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Weed management update, 1999

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Introduction

There have been a number of new herbicides registered, co-packs introduced, and prepackage mixtures developed. Also, there have been some new developments with some of the common weeds in Iowa. Finally, there has been a rapid adoption of the glyphosate resistant technologies. The purpose of this paper will be to assess these changes and provide some indication as to their significance to Iowa agriculture.

New herbicides

Aim (carfentrazone) is a new herbicide introduced by FMC for postemergence application in corn. Aim will be available as a 40% WDG and is labeled for field, silage, seed corn, and popcorn. Aim is a PPO inhibitor and in the same chemical family as Authority (sulfentrazone). Aim is labeled to control a limited number of weeds when they are one to four inches tall including black nightshade, velvetleaf, morningglories, common lambsquarters and redroot pigweed. Velvetleaf can be controlled as large as 36 inches tall. Apply 1/3 oz Aim per acre with 0.25% v/v. Aim can be tank-mixed with atrazine, Banvel, Clarity and 2,4-D for improved control of a broader spectrum of weeds. Other labeled tank-mixes include Accent, Basis, Beacon, Exceed, Hornet, Marksman, Permit, Scorpion III, Spirit, and Liberty. When conditions are dry, crop oil concentrate can be used, but the potential for corn injury increases.

Axiom (flufenacet [proposed] plus metribuzin) is prepackage herbicide mixture introduced by Bayer for preplant surface, preplant incorporated, and preemergence application in corn and soybeans. Axiom is formulated as a 68% DF and contains 54.4% flufenacet and 13.8% metribuzin which equals 0.17 lb/A metribuzin in 16 oz/A flufenacet. The rate range in corn is 13 to 23 oz/A of Axiom while in soybeans, the range is seven to 13 oz/A. In soybeans, Bayer claims only early season control of sensitive weeds for medium and fine textured soils.

Balance (isoxaflutole) from Rhone Poulenc has finally received registration and is available as a 75% WDG. Balance is labeled for preplant, preplant incorporated and preemergence application for use in field corn. Balance inhibits pigment synthesis and sensitive plants have a bleached appearance similar to those affected by Command. However the specific site of herbicide action for Balance is different than that of Command. The application rates are one to three oz/A, depending upon application technique and soil characteristics. Balance controls a number of small-seeded annual broadleaf weeds and has activity on woolly cupgrass. Balance will provide
control of velvetleaf but is weak on common cocklebur. Balance provides some control of
foxtails. Corn has been injured from Balance, but the injury is typically short-lived. Conditions
that favor injury are cool, moist soils and shallow planting.

Balance was given a three-year, geographically restricted registration due to concerns expressed
by the EPA for off-target movement of Balance resulting in damage to sensitive plants and
ground and surface water contamination. While isoxaflutole is fairly mobile in soils, it is
metabolized rapidly. However the primary metabolite is also mobile in soils but is slower to
degrad. Thus, the EPA has issued a Balance label for 16 states in the corn-belt, but has not
offtered a label for Minnesota and Wisconsin.

Celebrity (dicamba and nicosulfuron) is a co-package mixture of Banvel and Accent and
represents a marketing agreement between BASF and DuPont. Celebrity is registered by BASF
for postemergence application in field corn, seed corn and popcorn. Celebrity has two packages,
the Celebrity B package has three pounds of dicamba and the Celebrity G package has 5.33
ounces of nicosulfuron. Thus, at a rate of 6.67 oz/A, one “package” of Celebrity can be used to
treat eight acres which represents 6 oz/A dicamba and 0.67 oz/A nicosulfuron. Apply Celebrity
broadcast postemergence or with drop nozzles in corn up to 20 inches tall or with six or fewer
leaf collars (V6), whichever is more restrictive. A rescue application can be made on corn from
20 to 36 inches with drop nozzles. Do not apply to corn taller than 36 inches or exhibiting 10 or
more leaf collars (V10). Applications to corn with 7 to 10 leaf collars may result in ear
malformation. Celebrity controls a relatively broad spectrum of annual weeds.

Leadoff is a prepackage mixture of dimethenamid (Frontier) and atrazine and will be marketed
by DuPont for broad-spectrum weed control in field corn, seed corn, sweet corn, popcorn and
grain sorghum. Leadoff is similar to Guardsman and is formulated as a five pound gallon
material with the same amount of dimethenamid/atriazine (2.33/2.67 lbs/gal) as Guardsman.

