2009 Herbicide Guide for Iowa Corn and Soybean Production

New herbicide products for 2009

Robert Hartzler, extension weed specialist, Iowa State University

Several new products are, or are expected to be, available for use in the 2008 growing season. It is wise to evaluate how any new technology fits within an operation by initially using on a limited basis. However, since most of the new products are based on previously registered active ingredients, many farmers may already have experience with these materials. In addition, since most active ingredients are off patent, they may be sold under new trade names by a variety of manufacturers. Failure to include these products in this bulletin is not intended to imply non-approval.

BASF

Distinct is now labeled for burndown applications in soybean. Apply at a rate of 2-4 oz/A at least 30 days ahead of planting.

Status is registered for use on popcorn. Apply 5 to 10 oz/A when popcorn is 4 to 36" tall, at least 15 days before tassel emergence.

Bayer CropScience

Ignite 280 will replace Liberty for use with Liberty Link corn and soybean. Ignite 280 contains 2.34 lbs glufosinate/gallon, whereas Liberty contains 1.67 lb glufosinate. The recommended rate for both LL corn and soybean is 22 oz/A, and two applications per season are allowed. Ignite at 22 oz provides the equivalent amount of glufosinate as 30.7 oz of Liberty. The addition of 3 lb AMS/A is required with Ignite on LL corn. Ignite should be applied in a minimum of 15 GPA using nozzles producing droplets in the Medium category size.

Balance Flexx is a new formulation of isoxaflutole (Balance Pro) that will include a crop safener. It will be labeled for preplant, preemergence and early postemergence applications in corn. Registration is expected in time for the 2009 growing season.

Corvus is a premix containing isoxaflutole (bleacher), thiencarbazone-methyl (ALS inhibitor), and a safener. It will be labeled for use in corn from preplant applications to early post applications. Use rates range from 3.3 to 5.6 oz/A. Bayer anticipates EPA approval in time for the 2009 growing season.

DuPont

Resolve Q is a multipack containing rimsulfuron and thifensulfuron plus a crop safener. It will be marketed primarily as a tank-mix partner with glyphosate for POST applications in RR corn. Thifensulfuron (Harmony) will improve control of certain broadleaf species (not waterhemp since most is resistant to ALS herbicides) and provide short residual control of certain grasses. It is labeled for application to corn up to 20 inches tall or exhibiting less than six collars. Use rate is 1.25 oz/A.

Require Q is a multipack containing rimsulfuron and dicamba plus a crop safener. It will be positioned as a tank-mix partner with glyphosate in RR corn for improved broadleaf control and short residual control of grasses. The use rate is 4 oz/A on corn up to 20 inches tall or exhibiting less than six collars.

FMC

Cadet contains fluthiacet, a PPO inhibitor. Cadet is labeled for postemergence use in both corn (field, sweet and popcorn) and soybean at rates of 0.4 to 0.9 fl oz/A. The 0.4 oz/A rate is recommended for tank-mixes with glyphosate. Cadet controls many annual broadleaf weeds, and is particularly strong on velvetleaf. Fluthiacet was evaluated by Norvartis (Syngenta) in the late 1990's under the tradename Action, but was not released for sale.

Monsanto

Harness and **Degree** have been changed from Restricted Use to General Use products. It is anticipated that sweet corn will be added to the label of Harness, Harness Xtra and Degree in time for the 2009 growing season, and additional rotational crops will be added.

Syngenta

Callisto received clearance for use on several new crops, including oats.

Lumax, **Lexar** and **Camix** added sweet corn and yellow popcorn to the list of registered crops. A statement not to apply other HPPD inhibiting herbicides (Callisto, Impact, Laudis) to treated fields during the same growing season was added to the labels.

Valent

Valor has been registered for use on no-till or minimum till corn at a rate of 2.0 oz/A. Application must be made 14-30 days ahead of planting

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Stewardship concerns: Weed management requires more stewardship

Mike Owen, extension weed specialist, Iowa State University

Introduction: While recent discussions and publications have stressed the need for stewardship to preserve the utility of glyphosate resistant crops and glyphosate, the conversation needs to expand and include weed management in general. There is anecdotal evidence that Iowa now has populations of PPO inhibitor herbicide resistant common waterhemp and concerns about glyphosate resistance in Iowa weed communities continue to grow. Surveys conducted last year demonstrate that growers and AgChem dealers see a different picture with regards to pending weed issues. Reports suggest that overall weed control in the glyphosate-based production systems is not as good as originally experienced when glyphosate resistant soybeans were introduced. Thus the intent of this paper is to discuss the need to establish stewardship of weed management in Iowa crop production systems and provide a perspective of the importance of stewardship to crop profitability.

The problem: Weeds adapt to the management tactics used to produce crops. The adaptation can be phenological (i.e. extended period of germination) or biochemical (i.e. evolved herbicide resistant). In either case, the adaptation is heritable and results in weed populations that are more costly. The adaptation is a function of the specific tactic which selects for heritable traits within the weed community (species or biotypes within species) that are less affected by the tactic. In essence, this is Darwinian evolution in fast forward; the fittest plants survive and become greater economic problems.

A management tactic that has a high impact on the crop production system (i.e. tillage) imparts the greatest selection pressure on the weed community. While herbicides are typically thought to have the greatest impact on weed communities, all management tactics may impart selection pressure and thus influence changes in the weed community. Unfortunately, these factors may interact and thus complicate our ability to fully understand the implications of weed management decisions. Tillage is likely the most influential management practice that affects weed communities. Reduced tillage systems have different weed communities than aggressive tillage systems. The increasing prominence of winter annual and perennial weeds in Iowa crop production systems is an indication of the influence that tillage has on weed communities and illustrates the selection pressure that is imparted upon the system.

In the case of herbicides, there are numerous examples of the selection they impart on weed communities. The evolution of weed resistance to ALS inhibiting herbicides (i.e. Pursuit®) was the result of consistent and repeated use of these products. Currently, the use of glyphosate is causing changes in weed communities and these changes are occurring at an increasing rate. Interestingly, growers are apparently less concerned than AgChem Dealers (Figure 1). AgChem Dealers suggested that glyphosate was providing **less control** of common lambsquarters (56% of the AgChem Dealers reported less control), common waterhemp (63%), and giant ragweed (50%) than what was previously experienced. A majority of growers reported that the control of these weeds by glyphosate **had not** declined (values ranged from 65% to 56% reporting no change in control). The only consensus between AgChem Dealers and growers was with common ragweed where reported control with glyphosate had not declined (64% and 73% for AgChem Dealers and growers, respectively).

The dramatic difference in opinions comparing AgChem Dealers and growers likely reflects the broader view that AgChem Dealers have compared to growers. Growers may not be aware of new weed issues until they appear on their farm while AgChem Dealers see the issues more widely. Regardless, this discrepancy does not bode well for proactive stewardship of weed management tactics; typically changes in weed management are not made until the problem occurs. Unfortunately, when growers recognize that the problem has indeed appeared these "new" problems likely will have become established in fields and will remain problems for a long time.

The solution: The solution to the problem of weeds adapting to crop production systems is to make a conscious and consistent effort to include stewardship. This begs the obvious question; "what is stewardship?" Stewardship is based on the word "steward" which is a Middle English word derived from Old English "*stigweard, st ward : stig, st , hall + weard, keeper*". The modern definition, based on the Merriam-Webster dictionary is "*the conducting, supervising, or managing of something; especially : the careful and responsible management of something entrusted to one's care <stewardship of our natural resources>*". The latter definition fits well for agriculture and in particular, weed management. However, the definition needs more teeth if it is to be useful to production agriculture. Thus, not only must stewardship practices "provide careful and responsible management" of herbicide resistant crop traits and herbicides but stewardship also must be profitable However, most options that provide stewardship are not thought to be convenient or simple by growers. This represents the conundrum; while stewardship has untold future value (i.e. by preserving the utility of herbicides) and provides for immediate economic return (i.e. protecting crop yield potential), tactics are perceived to be difficult to implement. However, stewardship tactics can actually provide for better time management as well as protect crop yield potential and preserve important agronomic traits and herbicides. Below are general recommendations for developing

and effective and economically rewarding stewardship program.

