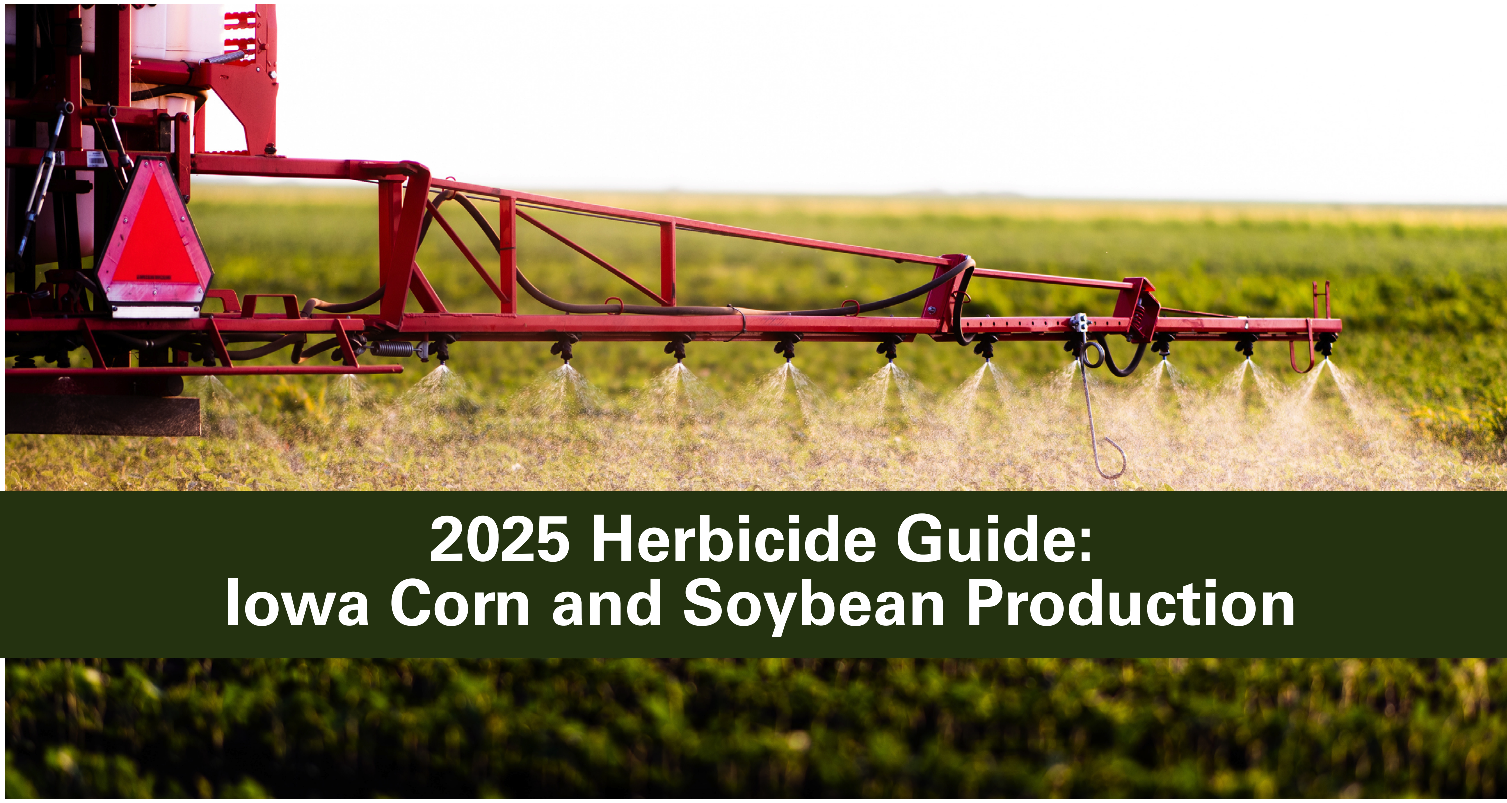

2025 Herbicide Guide: Iowa Corn and Soybean Production

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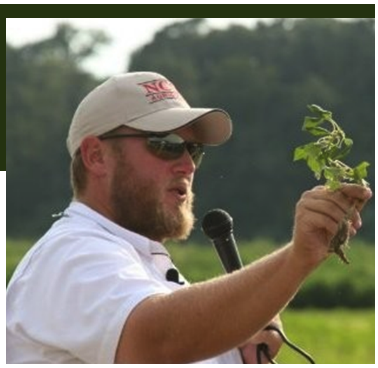
Meet the New Extension Weed Specialist



"I am optimistic that by working together we can find solutions that will be effective and sustainable into the future. As I make my way around the state, I hope to meet as many of you as possible, and I am excited to work with you all in the future."
- Wesley Everman.

Wesley Everman has joined Iowa State University as an extension weed specialist working in row crops. Everman is a native Iowan, having grown up in the northeast part of the state, and is excited to transition to Iowa to help tackle the weed management challenges that many farmers face.

Everman has been an extension weed specialist and professor at North Carolina State University for the past 13 years, identifying and developing management practices for herbicide resistant weed species, including waterhemp, Palmer amaranth, common ragweed, and other challenging species. He plans to bring the experience gained over the past 20 years in herbicide resistant weed management, precision weed mapping and spraying, weed biology, and cultural weed management practices, such as cover crops, to address the weed management challenges in Iowa.

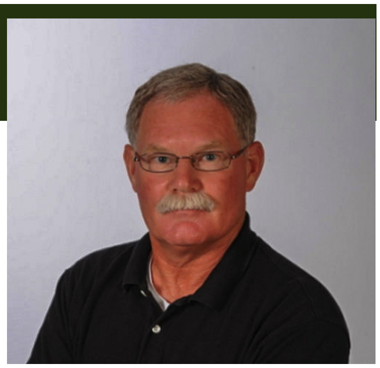
In the coming months, Wes plans to visit as much of the state as he can to meet with farmers, industry, and other stakeholders to identify the key issues they are facing with weed management, herbicide resistance, and application technology. Through these meetings, he hopes to gain a better understanding to direct the research projects starting in the coming years. Everman states that he has a very direct, applied approach when it comes to managing weeds and conducting research, with extension and research going hand-in-hand.

Contact Wes at weseverman@iastate.edu.

Iowa State University
Extension and Outreach

WC94 November 2024

And Yet the Weeds Persist



A personal note from Micheal D.K. Owen, University Professor Emeritus at Iowa State University.

This is likely my "swan song" addressing management and problems with weeds in Iowa. I hope to point out that past weed management, perhaps better said "herbicide management" has resulted in the current problems for growers across the Midwest, but particularly in Iowa. There is an ecological and economic cost to simplicity and convenience! I once wrote you cannot fix a herbicide problem caused by past herbicide use by spraying new herbicides. The waterhemp populations in Iowa have demonstrated this concept by evolving resistances to most of the available herbicides and most recently the Herbicide Group (HG) 4 herbicides dicamba and 2,4-D.

It appears that when a problem with weeds evolves the tendency is to spray the newest "solution" being promoted by the companies and advisers. In many cases, advisers will make recommendations that best fit what they have available. Typically, the problem weeds are not understood regarding resistance(s) and the same tactics are used on all fields without considering the differences that likely exist in different fields. All fields and weed populations are not the same, and require different solutions.

The cost of weed management programs may dictate the tactics. For example, the use of set up rates for preemergence herbicides with later postemergence applications used to complete the weed management. This tactic is destined to fail given that the plan does not consider the emergence biology of weeds, the need for coverage when crop canopy likely interferes with herbicide distribution, and how the weather dictates when things happen. Cheap solutions usually cost more in the end. The use of maximum labeled herbicide rates is the cheapest way to go and likely will provide the best chance for effective weed control.

Evolved herbicide resistance is widely distributed in Iowa in several weeds, and most waterhemp populations, for example, have multiple HG resistances. While resistance to HG 15 (i.e., metolachlor) has not been verified in Iowa, given the problems in Illinois, there is no question that this resistance exists in Iowa waterhemp populations. The use of HG 4 herbicides is also selecting for resistant waterhemp populations. Diversity of weed management tactics should be considered and included in plans for 2025.

The problems with diverse weed management are that they require extensive knowledge about fields, they take more time, may be more costly than simplistic solutions, and they must be employed differently on different fields. Mechanical weed management requires considerable time and effort but consider that not all fields, or even all parts of an individual field may require or respond favorably to mechanical weed management. Cover crops are an important weed management tactic but can be a challenge to establish and manage for weed control. Crop rotation in Iowa does not necessarily provide greater diversity unless crops like winter annuals and perennials are included in the rotation. Including forages or small grains in the rotation also provides excellent diversity and improves weed management. Planting soybean later allows for weed populations to emerge and be more easily controlled with tillage (i.e., rotary hoe) and herbicides.

There has not been a truly new herbicide (different HG and mechanism of action) in more than 30 years. The likelihood of a new "silver bullet" coming to the marketplace soon is slim at best, despite what company advertisements and promotions might suggest. Learn how best to use the tools and tactics that are currently available for weed management. Learn more about the weed populations in individual fields and how individual fields respond to various diverse tactics. The greater the diversity of tactics, the better chance of keeping ahead of weeds.

Dicamba and 2,4-D

Due to the emergence of glyphosate-resistant and other herbicide-resistant weeds, several pesticide companies have turned to dicamba-tolerant and 2,4-D resistant technology.

Dicamba

Background

Dicamba was first registered for Over the Top (OTT) uses on dicamba-tolerant cotton and soybean in 2016. In 2017 and again in 2018, the United States EPA amended the registrations of all OTT dicamba products following reports that growers had experienced crop damage and economic losses resulting from the off-site movement of dicamba. The U.S. Court of Appeals for the Ninth Circuit vacated the 2018 registrations in June 2020 on the basis that EPA substantially understated risks that it acknowledged and failed entirely to acknowledge other risks. Days after the court's decision, the EPA issued an order for the affected products that addressed existing stocks.

In October 2020, the EPA issued new registrations for two dicamba products and extended the registration of an additional dicamba product until 2025. All three registrations included new measures that the EPA expected to prevent off-target movement and damage to non-target crops and other plants. Further state-specific amendments to the registrations occurred in 2022 and 2023.

In response to a lawsuit against the EPA concerning these registrations, on February 6, 2024, a ruling by the U.S. District Court of Arizona vacated the 2020 registrations for OTT dicamba products XtendiMax, Engenia, and Tavium. EPA issued an "Existing Stocks Order" on February 14, 2024 (later revised on March 12, 2024), to allow for limited sale and distribution of dicamba OTT products that were already in the possession of growers or in the channels of trade and outside the control of the pesticide companies. The order also prohibits the use of these dicamba products except where the use is consistent with the previously approved labeling, including measures intended to reduce environmental damage caused by offsite movement of the pesticide.

Proposed Uses

Pesticide manufacturers Syngenta, Bayer, and BASF have submitted applications to the EPA to register new uses for their previously registered OTT dicamba products for additional food use (Table 1). There are currently no registrations in place for dicamba OTT for 2025.

