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North Dakota Weed Control Guide

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WEED GUIDE INFORMATION

The information in this guide provides a summary of herbicide uses in crops grown in North Dakota and is based on federal and state herbicide labels, research at North Dakota Ag. Experiment Stations, and information from the North Dakota Department of Agriculture.

ALWAYS READ AND FOLLOW LABEL DIRECTIONS.

Instructions for registered uses of herbicides are given on container labels. The label is the final guide and should be strictly followed. The information in this guide only applies to North Dakota because some herbicide uses are allowed only by supplemental or specific ND labeling. Label possession is required at the time of application.

This bulletin is provided for your information. North Dakota State University or its officers or employees make no claims, representations, or guarantees as to product performance nor accept responsibility for results from using herbicides. See legal disclaimer on the next page.

Below is information to aid in using this guide:

Herbicides. Herbicides in tables are listed by trade name followed by common name in parenthesis except where several brands are available. Contact chemical suppliers and the ND Dept of Ag for new label information.

Rates. Rates in tables are based on broadcast application and are expressed according to formulated product per acre with active ingredient (ai) or acid equivalent (ae) per acre given in parentheses. Commercial formulations of the same ai may vary in concentration.

For example, a pint of 4 lb ae/gal 2,4-D contains 0.5 lb while a pint of 6 lb ae/gal 2,4-D contains 0.75 lb or a quart of 3 lb ae/gal glyphosate contains 0.75 lb while a quart of 4.5 lb ae/gal glyphosate contains 1.125 lbs.

What is the difference between ai and ae? The ai of glyphosate is the weight of both glyphosate acid plus the salt formulated with the glyphosate molecule. The acid equivalent (ae) of glyphosate is only the weight of glyphosate without the salt. The label of commercial products list both active ingredient (ai) and inert ingredients. Inert ingredients are not phytotoxic but are used to create stable formulations and to aid in application, herbicide retention, deposition, and absorption. The active ingredient of some herbicides are formulated with salts or esters (See Herbicide Compendium). Glyphosate is formulated at different concentrations, as pure acid, and with five salts, isopropyl amine (ipa), dimethyl amine (dma), ammonium, diammonium (2(NH₃)), and potassium (K). The salt formulated with herbicide molecules does not contribute to weed control. Glyphosate formulated at different concentrations and with different salts require using acid equivalent (ae) when calculating rates. The following table gives the relationship between ae and active ingredient (ai).

Table. Glyphosate product rates based on ae and ai formulation concentrations.

		Rate as acid equivalent (lb ae)			
		0.75	1.125	1.5	2.25
lb ae or ai/gallon		fl oz/A			
3 lb ae	= 4 lb ai =	32	48	64	96
3.75 lb ae	= 5 lb ai =	25.6	38.4	51.2	76.8
4 lb ae	= 5.4 lb ai =	24	36	48	72
4.17 lb ae	= 5.1 lb ai =	23	34.5	46	69
4.5 lb ae	= 5.5 lb ai =	21.3	32	42.6	64
4.72 lb ae	= 6.3 lb ai =	20.3	30.5	40.7	61
5 lb ae	= 6.1 lb ai =	19.2	28.8	38.4	57.6

Weed Control Ratings. Herbicide effectiveness ratings listed in tables show general comparative ratings based on field observations. Weed control may be equal or greater than what is indicated in the table under favorable conditions or may be reduced and unsatisfactory in unfavorable conditions.

Abbreviations Used

Units of Measurement

oz	= ounce (16 oz/lb)
fl oz	= fluid ounce (128 fl oz/gal)
pt	= pint (8 pt/gal)
gal	= gallon
ae	= acid equivalent
ai	= active ingredient
conc	= concentration
v/v	= volume/volume
lb, lb/gal	= pound, pounds/gallon
gpa	= gallons per acre

Type of Application

EPP	= Early preplant
PPI	= Preplant incorporated
PRE	= Preemergence
EPOST	= Early postemergence
POST	= Postemergence
POST Directed	= Postemergence directed
	= Aerial application prohibited

Herbicide Group Numbering

Herbicide name^{number 1-30} = herbicide site of action group - see pages 100-101

Types of Formulation

DF	= Dry flowable
EC	= Emulsifiable concentrate
F	= Flowable
G	= Granule
ME	= Micro-encapsulated
OD	= Oil dispersion
S/SL	= Solution/Soluble Liquid
SC	= Suspension "Suspo" concentrate
SE	= Solution emulsion
SG	= Soluble granule
WDG/XP	= Water dispersible granule
ZC	= Suspension of microcapsules and solid fine particles

Miscellaneous

ACCCase	= Acetyl CoA carboxylase
ALS	= Acetolactate synthase
AMS	= Ammonium sulfate
DAA	= Days after application
IMI	= Imidazolinone
MSO	= Methylated seed oil
NIS	= Nonionic surfactant
OM	= Organic matter
PHI	= Preharvest interval
RUP	= Restricted Use Pesticide
SU	= Sulfonylurea
UAN	= Urea ammonium nitrate

GENERAL INFORMATION

LEGAL DISCLAIMER

The weed control suggestions presented in this guide are based on Federal label clearance, on information obtained from the North Dakota Agricultural Experiment Station, and reports in North Dakota Weed Control Research.

CAUTION: Instructions for registered uses of herbicides are given on container labels. **Read and follow label instructions carefully.** Pesticide labels supersede recommendations given in this guide. Weed control suggestions in this guide are based on the assumption that all herbicides mentioned will continue to have a registered label with the Environmental Protection Agency. This guide may contain recommendations for herbicides that are labeled only for North Dakota. The user of any pesticide must possess a copy of the label at the time of application. State labels can be obtained from chemical dealers or distributors or found on the NDDOA web site at: <http://www.kellysolutions.com/nd>

Use pesticides only on registered crops. Some formulations of an active ingredient may not be labeled for certain uses. Federal law makes liable for seizure any raw agricultural commodity that possesses a pesticide residue for which no exemption or tolerance has been established or that exceeds the tolerances established by the Food and Drug Administration. Persons using pesticides in a manner contrary to label instructions are subject to penalty under federal and state laws. North Dakota State University or its officers or employees makes no claims or representations that the chemicals discussed will or will not result in residues on agricultural commodities and assume no responsibility for results from using herbicides.

USE PESTICIDES ONLY AS LABELED.

Pesticide Labeling and Registration

No pesticide may be sold or used in the United States until the U.S. Environmental Protection Agency (EPA) has registered and approved the product use and the labeling. Canadian and other foreign labeled pesticides may not be used in the United States until registered by the EPA.

TYPES OF PESTICIDE REGISTRATIONS

Federal EPA Registrations, also known as 3e and 2ee labels, are the most common and widely used type of pesticide registration. Product labels of pesticides being applied must be at the application site during the time of application. Aerial applicators must have the label at the loading site.

Section 24(c) Registrations, also known as (SLN) State Local Needs registrations:

- are state-specific registrations issued by states
 - are used to address a special local need
 - must prove there is an existing or imminent pest problem for which a federally registered pesticide is not available
 - can be used to address pest resistance management.
- SLN registrations can be used to register additional uses or add limitations for a federally registered pesticide, like adding application sites, pests, or alternate control methods to those listed on federally registered labeling. SLN labels are initiated by the ND Department of Ag and must be

approved by EPA.

Supplemental labeling must be provided for each SLN registration. Applicators must have the SLN label and federal label in their possession at application. These registrations are legal only in the state or local area specified in the labeling.

Section 18 “Emergency” and “Crisis” exemptions from FIFRA allows the unregistered use of a pesticide to address an emergency pest situation and are used when a crisis pest situation:

- is an emergency and non-routine
- has no or ineffective alternative management tools and
- is severe and can be documented to cause yield or economic loss (>20%) on the specified crop.

Both types of exemptions from registration allows use of a pesticide for a non-registered purpose for a specified period of time. ND “Emergency” Section 18 exemptions are registrations initiated by the NDDA, are approved by the EPA, and can be declared if both federal and SLN registrations are not or cannot be enacted in time to prevent the condition. In rare occasions, when time is critical and the emergency is acute, NDDA can declare a “Crisis” exemption without written approval of EPA. The NDDA informs EPA of the condition prior to the action and allows EPA to support the state action. This process usually takes 10 to 14 days to complete. The duration of a “Crisis” exemption (14 to 21 days) is shorter than an “Emergency” exemption. If an “Emergency” exemption is being reviewed by the EPA at the time the “Crisis” exemption is declared the EPA may elect to grant the “Emergency” exemption and increase the period of duration. An applicator must possess federal labels and Section 18 exemption labeling at application.

RESTRICTED USE PESTICIDES (RUP)

EPA categorizes pesticides as either unclassified (general use) or restricted. **Restricted-Use Pesticides (RUP)** are pesticides that can cause harm to humans or environment and must be applied by certified applicators. Only certified dealers may sell RUPs and only certified applicators may purchase, or apply an RUP. Private and commercial/public applicators must record certain information for all pesticide applications.

RESTRICTED USE HERBICIDES:

All products and premixes containing the active ingredients listed below are restricted use pesticides. See Mode of Action table in Section X1.

Atrazine = Mode of Action 5

Isoxaflutole = Mode of Action 27

Paraquat = Mode of Action 22

Picloram = Mode of Action 4

Sulfuric acid

Brand names of other RUP:

Amitrole-T, Cytrole (amitrole)

Dicamba: **Engenia, Tavium, XtendiMax** = Mode of Action 4

Huskie Complete = Mode of Action 2, 6, 27

Kerb 50W (pronamide)

SAFETY AND EMERGENCY PHONE NUMBERS:

ND Poison Control Line: 800 222-1222

ND Emergency Assistance Line: 800 472-2121

Report pesticide incident to NDDA: 701 328-4922

CHEMICAL WEED CONTROL FOR FIELD CROPS

Plant-back Interval for Fall, Pre-Plant, and Burndown Herbicides

	Rate/A ^a	See paragraph	Alfalfa	Barley	Canola	Chick pea / Lentil	Corn	Dry bean	Field pea	Flax	Oat	Potato	Safflower	Soybean	Sugarbeet	Sunflower	HRS / Durum Wheat	
----- months before planting (d = days) -----																		
2,4-D ⁴ amine	0.5 lb ai	B3	1	0	1	1	7d	1	1	1	1	1	1	15d	1	1	0	
	1 lb ai	B3	1	0	1	1	14d	1	1	1	1	1	1	1	1	1	0	
2,4-D ⁴ ester	0.5 lb ai	B3	1	0	1	1	7d	1	1	1	1	1	1	7d	1	1	0	
	1 lb ai	B3	1	0	1	1	14d	1	1	1	1	1	1	1	1	1	0	
E-99 / Weedone 650 ⁴	1 lb ai	B3	1	0	1	1	14d	1	1	1	1	1	1	15d	1	1	0	
Aim ¹⁴	0.5 to 1 fl oz	B4	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	
Afforia ^{2,2,14*a}	2.5 - 3.75 oz	E5	3-4	3-4	4-12	4-12	.5-1	3-4	3-4	3-4	4-5	4-12	3-4	1-7d	4-10	45d	1-2	
Alluvex ^{2,2}	1.5 oz	E5	18	9	18	18	0	10	10	10	9	1	18	10	18	10	9	
Anthem Flex ^{14,15}	2.5 - 4.5 fl oz	D6	10	11	18	6	0	11	6	18	11	4	18	0	12	4	1	
Autumn Super ^{2,2}	0.5 oz	B5	Apply post-harvest in fall and plant only corn the next spring.															
Banvel/DMA ^{4*a}	1 pt	B6	NCS	3d/oz	NCS	NCS	0 ^a	NCS	NCS	NCS	3d/oz	NCS	NCS	45 d	NCS	NCS	3d/oz	
	1 to 2 pt	B6	NCS	NCS	NCS	NCS	0 ^a	NCS	NCS	NCS	NCS	NCS	NCS	90 d	NCS	NCS	3d/oz	
Boundary ^{5,15}	2 - 3.5 pt	E6	4.5	8	12	12	4	12	12	12	12	0	12	0	18	12	8	
Clarity/DGA ^{4*a}	8 fl oz	B6	4	22 d	4	4	0 ^a	4	4	4	22 d	4	4	4	4	4	22 d	
	16 fl oz	B6	6	44 d	6	6	4 ^a	6	6	6	44 d	6	6	6	6	6	44 d	
Dual Magnum ¹⁵	1 - 2 pt	F3	4	4.5	12	0	0	0	0	12	4.5	0	0	0	0	0	4.5	
Elevore	1 fl oz		9	14d	14d	9/15	3d	9	9	9	14d	15	9	14d	15	14d	14d	
Express / tribenuron ^{2*} Labeled rates		E5	1.5	0	2	1.5	.5-2 ^a	1.5	1.5	1.5	1.5	1.5	1.5	1.5	7d ^{ac}	2	0-2 ^{ae}	0
Facet 4L ^{4,26}	22 fl oz	B10	24b	10	10	24b	10	24b	24b	24b	10	24b	24b	24b	24b	24b	0	
Fierce EZ ^{14,15}	6 fl oz	D6	10	11	12	10.5/6	7d-1 ^a	10.5	2	18	11	4	18	0	12	4	1	
Glyphosate ^{9*}	0.75 - 3 lb ae	B2,8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Harmony/thifensulfuron ^{2*} Label rates		E5	1.5	0	1.5	1.5	0	1.5	1.5	1.5	0	1.5	1.5	0	1.5	1.5	0	
Liberty ¹⁰	32 - 43 fl oz	B9	6	70d	0	6	0	6	6	6	70d	70d	6	0	0	6 ^a	70d	
Paraquat ^{22*} - RUP	Label rates	B11	0	0	N/R	N/R	0	0	0	N/R	N/R	0	0	0	0	0	0	
Pre-Pare ²	0.3 oz	C7	24	9	9	24	11	9	11	9	11	9	9	9	9	9	0/4	
Reviton ¹⁴	1-3 oz		4-6 ^a	4-6 ^a	4-6 ^a	4-6 ^a	0	4-6 ^a	14d	1-2 ^a	4-6 ^a	0						
Quelex	0.55 - 0.75 oz		9	0	9	9/15	3	9	9	9	3	15	9	3	15	3	0	
Select/clethodim ^{1*}	4 - 16 fl oz	E2	0	1	0	0	6d-1 ^a	0	0	0	1	0	0	0	0	0	1	
Sharpen ¹⁴	1 fl oz	B12	4	0	4	0	0	4	0	4	0	4	4	0 ^f	4	4	0	
	1.5 fl oz	B12	5	0	5	0/1	0	5	0	5	0	5	5	14d ^f	5	5	0	
	2 fl oz	B12	5	0	5	0/1	0	5	0	5	0	5	5	1 ^f	5	5	0	
	3 fl oz	B12	6	0	6	2/3	0	6	2	6	0	6	6	2 ^f	6	6	0	
Spartan Charge ^{14,14}	3 - 10.2 fl oz	E11	12	4	24	0	4	0	0	12	12	4	12	0	24b	0	4	
Valor ¹⁴ + tillage	2 oz	E12	4	3	4	3/6	7d-1 ^a	3	3	3	4	4	3	0	4	1 ^a	14d-1 ^a	
- tillage	2 oz	E12	8	3	8	3/6	7d-1 ^a	3	3	3	8	8	3	0	8	1 ^a	14d-1 ^a	
+ tillage	3 oz	E12	5	4	6	4/7	14d-	4	4	4	5	5	4	0	5	2 ^a	2 ^a	
- tillage	3 oz	E12	10	4	12	4/7	14d-	4	4	4	10	10	4	0	10	2 ^a	2 ^a	
Verdict ^{14,15}	5-18 fl oz	B12	NCS	NCS	NCS	NCS	0	NCS	NCS	NCS	NCS	NCS	NCS	0-4	NCS	NCS	NCS	
Zidua SC ¹⁵	1.75 fl oz	D6	10	11	12	1	0	11	1	2	11	4	1	0	12	1	1	
	3.25 fl oz	D6	10	11	12	1	0	11	1	4	11	4	1	0	12	2	1	
	5.00 fl oz	D6	10	11	15	1/2	0	11	1	6	11	4	1	0	15	3	4	
	6.50 fl oz	D6	10	18	18	2/4	0	11	2	8	18	4	2	4	15	3	6	

*= Or generic equivalent.

Herbicide name^{number 1-30} = herbicide site of action

^a = Refer to label for approved rates and restrictions.

^b = bioassay

^c = Soybean = 1 day before planting at 0.25 oz SG

= 7 days before planting at 0.3 to 0.5 oz SG

^d = days before planting

^e = ExpressSun sunflower = 0 days at 0.25 to 0.5 oz SG

^f = Soils must be medium to fine texture with >2% OM.

NCS = Next Cropping Season; NR = Not Registered

Actual glyphosate product rates based on acid equivalent (ae) and active ingredient (ai) formulation concentrations - Refer to page 4 for more information.

0.75 lb ae 1.125 lb ae 1.5 lb ae 2.25 lb ae 3 lb ae

lb ae	lb ai	----- fl oz/A -----					
3	= 4	=	32	48	64	96	128
3.75	= 5	=	25.6	38.4	51.2	76.8	102.4
4	= 5.4	=	24	36	48	72	96
4.17	= 5.1	=	23	34.5	46	69	92.1
4.5	= 5.5	=	21.3	32	42.6	64	85
4.72	= 6.3	=	20.3	30.5	40.7	61	81.4
5	= 6.1	=	19.2	28.8	38.4	57.6	76.8

CHEMICAL WEED CONTROL FOR FIELD CROPS

Efficacy of Fall Applied Herbicides on Emerged Seedlings

	Rate/A	Downy Brome	Horseweed (Marestail)	Narrowleaf Hawksbeard	Prickly Lettuce	Mustard, Wntr. Annual	Dandelion	Canada Thistle
2,4-D ⁴	0.25 lb ae	N	F-E	F	F-G	F-G	F-G	F
	0.5 lb ae	N	F-E	F	F-G	F-G	F-G	F
Afforia ^{2,2,14}	2.5 - 3.75 oz	N	N-P	G-E	G-E ^b	G-E	F-E	F-G
Dicamba	0.125 lb ae	N	F-E	F-E	E	P	F-G	F
	0.25 lb ae	N	G-E	G-E	E	P	F-G	F-G
Express / tribenuron ²	Labeled rates	N	N-P	G-E	G ^b	E	G-E	F-G
Glyphosate ⁹	0.75 - 3 lb ae	E	G-E ^b	F-E	F-E	G-E	F-E	F-E
Harmony/thifensulfuron ²	Label rates	N	N-P	F-G	F-G ^b	G-E	F-G	N
Paraquat ^{22*} - RUP	Label rates	-	F-E	F-E	F-E	G	P	P
Spartan ¹⁴	4 fl oz	N	N	N	N	N	N	N
Valor ¹⁴	2 oz	N	N	N	N	N	N	N
	3-4 oz	N	N	N	N	N	N	N

^aControl ratings are for weeds that are emerged at time of application. These ratings are for control of weeds treated in the fall and do not reflect control ratings of these products applied to emerged weeds in the spring.

^bHerbicide will not control resistant biotypes

Residual Weed Control with Fall Applied Herbicides (Weeds not emerged)^{a,b}

	Rate/A	Downy Brome	Horseweed (Marestail)	Narrowleaf Hawksbeard	Prickly Lettuce	Mustard, Wntr. Annual	Dandelion	Canada Thistle	Kochia
2,4-D ⁴	0.25 lb ae	N	N	N	N	N	N	N	N
	0.5 lb ae	N	N	N	N	N	N	N	N
Afforia ^{2,2,14}	2.5 - 3.75 oz	F-G	F-E	F-E	F-G	G	P	N	F-E
Dicamba	0.125 lb ae	N	N	N	N	N	N	N	N
	0.25 lb ae	N	P	P	P	P	P	N	P
Express / tribenuron ²	Label rates	N	N	N	N	N	N	N	N
Glyphosate ⁹	0.75 - 3 lb ae	N	N	N	N	N	N	N	N
Harmony/thifensulfuron ²	Label rates	N	N	N	N	N	N	N	N
S/Metolachlor ¹⁵	Label rates	F-E	N	N	N	N	N	N	N
Paraquat ²² - RUP	Label rates	N	N	N	N	N	N	N	N
Spartan ¹⁴	4 fl oz	N	P-F	P-F	P-G	P-G	N	N	F-G
Valor ¹⁴	2 oz	F-G	F-E	F-G	F-G	G	N	N	F-G
	3-4 oz	F-G	F-E	F-E	F-G	G	P-G	N	F-E

^aResidual control ratings are for plants that germinate in the fall and very early spring (through mid-April) following application. Fall and winter moisture are required to activate residual herbicides.

^bRatings do not reflect control of plants that are emerged at application.

Fall herbicide applications are important for weed control in no-till systems. Fall applications are primarily used to control winter annual weeds as they germinate or when they are young and more susceptible to herbicides. These applications should be made after crop harvest. In some cases, products with residual activity, like Valor (flumioxazin) can be applied in the fall to help control early emerging summer annual weeds like kochia. It is important to remember that Valor will have limited foliar activity on emerged weeds, and is applied for its residual activity. Heavy old-crop residue may intercept spray droplets and reduce residual activity of soil-applied herbicides. Fall-applied residual herbicides typically will not provide season-long weed control, but may significantly reduce early spring weed competition.

Fall-Applied / Early Preplant Herbicides

B1. FALL APPLICATION - HERBICIDES

Several herbicides may be applied in the fall. Some include Far-Go, Prowl, Sonalan, Spartan, Treflan, and Valor. Optimum activity occurs when herbicides are applied in late fall during consistent cold temperatures (below 50 F) to reduce degradation and winter moisture provides adequate activation for residual spring weed control. Application after October 15, when soil temperature is cold, minimizes herbicide loss by volatilization and microbial and chemical degradation. Many labels recommend application after October 1 or 15. Some herbicides, such as Far-Go, require immediate tillage for incorporation while many do not require tillage for incorporation. Spartan fall-applied may give poor weed control in spring because of warmer than normal weather between application and spring seeding which causes insufficient residual activity.

Both granular and liquid formulations of herbicides are registered for use in fall. Fall applied, granular herbicides usually give more effective weed control than the liquid formulations, especially under heavy crop residue situations. Research at NDSU with fall application of Far-Go indicates that, at similar rates, granular formulations performed more effectively than the liquid formulation but fall surface-applied Far-Go gave less consistent weed control than when fall incorporated.

B2. FALL APPLICATION - WEED CONTROL

Fall is an effective time to control winter annual weeds, simple perennials such as curly dock and dandelion, biennials such as biennial wormwood, and in some cases cool-season perennial weed species. This is especially true for no-tillage fields, but also for those fields receiving tillage other than moldboard plowing. For fields in which tillage is planned, apply POST herbicides at least 7 days prior to tillage. Herbicides may be applied within a few days of crop harvest or until the soil is frozen. The most consistent and effective control of dandelions is obtained with fall herbicide applications. Seed production of winter annual species can be prevented with fall herbicide applications or effective fall tillage. Apply herbicides in the fall under less than ideal conditions will give greater weed control, including dandelion rather than postpone until spring.

The most effective fall and spring herbicide treatment with the most cropping flexibility is glyphosate at 0.75 pound ae/A + 2,4-D ester at 0.5 lb ai/A + Express at 0.33 oz DF/A or 0.5 oz SG/A. The addition of 2,4-D is most important for dandelion control but will antagonize Canada thistle and perennial grass weed control from glyphosate.

Another herbicide option is the addition of Valor (flumioxazin) at 2 to 4 oz/A to the glyphosate plus 2,4-D mixture. Valor is a residual PRE herbicide that controls many broadleaf weeds. Valor applied with glyphosate improves control of many small broadleaf weeds but the rapid contact action may antagonize control from glyphosate on larger and less susceptible weeds.

Fall applications that include Valor will be most beneficial west of the Red River Valley where spring rains may not be sufficient to activate Valor. Fall and winter moisture will activate Valor even in the drier areas of the state. Preliminary studies with fall-applied Valor have shown potential to control or suppress weeds such as kochia, seedling dandelion, canola, and chamomile. Valor should only be applied in no-tillage fields and any substantial soil movement next spring during planting will reduce the effectiveness of Valor on spring emerging weed species.

B3. 2,4-D plus glyphosate applied as a preplant application up to emergence of small grains has been considered safe as shown by university research. Most 2,4-D labels list corn, soybean and small grains as registered. However, corn and soybean have more specific limitations for preplant use. Labeled crops may be at risk of crop injury or loss if planted soon after application, especially during the first 14 days. Risk is greater if higher rates of product were applied and soil temperatures have been cold and/or soils have been excessively wet or dry in the days following application. Under normal conditions, any crop can be planted without risk of injury if at least 90 days of above freezing soil temperatures have elapsed since application. Amine formulations have a longer residual and are more water soluble than ester formulations. As a consequence, amine residue will last longer in the soil and can leach with rain injuring germinating seedlings of broadleaf crops. 2,4-D applied with glyphosate improves broadleaf weed control, reduces resistant weeds, and may antagonize grass control depending on rates, formulation, and timing of application.

B4. Autumn Super (iodosulfuron & thiencazazon) contains two long-residual herbicides. Apply post-harvest in the fall for control of many grass and broadleaf weeds, including dandelion. Plant only corn the following spring after application.

B5. Dicamba is an effective foliar and residual herbicide. Dicamba applied alone controls many broadleaf weeds but usually is applied with other herbicides such as 2,4-D, MCPA, glyphosate, and SU herbicides to reduce the rate of dicamba and increase control of wild mustard and annual and perennial broadleaf weeds. Dicamba applied with glyphosate improves control of many annual and perennial broadleaf weeds. See label for crop rotation restrictions. Exclude months that soil is frozen.

B6. DNA herbicides (Prowl, Sonalan, Treflan) must be thoroughly and uniformly mixed in the top 2 to 3 inches of soil. The number of incorporation passes differ depending on formulation. For Treflan, incorporation must be performed within 24 hours after application. Sonalan must be incorporated within 48 hours after application. Prowl incorporation may be delayed 7 days. The second incorporation of liquid DNA herbicides can be done anytime after the first, but the second incorporation of trifluralin 10G granules must be done no sooner than 5 days after the first. The second incorporation of Sonalan 10G must be done no sooner than 3 to 5 days after the first. Delay between first and second incorporation of 10G formulations allows the active ingredient to release from granules. The first incorporation is to cover the granule and the second is to thoroughly mix the soluble active ingredient in the soil. The second incorporation can also be done in the spring.

B7. Glyphosate is a non-selective, non-residual, systemic (translocated) herbicide that can be in the fall, preplant, and preemergence. Glyphosate can be applied with most herbicides labeled for fall or preplant use. However, glyphosate used multiple times per year (e.g., prior to planting, preemergence, in resistant crops, PRE-harvest, POST-harvest, in fallow fields) greatly increases the risk of weed resistance.

B8. Paraquat is a non-selective, non-residual, contact herbicide that can be used as a crop desiccant or as a substitute for tillage applied alone or with residual herbicides. Apply in 5 to 10 gpa by air or 10 to 20 gpa of water by ground before crop emergence. NIS will enhance paraquat more than other adjuvant types. Oil adjuvants are least effective. Other contact type herbicides can enhance paraquat activity. Paraquat + metribuzin or Sharpen is effective for both burndown and residual weed control. 2,4-D or dicamba applied with paraquat will improve control of larger annual broadleaf weeds. However, the rapid contact action of paraquat may antagonize systemic herbicides if mixed together. The antagonism will be most pronounced on larger, less susceptible broadleaf weeds.

CHEMICAL WEED CONTROL FOR FIELD CROPS

Hard Red Spring and Durum Wheat, Winter Wheat and Barley

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Refer to page 6 for additional Fall, Early Preplant, and PRE Herbicides.				
Soil-Applied Herbicides				
Far-Go (triallate ¹⁵) 	HRSW & DURUM. 1 qt / 10 lb 10G (1 lb) BARLEY: 1.25 qt/12.5 lb 10G (1.25 lb)	Wild oat.	Spring: HRSW, Durum and Barley. Apply before or after seeding. PPI 3 or more days before seeding.	Application before seeding: PPI with field cultivator set at 4 inches deep. Two pass incorporation is recommended. Application after seeding: Apply before kernel sprouts exceed 0.5 inch in length and incorporate with harrows set more shallow than seed.
Treflan / generic trifluralin ³ Not for Winter Wheat	1 to 1.5 pt 4EC 5 to 7.5 lb 10G (0.5 to 0.75 lb)	Foxtail.	Fall incorporated	FOR BARLEY. HRSW. Durum. See label for incorporation instructions. Plant 1.5 inches deep
	1 pt 4EC 5 lb 10G (0.5 lb)		Spring PPI	FOR BARLEY ONLY. Plant 1.5" deep
	0.7 to 0.8 pt 4EC 3.5 to 4 lb 10G (0.35 to 0.4 lb)			FOR HRSW AND DURUM ONLY. For suppression of foxtail only. Use west of Hwy 3 only.
	0.7 to 1 pt 4EC 3.5 to 5 lb 10G (0.35 to 0.5 lb)			FOR HRSW AND DURUM ONLY. For foxtail suppression only. Use west of RRV
Anthem Flex (pyoxasulfone & carfentrazone ^{14,15}) Not for barley or durum	2 to 4.5 fl oz SC (1 to 2.25 oz)	Pre: Foxtail and pigweed. POST: Broadleaf weeds less than 2 inches.	PRE to 4 th tiller.	PRE requires precipitation for activation. Sequential rain events will improve weed control. Adjust rate for soil type. Add NIS at 1 qt/100 gal or PO at 1-2 pt/A + UAN or AMS.
Olympus (propoxy-carbazone ²) Not for barley or durum V. Long Residual	HRWW. 0.6 oz WDG (0.42 oz) HRSW. 0.2 oz WDG (0.14 oz)	Japanese and downy brome, mustard and pigweed species.	PRE.	Add NIS at 1 qt/100 gal for control of emerged species. Maximum propoxycarbazone rate per year allowed from Olympus or with combined products is 0.84 oz ai/A in winter wheat or 0.28 oz ai/A in spring wheat.
Pre-Pare (flucarbazone ²) Not for barley or durum Short to Long Residual	HRSW. 0.2 to 0.3 oz WDG (0.14 to 0.21 oz)	G. foxtail, mustard and pigweeds. Soil residue may control y. foxtail, wild oat, Japanese and downy brome.	Preplant within 10 days of planting or PRE.	Add NIS at 1 qt/100 gal for control of emerged species. Maximum flucarbazone rate per year allowed from Pre-Pare with combined products is 0.43 oz WDG.
Quelex (halauxifen ⁴ & florasulam ²) Short to Long Residual	0.55 to 0.75 oz WDG (0.055 to 0.075 & 0.055 to 0.075 oz)	Pre: Small emerged broadleaf weeds.	Preplant until cracking.	PRE requires precipitation for activation. Add NIS at 1 to 2 qt/100 gal.
Sharpen (saflufenacil ¹⁴)	WHEAT 1 to 4 fl oz SC (0.36 to 1.43 oz) BARLEY 1 to 2 fl oz SC (0.36 to 0.71 oz)	Annual broadleaf weeds	Preplant or PRE	Do not apply once crop is emerged. Requires rainfall for herbicide activation. Add MSO at 1 to 1.5 pt/A + AMS at 8.5 lbs/100 gal.