Conclusions: Growers and AgChem Dealers are reticent to establish stewardship in weed management for a number of reasons, including but not limited to the presumption that stewardship is costly, complex and inconvenient. None of these objections are correct; the inclusion of stewardship in a weed management program will make growers money and there is nothing simple or convenient about trying to manage a well-adapted weed population, whether resistant to the herbicide or ecological superior in the tillage program. The easiest stewardship practice to implement is the use of alternative herbicides applied as an EPP treatment. An ongoing on-farm ISU research project conducted in several states, including Iowa, over the last three years has demonstrated enhanced yields of corn and soybean when a soil-applied residual herbicide treatment is used in the weed management program when compared with a POST only program. Importantly, weed seed production is also reduced and the selection pressure on the weed community is minimized.

It is important to accept that weeds will always adapt to a simple and convenient system; the evolution of herbicide resistant weeds is an inevitable consequence to the repeated use of the herbicide. By accepting the need for stewardship in weed management and making the minor adjusts necessary to achieve better weed management stewardship, the rewards will be immediate and experienced in the long term.

1. **Always** use a soil-applied residual herbicide in corn and soybeans
   a. Select a herbicide that will control the weeds that emerge first, have the greatest population density and are of greatest concern for the evolution of herbicide resistance
   b. The risk of missing an application window with soil-applied herbicides can be minimized by applying the treatment as an early preplant application (EPP) several weeks prior to planting
2. **Recognize** that every field is different; thus each field could potentially have a different stewardship plan
   a. Simplicity and convenience have economic and ecological costs that may be greater than implementing a stewardship program
   b. Once a weed problem becomes established in a field, it will remain for a long time
3. **Avoid** repeated applications of the same herbicide; the more times an herbicide is applied, the greater the likelihood that weeds will adapt to the herbicide
4. **Scout** fields frequently and know which weeds are most populous.
   a. If you see a weed new to the field, eliminate it.
   b. Notice weed emergence patterns; they may point to problems with current management tactics
   c. If you see weeds unaffected by a POST herbicide treatment and note dead weeds of the same species next to those that survived the treatment, it is critically important to use another tactic in the future

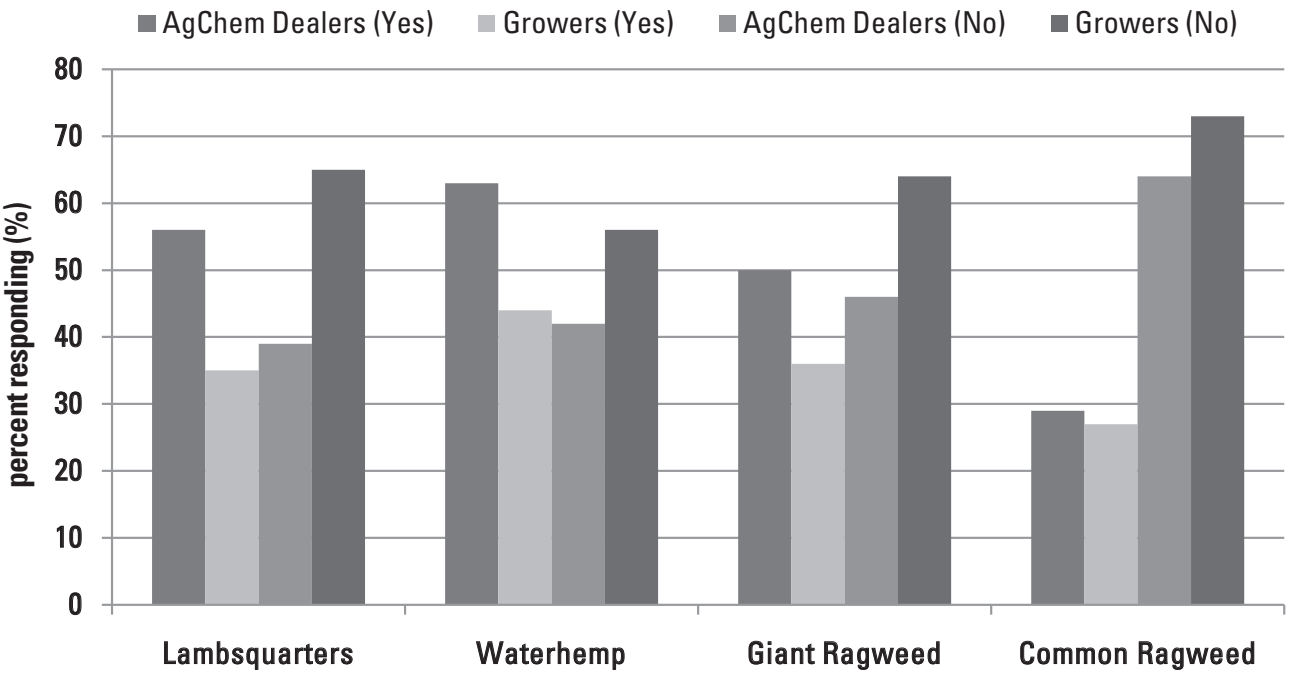

Figure 1. Is glyphosate less effective controlling four important weeds?

Grazing and haying restrictions for herbicides used in grass pastures

			Beef and Non-Lactating Animals			Lactating Dairy Animals	
Herbicide	A.I.	Rate/A	Grazing	Hay harvest	Removal before slaughter	Grazing	Hay harvest
Ally		0.1 - 0.3 oz	0	0	0	0	0
Clarity and many others	dicamba	Up to 1 pt	0	0	30 days	7 days	37 days
		1-2 pt	0	0	30 days	21 days	51 days
		2- 4 pt	0	0	30 days	40 days	70 days
		4 - 16 pt	0	0	30 days	60 days	90 days
Cimarron	metsulfuron methyl	0.1 - 1.0 oz	0	0	0	0	0
Cimarron Max (co-pack)	metsulfuron methyl + dicamba + 2,4-D	0.25-1 oz A + 1-4 pt B	0	0	30 days	7 days	37 days
Cimarron X-Tra	metsulfuron methyl + chlorsulfuron	0.1 - 1.0 oz	0	0	0	0	0
Crossbow	triclopyr + 2,4-D	1 - 6 qt	0	14 days	3 days	Growing season	Growing season
Escort XP	metsulfuron methyl	Up to 1.7 oz	0	0	0	0	0
		1.7- 3.3 oz	NA	3 days	NA	NA	3 days
ForeFront R&P	aminopyralid + 2,4-D	1.5 - 2.6 pt	0	7 days	0	0	7 days
Grazon P&D	picloram + 2,4-D	3 - 4 pt	0	0	0	7 days	30 days
Milestone	aminopyralid	3 - 7 pt	0	0	0	0	0
Overdrive	dicamba + diflufenzopyr	4 - 8 oz	0	0	0	0	0
Pasturegard	triclopyr + fluroxypyr	1.5 - 2 pt	0	14 days	3 days	1 year	1 year
Rave	dicamba + triasulfuron	2 - 5 oz	0	37 days	30 days	7 days	37 days
Redeem R&P	triclopyr + clopyralid	1.5 - 4 pt	0	14 days	3 days	Growing season	Growing season
Remedy Ultra	triclopyr	1 - 2 qt	0	14 days	3 days	Growing season	Growing season
Surmount	picloram + fluroxypyr	1.5-6 pts	0	7	3	14	7
Tordon 22K	picloram	< 2 pts	0	0	3	14	14
		> 2 pts	0	14	3	14	14
Weedmaster	dicamba + 2,4-D	1-4 pts	0	37 days	30 days	7 days	37 days
2,4-D (many tradenames) Uses may vary among products	2,4-D	2-4 pt 4 lb/G	0	30 days	3 days	7 days	30 days