2,4-D

Background

2,4-D-resistant technology was introduced in 2014 to control weeds in conventional and genetically modified corn, cotton, and soybean crops. Enlist Duo, which contains 2,4-D and glyphosate dimethylammonium salt, was registered in 2014, followed by Enlist One, which only contains 2,4-D choline salt in 2017.

Current Uses

In January 2022, the EPA renewed both products manufactured by Corteva through January 11, 2029. To protect plants and animals, including endangered species, the labels include runoff and spray drift measures. Additionally, the EPA prohibited the use of Enlist One and Enlist Duo in counties where the EPA identified risks to on-field listed species that use corn, cotton or soybean fields for diet and/or habitat. In March 2022, the EPA approved a registration amendment to allow use of Enlist One and Enlist Duo in 128 additional counties that Corteva did not originally propose for use and six counties that the EPA originally prohibited from use.

Table 1. EPA proposed registrations as of August 2024.

Registrant	Bayer		BASF		Syngenta	
Product name	KHNP0090 (formerly XtendiMax)		Engenia		Tavium	
Crop	Soybean	Cotton	Soybean	Cotton	Soybean	Cotton
Timing	Pre-emergence before, during, or immediately after planting	Pre-emergence before, during, immediately after planting, or OTT	Pre-plant, at planting, pre-emergence or post-emergence OTT	Pre-plant, at planting, pre-emergence or post-emergence OTT	Pre-plant, at planting, pre-emergence or post-emergence OTT	Pre-plant, at planting, pre-emergence or post-emergence OTT
Growth stage and cutoff dates	Until emergence of the seedling, but no later than June 12	No later than July 30	Before V2 or after June 12, whichever comes first		Before V2 or June 12, whichever comes first	Until 6-leaf growth stage, but no later than July 30
Total maximum number of applications			2	2	2	2

Table 2. Iowa Department of Agriculture and Land Stewardship (IDALS) misuse investigations 2013-2023.

Crop Year[1]	MSU[2]	PHNX[3]	OTT Dicamba[4]
2013	125	39	-
2014	88	31	-
2015	118	40	-
2016	110	43	-
2017	248	171	87
2018	245	145	56
2019	248	128	87
2020	298	222	116
2021	296	217	104
2022	326	211	50
2023	208	93	16

[1]Crop year = Crop year runs from 10/1 to 9/30.

[2]MSU = All misuse investigations.

[3]PHNX = All misuse investigations allegedly linked to applications of growth regulator herbicides based on signs and symptoms of herbicide injury reported to IDALS.

[4]OTT Dicamba = Subset of PHNX that includes confirmed over-the-top dicamba applicators on soybeans. Applicator affidavits AND product labels have been collected and added to the case file.

Enforcement Investigations in Iowa

Complaints about pesticides received by the Iowa Department of Agriculture and Land Stewardship (IDALS) have varied over the years (see Table 2).

Conclusion

While enforcement issues with dicamba-tolerant and 2,4-D-tolerant technology within Iowa are decreasing, the future of these products is uncertain. EPA regulation and court decisions will continue to affect product registrations.

EPA's Final Herbicide Strategy for ESA: What Could Change

The Environmental Protection Agency (EPA) released their final herbicide strategy on August 20, 2024. This strategy outlines specific plans to protect over 900 threatened and endangered species, 19 of which are believed to or known to occur in Iowa, from potentially harmful impacts of herbicides, meeting requirements set forth by the Endangered Species Act (ESA) in 1973. The following is a question-and-answer format description of the strategy and how it will affect herbicide use in the future.

The following description has been endorsed by the Weed Science Society of America (WSSA).

1. What is the Endangered Species Act (ESA)?

The Endangered Species Act is a long-standing federal law, passed in 1973, requiring government agencies to ensure any actions they take do not jeopardize a species that has been **federally listed as endangered or threatened**, ecos.fws.gov/ecp0/pub/listedAnimals.jsp. When an agency has proposed a project or an action that might affect a listed species or its habitat, they consult with the agencies responsible for the ESA, the **US Fish and Wildlife Service**, fws.gov/program/endangered-species (terrestrial ESA species) or the **National Marine Fisheries Service**, fisheries.noaa.gov/topic/endangered-species-conservation (aquatic ESA species). This is known as "a consultation" with "the Services". The services may then recommend changes to the project or action to protect listed species or habitats. A pesticide registration or re-registration under the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) are actions that must also comply with the Endangered Species Act.

Meeting this ESA responsibility is a formidable task, considering the tens of thousands of pesticide products and registration amendments for which the EPA is required to review the potential effects for over 1,700 U.S. listed species. Due to previous lawsuits by environmental groups, the EPA has developed new strategies to protect endangered species and their habitats from pesticides. These include the **Vulnerable Species Action Plan**, downloads.regulations.gov/EPA-HQ-OPP-2023-0327-0208/content.pdf, the **final Herbicide Strategy**, https://downloads.regulations.gov/EPA-HQ-OPP-2023-0365-1137/content.pdf, the draft Insecticide and Rodenticide Strategies, and the future draft Fungicide Strategy. The EPA has also developed a draft "Hawaii Strategy" aimed at protecting ESA species from pesticide use in Hawaii, since approximately 40% of all ESA listed species occur in Hawaii. The final protections will be described on pesticide labels and in bulletins located in the website **Bulletins Live! Two,** www.epa.gov/endangered-species/bulletins-live-two-view-bulletins.

2. What is the Final Herbicide Strategy?

On August 20, 2024 the EPA released a **Herbicide Strategy to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides**, https://www.regulations.gov/document/EPA-HQ-OPP-2023-0365-1137. This 79-page document reflects the EPA's three-step process to identify runoff/erosion and spray drift mitigation to protect listed species and their habitats as part of EPA's conventional herbicide registration and re-evaluation processes.

The herbicide strategy covers only conventional herbicides for agricultural uses in the lower 48 states. The mitigations identified in the strategy address potential impacts to listed plants (terrestrial, wetland, and aquatic), which are the types of species likely to be most impacted by herbicides. By identifying mitigations to protect plants, listed animal species that depend on plants would also be protected. This includes animals that depend on plants for food and shelter (habitat). By identifying and defining mitigations for these listed plant and animal species, EPA will consider and apply the Herbicide Strategy as appropriate in FIFRA herbicide registration and re-registration actions, which should result in reductions of population-level impacts to over 900 listed ESA species in the lower 48 states.

The herbicide strategy is not self-implementing and will require individual label changes. The strategy considers field and regional conditions and is intended to allow growers to select mitigation options that work best for their situation. Herbicide labels will start to change within one to three years, but it may take several years for the process to be completed for all herbicides.

3. How will the herbicide strategy affect pesticide use?

In cases where a herbicide has the potential to impact listed species or their habitat, the EPA could require spray drift mitigations, and/or runoff/erosion mitigations on the product label with more restrictive mitigation in specific geographic areas called Pesticide Use Limitation Areas (PULAs). PULAs identify the critical areas where listed species are most likely to occur. The applicator will be required to visit EPA's **Bulletins Live! Two**, .epa.gov/endangered-species/bulletins-live-two-view-bulletin) to determine whether the fields(s) are within listed species PULAs and have more restrictive mitigations in that area. The applicator can do this on the day of the herbicide application, but can also plan ahead and check up to 6 months prior to the application..

4. What about fungicides, insecticides, and rodenticides?

The EPA is developing strategies to protect threatened and endangered species and their critical habitat for all types of conventional pesticides. Like herbicides, EPA's strategies for fungicides, insecticides, and rodenticides will identify the need for, the level of, and the geographic placement of mitigations to protect endangered species.

5. How can I reduce spray drift?

Spray drift mitigations were developed to reduce the likelihood of impacts to listed species and designated critical habitat. EPA's mitigation approach includes minimum droplet size, maximum windspeed, and maximum release height requirements, as well as requirements for downwind spray drift buffers when needed. The maximum downwind buffer distances for different application methods are: aerial 0 to 320 feet, ground boom 0 to 230 feet, and airblast in orchards for plant growth regulators (e.g., when fruit and blossom thinning uses are included in the herbicide strategy), 0 to 160 feet. Chemigation applications for overhead and impact sprinklers do not have spray drift buffers, but other mitigation measures may be identified. Applicators can use various mitigation strategies to reduce the size of the required downwind buffers. Some examples include using coarser droplet size, drift-reducing adjuvant, hooded sprayers, treating a reduced proportion of the field, presence of downwind windbreaks, reducing the single application rate, or weather conditions that include relative humidity greater than 60% at time of application.

Each of these mitigations reduce the buffer as a percentage of the maximum and are additive such that two mitigations of 75% and 25% reduction would add to 100% reduction in the buffer requirement. Some managed areas can be included in the buffer area, for example: agricultural fields, roads, grassy areas next to field, or field borders. Some application methods are not prone to spray drift and will not require a buffer. Examples include: in-furrow sprays, tree trunk drench, tree injection, soil injection, or small area applications (<1/10 acre or < 1,000 square feet).

6. How can I reduce runoff/erosion?

EPA's Mitigation Menu was developed, .epa.gov/pesticides/mitigation-menu to reduce pesticide off-site movement via runoff or due to soil erosion. The product label and/or bulletins will outline mitigation requirements of 0 to 9 mitigation points that will depend on factors such as the herbicide used, crop, application parameters, and site-specific geographic conditions. The EPA's Mitigation Menu Website includes descriptions of each mitigation and mitigation relief measure, cross references to NRCS conservation practice standards, and will include a runoff point calculator.

The EPA's mitigation measures for erosion/runoff risk reduction include field characteristics like slope ≤3% or predominantly sandy soil, in-field runoff mitigation measures (conservation tillage, contour farming, cover crops, in-field vegetative strips, management of irrigation water, or terrace farming), measures adjacent to the treated field (grassed waterway, vegetated filter strips, riparian area), and systems that capture runoff and discharge (water retention systems such as ponds or sediment basins), and application parameters (partial field treatment, reduced annual application rate, soil incorporation). If certain mitigation measures are in place, then no further runoff/erosion mitigations are needed, such as systems with permanent basins, tailwater return systems, or subsurface tile-drains with controlled drainage structures. Similarly, some application methods such as tree injection, soil injection, or small area applications (less than 1/10 acre or <1,000 square feet) are not prone to runoff/erosion and will not require further mitigation.

Each of these mitigations have an assigned point value of one to four mitigation points. Other ways to receive mitigation points include working with a technical expert in runoff/erosion control, such as a USDA NRCS technical service provider or independent crop consultant in runoff/erosion control, participating in a conservation program to reduce runoff, or tracking mitigation measures used on their field. Mitigation points are additive; for example if a grower uses three practices worth obe point, plus two points, plus three points, the three combined runoff/erosion control practices add up to six mitigation points. Thus, in this example if a herbicide for their crop or site requires six points, this grower would have enough runoff/erosion mitigation points to use that herbicide.

7. Mitigation relief points for runoff vulnerability:

The EPA has determined that for counties with medium, low, and very low runoff potential, less runoff/erosion mitigation is needed to reduce risks to listed species. Therefore, the EPA assigned relief points based on runoff vulnerability that count toward the required mitigation points.