Northstar is a prepackage mixture of primisulfuron (Beacon) and dicamba (Banvel) marketed
by Novartis for postemergence weed control in field corn, silage corn, seed corn and popcorn.
Northstar will be positioned as a replacement for Exceed in Iowa and will provide control of
annual broadleaf weeds and suppression of some annual grasses. Northstar is formulated as a
47.4% WDG and the five oz/A application rate is the equivalent of 0.5 oz/A Beacon and 3.6 oz/A
dicamba. Northstar is targeted for corn that is 4 to 12 inches tall (V2-V4), but may be broadcast
applied to corn as tall as 20 inches (V6). Corn that is 20 inches up to 36 inches, or at least 15
days prior to tassel, whichever is more restrictive, should be treated post-directed to minimize
crop injury.

Northstar can be tank-mixed with Aatrex, Accent, Resource, and Tough for improved weed
spectrum. Include a nonionic surfactant (0.25% v/v) or crop oil concentrate (1-4 pt/A, not to
exceed 2.5% v/v) with Northstar. Do not use a crop oil concentrate on corn taller than 12 inches
tall. Liquid nitrogen fertilizer (28-34% nitrogen-ammonium form) can be added at 2-4 qt/A or
spray grade ammonium sulfate at 2-4 lb/A can be added to Northstar in addition the other
adjuvants. Northstar has the same organophosphate insecticide and rotational restrictions as
Beacon.

**Glyphosate resistant crops**

The use of glyphosate-resistant soybeans has increased rapidly over the last few years. An
estimated 1 million acres of RR soybeans were planted in 1996. In 1997, 9 million acres were
planted and last year, an estimated 28 million acres of glyphosate-resistant soybean varieties were
planted in the United States. This represents approximately 39% of the soybean acres in the United States and projects are for this number to increase in 1999. Survey data from 1998 indicate that 50% of the acres were from first-time users of the technology. There are adapted varieties available throughout the soybean production area and approximately 300 soybean varieties now contain the Roundup Ready technology.

Importantly, Monsanto has licensed glyphosate to Cheminova, NuFarm and Novartis. When glyphosate goes off patent in the United States, it is anticipated that a number of other companies will also enter into licensing agreements with Monsanto. While Monsanto currently supplies most of the glyphosate for the world market, many other countries are manufacturing glyphosate due to the world patent situation. For example, there are approximately 30 Chinese manufacturers of glyphosate. Further, the world glyphosate price is considerably lower than the price currently paid in the United States.

Results with Roundup Ready technology have generally been good. However, there are still significant management concerns. Application timing continues to be a major problem, both from the perspective of determining when the herbicide should be applied to protect the soybean yield, but also finding the opportunity to make the application. Given the strong influence that environmental conditions have on the occurrence and severity of weed interference in any given field, it is unlikely that major improvements on the prediction of application date will be made. Further, with the strong trend to custom application and the limited equipment available, it is suggested that the problem of finding time to make glyphosate applications will only get worse.

Another consideration with glyphosate use is the concern for off-target drift during applications. It is critical to recognize that all herbicide applications are prone to drift, not just glyphosate. However there may be some key considerations to this technology that supports added concerns for glyphosate drift. Mueller and Womac (1997) reported that the Roundup Ultra formulation caused a higher percentage of spray droplets less than 191 microns in diameter to occur when compared to the Roundup formulation. The smaller the spray droplet, the greater the drift potential. Further, with the large acres anticipated for RR technologies and the relatively narrow window available for application timing in order to protect soybean yields from weed interference, the custom applicator will likely make applications with conditions favor drift.

In 1998, second and third glyphosate applications were often used to meet weed control expectations. Whether or not yields will reflect the delayed initial applications that are used is, as of yet, not determined. However, given that moisture was typically not limiting, it is suggested that in most situations, weed interference was not a factor as early as it might be and thus there was a longer period in which to make the applications. Weeds did become larger in these situations and were more difficult to control. Also, with the rainfall, there were a number of weed flushes and thus more glyphosate applications were needed to achieve the desired level of weed control. One of the major problems in 1998 for the RR technology was common waterhemp control.

Iowa State University suggests that while growers have achieved some success with using only glyphosate in these systems, a better, less risky strategy would be to include other weed management techniques. These could include the use of a soil-applied herbicide that has residual weed efficacy or mechanical treatments such as rotary hoeing and cultivation. If the sole weed management program is the use of multiple applications of Roundup, weeds that no longer
respond to glyphosate, whether the reasons is resistance (Powles et al. 1998) or biological adaptation (Hartzler 1998), are likely to develop quickly. To that end, Monsanto appears to have softened with regard to their approach to using residual herbicides and Roundup Ready technology.

Roundup Ready corn technologies are continuing to expand. It is estimated that there will be four to five million acres of RR corn in 1999. These acres will be planted with Dekalb and Asgrow seed. Monsanto purposes three application strategies. These are the use of a preemergence herbicide followed by glyphosate postemergence, a postemergence application of a tank-mix combination of a residual herbicide and glyphosate, and a split postemergence application of glyphosate. It is suggested that the first strategy poses the least weed management risk while the second strategy has the greatest risk of weed management problems.