Corn Herbicide Effectiveness Ratings[1]

Weed response to selected herbicides
E = excellent G = good
F = fair P = poor

	Grasses						Broadleaves									Perennials		
	Crop tolerance	Crabgrass	Fall panicum	Foxtail	Woolly cupgrass	Shattercane	Amaranthus spp.[2]	Black nightshade	Cocklebur[2]	Common ragweed	Giant ragweed[2]	Lambsquarter	Smartweed	Sunflower[2]	Velvetleaf	Canada thistle	Quackgrass	Yellow nutsedge
Preplant/Preemergence																		
Atrazine	E	F	P	F	P	P	E	G	G	E	F-G	E	E	G	G	P	F	F
Axiom, Breakfree, Dual II Magnum, Frontier, Outlook, etc	E	E	E	E	F	F	F-G	G	P	P	P	P	P	P	P	P	P	G
Balance Pro	F-G	G	F-G	G	G-E	F-G	G-E	F	P-F	F-G	P	G	G-E	F	G-E	P	P	G
Callisto	E	P	P	P	P	P	G-E	G-E	F-G	F-G	F	E	F-G	G-E	E	P	P	P
Degree, Harness, Surpass, Topnotch, etc	E	E	E	E	F-G	F-G	G	G	P	P	P	P-F	P-F	P	P	P	P	G
Hornet WDG	G	P	P	P	P	P	F-G	P	G	G	G	G	G-E	G-E	G	P	P	P
Pendimax, Prowl, etc	F-G	G-E	G-E	G-E	G	G	G	P	P	P	P	G-E	F	P	P-F	P	P	P
Pursuit[3]	E	F-G	F	F-G	P-F	G	F-E	G-E	F	G	F	P	G-E	F-G	G	P	P	P
Python	G	P	P	P	P	P	E	F	F	F	P	F	G-E	F-G	E	P	P	P
Postemergence																		
Accent, Steadfast	G-E	P	G	G-E	G-E	E	G	P	F	P	P	P	G	P	F	F	G	F
Aim	G	P	P	P	P	P	F-G	G	P	P	F	G	P	P	E	P	P	P
Atrazine	G	F	P	F	P	P	E	E	E	E	G	E	E	E	E	F*	F	G
Basagran	E	P	P	P	P	P	P	P	E	E	F	P	E	G	G-E	G*	P	G*
Basis	F	F	F-G	G	F	G	G	P	F	F	P	G-E	G-E	G-E	G	P	G	P
Banvel, Clarity, etc	F-G	P	P	P	P	P	G-E	G	E	G-E	E	G	E	G	F-G	G*	P	P
Beacon	G	P	F-G	P-F	P	E	E	G	G	G	E	P	G	G	F-G	F-G*	G	F
Buctril	G	P	P	P	P	P	G	G-E	E	E	G	G-E	G-E	E	G	P	P	P
Callisto	G-E	P	P	P	P	P	E	E	G-E	F	G	G	E	G-E	E	P	P	P
Distinct	F-G	P	F	F	P	F	G-E	G	E	G-E	G	G	E	G	G	G*	P	P
Equip	F-G	P	G	G-E	F-G	E	G	E	E	E	G	G	E	E	G-E	G*	G	P
Glyphosate (Roundup, Touchdown)[3]	E	E	E	G-E	E	E	G-E	F-G	E	E	G-E	G	E	E	G	G	G-E	F
Hornet WDG	G	P	P	P	P	P	E	F	E	E	G	F	G-E	E	G-E	G	P	P
Ignite[3]	E	E	G	G-E	E	E	G	E	E	E	G	G	E	E	E	F-G	G	P
Impact	G-E	F-G	F	G	F	F	G-E	G-E	G-E	G	G	G	G	E	E	P	P	P
Lightning[3]	G-E	G	G	E	G	E	F-G	E	E	G	F-G	G-E	E	E	E	G	F	F
NorthStar	G	P	F-G	F	P	E	F-G	G	E	E	E	G	E	E	G	F-G	G	F
Option	G	P	G	G-E	F-G	E	G	E	F	F	P	P	P	G	G	P	G	P
Permit, etc	G	P	P	P	P	P	E	P	G-E	G-E	G	P	G-E	E	E	P	P	G
Pursuit[3]	G-E	G	G	F-G	F	E	F-G	E	G-E	G	F	P-F	E	G	G-E	F	P	P
Resolve	F	F	F-G	G	F	G	G	P	F	F	P	G-E	G	P	F-G	F	G	F
Resource	G-E	P	P	P	P	P	G	P	F	F-G	P	F	P	P	E	P	P	P
Yukon	F-G	P	P	P	P	P	G	G	G-E	G-E	G	G	G-E	E	E	P	P	G
2,4-D	F	P	P	P	P	P	G	F	E	G	G-E	G	F	G	G	F*	P	P

[1]Ratings in this table are based on full label rates. Premix products containing ingredients marketed as single a.i. products may not be listed in this table.
[2]ALS-resistant biotypes of these weeds have been identified in Iowa. These biotypes may not be controlled by all ALS herbicides.
[3]Use only on designated resistant hybrids.
*Degree of perennial weed control is often a result of repeated application.
This chart should be used only as a guide. Ratings of herbicides may be higher or lower than indicated depending on soil characteristics, managerial factors, environmental variables, and rates applied. The evaluations for herbicides applied to the soil reflect appropriate mechanical weed control practices.

Soybean Herbicide Effectiveness Ratings[1]