Counties with **medium runoff** vulnerability will receive two relief points, counties with **low runoff** vulnerability will receive three relief points, and counties with **very low runoff** vulnerability will receive six relief points. These points reduce the amount of additional mitigation that may be needed, such that a field in a county identified with six relief points due to very low runoff potential would not need to implement any other runoff/erosion mitigations for a product that requires six mitigation points. Relief points will reduce mitigation needs for approximately 80% of cultivated agricultural acres and 95% of specialty and minor crop production acres.

8. Pesticide use in critical areas: Pesticide Use Limitation Areas (PULA)

The **EPA's Bulletins Live! Two**, epa.gov/endangered-species/bulletins-live-two-view-bulletins, is a website designed to provide information for specific geographic areas (PULAs) where listed species or their critical habitat are found. If EPA requires additional mitigations in these areas, those pesticide-specific requirements will be outlined for each PULA. The applicator will be required to check EPA's Bulletins Live! Two within six months of the application to determine whether the application site is in a PULA. If it is, the pesticide label and/or bulletins on the EPA's Bulletins Live! Two website would identify the amount or type of additional mitigation needed. The EPA is developing an approach to refine the PULAs (maps) where the listed species and their critical habitat are found. This refinement process is intended to ensure that additional mitigation steps are required where they are most needed to protect listed species and their habitat.

Table 3. Herbicide classification by group number and site of action.

Group Number	Site of action (mode of action)	Examples
1	ACCase (lipid synthesis)	Poast, Select Max
2	ALS (amino acid synthesis)	Pursuit, Classic, Accent
3	Tubulin (cell division)	Treflan, Prowl
4	Auxin binding site (synthetic auxin)	2,4-D, Clarity
5	D1 protein (Photosystem II inhibition)	atrazine, metribuzin
6	D1 protein (Photosystem II inhibition)	Basagran, Tough
7	D1 protein (Photosystem II inhibition)	linuron
9	EPSPS (shikimic acid pathway inhibition)	Roundup, glyphosate
10	Glutamine synthetase (photosynthesis inhibition)	Liberty
13	DPX synthase (carotene synthesis)	Command
14	PPO (chlorophyll synthesis)	Cobra, Flexstar, Valor, Authority
15	Very long chain fatty acid synthesis inhibitors	Dual II Magnum, Harness, Zidua
19	Auxin transport	N/A
22	Photosystem I (cell membrane disruption)	Paraquat
27	HPPD (carotene synthesis)	Callisto, Balance Flexx, Impact

Table 4. Active ingredients and group numbers of single ingredient products.

Trade name	Herbicide Group number	Active ingredient
2,4-D, Enlist One, others	4	2,4-D
Accent Q	2	nicosulfuron
Aim	14	carfentrazone
Assure II	1	quizalofop
atrazine	5	atrazine
Autumn	2	iodosulfuron
Balance Flexx	27	isoxaflutole
Banvel, Clarity, DiFlexx, others	4	dicamba
Basagran	6	bentazon
Beacon	2	primisulfuron
Beyond Xtra	2	imazamox
Buctril	6	bromoxynil
Cadet	14	fluthiacet-methyl
Callisto	27	mesotrione
Classic	2	chorimuron
Cobra	14	lactofen
Command	13	clomazone
Dual/EverpreX	15	S-metolachlor
Express	2	tribenuron
FirstRate	2	cloransulam-methyl
FlexStar/Reflex	14	fomesafen
Fusilade DX	1	fluazifop
Gramoxone SL	22	paraquat
Harmony	2	thifensulfuron
Harness/Surpass NXT	15	acetochlor
Impact/Armezon	27	topramezone
Laudis	27	tembotrione
Liberty	10	glufosinate
Lorox/Linex	7	linuron
Metribuzin/TriCor/Sencor	5	metribuzin
Option	2	foramsulfuron
Outlook	15	dimethenamid-P
Peak	2	prosulfuron
Permit	2	halosulfuron
Poast	1	sethoxydim
Prowl	3	pendimethalin
Pursuit	2	imazethapyr
Python	2	flumetsulam
Resolve/Bestow	2	rimsulfuron
Resource	14	flumiclorac
Roundup, others	9	glyphosate
Scepter	2	imazaquin
Select Max	1	clethodim
Sharpen	14	saflufenacil
Shieldex	27	tolpyralate
Sonalan	3	ethalfluralin
Spartan/Authority	14	sulfentrazone
Stinger HL	4	clopyralid
Tough	6	pyridate
Treflan/Thrust	3	trifluralin
UltraBlazer	14	acifluorfen
Valor EZ/Panther SC	14	flumioxazin
Warrant/Enversa	15	acetochlor (encapsulated)
Zidua SC	15	pyroxasulfone
Only sold in premix	2	thiencarbazone-methyl
Only sold in premix	19	diflufenzopyr
Only sold in premix	1	fenoxaprop
Only sold in premix	27	bicyclopyrone

Table 5. Active ingredients and group numbers of herbicide premixes.

Trade name	Herbicide group number	Active ingredient
Acuron	5, 15, 27, 27	atrazine, S-metolachlor, mesotrione, bicyclopyrone
Acuron Flexi	15, 27, 27	S-metolachlor, mesotrione, bicyclopyrone
Acuron GT	15, 27, 27, 9	S-metolachlor, mesotrione, bicyclopyrone, glyphosate
Afforia	2, 2, 14	thifensulfuron, tribenuron, flumioxazin
Alluvex	2, 2	rimsulfuron, thifensulfuron
Anthem	14, 15	fluthiacet-methyl, pyroxasulfone
Anthem ATZ	5, 14, 15	atrazine, fluthiacet-methyl, pyroxasulfone
Anthem Maxx	14, 15	fluthiacet-methyl, pyroxasulfone
Armezon Pro	15, 27	dimethenamid-P, topramezone
Authority Assist	2, 14	imazethapyr, sulfentrazone
Authority Edge/Authority Supreme	14, 15	sulfentrazone, pyroxasulfone
Authority Elite	14, 15	sulfentrazone, S-metolachlor
Authority MTZ	5, 14	metribuzin, sulfentrazone
Authority XL	2, 14	chlorimuron, sulfentrazone
Autumn Super	2, 2	iodosulfuron, thiencarbazone-methyl
Basis Blend	2, 2	rimsulfuron, thifensulfuron
Bicep II Magnum, Bicep Lite II Magnum	5, 15	atrazine, S-metolachlor
Boundry	15, 5	S-metolachlor, metribuzin
BroadAxe	14, 15	sulfentrazone, S-metolachlor
Calibra	15, 27	S-metolachlor, mesotrione
Callisto GT	9, 27	glyphosate, mesotrione
Callisto Xtra	5, 27	atrazine, mesotrione
Canopy	2, 5	chlorimuron, metrbuzin
Canopy EX	2, 2	chlorimuron, tribenuron
Capreno	2, 27	thiencarbazone, tembotrione
Charger Max ATZ	5, 15	atrazine, S-metolachlor
Cheetah Max	10, 14	glufosinate, fomesafen
Cinch ATZ	15, 5	S-metolachlor, atrazine
Confidence Xtra	5, 15	atrazine, acetochlor
Corvus	2, 27	thiencarbazone, isoxaflutole
Coyote	15, 27	metolachlor, mesotrione
Crusher	2, 2	rimsulfuron, thifensulfuron
Degree Xtra	5, 15	atrazine, acetochlor
DiFlexx	4, 27	dicamba, isoxaflutole
Diflexx Duo	4, 27	dicamba, tembotrione
Enlist Duo	4, 9	2,4-D, glyphosate
Enlite	2, 2, 14	chlorimuron, thifensulfuron, flumioxazin
Envive	2, 2, 14	chlorimuron, thifensulfuron, flumioxazin
Extreme	2, 9	imazethapyr, glyphosate
Fierce EZ	14, 15	flumioxazin, pyroxasulfone
Fierce MTZ	5, 14, 15	metribuzin, flumioxazin, pyroxasulfone
Fierce XLT	2, 14, 15	chlorimuron, flumioxazin, pyroxasulfone
Flexstar GT	9, 14	glyphosate, fomesafen
FulTime NXT	5, 15	atrazine, acetochlor
Halex GT	9, 15, 27	glyphosate, S-metolachlor, mesotrione
Harness MAX	15, 27	acetochlor, mesotrione
Harness Xtra	5, 15	atrazine, acetochlor
Harrow	2, 2	rimsulfuron, thifensulfuron
Hornet WDG	2, 4	flumetsulam, clopyralid
Impact Core	15, 27	acetochlor,topramezone
ImpactZ	5, 27	atrazine, topramezone
Instigate	2, 27	rimsulfuron, mesotrione
Intermoc	10, 15	glufosinate, metolachlor
Keystone NXT, Keystone LA NXT	5, 15	atrazine, acetochlor
Kyro	4, 15, 27	clopyralid, acetochlor, topramezone
Latir	2, 14	imazethapyr, flumioxazin
Lexar EZ	5, 15, 27	atrazine, S-metolachlor, mesotrione
Lumax EZ	5, 15, 27	atrazine, S-metolachlor, mesotrione
Marksman	4, 5	dicamba, atrazine
Marvel	14, 14	fluthiacet-methyl, fomesafen
Maverick Corn Herbicide	4, 15, 27	clopyralid, pyroxasulfone, mesotrione
Moccasin MTZ	5, 15	metribuzin, metolachlor

Table 5. Active ingredients and group numbers of herbicide premixes (continued).

