional tillage corn production systems are not described on the label. Fierce™ is formulated as a 76% water dispersible granule and is a prepackage mixture of flumioxazin (Group 14) and Pyroxasulfone (Group 15) herbicides which provides contact and residual activity on susceptible weeds. The maximum seasonal application rate of 4.5 oz/A results in 0.12 lb a.i. pyroxasulfone. This product is not registered for sweet corn, popcorn or corn grown for seed. Fierce™ can be applied aerially.

Valent has provided detailed information and description on how to clean sprayers, mixing vessels and nurse tanks daily after the use of Valor, Chateau, Valor XLT, Gangster and Fierce herbicides. Valent requires the use of Valent Tank Cleaner which is described to neutralize and remove these herbicides from tanks, hoses and nozzles when mixed at the correct concentration and kept in the equipment over night.

Herbicide carryover

Given the lack of rain during the summer and fall 2012, the potential for herbicide carryover must be a consideration for 2013 plans. However, the extent of herbicide carryover and the actual risk of carryover injury to rotational crops will vary widely in Iowa and will be strongly influenced by a number of factors including but not limited to the specific herbicide, rate and timing of application and the weather, particularly the conditions that exist for the rotational crop in 2013. An article describing these factors can be found at http://www.extension.iastate.edu/CropNews/2012/0807hartzlerowen.htm. Specific herbicides and an assessment of carryover potential are listed in Table 1.

Generally, if herbicides applied in 2012 were allied in a timely fashion and if growing conditions for the 2013 crop are favorable, the likelihood of herbicide carryover that results in significant crop injury is slight. However, if multiple applications of the same herbicide or herbicide mechanism of action (e.g. multiple applications of HPPD inhibitor herbicides) were used, if high rates of the herbicides were applied and the herbicides were applied later in the growing season, the risk of carryover increases.

There is no good way to determine the potential for herbicide carryover. While there have been discussions about conducting bioassays to assess the level of carryover, these are not going to provide an accurate assessment of the carryover. Importantly there is a good chance of either a false positive (carryover is likely) or a false negative (carryover is unlikely). If you determine, by whatever means, that carryover is a strong possibility, it may be advisable to plant a rotational crop that is not sensitive to the herbicide. Past experiences on changing tillage plans do not suggest that this is an advisable solution for a number of reasons, not the least of which that changing tillage is unlikely to resolve the potential for herbicide carryover.

Table 1. Assessment of herbicide carryover risk for specific herbicides

Risk assessment	Herbicide
High	Atrazine
	Chlorimuron (e.g Canopy, Authority XL, Envive, Valor XLT and others)
	Imazaquin (e.g. Scepter)
	Simazine (e.g. Princep and others)
Moderate to slight	Fomesafen (e.g. Reflex, Flexstar, Prefix)
	Clopyralid (e.g. Hornet)
	Cloransulam (e.g. FirstRate, Hornet, Gauntlet and others)
	Imazethapyr (e.g. Pursuit)
	Dinitroaniline herbicides (e.g. Prowl, Treflan and others)
	HPPD inhibitor herbicides (e.g. Balance Flexx, Callisto, Lumax, Lexar, Laudis, Caprino, Impact and others)

Palmer pigweed

Palmer pigweed has been a significant problem in cotton and soybean production in the Mississippi Delta and the Southeastern United States. Interestingly, this weed originated in the arid Southwestern United States and was not a major concern until the unprecedented adoption of the glyphosate-resistant crop technologies and the subsequent use of glyphosate as the primary if not sole tactic to control weeds in these crops. In many respects, Palmer pigweed is similar to common waterhemp (*A. tuberculatus*) which dominates fields in the Midwest United States. These weeds are dioecious (male flowers and female flowers on separate plants), adapted to current tillage and crop production systems, produce incredible numbers of seeds and have opportunistic germination habits. Palmer pigweed, like common waterhemp has evolved resistances to several herbicides including the ALS inhibitor herbicides and glyphosate. However, Palmer pigweed seems to be more aggressive in growth and competitive habit with crops. Research conducted at Kansas State University a number of years ago demonstrated that Palmer pigweed and common waterhemp would approach the same heights but Palmer pigweed produced approximately 30% more dry matter. The problem is that with current agricultural practices, the mobility of weeds no longer is a function of natural processes (i.e. gravity or water) to move seeds. Palmer pigweed seeds have been documented in cotton meal which is used as livestock feed and in manure. When these products move across state lines and are used, they provide a new opportunity for Palmer pigweed to become a serious problem. As a result, Palmer pigweed infestations are appearing many states away for the original infestations. Palmer pigweed infestations have been identified in Southwest Michigan and Wisconsin (Figure 2). Missouri, Kansas and Nebraska all have Palmer pigweed and recently, several locations in Illinois have been identified (see http://bulletin.ipm.illinois.edu/article.php?id=432 and http://bulletin.ipm.illinois.edu/article.php?id=1688). While there are no documented samples of Palmer pigweed found in the Ada Hayden Herbarium at Iowa State University, and while no verified Palmer pigweed infestations have been identified by Iowa State University weed scientists, it is highly likely that Palmer pigweed populations exist in Iowa and if established, will adapt quickly to Iowa production systems.