Weed response to selected herbicides
E = excellent G = good
F = fair P = poor

	Grasses						Broadleaves									Perennials		
	Crop tolerance	Crabgrass	Fall panicum	Foxtail	Woolly cupgrass	Shattercane	Amaranthus spp.[2]	Black nightshade	Cocklebur[2]	Common ragweed	Giant ragweed[2]	Lambsquarter	Smartweed	Sunflower[2]	Velvetleaf	Canada thistle	Quackgrass	Yellow nutsedge
Preplant/Preemergence																		
Authority/Spartan	G	P	P	P	P	P	E	E	F	F	F	G-E	F	P	F-G	P	P	F-G
Command	E	G-E	G-E	E	F	F	P	F	F	G	P	G-E	G	F	E	P	P	P
Dual II Magnum, INT*RR*O, Frontier, etc	E	E	E	E	F	F	F-G	G	P	P	P	P	P	P	P	P	P	P
FirstRate/Amplify	G-E	P	P	P	P	P	F-G	P	G	G-E	G-E	G	G-E	G	F-G	P	P	F-G
Sencor	F-G	P	P	P-F	P	P	E	F	F	E	P	E	E	F-G	G-E	P	P	P-F
Pendimax, Prowl, Sonalan, Treflan, etc	G-E	E	E	E	E	G-E	G	P	P	P	P	G	F	P	P	P	P	P
Pursuit	G	F-G	F	F-G	P-F	G	F-E	G-E	F	G	F	P	G-E	F-G	G	P	P	P
Python	E	P	P	P	P	P	E	F	F	F	P	F-G	G-E	F	E	P	P	P
Valor SX	F-G	P-F	P-F	P-F	P	P	G-E	E	F	G	F	E	F	P	F	P	P	P
Postemergence																		
Assure II, Fusilade DX, Fusion, Poast Plus, Select, etc.	E	E	E	E	E	E	P	P	P	P	P	P	P	P	P	P	G-E*	P
Basagran	E	P	P	P	P	P	P-F	P-F	E	E	F	P	E	G	G-E	G*	P	G*
Blazer	F-G	P	P	F	P	F	E	G	F	G	F	F	E	F	F	F	P	P
Classic	G	P	P	P	P	P	E	P	E	G-E	F	P	G-E	E	G-E	F	P	G-E
Cobra/Phoenix	F-G	F	P	P	P	P	E	G	G-E	E	F-G	F	G	G	F	F	P	P
FirstRate/Amplify	G	P	P	P	P	P	P	P	G-E	E	E	P	G	E	G	P	P	P
Glyphosate (Roundup, Touchdown)[3]	E	E	G-E	E	E	E	G-E	F-G	E	E	G-E	G	E	E	G	G	G-E	F
Harmony GT	F	P	P	P	P	P	E	P	F	F	P	G-E	G-E	G-E	G	P	P	P
Ignite	E	E	G	G-E	E	E	G	E	E	E	G	G	E	E	E	F-G	G	F
Pursuit	G	G	G	F-G	F	E	F-G	E	G-E	G	F	P-F	E	G	G-E	F	P	P
Raptor	G	G-E	G-E	G-E	G	E	F-G	E	G-E	G	G	G	E	E	G-E	F	F	F
Reflex/Flexstar	F-G	P	P	P	P	P	E	F-G	F	G	G	F	G-E	F	F	P-F	P	P
Resource	G-E	P	P	P	P	P	G	P	F	F-G	P	F	P	P	E	P	P	P

[1]Ratings in this table are based on full label rates. Premix products containing ingredients marketed as single a.i. products may not be included in this table.
[2]ALS-resistant biotypes have been identified in Iowa. These biotypes may not be controlled by all ALS products.
[3]Use only on appropriate resistant varieties.
*Degree of perennial weed control is often a result of repeated application.
This chart should be used only as a guide. Ratings of herbicides may be higher or lower than indicated depending on soil characteristics, managerial factors, environmental variables, and rates applied. The evaluations for herbicides applied to the soil reflect appropriate mechanical weed control practices.

Herbicide Package Mixes

The following table provides information concerning the active ingredients found in prepackage mixes, the amount of active ingredients applied with a typical use rate, and the equivalent rates of the individual products.

Corn Herbicide Premixes or Co-packs and Equivalents

Herbicide	Components (a.i./gal or % a.i.)	If you apply (per acre)	You have applied (a.i.)	An equivalent tank mix of (product)
Accent Gold	6.5% nicosulfuron 6.5% rimsulfuron 19.1% flumetsulam 51.7% clopyralid	2.9 oz	0.1885 oz nicosulfuron 0.1885 oz rimsulfuron 0.5539 oz flumetsulam 1.5 oz clopyralid	0.25 oz Accent 0.1885 oz rimsulfuron 0.69 oz Python* 3.66 oz Stinger* *= 3.0 oz of Hornet
Accent Gold WDG	5.4% nicosulfuron 5.4% rimsulfuron 15.9% flumetsulam 51.4% clopyralid	3.5 oz	0.1885 oz nicosulfuron 0.1885 oz rimsulfuron 0.5539 oz flumetsulam 1.5 oz clopyralid	0.25 oz Accent 0.1885 oz rimsulfuron 0.69 oz Python* 3.66 oz Stinger* *= 3.0 oz of Hornet
Basis 75DF	50% rimsulfuron 25% thifensulfuron	0.33 oz	0.167 oz rimsulfuron 0.083 oz thifensulfuron	0.167 oz rimsulfuron 0.33 oz Pinnacle 25DF
Basis Gold 89.5DF	1.34% rimsulfuron 1.34% nicosulfuron 86.8% atrazine	14 oz	0.188 oz rimsulfuron 0.188 oz nicosulfuron 12.15 oz atrazine	0.188 oz rimsulfuron 0.25 oz Accent 75DF 13.5 oz atrazine 90DF
Bicep II MAG. 5.5L, Cinch ATZ	2.4 lb S-metolachlor 3.1 lb atrazine	2.1 qt	1.26 lb S-metolachlor 1.63 lb atrazine	21 oz Dual II MAGNUM 52 oz atrazine 4L
Bicep Lite II MAG, Cinch ATZ Lite	3.33 lb S-metolachlor 2.67 lb atrazine	1.5 qt	1.24 lb S-metolachlor 1.00 lb atrazine	21 oz Dual II MAGNUM 32 oz atrazine 4L
Breakfree ATZ 5.25L	3.0 lb acetochlor 2.25 lb atrazine	2.7 qt	2.0 lb acetochlor 1.5 lb atrazine	2.5 pt Breakfree 6.4E 3.0 pt atrazine 4L
Breakfree ATZ Lite 5.5L	4.0 lb acetochlor 1.5 lb atrazine	2.0 qt	2.0 lb acetochlor 0.75 lb atrazine	2.5 pt Breakfree 6.4E 1.5 pt atrazine 4L
Buctril + Atr.	1.0 lb bromoxynil 2.0 lb atrazine	2.0 pt	0.25 lb bromoxynil 0.50 lb atrazine	1 pt bromoxynil 2E 1 pt atrazine 4L
Bullet 4ME	2.5 lb alachlor 1.5 lb atrazine	4.0 qt	2.5 lb alachlor 1.5 lb atrazine	2.5 qt Micro-Tech 4ME 1.5 qt atrazine 4L
Degree Xtra	2.7 lb acetochlor 1.34 lb atrazine	3 qt	2 lb acetochlor 1 lb atrazine	36.6 oz Harness 7E 1 qt atrazine 4L

Corn Herbicide Package Mixes (continued)

Herbicide	Components (a.i./gal or % a.i.)	If you apply (per acre)	You have applied (a.i.)	An equivalent tank mix of (product)
Distinct 70WDG	21.4 % diflufenzopyr 55.0% dicamba	6 oz	1.3 oz diflufenzopyr 3.3 oz dicamba	1.3 oz diflufenzopyr 6 oz Banvel
Epic 58DF	48% flufenacet 10% isoxaflutole	12 oz	0.36 lb flufenacet 0.075 lb isoxaflutole	9.6 oz Define 1.6 oz Balance
Exceed 57WG	28.5% prosulfuron 28.5% primisulfuron	1 oz	0.018 lb prosulfuron 0.018 lb primisulfuron	0.5 oz Peak 57WG 0.38 oz Beacon 75SG
Expert 4.9SC	1.74 lb S-metolachlor 2.14 lb atrazine 0.74 lb ae glyphosate	3 qt	1.3 lb S-metolachlor 1.61 lb atrazine 0.55 lb ae glyphosate	1.4 lb Dual II Mag. 1.6 qt Aatrex 4L 1.5 pt Glyphosate 3L
FieldMaster	2.0 lb acetochlor 0.75 lb glyphosate 1.5 lb atrazine	4.0 qt	2.0 lb acetochlor 0.75 lb glyphosate 1.5 lb atrazine	2.3 pt Harness 24 oz Roundup Ultra 1.5 qt atrazine 4L
FulTime 4CS	2.4 lb acetochlor 1.6 lb atrazine	4 qt	2.4 lb acetochlor 1.6 lb atrazine	3 pt Surpass 6.4EC 3.2 pt atrazine 4L
Guardsman 5L	2.33 lb dimethenamid 2.67 lb atrazine	4 pt	1.17 lb dimethenamid 1.34 lb atrazine	1.6 pt Frontier 6E 2.7 pt atrazine 4L
G-Max Lite 5L	2.25 lb dimethenamid 2.75 lb atrazine	3.0 pt	0.84 lb dimethenamid-P 1.0 lb atrazine	18 oz Outlook 2 pt Aatrex 4L
Guardsman Max 5L	1.7 lb dimethenamid-P 3.3 lb atrazine	3.4 pt	0.7 lb dimethamid-P 1.4 lb atrazine	15 oz Outlook 1.4 lb atrazine 4L
Halex GT	2.09 lb *S*-metolachlor 0.209 lb mesotrione 2.09 lb glyphosate	3.6 pt	0.94 lb *S*-metolachlor 0.09 lb mesotrione 0.94 lb glyphosate ae	1.0 pt Dual II Magnum 3.0 oz Callisto 24 oz Touchdown HiTech
Harness Xtra	4.3 lb acetochlor 1.7 lb atrazine	2.3 qt	2.5 lb acetochlor 0.98 lb atrazine	46 oz Harness 7E 1 qt atrazine 4L
Harness Xtra 5.6L	3.1 lb acetochlor 2.5 lb atrazine	3 qt	2.325 lb acetochlor 1.875 lb atrazine	42.5 oz Harness 7E 1.9 qt atrazine 4L
Hornet WDG	18.5% flumetsulam 60% clopyralid	5 oz	0.924 oz flumetsulam 0.195 lb clopyralid	1.15 oz Python WDG 6.68 oz Stinger 3S
Keystone 5.25L	3.0 lb acetochlor 2.25 lb atrazine	2.7 qt	2.0 lb acetochlor 1.5 lb atrazine	2.5 pt Surpass 6.4E 3.0 pt Aatrex 4L

