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WEED MANAGEMENT 2005: WEED SHIFTS, HERBICIDE RESISTANCE, ISSUES AND OPPORTUNITIES

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Introduction

A number of factors influenced the record crop in Iowa during 2004. While weed control was generally good, the cool and wet conditions enhanced potential injury from a number of herbicides. Furthermore, with increase adoption of transgenic glyphosate resistant corn and soybean, changes in weed populations, either weed population shifts or the evolution of resistant weeds, must be given due consideration for a successful 2005 growing season. The paper will describe some of the issues and opportunities facing Iowa growers in the next growing season.

Weed Population Shifts

Agroecosystems impart selection pressure on weed communities that inevitably result in weed population shifts. The most important selective forces on a weed community in an agroecosystem are the tillage and herbicide regimes. The adoption of herbicide resistant (HR) crops potentially causes greater selection pressure on the weed community due to a limited number of different herbicides used than other herbicide systems. Increased selection pressure will increase the number weed population shifts and the speed at which these changes occur.

Selection pressure imparted by herbicide tactics can result in weed shifts attributable to adaptation of the weed species to the production system, the natural resistance of a particular species to the herbicide, or the evolution of herbicide resistance within the weed population. An example of a weed shift attributable to the biological adaptation of the weed is the increase in woolly cupgrass. A weed shift attributable to natural herbicide resistance is exemplified by the isolated problems with Asiatic dayflower, and an example of evolved herbicide resistance is the widely distributed populations of common waterhemp resistant to ALS inhibiting herbicides. All of these types of weed shifts can occur in response to grower adoption of crop production systems based on a HR crop and the resultant application of the herbicide.

Evolved Herbicide Resistance

Numerous (174) weed species have evolved resistance to a number of herbicides in many, if not most, agroecosystems. In Iowa, resistance to triazine herbicides in common lambsquarters and pigweed species has been identified, and resistance to ALS inhibiting herbicides has been widely documented in common waterhemp, common sunflower, common cocklebur, giant ragweed, and shattercane. To date, no resistance to PPO inhibiting herbicides or glyphosate have been identified. However, with glyphosate resistant crops being widely adopted, and the applications of glyphosate increasing, it is argued that the evolution of HR weed populations will escalate rapidly.

Given the inevitability of evolved herbicide resistance, it is important to consider tactics to deter or delay the development of resistant weed populations. Several strategies have been proposed
that may effectively impact the evolution of herbicide resistance; the alternation of low and high herbicide rates, the rotation of herbicides with different modes of action, or the use of herbicides in combination. The latter has been modeled and appears to substantially delay herbicide resistance when compared to the rotation of herbicides. Below is a brief update of currently important herbicides and cases of evolved resistance as related to the adoption of HR crops.

**Horseweed (Conyza canadensis)**

Horseweed evolved eight- to 13-fold glyphosate resistance within three years of the adoption of glyphosate resistant soybean and the concomitant use of glyphosate. Horseweed, like many other weeds that have evolved herbicide resistance, appears to have the “innate ability” to evolve resistance to herbicide with different mechanisms of action. Anecdotal reports suggest that glyphosate resistant horseweed populations are now frequent in the mid-Atlantic, mid-south, Mississippi River Delta and Midwest regions of the United States and represents a serious problem in no-tillage production systems. To date, no glyphosate resistant horseweed populations have been identified in Iowa. However resistance has been identified in Illinois and Missouri.

Herbicide resistance in a weed like horseweed is the worst case scenario. Notably, horseweed is adapted to conservation tillage agroecosystems, is primarily self-pollinated but can cross-pollinate (<10%), and produces many seeds that are wind-dispersed. Furthermore, recent research reports from Iowa State University indicate that the resistance trait in glyphosate resistant horseweed is due to an incompletely-dominant single locus nuclear gene. Thus, the rapidity of the evolution of glyphosate resistance in horseweed and the large geographical distribution of these populations is understood. Furthermore, the difficulty of managing horseweed indicates that this is a significant agronomic problem unless tillage is reintroduced into the agroecosystem.