The best way to keep Palmer pigweed from becoming a serious problem in Iowa is to identify the initial infestations and control them prior to seed production. Use whatever extraordinary tactics as deemed necessary. However, given the likelihood that the Palmer pigweed will have evolved herbicide resistance(s), the best tactic is hand removal. An excellent pigweed identification brochure is available at http://www.weeds.iastate.edu/weed-id/waterhemp/default.htm from Iowa State University. If a suspected infestation is discovered, please save one plant and send to Iowa State University at: Micheal D.K. Owen, 3218 Agronomy Hall, Ames, IA 50011 with the contact information. Then destroy all of the other plants before they flower.

Figure 2. Midwest States with documented infestations of Palmer pigweed (*Amaranthus palmeri*)

Iowa herbicide resistant weed update

In 2008, approximately 220 fields with common waterhemp populations were sampled arbitrarily and screened for resistance to glyphosate. In 2011, the Iowa Soybean Association requested that Iowa State University submit a proposal to evaluate herbicide resistance in Iowa and subsequently funded the project. More than 200 common waterhemp populations and a number of giant ragweed (*Ambrosia trifida*) and horseweed (aka. marestail, *Conyza canadensis*) were collected in 2011 and similar collections were made in 2012 (Figure 3). Evaluations of the populations are currently underway and approximately 60% of the 2011 common waterhemp collections have been evaluated for resistance to five sites of herbicide action; the populations of giant ragweed and horseweed will be evaluated after the common waterhemp populations have been completed. The herbicide sites of action included in the evaluations are representatives of the ALS inhibitor herbicides (Group 2), PSII inhibitors (Group 5), EPSPS (Group 9), PPO inhibitor herbicides (Group 14) and HPPD inhibitor herbicides (Group 27). Representatives of each of these herbicide sites of action were applied postemergence to common waterhemp populations in the greenhouse at the typical field use rates and at four times this rate. A summary of the evaluations thus far can be seen at: http://www.weeds.iastate.edu/mgmt/2012/resistancereport.html.

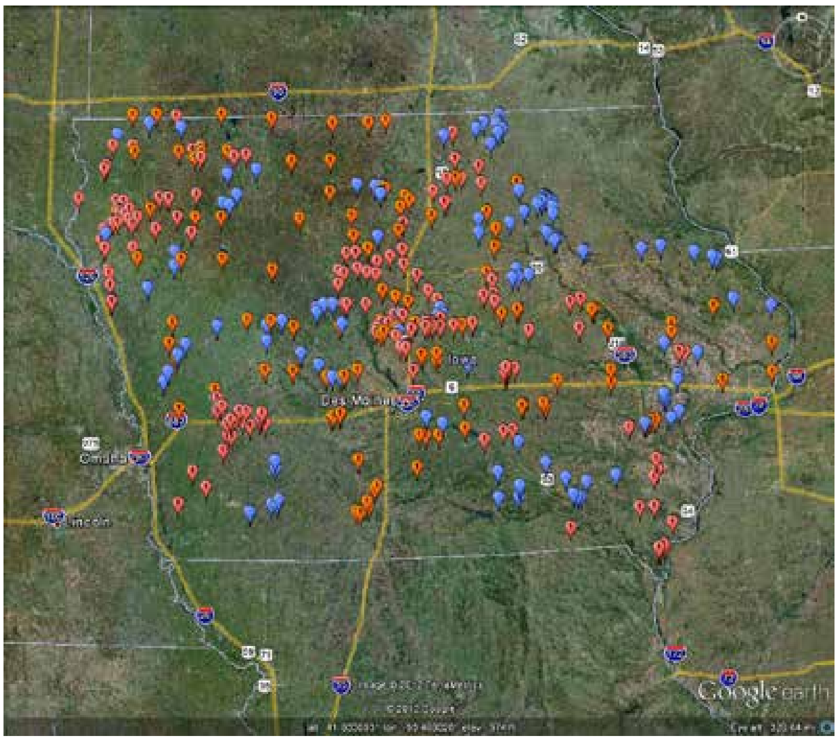

Figure 3. Iowa weed populations collected in 2008, 2011 and 2012 used to assess herbicide resistance.