Hard Red Spring and Durum Wheat, Winter Wheat and Barley

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
POST-Applied Herbicides				
Prowl H20 (pendimethalin ³) Not for Barley	1.5 to 3 pt ACS (0.7 to 1.4 lb)	Foxtail and some small-seeded broadleaf weeds.	Wheat: 1- to 3-leaf.	Soil residual provides PRE control of weeds. Does not control emerged weeds. Adjust rate for soil type. Allow a 60 day PHI. Refer to label for tank-mixtures.
Zidua SC (pyroxasulfone ¹⁵) Not for Barley or Durum wheat	1.25 to 4 fl oz SC (0.65 to 2 oz)	Some small-seeded grass and broadleaf weeds, including pigweeds.	Wheat: Emergence through 4 th tiller.	Soil residual provides PRE control of weeds. Requires 1 inch of rainfall for activation. Sequential rain events will improve weed control. Refer to label for use directions and restrictions.
MCPA ⁴ amine MCPA ⁴ ester	0.5 to 1.33 pt 4SL 0.5 to 1.33 pt 4EC (0.25 to 0.66 lb)	Broadleaf weeds.	Crop: 3-leaf until prior to boot depending on label.	Follow label directions as MCPA labels vary on application timing. Use high rate for large or perennial weeds.
2,4-D ⁴ amine 2,4-D ⁴ ester	0.5 to 1 pt 4SL 0.5 to 1 pt 4EC (0.25 to 0.5 lb)		Winter wheat: In spring - well tillered until prior to boot. <i>Do not apply to winter wheat in fall.</i>	Follow label directions as 2,4-D labels vary on application timing. Do not apply from early boot to dough stage.
Dicamba ⁴	2 to 4 fl oz 4SL 1.6 to 3.2 fl oz 5 SL (1 to 2 oz) Barley: 2 to 3 fl oz (1 to 1.5 oz)	Broadleaf weeds including wild buckwheat, sunflower, Russian thistle and kochia.	HRSW/Durum: Up to 5-leaf. Barley: Up to 4-leaf. HRWW: Pre-joint.	Dicamba must be applied before 6-leaf stage. Use low dicamba rate and high MCPA rate on 4-leaf HRSW or durum. Barley is relatively susceptible to injury from dicamba. Do not apply dicamba with 2,4-D to barley.
Starane Ultra / generic fluroxypyr ⁴	0.67 pt 1.5EC 0.35 pt 2.8EC 5 oz 40WDG (2 oz)	Kochia, volunteer flax, and few other broadleaf weeds.	Crop: 2-leaf through flag leaf emergence.	Refer to label for weeds controlled, registered tank-mix options, and rates. Commercial mixture with MCPA ester available as Hat Trick.
Pixxaro EC (fluroxypyr ⁴ + halauxifen-methyl ⁴)	6 fl oz EC (0.11 + 0.005 lb)	Broadleaf weeds including kochia, wild buckwheat, and marestalk	Weeds: Small.	Tank-mix with 2,4-D, MCPA, and grass herbicides to increase weed spectrum
Curtail M / generic clopyralid ⁴ & MCPA ⁴	1.75 to 2.33 pt EC (0.09 to 0.12 lb & 0.5 to 0.68 lb)	Broadleaf weeds and Canada thistle.	Crop: 3-leaf until prior to boot.	Apply to Canada thistle at rosette to early bolting stage. Do not harvest hay from treated fields.
Curtail / generic clopyralid ⁴ & 2,4-D ⁴	2 to 2.67 pt SL (0.09 to 0.13 lb & 0.5 to 0.67 lb)		Crop: 4-leaf until prior to boot.	
WideMatch / generic clopyralid ⁴ & fluroxypyr ⁴	1 to 1.33 pt EC (0.09 to 0.125 lb & 0.09 to 0.125 lb)	Broadleaf weeds including kochia, wild buckwheat, vol. flax, and Canada thistle.	Crop: 3-leaf through flag leaf emergence. Weeds: Up to 4 inches tall or vining.	An economical formulation of clopyralid. Apply with 2,4-D, MCPA, or thifensulfuron to increase spectrum of broadleaf weed control. Does not antagonize POST grass herbicides labeled in small grains. WideMatch commercial mixture with MCPA ester available as Hat Trick or Weld. Refer to label for application information.
WideARmatch (clopyralid ⁴ & fluroxypyr ⁴ & halauxifen-methyl ⁴)	14 fl oz EC (0.09 + 0.11 + 0.005 lb)		Crop: 2-leaf through flag leaf emergence	
Rezuvant (fluroxypyr ⁴ & halauxifen-methyl ⁴ & pinoxaden ¹)	16.4 fl oz EC (0.11 + 0.005 + 0.053 lb)		Weeds: small	Do not tank-mix with 2,4-D. Tank-mix with MCPA to increase broadleaf weed spectrum. Refer to label for tank-mixing information.

Hard Red Spring and Durum Wheat, Winter Wheat and Barley

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
PerfectMatch (pyroxsulam ² & clopyralid ⁴ & fluroxypyr ⁴) Not for Barley	1 pt SE (0.014 lb & 0.094 lb & 0.094 lb)	Also controls foxtail, wild oat, barnyardgrass, and partial control of bromes.	Crop: 3-leaf until prior to jointing. Weeds: Up to 4 inches tall.	Refer to label for application information.
Bromoxynil ⁶	1 to 2 pt EC (0.25 to 0.5 lb)	Small broadleaf weeds including small Kochia.	Crop: Emergence until prior to boot.	Contact, non-residual herbicide requiring thorough coverage. Most active in hot and sunny conditions. Refer to label for tank-mix options.
Bromoxynil ⁶ & MCPA ⁴	1 to 2 pt 4EC 0.8 to 1.6 pt 5EC (0.25 to 0.5 lb & 0.25 to 0.5 lb)	Small broadleaf weeds including wild buckwheat, sunflower, Russian thistle and Kochia.	Crop: 3-leaf stage until prior to boot.	
Bromoxynil ⁶ & 2,4-D ⁴	0.75 to 1.5 pt EC (0.18 to 0.38 lb & 0.25 to 0.5 lb) Rates vary by label.			
Bromoxynil ⁶ & fluroxypyr ⁴	14 to 21 fl oz EC (0.25 to 0.38 lb & 0.06 to 0.09 lb)		Crop: 3-leaf to flag leaf emergence.	
Aim (carfentrazone ¹⁴)	0.5 fl oz EC (0.128 oz)	Small broadleaf weeds including pigweed and Kochia.	Crop: Up to jointing stage. Weeds: Small. Up to 1 inch tall.	Contact, non-residual herbicide requiring thorough coverage. May cause cosmetic speckling on wheat leaves. Add NIS at 1 qt/100 gal. Refer to label for tank-mix options and application information.
Huskie Complete (bromoxynil ⁶ & pyrasulfotole ²⁷ & thiencazuron ² & mefenpyr safener) Not for Barley RUP	13.7 fl oz OD (0.156 lb phenol or 0.22 lb ester & 0.028 lb & 0.072 oz)	Wild oat, foxtails, barnyardgrass, Persian dandelion, and most annual broadleaf weeds	Wheat: 1-leaf to 60 day PHI. Grass weeds: Up to 2 tillers. Broadleaf weeds: Up to 4 inches tall.	Do not apply to barley. Will control some ACC-ase resistant grass biotypes. Refer to label for crop rotation restrictions, tank-mix options, and application information.
Huskie FX (bromoxynil ⁶ & fluroxypyr ⁴ & pyrasulfotole ²⁷ & mefenpyr safener)	13.5 to 18 fl oz/A EC (0.15 to 0.2 lb & 0.063 to 0.084 lb & 0.027 to 0.036 lb)	Most annual broadleaf weeds including resistant weeds.	Crop: Up to flag leaf emergence. Weeds: Up to 4 inches tall.	Huskie FX provides a third a.i. that is effective against Kochia. Most crops can be planted the year following application. Do not plant lentil for 18 months after application. Refer to label for tank-mix options and application information.
Huskie (bromoxynil ⁶ & pyrasulfotole ²⁷ & mefenpyr safener)	11 to 15 fl oz EC (0.15 to 0.2 lb & 0.027 to 0.036 lb)		Crop: Up to flag leaf emergence. Weeds: Up to 4 inches tall.	
Wolverine Advanced (fenoxaprop ¹ & bromoxynil ⁶ & pyrasulfotole ²⁷ & mefenpyr safener)	1.7 pt EC (0.085 lb & 0.223 lb & 0.028 lb)	Annual grass and broadleaf weeds.	Wheat: Emergence to 60 days PHI. Barley: Emergence to 5-leaf. Grass weeds: 1-leaf to 2-tiller.	
Talinor (bromoxynil ⁶ & bicyclopyrone ²⁷ & safener)	13.7 to 18.2 fl oz EC (0.156 to 0.208 lb & 0.033 to 0.044 lb)	Most annual broadleaf weeds including resistant weeds.	Crop: 2-leaf to pre-boot. Weeds: Up to 4 inches tall.	Must include co-pack of CoAct adjuvant and COC at 1 gal/100 gal or NIS at 1 qt/100 gal. Do not add oil or surfactant if tank mixed with a herbicide containing a built-in adjuvant. Do not add AMS-containing products or UAN as severe injury may occur.

Hard Red Spring and Durum Wheat, Winter Wheat and Barley

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Short Residual ALS Herbicides				
Orion (florasulam ² & MCPA ⁴ ester)	17 fl oz SE (0.07 oz & 0.31 lb)	Some broadleaf weeds.	Crop: 3-leaf to jointing. Weeds: Small.	Add NIS at 1 qt/100 gal. May be tank-mixed with grass herbicides. Allow a 60 day PHI. Refer to label for application information.
Starane Flex (florasulam ² & fluroxypyr ⁴)	13.5 fl oz EC (0.07 oz & 1.4 oz)		Crop: 3-leaf to flag leaf emergence. Weeds: Small.	May be tank-mixed with Group 1 POST grass herbicides. Allow a 60 day PHI. Has shorter crop rotation restrictions than WideMatch.
Quelex (florasulam ² & halauxifen ⁴)	0.75 oz WDG (0.075 oz & 0.075 oz)		Crop: 2-leaf to flag leaf emergence. Weeds: Small.	Add NIS at 1 to 2 qt/100 gal. Has not been proven safe to some rotational crops. Allow a 60 day PHI.
thifensulfuron ²	0.3 to 0.6 oz DF 0.45 to 0.9 oz SG (0.225 to 0.45 oz)	Mustards, redroot pigweed, lambsquarters, wild buckwheat, smartweed, and sunflower.	Crop: 2-leaf until prior to flag leaf emergence. Allow a 45 day PHI.	Do not apply higher tribenuron rates with POST Group 1 (ACCase) grass herbicides to avoid grass herbicide antagonism. Tribenuron may enhance control of some Group 2 (ALS) herbicides (e.g. flucarbazone) for yellow foxtail. Addition of MCPA ester or 2,4-D ester improves broadleaf weed control and crop safety. Add NIS at 1 pt/100 gal except when adding 2,4-D or MCPA at 0.75 pt/A. Sentrallas may control kochia. No crop rotation restrictions the following year. Refer to label for list of registered tank-mixes.
Sentrallas (thifensulfuron ² & fluroxypyr ⁴)	7 to 14 fl oz OD (0.22 to 0.44 & 1.12 to 2.24)			
Express / generic tribenuron ²	0.17 to 0.33 oz DF 0.25 to 0.5 oz SG (0.125 to 0.25 oz)	Mustards, marshelder, prickly lettuce, Russian thistle, Canada thistle.		
thifen ² & tribenuron ² 4:1 ratio 75DF Affinity T/M 50SG 3:1 Audit 75DF 2:1 ratio 75DF 1:1 ratio 75DF Affinity B/S 50SG	0.4 to 0.67 oz DF 0.6 to 1 oz SG 0.3 to 0.5 oz DF 0.3 to 0.66 oz DF 0.25 to 0.5 oz DF 0.4 to 0.8 oz SG			
Supremacy (fluroxypyr ⁴ & thifensulfuron ² & tribenuron ²)	4 to 6 oz WDG (1 to 1.5 oz ae & 0.18 to 0.27 oz & 0.06 to 0.09 oz)	Broadleaf weeds including pigweed, buckwheat, kochia, mustard, flax, and Canada thistle.		Add NIS at 1-2 qt/100 gal except when adding an EC or ester formulated herbicide. Use higher rates for larger weeds.
Long Residual ALS Herbicides				
Ally / generic metsulfuron ²	0.1 oz XP (0.06 oz)	Broadleaf weeds including perennial sowthistle. Partial control of wild buckwheat.	Crop: 2-leaf until prior to boot.	Addition of 2,4-D ester or MCPA ester improves broadleaf weed control and crop safety. Add NIS at 1 pt/100 gal except when adding 2,4-D or MCPA at 0.75 pt/A. Refer to label for crop rotation restrictions. Do not apply within 22 months of last metsulfuron treatment. Do not apply to soils above pH 7.9.
Ally Extra / generic metsulfuron ² & thifensulfuron ² & tribenuron ²	0.3 to 0.6 oz DF (0.174 to 0.347 oz)	Broadleaf weeds including perennial sowthistle. Improved control of wild buckwheat.	Crop: 2-leaf until prior to flag leaf emergence.	
Travallas (metsulfuron ² & thifensulfuron ² & fluroxypyr ⁴)	7 fl oz OD (0.022 & 0.22 & 1.1 oz)			
Very Long Residual ALS Herbicides				
Amber / generic triasulfuron ²	0.28 to 0.56 oz DF (0.21 to 0.42 oz)	Broadleaf weeds.	Crop: 2-leaf until prior to boot stage.	Add NIS at 1 qt/100 gal.
Glean / generic chlorsulfuron ²	0.167 to 0.33 oz DF (0.125 to 0.25 oz)	Broadleaf weeds and suppression of foxtail and Canada thistle.	Crop: 2-leaf until prior to flag leaf emergence.	Add NIS at 1 pt/100 gal except when adding 2,4-D ester or MCPA ester at 0.75 pt/A. Refer to label for application timings, tank-mix options, weeds controlled, and soil pH restrictions.
Finesse / generic chlorsulfuron ² & metsulfuron ²	0.2 to 0.4 oz DF (0.15 to 0.3 oz)			

Hard Red Spring and Durum Wheat, Winter Wheat and Barley

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
POST-Applied Grass Herbicides				
Axial Star (pinoxaden ¹ & fluroxypyr ⁴) Not for Durum	16.4 fl oz EC (0.053 lb & 0.094 lb)	Foxtail, wild and volunteer oat, Persian darnel, and annual ryegrass + fluroxypyr also controls kochia with partial control of annual broadleaf weeds.	Crop: 2-leaf until prior to boot. Foxtail: 1- to 3-leaf. Wild oat: 1- to 6-leaf.	Axial Bold and Axial Star are formulated with Adigor adjuvant. Axial Star = Full Axial XL rate & fluroxypyr Axial Bold = ½ Axial XL rate & yellow foxtail rate of fenoxaprop May be tank-mixed with most broadleaf herbicides. Refer to label for tank-mix information and restrictions.
Axial Bold (pinoxaden ¹ & fenoxaprop ¹) Not for Durum	15 fl oz EC (0.054 lb & 0.027)	Foxtail, wild oat, barnyardgrass, Persian darnel	Wheat: Emerge to pre-boot. Barley: Prior to jointing. P. Darnel, wild oat: 1- to 6-leaf. Foxtails, Bygrass: 1- to 5-leaf.	
Discover NG (clodinafop ¹ & cloquintocet safener) Not For Barley	12.8 to 16 fl oz EC (0.05 to 0.06 lb)	Wild oat, green and yellow foxtail, barnyardgrass, Persian darnel, and annual ryegrass.	Wheat: 2-leaf until prior to boot. Wild oat: 1- to 6-leaf. Foxtails: 1- to 5-leaf.	Discover NG is formulated with oil adjuvant. Add MSO adjuvant at 1 qt/100 gal if >10 gpa. Apply higher rates for Persian darnel and ryegrass. Refer to label for rates and tank-mix information.
Fenoxaprop ¹ & mefenpyr safener	0.33 to 0.66 pt EC (0.04 to 0.08 lb)	Wild oat, green and yellow foxtail, millets, corn, and barnyardgrass.	Wheat: Emergence to 60 days PHI. Barley: 1-leaf to 4-leaf. Grass weeds: 1-leaf to 2-tiller.	Apply 0.33 pt/A for green foxtail, corn and millet. Apply 0.4 pt/A for yellow foxtail and proso millet. Apply 0.66 pt/A for barnyardgrass and wild oat. Refer to label for tank-mix options.
Wolverine Advanced (fenoxaprop ¹ & bromoxynil ⁶ & pyrasulfotole ²⁷ & mefenpyr safener)	1.7 pt EC (0.085 lb & 0.223 lb & 0.028 lb)	Annual grass and broadleaf weeds.	Wheat: Emergence to 60 days PHI. Barley: Emergence to 5-leaf. Grass weeds: 1-leaf to 2-tiller.	Most crops can be planted the year following application. Do not plant lentil for 18 months after application.
Everest 3.0 Sierra (flucarbazone ² & safener) Not for Barley Short to Long Residual	1 to 2 fl oz OD 0.5 to 1 fl oz SC (0.219 to 0.438 oz)	Wild oat, green foxtail, mustards, and pigweed. Partial control of yellow foxtail, barnyardgrass, downy brome, Japanese brome and Persian darnel	Wheat: Everest: 1-leaf to 60 days PHI. Sierra: 1-leaf to prior to jointing. Grass weeds: Up to 4 leaves.	Add basic pH blend adjuvant at 2-4 qt/100 gal or NIS at 1 qt/100 gal + AMS. Apply Everest at 2 fl oz/A or Sierra at 0.75 to 1 fl oz/A for wild oat and other grasses. Everest at 1 to 1.3 fl oz/A can be applied after Pre-Pare. Apply Sierra at 0.5 fl oz/A for green foxtail or sequentially after Pre-Pare. Do not apply more than a total of 0.438 oz ai/A flucarbazone to the crop. Tankmixes with tribenuron improve grass control.
Varro (thiencarbazone ² & mefenpyr safener) Not for Barley Short Residual	6.85 fl oz EC OD (0.072 oz)	Wild oat, foxtails, barnyardgrass, Persian darnel, and some annual broadleaf weeds.	Wheat: 1-leaf to prior to jointing. Grass weeds: Up to 2 tillers. Broadleaf weeds: Up to 3 inches tall.	May control some ACC-ase resistant grass biotypes. Varro may be tank-mixed with many broadleaf herbicides. Adjuvants are not recommended with Varro. Refer to label for crop rotation restrictions, tank-mix options, and application information.
Luxxur A & B (tribenuron ² & thiencarbazone ² & mefenpyr safener) Not for Barley Short Residual	0.21 oz DF & 6.85 fl oz OD (0.105 & 0.072 oz)	Wild oat, foxtails, barnyardgrass, Persian darnel, Canada thistle and most annual broadleaf weeds including resistant weeds.		Luxxur is a co-pack consisting of Luxxur A and Luxxur B that must be mixed in the spray tank. Will control some ACC-ase resistant grass biotypes. Adjuvants and AMS are not recommended with Luxxur. Refer to label for crop rotation restrictions, tank-mix options, and application information.

Hard Red Spring and Durum Wheat, Winter Wheat and Barley

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Olympus (propoxy-carbazone ²) Not For Barley Very Long Residual	Winter wheat: 0.6 to 0.9 oz WDG (0.42 to 0.63 oz) Spring/durum wheat 0.2 oz WDG (0.14 oz)	Quackgrass, downy brome, Japanese brome, foxtail barley and mustard species.	Wheat: 2-leaf to jointing. Grasses: 2-leaf to 2-tiller. Broadleaf weeds: Less than 2 inches tall or in diameter.	Application at high rates may injure spring wheat. Do not apply after wheat jointing begins. Add NIS at 1 to 2 qt/100 gal. May be applied with liquid fertilizer in winter wheat. Use high rate for wild oat and brome species. Allow a 71 day PHI. Refer to label for tank-mix options.
Osprey (mesosulfuron ² & mefenpyr safener) Winter wheat only Short Residual	3.2 to 4.75 oz WDG (0.14 to 0.21 oz)	Wild oat, Persian darnel, and mustard species.	Wheat: Up to jointing. Weeds: Less than 2 inches or 1-tiller.	Do not use in spring wheat. Add MSO adjuvant at 1.5 pt/A. May control some ACC-ase resistant wild oat biotypes. Refer to label for tank-mix options.
Rimfire Max (mesosulfuron ² & propoxycarbazone ² & mefenpyr safener) Not For Barley Short to Long Residual	3 oz WG (0.057 oz & 0.143 oz)	Wild oat, barnyardgrass, seedling foxtail barley, bromus grass species, Persian darnel and mustard species.	Wheat. Spring: 1-leaf to flag leaf emergence. Grasses: 1-leaf to 2-tiller. Broadleaf weeds: Less than 2 inches tall.	Add MSO adjuvant at 1.25 pt/A, or NIS at 2 qt/100 gal + 28% UAN at 1 to 2 qt/A, or basic pH blend adjuvant at 1 gal/100 gal (0.8 to 1.6 pt/A). Do not use petroleum oil or adjuvants containing organosilicone because wild oat control will be reduced. Refer to label for tank-mix options.
PowerFlex HL (pyroxsulam ² + cloquintocet safener) Only for Winter Wheat Short Residual	2 oz WDG (0.26 oz)	Wild oat, foxtail, bromes, barnyardgrass, Persian darnel, and mustard species.	Wheat: 3-leaf to prior to jointing.	May control some ACC-ase resistant wild oat biotypes. Allow a 60 day PHI. For PowerFlex: Add NIS at 1-2 qt/100 gal + AMS at 1.5 lb/A or petroleum oil adjuvant at 0.8 gal/100 gal. May be applied in a 50% N spray solution. Refer to label for application information.
Teammate (pyroxsulam ² & safener) Not for Barley Short Residual Registration Pending	1 oz WDG (0.21 oz)		Grass weeds: 2- to 4-leaf.	
GoldSky (pyroxsulam ² + florasulam ² + fluroxypyr ⁴ + cloquintocet safener) Not for Barley Short Residual	1 pt OD (0.21 oz & 0.04 oz & 1.42 oz)	Wild oat, bromes, barnyardgrass, foxtail, P. darnel, and many annual broadleaf weeds.	Wheat: 3-leaf to prior to jointing. Grass weeds: 2- to 4-leaf. Broadleaf weeds: Less than 3 inches tall.	Add NIS at 1-2 qt/100 gal + AMS at 1.5 lb/A. Do not add NIS with tank-mix of EC herbicides. Refer to label for tank-mix information and restrictions.
OpenSky (pyroxsulam ² + fluroxypyr ⁴ + cloquintocet safener) Not for Barley Short Residual	Spring wheat: 1 pt SE (0.21 oz & 1.9 oz) Winter wheat: 1.25 pt SE (0.27 oz & 2.38 oz)	Greater kochia control.	Wheat: 3-leaf to prior to flag leaf emergence. Grass weeds: 2- to 4-leaf. Broadleaf weeds: Less than 4 inches tall.	
PerfectMatch (pyroxsulam ² & clopyralid ⁴ & fluroxypyr ⁴) Not for Barley Long Residual	1 pt OD (0.014 lb & 0.094 lb & 0.094 lb)	Also controls Canada thistle.	Crop: 3-leaf until prior to jointing. Weeds: Up to 4 inches tall.	Apply with 2,4-D or MCPA to increase spectrum of broadleaf weed control. Refer to label for application information.

HERBICIDE-RESISTANT WHEAT

Clearfield and Clearfield Plus Wheat

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Beyond (imazamox ²) Short Residual	Clearfield wheat varieties 4 fl oz SL (0.5 oz) Clearfield Plus spring wheat varieties 5 fl oz SL (0.625 oz) Clearfield Plus winter wheat varieties 5 to 6 fl oz SL (0.625 to 0.75 oz)	Annual grass and broadleaf weeds including wild oat, green and yellow foxtail, Japanese and downy brome, and Persian darnel.	Spring Wheat: After tiller initiation to prior to jointing. Winter wheat: See label for application timing and adjuvant restrictions. Weeds: 1 to 3 inches tall.	Apply only to Clearfield and Clearfield Plus wheat varieties. Add NIS at 1 qt/100 gal + UAN at 1 to 2 qt/A or AMS at 8.5 lbs/100 gal. MSO at 1 pt/A may be used only on Clearfield Plus wheat. Will not control ALS-resistant kochia and wild oat. Refer to label for tank-mix options and application information. Will suppress feral rye.

Grass weed control from POST applied herbicides.

POST GRASS HERBICIDES	Wild oat	Foxtail, Green	Foxtail, Yellow	Barley, Volunteer	Barnyardgrass	Corn, Volunteer	Brome, Downy**	Brome, Japanese**	Persian darnel	Ryegrass, Annual	Quackgrass	Foxtail barley
Axial XL ¹ /Star ^{1,4} /Bold ¹	E*	G-E*	G-E*	N	G-E	N	N	N	E	E	N	N
Beyond ² /ClearMax ^{2,4}	E*	E*	G-E*	E	E	G-E	G-E	E	E	G-E	F	-
Discover NG ¹	E*	E*	G-E*	P-G	E	E	N	N	G-E	G-E	-	N
Everest 3.0 / Sierra ²	G-E*	E*	P-G*	P-F	P	F-G	P	G-E	F-G	P-F	P-F	F
Fenoxaprop ¹	E*	E*	E*	N	E	E	N	N	N	-	N	N
GoldSky ^{2,2,4}	G-E*	F-G*	G-E*	N	G-E	G	F-G	G-E	G	G-E	F	F
Huskie Complete ^{2,6,27}	G*	F-G*	F-G*	-	G-E	-	P-F	F-G	F-G	-	-	F
Outrider ^{2***}	E*	P-F*	P-F*	P-F	P	-	F-G	G	-	P-F	G	-
Olympus ²	G-E*	P-F*	P-F*	P-F	G	-	F-G	E	N	-	F-G	G
OpenSky ^{2,4}	G-E*	F-G*	G-E*	N	G-E	G	F-G	G-E	G	G-E	F	F
Perfectmatch ^{2,4,4}	G-E*	F-G*	G-E*	N	G-E	G	F-G	G-E	G	G-E	F	F
PowerFlex ²	G-E*	F-G*	G-E*	N	G-E	G	F-G	G-E	G	G-E	F	F
Rimfire Max ^{2,2}	G-E*	P-F*	P-F*	P-F	G	F-G	P-F	G	G	-	F	F-G
Teammate ²	G-E*	F-G*	G-E*	N	G-E	G	F-G	G-E	G	G-E	F	F
Varro ²	G*	G*	G*	-	G-E	N	P-F	F-G	F-G	-	-	F-G
Wolverine Advanced ^{1,6,27}	E*	G-E*	G-E*	N	E	E	N	N	N	N	N	N

*Will not control herbicide resistant biotypes.

**Early fall applications provide better control than late fall or spring. Earlier spring application are more effective than late spring or mid-season application.

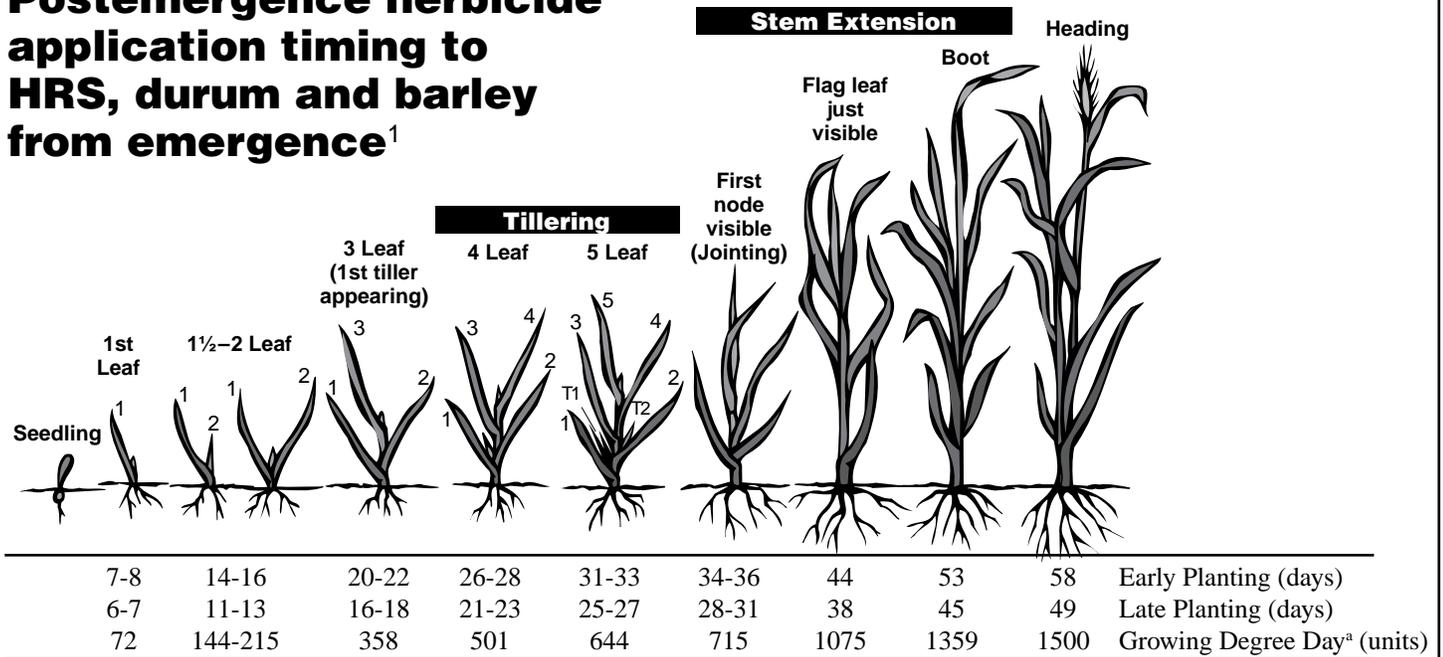
***Suggested for use only in continuous wheat because of crop rotation restrictions.

Weed control ratings are based on the following scale:

- E = Excellent = 90 to 99% control
- G = Good = 80 to 90% control
- F = Fair = 65 to 80% control
- P = Poor = 40 to 65% control
- N = None = No control

- = insufficient information

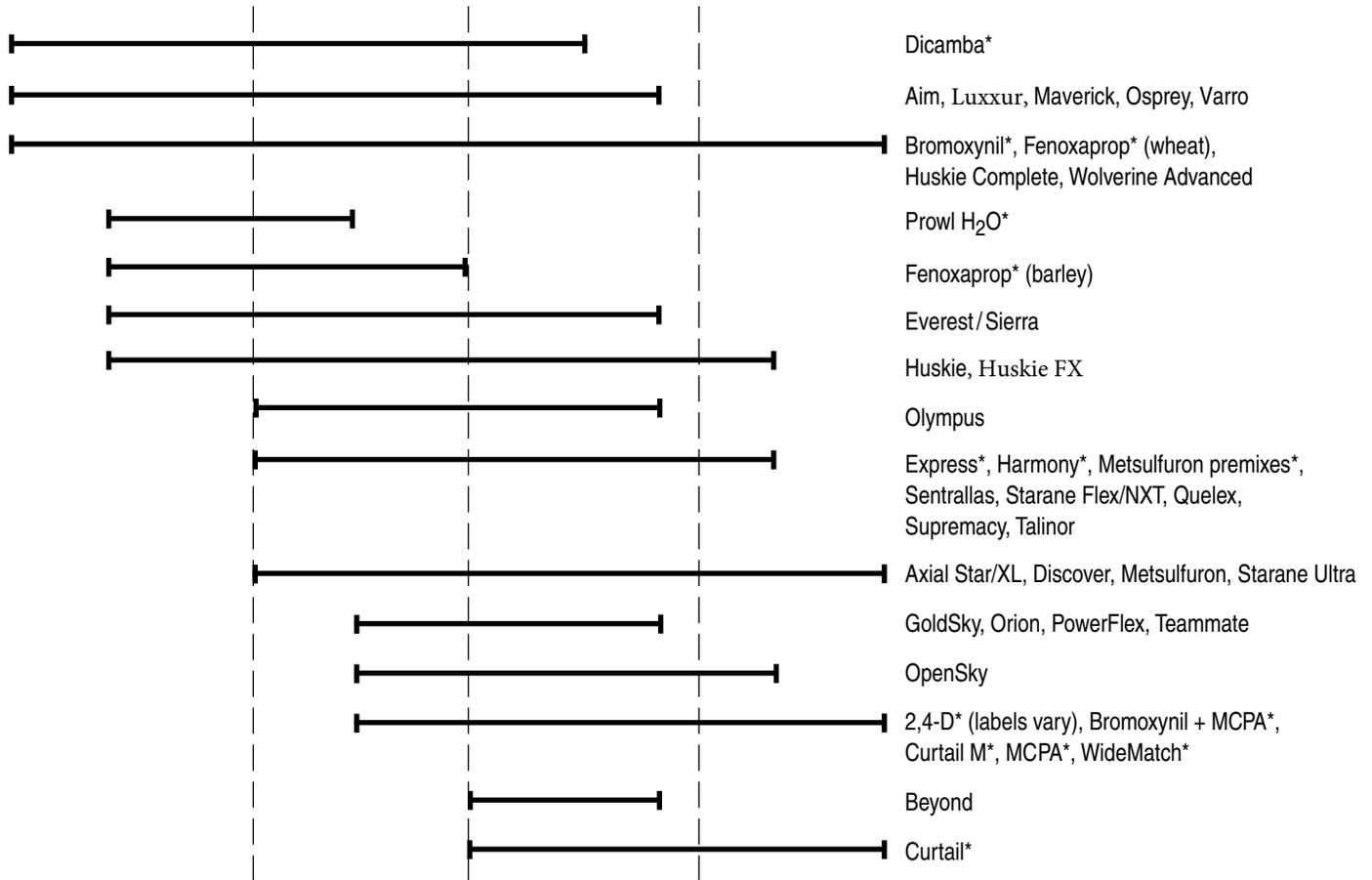
Postemergence herbicide application timing to HRS, durum and barley from emergence¹



The lettering on the drawing represents the following: 1=1st leaf on the main stem of the plant; and so forth to 5=5th leaf on the main stem; and T=Tiller – not counted as a leaf when determining leaf stages.

$$^a\text{Growing Degree Day Units} = \frac{(\text{Maximum Day Temperature} + \text{Minimum Day Temperature}) - 32}{2}$$

Herbicide



¹ Herbicide may have different application timings for individual crops. Use specific label information for individual crops.