Corn Herbicide Package Mixes (continued)

Herbicide	Components (a.i./gal or % a.i.)	If you apply (per acre)	You have applied (a.i.)	An equivalent tank mix of (product)
Keystone LA 5.5L	4.0 lb acetochlor 1.5 lb atrazine	2.0 qt	2.0 lb acetochlor 0.75 lb atrazine	2.5 pt Surpass 6.4E 1.5 pt Aatrex 4L
Laddok S-12 5L	2.5 lb bentazon 2.5 lb atrazine	1.67 pt	0.52 lb bentazon 0.52 lb atrazine	1.0 pt Basagran 4S 1.0 pt atrazine 4L
Lariat 4L	2.5 lb alachlor 1.5 lb atrazine	4 qt	2.5 lb alachlor 1.5 lb atrazine	2.5 qt Lasso 4E 1.5 qt atrazine 4L
Lexar 3.7L	1.74 lb S-metolachlor 1.74 lb atrazine 0.224 lb mesotrione	3.5 qt	1.52 lb S-metolachlor 1.52 lb atrazine 0.196 lb mesotrione	1.6 pt Dual II Mag. 3 pt Aatrex 4L 6.27 oz Callisto
Liberty ATZ	1.0 lb glufosinate 3.3 lb atrazine	32 oz	0.25 lb glufosinate 0.825 lb atrazine	20 oz Liberty 0.825 qt atrazine 4L
Lightning 70DF	52.5% imazethapyr 17.5% imazapyr	1.28 oz	0.672 oz imazethapyr 0.224 oz imazapyr	0.96 oz Pursuit 70DG 0.78 oz Arsenal 28.7DF
Lumax	0.268 lb mesotrione 2.68 lb S-metolachlor 1.0 lb atrazine	3 qts	0.2 lb mesotrione 2.0 lb S-metolachlor 0.75 lb atrazine	6.4 oz Callisto 2 pt Dual II MAGNUM 0.75 qt Aatrex 4L
NorthStar	7.5% primisulfuron 43.9% dicamba	5.0 oz	0.375 oz primisulfuron 2.20 oz dicamba	0.5 oz Beacon 75SG 4.0 oz Banvel 4L
Priority	12.3% carfentrazone 50% halosulfuron	1.0 oz	0.008 lb carfentrazone 0.032 lb halosulfuron	0.5 oz Aim 0.68 oz Permit
Radius	3.57 lbs flufenacet 0.43 lbs isoxaflutole	16 oz	0.47 lb flufenacet 0.05 lb isoxaflutole	15 oz Defince 4SC 1.7 oz Balance Pro
ReadyMaster ATZ,	2 lb glyphosate 2 lb atrazine	2 qt	1 lb glyphosate 1 lb atrazine	1 qt Roundup Ultra 1 qt atrazine 4L
Require Q	0.062 lb rimsulfuron 0.481 lb dicamba	4 oz	0.016 lb rimsulfuron 0.12 lb dicamba	1.0 Resolve 3.9 Clarity/Banvel
Resolve Q	0.184 lb rimsulfuron 0.04 lb thifensulfuron	1.25 oz	0.0143 lb rimsulfuron 0.0031 lb thifensulfuron	0.9 oz Resolve 0.067 oz Harmony GT
Shotgun 3.25L	2.25 lb atrazine 1 lb 2,4-D	2 pt	0.56 lb atrazine 0.25 lb a.e. 2,4-D	1.12 pt atrazine 4L 0.53 pt Esteron 99 3.8E
Spirit 57WG	14.25% prosulfuron 42.75% primisulfuron	1 oz	0.1425 oz prosulfuron 0.4275 oz primisulfuron	0.25 oz Peak 57WG 0.57 oz Beacon 75SG

Corn Herbicide Package Mixes (continued)

Herbicide	Components (a.i./gal or % a.i.)	If you apply (per acre)	You have applied (a.i.)	An equivalent tank mix of (product)
Steadfast 75DF	50% nicosulfuron 25% rimsulfuron	0.75 oz	0.37 oz nicosulfuron 0.19 oz rimsulfuron	0.5 oz Accent -
Steadfast ATZ	2.7% nicosulfuron 1.3% rimsulfuron 85.3% atrazine	14 oz	0.38 oz nicosulfuron 0.18 oz rimsulfuron 0.75 lb atrazine	0.5 oz Accent - 1.5 pt Atrazine 4L
SureStart SE	3.75 lb acetochlor 0.29 lb clopyralid 0.12 lb flumetsulam	2.0 pt	0.94 lb acetochlor 1.2 oz clopyralid 0.48 oz flumetsulam	1.2 pt Surpass 6.4E 3.2 oz Stinger 3S 0.6 oz Python WDG
Surpass 100 5L	3 lb acetochlor 2 lb atrazine	2.5 qt	1.88 lb acetochlor 1.25 lb atrazine	1.18 qt Surpass 6.4E 1.25 qt atrazine 4L
WideMatch 1.5EC	0.75 lb fluroxypyr 0.75 lb clopyralid	1.3 pt	0.125 lb fluroxypyr 0.125 lb clopyralid	10.6 oz Starane 1.5E 5.3 oz Stinger 3S
Yukon	12.5% halosulfuron 55% dicamba	4 oz	0.031 lb halosulfuron 0.125 lb dicamba	0.66 oz Permit 4.0 oz Banvel