Trade name	Herbicide group number	Active ingredient
Optill	2, 14	imazethapyr, saflufenacil
Panoflex	2, 2	tribenuron, thifensulfuron
Panther Pro	2, 5, 14	imazethapyr, metribuzin, flumioxazin
Perpetuo	14, 15	flumiclorac, pyroxasulfone
Permit Plus	2, 2	halosulfuron, thifensulfuron
Prefix	14, 15	fomesafen, S-metolachlor
Presidual	5, 15	metribuzin, S-metolachlor
Prequel	2, 27	rimsulfuron, isoxaflutole
Preview 2.1 SC	5, 14	metribuzin, sulfentrazone
Priority	2, 14	halosulfuron, carfentrazone
Pummel	2, 15	imazethapyr, metolachlor
Realm Q	2, 27	rimsulfuron, mesotrione
Require Q	2, 4	rimsulfuron, dicamba
Resicore, Resicore REV	4, 15, 27	clopyralid, acetochlor, mesotrione
Resolve Q	2, 2	rimsulfuron, thifensulfuron
Restraint	15, 27	acetochlor, tolpyralate
Revulin Q	2, 27	nicosulfuron, mesotrione
Scorch	4, 4, 4	2,4-D, dicamba, fluroxypyr
Sinate	10, 27	glufosinate, topramezone
Sequence	9, 15	glyphosate, S-metolachlor
Sinate	10, 27	glufosinate, topramezone
Solstice	14, 27	fluthiacet-methyl, mesotrione
Sonic	2, 14	cloransulam-methyl, sulfentrazone
Spitfire	4, 4	2,4-D, dicamba
Statement	15, 14	metolachlor, fomesafen
Status	4, 19	dicamba, diflufenzopyr
Steadfast Q	2, 2	nicosulfuron, rimsulfuron
Storen	15, 15, 27, 27	S-metolachlor, pyroxasulfone, mesotrione, bicyclopyrone
Surpass NXT	5, 15	atrazine, acetochlor
Surestart II	2, 4, 15	flumetsulam, clopyralid, acetochlor
Surtain	14, 15	saflufenacil, pyroxasulfone
Surveil	2, 14	cloransulam-methyl, flumioxazin
Synchrony	2, 2	chlorimuron, thifensulfuron
Tailwind	5, 15	metribuzin, metolachlor
Tendovo	15, 2, 5	S-metolachlor, cloransulam-methyl, metribuzin
Torment	2, 14	imazethapyr, fomesafen
Tough R	6, 27	pyridate, mesotrione
TripleFLEX II	2, 4, 15	flumetsulam, clopyralid, acetochlor
Tripzin ZC	3, 5	pendimethalin, metribuzin
Trisidual	2, 4, 15	flumetsulam, clopyralid, acetochlor
Trivence	2, 5, 14	chlorimuron, metribuzin, flumioxazin
Trivolt	2, 15, 27	thiencarbazone-methyl, flufenacet, isoxaflutole
Valor XLT	2, 14	chlorimuron, flumioxazin
Varisto	2, 6	imazamox, bentazon
Verdict	14, 15	saflufenacil, dimethenamid-P
Warrant Ultra	14, 15	fomesafen, acetochlor
Weedmaster	4, 4	2,4-D, dicamba
Yukon	2, 4	halosulfuron, dicamba
Zalo	1, 10	quizalofop-p-ethyl, glufosinate
Zidua Pro	2, 14, 15	imazethapyr, saflufenacil, pyroxasulfone
Zone Defense	14, 14	sulfentrazone, flumioxazin
Zone Assist	2, 14	imazethapyr, sulfentrazone
Zone Elite	14, 15	sulfentrazone, S-metolachlor
Zone Maxx	2, 14	chlorimuron, sulfentrazone

Table 6. Grass pasture hay fields.

				Beef non-lactating animals			Lactating dairy animals	
Herbicide	A.I.	HG	Rate/A	Grazing	Hay harvest	Removal before slaughter	Grazing	Hay harvest
2,4-D	2,4-D	4	1.5-2.0 lb. a.e.[1]	0	7 days	0	0	7 days
Clarity and many others	dicamba	4	Up to 1 pt.	0	7 days	30 days	7 days	37 days
			1-2 pt.	0	7 days	30 days	21 days	51 days
			2-4 pt.	0	7 days	30 days	40 days	70 days
Chaparral	aminopyralid + metsulfuron methyl	4, 2	1-3.3 oz.	0	0	0	0	0
Cimarron Max (co-pack)	metsulfuron methyl + dicamba + 2,4-D	2, 4, 4	0.25-1 oz. A + 1-4 pt. B	0	37 days	30 days	7 days	37 days
Cimarron X-Tra or Cimmaron Plus	metsulfuron methyl + chlorsulfuron	2, 2	0.1-1.0 o.z.	0	0	0	0	0
Crossbow	triclopyr + 2,4-D	4, 4	1-6 qt.	0	14 days	3 days	Growing season	14 days
Curtail	clopyralid + 2,4-D	4, 4	2-4 qt.	0	7 days	7 days[2]	14 days	7 days
Duracor	aminopyralid + florpyrauxifen-benzyl	4, 4	12-20 fl. oz.	0	14 days	0	0	14 days
Escort XP	metsulfuron methyl	2	Up to 1.7 oz.	0	0	0	0	0
ForeFront HL, GrazonNext HL	aminopyralid + 2,4-D	4, 4	1.2-2.1 pt.	0	7 days	0	0	7 days
Grazon P&O	picloram + 2,4-D	4, 4	3-4 pt.	0	30 days	3 days	7 days	30 days
Milestone	aminopyralid	4	3-7 fl. oz.	0	0	0	0	0
Outrider	sulfosulfuron	2	0.75-2.0 oz.	0	0	0	0	0
Overdrive	dicamba + diflufenzopyr	4, 19	4-8 oz.	0	0	0	0	0
PastureGard HL	triclopyr + fluroxypyr	4, 4	1-1.5 pt.	0	14 days	3 days	0	14 days
Rave	dicamba + triasulfuron	4, 2	2-5 oz.	0	7 days	30 days	7 days	7 days
Remedy Ultra	triclopyr	4	1-2 qt.	0	14 days	3 days	0	14 days
Surmount	picloram + fluroxypyr	4, 4	1.5-6 pt.	0	7 days	3 days	14 days	7 days
Tordon 22K	picloram	4	< 2pt	0	0	3 days	14 days	14 days
			> 2pt.	0	14 days	3 days	14 days	14 days
Weedmaster	dicamba + 2,4-D	4, 4	1-4 pt.	0	7 days	30 days	7 days	7 days

[1]a.e. = acid equivalent

[2]Seven day slaughter interval if Curtail was freshly applied, withdrawal not needed if two weeks or more have elapsed since application.

Table 7. Active ingredients and group numbers of single ingredient products.

Crop	Herbicide	A.I.	HG	Rate/A	Pre Harvest Interval for Hay	Application timing	
						Seedling/ Establishment	Established stands**
Alfalfa	Gramoxone SL 3.0	paraquat	22	1.3-2.0 pt.			Dormant in winter, spring, fall
Alfalfa	Gramoxone SL 3.0	paraquat	22	0.7 pt.	30 days		Within five days after cutting
Alfalfa	Gramoxone SL 3.0	paraquat	22	1.3-2.7 pt.	30 days	prior to crop emergence	
Alfalfa, birdsfoot trefoil, and clover	Pursuit	imazethapyr	2	3-6 fl. oz.	30 days	second trifoliate or larger	Dormant/semidormant in winter, spring, fall, or between cuttings (< 3 inches regrowth)
Alfalfa	Raptor	imazamox	2	4-6 fl. oz.	0 days	second trifoliate or larger	Dormant/semidormant in winter, spring, fall, or between cuttings (< 3 inches regrowth)
Alfalfa and sainfoin	Metribuzin 75 WDG, Dimetric, Glory, MetriCor	metribuzin	5	0.3-1.3 lb.	28 days		Dormant in fall, winter, and spring
Alfalfa/perennial forage grass (cool season)	Metribuzin 75 WDG, Dimetric, Glory, MetriCor*	metribuzin	5	0.6-1 lb.	28 days		Dormant in fall, winter, and spring
Alfalfa	Prowl H2O	pendimethalin	3	1.1-2.1 pt.	14 days	after two fully expanded trifliate, < 6 inches	
Alfalfa and alfalfa/ perennial forage grasses (cool-season)	Prowl H2O	pendimethalin	3	1.1-4.2 qt.	14, 50 days (at max application)		Dormant/semidormant in winter, spring, fall, or between cuttings (< 6 inches regrowth)
Perennial forage grasses (cool-season)	Prowl H2O	pendimethalin	3	1.1-4.2 qt.	14 days		6 or more tillers in Fall, winter, and spring or between cuttings
Perennial forage grasses (warm-season)	Prowl H2O	pendimethalin	3	1.1-4.2 qt.	0 days		After first-cutting when dormant in fall, winter and spring
Alfalfa and clover	Chateau EZ	flumioxazin	14	2-4 fl. oz.	25 days		< 6 inches tall following a cutting
Alfalfa and alfalfa/ perennial forage grasses (cool-season)	Sharpen 2.85SC	saflufenacil	14	1-2 fl. oz.	28 days		Dormant in fall, and winter
Perennial forage grasses (cool- and warm-season)	Sharpen 2.85SC	saflufenacil	14	1-2 fl. oz.	0 days	Preemergence	Dormant in fall, winter, and spring; in season for cool-season grasses
Alfalfa and clover	Aim 2EC	carfentrazone	14	0.5-2.5 fl. oz.	21 days		< 6 inches tall
Alfalfa	Warrant	acetochlor	15	1.25-2 qt.	20 days	< 4th trifoliate	< 7 days following cuttings
Alfalfa and seedling birdsfoot trefoil	Butyrac (200)	2,4-D	4	1-3 qt.	30 days for established, 60 days for seedling	Apply to seedlings, Minimum of 4 trifoliate leaves	30 days prior to harvest
Alfalfa	Maestro 4EC	Bromoxynil	6	0.5-0.75 pt.	30 days, unless fall sprayed then 60 days	Minimum of 4 trifoliate leaves	
Round-up Ready alfalfa	Round up	glyphosate	9	0.75-1.5 lb. ae.	5 days	anytime outside of 5 days before harvest	
Alfalfa, sainfoin, Holy clover, birdsfoot trefoil	Select 2EC	clethodim	1	6-16 fl. oz.	15 days		15 days prior to harvest
Alfalfa, sainfoin, birdsfoot trefoil	Poast Plus	sethoxydim	1	1.5-2.5; 3.75 pt.	14 days	14 days prior to harvest	14 days prior to harvest
Clover	Poast Plus	sethoxydim	1	1.5-2.5; 3.75 pt.	20 days	20 days prior to harvest	20 days prior to harvest
Alfalfa	Velpar L	hexazinone	5	2-6 pt.	30 days		Spring or between cutting < 2 in tall
Alfalfa	Velpar Alfalfamax	hexazinone, diuron	5, 7	1.5-4.3 lb.	30 days		Spring before new growth

*May reduce forage grass stand.