* or generic equivalent

Remember to always follow the label — it's the law!

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Refer to page 6 for Fall or Spring Early Preplant Herbicides.				
Soil-Applied Herbicides				
Sharpen (saflufenacil ¹⁴)	1 to 2 fl oz SC (0.36 to 0.71 oz)	Broadleaf weeds including winter annuals.	PRE or PPI.	Add MSO at 1 to 1.5 pt/A plus an ammonium source if weeds are present. Use 2 fl oz/A for short residual control of weeds.
Callisto (mesotrione ²⁷)	3 to 6 fl oz (1.5 to 3 oz)	Many broadleaf weeds including those resistant to other herbicides. Suppresses 2-leaf foxtail or smaller.	PRE.	Callisto PRE requires rain for activation. For POST application add petroleum oil at 1 qt/A or NIS at 1 qt/100 gal + UAN at 2.5 gal/100 gal or AMS at 8.5 lb/100 gal water. Addition of bromoxynil will increase risk of oat injury. Allow a 50 day PHI.
	3 fl oz (1.5 oz)		POST. Weeds: Up to 5 inches tall.	
POST-Applied Herbicides				
Aim (carfentrazone ²)	0.5 fl oz EC (0.128 oz)	Small broadleaf weeds.	Crop: Up to jointing stage. Weeds: Small.	Contact, non-residual herbicide requiring thorough coverage. May cause cosmetic speckling on oat. Add NIS at 1 qt/100 gal.
MCPA ⁴ amine MCPA ⁴ ester	0.5 to 1 pt 4SL 0.5 to 1 pt 4EC (0.25 to 0.5 lb)	Broadleaf weeds.	Oat: 3-leaf until prior to boot stage.	Possible oat injury at any stage.
Bromoxynil ⁶	1 to 1.5 pt EC (0.25 to 0.38 lb)	Small broadleaf weeds including wild buckwheat, and volunteer sunflower.	Oat: 3-leaf until prior to boot stage.	Bromoxynil is a non-residual, contact herbicide requiring thorough coverage. Most active in hot and sunny conditions. Controls ALS-resistant kochia. Refer to label for tank-mix options.
Bromoxynil ⁶ & MCPA ⁴	1 to 2 pt 4EC 0.8 to 1.6 pt 5EC (0.25 to 0.5 lb & 0.25 to 0.5 lb)			
Dicamba ⁴ + MCPA ⁴	2 to 4 fl oz 4SL + 0.5 to 0.75 pt 4L (0.06 to 0.12 lb + 0.25 to 0.38 lb)	Broadleaf weeds.	Oat: 3- through 5-leaf stage.	Use the low dicamba rate and high MCPA rate on 5-leaf oat. Early application increases crop safety.
Curtail M / generic clopyralid ⁴ & MCPA ⁴	1.75 to 2.33 pt (0.09 to 0.12 lb & 0.5 to 0.68 lb)	Broadleaf weeds and Canada thistle.	Oat: 3-leaf to jointing.	Apply to Canada thistle at the rosette to early bolting stage.
Fluroxypyr ⁴	0.67 pt 1.5EC 0.35 pt 2.8EC 5 oz 40WDG (2 oz)	Kochia including ALS-resistant and volunteer flax.	Oat: 2-leaf through flag leaf emergence. Weeds: Small.	Non-residual herbicide. Allow a 40 day PHI. Refer to label for tank-mix options. Commercial mixtures with bromoxynil available as Starane NXT and with MCPA as Colt + Sword.
Widematch / generic clopyralid ⁴ & fluroxypyr ⁴	1.33 pt (0.125 lb & 0.125 lb)	Broadleaf weeds including kochia, wild buckwheat, volunteer flax, and Canada thistle.	Oat: 3-leaf through flag leaf emergence. Weeds: Up to 4 inches tall or vining.	An economical formulation of clopyralid. Addition of 2,4-D, MCPA, or thifensulfuron increases broadleaf weed control. Commercial mixture with MCPA ester available as Hat Trick or Weld.
thifen ² & tribenuron ² 1:0 75DF 1:0 50SG 4:1 ratio 75DF Affinity T/M 50SG 3:1 Audit 75DF 2:1 ratio 75DF 1:1 ratio 75DF Affinity B/S 50SG Sentrallas	0.3 to 0.4 oz DF 0.45 to 0.6 oz SG 0.4 to 0.67 oz DF 0.6 to 1 oz SG 0.3 to 0.5 oz DF 0.3 to 0.66 oz DF 0.25 to 0.5 oz DF 0.4 to 0.8 oz SG 7 to 9 fl oz	Provides a broader spectrum of control than either a.i. alone. Choose ratio based on prevalent weeds.	Oat: 3- through 5-leaf stage but before jointing.	Do not use on Ogle, Porter, or Premier oat varieties. Addition of MCPA ester at 0.75 pt/A enhances broadleaf weed control and oat safety. Add NIS at 1 pt/100 gal except when adding MCPA at 0.75 pt/A. Refer to label for list of tank-mix options. Sentrallas = thifensulfuron & fluroxypyr
Orion (florasulam ² & MCPA ⁴ ester)	17 fl oz (0.07 oz & 0.31 lb)	Some broadleaf weeds.	Crop: 3-leaf to jointing. Weeds: Small.	Add NIS at 1 qt/100 gal. Allow a 60 day PHI. Refer to label for application information.

OAT

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Supremacy (fluroxypyr ⁴ & thifensulfuron ² & tribenuron ²)	4 to 6 oz (1 to 1.5 oz & 0.18 to 0.27 oz & 0.06 to 0.09 oz)	Broadleaf weeds including pigweed, buckwheat, kochia, mustard, flax, and Canada thistle.	Wheat: 2-leaf through flag leaf emergence.	Add NIS at 1-2 qt/100 gal except when adding an EC or ester formulated herbicide. Use higher rates for larger weeds.

RYE

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Soil-Applied Herbicides				
Sharpen (saflufenacil ¹⁴)	1 to 2 fl oz SC (0.36 to 0.71 oz)	Broadleaf weeds including winter annuals.	PRE or PPI.	Add MSO at 1 to 1.5 pt/A plus an ammonium source if weeds are present. Use 2 fl oz/A for short residual control of weeds.
POST-Applied Herbicides				
Starane Flex (florasulam ² & fluroxypyr ⁴)	13.5 fl oz EC (0.07 oz & 1.4 oz)	Broadleaf weeds up to 4 inches tall.	Crop: 3-leaf to flag-leaf emergence.	Adjuvant is not necessary but might aid control under adverse conditions. Allow a 60 day PHI.
Orion (florasulam ² & MCPA ⁴ ester)	17 fl oz EC (0.07 oz & 5 oz)		Crop: 3-leaf to jointing.	Add NIS at 1 qt/100 gal. Allow a 60 day PHI.
MCPA ⁴ amine MCPA ⁴ ester	0.5 to 1.3 pt 4SL 0.5 to 1.3 pt 4EC (4 to 10.4 oz) Rates vary by label.	Broadleaf weeds. Use high end of rate range for larger or perennial weeds.	Crop: 3-leaf until prior to boot stage, labels vary.	Follow label for specific application timing. Some labels allow higher rates. <i>Do not apply 2,4-D to winter rye in fall.</i>
2,4-D amine ⁴ 2,4-D ester ⁴	0.5 to 1 pt 4SL 0.5 to 1 pt 4EC (4 to 8 oz) Rates vary by label.			
Bromoxynil ⁶ & MCPA ⁴	1 to 2 pt 4EC 0.8 to 1.6 pt 5EC (4 to 8 oz & 4 to 8 oz) Rates vary by label.	Small broadleaf weeds including wild buckwheat, sunflower, kochia, Russian thistle.	Crop: 3-leaf until prior to boot stage, labels vary.	Follow label for specific application timing. Some labels allow higher rates. Ratios of bromoxynil to MCPA/2,4-D vary by label
Bromoxynil ⁶ & 2,4-D ⁴	0.75 to 1.5 pt EC (3 to 6 oz & 4 to 8 oz) Rates vary by label.			
Bromoxynil ⁶	1 to 2 pt 2EC 0.5 to 1 pt 4EC (4 to 8 oz)	Broadleaf weeds smaller than 2 inches tall	Crop: Emergence until prior to boot.	Bromoxynil is a non-residual, contact herbicide requiring thorough coverage. Most active in hot and sunny conditions. Controls ALS-resistant kochia.
Huskie (bromoxynil ⁶ & pyrasulfotole ²⁷ & mefenpyr safener)	11 to 15 fl oz EC (2.4 to 3.3 oz & 0.43 to 0.58 oz)	Most annual broadleaf weeds including resistant weeds up to 3 inches tall.	Crop: Up to flag leaf emergence.	Do not plant lentil for 18 months after Huskie application. Adjuvants such as AMS, UAN, or NIS might improve herbicidal activity under adverse conditions. Allow a 60 day PHI.
Huskie FX (bromoxynil ⁶ & fluroxypyr ⁴ & pyrasulfotole ²⁷ & mefenpyr safener)	13.5 to 18 gl oz/A EC (0.15 to 0.2 & 0.063 to 0.084 & 0.027 to 0.036 lb)	Most annual broadleaf weeds including resistant weeds.	Crop: Up to flag leaf emergence. Weeds: Up to 4 inches tall.	Huskie FX provides a third a.i. that is effective against kochia. Most crops can be planted the year following application. Do not plant lentil for 18 months after application. Refer to label for tank-mix options and application information.
Aim (carfentrazone ¹⁴)	0.5 fl oz EC (0.128 oz)	Broadleaf weeds smaller than 2 inches tall.	Crop: Up to jointing stage.	Contact, non-residual herbicide requiring thorough coverage. May cause cosmetic speckling on rye. Add NIS at 1 qt/100 gal.

SMALL GRAIN PRE-HARVEST WEED CONTROL (NOT FOR DESICCATION)

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs																									
Glyphosate ⁹ For HRS, Durum and Winter Wheat and Feed Barley Only.	Up to 0.75 lb ae See Remarks.	Annual and perennial grass and broadleaf weeds including Canada thistle.	Wheat and barley: Hard-dough stage, 30% or less grain moisture. Allow a 7 day PHI.	<table border="0"> <tr> <td><u>lb ae/gal</u></td> <td><u>lb ai/gal</u></td> <td><u>0.38 ae</u></td> <td><u>0.57 ae</u></td> <td><u>0.75 ae</u></td> </tr> <tr> <td>3</td> <td>4</td> <td>= 16 fl oz</td> <td>24 fl oz</td> <td>32 fl oz</td> </tr> <tr> <td>4/4.17</td> <td>5.4/5.1</td> <td>= 12 fl oz</td> <td>18 fl oz</td> <td>24 fl oz</td> </tr> <tr> <td>4.5</td> <td>5.5</td> <td>= 11 fl oz</td> <td>16 fl oz</td> <td>22 fl oz</td> </tr> <tr> <td>5</td> <td>6.1</td> <td>= 10 fl oz</td> <td>15 fl oz</td> <td>20 fl oz</td> </tr> </table> <p>Do not apply more than 0.75 lb ae/season. Do not apply on wheat or barley grown for seed because reduced germination/vigor may occur. Apply 0.75 lb ae/A for Canada thistle control. May be applied with 2,4-D or dicamba for improved broadleaf weed control. Add AMS fertilizer at 8.5 lb/100 gal. Refer to label for adjuvant use and application information.</p>	<u>lb ae/gal</u>	<u>lb ai/gal</u>	<u>0.38 ae</u>	<u>0.57 ae</u>	<u>0.75 ae</u>	3	4	= 16 fl oz	24 fl oz	32 fl oz	4/4.17	5.4/5.1	= 12 fl oz	18 fl oz	24 fl oz	4.5	5.5	= 11 fl oz	16 fl oz	22 fl oz	5	6.1	= 10 fl oz	15 fl oz	20 fl oz
<u>lb ae/gal</u>	<u>lb ai/gal</u>	<u>0.38 ae</u>	<u>0.57 ae</u>	<u>0.75 ae</u>																									
3	4	= 16 fl oz	24 fl oz	32 fl oz																									
4/4.17	5.4/5.1	= 12 fl oz	18 fl oz	24 fl oz																									
4.5	5.5	= 11 fl oz	16 fl oz	22 fl oz																									
5	6.1	= 10 fl oz	15 fl oz	20 fl oz																									
2,4-D ⁴ ester For HRS, Durum, and Winter Wheat, Barley, and Rye	1.5 to 3 pt 4EC/SL (0.75 to 1.5 lb)	Broadleaf weeds.	Wheat and oat: Hard dough stage to harvest. Allow a 14 day PHI.	Do not feed straw to livestock. Use only 2,4-D brands labeled for preharvest application. Drift to broadleaf crops is especially hazardous at this time.																									
Dicamba ⁴ + 2,4-D ⁴ For HRS, Durum, and Winter Wheat Only	0.5 to 1 pt 4SL + 1 to 2 pt 4EC/SL (0.25 to 0.5 lb + 0.5 to 1 lb)		Wheat: Hard-dough stage and green color is gone from the nodes (joints) of the stem. Allow a 7 day PHI.		Do not feed treated straw to livestock. Drift to broadleaf crops is especially hazardous at this time.																								
Sharpen (saflufenacil ¹⁴) For HRS, Durum, and Winter Wheat Barley and Triticale Only	1 to 2 fl oz (0.36 to 0.72 oz)	Annual broadleaf weeds.	Wheat: Hard-dough stage and grain with less than 30% moisture. Allow a 3 day PHI.	Do not apply Sharpen to cereals grown for seed because reduced germination/vigor may occur. Apply with MSO adjuvant at 1.5 pt/A + AMS at 8.5 to 17 lbs/100 gal or 28% N at 1.25 to 2.5 gal/100 gal. Apply with glyphosate for additional weed control weed and desiccation. Sharpen has no grass activity. Refer to label for crop rotation intervals. Caution: MRL's may change and growers/exporters are responsible for checking a reliable database to ensure an MRL is in effect prior to export.																									
Valor SX Valor EZ + MSO adjuvant (flumioxazin ¹⁴) For HRS, Durum, and Winter Wheat Only	2 oz WDG 2 fl oz EZ + 2 pt (1.02 oz)	Annual broadleaf weeds.	Wheat: Hard dough stage and grain with less than 30% moisture. Allow 10 day PHI	Apply with MSO adjuvant at 2 pt/A. Spray grade nitrogen source (AMS at 2.5 lb/A or 28% or 32% nitrogen solution at 2-4 pt/A) may be added to spray mixture with MSO. Tank mix with glyphosate to increase control of emerged weeds and aid in harvest.																									

MILLET

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Soil-Applied Herbicides				
Callisto or generic (mesotrione ²⁷) pearl millet	3 to 6 fl oz 4SE/SC/L (1.5 to 3 oz)	Broadleaf weeds.	Crop: PRE.	Add PO at 2 pt/A plus an ammonium source if weeds are present. Several generics available.
Sharpen (saflufenacil ¹⁴) pearl or proso millet Not for foxtail millet	1 to 2 fl oz SC (0.36 to 0.71 oz)	Broadleaf weeds including winter annuals.	Crop: PRE or PPI.	Add MSO at 1 to 1.5 pt/A plus an ammonium source if weeds are present. Use 2 fl oz/A for short residual control of weeds. Do not use for millet if soil pH is 7.8 or greater.
POST-Applied Herbicides				
Permit/Sandea (halosulfuron ²)	0.5 to 0.67 oz DF (0.375 to 0.5 oz)	Small broadleaf weeds and yellow nutsedge	Crop: 2-leaf to boot stage.	Add NIS at 1 to 2 qt/100 gal. Allow a 50 day PHI. All millet types for hay and forage, not for grain. Only proso millet for grain.
Yukon (halosulfuron ² & dicamba ⁴)	3 to 4 oz DF (0.375 to 0.5 & 1.5 to 2 oz)	Many broadleaf weeds including ALS-resistant kochia.	Crop: 3-leaf to 5-leaf stage	Add NIS at 1 to 2 qt/100 gal. Allow a 50 day PHI. Allowed on pearl millet up to 8 oz/A for forage use only. All millet types for hay and forage, not for grain. Only proso millet for grain.
2,4-D amine ⁴ 2,4-D ester ⁴ millet	0.5 to 1 pt 4SL 0.5 to 1 pt 4EC (4 to 8 oz) Rates vary by label.	Broadleaf weeds. Use high end of rate range for larger or perennial weeds.	Crop: 3-leaf until prior to boot stage, labels vary.	Follow label for specific application timing. Some labels allow higher rates.
dicamba ⁴ proso millet	2 to 4 fl oz 4SL 1.6 to 3.2 fl oz 5SL (1 to 2 oz)	Broadleaf weeds including wild buckwheat, sunflower, and Russian thistle.	Crop: 2-leaf to 5-leaf stage.	Adjuvant is not necessary but might aid control under adverse conditions. Broadleaf weed control can be improved in tankmix with 2,4-D, but some cultivars might be injured with this combination.
Starane Ultra (2ee)/ Comet (fluroxypyr ⁴)	5.7 fl oz 2.8EC 10.7 fl oz 1.5EC (2 oz)	Some broadleaf weeds up to 4 inches tall including kochia.	Crop: 2-leaf to prior to boot stage.	Adjuvant is not necessary but might aid control under adverse conditions. Allow a 40 day PHI. Millet grown for grain, forage, or hay.
Trumpcard (fluroxypyr ⁴ & 2,4-D ⁴)	10 to 16 fl oz EC (0.82 to 1.32 & 3.3 to 5.3 oz)	Many annual broadleaf weeds up to 4 inches tall.	Crop: 2-leaf until prior to boot stage.	Use high rate if kochia is present or weeds are large. Adjuvant is recommended under adverse conditions, low water carrier volume, or when "puffball" kochia is present - so any time spraying in North Dakota. Allow a 40 day PHI. All millet types
Scorch (dicamba ⁴ & 2,4-D ⁴ & fluroxypyr ⁴) proso millet	1 pt EC (2 & 6 & 1.5 oz)	Many broadleaf weeds including ALS-resistant kochia, sunflower, wild buckwheat, and Russian thistle	Crop: 2-leaf to 5-leaf stage	NIS at 1 to 2 qt/100 gal may be added to improve herbicide efficacy under adverse conditions. Do not include oil adjuvants for POST application as severe crop injury might occur. Allow a 40 day PHI.

HERBICIDES REGISTERED ON SMALL ACREAGE CROPS

The following chart is only an aid to identify registered herbicides on the following crops. Not all labels of similar active ingredients cover identical crops. Not all formulations are registered in the state of North Dakota. Refer to the ND Dept of Ag web site for formulations registered in the state. Many products require specific application instructions and not all formulations can be used in-crop with adequate crop tolerance. For example, glyphosate is registered on most crops listed as a PRE or directed application between rows but glyphosate applied POST on crop foliage will kill crop plants. Refer to Herbicide Compendium for additional information on products listed. User must follow label directions. Refer to label of specific product to determine what crops are registered, for application instructions, and for all other restrictions and use information.

Herbicides registered on small acreage crops:

BUCKWHEAT	
Aim (carfentrazone ¹⁴) - Preplant ET (pyraflufen ¹⁴)	Poast (sethoxydim ¹) Glyphosate ^{9*} - Preplant
HEMP	
No Herbicides Registered for use in hemp.	
FABABEAN	
Assure II (quizalofop ¹) Basagran (bentazon ⁵) Dual Magnum (s-metolachlor ¹⁵) Glyphosate ^{9*} - Desiccant Prowl H2O (pendimethalin ³) Select (clethodim ¹) Sonalan (ethalfluralin ³)	Spartan Charge (sulf ¹⁴ + carf ¹⁴) Spartan Elite (sulf ¹⁴ + s-meto ¹⁵) Treflan (trifluralin ³) Varisto (bent ⁵ + imazamox ²) Paraquat ^{22*} - Desiccant Valor (flumiox ¹⁴) - Desiccant
JUNEBERRY	
Chateau SW/EZ (flumioxazin ¹⁴) Poast (sethoxydim ¹)	
MINT	
Assure II / Targa (quizalofop ¹) Basagran / bentazon ^{6*} Buctril / bromoxynil ^{6*} Chateau SW/EZ (flumioxazin ¹⁴) Glyphosate ^{9*} - Preplant Goal (oxyfluorfen ¹⁴) Karmex / diuron ^{7*}	Paraquat ^{22*} - Preplant Panther (flumioxazin ¹⁴) Poast (sethoxydim ¹) Prowl H2O (pendimethalin ³) Select / clethodim ^{1*} Stinger / clopyralid ^{4*} Spartan (sulfentrazone ¹⁴) Tough (pyridate ⁶)
ONION	
Buctril / bromoxynil ^{6*} Chateau SW/EZ (flumioxazin ¹⁴) Dacthal (DCPA) Fusilade DX (fluazifop ¹) Glyphosate ^{9*} - Preplant Goal, Collide (oxyfluorfen ¹⁴) Nortron (ethofumesate ⁸) Outlook / dimethenamid ^{15*}	Paraquat ^{22*} - Preplant Poast (sethoxydim ¹) Prefar (bensulide) Sattelite H2O (pendimethalin ³) Select / clethodim ^{1*} Treflan / trifluralin ^{3*}

SORGHUM			
	<u>Sorghum</u>	<u>Sudangrass</u>	<u>Sorghum-Sudan</u>
Aim	Yes	No	No
Basagran	Yes	No	No
Buctril	Yes	Yes	No
Callisto	Yes	DO NOT USE	DO NOT USE
Dicamba	Yes	Yes	No
Dual II Magnum	Yes	No	No
Facet	Yes	No	No
Huskie/FX	Yes	No	No
Outlook	Yes	No	No
Paraquat	Yes	No	No
Permit	Yes	No	No
Prowl	Yes	No	No
Sequence	Yes	No	No
Sharpen	Yes	DO NOT USE	DO NOT USE
Starane Ultra	Yes	Yes	Yes
2,4-D (varies)	Yes	Yes	Yes
Atrazine	Yes	No	Yes
Yes = specifically listed on label No = not specifically listed on label			
TRITICALE			
Affinity / thifen ² & triben ^{2*} Aim (carfentrazone ¹⁴) Ally Extra (thif ² & triben ² & met ²) Accurate Extra (thifen ² & triben ² & met ²) Dicamba ^{4*} Buctril / bromoxynil ^{6*} DeadBolt (bromx ⁶ & 2,4-D ⁴) Express / tribenuron ^{2*} Far-Go/Avadex (trillate ⁸) Goal/Tender (oxyfluorfen ¹⁴) GoldSky (pyrox ² & fluras ² & flurx ⁴) Huskie (bromox ⁶ & pyrasulfatol ²⁷)	Huskie FX (bromox ⁶ & flurox ⁴ & pyrasulf ²⁷) MCPA ^{4*} Olympus (propoxycarbazone ²) Orion (florasulam ² & MCPA ⁴) PerfectMatch (pyrox ² & clop & flur) PowerFlex (pyrox ²) Wntr-triticale Quelex (halauxifen & floras ^{4,2}) Scorch (2,4-D & dic & flurox ^{4,4,4}) Sharpen (saflufenacil ¹⁴) Starane/NXT/Flex (fluroxypyr ^{4*}) Stealth (pendimethalin ³) Voucher (fluroxypyr & MCPA ^{4,4}) 2,4-D ^{4*}		

* Or generic equivalent

CORN

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Dual/II/Magnum (S/metolachlor ¹⁵ & benoxacor safener)	1 to 2 pt EC (0.95 to 1.9 lb)	Annual grass and some broadleaf weeds.	Shallow PPI or PRE.	PRE requires precipitation for activation. Pyroxasulfone may require multiple rain events for activation. Adjust rate for soil type. Shallow PPI gives more consistent weed control than PRE. 3 to 4 weeks residual weed control after activation. Weed control: pyroxasulfone = acetochlor > dimethenamid = metolachlor. Outlook may be applied as a single application or sequentially. See Outlook label for rates allowed per application. Use the highest rates allowed for greater and more consistent weed control. Refer to label for tank-mix options.
Harness/Surpass (acetochlor ¹⁵ & furilazole safener) 	1.25 to 2.75 pt 7EC (1.1 to 2.4 lb) 1.5 to 3 pt 6.4EC (1.2 to 2.4 lb)			
Outlook (dimethenamid-P ¹⁵)	10 to 24 fl oz EC (0.47 to 1.125 lb)		Shallow PPI, PRE or EPOST to corn up to 12" tall.	
Zidua SC (pyroxasulfone ¹⁵)	1.75 to 6.5 fl oz SC (0.9 to 3.4 oz)		Shallow PPI, PRE or EPOST to V8 corn.	
Anthem Maxx (pyroxasulfone ¹⁵ & fluthiacet ¹⁴)	2.5 to 6.5 fl oz SC (1.3 to 3.4 oz + 0.04 to 0.1 oz)		Shallow PPI, PRE or EPOST through V4 corn.	Fluthiacet (Cadet) in Anthem Maxx is for POST control of emerged weeds and does not have soil activity.
Perpetuo (pyroxasulfone ¹⁵ & flumiclorac pentyl ¹⁴)	6 to 10 fl oz SC (1.28 to 2.14 & 0.28 to 0.43 oz)	Annual grass and broadleaf weeds.	EPP or PRE. Post V2 to V6 corn.	Apply with PO or MSO at 1 to 2 pt/A. Certain tank mixes require use of NIS in place of oil. Follow tank mix partner recommendation. AMS or UAN can be added to tank mix to enhance weed control. Refer to label for tank-mix options and rotation restrictions.
Fierce EZ (pyroxasulfone ¹⁵ & flumioxazin ¹⁴)	6 fl oz SC (1.28 oz & 1 oz)	Annual grass and broadleaf weeds.	EPP - At least 7 days prior to planting.	Refer to page 6 for crop rotation intervals. Use only on no-till or min-till fields where crop residue hasn't been incorporated into the soil. Requires precipitation for herbicide activation. Refer to label for tank-mix options and crop rotation restrictions.
Fierce MTZ/Kyber (pyroxasulfone ¹⁵ & flumioxazin ¹⁴ & metribuzin ⁵)	1 to 1.5 pt (1.28 to 1.92 & 1 to 1.5 & 3 to 4.5 oz)			
Valor SX/EZ (flumioxazin ¹⁴)	2 to 3 oz WDG/SC (1 to 1.5 oz)			
Sharpen (saflufenacil ¹⁴)	1 to 3 fl oz SC (0.36 to 1.07 oz)	Annual broadleaf weeds.	EPP, shallow PPI, or PRE.	PRE requires precipitation for herbicide activation. Adjust rate for soil type. Sharpen has no grass activity. Provides burndown and rate dependant residual control of emerged broadleaf weeds. Refer to label for tank-mix options.
Verdict (saflufenacil ¹⁴ & dimethenamid ¹⁵)	10 to 18 fl oz EC (0.71 to 1.28 oz + 0.39 to 0.7 lb)	Annual grass and broadleaf weeds.	Shallow PPI, PRE or EPOST up to V2 corn.	PRE requires precipitation for herbicide activation. Adjust rate for soil texture and pH. Provides residual weed control after activation. Do not apply EPOST with oil adjuvant. Balance Flexx and Corvus contains cyprosulfamide to safen corn. Refer to label for crop rotation restrictions.
Balance Flexx  (isoxaflutole ²⁷ & cyprosulfamide safener) RUP	3 to 6 fl oz L (0.75 to 1.5 oz)			
Corvus  (isoxaflutole ²⁷ & thiencazone ² & cyprosulfamide safener) RUP	3.33 to 5.6 fl oz SC (0.78 to 1.32 oz & 0.31 to 0.53 oz)			
SureStart/II TripleFlex/II  (acetochlor ¹⁵ & flumetsulam ² & clopyralid ⁴ & furilazole safener)	1.5 to 3 pt SC (0.7 to 1.4 lb & 0.36 to 0.72 oz & 0.87 to 1.74 oz)		Shallow PPI, PRE or EPOST up to 11 inch tall corn.	
Resicore  (acetochlor ¹⁵ & mesotrione ²⁷ & clopyralid ⁴ & furilazole safener)	2 to 3 qt SC (1.4 to 2.1 lb & 2.4 to 3.6 oz & 1.52 to 2.24 oz)			

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Acuron Flexi (S-metolachlor ¹⁵ & mesotrione ²⁷ & bicyclopyrone ²⁷ & benoxacor safener)	1.2 to 2.25 qt SC (0.43 to 0.8 lb & 0.77 to 1.44 oz & 0.19 to 0.37 oz)		Shallow PPI, PRE or EPOST up to 30 inch tall corn.	PRE requires precipitation for herbicide activation. Adjust rate for organic matter. Provides residual weed control after activation. Bicyclopyrone improves large-seeded broadleaf weed control. Apply Acuron Flexi EPOST with atrazine at 0.38 lb ai/A for greater weed control. Add NIS at 1 qt/100 gal water for POST applications. Do not apply with MSO or nitrogen based adjuvants to emerged corn. Refer to label for tank-mix options and crop rotation restrictions.
Acuron (S-metolachlor ¹⁵ & mesotrione ²⁷ & bicyclopyrone ²⁷ & atrazine ⁵ & benoxacor safener)	1.5 to 3 qt SC (0.8 to 1.6 lb & 1.44 to 2.88 oz & 0.36 to 0.72 oz & 0.375 to 0.75 lb)		Shallow PPI, PRE or POST up to 12 inch tall corn.	
Dicamba⁴	0.25 to 0.5 pt 4SL 3.2 to 6.4 fl oz 5SL (0.125 to 0.25 lb)	Broadleaf weeds.	PRE or EPOST up to 8 inch tall corn.	Seed corn at least 1.5 inches. PRE applications require precipitation for herbicide activation. Residual weed control from soil application is weed and dicamba rate dependent.
DiFlexx (dicamba ⁴ & cyprosulfamide safener)	0.5 to 1 pt SL (0.25 to 0.5 lb)		PRE or POST up to 24 inch tall corn. Weeds: Small.	DiFlexx/Duo contains cyprosulfamide safener and Status contains isoxadifen-ethyl to safen dicamba on corn. In one growing season do not apply more than 2 qt/A of dicamba, 24 fl oz/A of DiFlexx, 40 fl oz/A of DiFlexx Duo, or 12.5 oz/A of Status.
DiFlexx Duo (dicamba ⁴ & tembotrione ²⁷ & cyprosulfamide safener)	24 to 40 fl oz SC (0.24 to 0.39 lb + 0.051 to 0.08)	Broadleaf weeds and some annual grass weeds.	PRE or POST prior to V7 or 24 inch tall corn. Weeds: Small.	Apply with PO and MSO adjuvants at 1% v/v to improve weed control. Apply with HSMOC adjuvants when mixed with glyphosate. Refer to label for adjuvant type and rate recommendations, crop rotation restrictions, and other information.
Status (dicamba ⁴ & diflufenzopyr ¹⁹ & isoxadifen safener)	3.5 to 10 oz WDG (0.0875 to 0.25 lb)	Broadleaf weeds.	POST from V2 to V10 or from 4 to 36 inch tall corn. Weeds: Small	It is not recommended to apply Diflexx or Diflexx Duo with AMS.
Armezon / Impact + Atrazine⁵ (topramezone ²⁷)	0.5 to 1 fl oz SC + 0.75 pt 4L 0.42 lb DF (0.175 to 0.26 oz + 0.375 lb)	Broadleaf weeds and foxtail.	POST to corn. Up to 45 day PHI. Weeds: Small.	Apply early to small weeds to increase residual weed control. Add atrazine at 0.42 lb DF/A or 0.75 pt 4L/A + UAN at 2.5 gal/100 gal or AMS at 8.5 lb/100 gal water + adjuvant recommendation below. Apply to corn less than 12 inches when atrazine is applied alone or with other herbicides.
Shieldex + atrazine⁵ (tolpyralate ²⁷)	1 to 1.35 fl oz SC + 0.75 pt 4L 0.42 lb DF (0.42 to 0.56 oz + 0.375 lb)			Adjuvant recommendations: Armezon/Impact, Shieldex, and Laudis: Add MSO oil adjuvant at 1 to 2 pt/A. Impact Core: Add MSO 1 to 2 qt/100 gal + UAN or AMS or NIS 0.25% v/v + UAN or AMS. ImpactZ: Add MSO at 1 to 1.5 gal/100 plus UAN or AMS.
Armezon Pro + Atrazine⁵ (topramezone ²⁷ & dimethenamid ¹⁵)	14 to 20 fl oz SC + 0.75 pt 4L 0.42 lb DF (0.175 to 0.25 oz & 0.57 to 0.82 lb + 0.375 lb)		Up to 12-inch corn	Armezon Pro: Add NIS at 1 to 2 pt/100 gal. Callisto, Capreno, and Revulin Q: Add PO adjuvant at 2 to 4 pt/A or HSOC at 2 qt/A. Do not apply Armezon Pro, Callisto, Resicore, or Revulin Q with MSO adjuvants.
ImpactZ (topramezone ²⁷ & atrazine ⁵)	8 to 10.7 fl oz (0.26 to 0.35 oz & 0.25 to 0.33 lb)			
Impact Core + Atrazine⁵ (topramezone ²⁷ & acetochlor ¹⁵)	20 to 40 fl oz EC + 0.75 pt 4L 0.42 lb DF (0.01 to 0.02 & 0.11 to 0.22 + 0.375 lb)		POST up to 11 inch tall corn.	Refer to label for tank-mix options and restrictions.