Soybean Herbicide Package Mixes or Co-packs and Equivalents

Herbicide	Components (a.i./gal or % a.i.)	If you apply (per acre)	You have applied (a.i.)	An equivalent tank mix of (product)
Authority First/Sonic	6.21% sulfentrazone 7.96% cloransulam-methyl	8.0 oz	0.31 lb sufentrazone 0.04 lb cloransulam-methyl	6.6 oz Authority 75DF 0.76 oz FirstRate
Authority MTZ	18% sulfentrazone 27% metribuzin	16 oz	0.18 lb sulfentrazone 0.27 metribuzin	3.8 oz Authority 75DF 1.0 pt Sencor 4L
Boundary 7.8EC	5.2 lbs s-metolachlor 1.25 lbs metribuzin	2.1 pt	1.4 lb s-metolachlor[1] 0.3 lb metribuzin	1.5 pt Dual II MAG. 6.4 oz Sencor 75DF
Canopy 75DF	10.7% chlorimuron ethyl 64.3% metribuzin	6 oz 0.24 lb	0.64 lb chlorimuron metribuzin	2.57 oz Classic 25DF 5.14 oz metribuzin 75DF
Commence 5.25E	2.25 lb clomazone 3.00 lb trifluralin	2.5 pt	0.70 lb clomazone 0.94 lb trifluralin	1.4 pt Command 4E 1.9 pt Treflan 4E
Detail 4.1E	0.5 lb imazaquin 3.6 lb dimethenamid	1 qt	0.125 lb imazaquin 0.90 lb dimethenamid	0.67 pt Scepter 1.5S 1.20 pt Frontier 6.0E
Enlite 47.9DG	36.2% flumioxazin 8.8% thifensulfuron 2.8% chlorimuron ethyl	2.8 oz	1.0 oz flumioxazin 0.25 oz thifensulfuron 0.08 chlorimuron ethyl	2.0 oz Valor 0.33 oz Harmony GT 0.32 oz Classic

Soybean Herbicide Package Mixes (continued)

Herbicide	Components (a.i./gal or % a.i.)	If you apply (per acre)	You have applied (a.i.)	An equivalent tank mix of (product)
Envive 41.3DG	29.2% flumioxazin 2.9% thifensulfuron 9.2% chlorimuron ethyl	5.3 oz	1.5 oz flumioxazin 0.15 oz thifensulfuron 0.49 oz chlorimuron ethyl	3.0 oz Valor 0.20 oz Harmony GT 1.9 oz Classic
Extreme	1.8% imazethapyr 22% glyphosate	3 pt	0.064 lb imazethapyr 0.75 lb glyphosate	1.44 oz Pursuit DG 24 oz Roundup
FrontRow	flumetsulam chloransulam	5 acres/pkg	0.15 oz flumetsulam 0.25 oz chloransulam	0.12 oz Python 80WDG 0.3 oz FirstRate 84WDG
Fusion 2.67E	2 lb fluazifop 0.67 lb fenoxaprop	8 fl oz	0.125 lb fluazifop 0.042 lb fenoxaprop	8 fl oz Fusilade DX 2E 8 fl oz Option II 0.67E
Galaxy 3.67S	3 lb bentazon 0.67 lb acifluorfen	2 pt	0.75 lb bentazon 0.17 lb actfluorfen	1.5 pt Basagran 4S 0.67 pt Blazer 2S
Gangster (co-pack)	51% flumioxazin 84% chloransulam	3.6 oz	1.5 oz flumioxazin 0.5 oz chloransulam	3.0 oz Valor 0.6 oz FirstRate
Pursuit Plus 2.9E	0.2 lb imazethapyr 2.7 lb pendimethalin	2.5 pt	0.063 lb imazethapyr 0.84 lb pendimethalin	4.0 oz Pursuit 2S 2.00 pt Prowl 3.3E
Sequence 5.25L	3.0 lb S-metolachlor 2.25 lb glyphosate	3 pt	1.13 lb S-metolachlor 0.84 lb ae glyphosate	1.2 pt Dual Magnum 26 oz Touchdown Total
Sonic	6.21% sulfentrazone 7.96% cloransulam-methyl	8.0 oz	0.361 lb sulfentrazone 0.04 lb cloransulam-methyl	6.6 oz Authority 75DF 0.76 oz FirstRate
Stellar 3.1E	2.4 lb lactofen 0.7 lb flumiclorac	5 fl oz	0.094 lb lactofen 0.027 lb flumiclorac	6 fl oz Cobra 2E 4 fl oz Resource 0.86E
Storm 4S	2.67 lb bentazon 1.33 lb acifluorfen	1.5 pt	0.50 lb bentazon 0.25 lb acifluorfen	1 pt Basagran 4S 1 pt Blazer 2S
Synchrony STS DF	31.8% chlorimuron 10.2% thifensulfuron	0.5 oz	0.159 oz chlorimuron 0.051 oz thifensulfuron	0.64 oz Classic 25DF 0.068 oz Harmony GT
Valor XLT	30.3% flumioxazin 10.3% chlorimuron ethyl	3 oz	0.056 lb flumioxazin 0.019 lb chlorimuron	1.76 oz Valor 1.24 oz Classic

Herbicide Site of Action and Injury Symptoms

Herbicides kill plants by disrupting an essential physiological process. This normally is accomplished by the herbicide specifically binding to a single protein. The target protein is referred to as the herbicide "site of action." Herbicides in the same family generally have the same site of action. The mechanism by which a herbicide kills a plant is known as its "mode of action." For example, triazine herbicides interfere with photosynthesis by binding to the D1 protein involved in photosynthetic electron transfer. Thus, the site of action for triazines is the D1 protein, whereas the mode of action is the disruption of photosynthesis. An understanding of herbicide mode of action is essential for diagnosing crop injury or off-target injury problems and for designing weed management programs with a low risk of selecting for herbicide-resistant weed populations.

ACCase Inhibitors

The ACCase enzyme is involved in the synthesis of fatty acids. Two herbicide families attack this enzyme. Aryloxyphenoxypropanoate (commonly referred to as "fops") and cyclohexanedione (referred to as "dims") herbicides are used postemergence, although some have limited soil activity (e.g., fluazifop). ACCase inhibitors are active only on grasses, and selectivity is due to differences in sensitivity at the site of action, rather than differences in absorption or metabolism of the herbicide. Most herbicides in this class are translocated within the phloem of grasses. The growing points of grasses are killed and rot within the stem. At sublethal rates, irregular bleaching of leaves or bands of chlorotic tissue may appear on affected leaves. Resistant weed biotypes have evolved following repeated applications of these herbicides. An altered target site of action is responsible for the resistance.

ALS Inhibitors

Several chemical families interfere with acetolactate synthase (ALS), an enzyme involved in the synthesis of branched-chain amino acids, specifically valine, leucine, and isoleucine. These amino acids are necessary for protein synthesis and plant growth. Generally, these herbicides are absorbed in plant roots and foliage and are readily translocated in the xylem and phloem. The herbicides accumulate in meristematic regions of the plant and the herbicidal effects are first noted there. Symptoms include plant stunting, chlorosis (yellowing), and tissue necrosis (death), and are evident 1 to 4 weeks after herbicide application, depending upon the plant species and environmental conditions. Soybeans and other affected broad-leaves often develop reddish veins on undersides of leaves. Symptoms in corn include reduced secondary root formation, stunted roots, shortened internodes, leaf malformations (chlorosis, window-paning) and nutrient deficiency. However, symptoms typically are not distinct or consistent. Factors such as soil moisture, temperature, and soil compaction can enhance the occurrence of injury or may mimic the herbicide injury. Some ALS inhibiting herbicides have long soil residual properties and may carry over and injure sensitive rotational crops. Herbicide resistant weed biotypes possessing an altered site of action have evolved after repeated applications of these herbicides.

Microtubule Inhibitors

Dinitroaniline (DNA) herbicides inhibit cell division by interfering with the formation of microtubules. Dinitroaniline herbicides are soil-applied and absorbed mainly by roots. Very little herbicide translocation in plants occurs, thus the primary herbicidal effect is on root development. Soybean injury from DNA herbicides is characterized by root pruning. Roots that do develop are thick and short. Hypocotyl swelling also occurs. The inhibited root growth causes tops of plants to be stunted. Corn injured by DNA carryover demonstrates root pruning and short, thick roots. Leaf margins may have a reddish color. Since DNAs are subject to little movement in the soil, such injury is often spotty due to localized concentrations of the herbicide. Early season stunting from DNA herbicides typically does not result in significant yield reductions.