Table 2. Rates of herbicides included in the greenhouse evaluation of Iowa weed populations

Herbicide	Field rate of product (1x)	4X rate of product
ALS inhibitor (Pursuit)	4 oz/A	16 oz/A
PSII inhibitor (atrazine)	1 lb/A	4 lb/A
GLY (glyphosate)	22 oz/A	88 oz/A
PPO inhibitor (Cobra)	12 oz/A	48 oz/A
HPPD inhibitor (Callisto)	3 oz/A	12 oz/A

The herbicides were applied and appropriate additives included when the common waterhemp were two to four inches tall. Evaluations were made 7, 14, and 21 days after herbicide application. Resistance was assessed on the relative control of the populations when compared to a known susceptible common waterhemp populations. Evaluations were on a 0 to 100% control where 0 indicated no herbicide activity and 100% indicated all plants were sensitive. Values below 90% control when compared to the susceptible population were deemed to indicate that resistance had evolved in the specific population. Most of the populations that were designated as resistant still contain sensitive plants but resistance will become the primary phenotype if the herbicide(s) continue to be used. These evaluations are ongoing and as new populations are evaluated, the information will be included in the website.

As anticipated, most of the common waterhemp populations in Iowa have evolved resistance to the ALS inhibitor herbicides (Figure 4). More than 95% of the populations evaluated thus far demonstrate a resistant phenotype when challenged with a field rates of imazethapyr applied. When the rate increased to 4X 88% of the populations were still evaluated as resistant. The rate of the PSII herbicide did not change the relative percentages of the resistant populations as 58% and 57% of the common waterhemp populations had a resistant phenotype to 1X and 4X atrazine, respectively (Figure 4). When the populations evaluated thus far were treated with a field rate of glyphosate, 54% of the common waterhemp populations were assessed to be resistant while the number declined to 22% when the glyphosate rate was quadrupled (Figure 4). Assuming that the mechanism of resistance to glyphosate is similar to that reported for Palmer pigweed (Tranel, personal communication), the rate response demonstrated in the common waterhemp populations evaluated thus far is appropriate (Gaines et al., 2011; Tranel, 2007; Tranel, 2011).

There was no effect of lactofen rate on the percentage of resistance in common waterhemp; 6% were resistant to the field rate while 5% were resistant to the 4X rate (Figure 4). There was a significant effect of rate for mesotrione as 28% of the common waterhemp populations evaluated thus far were assessed to be resistant to the field rate of mesotrione while the percentage declined to 4% at the 4X rate (Figure 4). Resistance to the HPPD inhibitor herbicides is suggested to be attributable to metabolism. Thus, the rate response to the higher rates is appropriate and explicable based on a metabolic type of resistance.

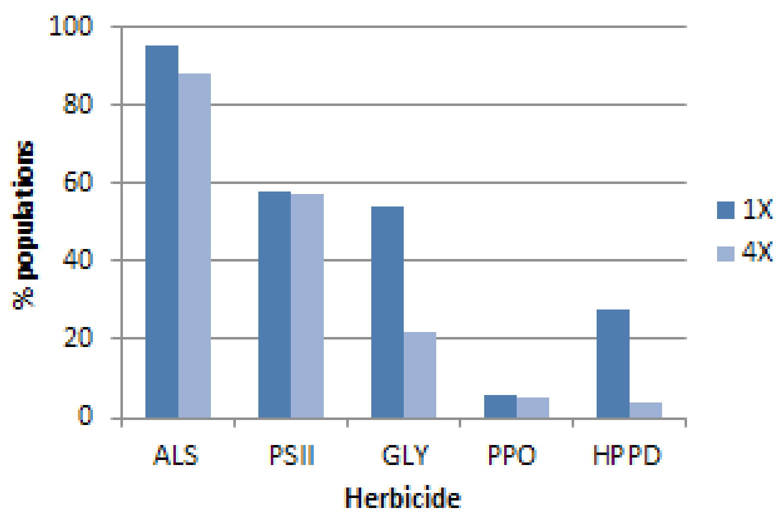

Figure 4. Preliminary data describing Iowa common waterhemp (*Amaranthus tuberculatus*) populations collected in 2011 resistance(s) to field application rates (1X) and four times this rate of five herbicides[a] (preliminary data)
[a]Herbicides included are imazethapyr (ALS), atrazine (PSII), glyphosate (GLY), lactofen (PPO), and mesotrione (HPPD).

One important aspect of the research sponsored by the Iowa Soybean Association, compared to the assessment of glyphosate resistance in Iowa common waterhemp populations that was conducted in 2008 was the ability to assess multiple resistances in the populations. Given that common waterhemp has demonstrated the ability to evolve resistance to six different sites of herbicide action (the five included in this study and the auxinic herbicides dicamba and 2,4-D), it is critically important to know exactly what herbicides are still effective when planning a common waterhemp management program. When populations have evolved resistance to more than one site of herbicide action, the herbicide options available quickly decline.