CORN

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Callisto + Atrazine ⁵ (mesotrione ²⁷)	3 fl oz S + 0.75 pt 4L 0.42 lb DF (1.5 oz + 0.375 lb)	Broadleaf weeds.	POST up to V8 or 30 inch tall corn. Weeds: Small.	Commercial mixtures with Callisto available: Acuron = mesotrione + bicyclopyrone + S-meto + atra Acuron Flexi = mesotrione + bicyclopyrone + S-meto Callisto Xtra = mesotrione + atrazine Lumax EZ = mesotrione + S-metolachlor + atrazine Maverick = mesotrione + pyroxasulfone + clopyralid Resicore = mesotrione + acetochlor + clopyralid Resicore: Add NIS at 1 pt/100 gal or PO adjuvant at 2 pt/A. Refer to label for tank-mix options and restrictions.
Callisto Xtra (mesotrione ²⁷ & atrazine ⁵)	20 to 24 fl oz SC (1.25 to 1.5 oz & 0.5 to 0.6 lb)	Broadleaf weeds.	PRE, POST up to V8 or 30 inch tall corn. Weeds: Small.	
Resicore (acetochlor ¹⁵ & mesotrione ²⁷ & clopyralid ⁴)	1.25 to 1.75 qt SC (0.88 to 1.23 lb & 1.5 to 2.1 oz & 0.95 to 1.33 oz)	Broadleaf weeds, annual grasses and quackgrass.	POST up to 11 inch tall corn. Weeds: Small.	
Revulin Q (mesotrione ²⁷ & nicosulfuron ² & isoxadifen safener)	3.4 to 4 oz SG + (1.25 to 1.5 oz + 0.5 to 0.58 oz)	Broadleaf weeds, annual grasses and quackgrass.	POST up to V6 or 20 inch tall corn. Weeds: Small.	
Laudis + Atrazine ⁵ (tembotrione ²⁷ & isoxadifen safener)	3 fl oz SC + 0.75 pt 4L 0.42 lb DF (1.31 oz + 0.375 lb)	Broadleaf weeds, some grass weeds. Partial green foxtail control.	POST up to V8 stage corn. Weeds: Less than 3 to 4 inches tall.	
Capreno + Atrazine ⁵ (tembotrione ²⁷ & thiencazone ² & isoxadifen safener)	3 fl oz SC + 0.75 pt 4L 0.42 lb DF (1.08 oz & 0.21 oz + 0.375 lb)	Broadleaf weeds and most grass weeds including brome and barnyardgrass.	POST up to V5 stage corn. Weeds: Less than 3 to 4 inches tall.	
Atrazine ⁵ + oil adjuvant RUP	0.75 to 1.5 pt 4L + 0.42 to 0.84 lb DF + 1 qt (0.38 to 0.75 lb)	Annual broadleaf weeds.	EPOST up to 12 inch tall corn. Weeds: Small.	Apply with other POST herbicides to improve weed control. Atrazine may leave a soil residue and injure crops planted the following year.
Bromoxynil ⁶	1 to 1.5 pt EC (0.25 to 0.37 lb)	Small pigweed and lambsquarters, nightshade, kochia and buckwheat.	EPOST up to 12 inch tall corn. Weeds: Less than 2 to 3 inches.	Contact, non-residual herbicides requiring >15 gpa and full sunlight. Apply with other herbicides. May cause speckling on corn leaves. Refer to label for tank-mix options and adjuvant use.
Resource (flumiclorac ¹⁴)	2 to 6 fl oz EC (0.215 to 0.65 oz)			
Tough 5 EC (pyridate ⁶)	1.5 pt EC (0.9375 lb)	Annual broadleaf weeds	POST: Up to V8 stage corn. Weeds: small.	Add NIS at 0.25 %v/v or PO at 1 to 4 pt/A. AMS or UAN can be added to tank mix to enhance weed control.
Preharvest Herbicides				
Glyphosate ⁹	Up to 3.7 lb ae See Remarks.	Grass and broadleaf weeds.	Preharvest. Apply when grain moisture is <35% and corn seed has formed a black layer.	Add AMS fertilizer at 8.5 lb/100 gal. Allow a 7 day PHI.
Paraquat ²² RUP	1 to 2 pt 2SL 0.8 to 1.3 pt 3SL (0.25 to 0.5 lb)	Annual broadleaf and grass weeds.		Add NIS at 0.25% to 0.5% v/v. Allow a 7 day PHI.
Defol 5 (Sodium chlorate)	4.8 Qt (6 lb)	Desiccant.	Preharvest. At least 14 days prior to harvest.	Add NIS at 0.25% v/v or MSO/PO at 1 %v/v. Apply in 5 to 7 GPA aerially or 10 to 20 GPA on the ground.

HERBICIDE-RESISTANT CORN

Refer to Herbicide Resistant Weeds section (X1) for weed management strategies to delay herbicide resistant weeds.

Rule #1 - Control weeds BEFORE 2 to 4 inches tall to avoid yield loss.
Remove weeds early especially when grass weed populations are high.

Average ND corn yield loss vs. weed free or herbicide applied at corn planting.		
Weed height when weeds were removed	Average corn yield loss vs. weed-free control	
	ND research*	Mid-west research**
2-6 inches	0%	6%
6-8 inches	16%	9%
8-12 inches	20%	21%
Untreated	63%	Not harvested

Corn yield loss from weeds may be greater in dry North Dakota environments than other areas of the mid-west that receive greater precipitation.

*Source: 8 site-years (Carrington and Minot, 2009-2014).

**Source: 2005 Ohio State University summary of 35 university trials in IA, MI, IL, MO, KY, OH TN, and WI.

LibertyLink Corn

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Liberty 280 + AMS (glufosinate ¹⁰)	32 fl oz SL + 3 lb/A (0.58 lb) Maximum total = 87 fl oz	Annual grass and broadleaf weeds including ALS and glyphosate weeds.	POST. Corn: Up to 7 collars (V7). Weeds: 1 to 3 inches tall.	Apply only to LibertyLink corn varieties. Contact herbicide requiring thorough coverage. Most active in high humidity and temperature. Add AMS - do not use non-AMS adjuvants.
Interline + AMS (glufosinate ¹⁰)	22 to 43 fl oz SL + 3 lb/A (0.40 to 0.79 lb) Maximum total = 87 fl oz	Annual grass and broadleaf weeds including ALS and glyphosate weeds.	POST. Corn: Up to 7 collars (V7). Weeds: 1 to 3 inches tall.	Apply only to LibertyLink corn varieties. Contact herbicide requiring thorough coverage. Most active in high humidity and temperature. Add AMS - do not use non-AMS adjuvants.
Sinate 2.57 (glufosinate ¹⁰ & topramezone ²⁷)	21 to 28 fl oz SL (0.4 to 0.54 & 0.0164 to 0.022 lb)	Annual grass and broadleaf weeds including ALS and glyphosate weeds.	POST. Corn: Up to 7 collars (V7) or 24" tall. Up to 36" with drop nozzles. Weeds: 1 to 3 inches tall.	Apply only to LibertyLink corn varieties. Contact herbicide requiring thorough coverage. Use nozzles delivering medium droplets (250 to 400 microns) and 15 to 20 GPA. Most active in high humidity and temperature. Add MSO at 1 % v/v and AMS at 3 lb/A - do not use non-AMS adjuvants.

Roundup Ready Corn

Herbicide	Product/A (ae/A)	Weeds	When to Apply	Remarks and Paragraphs																																										
Glyphosate ⁹	Maximum single application = 0.75 lb ae Maximum in-crop = 1.5 lb ae See Remarks.	Annual and perennial grass and broadleaf weeds.	POST. Corn: Up to 30 inches tall or 8 collars.	Apply only to Roundup Ready corn varieties. <table border="0"> <tr> <td></td> <td></td> <td></td> <td><u>Maximum single</u></td> <td><u>Maximum in-crop</u></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td><u>lb ae</u></td> <td><u>lb ae</u></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td><u>0.75</u></td> <td><u>1.125</u></td> <td><u>1.5</u> <u>2.25</u></td> </tr> <tr> <td><u>lb ae/gal</u></td> <td><u>lb ai/gal</u></td> <td></td> <td colspan="3"><u>----- fl oz -----</u></td> </tr> <tr> <td>3</td> <td>= 4</td> <td>= 32</td> <td>48</td> <td>64</td> <td>96</td> </tr> <tr> <td>4/4.17</td> <td>= 5.4/5.1</td> <td>= 24/23</td> <td>36/35</td> <td>48/46</td> <td>72/69</td> </tr> <tr> <td>4.5</td> <td>= 5.5</td> <td>= 21.3</td> <td>32</td> <td>42.6</td> <td>64</td> </tr> </table> <p>Apply with AMS fertilizer at 8.5 lbs/100 gal. Refer to label for tank-mix options, application information, and restrictions.</p>				<u>Maximum single</u>	<u>Maximum in-crop</u>					<u>lb ae</u>	<u>lb ae</u>					<u>0.75</u>	<u>1.125</u>	<u>1.5</u> <u>2.25</u>	<u>lb ae/gal</u>	<u>lb ai/gal</u>		<u>----- fl oz -----</u>			3	= 4	= 32	48	64	96	4/4.17	= 5.4/5.1	= 24/23	36/35	48/46	72/69	4.5	= 5.5	= 21.3	32	42.6	64
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3	= 4	= 32	48	64	96																																									
4/4.17	= 5.4/5.1	= 24/23	36/35	48/46	72/69																																									
4.5	= 5.5	= 21.3	32	42.6	64																																									
Glyphosate ⁹	Maximum single application = 1.125 lb ae Maximum in-crop 2.25 lb ae See Remarks.		POST. RR Corn 2: Up to 30 inches tall or 8 collars. Drop nozzles: 30 to 48 inches tall (free standing).	Apply only to Roundup Ready Corn II varieties. Refer to glyphosate above for remarks. Refer to label for registered uses and for additional information and restrictions.																																										

Enlist Corn

Herbicide	Product/A (ae/A)	Weeds	When to Apply	Remarks and Paragraphs
Enlist One (2,4-D Choline ⁴) 	1.5 to 2 pt (0.7125 to 0.95 lb ae)	Annual and perennial broadleaf weeds.	POST: Up to 30 inches tall or 8 collars. Drop nozzles: 30 to 48 inches tall (free standing)	Apply these rates only to Enlist corn varieties. Applications intervals must be greater than 12 days apart.
Enlist Duo (2,4-D Choline ⁴ & glyphosate ⁹) 	3.5 to 4.75 pt (0.7 to 0.95 & 0.74 to 1 lb ae)	Annual and perennial grass and broadleaf weeds.	POST: Up to 30 inches tall or 8 collars. Drop nozzles: 30 to 48 inches tall (free standing).	Apply these rates only to Enlist corn varieties. Applications intervals must be greater than 12 days apart.
Assure II (Quizalofop-P-ethyl ¹) 	5 to 12 fl oz EC (0.034 to 0.083 lb) Maximum in-crop = 12 fl oz	Grass weeds	POST: V2 through V6 growth stage.	Apply Only to Enlist Corn varieties. Add PO at 1 %v/v or NIS at 0.25 %v/v. PO is the preferred adjuvant to enhance efficacy. Application intervals must be greater than 7 days apart.

Roundup Ready Corn - Herbicides to apply in tank-mix or sequentially with glyphosate for control of weeds not controlled by glyphosate.

Herbicides ^{Site of action}	Rate/A	Buckwheat, Wild	Canola, Vol. RR	Horseweed (Marestail)**	Kochia	Lambsquarters	Nightshade species	Pigweed, Redroot	Prickly lettuce	Ragweed, Common	Smartweed, Annual	Waterhemp / Palmer
Preplant-burndown Herbicides^a - add AMS at 1.5-3 lb/A.		Weed Control Ratings^{b,c}										
Glyphosate ⁹ (4.5 lb ae) + AMS + HSMOC + 2,4-D ⁴ + 2,4-D ⁴ + Express ² + Dicamba ⁴ + Dicamba ⁴ + Sharpen ¹⁴	32 - 105 fl oz + 1 pt + 1-2 pt + 1pt+0.3oz + 8 fl oz 4SL + 16 fl oz 4SL +8 floz + 2-3 floz	F-E F-E F-E E E E	N P-G G-E N N G-E	P-E F-E P-E F-E E E	P-E P-E P-E E E E	E E E G E E	E P-G E E E E	E E E E E E	P-E E E G-E E E	E E P-E G E E	E P-E E E E E	P-E F-G P-E F G E
Paraquat ^{22*} + NIS + Dicamba ⁴ + MSO + Sharpen ¹⁴ + MSO	3 pt 2SL+1-2 qt 8 fl oz + 1.5 pt 2-3 fl oz + 1.5 pt	F F G-E	- - F-E	F-G F-G G-E	G-E G-E E	P-E E E	G-E G-E G-E	E E G-E	F-G F-G G-E	G-E G-E G-E	E E E	G-E G-E G-E
PRE herbicides^a		Weed Control Ratings^{b,c} - without glyphosate										
Acetochlor ¹⁵ + Balance Flexx ²⁷ No aerial application + Dicamba ⁴ + SureStart II/Triple Flex II ^{4,15,27} No aerial application + Sharpen ¹⁴	1.25 - 2.25 pt + 1.5 fl oz + 8 fl oz 4SL + 2 pt + 3 fl oz	P P G-E G-E G-E	N E F-E P-F F-E	N-P G-E G-E F-E G-E	P-F E G-E P-F E	F-E E E E E	F-G E E G-E E	G-E E E E E	- G-E G-E - G-E	N-P G-E G-E F-G E	P F-G E G-E E	F-E E G-E G-E E
Acuron Flexi ^{15,27,27} No aerial application Acuron ^{5,15,27,27} No aerial application Anthem Maxx ^{14,15} Balance Flexx ²⁷ No aerial application Corvus ^{2,27} No aerial application + Verdict ^{14,15} No aerial application	1.2 - 2.25 qt 1.5 - 3 qt 2.5 - 6.5 fl oz 3 - 4.5 fl oz 3.33 - 5.6 fl oz + 15 fl oz	P-F G-E F-E P P G-E	E E P-F E E E	F-G E N-P G-E G-E G-E	P-G E F-E G-E G-E E	E E F-E E E E	E E F-E G-E E E	E E G-E E E E	- G-E - G-E G-E E	G-E G-E P-F G-E G-E E	G-E G-E F-E G G E	G-E G-E G-E E E E
Dicamba ⁴ DiFlexx ⁴ DiFlexx Duo ^{4,27} Fierce EZ ^{14,15} Harness Max ^{15,27} No aerial application Hornet ^{2,4} Instigate ^{2,27} No aerial application Lumax EZ ^{5,15,27} No aerial application Prequel ^{2,27} Resicore ^{4,15,27} Sharpen ¹⁴ SureStart II ^{2,4,15} No aerial application TripleFlex II ^{2,4,15} No aerial application Valor ¹⁴ Verdict ^{14,15} + Prowl ³ + Dicamba ⁴ (no-till)	0.5 - 1 pt 4SL 0.5 - 1 pt 1.5 - 2.5 pt 6 fl oz 55 - 88 fl oz 3 - 4 oz 5.25 - 7 oz 3* - 4 pt 1.66 - 2.5 oz 2.25 - 3 qt 2 - 3 fl oz 1.5 - 3 pt 1.5 - 3 pt 2 - 3 fl oz 10 - 16 fl oz + 3 pt + 8 fl oz	E E E P-F P-F G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E E	N-P N-P E G-E G-E E E E E E E E E E E E E E E E E	G-E G-E G-E F-G F-G F-G F-G F-G G G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E	G-E G-E E F-E F-G F-E F-G F-G E E E E E E E E E E E E E	G G E E E E E E E E E E E E E E E E E E E	F-E F-E E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E	E E E F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G	E E E F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G	E E E F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G F-G	F-G F-G G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E G-E	
^a May carryover more than one cropping season. Follow labeled crop rotation restrictions - see Y15. ^b E = Excellent (90-99%), G = Good (80-90%), F = Fair (65-80%), P = Poor (40-65%), N = None. ^c Includes resistant populations. * Atrazine at 0.38 lb ai/A. Atrazine and paraquat are RUP. **Ratings for PRE herbicides are for horseweed plants prior to their emergence (spring-emerging populations).												

Roundup Ready Corn - cont.

Herbicides ^{Site of action}	Rate/A	Buckwheat, Wild	Canola, Vol. RR ^b	Horseweed (Marestail)**	Kochia	Lambsquarters	Nightshade species	Pigweed, Redroot	Prickly lettuce	Ragweed, Common	Smartweed, Annual	Waterhemp / Palmer
PRE Herbicides^a - cont.		Weed Control Ratings^{b,c} - <i>without glyphosate</i>										
Zidua¹⁵	1.75-6.5 fl oz SC	F-E	P-F	-	F-E	F-E	F-E	G-E	-	P	F-E	G-E
+ Balance Flexx No aerial application	+ 1.5 fl oz	F-E	E	G-E	G-E	E	G-E	E	G-E	G-E	F-E	G-E
+ Dicamba based product	+ 8 fl oz	G-E	F-E	G-E	E	E	G-E	E	G-E	G-E	E	E
+ SureStart II/Triple Flex II No aerial ap	+ 2 pt	E	E	E	E	E	E	E	E	E	E	E
+ Sharpen	+ 3 fl oz	G-E	F-E	G-E	E	E	G-E	E	G-E	G-E	E	G-E
+ Dicamba ⁴ + Sharpen¹⁴ (no-till)	+ 8 fl oz + 3 fl oz	E	G-E	E	E	E	E	E	E	E	E	E
Weed Control Ratings^{b,c} - <i>without glyphosate</i>												
Acetochlor ¹⁵ or	1.25 - 2.25 pt	P	N	N-P	P-F	F-E	F-G	G-E	-	N-P	P	F-E
Acuron Flexi^{15,27,27} or No aerial application	1.2 - 2.25 qt	G-E	E	E	E	E	E	E	G-E	G-E	G-E	G-E
Acuron^{5,15,27,27} or No aerial application	1.5 - 3 qt	G-E	E	E	E	E	E	E	G-E	G-E	G-E	G-E
Harness Max^{15,27} or No aerial application	55 - 88 fl oz	G-E	E	E	E	E	E	E	G-E	G-E	G-E	G-E
Lumax EZ^{5,15,27} or No aerial application	3* - 4 pt	G-E	E	E	E	E	E	E	G-E	G-E	G-E	G-E
Resicore^{4,15,27} or	2 - 2.25 qt	G-E	G-E	E	G	E	E	E	F-G	E	G-E	G-E
Verdict^{14,15} or	10 - 16 fl oz	G-E	F-E	G-E	E	E	G-E	E	G-E	G-E	E	E
Zidua¹⁵	1.75-6.5 fl oz SC	F-E	P-F	-	F-E	F-E	F-E	G-E	-	P	F-E	G-E
fb DiFlexx⁴ or	8 - 16 fl oz	E	N-P	G-E	G-E	G-E	G	F-E	G-E	E	E	F-G
fb Status⁴ + Atrazine ^{5*} + oil adjuvant	fb 5 oz	E	P-G	E	E	E	G	E	E	G-E	E	E
fb SureStart II^{2,4,15} + oil adj. No aerial	1.5 - 3 pt	G-E	P-F	F-E	P	G-E	G-E	G-E	-	F-G	G-E	P
fb TripleFlex II^{2,4,15} + oil adj. No aerial	1.5 - 3 pt	G-E	P-F	F-E	P	G-E	G-E	G-E	-	F-G	G-E	P
fb WideMatch^{4,4} + Atrazine ^{5*} + oil adjuvant	fb 1.33 pt	E	P-G	E	G	F-E	G-E	G-E	E	G-E	G	F-E
fb Status⁴ + WideMatch^{4,4} + Atrazine ^{5*} + oil adjuvant	fb 5 oz + 1 pt	E	P-G	E	E	E	G-E	E	E	E	E	E
^a May carryover more than one cropping season. Follow labeled crop rotation restrictions - see Y15. ^b E = Excellent (90-99%), G = Good (80-90%), F = Fair (65-80%), P = Poor (40-65%), N = None. ^c Includes resistant populations. * Atrazine at 0.38 lb ai/A. Atrazine and paraquat are RUP. **Ratings for PRE herbicides are for horseweed plants prior to their emergence (spring-emerging populations).												

Roundup Ready Corn - cont.

Herbicides ^a Site of action	Rate/A	Buckwheat, Wild	Canola, Vol. RR ^b	Horseweed (Marestail)	Kochia	Lambsquarters	Nightshade species	Pigweed, Redroot	Prickly lettuce	Ragweed, Common	Smartweed, Annual	Waterhemp / Palmer
POST Herbicides^a - add MSO or HSMOC adjuvant + AMS at 1.5 lb/A or see label for adjuvant requirements.		Weed Control Ratings^{b,c} - <i>without glyphosate</i>										
Acuron GT^{9,15,27,27} + NIS + AMS	3.75 pt	P-G	E	E	E	E	E	E	F-G	E	E	E
Atrazine ^{5*} + oil adjuvant	0.75 pt/0.42 lb	G	P-G	F	F	F	F	F	-	P	F	P-F
Dicamba ⁴ + oil adjuvant	4 - 8 fl oz 4SL	E	N-P	G	F-E	G-E	G	F-G	G-E	E	E	F-G
Armezon²⁷ + Atrazine^{5*} + oil adjuvant	0.5 - 0.75 fl oz	E	G-E	G-E	E	E	E	E	E	E	E	G-E
Armezon Pro^{15,27} + Atrazine^{5*} + adjuvant	14 - 20 fl oz	E	E	E	E	E	E	E	E	E	E	E
Callisto GT^{9,27} + Atrazine^{5*} + NIS + AMS	2 pt	G-E	G-E	G-E	E	E	E	E	E	F	E	E
Callisto Xtra^{5,27} + oil adjuvant	15* - 24 fl oz	G-E	G-E	G-E	E	E	E	E	E	F	E	E
Capreno^{2,27} + Atrazine^{5*} + adj. No aerial app.	3 fl oz	G-E	G-E	G-E	G-E	E	E	E	G-E	E	G-E	E
DiFlexx⁴ + Atrazine + oil adjuvant	0.5 - 1 pt	E	N-P	G-E	G-E	G-E	G	F-G	E	E	E	F-E
DiFlexx Duo^{4,27} + Atrazine + oil adjuvant	24 - 40 fl oz	E	E	G-E	E	E	E	E	E	E	E	G-E
Glyphosate⁹ (4.5 lb ae) + NIS + AMS	32 fb 32 fl oz	G	N	P-E	P-E	E	E	E	E	P-E	E	P-E
Halex GT^{9,15,27} + NIS + AMS	3.6 - 4 pt	P-G	E	G-E	E	E	E	E	F-G	E	E	G-E
Harness Max^{15,27} + Atrazine^{5*} + NIS+AMS	40 - 75 fl oz	G-E	G-E	G-E	E	E	E	E	E	F	E	E
Impact²⁷ + Atrazine^{5*} + oil adjuvant	0.5 - 0.75 fl oz	E	G-E	G-E	E	E	E	E	E	E	E	G-E
Impact Core^{15,27} + Atrazine^{5*} + oil adjuvant	20 - 40 fl oz	E	G-E	G-E	E	E	E	E	E	E	E	G-E
Instigate^{2,27} + Atrazine+oil adjuvant+AMS	6 oz	P-F	G	F-G	E	E	E	E	N	P	E	G-E
Laudis²⁷ + Atrazine^{5*} + MSO No aerial app.	3 fl oz	E	G-E	G-E	E	E	E	E	E	E	E	E
Lumax EZ^{5,15,27} + oil adjuv. No aerial app.	3* - 4 pt	E	E	G-E	E	E	E	E	E	F	E	E
Realm Q^{2,27} + Atrazine+oil adj. No aerial app.	4 oz	P-F	E	F-G	E	G-E	E	E	N	P	E	G-E
Resicore^{4,15,27}	2.25 - 3 qt	G-E	G-E	G-E	G	E	E	E	E	E	E	G-E
Resolve Q² + Atrazine+oil adj. No aerial app.	1 - 1.25 oz	P	G	N	N	F-G	P-G	E	N	F	F-G	N
Revulin Q^{2,27} +Atrazine+oil adj. No aerial app.	3.4 - 4 oz	P-F	E	F-G	E	G-E	E	E	N	P	E	G-E
Status^{4,19} + MSO No aerial app.	5 to 10 oz WDG	E	N-P	G-E	G-E	G-E	G	G-E	E	E	E	G-E
SureStart II^{2,4,15} + oil adj. No aerial app.	1.5 - 3 pt	G-E	P-F	F-E	P	G-E	G-E	G-E	-	F-G	G-E	P
TripleFlex II^{2,4,15} + oil adj. No aerial app.	1.5 - 3 pt	G-E	P-F	F-E	P	G-E	G-E	G-E	-	F-G	G-E	P
WideMatch^{4,4} + oil adjuvant	1.33 pt	E	N	G-E	G	N	G-E	N	E	G-E	G	N
Herbicides for Liberty Link corn ONLY - add AMS at 3 lb/A		Weed Control Ratings^{b,c} - <i>without glyphosate</i>										
Liberty 280¹⁰ +	32 fl oz	F-G	F-E	G	F-E	F-E	F-E	F-E	P-E	F-E	F-E	F-E
+ Atrazine ^{5*} + AMS	+ 0.38 lb ai	E	G-E	G-E	G-E	G-E	E	E	G-E	E	E	G-E
+ Dicamba ⁴ based product + AMS	+ 8 fl oz	F-E	F-E	G-E	E	G-E	E	E	G-E	E	E	F-E
Sinate^{10,27}	28 fl oz	F-G	G-E	G-E	G-E	G-E	G-E	G-E	F-E	G-E	F-E	G-E
+ Atrazine ⁵ + AMS	+ 0.38 lb ai	E	G-E	G-E	E	E	E	E	E	E	E	G-E
Residual PRE fb Liberty¹⁰ + Atrazine^{5*} + AMS	X rate fb 22 fl oz + 0.38 lb ai	E	E	E	E	E	E	E	E	E	E	E

^aMay carryover more than one cropping season. Follow labeled crop rotation restrictions - see Y15.

^bE = Excellent (90-99%), G = Good (80-90%), F = Fair (65-80%), P = Poor (40-65%), N = None.

^c**Includes resistant populations.**

*Atrazine at 0.38 lb ai/A. Atrazine and paraquat are RUP.

SOYBEAN

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Soil-Applied Herbicides				
Prowl Prowl H2O (pendimethalin ³)	2.4 to 3.6 pt EC 2.1 to 3 pt ACS (1 to 1.5 lb)	Annual grass and some broadleaf weeds.	PPI. Fall or Spring.	Adjust rate for soil type. Do not apply PRE. Poor control of weeds with large seeds, including wild oat and wild mustard.
Sonalan Sonalan 10G (ethalfluralin ³)	1.5 to 3 pt EC 5.5 to 11.5 10G (0.55 to 1.15 lb)			
Treflan / generic trifluralin ³	1 to 2 pt EC (0.5 to 1 lb)			
Valor SX Valor EZ (flumioxazin ¹⁴)	2 to 3 oz WDG 2 to 3 fl oz SC (1.02 to 1.53 oz)	Small-seeded broadleaf weeds.	EPP, Shallow PPI, or PRE.	PRE requires precipitation for herbicide activation. Refer to label for tank-mix options, application information, and restriction. Commercial mixtures available: Afforia = flumioxazin + thifensulfuron + tribenuron Authority Assist = sulfentrazone + imazethapyr Authority Edge = sulfentrazone + pyroxasulfone Authority Elite = sulfentrazone + S-metolachlor Authority First = sulfentrazone + cloransulam Authority MTZ = sulfentrazone + metribuzin Authority Supreme = sulfentrazone + pyroxasulfone BroadAxe XC = sulfentrazone + S-metolachlor Fierce EZ = flumioxazin + pyroxasulfone Fierce MTZ = flumioxazin+pyroxasulfone+metribuzin Kyber = flumioxazin+pyroxasulfone+metribuzin Sonic = sulfentrazone + cloransulam Surveil = flumioxazin + cloransulam Zone Defense = sulfentrazone + flumioxazin
Spartan (sulfentrazone ¹⁴)	4.5 to 12 fl oz F (2.25 to 6 oz)			
Metribuzin ⁵	Soil pH >7.5 = 0.25 lb ai Soil pH <7.5 = 0.25 to 0.38 lb ai			
Sharpen (saflufenacil ¹⁴)	1 to 1.5 fl oz SC (0.36 to 0.54 oz)	Broadleaf weeds including winter annuals.		PRE requires precipitation for herbicide activation. Apply with MSO adjuvant at 1 to 1.5 pt/A for burndown control of emerged broadleaf weeds. Planting interval is dependent on soil texture and OM. Sharpen at 1.5 fl oz and Verdict at 7.5 fl oz require a 14 day plantback interval. Refer to label for tank-mix options.
Verdict (saflufenacil ¹⁴ & dimethenamid ¹⁵)	5 to 7.5 fl oz EC (0.36 to 0.54 oz & 0.2 to 0.29 lb)			
Dual/II/Magnum (S/metolachlor ¹⁵)	1 to 2 pt EC (0.95 to 1.9 lb)	Annual grasses and some broadleaf weeds.	EPP, Shallow PPI, PRE and EPOST. POST PHI: Dual = 75 days.	Requires precipitation for soil activation. Multiple rain events increase activation of pyroxasulfone. Provides 3 to 4 weeks residual weed control after activation. Adjust rate for soil type. Shallow PPI gives more consistent weed control than PRE. Use highest rates for greater and more consistent weed control. Warrant: Do not PPI. Application with other PRE or EPOST herbicides and stress environment after application may increase risk of soybean injury. Refer to labels for tank-mix options. Commercial mixtures available (See page 30): Authority Elite = S-metolachlor + sulfentrazone Boundary = S-metolachlor + metribuzin BroadAxe XC = S-metolachlor + sulfentrazone Fierce = pyroxasulfone + flumioxazin Zidua Pro = pyroxasulfone + saflufenacil + imazethapyr
Outlook / generic dimethenamid ¹⁵	10 to 24 fl oz EC (0.47 to 1.125 lb)			
Warrant (acetochlor ¹⁵ - microencapsulated)	1.25 to 2 qt ME (0.94 to 1.5 lb)			
Anthem Maxx (pyroxasulfone ¹⁵ & fluthiacet ¹⁴)	2 to 5.5 fl oz SC (1 to 2.87 oz & 0.03 to 0.087 oz)			
Zidua SC (pyroxasulfone ¹⁵)	1.75 to 5.75 fl oz SC (0.91 to 3 oz)			
Perpetuo (pyroxasulfone ¹⁵ & flumiclorac penty ¹⁴)	6 to 10 fl oz SC (1.28 to 2.14 & 0.28 to 0.43 oz)			
			EPP or PRE. Post Up to V6 soybean.	Apply with PO or MSO at 1 to 2 pt/A. Certain tank mixes require use of NIS in place of oil. Follow tank mix partner recommendation. AMS or UAN can be added to tank mix to enhance weed control. Refer to label for tank-mix options and rotation restrictions. Do not apply more than 8 fl oz/A on coarse soils.