Synthetic Auxins

Several chemical families cause abnormal root and shoot growth by upsetting the plant hormone (auxin) balance. These herbicides are primarily effective on broadleaf species. Uptake can occur through seeds or roots with soil-applied treatments or leaves when applied postemergence. Synthetic auxins translocate throughout plants and accumulate in areas of high growth. Corn injury may occur in the form of onion leafing, proliferation of roots, or abnormal brace root formation. Corn stalks may become brittle following application; this response usually lasts for 7 to 10 days following application. The potential for injury increases when applications are made to corn larger than 10 to 12 inches in height. Soybean injury from synthetic auxin herbicides is characterized by cupping and crinkling of leaves. Soybeans are extremely sensitive to dicamba; however, early season injury resulting only in leaf malformation usually does not affect yield potential. Soybeans occasionally develop symptoms characteristic of dicamba in the absence of this herbicide. This response is poorly understood, but usually develops during periods of rapid growth or following stress from other postemergence herbicide applications. Dicamba has a high vapor pressure and may move off target due to volatilization.

Photosystem II Inhibitors

Several families of herbicide bind to a protein involved in electron transfer in Photosystem II (PSII). These herbicides inhibit photosynthesis, which may result in chlorosis of plant leaves followed by necrosis of leaf tissue. A secondary substance formed as a result of photosynthesis inhibition may be responsible for plant death. When PSII inhibitors are applied to the leaves, uptake occurs into the leaf but very little movement out of the leaf occurs. Injury to corn occurs as yellowing of leaf margins and tips followed by browning, whereas injury to soybean occurs as yellowing or burning of outer leaf margins. The entire leaf may turn yellow, but veins usually remain somewhat green (interveinal chlorosis). Lower leaves are most affected, and new leaves may be unaffected. Triazine and urea herbicides generally are absorbed both by roots and foliage, whereas benzothiadiazole and nitrile herbicides are absorbed primarily by plant foliage. Triazine-resistant biotypes of several weed species have been confirmed in Iowa following repeated use of triazine herbicides. Although the other PSII herbicides attack the same target site, they bind on a different part of the protein and remain effective against triazine resistant weeds.

Photosystem I Inhibitors

Herbicides in the bipyridilium family rapidly disrupt cell membranes, resulting in wilting and tissue death. They capture electrons moving through Photostystem I (PSI) and produce highly destructive compounds. Very little translocation of bipyridilium herbicides occurs due to loss of membrane structure. Injury occurs only where the herbicide spray contacts the plant. Complete spray coverage is essential for weed control. The herbicide molecules carry strong positive charges that cause them to be very tightly adsorbed by soil colloids. Consequently, bipyridilium herbicides have no significant soil activity. Injury to crop plants from paraquat drift occurs in the form of spots of dead leaf tissue wherever spray droplets contact the leaves. Typically, slight drift injury to corn, soybeans, or ornamentals from a bipyridilium herbicide does not result in significant growth inhibition.

Protoporphyrinogen Oxidase (PPO) Inhibitors

The specific site of action is an enzyme involved in synthesis of a precursor of chlorophyll; the enzyme is referred to as PPO. Postemergence applied diphenyl ether herbicides (e.g., aciflurofen) kill weed seedlings through contact action, membrane destruction, and photosynthesis inhibition. Thorough plant coverage by the herbicide spray is required. Applying the herbicide prior to prolonged cool periods or during hot, humid conditions will result in crop injury. Injury symptoms range from speckling of foliage to necrosis of whole leaves. Under extreme situations, herbicide injury has resulted in the death of the terminal growing point, which produces short, bushy soybean plants. Most injury attributable to diphenyl ether herbicides is cosmetic and does not affect yields. The aryl triazolinones herbicides are absorbed both by roots and foliage. Susceptible plants emerging from soils treated with these herbicides turn necrotic and die shortly after exposure to light. Soybeans are most susceptible to injury if heavy rains occur when beans are cracking the soil surface.

Enolpyruvyl Shikimate Phosphate Synthase (EPSPS) Inhibitors

Glyphosate is a substituted amino acid that interferes with amino acid synthesis by inhibiting the EPSPS enzyme. This enzyme is involved in the synthesis of several essential amino acids. Glyphosate is nonselective and is very tightly bound in soil, so no root uptake occurs. Applications must be made to plant foliage. Translocation occurs out of leaves to all plant parts including underground storage organs of perennial weeds. Translocation is greatest when plants are actively growing. Injury symptoms are fairly slow in appearing. Leaves slowly wilt, turn brown, and die. Sub-lethal rates of glyphosate sometimes produce phenoxy-type symptoms with feathering of leaves (parallel veins) and proliferation of vegetative buds, or in some cases cause bleaching of foliage.

Glutamine Synthetase Inhibitors

Glufosinate (Liberty, Ignite) inhibits the enzyme glutamine synthetase, causing a buildup of ammonia in the plant which becomes phytotoxic. Glufosinate is relatively fast acting and provides effective weed control in three to seven days. Symptoms appear as chlorotic lesions on the foliage followed by necrosis. There is limited translocation of glufosinate within plants. The herbicide has no soil activity. Ignite is nonselective except to crops that carry the Liberty Link gene.

Hydroxyphenyl Pyruvate Dioxygenase (HPPD) Inhibitors

Isoxaflutole (Balance Pro), mesotrione (Callisto), tembotrione (Laudis), and topramezone (Impact) bind to HPPD, an enzyme involved in the synthesis of carotene pigments. Injury symptoms include bleaching or chlorosis. Although the chemicals have the same site of action, they are not chemically related. The herbicides are absorbed both by roots and foliage.

Diterpene Inhibitors

Clomozone interferes with the synthesis of the same pigments as the HPPD inhibitors, but acts at a different enzyme within the metabolic pathway. Sensitive plants exposed to the herbicide turn white. Clomazone is xylem mobile and taken up in roots and shoots. Differential metabolism of clomazone confers tolerance to plants. Clomozone has a relatively high vapor pressure and may volatilize off the soil surface resulting in off-target injury.

Auxin Transport Inhibitors

Diflufenzopyr (Distinct) has a unique mode of action in that it inhibits the transport of auxin, a naturally occurring growth regulator. It is sold only in combination with dicamba. Diflufenzopyr is primarily active on broadleaf species, but it may suppress certain grasses under favorable conditions. Diflufenzopyr is primarily active through foliar uptake, but it can be absorbed through the soil for some residual activity. Injury symptoms are similar to growth regulator herbicides. Status (dicamba + diflufenzopyr) includes a safener to improve crop safety.

Lipid Synthesis Inhibitors

Two families of chemistry, the thiocarbamates and amide, are believed to inhibit the synthesis of lipids. The specific site of action was unknown until relatively recently, but now it is believed these chemicals inhibit a family of elongase enzymes that are responsible for the formation of very long chain fatty acids. These compounds are important components of membranes and the cuticle. In grasses, thiocarbamate herbicides inhibit meristem activity and cause abnormal emergence of leaves from the coleoptile. The growth of susceptible broadleaf weeds is inhibited, and plants exhibit cupped or crinkled leaves. Uptake may occur through seeds, shoots, and roots; shoots are more affected than roots. These herbicides are soil-applied and most must be physically incorporated into the soil due to volatility characteristics. Corn injury from thiocarbamate herbicides is demonstrated by leaves not properly unrolling from the coleoptile. Leaves are stunted and twisted, often appearing knotted. Safeners have been developed that help to prevent thiocarbamate injury to corn. These safeners enable corn to more rapidly degrade the herbicides. The antidotes are formulated directly with the herbicides; Sutan+ contains R-25788, and Eradicane contains R-29148. Soybean injury from thiocarbamate herbicides occurs as slowed emergence and crinkling of leaves on seedling plants. The antidotes or safeners do not protect soybeans from thiocarbamate herbicides.