A majority of the common waterhemp populations from the 2011 collections evaluated thus far demonstrated multiple resistances (Figure 5). The most prevalent multiple resistant phenotype was populations of Iowa common waterhemp that were resistant to ALS inhibitor herbicides, PSII herbicides and glyphosate (29%). Common waterhemp populations that had evolved resistance to two sites of herbicide action accounted for 32% of the field evaluated thus far. Resistance to three herbicide sites of action included 37% of the populations (the dominate phenotype was resistance to ALS/PSII/GLY) while resistance to four herbicide sites of action included 14% of the populations. Three populations (2%) were resistant to all herbicide sites of action tested while 2% of the populations evaluated thus far were sensitive to all five herbicide sites of action.

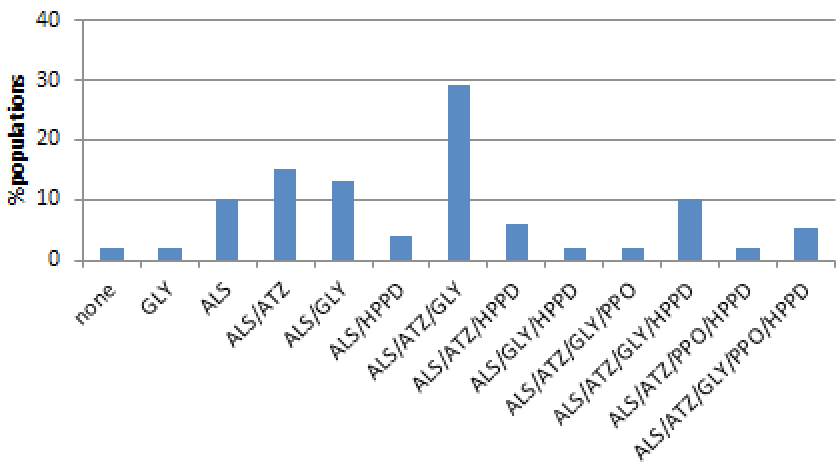

Figure 5. Assessment of Iowa common waterhemp populations demonstrating resistance to multiple herbicide sites of action (preliminary data)

Based on the preliminary data, it is clear that managing herbicide resistant populations of common waterhemp will become increasingly challenging in the near future. Of great concern is the resistance to the HPPD inhibitor herbicides. It is important to recognize that the data is preliminary but if the trend established thus far holds when the 2012 collections are completed, the prevalence of resistant phenotypes will make weed management in corn and soybean increasingly difficult. Recognize that this screen is with the postemergence application of these herbicides; there is a possibility the common waterhemp populations may respond differently to soil-applied herbicides. Furthermore, the heritability of resistance, particularly the HPPD inhibitor herbicides, will influence how quickly this phenotype emerges in common waterhemp. Regardless, these preliminary data indicate that better management of weeds in Iowa is of utmost importance and alternatives strategies must be quickly adopted in order to maintain effective weed management.

Conclusions

While there have not been any new herbicide sites of action discovered and made commercially available in over 20 years, many manufacturers continue to develop older products and products based on older sites of action. However, the likelihood of having a truly new herbicide in the next ten years is not good. Thus, it is critical that we begin to use the available products more wisely and include more diverse weed management tactics in order to preserve the herbicides and crop traits currently available. Other issues brought about by unfavorable weather conditions will add further complexity to decisions about which herbicides to use and how to use them in 2013. Finally, the weed community has not been sedentary and continues to demonstrate the principles of natural selection; resistance in weeds, particularly common waterhemp, continues to increase at an increasing rate. Multiple resistances within populations are becoming more prevalent. All of these indicate the need for diligence and management in order to maintain effectively weed control. The simplicity and convenience of using only glyphosate, as was done in the previous decade and unfortunately continues in this decade, has resulted in problems that cannot be addressed with any one tactic or herbicide. Better weed management begins with the inclusion of more diverse tactics, scouting and using multiple herbicides with alternative effective sites of action.

References

Gaines, T. A., Shaner, D. L., Ward, S. M., Leach, J. E., Preston, C., and Westra, P. 2011. Mechanism of resistance of evolved glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*). Journal of Agricultural and Food Chemistry 59: 5886-5889.

Tanetani, Y., Kaku, K., Fujioka, T., and Shimizu, T. 2009. Action mechanism of a novel herbicide, pyroxasulfone. Pesticide Biochemistry and Physiology 95: 47-55.

Tranel, P. J. Predicting the evolution and spread of glyphosate-resistant waterhemp. Pages 68-69 in Proceedings of the Illinois Crop Protection Technology Conference. Champaign, IL.

Tranel, P. J. Herbicide resistance in waterehemp: Past, present and future. Pages 37-40 in Proceedings of the Integrated Crop Management Conference. Ames, IA: Agribusiness Education Program.