**Common Waterhemp (Amaranthus tuberculatus)**

Common waterhemp control in the Midwest with glyphosate has been variable with anecdotal reports of resistant populations. Most of the management problems are attributable to the inherent characteristics of this weed. These characteristics include variable dormancy and requirements for germination, an extended germination period, high seed productivity and an apparent adaptation to conservation tillage programs. Furthermore, poor management decisions such as reduced herbicide rates, delayed application timing and poor application technique also contributed to the widespread problems controlling common waterhemp. The relatively recent and widespread adoption of glyphosate resistant soybean was directly implicated in the new development of common waterhemp management issues.

The first investigated reports of control problems were in 1998 from Badger and Everly, Iowa and resulted in an assessment that portions of the common waterhemp population in those fields were not responding to multiple applications of glyphosate, while the majority of the population was sensitive. Reports from other Midwest states corroborated the findings from Iowa and suggested that common waterhemp plants survived high rates of glyphosate and produced viable seed. Tests conducted at Iowa State University demonstrated a 1.7- and 3.5-fold increase in resistance to glyphosate. The specific mechanism(s) of glyphosate resistance in common
waterhemp have yet to be determined.

**Interspecific hybridization between weed species: another potential problem**

Interspecific hybridization between indigenous weedy plants has been commonly reported and natural hybridization in *Conyza* has been documented in numerous instances. Typically, these hybrids do not evolve into significant weed problems. However, the implication of hybridization between HR and sensitive weed populations and the introgression of the resistance trait is important. Given that glyphosate resistant horseweed has become a significant problem the potential for interspecific hybridization with glyphosate susceptible dwarf fleabane (*Conyza ramosissima*) was determined to be possible.

Other interspecific hybrids that can occur include sunflower (*Helianthus*) species, ragweed (*Ambrosia*) species, and sorghum (*Sorghum*) species. In each case, hybrids have been shown to occur, and resistance to ALS inhibiting herbicides will introgress into the hybrid. The implications of interspecific hybridization are not currently known, but importantly, this ability is indicative of the complexity of weed communities in agroecosystems.

**Naturally resistant species**

A number of weeds have been described as having inherent resistance to various herbicides. Glyphosate resistance has been an important consideration for many years, but was brought to prominence with the adoption of glyphosate resistant crops. Examples of weeds that can be described as having natural resistance to glyphosate are listed below.

**Asiatic dayflower (*Commelina communis*)**

Recent grower reports suggest that dayflower species are becoming serious weed problems in isolated soybean, peanut and cotton fields in the Midwest, mid-south and southeast. In Iowa, the occurrence of Asiatic dayflower is attributable to the adoption of glyphosate resistant crops and the concomitant use of glyphosate as the primary or sole strategy for weed control. It is important to note that Asiatic dayflower is not listed on the glyphosate label as a sensitive species and control is not claimed. Apparent natural tolerance to glyphosate and other biological characteristics contribute to the inability of growers to effectively manage this weed. The best Asiatic dayflower control was provided by three timely applications of glyphosate, but sufficient escapes occurred, thus suggesting that the weed would increase in future prominence.

**Velvetleaf (*Abutilon theophrasti*)**

Velvetleaf has historically been described as difficult to control with glyphosate. However, the natural resistance of this economically important weed to glyphosate was not an issue until the wide spread adoption of glyphosate resistant soybean. Recent reports suggest that the survival of velvetleaf after exposure to glyphosate is rate dependent but can be quite high. Plants were damaged and biomass accumulation compared to untreated velvetleaf was reduced 90% by the high glyphosate treatment. However, injured plants did develop viable seed, thus suggesting an increasing problem for future velvetleaf management with glyphosate.

**Common lambsquarters (*Chenopodium album*)**
Common lambsquarters is adapted to conservation tillage systems and has been a difficult weed to manage, irrespective of the tactic used. Recent anecdotal observations in Iowa, Minnesota and Wisconsin suggested that common lambsquarters populations were not responding to glyphosate in glyphosate resistant soybean. Field investigations by the author resulted in an assessment that poor management decisions, unfavorable weather and other biologically controlled factors, rather than natural resistance to glyphosate, were the cause of the inconsistent common lambsquarters control. However, other observations (C. Boerboom, personal communication) suggested that indeed, phenotypic differences in natural resistance occurred in common lambsquarters. The author suggests that this weed will continue to increase in prominence and the use of transgenic glyphosate resistant crops will exacerbate the problem.