Unknown Site of Action

Herbicides in the amide family (also referred to as acetanilides or acetamides) inhibit root and shoot growth causing stunted, malformed seedlings. The herbicides must be present in early stages of germination and growth of weeds for effective control. These herbicides are most effective on annual grass weeds, although some small-seeded annual broadleaf weeds are also sensitive. Injury symptoms to corn from these herbicides include leafing out underground and failure of leaves to properly unfurl. Soybean injury from these herbicides occurs in the form of a shortened mid-vein in the leaflets resulting in crinkling and a heart-shaped appearance. Dimethenamid (Frontier) and flufenacet (Axiom) have slightly different chemical structures than the amide herbicides, but it is believed they kill plants in the same manner as the amides (inhibition of synthesis of very long chain fatty acids). Safeners are formulated with metolachlor (Dual II Magnum) and acetochlor (Harness, Surpass, others) to reduce the risk of corn injury.

ACCase inhibitor	
aryloxyphenoxy-propanoate	
Assure II, others	quizalofop-p-ethyl
Fusilade DX	fluazifop-p-butyl
Fusion	fluazifop-p-butyl + fenoxaprop
Hoelon	diclofop
cyclohexanediones	
Poast, Poast Plus	sethoxydim
Select, Arrow, others	clethodim

ALS inhibitors	
imidazolinones	
Lightning	imazethapyr + imazapyr
Pursuit	imazethapyr
Pursuit Plus	imazethapyr + pendimethalin
Raptor	imazamox
Scepter	imazaquin
Squadron	imazaquin + pendimethalin
sulfonanilides	
FirstRate, Amplify	chloransulam
Hornet WDG	flumetsulam + clopyralid
Python	flumetsulam
sulfonylureas	
Accent	nicosulfuron
Ally, Cimarron	metsulfuron
Basis	rimsulfuron + thifensulfuron
Beacon	primisulfuron
Canopy	chlorimuron + metribuzin
Classic	chlorimuron
Envive	flumioxazin + thifensulfuron + chlorimuron
Enlite	flumioxazin + thifensulfuron + chlorimuron
Equip	foramsulfuron + iodosulfuron + safener
Exceed, Spirit	prosulfuron + primisulfuron
Express	tribenuron
Harmony GT	thifensulfuron
NorthStar	primisulfuron + dicamba
Option	foramsulfuron + safener
Permit	halosulfuron
Require Q	rimsulfuron + dicamba
Resolve Q	rimsulfuron + thifensulfuron
Steadfast	nicosulfuron + rimsulfuron
Steadfast ATZ	nicosulfuron + rimsulfuron + atrazine
Synchrony STS	chlorimuron + thifensulfuron
Valor XLT	flumioxazin + chlorimuron

Yukon	halosulfuron + dicamba
Other	
Corvus	thiencarbazone-methyl + isoxaflutole

Microtubule inhibitor

dinitroanilines	
Balan	benefin
Commence	trifluralin + clomazone
Prowl H_2O, Pentagon, Pendimax, others	pendimethalin
Sonalan	ethalfluralin
Surflan	oryzalin
Treflan, others	trifluralin

Synthetic auxin

benzoic	
Banvel, Clarity, others	dicamba
Distinct, Status	dicamba + diflufenzopyr
NorthStar	dicamba + primisulfuron
Require Q	rimsulfuron + dicamba
Yukon	dicamba + halosulfuron
phenoxy	
many	MPCA
many	2,4-D
Butyrac, Butoxone	2,4-DB
pyridines	
Crossbow	triclopyr + 2,4-D
Grazon P&D	picloram + 2,4-D
GrazonNext, ForeFront R&P	aminopyralid + 2,4-D
Hornet WDG	clopyralid + flumetsulam
PastureGard	triclopyr + fluroxypyr
Redeem	triclopyr + clopyralid
Remedy Ultra, Pathfinder II	triclopyr
Milestone	aminopyralid
Stinger, Transline	clopyralid
Tordon	picloram

Photosystem II inhibitors

benzothiadiazole	
Basagran	bentazon
Galaxy, Storm	bentazon + acifluorfen
Laddok	bentazon + atrazine
nitriles	
Buctril, others	bromoxynil
Buctril + atrazine	bromoxynil + atrazine
triazines	
AAtrex, others	atrazine
Evik	ametryne
Princep	simazine
Sencor	metribuzin
ureas	
Karmex	diuron
Lorox	linuron

Photosystem I inhibitors

Diquat, Reward	diquat
Gramoxone Max	paraquat

Protoporphyrinogen Oxidase (PPO) inhibitors

aryl triazolinones	
Aim	carfentrazone
Authority, Spartan	sulfentrazone
Authority First, Sonic	sulfentrazone + cloransulam
Command Xtra	sulfentrazone + clomazone
diphenyl ethers	
Blazer, UltraBlazer	acifluorfen
Cobra, Phoenix	lactofen
ET	pyraflufen
Flexstar, Reflex	fomesafen
Goal	oxyfluorfen
phenylphthalimides	
Envive	flumioxazin + thifensulfuron + chlorimuron
Enlite	flumioxazin + thifensulfuron + chlorimuron
Gangster	flumioxazin + cloransulam
Resource	flumiclorac
Valor	flumioxazin
Valor XLT	flumioxazin + chlorimuron
other	
Cadet	fluthiacet

Enolpyruvyl shikimate phosphate synthase (EPSPS) inhibitors

Roundup, Touchdown, others	glyphosate
ReadyMaster ATZ	glyphosate + atrazine
Extreme	glyphosate + imazethapyr
Sequence	glyphosate + s-metolachlor

Glutamine synthetase inhibitors

Liberty, Ignite	glufosinate
Liberty ATZ	glufosinate + atrazine

Hydroxyphenyl pyruvate dioxygenase (HPPD) inhibitors

Balance Pro	isoxaflutole
Epic, Radius	isoxaflutole + flufenacet
Callisto	mesotrione
Impact	topramezone
Lexar, Lumax	mesotrione + atrazine + s-metolachlor
Corvus	isoxaflutole + theincarbazone-methyl

Diterpene inhibitors

Command	clomazone
Command Xtra	clomazone + sulfentrazone

Auxin transport inhibitors

Distinct, Status	diflufenzopyr + dicamba

Lipid synthesis inhibitors

thiocarbamates	
Eradicane, Eptam, others	EPTC
amides or acetanilides	
Bicep II MAGNUM, Bicep Lite II MAGNUM, Cinch ATZ, others	s-metolachlor + atrazine + safener
Boundary	metolachlor + metribuzin
Bullet	alachlor + atrazine
Degree, Harness, Surpass, TopNotch, others	acetochlor + safener
Dual II MAGNUM, Cinch, others	s-metolachlor + safener
Radius	flufenacet + isoxaflutole
FieldMaster	acetochlor + atrazine + glyphosate + safener
Frontier, Outlook, others	dimethenamid
FulTime, Surpass 100	acetochlor + atrazine + safener
Guardsman Max, others	dimethenamid + atrazine
Lariat	alachlor + atrazine
Lasso, Intrro, MicroTech	alachlor

Common chemical and trade names are used in this publication. The use of trade names is for clarity by the reader. Due to the large number of generic products available ISU is not able to include all products. Inclusion of a trade name does not imply endorsement of that particular brand of herbicide and exclusion does not imply non-approval.

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