**Established stands are defined as stands planted in the fall or spring which have gone through a cutting/mowing.

Table 8. Soybean Herbicide Effectiveness Ratings.[1]

Weed response to selected herbicides: E = excellent, G = good, F = fair, P = poor	Herbicide Group Number	Crop tolerance	Grasses: Crabgrass	Fall panicum	Foxtails	Woolly cupgrass	Shattercane[2]	Broadleaves: Waterhemp[2, 4, 5, 6, 7, 8]	Black nightshade	Cocklebur[2]	Common ragweed	Giant ragweed[2, 4, 8]	Lambsquarter	Smartweed	Sunflower[2]	Velvetleaf	Perennials: Canada thistle	Quackgrass	Yellow nutsedge
Preplant/Preemergence																			
Authority, Spartan, Zone (sulfentrazone)	14	G	P-F	P	P-F	P	P	E	E	F	F	F	G-E	F	P	F-G	P	P	F-G
Breakfree, Harness, Surpass NXT, etc. (acetochlor)	15	E	E	E	E	F	F	F-G	G	P	P	P	P	P	P	P	P	P	P
Dual Magnum, Outlook, Warrant, Zidua, etc. (S-metolachlor, pyroxasulfone, etc)	15	E	E	E	E	F	F	F-E	G	P	P	P	P	P	P	P	P	P	P
Command (clomazone)	13	E	G-E	G-E	E	F	F	P	F	F	G	P	G-E	G	F	E	P	P	P
FirstRate, Amplify (cloransulam-methyl)	2	G-E	P	P	P	P	P	P-G	P	G	G-E	G-E	G	G-E	G	F-G	P	P	F-G
Linex, Lorox (linuron)	7	F	P-F	P-F	P	P	P	G-E	F	F	G	P-F	G-E	G-E	F	F	P	P	P
Prowl, Treflan, etc (pendimethalin, trifluralin)	3	G-E	E	E	E	E	G-E	G	P	P	P	P	G	F	P	P	P	P	P
Pursuit (imazethapyr)	2	G	F-G	F	F-G	P-F	G	P-E	G-E	F	G	F	G	G-E	F-G	G	P	P	P
Python (flumetsulam)	2	E	P	P	P	P	P	P-E	F	F	F	P	F-G	G-E	F	E	P	P	P
Metribuzin, TriCor, Mauler, etc	5	F-G	P	P	P-F	P	P	E	F	F	E	P	E	E	F-G	G-E	P	P	P-F
Sharpen (saflufenacil)	14	G	P	P	P	P	P	F	F	F	F	F	F	F	F	F	P	P	P
Valor EZ (flumioxazin)	14	F-G	P	P	P	P	P	G-E	E	P	G	F	G-E	F	P	F	P	P	P
Postemergence																			
Assure II, Fusilade DX, Poast Plus, Select Max (quizalofop, fluazifop, sethoxydim, clethodim)	1	E	E	E	E	E	E	P	P	P	P	P	P	P	P	P	P	G-E*	P
Basagran (bentazon)	6	E	P	P	P	P	P	P-F	P-F	E	E	F	P	E	G	G-E	G*	P	G*
Blazer (acifluorfen)	14	F-G	P	P	F	P	F	E	G	F	G	F	F	E	F	F	F	P	P
Classic (chlorimuron)	2	G	P	P	P	P	P	P-E	P	E	G-E	F	P	G-E	E	G-E	F	P	G-E
Cobra, Phoenix (lactofen)	14	F-G	F	P	P	P	P	E	G	G-E	E	F-G	F	G	G	F	F	P	P
Enlist One (2,4-D)[3]	4	E	P	P	P	P	P	G-E	G	E	E	E	E	F-G	G-E	G-E	F-G*	P	P
FirstRate, Amplify (cloransulam-methyl)	2	G	P	P	P	P	P	P	P	G-E	E	E	P	G	E	G	P	P	P
Roundup (glyphosate)[3]	9	E	E	G-E	E	E	E	G-E	F-G	E	E	G-E	G	E	E	G	G	G-E	F
Harmony (thifensulfuron)	2	F	P	P	P	P	P	P-E	P	F	F	P	G-E	G-E	G-E	G	P	P	P
Liberty (glufosinate)[3]	10	E	E	G	G-E	E	E	G	E	E	E	G	G	E	E	E	F-G	G	F
Pursuit (imazethapyr)	2	G	G	G	F-G	F	E	P-G	E	G-E	G	F	P-F	E	G	G-E	F	P	P
Beyond Xtra (imazamox)	2	G	G-E	G-E	G-E	G	E	P-G	E	G-E	G	G	G	E	E	G-E	F	F	F
Reflex, Flexstar (fomesafen)	14	F-G	P	P	P	P	P	E	F-G	F	G	G	F	G-E	F	F	P-F	P	P
Resource (flumiclorac)	14	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 are dominant in Iowa. These biotypes may not be controlled by all ALS products.
[3]Use only on appropriate resistant varieties.
[4]Glyphosate-resistant biotypes are dominant in Iowa. These biotypes may not be controlled by glyphosate.
[5]PPO-resistant biotypes of common waterhemp have been identified in Iowa. These biotypes may not be controlled by PPO inhibitor herbicides.
[6]HPPD-resistant biotypes of common waterhemp have been identified in Iowa. These biotypes may not be controlled by HPPD herbicides.
[7]PSII-resistant biotypes of these weeds are prevalent in Iowa. These biotypes may not be controlled by PSII inhibitor herbicides.
[8]Biotypes of this weed with resistance to multiple sites of herbicide action have been identified in Iowa.

*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.

Table 9. Corn Herbicide Effectiveness Ratings.[1]

Weed response to selected herbicides E = excellent G = good F = fair P = poor			Grasses					Broadleaves									Perennials		
	Herbicide Group Number	Crop tolerance	Crabgrass	Fall panicum	Foxtail	Woolly cupgrass	Shattercane[2]	Waterhemp[2, 4, 5, 6, 7, 8]	Black nightshade	Cocklebur[2]	Common ragweed	Giant ragweed[2, 4, 8]	Lambsquarter	Smartweed	Sunflower[2]	Velvetleaf	Canada thistle	Quackgrass	Yellow nutsedge
Preplant/Preemergence																			
Atrazine	5	E	F	P	F	P	P	P-E	G	G	E	F-G	E	E	G	G	P	F	F
Balance Flexx (isoxaflutole)	27	E	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
Harness, Surpass NXT, etc (acetochlor)	15	E	E	E	E	F-G	F-G	G	G	P	P	P	P-F	P-F	P	P	P	P	G
Callisto (mesotrione)	27	E	P	P	P	P	P	G-E	G-E	F-G	F-G	F	E	F-G	G-E	E	P	P	P
Dual II Magnum, Outlook, Zidua, etc (S-metolachlor, pyroxasulfone, etc)	15	E	E	E	E	F	F	F-G	G	P	P	P	P	P	P	P	P	P	G
Hornet WDG (flumetsulam, clopyralid)	2, 4	G	P	P	P	P	P	P-E	F-G	G	G	G	G	G-E	G-E	G	P	P	P
Linex, Lorox (linuron)	7	G	P-F	P-F	P	P	P	G-E	F	F	G	P-F	G-E	G-E	F	F	P	P	P
Pendimax, Prowl, etc (pendimethalin)	3	F-G	G-E	G-E	G-E	G	G	G	P	P	P	P	G-E	F	P	P-F	P	P	P
Python (flumetsulam)	2	G	P	P	P	P	P	P-E	F-G	F	G	F	F-G	G-E	F-G	G-E	P	P	P
Sharpen (saflufenacil)	14	G	P	P	P	P	P	G-E	G-E	G	G	G	G-E	G	G-E	G-E	P	P	G
Valor EZ (flumioxazin)	14	F-G	P	P	P	P	P	G-E	E	P	G	F	G-E	F	P	F	P	P	P
Postemergence																			
Accent Q, Steadfast Q (nicosulfuron, rimsulfuron)	2	G-E	P	G	G-E	G-E	E	P-G	P	F	P	P	P	G	P	F	F	G	F
Aim (carfentrazone)	14	G	P	P	P	P	P	F-G	G	P	P	F	G	P	P	E	P	P	P
Armezon, Impact (topramezone)	27	G-E	F-G	F	G	F	F	G-E	G-E	G-E	G	G	G	G	E	E	P	P	P
atrazine	5	G	F	P	F	P	P	F-E	E	E	E	G	E	E	E	E	F*	F	G
Basagran (bentazon)	6	E	P	P	P	P	P	P	P	E	E	F	P	E	G	G-E	G*	P	G*
Basis, Basis Blend (rimsulfuron, thifensulfuron)	2	F	F	F-G	G	F	G	P-G	P	F	F	P	G-E	G-E	G-E	G	P	G	P
Banvel, Clarity, DiFlexx, etc. (dicamba)	4	F-G	P	P	P	P	P	G-E	G	E	G-E	E	G	E	G	F-G	G*	P	P
Beacon (primisulfuron)	2	G	P	F-G	P-F	P	E	P-E	G	G	G	E	P	G	G	F-G	F-G*	G	F
Buctril (bromoxynil)	6	G	P	P	P	P	P	G	G-E	E	E	G	G-E	G-E	E	G	P	P	P
Callisto (mesotrione)	27	G-E	P	P	P	P	P	E	E	G-E	F	G	G	E	G-E	E	P	P	P
Enlist One (2,4-D)[3]	4	E	P	P	P	P	P	G-E	G	E	E	E	E	F-G	G-E	G-E	F-G	P	P
Roundup (glyphosate)[3]	9	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 (flumetsulam, clopyralid)	2, 4	G	P	P	P	P	P	P-E	F	E	E	G-E	F	G-E	E	G-E	G	P	P
Liberty (glufosinate)[3]	10	E	E	G	G-E	E	E	G	E	E	E	G	G	E	E	E	F-G	G	P
Laudis (tembotrione)	27	G-E	F-G	F	G-E	F-G	F-G	E	G-E	G-E	G	G	G	G	E	E	P	P	P
Permit, Halomax, etc. (halosufuron)	2	G	P	P	P	P	P	P-E	P	G-E	G-E	G	P	G-E	E	E	P	P	G
Resolve (rimsulfuron)	2	F	F	F-G	G	F	G	P-G	P	F	F	P	G-E	G	P	F-G	F	G	F
Resource (flumiclorac)	14	G-E	P	P	P	P	P	G	P	F	F-G	P	F	P	P	E	P	P	P
Shieldex (topyrlate)	27	G-E	F-G	P	G	P	G	E	E	F-G	G	G	G	F-G	E	E	P	P	P
Status (dicamba, diflufenzopyr)	4, 19	F-G	P	F	F	P	F	G-E	G	E	G-E	G	G	E	G	G	G*	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 are dominant in Iowa. These biotypes may not be controlled by all ALS products.
[3]Use only on appropriate resistant varieties.
[4]Glyphosate-resistant biotypes are dominant in Iowa. These biotypes may not be controlled by glyphosate.
[5]PPO-resistant biotypes of common waterhemp have been identified in Iowa. These biotypes may not be controlled by PPO inhibitor herbicides.
[6]HPPD-resistant biotypes of common waterhemp have been identified in Iowa. These biotypes may not be controlled by HPPD herbicides.
[7]PSII-resistant biotypes of these weeds are prevalent in Iowa. These biotypes may not be controlled by PSII inhibitor herbicides.
[8]Biotypes of this weed with resistance to multiple sites of herbicide action have been identified in Iowa.
*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.

Table 10. Corn herbicide premixes or co-packs and equivalents.