SOYBEAN

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
POST-Applied Herbicides				
Warrant (acetochlor ¹⁵ - microencapsulated)	1.25 to 2 qt ME (0.94 to 1.5 lb)	PRE control of grass and broadleaf weeds.	POST. Soybean: After emergence until R2.	Rainfall required for PRE activation. Does not control emerged weeds. Provides residual weed control after activation. No adjuvant required.
Basagran 5L / generic bentazon ⁶ + MSO adjuvant	0.4 to 1.6 pt SL / 0.5 to 2 pt applied 1 to 4 times. (0.25 to 1 lb)	Some broadleaf weeds.	POST. Soybean: After emergence. Broadleaf weeds: Small.	Non-residual, contact herbicide requiring >15 gpa and full sunlight. Add MSO adjuvant at 1 to 1.5 pt/A. Maximum bentazon amount per season is 2 lb/A.
Cadet (fluthiacet ¹⁴)	0.4 to 0.9 fl oz EC (0.045 to 0.1 oz)	Some small broadleaf weeds including pigweed species.	POST. Soybean: 1 to 2 trifoliates.	Contact herbicides requiring small weed size, >15 gpa, NIS or oil adjuvant at 1 to 2 pt/A, and full sunlight. May cause speckling on soybean leaves. Cadet may improve lambsquarters control. Apply Cobra with oil adjuvant at 1 to 2 pt/A. Refer to label for crop response, adjuvant type and rate, and tank-mix options.
Cobra (lactofen ¹⁴)	8 to 12.5 fl oz EC (2 to 3.2 oz)		Weeds: Small.	
Resource (flumiclorac ¹⁴)	2 to 8 fl oz EC (0.215 to 1.72 oz)			
Ultra Blazer (acifluorfen ¹⁴)	0.5 to 1.5 pt EC (0.125 to 0.375 lb)			
Flexstar / generic fomesafen ¹⁴ + oil adjuvant	0.75 pt EC (0.176 lb)	Many small broadleaf weeds. Poor buckwheat, lambsquarters and hairy nightshade control.	POST Soybean: Prior to flowering. Weeds: Small. Do not use as a rescue treatment. Contact herbicide requiring small weed size.	Apply at >15 gpa, oil adjuvant at 1 to 2 pt/A, and full sunlight. MSO at 1 to 2 pt/A + AMS at 8.5 lbs/100 gal water will increase weed control and risk of crop injury. Apply at 1 pt/A in ND east of I-29 and south of I-94. Apply at 0.75 pt/A in ND east of Hwy 281 and in the following counties west of Hwy 281: Benson, Bottineau, Burleigh, Dickey, Eddy, Emmons, Foster, Grant, Kidder, LaMoure, Logan, McHenry, McIntosh, McLean, Mercer, Morton, Oliver, Pierce, Renville, Rolette, Sheridan, Sioux, Stutsman, Towner, Ward, and Wells. West of Hwy 281: - Do not apply to soil with OM >4%. - Do not apply after June 20. Refer to product label and ND SLN label for crop rotation restrictions and other restrictions.
FirstRate (cloransulam ²)	0.3 oz WDG or 10 A/pack (0.25 oz)	Large-seeded broadleaf weeds.	POST. Soybean: Up to full flower stage (R2). Weeds: Small.	Add oil adjuvant at 1 to 2 pt/A + 28% UAN at 2.5% v/v. Refer to label for weed size, and tank-mix options.
Harmony / generic thifensulfuron ²	0.083 (1/12) oz DF 0.125 (1/8) oz SG (0.062 oz)	Mustard, pigweed, and lambsquarters.	POST. Soybean: 1 st trifoliolate until 60 days PHI.	Add oil additive at 1 to 2 pt/A + 28% UAN or AMS. Refer to label for tank-mix options.
Pursuit (imazethapyr ²)	2 to 3 fl oz SL (0.5 to 0.75 oz)	Annual broadleaf weeds. Poor lambsquarters,	POST. Soybean: Prior to flowering.	Add oil adjuvant at 1 to 2 pt/A + 28% UAN at 2.5% v/v. MSO adjuvants enhance weed control more than petroleum oil or NIS adjuvants. Refer to label for weed size and application information. Raptor has less soil residual carryover than Pursuit.
Raptor (imazamox ²)	4 to 5 fl oz SL (0.5 to 0.625 oz)	ragweed, buckwheat and b. wormwood control.	Weeds: Small and actively growing.	
Varisto (bentazon ⁶ & imazamox ²)	11 to 27 fl oz SL (0.34 to 0.84 lb + 0.26 to 0.64 oz)	Small annual grass and broadleaf weeds and suppression of Canada thistle.	Allow a 30 day PHI.	Add MSO adjuvants at 1.25 to 1.5 pt/A and AMS at 8.5 lb/100 gal. Apply 11 fl oz to pre-bolt canola.

SOYBEAN

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Assure II Targa (quizalofop ¹)	4 to 12 fl oz EC (0.44 to 1.32 oz)	Annual grasses and quackgrass.	Soybean: Prior to pod set. Grass weeds: Refer to table below.	Add oil adjuvant at 1 gal/100 gal water but not less than 1.25 pt/A. Use highest rate of Assure II for yellow foxtail control. Grass control is reduced by tank mixtures or close interval application of POST broadleaf control herbicides. Antagonism generally can be avoided by applying a higher rate of grass herbicide or apply the grass control herbicide 1 or more days before or 7 days after the broadleaf control herbicide. Do not cultivate prior to 5 days before or 7 days after application. Refer to label for tank-mix options. Refer to page 113 for control of volunteer canola and corn.
Fusilade DX (fluazifop ¹)	5 to 12 fl oz EC (1.25 to 3 oz)			
Poast (sethoxydim ¹)	0.5 to 1.5 pt EC (0.1 to 0.3 lb)	Annual grasses.	Soybean: All stages. Grass weeds: Refer to table below.	
Select Max 1EC Select 2EC Shadow 3EC (clethodim ¹)	9 to 16 fl oz EC 4 to 8 fl oz EC 2.66 to 5.33 EC (1 to 2 oz)	Annual grasses and quackgrass.		

Grass Control with POST Herbicides

	Foxtail, green and yellow		Corn, volunteer		Quackgrass		Wheat, barley, and oat		Proso millet, wild	
	inches	fl oz/A	inches	fl oz/A	inches	fl oz/A	inches	fl oz/A	inches	fl oz/A
Assure II/Targa ¹	2 to 4	7 to 8	6 to 30	5 to 8	6 to 10	12	2 to 6	7 to 8	2 to 6	5 to 8
Fusilade DX ¹	2 to 4	10 to 12	12 to 24	4 to 6	6 to 10	12	2 to 6	8	4 to 8	6
Poast ¹	2 to 4	1 pt	1 to 20	1 pt	6 to 8	2 pt	1 to 4	1 pt	4 to 6	0.5 pt
Select Max 1EC ¹	2 to 4	9 to 12	4 to 24	9 to 12	4 to 12	12	2 to 6	9	2 to 6	9
Select 2EC ¹	2 to 4	4 to 6	4 to 24	6	4 to 12	8	2 to 6	6	2 to 6	4 to 6
Shadow 3EC ¹	2 to 4	2.66-5.33	4 to 24	2.66-5.33	4 to 12	5.3-10.6	2 to 6	4 to 5.33	2 to 6	4 to 5.33

Preharvest Application

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Glyphosate ⁹	Up to 1.5 lb ae See Remarks.	Preharvest weed control - broadcast or spot application.	Prior to harvest. Apply when soybean seed pods are a mature brown color, >75% leaf drop, and <30% seed moisture.	Add NIS plus AMS fertilizer at 8.5 lb/100 gal. Do not apply on soybean grown for seed because reduced germination/vigor may occur.
Banvel / generic dicamba ⁴ + MSO adjuvant	Up to 32 floz 4SL + 1 qt/A (1 lb)			Do not apply on soybean grown for seed because reduced germination/vigor may occur. Add oil adjuvant at 1 to 2 pt/A.
Aim + MSO adjuvant (carfentrazone ¹⁴)	1 to 6 oz SL + 1 qt/A (0.256 to 1.5 oz)	Desiccant.	PHI: RU = 7 days Dicamba = 7 days. Paraquat = 15 days Aim = 3 days Sharpen = 3 days	Contact herbicides require >15 gpa and full sunlight. Apply at >10/>5 gpa for ground/aerial application. Apply paraquat with NIS at 2 qt/100 gal water. Sharpen requires up to 10 days for optimum desiccation. Apply dicamba, Aim, and Sharpen with AMS at 8.5 lb/100 gal water or UAN at 2.5 gal/100 gal water. Do not apply Sharpen on soybean grown for seed because reduced germination/vigor may occur.
Paraquat ²² + NIS RUP	8 to 16 fl oz 2SL 5.4 to 10.7 floz 3SL (0.13 to 0.25 lb)			
Sharpen + MSO adjuvant (safinlufenacil ¹⁴)	1 to 2 fl oz SC + 1 to 2 pt/A (0.36 to 0.72 oz)			
Defol 5 (Sodium chlorate)	4 to 4.8 Qt (5 to 6 lb)			Preharvest. 7 to 10 days prior to harvest.

HERBICIDE-RESISTANT SOYBEAN

Refer to Herbicide Resistant Weeds section (X1) for weed management strategies to delay herbicide resistant weeds.

Rule #1 - Control weeds BEFORE 2 to 4 inches tall to avoid yield loss.
Remove weeds early especially when grass weed populations are high.

ND soybean yield loss from weeds removed at different intervals.

Weed height when weeds were removed.	Soybean stage	Soybean yield* (bu/A)
Weed free	-	44.3
2 to 4 inches	VC (cotyledon) to V1	42.1
6 to 8 inches	V2 to V4	40.8
>10 inches	V3 to R2	36.4
Weedy check	-	22.7

Soybean yield loss from weeds may be greater in dry North Dakota environments than other areas of the Midwest that receive greater precipitation.

*Source: Greg Endres, Carrington R&E Center. 8-site years (2011-2014). Carrington, Doyon, Langdon, and Minot.

LibertyLink, LLGT27, E3, Xtendflex Soybean

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Liberty 280, Interline (glufosinate ¹⁰)	32 to 43 fl oz SL (0.58 to 0.72 lb) Maximum total = 87 fl oz	Annual grass and broadleaf weeds including ALS and glyphosate resistant weeds.	POST. Soybean: Emergence to pre-bloom. Weeds: Up to 3 inches tall.	Apply only to LibertyLink soybean varieties or soybean varieties containing glufosinate-resistance genes. Non-selective, contact, non-residual herbicide requiring thorough coverage. Apply a PRE foundation treatment prior to Liberty POST. Add AMS at 3 lb/A - do not use AMS replacement or water conditioner adjuvants. Can be applied with a registered grass herbicide. Refer to label for tank-mix options and restrictions. Most active in hot and sunny conditions. Controls weeds resistant to other herbicides.
Cheetah (glufosinate ¹⁰)	29 to 43 fl oz SL (0.53 to 0.72 lb) Maximum total = 87 fl oz			
Intermoc (glufosinate ¹⁰ & S-metolachlor ¹⁵)	64 fl oz SL (0.535 & 1.25 lb)			

Roundup Ready/STS (sulfonylurea-tolerant) Soybean

Herbicide	Product/A (ae/A)	Weeds	When to Apply	Remarks and Paragraphs
Harmony/generic thifensulfuron ²	0.33 oz DF 0.5 oz SG (0.25 oz)	Annual broadleaf weeds including wild buckwheat, lambsquarters, mustard species, and vol. RR canola.	POST. RR/STS soybean: 1 st fully expanded trifoliolate to 60 days PHI.	Apply only to RR/STS soybean varieties. Apply with glyphosate at 0.38 to 1.125 lb ae/A. Add NIS at 1 qt/100 gal water. Apply with AMS fertilizer at 8.5 lb/100 gal. Refer to label for weeds controlled and application information.

Roundup Ready and Roundup Ready 2 Yield Soybean

Herbicide	Product/A (ae/A)	Weeds	When to Apply	Remarks and Paragraphs
Glyphosate ⁹	Maximum single application = 1.5 lb ae Maximum in-crop = 2.25 lb ae See Remarks.	Annual and perennial grass and broadleaf weeds.	POST. Soybean: Emergence through R2 of full flowering. Allow a 14 day PHI.	Apply only to RR / RR 2 Yield soybean varieties. Cannot plant harvested patented soybean seed. Add AMS fertilizer at 8.5 lb/100 gal. Multiple applications may be necessary for weed flushes. Refer to label for weeds controlled, application information, and tank-mix options with residual herbicides and restrictions.

Roundup Xtend, Xtendflex Soybean

Herbicide	Product/A (ae/A)	Weeds	When to Apply	Remarks and Paragraphs
Engenia 5 SL (dicamba ⁴) RUP Only certified applicators may purchase and apply.	Single application rate in-crop: 12.8 5SL (0.5 lb ae) Maximum total in-crop: 1 lb ae Maximum total/yr: 2 lb ae Do not apply less than 0.5 lb ae/A for any application.	Annual and perennial broadleaf weeds.	EPP, At Planting, PRE and POST. Soybean: Emergence to pre-bloom. No later than June 30. Weeds: Less than 4 inches tall.	Apply only to RU Xtend or Xtendflex soybean varieties. Drift and off-site movement may cause injury or death to susceptible plants and crops. For all application information and restrictions refer to: www.xtendimaxapplicationrequirements.com www.engeniatankmix.com https://www.syngenta-us.com/herbicides/tavium-tank-mixes <ul style="list-style-type: none"> • Do not deviate in use from label or web sites (above). • Dicamba or auxin-specific training is required. • Apply with approved nozzles and adjuvants. • Apply with minimum 15 GPA.
XtendiMax 2.9SL (dicamba ⁴) RUP Only certified applicators may purchase and apply.	Single application rate in-crop: 22 fl oz 2.9SL (0.5 lb ae) Maximum total in-crop: 1 lb ae Maximum total/yr: 2 lb ae Do not apply less than 0.5 lb ae/A for any application.		EPP, At Planting, PRE and POST. Soybean: Emergence through R1. No later than June 30. Weeds: Less than 4 inches tall.	<ul style="list-style-type: none"> • Do not add any product containing ammonium. • Must add approved pH buffer agent or Vapor Reduction Agent (see product labels). • Do not apply before/during temperature inversion. • Only apply 1 hour after sunrise until 2 hours before sunset. • Do not apply when wind speed is <3 or >10 mph. • Maintain a 240 foot downwind buffer. • Maintain a 110 foot downwind buffer when using a qualified hooded sprayer. • Do not spray when adjacent sensitive crops are downwind.
Tavium 3.38 SL (dicamba ⁴ & S-metolachlor ¹⁵) RUP Only certified applicators may purchase and apply.	56.5 fl oz CS (0.5 lb & 1 lb)	Annual and perennial broadleaf weeds. Residual control of grass and small-seeded broadleaf weeds	EPP, At Planting, PRE and POST. Soybean: Emergence to V4. No later than June 30. Weeds: Less than 4 inches tall.	

*Registration Pending at time of publication.

Dicamba Applications to DT Soybeans in 2021

Some reasons why off-site movement of dicamba can occur:

1. Soybean can show phytotoxic symptoms from dicamba at rates as low as 0.0004 oz ae/A (0.028 g/ha). Very small amounts of dicamba from contaminated sprayers, particle drift, and volatility can cause injury symptoms on soybean. Extremely high soybean sensitivity to dicamba influences all other discussion points.
2. Dicamba rate used in DT soybean is 8 oz ae/A compared to 0.5 to 2 oz ae/A used in wheat and corn. The higher dicamba rate applied in DT soybean applied during late June and early July can result in very high release of dicamba into the environment, which could be a source for particle drift and volatility.
3. Higher temperatures occur in late June and early July. The vapor pressure of dicamba significantly increases as temperature increases.
4. Dicamba is normally applied in May and early June in wheat and corn. Dicamba in DT soybean allows application prior to R1 stage. Later applications are more prone to dicamba drift because temperatures are higher, which allows greater dicamba volatility while soybeans are more advanced in growth to intercept dicamba, express injury symptoms, and possibly reduce yield.
5. Dicamba drift is more likely to cause yield loss the closer to and including reproductive stage. Summer solstice (June 21) is the reproductive trigger in soybean.
6. Precipitation normally decreases after late June. Dicamba is highly water soluble and rain events after application can "wash" dicamba off plant leaves into the soil to trap dicamba and reduce off-target movement.

NDSU Weed Science recommends no dicamba applications after June 20 - See #3-6 above.

- This allows for PRE and Early POST applications.
- This supports the residual PRE concept for effective weed management and encourages timely applications.
- Soybeans are photoperiod sensitive: the reproductive phase begins after the longest day of the year (June 21). Off-target drift of dicamba is more likely to injure non-tolerant soybean yield when it enters the reproductive phase.
- Most off-target dicamba drift complaints result from postemergence applications. Postemergence applications have the greatest potential to contact and injure susceptible vegetation. Spraying conditions may be favorable after June 20 but average temperatures are higher, which exponentially increase the potential for dicamba volatilization. Soybean plants will be larger to intercept more herbicide.

Enlist Soybean

Herbicide	Product/A (ae/A)	Weeds	When to Apply	Remarks and Paragraphs
Enlist One 3.8 SL (2,4-D Choline ⁴)	1.5 to 2.0 pt SL (0.7 to 0.95 lb ae)	Annual and perennial broadleaf weeds.	EPP, At Planting, PRE and POST. Soybean: Emergence to no later than R2 (full bloom)	Apply only to Enlist soybean varieties. Drift and off-site movement may cause injury or death to susceptible plants and crops. For all application information and restrictions refer to: https://www.enlist.com/en/approved-tank-mixes.html <ul style="list-style-type: none"> • Do not deviate in use from label or web sites (above). • Apply with approved nozzles and adjuvants. • Do not apply before/during temperature inversion. • Do not apply when wind speed is <3 or >15 mph. • Maintain a 30 foot buffer.
Enlist Duo 3.3 SL (2,4-D Choline ⁴ & glyphosate ⁹)	3.5 to 4.75 pt SL (0.7 to 0.95 lb ae & 0.75 to 1 lb ae)	Annual and perennial grass and broadleaf weeds.		

Only glyphosate formulations that have been approved for use over the top of “Enlist” or “glyphosate-tolerant” soybeans can be used on Enlist soybeans.

Enlist “E3” soybean varieties are also tolerant to glufosinate. Apply only glufosinate formulations that have been approved for use over the top of “Enlist” or “glufosinate-tolerant” soybeans.

Enlist One can have tank-mix compatibility issues with potassium (K) salts of glyphosate and AMS that is not fully dissolved in the spray tank. These issues can be avoided by following the correct tank-mixing procedure and allowing plenty of time for recirculation before adding the next product.

Enlist One can antagonize Group 1 (ACC-ase-inhibiting) herbicides in tank-mixes. It is recommended to increase the rate of the group 1 herbicide by at least 1/3 over the planned rate in order to overcome antagonism.

Roundup Ready Soybean - Herbicides to apply in tank-mix or sequentially with glyphosate for control of weeds not controlled by glyphosate.

Herbicide	Site of action	Rate/A	Buckwheat, Wild	Canola, Vol. RR	Horseweed (Marestail)***	Kochia	Lambsquarters	Nightshade species	Pigweed, Redroot	Prickly lettuce	Ragweed, Common	Smartweed, Annual	Waterhemp / Palmer
Weed Control Ratings ^{b,c}													
Glyphosate ⁹ (4.5 lb ae)+ AMS + HSOC		32-105 fl oz	F-E	N	P-E	P-E	E	E	E	E	P-E	E	P-E
+ 2,4-D ^{4e}		+ 1 pt	F-E	P-E	G-E	P-E	E	E	E	E	E	E	P-E
+ 2,4-D ^{4e} + Express		+ 1 pt + 0.3 oz	F-E	G-E	P-E	P-E	E	E	E	E	P-E	E	P-E
+ 2,4-D ^{4e} + Metribuzin ⁵		+ 1 pt + 0.33 lb	G-E	G-E	G-E	F-E	E	G-E	E	E	E	E	F-E
+ Afforia ^{2,14}		2.5-3.75 oz WDG	G-E	G-E	F-G	P-G	G-E	G-E	G-E	F-E	P	F	G
+ Verdict ^{14,15}		+ 5 fl oz	G-E	P-G	G-E	G-E	E	G-E	E	G-E	G-E	E	E
+ Verdict ^{14,15} + Metribuzin ⁵		+ 5 fl oz + 0.33 lb	E	G-E	E	E	E	E	E	E	E	E	E
+ Verdict ^{14,15} + Zidua SC ¹⁵		+ 5 fl oz + 3.25 fl oz	E	G-E	G-E	G-E	E	E	E	E	G-E	E	G-E
Paraquat ²² + NIS adjuvant		3 pt 2SL + 1-2 pt	F	-	F-G	G-E	P-E	G-E	E	F-G	G-E	E	G-E
+ Verdict ^{14,15} + Metribuzin ⁵ + oil adj.		+ 5 fl oz + 0.33	G-E	E	G-E	G-E	E	G-E	E	G-E	E	E	G-E
+ 2,4-D ^{4e} +Verdict ^{14,15} +Metrib ⁵ + oil adj.		+ 5 oz + 0.33 lb	E	E	E	E	E	E	E	E	E	E	E

Weed Control Ratings ^{b,c} - <i>without glyphosate</i>													
Afforia ^{2,14}		2.5-3.75 oz WDG	G-E	G-E	F-G	P-G	G-E	G-E	G-E	F-E	P	F	G
Anthem Maxx ^{14,15}		2-5.5 oz WDG	F-E	P-F	-	F-E	F-E	F-E	G-E	-	P	F-E	G-E
Authority Assist ^{2,14}		6-9 fl oz	P-G	G-E	F	F-E	G-E	F-E	F-E	E	N	G-E	F-E
Authority Elite ^{14,15}		20-32 fl oz	P-G	P	F	G-E	G-E	G-E	G-E	P	N	G-E	G-E
Authority First ^{2,14}		4-8 oz WDG	P-G	E	P-G	F-E	G-E	F-E	E	P	N	G-E	F-E
Authority MTZ ^{5,14}		12-15* oz	F-G	E	F	F-E	G-E	G-E	G-E	G-E	P-F	G-E	F-E
Authority Supreme ^{14,15}		6-11.5 fl oz	P-F	P	P-F	F-E	G-E	F-E	G-E	P	N	G-E	G-E
Boundary ^{5,15}		1.6*-2.4** pt	F-G	E	F	F-G	G	P	G-E	G-E	P-F	G	G-E
BroadAxe XC ^{14,15}		20-32 fl oz	P-G	P-F	F	G-E	G-E	G-E	G-E	P	N	G-E	G-E
Fierce ^{14,15}		3 oz WDG	P-F	G-E	F-G	F-E	F-G	F-E	G-E	F-G	F-G	F-G	G-E
Fierce MTZ/Kyber ^{5,14,15}		1-1.5 pt	F-G	G-E	F-G	F-E	G-E	G-E	G-E	G-E	F-G	F-G	G-E
FirstRate ²		0.3-0.75 WDG	N	E	P-E	N	P-F	N	P-F	-	P	G-E	N
Metribuzin ⁵		0.33-0.5 lb DF	F-G	E	F	F-G	P-G	P	G-E	G-E	P-F	G	F-G
Prowl ³ (PPI)		See label	N	N	N	P	F-G	N	E	N	N	N-P	F-G
Panther Pro ^{2,5,14}		12* fl oz	F-G	E	F-G	F-G	F-E	G-E	E	G-E	P-F	G	G
Perpetuo ^{14,15}		6-10 fl oz	F-E	P-F	-	F	F-E	F-E	G-E	-	P-F	F-E	G-E
Pursuit ²		2 fl oz	F-G	G-E	N	N	P	P-E	E	-	N	G	N
Sharpen ¹⁴		1 fl oz	P-F	G-E	P-F	P	F	P	F-P	P	P	P	P-F
Sonalan ³ (PPI)		See label	P	N	N	P	F-G	N	E	N	N	N-P	F-G
Sonic ^{2,14}		4-8 oz WDG	F-G	E	P-G	F-E	G-E	F-E	E	P	N	G-E	F-E
Spartan ¹⁴		4.5-9 fl oz	F-G	P	F	F-E	G-E	F-E	F-E	P	N	G-E	F-E
Surveil ^{2,14}		2.1-4.2 oz WDG	P	E	-	P-G	G-E	E	E	-	F-E	G-E	F-E
Treflan ³ (PPI)		See label	N	N	N	P	F-G	N	E	N	N	N-P	F-G
Valor EZ ¹⁴		2-3 oz SC/WDG	P-F	F-E	F-G	F-G	F-E	G-E	G-E	F-E	P-F	F	G
Verdict ^{14,15}		5 fl oz	P-F	G-E	P-F	P	F-G	F	G	G-E	P-F	F	F-G
Zidua SC ¹⁵		2.5 - 5.75 fl oz	F-E	P-F	-	F	F-E	F-E	G-E	-	P-F	F-E	G-E
Zidua Pro ^{2,14,15}		4.5 fl oz	F-E	P-F	-	F-E	F-E	F-E	G-E	-	F-G	F-E	G-E

^aMay carry over more than one cropping season. Follow labeled crop rotation restrictions - see Y15.

^bE = Excellent (90-99%), G = Good (80-90%), F = Fair (65-80%), P = Poor (40-65%), N = None.

^c**Includes resistant populations.**

*Metribuzin at 0.33 lb/A DF, **Metribuzin at 0.5 lb/A DF.

***Ratings for PRE herbicides are for horseweed plants prior to their emergence (spring-emerging populations).

Roundup Ready Soybean - Herbicides to apply in tank-mix or sequentially with glyphosate for control of weeds not controlled by glyphosate.

Herbicide	Site of action	Rate/A	Buckwheat, Wild	Canola, Vol. RR	Horseweed (Marestail)***	Kochia	Lambsquarters	Nightshade species	Pigweed, Redroot	Prickly lettuce	Ragweed, Common	Smartweed, Annual	Waterhemp / Palmer
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PRE fb POST Weed Management Programs - add AMS at 1.5 lb/A and see label for adjuvant requirements.

Weed Control Ratings^{b,c}

RP = Residual PRE listed on page 30, such as, Boundary, Fierce, Sharpen, Spartan, or Zidua, or combinations above.

RP fb RU ⁹ (4.5 lb ae)+ AMS + HSOC	32-105 fl oz		PE	P-E	P-E	P-E	E	P-E	E	P-E	P-E	P-E	P-E
RP fb RU ⁹ + Flexstar GT ^{9,14} + HSMOC	32floz+2.68pt+1pt		G-E	E	P-G	G-E	E	E	E	G	E	E	P-E
RP fb RU ⁹ + Marvel ^{14,14} + NIS fb	32 fl oz + 7.25 fl oz		G-E	E	P-G	F-E	E	E	E	G	E	E	P-E
RU ⁹ + Cobra ¹⁴ + NIS	fb 32floz+8-12 floz												
RP fb RU fb Storm + NIS fb RU if need	32 fl oz fb 1.5 pt		G	F-G	P-E	F-E	G-E	G-E	E	G-E	F-E	E	F-E

POST herbicides^a - add AMS at 1.5 lb/A
- see label for adjuvant requirements.

Weed Control Ratings^{b,c} - **without glyphosate**

Basagran ⁶ + MSO	1.5-2 pt + 1.5 pt		P-G	P-G	P-F	P-E	F-E	N-G	F-E	G	P-F	E	F-E
Cadet ¹⁴ + NIS	0.65-0.9 fl oz		N-P	-	N	P-F	F-G	-	F-G	-	N	-	P-G
Cobra ¹⁴ + PO	8-12.5 fl oz		P	P	N	P-F	N	G	G-E	-	P-E	P	P-G
Extreme ^{2,9} + HSMOC	1.5-2.25 pt		G	P-E	P-G	P-E	G	E	E	G-E	P-E	G-E	P-E
FirstRate ² + PO	0.3-0.6 oz WDG		P-F	P-G	G-E	P	P	N	N-P	-	N	E	N
Flexstar ¹⁴ + MSO	0.75 pt + 1-1.5 pt		P	E	N-P	G-E	P-F	F-E	E	-	P-E	G-E	P-E
Flexstar GT ^{9,14} + HSMOC	2.68 pt + 1 pt		P-G	E	P-G	G-E	G-E	G-E	E	F-G	F-E	E	P-E
Glyphosate ⁹ (4.5 lb ae) + AMS	32 fb 32 fl oz		G	N	P-E	P-E	E	E	E	E	P-E	E	P-E
Harmony DG/SG ² + NIS + AMS	1/12 oz / 1/8 oz		N	P	N	N	F-G	N	G	P	N	F-G	N
Marvel ¹⁴ + NIS	5 to 7 fl oz		P	E	N-P	G-E	F-G	F-E	E	-	P-E	G-E	P-E
Pursuit ² + MSO	2-3 fl oz + 1.5 pt		P	P-E	N	N	P	P-E	E	P-E	N	G	N
Raptor ² + MSO	4-5 fl oz + 1.5 pt		P	P-E	N	N	P-F	E	E	G	N	G-E	N
Resource ¹⁴ + NIS or MSO	3 fl oz		-	-	N	-	F-G	-	F-G	-	N-P	-	N-P
Storm ^{6,14} + NIS or MSO	1.5 pt		P-F	P-E	N	P-E	F-E	F-G	E	G	P-F	E	F-E
Ultra Blazer ¹⁴ + NIS or MSO	1.5-2 pt		P	F-G	N	P-G	N	F-G	E	-	N-F	E	P-E
Varisto ^{2,6} + MSO	16-27 fl oz + 1.5 pt		P-G	P-E	P-F	P-E	F-E	E	E	G	P-F	E	F-E

Herbicides for Liberty Link soybean ONLY
- add AMS at 3 lb/A.