For the preemergence followed by postemergence strategy, Monsanto suggests that 50 to 75% of the residual herbicide be applied preemergence. Glyphosate at 24 to 32 oz/A should be applied postemergence before weeds exceed six inches in height. If the corn is taller than 24 inches, the glyphosate should be applied with drop nozzles. The postemergence tank-mix option must be applied prior to weeds exceeding four inches in height and using the above-suggested rates of residual herbicide and glyphosate. The postemergence sequential strategy includes glyphosate at 24 to 32 oz/A before weeds exceed four inches in height followed by glyphosate at 24 to 32 oz/A after the next weed emergence event.

Monsanto emphasizes the need to start with a weed-free field. The even start concept, which provides the corn crop with a competitive head-start over the weeds (Staniforth, personal communication), is a recognized strategy and endorsed by Iowa State University. Glyphosate can be applied to corn from emergence until the corn is 30 inches tall, or has eight leaf collars (V8), whichever is more restrictive. The maximum single application of glyphosate to Roundup Ready corn is 32 oz/A and a total amount of glyphosate applied to the corn, excluding pre-harvest treatments) must not exceed 64 oz/A.

Problem weeds

Woolly cupgrass tends to germinate earlier and at higher populations than other annual grass weeds (Hartzler 1996a; Hartzler 1996c; Hartzler and Buhler 1997). Woolly cupgrass germinates several weeks earlier than giant foxtail (Setaria faberii L. Herrm) and exhibits a narrow emergence period (Hartzler 1996c). However, woolly cupgrass will also germinate later in the season and has been observed to have as many as eight germination cohorts during one growing season (Owen, 1990). Recent data by Liu (unpublished) supports the importance of the first, early germination cohort but also indicates that multiple germination events contributes to the management difficulties of woolly cupgrass.

Bello (1988) reported that woolly cupgrass could successfully germinate in a temperature range of 50°F to 104°F and successfully emerge at the soil surface or as deep as 4 inches. Franzenburg (1994) suggested that there was a strong genetic component to woolly cupgrass adaptability and genotypic characteristics that influence dormancy and germination are conserved. Thus, the biological flexibility makes woolly cupgrass extremely well adapted to succeed in the conservation tillage systems that dominate current agriculture.

Importantly, the deeper emerging and later germinating woolly cupgrass seedlings are more likely to escape herbicidal control. Deeper germinating seedlings will contact less herbicide due to concentration gradients from the soil surface to lower soil depths. Herbicides degrade over the
growing season; thus there will be less herbicide available to control later germinating woolly cupgrass cohorts.

Woolly cupgrass has demonstrated the ability tiller rapidly and profusely (Bello 1988; Pecinovsky 1994). This ability was considerably greater than giant foxtail and was suggested to be a primary feature in the competitive ability of woolly cupgrass. However, recent unpublished research by Liu suggested that tillering had a significant impact on the herbicide response demonstrated by woolly cupgrass. This research expanded upon observations woolly cupgrass survived nicosulfuron applications by initiating new tillers (Pullins 1995). Liu (unpublished data) demonstrated that there was a vascular connection between the main stem and all tillers and that nicosulfuron would translocate from the main stem to all tiller buds. He speculated that tiller re-initiation resulted in poor control of woolly cupgrass even when observations suggested that the main stem was killed by the herbicide. The exact mechanism by which tillers were able to tolerate the herbicide was not described.

When developing a woolly cupgrass management program, all tools should be considered and used as appropriate. Importantly, the management program must be developed to accommodate the crop agroecosystem and biological characteristics of woolly cupgrass. With intense management, woolly cupgrass can be eliminated from a field in three years (Liu, unpublished data). However, to accomplish this, seed production and importation in the field must be eliminated. A more realistic goal is to maintain or diminish the seedbank and eliminate yield losses attributable to woolly cupgrass competition. This requires an integrated program utilizing tillage, crop rotation, sanitation, mechanical tactics, and herbicides (Owen 1990; Hartzler 1996a).

Liu (unpublished data) demonstrated that tillage lessened the woolly cupgrass seedbank when compared to a no-tillage system and also caused seedlings to germinate deeper. Importantly, tillage can be timed to effectively destroy the initial germination cohort without a loss of potential yield for corn and soybeans. Further, soil-applied herbicides tend to have more consistent efficacy when applied to a production system with lower amounts of plant residue on the surface. Weeds tend to germinate more uniformly in time and soil depth with tillage, compared to no-tillage, and thus subsequent management strategies can be timed more accurately and are likely more effective. It is important, however, to balance the benefits of tillage for woolly cupgrass management with the risks of soil erosion.