Herbicide	Group	Components (a.i./gal or % a.i. or a.e.)	If you apply (per acre)	You have applied (a.i. or a.e.)
Acuron	15	2.14 lb. S-metolachlor	3 qt.	1.6 lb. S-metolachlor
	5	1.0 lb. atrazine		0.75 lb. atrazine
	27	0.24 lb. mesotrione		0.180 lb. mesotrione
	27	0.06 lb. bicyclopyrone		0.045 lb. bicyclopyrone
Acuron Flexi	27	0.08 lb. bicyclopyrone	2.25 qt.	0.045 lb. bicyclopyrone
	27	0.320 lb mesotrione		0.180 lb. mesotrione
	15	2.860 lb S-metolachlor		1.609 lb. S-metolachlor
Acuron GT	15	2.000 lb. S-metolachlor	3.75 pt.	0.938 lb. S-metolachlor
	9	2.000 lb. a.e. glyphosate		0.938 lb. a.e. glyphosate
	27	0.200 lb. mesotrione		0.094 lb. mesotrione
	27	0.095 lb. bicyclopyrone		0.045 lb. bicyclopyrone
Alluvex WSG	2	0.167% rimsulfuron	1.5 oz.	0.016 lb. rimsulfuron
	2	0.167% thifensulfuron		0.016 lb. thifensulfuron
Anthem	15	2.087 lb. pyroxasulfone	10 fl. oz.	0.163 lb. pyroxasulfone
	14	0.063 lb. fluthiacet-methyl		0.005 lb. fluthiacet-methyl
Anthem Maxx	15	4.174 lb. pyroxasulfone	5 fl. oz.	0.163 lb. pyroxasulfone
	14	0.126 lb. fluthiacet-methyl		0.005 lb. fluthiacet-methyl
Anthem ATZ	5	4.006 lb. atrazine	2 pt.	1.002 lb. atrazine
	15	0.485 lb. pyroxasulfone		0.121 lb. pyroxasulfone
	14	0.014 lb. fluthiacet -methyl		0.004 lb. fluthiacet-methyl
Armezon Pro	15	5.250 lb. dimethenamid-P	20 fl. oz.	0.820 lb. dimethenamid-P
	27	0.100 lb. topramezone		0.016 lb. topramezone
Basis Blend	2	0.200% rimsulfuron	0.825 oz.	0.010 lb. rimsulfuron
	2	0.100% thifensulfuron		0.005 lb. thifensulfuron
Bicep II MAGNUM, Charger Max ATZ	15	2.400 lb. S-metolachlor	2.1 qt.	1.260 lb. S-metolachlor
	5	3.100 lb. atrazine		1.628 lb. atrazine
Bicep Lite II MAGNUM, Charger Max ATZ Lite	15	3.330 lb. S-metolachlor	1.5 qt.	1.249 lb. S-metolachlor
	5	2.670 lb. atrazine		1.001 lb. atrazine
Calibra	15	2.820 lb. S-metolachlor	2 qt.	1.410 lb. S-metolachlor
	27	0.280 lb. mesotrione		0.140 lb. mesotrione
Callisto GT	9	3.800 lb. glyphosate	2 pt.	0.950 lb. glyphosate
	27	0.380 lb. mesotrione		0.095 lb. mesotrione
Callisto Xtra	27	0.500 lb. mesotrione	24 fl. oz.	0.094 lb. mesotrione
	5	3.200 lb. atrazine		0.600 lb. atrazine
Capreno	2	0.570 lb. thiencarbazone	3.0 fl. oz.	0.013 lb. thiencarbazone
	27	2.880 lb. tembotrione		0.068 lb. tembotrione
Corvus	27	1.880 lb. isoxaflutole	5.6 fl. oz.	0.082 lb. isoxaflutole
	2	0.750 lb. thiencarbazone		0.033 lb. thiencarbazone
Coyote	15	3.340 lb. metolachlor	2.4 qt.	2.004 lb. metolachlor
	27	0.330 lb. mesotrione		0.198 lb. mesotrione
Crusher 50 WDF	2	0.250% rimsulfuron	1 oz.	0.016 lb. rimsulfuron
	2	0.250% thifensulfuron		0.016 lb. thifensulfuron
Degree Xtra	15	2.700 lb. acetochlor	3 qt.	2.025 lb. acetochlor
	5	1.340 l.b atrazine		1.005 lb. atrazine
DiFlexx Duo	27	0.270 lb. tembotrione	32 fl. oz.	0.068 lb. tembotrione
	4	1.860 lb. dicamba		0.465 lb. dicamba
Distinct 70WDG	19	0.213% diflufenzopyr	6 oz.	0.080 lb. diflufenzopyr
	4	0.550% dicamba		0.206 lb. dicamba
Enlist Duo	4	1.600 lb. a.e. 2,4-D	4.75 pt.	0.950 lb. a.e. 2,4-D
	9	1.700 lb. a.e. glyphosate		1.009 lb. a.e. glyphosate

a.i. = active ingredient | a.e. = acid equivalent

Table 10. Corn herbicide premixes or co-packs and equivalents. (continued)

Herbicide	Group	Components (a.i./ gal or % a.i. or a.e.)	If you apply (per acre)	You have applied (a.i. or a.e.)
FulTime NXT	15	2.700 lb. acetochlor	3 qt.	2.025 lb. acetochlor
	5	1.340 lb. atrazine		1.005 lb. atrazine
Halex GT	15	2.090 lb. S-metolachlor	3.6 pt.	0.941 lb. S-metolachlor
	27	0.209 lb. mesotrione		0.094 lb. mesotrione
	9	2.090 lb. glyphosate		0.941 lb. a.e. glyphosate
Harness MAX	15	3.520 lb. acetochlor	75 fl. oz.	2.063 lb. acetochlor
	27	0.330 lb. mesotrione		0.193 lb. mesotrione
Harness Xtra, Confidence Xtra, Keystone LA NXT	15	4.300 lb. acetochlor	2.3 qt.	2.473 lb. acetochlor
	5	1.700 lb. atrazine		0.978 lb. atrazine
Harness Xtra 5.6L , Confidence Xtra 5.6, Keystone NXT	15	3.100 lb. acetochlor	3 qt.	2.325 lb. acetochlor
	5	2.500 lb. atrazine		1.875 lb. atrazine
Hornet WDG	2	0.185% flumetsulam	5 oz.	0.058 lb. flumetsulam
	4	0.500% clopyralid		0.156 lb. clopyralid
Impact Core	15	7.080 lb. acetochlor	30 fl. oz.	1.659 lb. acetochlor
	27	0.071 lb. topramezone		0.017 lb. topramezone
ImpactZ	5	4.000 lb. atrazine	10.7 fl. oz.	0.334 lb. atrazine
	27	0.260 lb. topramezone		0.022 lb. topramezone
Instigate	2	0.042% rimsulfuron	6.0 oz.	0.016 lb. rimsulfuron
	27	0.417% mesotrione		0.156 lb. mesotrione
Katagon	2	1.000 lb. nicosulfuron	2.3 fl. oz.	0.018 lb. nicosulfuron
	27	1.000 lb. tolpyralate		0.018 lb. tolpyralate
Kyro	4	0.247 lb. a.e. clopyralid	45 fl. oz.	0.087 lb. a.e. clopyralid
	15	2.780 lb. acetochlor		0.977 lb. acetochlor
	27	0.046 lb. topramezone		0.016 lb. topramzone
Lexar EZ	15	1.740 lb. S-metolachlor	3.5 qt.	1.523 lb. S-metolachlor
	5	1.740 lb. atrazine		1.523 lb. atrazine
	27	0.224 lb. mesotrione		0.196 lb. mesotrione
Lumax EZ	27	0.249 lb. mesotrione	3 qt.	0.187 lb. mesotrione
	15	2.490 lb. S-metolachlor		1.868 lb. S-metolachlor
	5	0.935 lb. atrazine		0.701 lb. atrazine
Maverick Corn Herbicide	4	0.693 lb. a.e. clopyralid	18 fl. oz.	0.097 lb. a.e. clopyralid
	15	0.693 lb. pyroxasulfone		0.097 lb. pyroxasulfone
	27	0.829 lb. mesotrione		0.117 lb. mesotrione
Panoflex 50 WSG	2	0.400% tribenuron	0.5 oz.	0.013 lb. tribenuron
	2	0.100% thifensulfuron		0.003 lb. thifensulfuron
Perpetuo	14	0.590 lb flumiclorac	8 fl. oz.	0.037 lb. flumiclorac
	15	1.710 lb. pyroxasulfone		0.107 lb. pyroxasulfone
Prequel 45% DF	2	0.150% rimsulfuron	2 oz.	0.019 lb. rimsulfuron
	27	0.300% isoxaflutole		0.038 lb. isoxaflutole
Preview 2.1 SC	5	2.230 lb. metribuzin	14 fl. oz.	0.244 lb. metribuzin
	14	1.120 lb. sulfentrazone		0.123 lb. sulfentrazone
Realm Q	2	0.075% rimsulfuron	4 oz.	0.019 lb. rimsulfuron
	27	0.313% mesotrione		0.078 lb. mesotrione
Resicore	15	2.800 lb. acetochlor	2.75 qt.	1.925 lb. acetochlor
	27	0.300 lb. mesotrione		0.206 lb. mesotrione
	4	0.190 lb. a.e. clopyralid		0.131 lb. a.e. clopyralid

a.i. = active ingredient | a.e. = acid equivalent

Table 10. Corn herbicide premixes or co-packs and equivalents. (continued)

Herbicide	Group	Components (a.i./ gal or % a.i. or a.e.)	If you apply (per acre)	You have applied (a.i. or a.e.)
Resicore REV	4	0.190 lb. a.e. clopyralid	2.75 qt.	0.131 lb. a.e. clopyralid
	15	2.800 lb. acetochlor		1.925 lb. acetochlor
	27	0.270 lb. mesotrione		0.186 lb. mesotrione
Resolve Q	2	0.184% rimsulfuron	1.25 oz.	0.014 lb. rimsulfuron
	2	0.040% thifensulfuron		0.003 lb. thifensulfuron
Restraint	15	6.404 lb. acetochlor	30 fl. oz.	1.501 lb. acetochlor
	27	0.094 lb. tolpyralate		0.022 lb. tolpyralate
Revulin Q	27	0.368% mesotrione	4 oz.	0.092 lb. mesotrione
	2	0.144% nicosulfuron		0.036 lb. nicosulfuron
Scorch	4	1.000 lb. dicamba	1.5 pt.	0.188 lb. dicamba
	4	3.020 lb. 2,4-D		0.566 lb. 2,4-D
	4	0.750 lb. fluroxypyr		0.141 lb. fluroxypyr
Sequence	9	2.250 lb. glyphosate	4 pt.	1.125 lb. glyphosate
	15	3.000 lb. S-metolachlor		1.500 lb. S-metolachlor
Sinate	10	2.470 lb. glufosinate	28 fl. oz.	0.540 lb. glufosinate
	27	0.100 lb. topramezone		0.022 lb. topramezone
Solstice	27	3.784 lb. mesotrione	3.15 fl. oz.	0.093 lb. mesotrione
	14	0.216 lb. fluthiacet-methyl		0.005 lb. fluthiacet-methyl
Spirit 57WG	2	0.142% prosulfuron	1 oz.	0.009 lb. prosulfuron
	2	0.428% primisulfuron		0.027 lb. primisulfuron
Spitfire	4	0.500 lb. a.e. dicamba	2 pt.	0.125 lb. a.e. dicamba
	4	3.070 lb. a.e. 2,4-D		0.768 lb. a.e. 2,4-D
Status 56WDG	19	0.171% diflufenzopyr	5 oz.	0.053 lb. diflufenzopyr
	4	0.440% dicamba		0.138 lb. dicamba
Steadfast Q	2	0.252% nicosulfuron	1.5 oz.	0.024 lb. nicosulfuron
	2	0.125% rimsulfuron		0.012 lb. rimsulfuron
Storen	15	2.690 lb. S-metolachlor	2.4 qt.	1.614 lb. S-metolachlor
	15	0.150 lb. pyroxaulfone		0.090 lb. pyroxasulfone
	27	0.310 lb. mesotrione		0.186 lb. mesotrione
	27	0.075 lb. bicyclopyrone		0.045 lb. bicyclopyrone
Surestart II, Tripleflex II, Trisidual	15	3.750 lb. acetochlor	2 pt.	0.938 lb. acetochlor
	4	0.380 lb. clopyralid		0.095 lb. clopyralid
	2	0.120 lb. flumetsulam		0.030 lb. flumetsulam
Surtain	14	0.626 lb. saflufenacil	14 fl. oz.	0.068 lb. saflufenacil
	15	1.002 lb. pyroxasulfone		0.110 lb. pyroxasulfone
Tough R	6	2.500 lb. pyridate	32 fl. oz.	0.625 lb. pyridate
	27	0.750 lb. mesotrione		0.188 lb. mesotrione
Tripzin ZC	3	2.900 lb. pendimethalin	29 fl. oz.	0.657 lb. pendimethalin
	5	1.100 lb. metribuzin		0.249 lb. metribuzin
Trivolt	2	0.230 lb. thiencarbazone-methyl	20 fl. oz.	0.036 lb. thiencarbazone-methyl
	15	2.850 lb. flufenacet		0.445 lb. flufenacet
	27	0.570 lb. isoxaflutole		0.089 lb. isoxaflutole
Verdict	14	0.570 lb. saflufenacil	14 fl. oz.	0.062 lb. saflufenacil
	15	5.000 lb. dimethenamid-P		0.547 lb. dimethenamid-P
WideMatch 1.5EC	4	0.750 lb. fluroxypyr	1.33 pt.	0.125 lb. fluroxypyr
	4	0.750 lb. clopyralid		0.125 lb. clopyralid
Yukon	2	0.125% halosulfuron	4 oz.	0.031 lb. halosulfuron
	4	0.550% dicamba		0.138 lb. dicamba