Weed Control Ratings^{b,c} - **without glyphosate**

Liberty 280 ¹⁰ + AMS	32 - 43 fl oz		F-G	F-E	G-E	F-E							
fb Liberty ¹⁰ + AMS	fb 32 - 43 fl oz		G-E	F-E	E	E	E	E	E	G-E	E	E	G-E
+ Flexstar ¹⁴ + adjuvant + AMS	+ 0.75 pt		G	E	G-E	E	G-E	E	E	F-E	E	E	G-E
Residual PRE fb Liberty ¹⁰ + AMS	X rate fb 36 fl oz		E	E	E	E	E	E	E	E	E	E	E
Herbicides for Enlist E3 Soybean ONLY - add AMS at 3 lb/A													
Enlist One ⁴ + AMS	2 pt		P	P	F-E	P-F	E	N-P	F-G	E	E	P	F
+ Liberty ¹⁰ + AMS	32 - 43 fl oz		E	F-E	E	E	E	G-E	E	E	E	E	G-E

^aMay carry over more than one cropping season. Follow labeled crop rotation restrictions - see Y15.

^bE = Excellent (90-99%), G = Good (80-90%), F = Fair (65-80%), P = Poor (40-65%), N = None.

^c**Includes resistant populations.**

*Metribuzin at 0.33 lb/A DF, **Metribuzin at 0.5 lb/A DF.

***Ratings for PRE herbicides are for horseweed plants prior to their emergence (spring-emerging populations).

DRY EDIBLE BEAN

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Soil-Applied and some POST-Applied Herbicides				
Eptam (EPTC ¹⁵)	3.5 to 4.5 pt EC 15 to 20 lb G (3 to 4 lb)	Grass and some broadleaf weeds.	PPI.	PPI immediately after application. Apply with other soil-applied herbicides for greater weed control.
Prowl Prowl H2O (pendimethalin ³)	2.4 to 3.6 pt 3.3EC 2.1 to 3 pt 3.8ACS (1 to 1.5 lb)	Poor wild oat and no wild mustard control.	PPI. Fall or Spring.	PPI within 24 hours after application. Apply fall applications when soil temperature is less than 45 F to reduce fall herbicide degradation. Adjust rate for soil type. Use EC formulation in spring and 10G formulation in fall for more consistent herbicide activation in soil. Refer to label for tank-mixtures.
Treflan / generic trifluralin ³	1 to 2 pt EC 5 to 10 lb 10G (0.5 to 1 lb)			
Sonalan (ethalfluralin ³)	1.5 to 4.5 pt EC (0.55 to 1.69 lb) 5.5 to 11.5 lb 10G (0.55 to 1.15 lb)			
Dual/II/Magnum (S/metolachlor ¹⁵)	1 to 2 pt EC (0.95 to 1.9 lb)	Grass and some broadleaf weeds.	Shallow PPI or PRE.	Shallow PPI improves consistency of weed control. PRE requires precipitation for herbicide activation. Adjust rate for soil type and OM. Allow a 70 day PHI.
Outlook / generic dimethenamid¹⁵	10 to 21 fl oz EC (0.47 to 1 lb)		Shallow PPI, PRE, or EPOST up to 3 rd trifoliolate.	
Authority/Spartan Elite (s-metolachlor ¹⁵ & sulfentrazone ¹⁴)	20 to 26 fl oz EC (0.98 to 1.28 lb & 1.75 to 2.25 oz)		Shallow PPI or PRE.	
Spartan Charge (carfentrazone ¹⁴ & sulfentrazone ¹⁴)	3.75 to 5.75 floz SE (0.16 to 0.25 oz & 1.48 to 2.26 oz)	Small-seeded broadleaf weeds.	Shallow PPI or PRE.	
Permit (halosulfuron ²)	0.5 to 0.67 oz DF (0.38 to 0.5 oz)	Many broadleaf weeds and yellow nutsedge.	Shallow PPI, PRE, or POST up to dry bean flowering.	PRE requires precipitation for herbicide activation. POST: Apply with NIS at 1 to 2 qt/100 gal water. Permit: PRE controls additional weeds than POST, including pigweed and lambsquarters. Refer to label when tank-mixing with other herbicides. Will not control ALS resistant weeds.
Pursuit (imazethapyr ²)	2 fl oz SL (0.5 oz)			
POST-Applied Herbicides				
Basagran 5L / generic bentazon⁶ + MSO adjuvant	0.4 to 1.6 pt SL / 0.5 to 2 pt applied 1 to 4 times. (0.25 to 1 lb)	Small broadleaf weeds and suppression of Canada thistle.	POST. Dry bean: After 1 st trifoliolate. Broadleaf weeds: Small.	Non-residual, contact herbicide requiring >15 gpa and full sunlight. Add oil adjuvant at 1 to 2 pt/A plus AMS at 8.5 lb/100 gal. Maximum bentazon amount per season is 2 lb/A.
Raptor (imazamox ²)	4 fl oz SL (0.5 oz)	Annual grass and broadleaf weeds. No control of ALS-resistant weeds.	POST. Drybean: 1 st trifoliolate but prior to flowering.	Add oil additive at 1 to 2 pt/A plus 28% UAN at 2 qt/A (except during high humidity).
Varisto (bentazon ⁶ & imazamox ²)	11 to 21 fl oz SL (0.34 to 0.66 lb + 0.26 to 0.5 oz)	Small annual grass and broadleaf weeds and suppression of Canada thistle.	Weeds: Small. Allow a 30 day PHI.	Add oil adjuvant at 1 to 2 pt/A plus AMS at 8.5 lb/100 gal. Bentazon may be applied sequentially to improve weed control.

DRY EDIBLE BEAN

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Reflex (fomesafen ¹⁴)	0.75 pt EC (0.188 lb)	Small annual broadleaf weeds including ragweed, kochia, and nightshade.	Weeds: 1 to 3 inches tall. PHI: 45 days.	Contact herbicide requiring small weed size, >15 gpa, oil adjuvant at 1 to 2 pt/A, and full sunlight. Oil adjuvant will increase weed control and risk of crop injury. Refer to E4 for improved weed control. See 24c label for list of approved counties.
Assure II Targa (quizalofop ¹)	7 to 12 fl oz EC (0.77 to 1.32 oz)	Annual grasses and quackgrass.	POST. Dry bean: PHI: Assure II, Poast, Select/Max = 30 days. Fusilade DX = 60 days.	Add oil adjuvant at 1 gal/100 gal water but not less than 1.25 pt/A. Refer to label for tank-mix options. Refer to Remarks in the POST grass herbicide section under Soybean for methods to avoid antagonism and reduced grass control from broadleaf herbicides.
Fusilade DX (fluazifop ¹)	5 to 12 fl oz EC 1.25 to 3 oz)			
Poast (sethoxydim ¹)	0.5 to 1.5 pt EC (0.1 to 0.3 lb)	Annual grasses.		
Select Max 1EC Select 2EC Shadow 3EC (clethodim ¹)	9 to 16 fl oz EC 4 to 8 fl oz EC 2.66 to 5.33 EC (1 to 2 oz)	Annual grasses and quackgrass.		
NDSU Dry Bean Tank-Mix				
Basagran 5L / bentazon⁶ 4L + Raptor² + Reflex¹⁴ + Select/clethodim¹ + MSO adjuvant	0.4 to 0.56 pt SL / 0.5 to 0.67 pt SL + 1 fl oz SL + 2 to 4 fl oz EC + 2 fl oz EC + 1 to 1.5 pt/A	Grass and broadleaf weeds, including kochia, pigweed, and nightshade. Will not control waterhemp, wild buckwheat, or ragweed >2 inches	POST. Weeds. Small. Must be less than 1 to 2 inches tall.	User assumes all risk of inadequate weed control when using this reduced-rate treatment. MSO adjuvant is required. Repeat application 7 to 10 days later with some or all herbicides in the tank-mix to kill uncontrolled weeds and control successive weed flushes. Reduced herbicide rates cause resistant weeds - scout weed control often and hand-pull any escaped weeds or small patches of weeds that could be resistant.
Varisto SL Basagran 5L Basagran 4L Raptor	5.25 fl oz contains 4.2 fl oz or 5.25 fl oz + 1 fl oz			
Dry Bean Preharvest / Desiccation Herbicides				
Glyphosate ⁹	Up to 0.75 lb ae	Harvest aid/ Weed control.	Prior to harvest. Pods = yellow and leather texture. Seed = hard dough stage with <30% moisture. PHI = 7 days.	Do not apply to dry bean grown for seed because reduced germination/vigor may occur. Use only labeled formulations. Add AMS at 8.5 lb/100 gal. Non-selective, non-residual, translocated, foliar herbicide.
Aim + MSO oil adjuvant (carfentrazone ¹⁴)	1 to 6 oz SL + 1 qt/A (0.256 to 1.5 oz)	Dry bean and weed desiccant.	Prior to harvest. >80% pods yellow/brown. >70% leaves lost green color. PHI: Aim = 0 days. paraquat = 7 days. Sharpen = 2 days. Valor = 5 days.	Contact herbicides require >15 gpa and full sunlight. Apply at >10 gpa for ground and >5 gpa for aerial application. Apply Aim, Sharpen and Valor with AMS at 8.5 to 17 lb/100 gal water or UAN at 2.5 gal/100 gal water and with glyphosate or paraquat for weed desiccation. Glyphosate improves weed control from Sharpen and Valor but antagonism may occur on biennial and perennial weeds. Do not apply Sharpen to dry bean grown for seed because reduced germination/vigor may occur.
Paraquat²² + NIS RUP	1.2 to 2 pt 2SL 0.8 to 1.3 pt 3SL (0.3 to 0.5 lb)			
Sharpen + MSO adjuvant (safluflufenacil ¹⁴)	1 to 2 fl oz SC + 1 to 1.5 pt/A (0.36 to 0.72 oz)			
Valor SX Valor EZ + MSO adjuvant (flumioxazin ¹⁴)	2 to 3 oz WDG 2 to 3 fl oz SC + 2 pt/A (1 to 1.53 oz)			
Defol 5 (Sodium chlorate)	4.8 Qt (6 lb)			
			Preharvest. 7 to 10 days prior to harvest.	Add NIS at 0.25% v/v or MSO/PO at 1 %v/v. Apply in 5 to 10 GPA aerially or 10 to 20 GPA on the ground.

FIELD PEA

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Soil-Applied Herbicides				
Far-Go (triallate ¹⁵)	1.25 qt EC (1.25 lb)	Wild oat.	PPI.	PPI immediately after application. Two pass incorporation improves weed control.
Prowl Prowl H2O (pendimethalin ³)	1.75 to 3.6 pt EC 1.5 to 3 pt ACS (0.72 to 1.5 lb)	Grass and some broadleaf weeds.	PPI. Fall or Spring.	Fall apply when soil temperature is less than 45 F to reduce fall herbicide degradation. Adjust rate for soil type. Some pea varieties may be injured.
Treflan / generic trifluralin ³	1 to 1.5 pt EC 5 to 7.5 lb 10G (0.5 to 0.75 lb)	Poor wild oat and no wild mustard control.		
Sonalan (ethalfluralin ³)	1.5 to 2 pt EC 5.5 to 7.5 lb 10G (0.55 to 0.75 lb)			
Dual/II/Magnum (S/metolachlor ¹⁵)	1 to 2 pt EC (0.95 to 1.9 lb)		Shallow PPI or PRE.	PRE requires precipitation for herbicide activation. Adjust rates for soil type, OM, and pH. Refer to label for rate structure.
BroadAxe XC Spartan Elite (metolachlor ¹⁵ & sulfentrazone ¹⁴)	20 to 32 fl oz EC (0.98 to 1.58 lb & 1.75 to 2.8 oz)	Annual grass and small-seeded broadleaf weeds.		
Spartan Charge (carfentrazone ¹⁴ & sulfentrazone ¹⁴)	3.75 to 7.75 fl oz SE (0.16 to 0.34 oz & 1.48 to 3.05 oz)	Small-seeded broadleaf weeds.		
Authority Supreme (sulfentrazone ¹⁴ & pyroxasulfone ¹⁵)	4.3 to 10 fl oz SC (1.12 to 2.6 oz & 1.12 to 2.6 oz)	Annual grass and small-seeded broadleaf weeds.		
Anthem Flex (pyroxasulfone ¹⁵ & carfentrazone ¹⁴)	2.75 to 5 fl oz SC (0.08 to 0.15 & 0.0057 to 0.01 lb)	Annual grass and small-seeded broadleaf weeds.	EPP or PRE	Adjust rates for soil type and OM. Seed must be planted a minimum of 1 inch deep.
Valor EZ (flumioxazin ¹⁴)	2 fl oz SC (1.02 oz)	Small-seeded broadleaf weeds.	PRE.	User assumes all risk of crop injury. Apply within 2 days after planting.
Pursuit (imazethapyr ²)	2 fl oz SL (0.5 oz)	Small broadleaf weeds. No control of ALS- resistant weeds.		Shallow PPI improves consistency of weed control. PRE requires precipitation for herbicide activation.
Sharpen (saflufenacil ¹⁴)	1 to 2 fl oz SC (0.36 to 0.72 oz)	Small broadleaf weeds including kochia, pigweed, lambsquarters, nightshade and winter annuals.	EPP, shallow PPI, or PRE.	PRE requires precipitation for herbicide activation. Provides burndown control of small emerged broadleaf weeds including winter-annual species. Refer to label for tank-mix options.
Metribuzin ⁵	0.25 to 0.5 lb DF 0.38 to 0.75 pt 4F (0.19 to 0.38 lb) 0.167 to 0.33 lb DF 0.25 to 0.5 pt 4F (0.125 to 0.25 lb)	Suppression of lambsquarters, henbit, mustard, and chickweed.	Preplant or PRE. POST. Weeds: Small.	Contact herbicide requiring small weed size, >20 gpa, and full sunlight. Use only registered formulations. Adjust rate for soil type. Refer to label for application and environment information, and special precautions that may affect weed control and crop safety. Allow a 50 day PHI.

FIELD PEA

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
POST-Applied Herbicides				
Basagran 5L / generic bentazon ⁶ + MSO adjuvant	0.4 to 1.6 pt SL / 0.5 to 2 pt applied 1 to 4 times. (0.25 to 1 lb)	Small broadleaf weeds and suppression of Canada thistle.	POST. Dry pea: At least 3 pair of leaves or 4 nodes. Broadleaf weeds: Small.	Non-residual, contact herbicide requiring >15 gpa and full sunlight. Add oil adjuvant at 1 to 2 pt/A plus AMS at 8.5 lb/100 gal. Maximum bentazon amount per season is 2 lb/A. Refer to E3 for additional information.
Pursuit (imazethapyr ²)	2 fl oz SL (0.5 oz)	Small annual broadleaf weeds. No control of ALS- resistant weeds.	POST. Pea: At least 3 inches tall but prior to 5 nodes and prior to flowering.	User assumes all risk of crop injury. Add NIS at 1 pt/100 gal or oil adjuvant at 1 to 2 pt/A plus AMS at 8.5 lb/100 gal. Oil adjuvant increases weed control and risk of crop injury. Do not apply during adverse weather conditions. Risk of Raptor carryover is less than Pursuit. Bentazon may be applied sequentially to improve weed control. Refer to E3 for additional information. Bentazon antagonizes Raptor and reduces risk of injury to field pea.
Raptor + Basagran 5L / generic bentazon ⁶ (imazamox ²)	4 fl oz SL + 0.4 to 0.8 pt/A SL / 0.5 to 1 pt/A SL (0.5 oz + 0.25 to 0.5 lb)	Small annual grass and broadleaf weeds and suppression of Canada thistle.	Weeds: Small. Allow a 60 day PHI.	
Varisto (bentazon ⁶ & imazamox ²)	11 to 21 fl oz SL (0.34 to 0.66 lb + 0.26 to 0.5 oz)			
Thistrol (MCPB ⁴)	2 to 6 pt SL (0.5 to 1.5 lb ae)	Small broadleaf weeds.	POST. Pea: Prior to 6 inches tall.	Slight, temporary injury may occur. Do not apply when temperature exceeds 90 F or when peas are stressed. Suppresses Canada thistle.
Assure II Targa (quizalofop ¹)	7 to 12 fl oz EC (0.77 to 1.32 oz)	Annual grasses and quackgrass.	POST. Pea: Refer to PHI. PHI:	Add oil adjuvant at 1 gal/100 gal water but not less than 1.25 pt/A. Refer to label for tank-mix options.
Poast (sethoxydim ¹)	0.5 to 1.5 pt EC (0.1 to 0.3 lb)	Annual grasses.	Assure = 60 days. Clethodim = 21 days.	Refer to Remarks in the POST grass herbicide section under Soybean for methods to avoid antagonism and reduced grass control from broadleaf herbicides. Clethodim may injure pea when applied during bloom.
Select Max 1EC Select 2EC Shadow 3EC (clethodim ¹)	9 to 16 fl oz EC 4 to 8 fl oz EC 2.66 to 5.33 EC (1 to 2 oz)	Annual grasses and quackgrass.	Poast = 30 days. Grass: Refer to soybean section on page 27.	
Preharvest Herbicides				
Glyphosate ⁹	Up to 2.25 lb ae.	Emerged grass and broadleaf weeds.	Prior to harvest. Pea: >80% yellow/ brown pods and <30% seed moisture. PHI: Glyphosate = 7 days. Aim = 0 days. paraquat = 7 days. Sharpen = 3 days. Valor = 5 days.	Use only registered formulations. Add AMS at 8.5 lb/100 gal. Do not apply to field pea grown for seed because reduced germination/vigor may occur.
Aim + MSO adjuvant (carfentrazone ¹⁴)	1 to 6 oz SL + 1 qt/A (0.256 to 1.5 oz)	Desiccant.		Contact herbicides require >15 gpa and full sunlight. Apply at >10 gpa for ground and >5 gpa for aerial application.
Paraquat ²² + NIS	1.2 to 2 pt 2SL RUP 0.8 to 1.3 pt 3SL (0.3 to 0.5 lb)			Apply Aim, Sharpen and Valor with AMS at 8.5 to 17 lb/100 gal water or UAN at 2.5 gal/100 gal water and with glyphosate or paraquat for weed desiccation. Glyphosate improves weed control from Sharpen and Valor but antagonism may occur on biennial and perennial weeds.
Sharpen + MSO adjuvant (saflufenacil ¹⁴)	1 to 2 fl oz SC + 1 to 1.5 pt/A (0.36 to 0.72 oz)			Do not apply Sharpen to field pea grown for seed because reduced germination/vigor may occur.
Valor SX Valor EZ + (flumioxazin ¹⁴) + MSO adjuvant	2 to 3 oz WDG 2 to 3 fl oz SC + 2 pt (1.02 to 1.53 oz)			

CHICKPEA/GARBANZO BEAN AND LENTIL

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Soil-Applied Herbicides				
Far-Go (triallate ¹⁵)	1.25 qt EC (1.25 lb)	Wild oat.	PPI.	PPI immediately after application. A two pass incorporation improves weed control.
Prowl Prowl H2O (pendimethalin ³)	1.75 to 3.6pt 3.3EC 1.5 to 3 pt 3.8ASC (0.72 to 1.5 lb)	Grass and some broadleaf weeds.	PPI. Fall or Spring.	Adjust rate for soil type. Apply in fall when soil temperature is less than 45 F to reduce fall herbicide degradation.
Treflan / generic trifluralin ³	1 to 1.5 pt EC (0.5 to 0.75 lb)	Poor wild oat and no wild mustard control.	PPI. Fall or Spring. See Remarks for use in Lentil.	Lentil: Tolerance is marginal and injury may occur under stress conditions. Refer to label for additional information.
Sonalan (ethalfluralin ³)	1.5 to 2 pt EC 5.5 to 7.5 lb 10G (0.55 to 0.75 lb)			Lentil: Fall-apply Sonalan 10G just prior to snow cover into stubble on fields that have been direct-seeded with 30% or less soil disturbance for 2 to 3 years. Incorporate once using minimum soil disturbance with a rotary hoe or heavy harrow. Refer to label.
Dual/II/Magnum (S/metolachlor ¹⁵)	1 to 2 pt EC (0.95 to 1.9 lb)		Shallow PPI or PRE.	Shallow PPI improves consistency of weed control. PRE requires precipitation to activate herbicide. Adjust rate for soil type, OM, and pH. Refer to label for tank-mix options. Do not apply products containing sulfentrazone to lentil.
Outlook / generic dimethenamid ¹⁵	16 to 21 fl oz EC (0.75 to 1 lb)			
Zidua (pyroxasulfone ¹⁵) Chickpea only	2.5 to 3.25 fl oz SC (1.3 to 1.7 oz)	Grass and some broadleaf weeds.		
BroadAxe XC Spartan Elite (s-metolachlor ¹⁵ & sulfentrazone ¹⁴) Chickpea Only	20 to 32 fl oz EC (0.98 to 1.58 lb & 1.75 to 2.8 oz)	Annual grass and small-seeded broadleaf weeds.		
Spartan Charge (carfentrazone ¹⁴ & sulfentrazone ¹⁴) Chickpea Only	3.75 to 7.75 fl oz SE (0.16 to 0.34 oz & 1.48 to 3.05 oz)	Small-seeded broadleaf weeds.		
Authority Supreme (sulfentrazone ¹⁴ & pyroxasulfone ¹⁵) Chickpea only	4.3 to 10 fl oz SC (1.12 to 2.6 oz & 1.12 to 2.6 oz)	Annual grass and small-seeded broadleaf weeds.		
Pursuit (imazethapyr ²)	2 fl oz SL (0.5 oz)	Small broadleaf weeds. No control of ALS-resistant weeds.		
Anthem Flex (pyroxasulfone ¹⁵ & carfentrazone ¹⁴)	2.75 to 5 fl oz SC (0.08 to 0.15 & 0.0057 to 0.01 lb)	Annual grass and small-seeded broadleaf weeds.	EPP or PRE	Adjust rates for soil type and OM. Seed must be planted a minimum of 1 inch deep.
Sharpen (saflufenacil ¹⁴)	Chickpea = 1 to 2 fl oz SC (0.36 to 0.72 oz) Lentil = 0.75 fl oz (0.27 oz)	Small broadleaf weeds including winter-annual species.	Fall, EPP, shallow PPI, and PRE.	PRE requires precipitation to activate herbicide. Provides burndown control of small emerged broadleaf weeds. Refer to label for tank-mix options.
Metribuzin ⁵ Lentil Only	0.25 to 0.5 lb DF 0.38 to 0.75 pt 4F (0.19 to 0.38 lb) 0.167 to 0.33 lb DF 0.25 to 0.5 pt 4F (0.125 to 0.25 lb)	Suppression of lambsquarters, henbit, chickweed and mustard.	PRE. POST. Weeds: Small.	Adjust rates for soil type. Refer to label for application and environment information and special precautions that may affect weed control and crop safety. Allow a 75 day PHI.

CHICKPEA/GARBANZO BEAN AND LENTIL

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
POST-Applied Grass Herbicides				
Assure II Targa (quizalofop ¹)	7 to 12 fl oz EC (0.77 to 1.32 oz)	Annual grasses and quackgrass.	POST. Crop: Refer to PHI. PHI:	Add oil adjuvant at 1 gal/100 gal water but not less than 1.25 pt/A. Refer to label for tank-mix options.
Poast (sethoxydim ¹)	0.5 to 1.5 pt EC (0.1 to 0.3 lb)	Annual grasses.	Assure = 60 days. Poast = 50 days. Clethodim = 30 days.	Refer to Remarks in the POST grass herbicide section under Soybean for methods to avoid antagonism and reduced grass control from broadleaf herbicides.
Select Max 1EC Select 2EC Shadow 3EC (clethodim ¹)	9 to 16 fl oz EC 4 to 8 fl oz EC 2.7 to 5.3 fl oz EC (1 to 2 oz)	Annual grasses and quackgrass.	Grass: Refer to soybean section on page 27.	
POST-Applied Broadleaf Herbicides				
Tough 5 EC (pyridate ⁶)	1.5 pt EC (0.9375 lb)	Annual broadleaf weeds	POST: Do not apply within 60 days of harvest.	Add NIS at 0.25 %v/v or PO at 1 to 4 pt/A. AMS or UAN can be added to tank mix to enhance weed control.
Chickpea Only				
Preharvest Herbicides				
Glyphosate ⁹	Up to 2.25 lb ae	Emerged grass and broadleaf weeds.	Harvest aid and desiccant. PHI: 7 days	Use only registered formulations. Apply with AMS at 8.5 lb/100 gal. Do not apply to crop grown for seed because reduced germination/vigor may occur. For spot treatment use a 2% solution for perennial broadleaf weeds at or beyond the bud stage. Crop will be killed in treated areas.
		Perennial weeds.	Spot treatment. PHI: 14 days.	
Paraquat ²² + NIS	RUP 1.2 to 2 pt 2SL 0.8 to 1.3 pt 3SL (0.3 to 0.5 lb)	Weed desiccant.	Prior to harvest. >80% yellow/ brown pods and <40% green chickpea leaves or <30% green lentil leaves.	Contact herbicides require >15 gpa and full sunlight. Apply at >10 gpa for ground and >5 gpa for aerial application. Apply Sharpen with AMS at 8.5 to 17 lb/100 gal water or UAN at 2.5 gal/100 gal water and with glyphosate or paraquat for weed desiccation. Glyphosate improves weed control from Sharpen and Valor but antagonism may occur on biennial and perennial weeds.
Sharpen + MSO adjuvant (saflufenacil ¹⁴)	1 to 2 fl oz SC + 1 to 1.5 pt/A (0.36 to 0.72 oz)	Sharpen - not for green lentil varieties.		
Valor SX Valor EZ + (flumioxazin ¹⁴) + MSO adjuvant	2 to 3 oz WDG 2 to 3 fl oz SC 2 pt (1.02 to 1.53 oz)	Valor - lentil only	PHI: paraquat = 7 days. Sharpen = 2 days Valor = 5 days.	Do not apply Sharpen to crop grown for seed because reduced germination/vigor may occur.

Clearfield Lentil

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Beyond (imazamox ²)	4 to 6 fl oz SL (0.5 to 0.75 oz)	Annual grass and broadleaf weeds including wild oat, foxtail, Japanese and downy brome and Persian darnel.	POST. Lentil: 2 to 6 leaf stage. Weeds: Small and actively growing.	Apply only to Clearfield lentil varieties. Add NIS at 1 qt/100 gal water + 28% UAN at 2.5 gal/100 gal water or AMS at 8.5 lbs/100 gal. Do not use PO or MSO adjuvants. Refer to label for weed size and application information.

SUNFLOWER

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Soil-Applied Herbicides				
Eptam (EPTC ¹⁵)	2.5 to 3.5 pt EC (2 to 3 lb)	Grass and some small seeded broadleaf weeds.	PPI.	No wild mustard control. PPI immediately after application.
Prowl Prowl H2O (pendimethalin ³)	2.4 to 3.6 pt 3.3EC 2.1 to 3 pt 3.8ACS (1 to 1.5 lb)		PPI.	Poor wild oat and no wild mustard control. Adjust rate for soil type. Refer to label for tank-mix options.
	3 to 3.6 pt 3.3EC 2.7 to 3 pt 3.8ACS (1.25 to 1.5 lb)		PRE - 30 days before to 1 day after seeding.	Apply PRE for no-till sunflower only.
Treflan / generic trifluralin ³	1 to 2 pt EC 5 to 10 lb 10G (0.5 to 1 lb)		PPI.	PPI within 24 hours after application. Poor wild oat and no wild mustard control. Adjust rate for soil type. Use highest rate allowed for broadleaf weed control.
Sonalan (ethalfluralin ³)	1.5 to 3 pt EC 5.5 to 11.5 lb 10G (0.55 to 1.15 lb)		PPI. Spring. Fall: From October 1 to December 31.	For reduced or conservation tillage: incorporate twice at 2 to 3 inches deep using a V-blade under-cutter or rotary hoe. For fall applications: incorporate once in the fall and once in the spring before seeding.
	7.5 to 11.5 lb 10G (0.75 to 1.15 lb)			
Dual Magnum (S-metolachlor ¹⁵)	1 to 2 pt EC (0.95 to 1.9 lb)	Shallow PPI or PRE.	PPI improves consistency of control. PRE requires moisture for activation.	
Spartan (sulfentrazone ¹⁴)	3 to 8 fl oz F (1.5 to 4 oz)	Small-seeded broadleaf weeds including kochia, lambsquarters, pigweed species, and b. wormwood.	EPP, shallow PPI, or PRE.	PRE requires precipitation for activation. EPP up to 30 days prior to planting improves likelihood of activation by moisture. Adjust rate for soil type, OM, and pH. Temporary sunflower injury may occur in coarse, low organic matter soils with pH greater than 7.8. May give 6 to 8 weeks residual weed control. BroadAxe may provide greater weed control as a premix product than activity from each herbicide.
Spartan Charge (carfentrazone ¹⁴ & sulfentrazone ¹⁴)	3.75 to 7.75 floz SE (0.16 to 0.34 oz & 1.48 to 3.05 oz)			
BroadAxe XC Spartan Elite (metolachlor ¹⁵ & sulfentrazone ¹⁴)	20 to 32 fl oz EC (0.98 to 1.58 lb + 1.75 to 2.8 oz)			
Authority Supreme (sulfentrazone ¹⁴ & pyroxasulfone ¹⁵)	5.8 to 15.4 fl oz SC (1.51 to 4.0 oz & 1.51 to 4.0 oz)	Annual grasses and small-seeded broadleaf weeds including kochia, lambsquarters, pigweed species, and b. wormwood.	EPP, PPI, or PRE	Adjust rates for soil type and OM. Seed must be planted a minimum of 1 inch deep.
Anthem Flex (pyroxasulfone ¹⁵ & carfentrazone ¹⁴)	2 to 7.3 fl oz SC (0.06 to 0.21 & 0.004 to 0.015 lb)			
Zidua (pyroxasulfone ¹⁵)	1.75 to 6.5 fl oz SC (0.9 to 0.21 lb)			
POST-Applied Herbicides				
Assure II / Targa (quizalofop ¹)	7 to 12 fl oz EC (0.77 to 1.32 oz)	Annual grasses and quackgrass.	POST. Sunflower: Refer to PHI.	Add oil adjuvant at 1 gal/100 gal water but not less than 1.25 pt/A. Refer to label for tank-mix options. Refer to Remarks in the POST grass herbicide section under Soybean for methods to avoid antagonism and reduced grass control from broadleaf herbicides. Allow a 70 day PHI.
Poast (sethoxydim ¹)	0.5 to 1.5 pt EC (0.1 to 0.3 lb)	Annual grasses.	Grass: Refer to soybean section on page 27.	
Select Max 1EC Select 2EC Shadow 3EC (clethodim ¹)	9 to 16 fl oz EC 4 to 8 fl oz EC 2.66 to 5.33 EC (1 to 2 oz)	Annual grasses and quackgrass.		