**Herbicide Resistant Crops as Weeds**

Corn and soybean have been consistently volunteer weeds in production systems where corn and soybean are rotated. However, very little information is available that describes the management or economic importance of the problem. Growers generally do not see volunteer corn or soybean as a serious problem and historically, acceptable management tactics exist. However, with transgenic glyphosate resistant traits, management of volunteer corn and soybean could become more costly. The biggest potential impact would be where the herbicide resistance trait was the same in the rotational crops (e.g. glyphosate resistant corn as a volunteer weed in glyphosate resistant soybean). However, if the HR corn volunteers into a conventional cultivar soybean, or if the transgene is for resistance to insects or plant pathogens, the volunteer herbicide resistant corn would not have a significant impact on the management tactics.

**Herbicide Drift**

Herbicide drift continues to be an issue in Iowa production systems, particularly as the adoption of transgenic glyphosate resistant soybean and postemergence applications of glyphosate increases. One of the most common complaints received this growing season was glyphosate drift on corn. Damage, while subtle, was in evidence widely across the state. Also, sprayer contamination was a common problem. Similarly, plant growth regulator herbicide drift to soybean was also a frequent problem, as was problems from sprayer contamination. These are problems that can be resolved to some degree with better management.

However, in 2004, given the wet conditions, days when conditions were appropriate for relatively drift free applications were rare. Thus, applications were made when drift was essentially guaranteed. Growers and custom applicators need to re-evaluate strategies and give serious consideration to alternatives that will allow better environmental stewardship and less risky weed management.

One very cost effective and time utilization efficient strategy to better manage potential drift is to use an early preplant herbicide application of a residual herbicide. The weed control derived from this application greatly broadens the window of opportunity for a drift-managed post application.

**Herbicide Injury**

Injury as a result of an herbicide application to the crop was observed during the 2004 growing
season, but was not a serious nor widely spread problem. There were also some instances of herbicide carryover from products applied in 2003. Environmental conditions which were generally cool and wet throughout the 2004 growing season enhanced the potential for herbicide injury, and to some degree, lessened the recovery of the crop.

Authority and Valor caused injury to soybean, particularly specialty soybean. In most instances, the injury was limited to foliar injury of the cotyledons or first trifoliates when treated soil splashed onto the tissue during hard rains. Valor injury was somewhat more serious and in some instances killed the terminal bud. In most situations, the fields recovered.

In southwest Iowa, Lumax carryover was observed on soybean in isolated fields. Given the conditions in 2003, the occurrence of some carryover situations was not unexpected. Usually injury was along turn rows and field margins and typically did not result in significant loss of stand. Carryover should not be a major consideration with regard to the use of Lumax. However, in lighter soils, later applications should be avoided.

**Metolachlor**

A number of generic metolachlor products are currently available and have been marketed at the same use rates as Dual II MAGNUM. These generics are formulated with the isomeric mixture of metolachlor molecules, as compared with the resolved isomer metolachlor in Dual II MAGNUM. See articles in the Iowa State University Weed Science Webpage for specific details (http://www.weeds.iastate.edu/mgmt/2000/stalwart2.shtml and http://www.weeds.iastate.edu/mgmt/qtr00-1/isomers.htm). While there has been some field results to support the claims of the companies marketing the generic mixed isomer products that their products provide equivalent control, it is suggested that there is a greater risk of consistent weed control with the mixed isomer metolachlor unless a higher rate is used.

**Conclusions**

Given the record yields in corn and soybean in 2004, expectations are high for 2005. It is anticipated that transgenic glyphosate resistant soybean will continue to dominate production fields and transgenic glyphosate resistant corn will increase. However, recognize the benefits of the transgenic crops must be evaluated with due consideration given to the risks. While glyphosate provides excellent weed control, there is strong evidence that weed communities are responding to the selection pressure and new and more difficult to manage weeds are becoming more prominent. Further, growers continue to tout the glyphosate based weed control systems as simple. Nothing could be further from reality. While glyphosate will effectively kill a wide variety of weeds and is effective on larger weeds, the purpose of herbicide applications is to protect potential crop yield. This implies that in order to be successful with a post herbicide, the timing must be prior to the (unpredictable) moment with weeds begin to interfere with yield potential. Given the acres that must be treated post, and the importance of managing herbicide drift, it is becoming increasingly difficult to make a timely first post application. A better tactic to manage risk is to use an initial residual herbicide application and follow with a post treatment.