a.i. = active ingredient | a.e. = acid equivalent

Table 11. Soybean herbicide premixes or co-packs and equivalents.

Herbicide	Group	Components (a.i./gal or % a.i.)	If you apply (per acre)	You have applied (a.i.)
Afforia	14	40.8% flumioxazin	3 oz.	0.077 lb. flumioxazin
	2	5.0% thifensulfuron		0.009 lb. thifensulfuron
	2	5.0% tribenuron		0.009 lb. tribenuron
Anthem Maxx	15	4.174 lb. pyroxasulfone	4 fl. oz.	0.130 lb. pyroxasulfone
	14	0.126 lb. fluthiacet-methyl		0.004 lb. fluthiacet-methyl
Authority Assist, Zone Assist	14	33.3% sulfentrazone	10 oz.	0.208 lb. sulfentrazone
	2	6.67% imazethapyr		0.042 lb. imazethapyr
Authority Edge	14	2.730 lb. sulfentrazone	10 fl. oz.	0.213 lb. sulfentrazone
	15	1.520 lb. pyroxasulfone		0.119 lb. pyroxasulfone
Authority Elite, Broad-Axe XC, Zone Elite	14	0.700 lb. sulfentrazone	25 fl. oz.	0.137 lb. sulfentrazone
	15	6.300 lb. S-metolachlor		1.230 lb. S-metolachlor
Authority First, sonic	14	62.1% sulfentrazone	6.45 oz.	0.250 lb. sulfentrazone
	2	7.96% cloransulam-methyl		0.032 lb. cloransulam-methyl
Authority MAXX, Zone Maxx	14	62.12% sulfentrazone	7 oz.	0.272 lb. sulfentrazone
	2	3.88% chlorimuron ethyl		0.017 lb. chlorimuron ethyl
Authority MTZ	14	18% sulfentrazone	16 oz.	0.180 lb. sulfentrazone
	5	27% metribuzin		0.270 lb. metribuzin
Authority Supreme	14	20.66% sulfentrazone	10 oz.	0.129 lb. sulfentrazone
	15	20.66% pyroxasulfone		0.129 lb. pyroxasulfone
Authority XL	14	62.2% sulfentrazone	8 oz.	0.311 lb. sulfentrazone
	2	7.8% chlorimuron ethyl		0.039 lb. chlorimuron ethyl
Boundary 6.5EC, Presidual	15	5.250 lb. S-metolachlor	2.1 pt.	1.378 lb. S-metolachlor
	5	1.250 lb. metribuzin		0.328 lb. metribuzin
BroadAxe XC	15	6.300 lb. S-metolachlor	32 fl. oz.	1.575 lb. S-metolachlor
	14	0.700 lb. sulfentrazone		0.175 lb. sulfentrazone
Canopy 75DF	2	10.7% chlorimuron-ethyl	6 oz.	0.040 lb. chlorimuron ethyl
	5	64.3% metribuzin		0.241 lb. metribuzin
Canopy EX	2	22.7% chlorimuron ethyl	1.5 oz.	0.021 lb. chlorimuron ethyl
	2	6.8% tribenuron		0.006 lb. tribenuron
Cheetah Max	10	2.000 lb. glufosinate	34 fl. oz.	0.531 lb. glufosinate
	14	1.000 lb. fomesafen		0.266 lb. fomesafen
Crusher	2	25% rimsulfuron	1 oz.	0.016 lb. rimsulfuron
	2	25% thifensulfuron		0.016 lb. thifensulfuron
Enlist Duo	4	1.60 lb. a.e. 2,4-D	4 pt.	0.80 lb. a.e. 2,4-D
	9	1.70 lb. a.e. glyphosate		0.85 lb. a.e. glyphosate
Enlite 47.9DG	14	36.20% flumioxazin	2.8 oz.	0.063 lb. flumioxazin
	2	8.80% thifensulfuron		0.015 lb. thifensulfuron
	2	2.85% chlorimuron ethyl		0.005 lb. chlorimuron ethyl
Envive 41.3DG	14	29.2% flumioxazin	3.5 oz.	0.064 lb. flumioxazin
	2	2.9% thifensulfuron		0.006 lb. thifensulfuron
	2	9.2% chlorimuron ethyl		0.020 lb. chlorimuron ethyl
Extreme	2	2.170 lb. imazethapyr	3 pt.	0.814 lb. imazethapyr
	9	1.480 lb. a.e. glyphosate		0.555 lb. a.e. glyphosate
Fierce EZ	14	1.340 lb. flumioxazin	6 fl. oz.	0.063 lb. flumioxazin
	15	1.700 lb. pyroxasulfone		0.080 lb. pyroxasulfone
Fierce MTZ	5	1.500 lb. metribuzin	16 fl. oz.	0.188 lb. metribuzin
	14	0.640 lb. pyroxasulfone		0.080 lb. pyroxasulfone
	15	0.500 lb. flumioxazin		0.063 lb. flumioxazin

a.i. = active ingredient | a.e. = acid equivalent

Table 11. Soybean herbicide premixes or co-packs and equivalents. (continued)

Herbicide	Group	Components (a.i./gal or % a.i.)	If you apply (per acre)	You have applied (a.i.)
Fierce XLT	14	24.57% flumioxazin	4 oz.	0.061 lb. flumioxazin
	15	31.17% pyroxasulfone		0.078 lb. pyroxasulfone
	2	6.67% chlorimuron ethyl		0.017 lb. chlorimuron ethyl
Flexstar GT 3.5	14	0.560 lb. fomesafen	3.5 pt.	0.245 lb. fomesafen
	9	2.260 lb. a.e. glyphosate		0.989 lb. a.e. glyphosate
Harrow	2	50% rimsulfuron	0.5 oz.	0.016 lb. rimsulfuron
	2	25% thifensulfuron		0.008 lb. thifensulfuron
Intermoc	10	1.070 lb. glufosinate	64 fl. oz.	0.535 lb. glufosinate
	15	2.500 lb. metolachlor		1.250 lb. metolachlor
Latir	14	31.5% flumioxazin	3.2 oz.	0.063 lb. flumioxazin
	2	23.5% imazethapyr		0.047 lb. imazethapyr
Marvel	14	0.117 lb. fluthiacet-methyl	7.25 fl. oz.	0.007 lb. fluthiacet-methyl
	14	2.883 lb. fomesafen		0.163 lb. fomesafen
Matador	15	4.010 lb. metolachlor	2.5 pt.	1.253 lb. metolachlor
	5	0.560 lb. metribuzin		0.175 lb. metribuzin
	2	0.130 lb. imazethapyr		0.041 lb. imazethapyr
Moccason MTZ	5	1.116 lb. metribuzin	2 pt.	0.279 lb. metribuzin
	15	3.350 lb. metolachlor		0.838 lb. metolachlor
OpTill	14	17.8% saflufenacil	2 oz.	0.022 lb. saflufenacil
	2	50.2% imazethapyr		0.063 lb. imazethapyr
Panoflex 50% WSG	2	40% tribenuron	0.5 oz.	0.013 lb. tribenuron
	2	10% thifensulfuron		0.003 lb. thifensulfuron
Panther MTZ	14	0.670 lb. flumioxazin	12 oz.	0.063 lb. flumioxazin
	5	3.000 lb. metribuzin		0.281 lb. metribuzin
Panther Pro	14	0.670 lb. flumioxazin	12 fl. oz.	0.063 lb. flumioxazin
	2	0.560 lb. imazethapyr		0.053 lb. imazethapyr
	5	3.000 lb. metribuzin		0.281 lb. metribuzin
Perpetuo	14	0.590 lb. flumiclorac	8 fl. oz.	0.037 lb. flumiclorac
	15	1.710 lb. pyroxasulfone		0.107 lb. pyroxasulfone
Prefix	15	4.340 lb S-metolachlor	2 pt.	1.085 lb. S-metolachlor
	14	0.950 lb fomesafen		0.238 lb. fomesafen
Preview 2.1 SC	5	2.230 lb. metribuzin	20 fl. oz.	0.348 lb. metribuzin
	14	1.120 lb. sulfentrazone		0.175 lb. sulfentrazone
Sequence	15	3.000 lb. S-metolachlor	3.5 pt.	1.313 lb. S-metolachlor
	9	2.250 lb. a.e. glyphosate		0.984 lb. a.e. glyphosate
Statement	15	4.330 lb. metolachlor	2 pt.	1.083 lb. metolachlor
	14	0.910 lb. fomesafen		0.228 lb. fomesafen
Storm 4S	6	2.670 lb. bentazon	1.5 pt.	0.501 lb. bentazon
	14	1.330 lb. acifluorfen		0.249 lb. acifluorfen
Surveil	14	36%% flumioxazin	3.6 oz.	0.081 lb. flumioxazin
	2	12%% cloransulam-methyl		0.027 lb. cloransulam-methyl
Synchrony NXT	2	21.5% chlorimuron ethyl	0.5 oz.	0.007 lb. chlorimuron ethyl
	2	6.9% thifensulfuron		0.002 lb. thifensulfuron
Tailwind	15	5.250 lb. metolachlor	2 pt.	1.313 lb. metolachlor
	5	1.250 lb. metribuzin		0.313 lb. metribuzin
Tendovo	15	3.470 lb. S-metolachlor	1.75 qt.	1.518 lb. S-metolachlor
	2	0.065 lb. cloransulam-methyl		0.028 lb. cloransulam-methyl
	5	0.642 lb. metribuzin		0.281 lb. metribuzin
Torment	14	2.000 lb. fomesafen	1 pt.	0.250 lb. fomesafen
	2	0.500 lb. imazethapyr		0.063 lb. imazethapyr

a.i. = active ingredient | a.e. = acid equivalent

Table 11. Soybean herbicide premixes or co-packs and equivalents. (continued)