The adaptability of woolly cupgrass to circumvent single management strategies, whether the strategy is herbicidal, mechanical, or cultural, dictates that growers develop an integrated management program. Not all strategies will be needed every year. However, if alternative tactics are eliminated without consideration of the risk their loss to an economically effective woolly cupgrass management

**common waterhemp** is a relatively new weed problem and generally, there has been little research conducted. Most of the research has focused on the relationship of this weed complex with herbicides. Specifically, due to difficulties in controlling common waterhemp with herbicides that inhibit acetolactate synthase (ALS) activity, there have been numerous studies describing ALS resistance (i.e. Hinz and Owen 1997) but little biology research.

However, at Iowa State University, weed scientists have begun to focus on the biology, ecology and biochemistry of common waterhemp (Hartzler 1996b; Hartzler 1996c; Hartzler 1997; Hartzler and Buhler 1997; Pratt et al. 1997; Pratt et al. 1998). Without an understanding of how common waterhemp populations develop, how the plant grows, the taxonomic characteristics of
the waterhems, and mechanisms of herbicide tolerance/resistance, it is not possible to develop effective management programs.

Hartzler and Buhler (1997) have initiated an extensive weed emergence research project in 1995. This research was begun because they recognized that current weed management strategies focused only on herbicide selection and were not providing the consistent control of weeds needed to insure economic success for producers. They understood that an understanding of weed emergence was critically important to improve the effectiveness of herbicide and to reduce the negative environmental impact of herbicides. A description of common waterhemp emergence patterns was a significant part of this research.

Hartzler (1996c) reported that common waterhemp emerged consistently late in the growing season. This pattern of late and extended emergence has been consistent over several management strategies. In many weeds, late emergence is not a major management issue because the crop canopy effectively competes with the weed. However, common waterhemp is able to emerge late and grow through the crop canopy (Owen, personal observation).

The biological and morphological reasons to support this observation are not fully understood. However, research by Hartzler and Battles (unpublished data) demonstrates that the crop canopy does have a significant effect on common waterhemp survival and growth. Common waterhemp that emerged after crop planting demonstrated a lower survival with the crop. However, some common waterhemp plants were able to survive even when they emerged when soybeans had six trifoliates.

Other biological characteristics that contribute to the rapid increase in common waterhemp populations are high seed production and an ability to germinate from shallow soil depths (Hartzler 1997). Small-seeded annual weeds like common waterhemp must be near the soil surface to successfully germinate and emerge. Reduced and no tillage systems which have increased in the Midwest favor the establishment and success of common waterhemp populations.

Recently, there have been several locations where common waterhemp control from glyphosate was inconsistent and poor. Cursory evidence has demonstrated a differential response by these populations to glyphosate rates that control other populations of common waterhemp. Field inspection by the author has ruled out poor application technique and application timing. The grower used multiple applications of glyphosate at rates that should provide control of most annual broadleaf weeds. Research is underway to determine the specific mechanisms responsible for the poor efficacy on these common waterhemp populations.

Observations by the author suggest that morphology may play a significant role in common waterhemp responses to postemergence herbicides. However, there have not been any definitive studies conducted to define this role. Common waterhemp appears to have the ability to grow rapidly and elongate stem length. This ability may have implications on herbicide translocation. Further, given the overall size of common waterhemp plants, there appears to be relatively little leaf area. Herbicide coverage and uptake may be negatively affected by the lack of leaf area. Finally, common waterhemp has multiple meristems at each leaf axil and the base of each branch. These could affect herbicides whether they are translocated or contact types.

There are several problems that must be resolved to develop an effective common waterhemp management program. Generally, common waterhemp seedlings are sensitive to most soil-applied herbicides. Acetamide, triazine and dinitroaniline herbicides are all effective. However, the delayed emergence of common waterhemp and applications of these herbicides early in the
spring result in inconsistent control. The rates of soil-applied herbicides commonly used will not last until most of the common waterhemp emerges (Hartzler 1997). Like other weeds, effective common waterhemp management programs are diverse and integrate a number of strategies.

Conclusions

There are several important changes occurring in Iowa agriculture. Some of these are positive, such as the introduction of new herbicides and the implementation of new technologies. Others are observed to be negative; the increasing problems with off-target herbicide movement, herbicide resistant weeds and increasing common waterhemp populations. The key to improving the economic sustainability of agriculture is to modify the system to best meet the goals of the grower and address the specific problems within particular fields. While using one system over a wide area may appear convenient and cheap, typically there is a greater cost of the convenience than is realized in the economic sustainability of the strategy.

Literature Cited