SUNFLOWER

Preharvest Herbicides				
Glyphosate ⁹	Up to 0.75 lb ae See Remarks.	Preharvest weed control.	Prior to harvest. Backside of sunflower heads yellow and bracts turning brown at the shoulder. Seed moisture content under 35%. PHI: glyphosate= 7 days paraquat = 7 days. Sharpen = 7 days. Valor = 5 days.	Do not apply to sunflower grown for seed because reduced germination / vigor may occur. Use only registered formulations. Add AMS at 8.5 lb/100 gal. Contact herbicides require >15 gpa and full sunlight. Use paraquat on confectionery and oilseed sunflower varieties. Apply at >10 gpa for ground and >5 gpa for aerial application. Apply Sharpen and Valor with AMS at 8.5 to 17 lb/100 gal water or UAN at 2.5 gal/100 gal water and with glyphosate or paraquat for weed desiccation. Glyphosate improves weed control from Sharpen and Valor but antagonism may occur on biennial and perennial weeds. Do not graze or hay treated plants. Do not apply after multiple minor frosts or a single major frost. Do not apply Sharpen to sunflower grown for seed because reduced germination/vigor may occur.
Paraquat ²² + NIS RUP	1.2 to 2 pt 2SL 0.8 to 1.3 pt 3SL (0.3 to 0.5 lb)	Desiccant.		
Sharpen + MSO adjuvant, (saflufenacil ¹⁴)	2 fl oz SC + 1 to 1.5 pt/A (0.71 oz)			
Valor SX Valor EZ + MSO adjuvant (flumioxazin ¹⁴)	2 to 3 oz WDG 2 to 3 fl oz EZ + 2 p/A (1.02 to 1.53 oz)			

HERBICIDE RESISTANT SUNFLOWER

Clearfield Sunflower

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Beyond (imazamox ²)	4 fl oz SL (0.5 oz)	Small annual broadleaf weeds including wild mustard and black nightshade. No ALS-resistant weed control.	EPOST. Sunflower: 2 to 8-leaf stage. Broadleaf weeds: Less than 3 inches tall. Grass weeds: Less than 4 to 5 leaves.	Apply only to Clearfield sunflower varieties. Add NIS at 1 qt/100 gal water + UAN at 2.5 gal/100 gal water or AMS at 8.5 lbs/100 gal. Do not add PO or MSO adjuvants or tankmix with Zidua. Refer to label for weeds controlled, adjuvant use, and tank-mix options.
	4 to 6 fl oz SL (0.5 to 0.75 oz)			Apply only to Clearfield Plus sunflower varieties. Clearfield Plus sunflower has increased tolerance to imazamox that allows higher herbicide rates and use of more effective MSO adjuvants. Add MSO at 1 to 1.5 pt/A + UAN at 2.5 gal/100 gal water or AMS at 12 to 15 lbs/100 gal.

Express Sun Sunflower

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Express SG (tribenuron ²)	0.25 to 0.5 oz SG (0.125 to 0.25 oz)	Small annual broadleaf weeds including wild mustard. Suppression of Canada thistle. No grass or ALS-resistant weed control.	EPOST. Sunflower: 1-leaf stage but prior to bud formation. Broadleaf weeds: Less than 3 inches tall.	Apply only to Express Sun sunflower varieties. Apply with MSO adjuvant at 1 to 1.5 pt/A and with a registered POST grass herbicide. Observe a 14 day interval between sequential applications but do not exceed a total rate of 1 oz/A. Allow a 70 day PHI.

SAFFLOWER

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Soil-Applied Herbicides				
Eptam (EPTC ¹⁵)	3.5 pt EC 15 lb 20G (3 lb)	Grass and some broadleaf weeds.	PPI.	Refer to narrative A1 for application information. Poor wild mustard control.
Prowl H20 (pendimethalin ³)	2.5 to 3.5 pt 3.8AS (1.19 to 1.66 lb)		PPI. Fall.	Poor wild oat and no wild mustard control. Adjust rate for soil type.
	2 to 3 pt 3.8ACS (0.95 to 1.43 lb)		PPI or PRE. Spring.	Refer to label for tank-mix options. Use highest rate allowed for broadleaf weed control.
Treflan / generic trifluralin ³	1 to 2 pt EC 5 to 10 lb 10G (0.5 to 1 lb)		PPI. Fall or spring.	
Sonalan (ethalfluralin ³)	1.5 to 3 pt EC 5.5 to 11.5 lb 10G (0.55 to 1.15 lb)		PPI. Fall or Spring.	
Dual Magnum (S-metolachlor ¹⁵)	1 to 2 pt EC (0.95 to 1.9 lb)	Small-seeded broadleaf weeds.	Shallow PPI or PRE.	Shallow PPI gives more consistent weed control. PRE requires precipitation for activation.
Spartan Charge (carfentrazone ¹⁴ & sulfentrazone ¹⁴)	2.5 to 5 fl oz SE (0.1 to 0.2 oz & 1 to 2 oz)		ND Section 24c label indemnification agreement required - user assumes all risk of crop injury. Do not use on coarse texture soils, soil <1.5% OM, or soil pH >7.6. Adjust rate for soil type and soil pH.	
Zidua (pyroxasulfone ¹⁵)	1.75 to 2.5 fl oz SC (0.91 to 1.3 oz)		Annual grasses and small-seeded broadleaf weeds.	Some varieties may be more sensitive than others.
POST-Applied Herbicides				
Harmony SG (thifensulfuron ²)	0.45 to 0.6 oz SG (0.225 to 0.3 oz)	Small annual broadleaf weeds.	POST: Allow an 81 day PHI. Weeds: Small.	Add oil adjuvant at 1 to 2 pt pt/A + UAN at 2 to 4 qt/A or AMS at 2 lb/A. Sequential applications are allowed but do not exceed 0.6 oz/A.
Poast (sethoxydim ¹)	0.5 to 1.5 pt EC (0.1 to 0.3 lb)	Annual grasses.	POST. Safflower: Refer to PHI. PHI: 70 days.	Add oil adjuvant at 1 gal/100 gal water but not less than 1.25 pt/A. Refer to label for tank-mix options.
Select Max 1EC Select 2EC Shadow 3EC (clethodim ¹)	9 to 16 fl oz EC 4 to 8 fl oz EC 2.66 to 5.33 EC (1 to 2 oz)	Annual grasses and quackgrass.	Grass weeds: Refer to soybean section - page 27.	Refer to Remarks in the POST grass herbicide section under Soybean for methods to avoid antagonism and reduced grass control from broadleaf herbicides.
Preharvest Herbicide				
Glyphosate ⁹	Up to 2.25 lb ae See Remarks.	Preharvest weed control.	White seed coat and >20 days after end of secondary branch flowering. PHI: 7 days	Do not apply to safflower grown for seed because reduced germination / vigor may occur. Use only registered formulations. Add AMS at 8.5 lb/100 gal.
Drexel Defol (sodium chlorate)	1 gal 6 SL (6 lb)	Desiccant.	Prior to harvest. After physiological maturity. PHI: Defol = 7 days. Sharpen = 7 days. Valor = 5 days.	Contact herbicides require >15 gpa and full sunlight. Apply at >10 gpa for ground and >5 gpa for aerial application. Apply Sharpen and Valor with AMS at 8.5 to 17 lb/100 gal water or UAN at 2.5 gal/100 gal water and with glyphosate or paraquat for weed desiccation. Glyphosate improves weed control from Sharpen and Valor but antagonism may occur on biennial and perennial weeds. Do not apply Sharpen to safflower grown for seed because reduced germination/vigor may occur.
Sharpen + MSO adjuvant (saflufenacil ¹⁴)	1 to 2 fl oz SC + 1 to 1.5 p/A (0.36 to 0.72 oz)			
Valor SX Valor EZ + MSO adjuvant (flumioxazin ¹⁴)	2 to 3 oz WDG 2 to 3 fl oz SC + 2 pt/A (1.02 to 1.53 oz)			

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Soil-Applied Herbicides				
Treflan / generic trifluralin ³	1 to 2 pt EC 5 to 10 lb 10G (0.5 to 1 lb)	Grass and some broadleaf weeds.	PPI. Fall.	Adjust rate for soil texture. Deep incorporate within 24 hours after application.
Sonalan (ethalfluralin ³)	1.5 to 3 pt EC 5.5 to 11.5 lb 10G (0.55 to 1.15 lb)		PPI	Poor wild oat and no wild mustard control. Adjust rate for soil type. Refer to label for tank-mix options. Use highest rate allowed for broadleaf weed control.
Callisto (mesotrione ²⁷)	3 to 6 fl oz SC (1.5 to 3 oz)	Small broadleaf weeds.	PRE to flax crop. PRE or POST to weeds.	POST: Add MSO adjuvant at 1.25 pt/A + UAN at 2.5 gal/100 gal or AMS at 8.5 lb/100 gallons water. Do not apply POST to flax.
Spartan (sulfentrazone ¹⁴)	3 to 8 fl oz F (1.5 to 4 oz)	Small-seeded broadleaf weeds including kochia, lambsquarters, pigweed species, nightshade, and b. wormwood.	EPP, shallow PPI, PRE or Fall.	PRE requires precipitation for activation. Adjust rate for soil type. May give 6 to 8 weeks residual weed control. Refer to label for application information.
Spartan Charge (carfentrazone ¹⁴ & sulfentrazone ¹⁴)	3.75 to 7.75 fl oz SC (0.16 to 0.34 oz & 1.48 to 3.05 oz)			
POST-Applied Herbicides				
Bromoxynil ⁶	1 pt (0.25 lb)	Small broadleaf weeds.	POST. Flax: 2- to 8-inches tall.	Most active in hot and sunny conditions. Poor wild mustard control. Flax injury is possible.
MCPA ⁴	0.5 pt 4EC/SL (0.25 lb ae)			Use MCPA ester on hard-to-kill weeds. Early application is less injurious to flax.
Bromoxynil ⁶ & MCPA ⁴	0.9 pt 4EC 11.4 fl oz 5EC (0.23 & 0.23 lb ae)			Apply to small weeds prior to bud stage of flax. Risk of flax injury is greatest in hot and humid weather.
Curtail M / generic clopyralid ⁴ &MCPA ⁴	1.33 to 1.75 pt SL (1.1 to 1.5 oz ae & 6.25 to 8.25 oz ae)	Broadleaf weeds including C. thistle and sowthistle.	POST. Flax: 2- to 6-inches tall. Weeds: Small.	Rates allowed through ND Supplemental labeling. Allow a 72 day PHI. Apply after most Canada thistle shoots have emerged and <6-inches tall.
Assure II / Targa (quizalofop ¹)	7 to 12 fl oz EC (0.77 to 1.32 oz)	Annual grasses and quackgrass.	POST. Flax: PHI: Assure = 60 days. Targa = 70 days. Poast = 75 days. Clethodim = 60 days and prior to bloom.	Add oil adjuvant at 1 gal/100 gal water but not less than 1.25 pt/A. Refer to label for tank-mix options. Refer to Remarks in the POST grass herbicide section under Soybean for methods to avoid antagonism and reduced grass control from broadleaf herbicides. May be tank-mixed with bromoxynil or MCPA ester for broad-spectrum weed control. Clethodim may injure flax when applied during bloom.
Poast (sethoxydim ¹)	0.5 to 1.5 pt EC (0.1 to 0.3 lb)	Annual grasses.		
Select Max 1EC Select 2EC Shadow 3EC (clethodim ¹)	9 to 16 fl oz EC 4 to 8 fl oz EC 2.66 to 5.33 EC (1 to 2 oz)	Annual grasses and quackgrass.	Grass: Refer to soybean section on page 27.	
Preharvest Herbicides				
Glyphosate ⁹	Up to 1.125 ae See Remarks.	Emerged annual and perennial grass and broadleaf weeds.	Prior to harvest. Flax seed = 30% or less moisture. PHI = 7 days.	Do not apply to flax grown for seed because reduced germination / vigor may occur. Use registered formulations. Add AMS at 8.5 lbs/100 gal.
Drexel Defol (sodium chlorate)	1 gal 6 SL (6 lb)	Desiccant.	Prior to harvest. Flax: 70 to 80% of the bolls are brown. PHI: Defol = 7 days. Sharpen = 7 days. Valor = 5 days.	Contact herbicides require >15 gpa and full sunlight. Apply at >10 gpa for ground and >5 gpa for aerial application. Apply Sharpen and Valor with AMS at 8.5 to 17 lb/100 gal water or UAN at 2.5 gal/100 gal water and with glyphosate or paraquat for weed desiccation. Glyphosate improves weed control from Sharpen and Valor but antagonism may occur on biennial and perennial weeds. Do not apply Sharpen to flax grown for seed because reduced germination/vigor may occur.
Sharpen + MSO (saflufenacil ¹⁴)	1 to 2 fl oz SC + 1 to 1.5 pt (0.36 to 0.72 oz)			
Valor SX Valor EZ + MSO (flumioxazin ¹⁴)	2 to 3 oz WDG 2 to 3 fl oz SC + 2 pt (1.02 to 1.53 oz)			

CANOLA AND RAPESEED

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Soil-Applied Herbicides				
Treflan / generic trifluralin ³	1 to 2 pt EC 5 to 10 lb 10G (0.5 to 1 lb)	Grass and some broadleaf weeds.	PPI. Spring or Fall.	Adjust rate for soil type.
Sonalan (ethalfuralin ³)	1.5 to 2.5 pt EC 5.5 to 9.5 lb 10G (0.55 to 0.95 lb)	Grass and some broadleaf weeds. May suppress kochia.	PPI. Fall or Spring.	Adjust rate for soil type. Poor wild oat and no wild mustard control. May result in reduced crop stand or early injury. May provide greater broadleaf weed control than trifluralin.
POST-Applied Herbicides				
Stinger / generic clopyralid ⁴	4 to 8 fl oz SL (1.5 to 3 oz ae)	Broadleaf weeds including thistles.	POST. Crop: 2- to 6-leaves. Annual weeds: Small.	Apply after most thistle shoots have emerged. Allow a 50 day PHI.
Assure II Targa (quizalofop ¹)	7 to 12 fl oz EC (0.77 to 1.32 oz)	Annual grasses and quackgrass.	POST. Crop: Refer to PHI. PHI: Assure = 60 days. Poast = 60 days. Clethodim = 70 days and prior to bolting. Grass weeds: Refer to soybean section - page 27.	Add oil adjuvant at 1 gal/100 gal water but not less than 1.25 pt/A. Refer to label for tank-mix options. Refer to Remarks in the POST grass herbicide section under Soybean for methods to avoid antagonism and reduced grass control from broadleaf herbicides. Avoid drift to small grain and desirable grass species. Clethodim may injure canola when applied during bloom.
Poast (sethoxydim ¹)	1 to 1.5 pt EC (0.2 to 0.3 lb)			
Select Max 1EC Select 2EC Shadow 3EC (clethodim ¹)	9 to 12 fl oz EC 4 to 6 fl oz EC 2.66 to 5.33 EC (1 to 2 oz)			
TAME MUSTARD				
Treflan / generic trifluralin ³	1.5 pt / 7 lb 10G (0.5 to 1 lb)	Grass and some broadleaf weeds.	PPI. Spring or Fall.	Adjust rate according to soil type.
Assure II/Targa ¹ (quizalofop)	7 to 12 fl oz EC (0.77 to 1.32 oz)	Annual grasses and quackgrass.	POST. Crop: Prior to bolting. PHI - Refer to Canola Grass weeds: Refer to soybean section - page 27.	Add oil adjuvant at 1 gal/100 gal water but not less than 1.25 pt/A. Refer to Remarks in the POST grass herbicide section under Soybean for methods to avoid antagonism and reduced grass control from broadleaf herbicides. Avoid drift to small grain and desirable grass species. Clethodim may injure tame mustard when applied during bloom.
Select Max 1EC Select 2EC Shadow 3EC (clethodim ¹)	9 to 12 fl oz EC 4 to 6 fl oz EC 2.66 to 5.33 EC (1 to 2 oz)			
Preharvest Herbicides for Canola, Rapeseed, and Tame Mustard				
Glyphosate ⁹	Up to 1.125 ae See Remarks.	Emerged annual and perennial grass and broadleaf weeds.	Physiologically mature crop. Seed = 30% or less moisture. PHI = 7 days.	Do not apply to canola, rapeseed, or tame mustard grown for seed because reduced germination/ vigor may occur. Add AMS at 8.5 lbs/100 gal.
Reglone + NIS (diquat ²²) For Canola Only	1.5 to 2 pt 2SL + 1 qt/100 gal water (0.37 to 0.5 lb)	Desiccant.	Prior to harvest. >60% of canola seed turns green to brown stage. PHI: Reglone = 7 days. Sharpen = 3 days.	Contact herbicides require >15 gpa and full sunlight. Apply at >10 gpa for ground and >5 gpa for aerial application. Apply Sharpen with AMS at 8.5 to 17 lb/100 gal water or UAN at 2.5 gal/100 gal and with glyphosate for weed desiccation. Glyphosate improves weed control from Sharpen and Valor but antagonism may occur on biennial and perennial weeds. Do not graze or feed treated plants. Do not apply Sharpen to canola and mustard crops grown for seed because reduced germination/vigor may occur.
Sharpen + MSO adjuvant (saflufenacil ¹⁴) For Canola Only	2 fl oz SC + 1 to 1.5 pt/A (0.71 oz)			

HERBICIDE-RESISTANT CANOLA

Clearfield Canola

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Beyond (imazamox ²)	4 fl oz SL (0.5 oz ae)	Annual grass and broadleaf weeds. Will not control ALS-resistant weeds.	POST. Canola: Prior to bloom. Weeds: Small.	Apply only to Clearfield canola varieties. Add oil adjuvant at 1 to 2 pt/A + UAN at 1 to 2 qt/A. Refer to label for weeds controlled, tank-mixtures, and application information. Allow a 60 day PHI.

SU Canola

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Draft (thifensulfuron & tribenuron ²)	0.3 oz DF (0.15 + 0.075 oz)	Small annual broadleaf weeds. Will not control ALS-resistant weeds.	POST. Canola: 2 to 5-leaf. Prior to bolt. Weeds: Small.	Apply only to Falco SU trait canola varieties. Add NIS at 0.25 to 0.5% v/v. Refer to label for weeds controlled, tank-mixtures and application information. Allow a 45 day PHI.

LibertyLink Canola

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs																				
Liberty 280, Cheetah, Interline, Scout (glufosinate ¹⁰)	22 to 29 fl oz SL (0.4 to 0.53 lb) Maximum in-crop total = 58 fl oz Maximum season total = 87 fl oz	Annual broadleaf weeds and control or suppression of grasses.	POST. Canola: Cotyledon up to early bolting stage. Broadleaf weeds: Up to 3 inches tall. Grass weeds: See Remarks. PHI: 65 days.	Apply only to LibertyLink canola varieties. Apply with a registered POST grass herbicide. Refer to label for tank-mix information. Add AMS fertilizer at 3 lb/A - do not use non-AMS adjuvants. Growth stage of grass weeds at application: <table border="1"> <thead> <tr> <th>Grass weed</th> <th># leaves</th> <th>Inches tall</th> <th># tillers</th> </tr> </thead> <tbody> <tr> <td>G/Y foxtail</td> <td><6/4</td> <td><4/2</td> <td><2/before tillering</td> </tr> <tr> <td>Wild oat*/Corn</td> <td><4</td> <td><4</td> <td>1 or less/ -</td> </tr> <tr> <td>Bygr/Millet</td> <td><6</td> <td><3</td> <td>1 or less</td> </tr> <tr> <td>Vol. cereals*</td> <td><3</td> <td><3</td> <td>1 or less</td> </tr> </tbody> </table> * = A second application may be required. Non-residual, contact herbicide requiring thorough coverage. Most active in hot, sunny conditions.	Grass weed	# leaves	Inches tall	# tillers	G/Y foxtail	<6/4	<4/2	<2/before tillering	Wild oat*/Corn	<4	<4	1 or less/ -	Bygr/Millet	<6	<3	1 or less	Vol. cereals*	<3	<3	1 or less
Grass weed	# leaves	Inches tall	# tillers																					
G/Y foxtail	<6/4	<4/2	<2/before tillering																					
Wild oat*/Corn	<4	<4	1 or less/ -																					
Bygr/Millet	<6	<3	1 or less																					
Vol. cereals*	<3	<3	1 or less																					

Roundup Ready and TruFlex Roundup Ready Canola

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs															
Glyphosate ⁹	Roundup Ready Maximum single application = 0.56 lb ae Maximum in-crop = 0.75 lb ae TruFlex Maximum single application = 1.5 lb ae – 6 leaf to flower Maximum in-crop = 1.5 lb ae See Remarks.	Annual and perennial grass and broadleaf weeds.	Roundup Ready Canola: Emergence to 6-leaf. Do not apply after the 6-leaf stage or once bolting begins because canola injury may occur. TruFlex Emergence to flower. Apply once or twice as needed. PHI: 8 weeks.	Apply only to Roundup Ready canola varieties. <table border="1"> <thead> <tr> <th></th> <th>Maximum - single appl.</th> <th>Maximum - season</th> </tr> <tr> <th></th> <th>0.56 lb ae</th> <th>0.75 lb ae</th> </tr> </thead> <tbody> <tr> <td>3 lb ae/gal = 4 lb ai/gal</td> <td>23.8</td> <td>32</td> </tr> <tr> <td>4/4.17 = 5.4/5.1</td> <td>18/17.2</td> <td>24/23</td> </tr> <tr> <td>4.5 = 5.5</td> <td>16</td> <td>21.3</td> </tr> </tbody> </table> Add AMS at 8.5 lb/100 gal. Sprayer overlap may result in yellowing, delayed flowering, and growth reduction. Allow a minimum interval of 10 days between sequential applications. TruFlex: Max rate for a single application is 1.5 lb ae prior to 6-leaf. Max rate from 6 leaf to first flower is 0.75 lb ae per application.		Maximum - single appl.	Maximum - season		0.56 lb ae	0.75 lb ae	3 lb ae/gal = 4 lb ai/gal	23.8	32	4/4.17 = 5.4/5.1	18/17.2	24/23	4.5 = 5.5	16	21.3
	Maximum - single appl.	Maximum - season																	
	0.56 lb ae	0.75 lb ae																	
3 lb ae/gal = 4 lb ai/gal	23.8	32																	
4/4.17 = 5.4/5.1	18/17.2	24/23																	
4.5 = 5.5	16	21.3																	

*Use only approved glyphosate brands

SUGARBEET

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Refer to page 6 for Fall or Spring Early Preplant Herbicides (See M6 to M9 for fall-applied herbicides).				
Soil-Applied Herbicides				
Far-Go (triallate ¹⁵) 	1.5 qt EC, 15 lb 10G (1.5 lb)	Wild oat.	PPI. Spring. Fall - see label for rates and timing.	Incorporate immediately after application. A second incorporation will improve wild oat control. A1-2 M1-2,7
Eptam (EPTC ¹⁵)	2.3 to 3.4 pt EC (2 to 3 lb)	Annual grasses and some broadleaf weeds.		Eptam may cause some sugarbeet stand reduction and temporary stunting. M1-2 M5-6 M18
Eptam (EPTC¹⁵) + Ro-Neet SB (cycloate ¹⁵)	1.1 to 2.3 pt EC + 2.7 to 3.3 pt EC (1 to 2 + 2 to 2.5 lb)			Less sugarbeet injury than from Eptam alone. Refer to narrative for suggested rates for various soil textures and organic matter. M1-2 M5-6 M18
Ro-Neet SB (cycloate ¹⁵)	4 to 5.3 pt EC (3 to 4 lb)			Ro-Neet is safer than Eptam. Weed control is poor on fine textured, high OM soils. M1-2 M5-6 M18
Nortron / generic ethofumesate¹⁵	6 to 7.5 pt SC (3 to 3.75 lb)	Pigweed, kochia, waterhemp.	PPI or PRE.	PPI improves weed control. Band application reduces cost and risk of carryover. M1-2 M9 M18
Dual/II/Magnum (S/metolachlor ¹⁵)	0.5 to 1 pt EC (0.48 to 0.96 lb)	Annual grasses and some broadleaf weeds, including pigweeds and waterhemp.	PRE	Dual Magnum rate dependent on rainfall up to 14 day after PRE application. Rainfall greater than 1.5-inch increases sugarbeet injury potential especially on soils with less than 3.5% OM or course textured soils. See 24(c) label for additional details.
Dual/II/Magnum (S/metolachlor ¹⁵) + Norton (ethofumesate ¹⁵)	0.5 pt EC + 2 pt SC (0.48 + 1 lb)			
POST-Applied Herbicides				
Nortron / generic ethofumesate¹⁵	3 to 12 fl oz SC (0.094 to 0.375 lb)	Improves control of kochia, pigweed, waterhemp, and lambsquarters.	POST with Betamix or UpBeet and glyphosate up to 90 days PHI.	Apply Norton* POST 3 times at 4 fl oz/A or 4 times at 3 fl oz/A but do not apply POST more than 12 fl oz/A total during the growing season due to crop rotation restrictions. 90 day PHI. Willowood Ethofumesate 4SC, 45 day PHI. M1-2 M8-9 M15 M18
Stinger HL Stinger / generic clopyralid⁴	1.8 to 6.4 fl oz (0.07 to 0.25 lb) 4 to 10.6 fl oz SL (0.09 to 0.25 lb)	Cocklebur, marshelder, ragweed, sunflower, buckwheat, and Canada thistle.	POST. Sugarbeet: Cotyledon up to 8-leaf stage.	Refer to narrative for rates and sizes for various species. Stinger* may be tank-mixed with Betamix*. Allow a 45 day PHI. M1-2 M8 M12 M15
UpBeet (triflurosulfuron ²)	0.25 to 1 oz DF (0.125 to 0.5 oz)	Annual broadleaf weeds.	POST. Weeds: Cotyledon to 2-leaf stage.	Do not exceed 2.5 oz/A/season. Must include MSO adjuvant at 2 pt/A unless prohibited. Allow a 60 day PHI. M1-2 M8 M11 M15
Ultra Blazer (acifluorfen ¹⁴) 	16 fl oz SL (0.25 lb ai)	Waterhemp, redroot pigweed, kochia, annual smartweed	POST. Weeds: small Sugarbeet: greater than 6-lf stage	Apply in 17-30 gallons per acre water carrier volume. Application before 6 leaf sugar beet may result in crop injury and potential yield loss. Use Ultra Blazer alone or Ultra Blazer mixtures with Roundup*, NIS at 0.25% and AMS at 8.5 lb/100 gal. Allow 45-Day PHI. See Section 18 label for additional details.
Liberty 280 SL (glufosinate ¹⁰)	29 fl oz SL (0.53 lb) Season max: 60 fl oz/A (1.10 lb)	Annual broadleaf weeds including waterhemp, redroot pigweed, kochia, common ragweed, and biennial wormwood	POST. Weeds: less than 3-inch Sugarbeet: between 6- and 10-lf stage Only use with approved hooded sprayer between rows	Apply to small and actively growing weeds, targeting less than 3-inch weeds in height. Two applications and up to a total of 60 fl oz Liberty 280 SL per acre may be applied per year. Sequential applications must be a minimum of 10 days apart. Spray in a minimum of 15 gallons per acre water carrier. Must use Ammonium sulfate (AMS) at 3 lbs/A. For best results, warm temperatures, high humidity, and bright sunlight improve the performance of Liberty® 280 SL herbicide. Allow 60-Day PHI. See 24(c) label for additional details.

*Or generic equivalent.

SUGARBEET

M1. Sugarbeet herbicides may be used to supplement cultural practices. Hand rouging and hoeing weeds can be reduced or eliminated by timely cultivations and herbicide applications.

M2. Herbicide tank-mixtures are commonly used on sugarbeet. Non-labeled herbicide combinations may be applied if all products in the mixture are registered for use on sugarbeet and are not prohibited. However, the user must assume liability for any crop injury, inadequate weed control, or illegal and/or harmful residues.

M3. Betamix (desmedipham & phenmedipham) applied POST may cause sugarbeet injury. Sugarbeet with four true leaves are more tolerant than smaller plants and continue to gain tolerance as size increases. Application rates totaling 3 pt/A or less should be followed by a second application in 5 to 7 days if weeds are present after 5 days. Split application with reduced rates reduces sugarbeet injury but increases weed control compared to one full-rate application - See table below. Risk of sugarbeet injury is reduced by applying in late afternoon so cooler temperatures follow application. Risk of injury increases during flooding, high temperature, and especially, a sudden change from cool, cloudy conditions to hot, sunny weather.

Betamix Broadcast Rate.

Sugarbeet stage	No soil herbicide			
	Low pressure (<100 psi)		High pressure or aerial	
	(lb/A)	(pt/A)	(lb/A)	(pt/A)
Coty to 2-leaf	0.25	1.5	0.16	1
2-leaf	0.33	2	0.25	1.5
4-leaf	0.5	3	0.4	2.5
6 to 8-leaf	0.75	4.6	0.75	4.6
Sugarbeet stage	With soil herbicide			
	Low pressure (<100 psi)		High pressure or aerial	
	(lb/A)	(pt/A)	(lb/A)	(pt/A)
Coty to 2-leaf	0.16	1	0.12	0.75
2-leaf	0.25	1.5	0.16	1
4-leaf	0.33	2	0.25	1.5
6 to 8-leaf	0.5	3	0.5	3

* Or generic equivalent.

M4. Dual Magnum (S-metolachlor) applied preplant incorporated or preemergence may cause sugarbeet injury. Sugarbeet injury is greater following Dual Magnum application preplant incorporated than preemergence. Growers are required to sign a liability form that releases manufacturer from liability for sugarbeet injury. Apply PPI or PRE in the spring or fall and adjust rate depending on soil texture and OM content. Make fall applications (MN only) after October 15 but before ground freezes. Lay-by applications can be done without signing a liability release form. Apply lay-by after sugarbeet has 2 true leaves. Multiple lay-by applications can be made but the total applied must not exceed 2.6 pt/A per season. Precipitation after application is required for activation.

M5. Eptam (EPTC) may cause reduced sugarbeet stands and temporary stunting without yield reduction if adequate sugarbeet population remains after thinning. Injury increases in light soils with low OM. Ro-Neet or Nortron* cause less sugarbeet injury on the low OM soils where Eptam injury may be excessive.

Ro-Neet SB (cycloate) gives better control than Eptam under

adequate spring rainfall but Eptam tends to give better weed control than Ro-Neet on fine-textured, high OM soils or under dry conditions. Ro-Neet causes less injury than Eptam and is safer on more coarse-textured, low OM soils. Eptam and Ro-Neet can be applied in the fall.

M6. Eptam (EPTC) plus **Ro-Neet SB** (cycloate) has less potential for sugarbeet injury and is less expensive than Ro-Neet alone. The rate of the mixture must be adjusted for soil texture and OM.

M7. Far-Go (trilalate) requires immediate incorporation after application at 3 to 4 inches deep for best wild oat control. Delaying the second incorporation for three days or longer after the first incorporation improves wild oat control. Delaying the second incorporation is especially important for granular formulations. One incorporation in the fall followed by spring seed-bed preparation is sufficient for fall-applied Far-Go. Far-Go should be fall-applied when temperatures are consistently below 50 F. Far-Go may be applied until snow cover or soil freeze up. Far-Go will control wild oat that have developed resistance to ACCase-inhibitor POST herbicides.

M8. Micro-rate or Mid-rate programs use low rates of herbicides in combination applied three or more times at 5 to 7 day intervals starting when weeds are just emerging. The micro-rate treatment is Betamix (8 to 12 fl oz/A) plus Nortron* (3 to 4 fl oz/A) plus MSO adjuvant (2 pt/A) or Betamix (8 to 12 fl oz/A) plus UpBeet (0.125 oz/A) plus Stinger* (1.3 fl oz/A) plus MSO adjuvant (2 pt/A). The MSO is essential to increase weed control when low herbicide rates are used.

The mid-rate treatment includes Betamix at 12 to 16 fl oz/A or Betamix plus Nortron* at 12 to 16 fl oz/A plus 3 to 4 fl oz/A after sugarbeet has four leaves along with the same rate of UpBeet, Stinger* and MSO. Add Select* at up to 6 fl oz/A or Assure II or Fusilade at 8 to 10 fl oz/A or Poast at 1 pt/A to the micro-rate to improve grass control. Always use the mid-rate program once sugarbeet has reached the 4-leaf stage and when the next application has been delayed beyond 7 days after the previous application. The micro-rate will not control lanceleaf sage or ALS-resistant kochia and is less effective on waterhemp.

The micro-rate and mid-rates applied a minimum of three times generally gives better weed control than two applications of conventional rates. Three applications of conventional rates may give better weed control than three applications of the micro-rate. Four micro-rate applications may give better weed control than three applications of conventional rates or the micro-rate due to controlling late-emerging weeds.

Precipitation and nozzle plugging is common with ground application of the micro-rate treatment.

Several factors may reduce nozzle plugging.