Herbicide	Group	Components (a.i./gal or % a.i.)	If you apply (per acre)	You have applied (a.i.)
Tripzin ZC	3	2.900 lb. pendimethalin	29 fl. oz.	0.657 lb. pendimethalin
	5	1.100 lb. metribuzin		0.249 lb. metribuzin
Trivence WDG	2	3.9% chlorimuron ethyl	6 oz.	0.015 lb. chlorimuron ethyl
	14	12.8% flumioxazin		0.048 lb. flumioxazin
	5	44.6% metribuzin		0.167 lb. metribuzin
Valor XLT	14	30.0% fluioxazin	3 oz.	0.056 lb. flumioxazin
	2	10.3% chlorimuron ethyl		0.019 lb. chlorimuron ethyl
Varisto	6	4.000 lb. bentazon	27 fl. oz.	0.844 lb. bentazon
	2	0.187 lb. imazamox		0.039 lb. imazamox
Verdict	14	0.570 lb. saflufenacil	14 fl. oz.	0.062 lb. saflufenacil
	15	5.000 lb. dimethenamid-P		0.547 lb. dimethenamid-P
Warrant Ultra	15	2.820 lb. acetochlor	50 fl. oz.	1.102 lb. acetochlor
	14	0.630 lb. fomesafen		0.246 lb. fomesafen
Zalo	1	0.230 lb. quizalofop-p-ethyl	32 fl. oz.	0.058 lb. quizalofop-p-ethyl
	10	2.290 lb. glufosinate		0.573 lb. glufosinate
Zidua Pro	14	0.480 lb. saflufenacil	4.5 fl. oz.	0.017 lb. saflufenacil
	2	1.330 lb. imazethapyr		0.047 lb. imazethapyr
	15	2.280 lb. pyroxasulfone		0.080 lb. pyroxasulfone
ZoneDefense	14	62.2% sulfentrazone	5 oz.	0.194 lb. sulfentrazone
	14	15.0% flumioxazin		0.047 lb. flumioxazin

a.i. = active ingredient | a.e. = acid equivalent

Herbicide site of action and typical injury symptoms

Herbicides kill plants by disrupting essential physiological processes. 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 chemical family (e.g. triazine, phenoxy, etc.) generally have the same site of action. The mechanism by which an herbicide kills a plant is known as its "mode of action". For example, triazine herbicides interfere with photosynthesis by binding to the D1 protein which is 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 herbicide injury problems, whereas knowledge of the site of action is needed for designing weed management programs with a low risk of selecting for herbicide-resistant weed populations.

The Weed Science Society of America (wssa.net) has developed a numerical system for identifying herbicide sites of action by assigning group numbers to the different sites of action. Certain sites of action (e.g., photosystem II inhibitors) have multiple numbers since different herbicides may bind at different locations on the target enzyme (e.g. photosystem II inhibitors) or different enzymes in the pathway may be targeted (e.g., carotenoid synthesis). The number following the herbicide class heading is the WSSA classification. Herbicide group numbers are included on the herbicide labels to aid in the development of herbicide resistance management strategies.. Prepackage mixes will contain the herbicide group numbers of all active ingredients.

ACCase Inhibitors – 1

The ACCase enzyme is involved in the synthesis of fatty acids. Three herbicide families attack this enzyme although there are two commonly associated with this site of action. Aryloxyphenoxypropanoate (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 and metabolism of these herbicides have been determined as responsible for the resistance.

ALS Inhibitors – 2

A number of chemical families interfere with acetolactate synthase (ALS), an enzyme involved in the synthesis of the essential branched chain amino acids (e.g., valine, leucine, and isoleucine). This enzyme is also called acetohydroxyacid synthase (AHAS). These amino acids are necessary for protein biosynthesis and plant growth. Generally, these herbicides are absorbed by both 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 observed there. Symptoms include plant stunting, chlorosis (yellowing), and tissue necrosis (brown, dead tissue), and are evident 1 to 4 weeks after herbicide application, depending upon the herbicide dose, plant species and environmental conditions. Soybeans and other sensitive broad-leaf plants often develop reddish veins visible on the undersides of leaves. Symptoms in corn include reduced secondary root formation, stunted, “bottle-brush” roots, shortened internodes, and leaf malformations (chlorosis, window-pane appearance). However, symptoms typically are not distinct or consistent. Factors such as soil moisture, temperature, and soil compaction can enhance injury or can 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. Resistance to the ALS inhibitor herbicides attributable to metabolism has also been identified in weeds. Some weed species have both target-site and metabolic resistances.

Microtubule Inhibitors – 3

Dinitroaniline (DNA) herbicides inhibit cell division by interfering with the formation of microtubules by inhibiting tubulin polymerization. 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 typically thick and short. Hypocotyl swelling also occurs and the hypocotyl may be brittle and easily snapped at the ground level. 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 – 4

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

Photosystem II Inhibitors – 5, 6, 7

Several families of herbicide bind to a protein involved in electron transfer in Photosystem II (PSII). These herbicides inhibit photosynthesis, which may result in inter-veinal yellowing (chlorosis) of plant leaves followed by necrosis (brown, dead) of leaf tissue. Highly reactive compounds formed due to inhibition of electron transfer cause the disruption of cell membranes and ultimately 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 may occur 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 (inter-veinal chlorosis). Lower leaves are first and most affected, and new leaves may be unaffected. Triazine (Group 5) and urea (Group 7) herbicides generally are absorbed both by roots and foliage, whereas benzothiadiazole (Group 6) and nitrile (Group 6) 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. Triazine resistance is due to an altered target site and examples of metabolic resistance also have been identified.

Photosystem I Inhibitors – 22

Herbicides in the bipyridilium family rapidly disrupt cell membranes, resulting in wilting, necrosis, and tissue death. They capture electrons moving through Photostystem I (PSI) and produce highly destructive secondary plant 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 – 14

Group 14 herbicides inhibit an enzyme involved in synthesis of a precursor of chlorophyll; the enzyme is referred to as PPO. Plant death results from destruction of cell membranes due to formation of highly reactive compounds. There are several herbicide families that are classified as PPO inhibitors. Postemergence applied diphenyl ether herbicides (e.g., aciflurofen, lactofen) are contact herbicides with little translocation. 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 significant 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 postemergence 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.

Carotenoid Synthesis Inhibitors – 13, 27

Herbicides in these families inhibit the synthesis of the carotene pigments. Inhibition of the carotene pigments results in loss of chlorophyll and bleaching of foliage at sublethal doses. Plant death is due to disruption of cell membranes. Several different enzymes in the synthesis of carotenoids are targeted by herbicides. Clomazone (Command) inhibits DOXP (Group 13), whereas the other bleaching herbicides used in corn (Callisto, Balance Flexx, Laudis, Armezon, Impact) inhibit HPPD (Group 27). The HPPD inhibiting herbicides are xylem mobile and absorbed by both roots and leaves, they are used for both preemergence and postemergence. Resistance to the Group 27 herbicides has evolved in waterhemp and is attributable to metabolism of the herbicide.

Enolpyruvyl Shikimate Phosphate Synthase (EPSPS) Inhibitors – 9

Glyphosate is a substituted amino acid (glycine) that inhibits the EPSPS enzyme. This enzyme is a component of the shikimic acid pathway, which is responsible for the synthesis of the essential aromatic amino acids and numerous other compounds. Glyphosate is nonselective and is tightly bound in soil, so little root uptake occurs under normal use patterns. 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. Resistance to glyphosate has evolved in a number of important weed species (e.g., waterhemp, giant ragweed, horseweed/marestail, Palmer amaranth). Several mechanisms have been identified that confer resistance to glyphosate in weeds.

Glutamine Synthetase Inhibitors – 10

Glufosinate (Liberty) inhibits the enzyme glutamine synthetase, known to incorporate ammonium in plants. Although glutamine synthetase is not involved directly in photosynthesis, inhibition of this enzyme ultimately results in the disruption of photosynthesis. Glufosinate is relatively fast acting and provides effective weed control in 3-7 days. Symptoms appear as chlorotic lesions on the foliage followed by necrosis. There is limited translocation of glufosinate within plants. Glufosinate has no soil activity due to rapid degradation in the soil by microorganisms. Liberty is nonselective except to crops that carry the Liberty Link gene. To date, there are only two weed species with evolved resistance to glufosinate and resistance has not been identified in Iowa.

Fatty Acid and Lipid Synthesis Inhibitors – 8

The specific site of action for the thiocarbamate herbicides (e.g., EPTC, butylate) is unknown, but it is believed they may conjugate with acetyl coenzyme A and other molecules with a sulfhydryl moiety. Interference with these molecules results in the disruption of fatty acid and lipid biosynthesis, along with other related processes. Thiocarbamate herbicides are soil applied and require mechanical incorporation due to high volatility. Leaves of grasses injured by thiocarbamates do not unroll properly from the coleoptiles, resulting in twisting and knotting. Broadleaf plants develop cupped or crinkled leaves.

Very Long Chain Fatty Acid Synthesis Inhibitors (VLCFA) – 15

Several chemical families (acetamide, chloroacetamide, oxyacetamide, pyrazole and tetrazolinone) are reported to inhibit biosynthesis of very long chain fatty acids. VLCFA are believed to play important roles in maintaining membrane structure. These herbicides disrupt the germination of susceptible weed seeds but have little effect on emerged plants. They are most effective on annual grasses, but have activity on certain small-seeded annual broadleaves. Soybean injury occurs in the form of a shortened mid-vein in leaflets, resulting in crinkling and a heart-shaped appearance. Leaves of grasses, including corn, damaged by these herbicides, fail to unfurl properly, and may emerge underground.

Auxin Transport Inhibitors – 19

Diflufenzopyr (Status) has a unique mode of action in that it inhibits the transport of auxin, a naturally occurring plant-growth regulator. Diflufenzopyr is sold only in combination with dicamba and 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 from the soil for some residual activity. Injury symptoms are similar to other growth regulator herbicides. Status (dicamba + diflufenzopyr) includes a safener to improve crop safety.

Authors

Micheal D.K. Owen, university professor emeritus; Meaghan Anderson, extension field agronomist; Wesley Everman, assistant professor and extension weed specialist; Betsy Danielson, co-coordinator of the Pesticide Safety Education Program; and Shelby Gruss, assistant professor and extension forage specialist, at Iowa State University.