- 1) Start with a clean sprayer and completely spray out the tank immediately after mixing, flush sprayer between loads, clean sprayer frequently, and avoid spray solution to set in the tank.
- 2) Allow the sprayer tank water to warm before mixing and increase the pH of water to 8 or 9 by adding ammonia or Quad 7.
- 3) Pre-mix the UpBeet in hot water or water with pH 8 to 9. Put UpBeet in the tank first and be sure it is dissolved before adding, in order, Betamix, Stinger*, and MSO type oil adjuvant. A 2% solution of household ammonia at 1 gal/100 gal of water will give about pH 9. Add ammonia slowly as the tank fills so water pH does not go much over pH 9.
- 4) Add a grass herbicide. Tests show Assure II* reduced precipitation more than Poast and Select* but all had an effect.
- 5) Use gentle agitation.

*Or generic equivalent.

M9. Nortron* (ethofumesate) is the best soil-applied herbicide for kochia control, providing fair to good control. Nortron* applied PPI improves weed control, especially kochia control. Do not incorporate less than 2 inches deep (2 to 4 inches preferable). Nortron* (1 to 3 pt/A) + Dual Magnum (0.5 (except course-textured soils) to 0.75 pt/A PRE can improve control of small-seeded broadleaf weeds, including waterhemp, when followed by Dual Magnum, Outlook or Warrant (chloroacetamides) early POST to sugarbeet and PRE to waterhemp (layby). Split application of chloroacetamide herbicides is recommended since in some environments, growth reduction may occur from chloroacetamides following Nortron and Dual Magnum compared with Nortron and Dual Magnum alone. Likewise, Ro-Neet or Eptam (fall-applied) can cause sugarbeet injury especially on medium to coarse textured soils. Nortron* plus spring-applied Eptam may cause serious injury and should only be used on fine textured soils with over 6% OM. See label for rate adjustment on various soil types.

Use the following recommendations to reduce nozzle plugging or incompatibility issues with Nortron*:

- 1) Fill partially used Nortron* jugs with water to prevent formation of insoluble Nortron* residue. Mark the level of remaining Nortron* in the jug before adding water.
- 2) Flush lines and clean nozzles and screens daily.
- 3) Use warm water.
- 4) Addition of liquid nitrogen may help.
- 5) Use 50 mesh or larger screens.

M10. Outlook* (dimethenamid) on medium to fine-textured soils may be used as a lay-by treatment when sugarbeet has 2 to 8 leaves. Apply once at a maximum of 21 fl oz/A or sequentially but the total must not exceed 24 fl oz/A. Sugarbeet leaf burn may occur from a single application at 18 to 21 fl oz/A. Precipitation after application is required for activation. Weeds that emerge prior to activation will not be controlled.

M11. UpBeet (triflurosulfuron) should be used with MSO adjuvant when applied with Stinger*, Betamix, or Nortron*. UpBeet will antagonize grass control from Assure II*, Fusilade DX, Poast, or Select*, similar to antagonism caused by Betamix. UpBeet at 0.5 to 1.0 oz/A applied with Roundup* + HSMOC and AMS has improved control of non-ALS resistant waterhemp and kochia. Research in eastern North Dakota and Minnesota has shown UpBeet + Nortron* or UpBeet + Nortron* and Betamix have improved control of glyphosate resistant waterhemp and kochia.

M12. Stinger* (clopyralid) applied with MSO adjuvant controls small weeds in the Composite, Polygonum, Legume, and Nightshade families. Apply to wild buckwheat in the 3- to 5-leaf stage before vining begins. Apply Stinger* at 0.5 to 0.66 pt/A to Canada thistle in the rosette to pre-bud growth stage. Rosette application will give better control than later application.

M13. Treflan* (trifluralin) will provide residual weed control. Broadcast and incorporate immediately with cultivators or tillage tools adjusted to mix the herbicides in the soil without excessive sugarbeet stand loss. The crop should be clean cultivated before application since established weeds are not controlled. Treflan* with good moisture conditions will control late germinating weeds that may become a problem late into the season.

M14. Warrant (acetochlor) may be applied singly or sequentially at 1.25 to 2 qt/A. Allow at least 7 days between sequential applications and do not exceed 2 qt/A as a single application. Precipitation is required for activation. Weeds that emerge prior to activation will not be controlled.

M15. Combinations of postemergence herbicides give more broad spectrum and greater total weed control compared to individual treatments. For example, Stinger* + Betamix have controlled wild buckwheat, eastern black nightshade, lambsquarters, buffalobur, giant ragweed, common ragweed, ladythumb, lanceleaf sage and Russian thistle superior to Stinger* or Betamix applied alone. Betamix + Nortron*, UpBeet + Nortron* or Betamix + UpBeet have improved control of glyphosate resistant waterhemp compared to Roundup* alone. Finally, UpBeet + Betamix + Nortron* or UpBeet + Nortron + Roundup* have improved control of glyphosate resistant kochia compared to Roundup* alone.

UpBeet generally has little effect on sugarbeet injury. UpBeet plus Betamix has provided improved control of redroot pigweed, prostrate pigweed, kochia, common mallow, nightshade, ladythumb, Venice mallow, nightflowering catchfly, wild mustard and velvetleaf compared to Betamix or Betamix + Nortron*. UpBeet + Betamix has provided similar control of waterhemp compared to Betamix + Nortron*.

HERBICIDE-RESISTANT SUGARBEET

Roundup Ready Sugarbeet

M16. Glyphosate may be applied to Roundup Ready sugarbeet from emergence to 30 days before harvest. Refer to labels for adjuvant use. Use registered formulations and always apply glyphosate at the full rate depending on weed species and weed size. The maximum rate of glyphosate that can be applied to sugarbeet at various times is listed in the tables. Glyphosate may be applied up to four times POST to sugarbeet with at least 10 days between applications. Apply glyphosate in the least amount of spray volume allowed but avoid drift of spray droplets. Apply with AMS at 8.5 lbs/100 gallons of water.

The initial glyphosate application should be applied to 1 to 2 inch weeds or 2 to 4-leaf stage sugarbeet at 0.98 to 1.125 lb ae/A. Sequential applications should be applied approximately 14 to 21 days after the previous application.

M17. Sequence (glyphosate-K & S-metolachlor) may be applied only to Roundup Ready sugarbeet from 2-leaf to canopy closure. Sequence may be applied from 2 to 8-leaf sugarbeet at the maximum rate of 2.5 pt/A on course soils and 3 pt/A on medium and fine soils in a single application. The maximum rate of Sequence that may be applied from 8-leaf to canopy closure is 2.5 pt/A for a single application. Sequential applications must be separated by 10 days. Additional glyphosate may be included but do not exceed single and multiple glyphosate application rates within each growth stage according to the label. Add AMS at the minimum rate of 8.5 lbs/100 gallon of water. The PHI for Sequence is 60 days. Do not exceed 7 pt/A of Sequence and 4 POST applications per season.

M18. Glyphosate-resistant waterhemp and kochia are difficult to control in Roundup Ready sugarbeet with conventional herbicides. Glyphosate-resistant waterhemp and kochia should be managed using an integrated approach that combines tillage to ensure a clean start and a strategy that includes herbicides with complimentary SOA in crops planted in sequence with sugarbeet.

In sugarbeet, Nortron*, Ro-Neet, Ro-Neet + Eptam, Dual Magnum, Outlook* or Warrant provide residual control of glyphosate-resistant waterhemp. Nortron* PRE followed by Betamix + UpBeet with Nortron* provided glyphosate-resistant kochia control. However, row cultivation and/or hand-labor may likely be required to achieve complete control, especially complete control of waterhemp.

*Or generic equivalent.

POTATO

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs	
Soil-Applied Herbicides					
Eptam (EPTC ¹⁵)	3.5 to 9 pt EC 15 to 30 lb 20G (3 to 6 lb)	Grass and some broadleaf weeds.	PPI, Dragoff, or Directed spray at layby.	Incorporate immediately after application at 4 to 6 inches deep. Poor wild mustard control. Adjust rate for soil type. Allow a 45 day PHI. May be applied with metribuzin at 0.33 to 0.67 lb DF/A. N1	
	5.25 to 7 pt EC 22.5 to 30 lb 20G (4.5 to 6 lb)		Fall: Incorporate after October 15 until freeze-up.		
Treflan / generic trifluralin ³	1 to 2 pt EC 0.8 to 1.7 lb 60DF (0.5 to 1 lb)		Postplant incorporate (PoPI).	Adjust rates for soil type. Poor wild oat and no wild mustard control. Incorporate above the seed piece after planting or immediately following drag-off or hilling but before potato and weed emergence. Sonalan labeled only west of Hwy 281.	
Sonalan (ethalfluralin ³)	1.33 to 2.67 pt EC (0.5 to 1 lb)				
Prowl Prowl H2O (pendimethalin ³)	1.75 to 3.6pt 3.3EC 1.5 to 3 pt 3.8ACS (0.72 to 1.5 lb)		PRE or EPOST. Potato: Before 6 inches tall.	Incorporation improves consistency of weed control.	
Outlook / generic dimethenamid ¹⁵	16 to 21 fl oz EC (0.75 to 1 lb)		PRE. PHI: 40 days.	Only one application allowed.	
Dual/II/Magnum (S/metolachlor ¹⁵)	1 to 2 pt EC (1 to 2 lb)		PPI or PRE. PHI: 40 days.	Commercial mixture with metribuzin available as Boundary. N1	
	1.67 pt EC (1.67 lb)		EPOST. PHI: 40 days.	Apply after hilling/lay-by. Will not control emerged weeds but will provide residual weed control. May be applied after PPI or PRE Dual application. Maximum season total = 3.6 pt/A.	
Lorox Linex (linuron ⁵)	 1 to 3 lb DF (0.5 to 1.5 lb) 1.5 to 3 pt L (0.75 to 1.5 lb)		Annual grass and broadleaf weeds.	PRE to potato. Small grass and broadleaf weeds.	Seed piece must be planted at least 2 inches deep. Apply after drag-off or hilling. Use higher rates for fine-textured soils. Apply with NIS at 1 qt/100 gal water to emerged weeds. N1
Metribuzin ⁵	0.33 to 1.33 lb DF 0.5 to 2 pt 4F (0.25 to 1 lb)		Annual broadleaf weeds and grass suppression.	PRE to potato.	Apply after planting and before potato emergence or after drag-off. Do not incorporate. Adjust rate according to soil type. Commercial mixture with S-metolachlor available as Boundary. N1 N3
	0.33 to 0.67 lb DF 0.5 to 1 pt 4F (0.25 to 0.5 lb)	POST. Weeds: Up to 1 inch tall. PHI: 60 days.		Only for russet type or white skinned varieties that are not early maturing. Do not use on early maturing, smooth skinned white or red-skinned varieties or Atlantic, Shepody, Chipbelle, Bellchip, or Centennial varieties. Soil residue may injure crops the following year. N1 N3	
Willowood Sulfentrazone (sulfentrazone ¹⁴)	2 to 8 fl oz EC (0.75 to 2 lb)	Small-seeded broadleaf weeds.	PRE.	Refer to label for varietal restrictions, usage rates for soil textures and organic matter. Do not use on soils classified as "sand" with <1% organic matter.	
Chateau SW Chateau EZ (flumioxazin ¹⁴)	1.5 oz WDG 1.5 fl oz SC (0.77 oz)	Annual broadleaf weed control.	PRE to potato.	Apply after planting and before potato emergence. Seed piece must be planted at least 2 inches deep. Refer to label for use instructions.	
Reflex / generic fomesafen ¹⁴	0.75 pt EC (0.188 lb)		PHI for Reflex: 70 days.	Apply after planting and before potato emergence. Use is restricted to east of Hwy 281. Do not apply PPI or POST to potato. Refer to label for other restrictions. N4	

POTATO

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
League (imazosulfuron ²)	4 to 6.4 oz WG (3 to 4.8 oz)	wild buckwheat, common	PRE	Be aware of rotation restrictions. Refer to label for use instructions.
	3.2 to 4 oz WG (2.4 to 3 oz)	lambsquarters, yellow nutsedge,	POST	
	3.2 fb 3.2 oz WG (2.4 fb 2.4 oz)	pigweeds, common ragweed	POST fb POST	
Matrix / generic rimsulfuron ²	1 to 1.5 oz DF (0.25 to 0.375 oz)	Annual grass and small broadleaf weeds.	PRE to potato and weeds. After hilling or drag-off.	Requires precipitation after application for soil activation. Apply with soil-applied herbicides or in PRE followed POST sequential applications.
		Suppression of lambsquarters and Canada thistle.	POST. Potato: Up to 14 inches tall. Annual weeds: Small.	Apply with oil adjuvant at 1 to 2 pt/A. Refer to label for application information and restrictions. N1-2
Matrix / generic rimsulfuron ² + Metribuzin ⁵	1 to 1.5 oz DF + 0.33 to 0.75 lb DF 0.5 to 1.12 pt 4F (0.25 to 0.375 oz + 0.25 to 0.56 lb)	Annual grass and quackgrass suppression and small broadleaf weeds including kochia,	PRE to potato and weeds. After hilling or drag-off but before potato emerge.	Refer to label for varietal restrictions. Injury may occur when metribuzin is applied POST to early maturing smooth-skinned white and all red- skinned potato varieties - use only the low rate of metribuzin and consider benefits of weed control vs risk of potato injury prior to application to "at risk" varieties. Allow a 60 day PHI. Use the low rate of metribuzin when applied PRE to coarse textured soil. N1-2
	1 to 1.5 oz DF + 0.25 to 0.67 lb DF 0.38 to 1 pt 4F (0.25 to 0.375 oz + 0.188 to 0.5 lb)	lambsquarters, wild buckwheat.	POST. Potato: Up to 14 inches tall. Annual weeds: Small.	
2,4-D LV4 ⁴ 2,4-D LV6 ⁴ (Use registered brands - See N5)	2.3 fl oz EC 1.6 fl oz EC (1.2 oz)	Broadleaf weeds suppression. Enhance and retain red color on skin.	Pre-bud - make sequential application 10 to 14 days later. PHI = 45 days.	Use on red potatoes grown for fresh market. Crop response may vary depending on variety, stress, and local conditions. Apply at 25 gpa by ground and 5 gpa aerially. Tank-mixtures with other pesticides and additives may increase risk of injury. N1 N5
Poast (sethoxydim ¹)	0.5 to 1.5 pt EC (0.1 to 0.3 lb)	Annual grasses.	POST. PHI: 30 days.	Add oil adjuvant at 1 gal/100 gal water but not less than 1.25 pt/A. Refer to label for tank-mix options.
Select Max 1EC Select 2EC Shadow 3EC (clethodim ¹)	9 to 16 fl oz EC 4 to 8 fl oz EC 2.66 to 5.33 EC (1 to 2 oz)	Annual grasses and quackgrass.	Grass weeds: Refer to soybean section on page 27.	Refer to Remarks in the POST grass herbicide section under Soybean for methods to avoid antagonism and reduced grass control from broadleaf herbicides. May be tank-mixed with metribuzin. N1
Zidua SC (pyroxasulfone ¹⁵)	2.5 to 3.25 SC (1.3 to 1.7 oz)	Annual grasses and some broadleaf weeds.	PRE	Apply after planting and drag-off and before potato emergence. Seed piece must be planted at least 2 inches deep. Refer to label for use instructions.

POTATO VINE DESICCATION

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs	
Reglone / generic diquat ²² + NIS	1 to 2 pt SL+ 2 qt/100 gal water (0.25 to 0.5 lb)	Desiccant.	PHI: Reglone = 7 days. Firestorm = 3 days Rely = 9 days. Aim = 7 days. Vida = 5 days.	Most active in hot, sunny conditions. Reglone/diquat at 2 pt/A can be applied to all potatoes varieties and seed potato. Sequential application may be made up to a total of 4 pt/A. Allow at least 5 days between applications. Paraquat use is for fresh market potatoes ONLY. Do not use paraquat on potatoes that will be stored or used as seed pieces. See specific paraquat label as not all carry this registration.	
Generic Paraquat + NIS (paraquat ²²) RUP	0.7 to 1.3 pt 3SL + 2 qt/100 gal water (0.25 to 0.5 lb)				Do not apply to potato grown for seed pieces. Best results when applied at the beginning of natural potato vine senescence. Requires thorough coverage. Most active in hot, sunny conditions. Apply at > 20 gpa by ground and 5 to 10 gpa by air. Use higher spray volumes on dense potato vines.
Rely 280 + AMS (glufosinate ¹⁰)	21 fl oz SL + 3 lb/A (0.38 lb)				
Aim (carfentrazone ¹⁴)	3.2 to 5.9 fl oz EW (0.8 to 1.6 oz)			Add MSO at 1 qt/A. Use sequential applications and higher spray volumes on dense potato vines. Thorough coverage essential. Most active in hot, sunny conditions.	
Vida (pyraflufen ¹⁴)	2 to 5.5 fl oz EC (0.05 to 0.14 oz)			Extremely corrosive.	
Sulfuric acid RUP	20 gal SL				
Defol 5 (Sodium chlorate)	4.8 Qt (6 lb)			Preharvest. 10 days prior to harvest.	Add NIS at 0.25% v/v or MSO/PO at 1 %v/v. Apply in 5 to 10 GPA aerially or 10 to 20 GPA on the ground.

POTATO

N1. Tillage through hilling and cultivation and herbicides are the two primary means of controlling weeds in potato. The first tillage operation after planting is usually a "blind" cultivation or harrowing before the crop emerges. The number of tillage operations will vary, but three cultivations and two hilling operations are common. After emergence, inter-row cultivation is used to control weeds and to form a ridge or hill over the seed piece and developing tubers. Besides controlling weeds, the ridge or hill helps protect tuber from sunburn (tuber greening), late season frosts, excessive rainfall or irrigation and reduces the amount of soil to be moved at harvest. Deep cultivation may cause root and tuber pruning.

N2. Matrix* (rimsulfuron) applied PRE or POST alone or with Metribuzin* controls annual grass and some broadleaf weeds. Use the low rate of Metribuzin* for PRE applications to coarse textured soil. Soil residual of Matrix* and Metribuzin* may injure susceptible crops the following year.

Matrix* controls eastern black nightshade and may control or suppress hairy nightshade but gives no black nightshade and lambsquarters control. Apply PRE to potato and weeds after hilling or drag-off but before potato emerge or POST before potato is 14 inches tall and annual weeds are less than 1 inch tall and quackgrass 4 to 6 inches tall. Best results occur when 0.75 inches of water occur soon after application. Apply with petroleum or MSO adjuvants at 1.25 pt/A to emerged weeds. Matrix* can be applied in a sequential program of 1 oz 25DF/A PRE followed by 1 oz 25DF/A POST. Matrix* may be tank-mixed with Eptam, Dual*, Metribuzin*, or Prowl. Follow label directions when tank-mixing Matrix* plus Metribuzin*. See Metribuzin paragraph for additional information.

N3. Metribuzin applied PRE or POST controls many broadleaf weeds and suppresses some grasses. Use lower rate on coarse textured soils and for weeds under 1 inch tall. Do not apply to red-skinned, early maturing, white-skinned varieties; or within 3 days after cool, wet, cloudy weather. Follow varietal restrictions according to Metribuzin* label. Injury may occur to russet type or white skin potato varieties; therefore, use only the low rate of Metribuzin* and consider the risk of weed control vs potato injury prior to application to "at risk" varieties. Refer to label for application information and restrictions.

N4. Reflex (fomesafen) applied PRE to potato controls many broadleaf weeds. A maximum of 0.75 pt may be applied in alternate years east of Hyw 281 in ND. Reflex can be tank-mixed with other registered herbicides. Do not apply PPI or POST or severe potato injury may occur. Potato varieties may vary in response to Reflex. Allow a 70 day PHI.

N5. 2,4-D products labeled for use in potato include but may not be limited to:

2,4-D LV4, Albaugh, Inc. Ankeny, Iowa
Weedone LV4 EC, Nufarm Americas, Inc. Burr Ridge, IL.
2,4-D Ester 6, Tacoma Ag, LLC. Durham, NC.
Turret, Nufarm Americas, Inc. Burr Ridge, IL.
2,4-D LV 6, Alligare, LLC. Opelika, AL.

*Or generic equivalent.

ALFALFA ESTABLISHMENT, No Companion Crop

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraph
Eptam (EPTC ¹⁵)	2 to 4.5 pt EC 10 to 20 lb 20G (1.75 to 4 lb)	Grass and some broadleaf weeds.	PPI.	Poor wild mustard control. Incorporate immediately after application. The 2 pt/A rate can be used on all varieties.
Treflan / generic trifluralin ³	1 to 1.5 pt EC (0.5 to 0.75 lb)			Alfalfa stand reduction/stunting possible but reduced weed competition will help alfalfa establishment. P1
Prowl H₂O (pendimethalin ³)	1 to 2 pt EC (0.48 to 0.95 lb)	Annual grass and some broadleaf weeds.	PRE to weeds. Alfalfa: 2 nd trifoliolate to <6 inches	Allow a 50 day PHI. Refer to label for use instructions.
Warrant (acetochlor ¹⁵ - microencapsulated)	1.25 to 2 qt 3ME (0.94 to 1.5 lb)	PRE control of grass and broadleaf weeds.	Fall or spring: Emergence up to 4 th trifoliolate stage	Sequential application is allowed. Wait a minimum of 20 days after application before cutting for forage or hay, or before open grazing of forage. See label for tank mix options. Do not use on alfalfa grown for seed.
2,4-DB ⁴ ester 2,4-DB ⁴ amine	2 to 4 pt 2EC/SL (0.5 to 1 lb ae)	Small broadleaf weeds.	Alfalfa: More than 2 trifoliolate leaves. Weeds: <3 inches.	Sweetclover may be killed by 2,4-DB. Poor wild mustard control. No absinth wormwood control. Allow a 60 day PHI or grazing interval.
Bromoxynil⁶ For Alfalfa Only	1 to 1.5 pt EC (0.25 to 0.38 lb)		Alfalfa: At least 4 trifoliate. Weeds: Small.	Sweetclover may be killed. Alfalfa injury may occur if temperature within 3 days of application exceeds 80F in the western half or 70F in the eastern half of ND. Can be tank-mixed with Pursuit or Raptor.
Pursuit (imazethapyr ²) For Alfalfa Only	3 to 4 fl oz SL (0.75 to 1 oz ae)	Small annual broadleaf and grass weeds.	Fall or Spring. POST: Alfalfa: At least 2 trifoliate.	Apply to seedling, established, dormant, actively growing alfalfa or between cuttings. Excellent alfalfa safety. Add MSO at 1.5 pt/A + UAN at 1 to 2 qt/A. Can be tank-mixed with Buctril/bromoxynil or Poast.
Raptor (imazamox ²) For Alfalfa Only	4 to 6 fl oz SL (0.5 to 0.75 oz ae)	Poor yellow foxtail, lambsquarters, ragweed, and buckwheat control. No perennial weed control.	Weeds: 1- to 3-inches tall.	
Poast (sethoxydim ¹)	0.5 to 1.5 pt EC (0.19 to 0.28 lb)	Annual grasses.	POST. Alfalfa: Allow a 15 days PHI.	May be applied to alfalfa and sainfoin. Add oil adjuvant at 1 gal/100 gal water but not less than 1.25 pt/A. Refer to label for tank-mix options.
Select Max 1EC Select 2EC Shadow 3EC (clethodim ¹)	9 to 16 fl oz EC 4 to 8 fl oz EC 2.66 to 5.33 EC (1 to 2 oz)	Annual grasses and quackgrass.		Refer to Remarks in the POST grass herbicide section under Soybean for methods to avoid antagonism and reduced grass control from broadleaf herbicides.

HERBICIDE RESISTANT ALFALFA

Roundup Ready Alfalfa - Established

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Glyphosate ⁹	Maximum single application = 1.56 lb ae Maximum in-crop = 4.5 lb ae See Remarks.	Emergenced annual and perennial grass and broadleaf weeds.	RR Alfalfa: Emergence to 5 days prior to any cutting (PHI). Apply as a single application or multiple applications at least 7 days apart.	Apply only to glyphosate resistant alfalfa. Add AMS fertilizer at 8.5 lb/100 gal. Multiple applications may be necessary to control weed flushes. Refer to label for weeds controlled, application information, tankmix options with residual herbicides, and restrictions.

ALFALFA - ESTABLISHED

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs																				
Paraquat ²² + NIS RUP	2 to 3 pt 2SL 1.3 to 2 pt 3SL (0.5 to 0.75 lb)	Small annual and early germinating weeds.	Alfalfa: Before spring regrowth is 2 inches tall.	Apply to well established stands, at least 1 year old, after dormancy but before spring regrowth reaches 2 inches. Allow a 60 day PHI or grazing interval.																				
	1 pt 2SL 0.7 pt 3SL (0.25 lb)	Larger weeds.	Between cuttings - includes first-year alfalfa.	Apply up to 5 days after cutting. Allow a 30 day PHI. May be applied to dormant alfalfa.																				
Sharpen + MSO adjuvant (saflufenacil ¹⁴)	1 to 2 fl oz SC + 1 to 1.5 pt (0.36 to 0.72 oz)	Broadleaf weeds.	Established and dormant alfalfa: Fall or spring. Weeds: Small.	Do not apply Sharpen to alfalfa grown for seed because reduced germination/vigor may occur. Apply at 10 gpa or greater. Allow a 28 day PHI. Refer to label for use and tank-mix instructions.																				
Metribuzin ⁵	0.33 to 1.33 lb DF 0.5 to 2 pt 4F (0.25 to 1 lb)	Annual broadleaf weeds and grass suppression.	Established and dormant alfalfa: Fall or spring. Weeds: Small.	Alfalfa must be dormant at application. Allow a 28 day PHI. Refer to label for use and tank-mix instructions.																				
Treflan / generic trifluralin ³	1.5 to 2 pt EC (0.75 to 1 lb)	Annual grass and some broadleaf weed.	Weeds: Prior to emergence.	Apply when crop is dormant, or in fall after a cutting. Incorporate by irrigation or mechanical equipment.																				
Prowl H₂O (pendimethalin ³)	1 to 2 pt EC (0.48 to 0.95 lb)		PRE to weeds. Alfalfa: <6 inches of regrowth.	Allow a 50 day PHI. Refer to label for use instructions.																				
Warrant (acetochlor ¹⁵ - microencapsulated)	1.25 to 2 qt 3ME (0.94 to 1.5 lb)	PRE control of grass and broadleaf weeds.	After spring green-up in established stands. Apply no later than 7 days after a cutting.	Sequential application is allowed. Wait a minimum of 20 days after application before cutting for forage or hay, or before open grazing of forage. See label for tank mix options. Do not use on alfalfa grown for seed. Do not apply more than 4 qt per year.																				
Chateau SW Chateau EZ (flumioxazin ¹⁴)	<4 oz or fl oz / application (<2 oz) <8 oz or fl / season (<4 oz)	Small-seeded broadleaf weed.	PRE to weeds. Alfalfa: <6 inches of regrowth.	Separate sequential Chateau applications by at least 60 days. Apply soon after cutting and removing alfalfa to minimize alfalfa injury. Refer to label for use instructions.																				
2,4-DB ⁴ ester 2,4-DB ⁴ amine	2 to 4 pt EC 2 to 4 pt SL (0.5 to 1.0 lb ae)	Broadleaf weeds.	Weeds: Less than 3 inches tall.	Sweet clover may be killed by 2,4-DB. No wild mustard or absinth wormwood control. Allow a 30 day hay, harvest or grazing interval.																				
Pursuit (imazethapyr ²)	3 to 4 fl oz SL (0.75 to 1 oz ae)	Small annual broadleaf and grass weeds.	POST. Alfalfa: At least 2 trifoliates.	For alfalfa and clover Only. Excellent alfalfa safety. Add oil additive at 1.5 to 2 pt/A + UAN at 1 to 2 qt/A. No absinth wormwood control. Can be tank-mixed with bromoxynil or Poast.																				
Raptor (imazamox ²)	4 to 6 fl oz SL (0.5 to 0.75 oz ae)		Weeds: 1- to 3-inches tall.																					
Poast (sethoxydim ¹)	0.5 to 1.5 pt EC (0.2 to 0.3 lb)	Annual grasses.	Grass. Alfalfa: PHI:15 days.	Add oil adjuvant at 1 gal/100 gal water but not less than 1.25 pt/A. Refer to label for tank-mix options. Refer to Remarks in the POST grass herbicide section under Soybean for methods to avoid antagonism and reduced grass control from broadleaf herbicides. Apply in two sequential applications for quackgrass control.																				
Select Max 1EC Select 2EC Shadow 3EC (clethodim ¹)	9 to 16 fl oz EC 4 to 8 fl oz EC 2.66 to 5.33 EC (1 to 2 oz)	Annual grasses and quackgrass.																						
Glyphosate ⁹	0.75 to 1.5 lb ae See Remarks.	Alfalfa and emerged grass and broadleaf weeds.	Apply in spring or fall for quackgrass control.	<table style="width: 100%; border-collapse: collapse;"> <tr> <td></td> <td style="text-align: center;"><u>0.75 lb ae</u></td> <td style="text-align: center;"><u>1.125 lb ae</u></td> <td style="text-align: center;"><u>1.5 lb ae</u></td> </tr> <tr> <td></td> <td style="text-align: center;">lb ae/gal</td> <td style="text-align: center;">lb ai/gal</td> <td style="text-align: center;">fl oz</td> </tr> <tr> <td></td> <td style="text-align: center;">-----</td> <td style="text-align: center;">-----</td> <td style="text-align: center;">-----</td> </tr> <tr> <td>3</td> <td style="text-align: center;">= 4</td> <td style="text-align: center;">= 32</td> <td style="text-align: center;">48 64</td> </tr> <tr> <td>4.5</td> <td style="text-align: center;">= 5.5</td> <td style="text-align: center;">= 21.3</td> <td style="text-align: center;">32 42.6</td> </tr> </table> <p>Apply where crop destruction is acceptable. Treated crop and weeds can be harvested and fed >36 hours after treatment. Apply with AMS fertilizer at 8.5 lbs/100 gal.</p>		<u>0.75 lb ae</u>	<u>1.125 lb ae</u>	<u>1.5 lb ae</u>		lb ae/gal	lb ai/gal	fl oz		-----	-----	-----	3	= 4	= 32	48 64	4.5	= 5.5	= 21.3	32 42.6
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CHEMICAL FALLOW

For Future Planting of Registered Crops.

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs																																			
Glyphosate ⁹	0.75 to 1.5 lb ae See Remarks.	Annual and perennial grass and broadleaf weeds.	Weeds: Less than 12 inches tall. See label.	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">lb ae/gal</th> <th style="text-align: left;">lb ai/gal</th> <th style="text-align: left;">0.75 lb ae</th> <th style="text-align: left;">1.125 lb ae</th> <th style="text-align: left;">1.5 lb ae</th> </tr> </thead> <tbody> <tr> <td>3</td> <td>= 4</td> <td>= 32</td> <td>48</td> <td>64</td> </tr> <tr> <td>3.75</td> <td>= 5</td> <td>= 25.6</td> <td>38.4</td> <td>51.2</td> </tr> <tr> <td>4/4.17</td> <td>= 5.4/5.1</td> <td>= 24/23</td> <td>36/35</td> <td>48/46</td> </tr> <tr> <td>4.5</td> <td>= 5.5</td> <td>= 21.3</td> <td>32</td> <td>42.6</td> </tr> <tr> <td>4.72</td> <td>= 6.3</td> <td>= 20.3</td> <td>30.5</td> <td>40.7</td> </tr> <tr> <td>5</td> <td>= 6.1</td> <td>= 19.2</td> <td>28.8</td> <td>38.4</td> </tr> </tbody> </table> <p>Non-selective, non-residual, translocated, foliar herbicide. Apply with AMS fertilizer at 8.5 lb/100 gal. Glyphosate will not control resistant volunteer crops. Apply with 2,4-D or Banvel/dicamba for improved broadleaf weed control. Refer to label of tank-mix partner for rates, application information, and other restrictions.</p>	lb ae/gal	lb ai/gal	0.75 lb ae	1.125 lb ae	1.5 lb ae	3	= 4	= 32	48	64	3.75	= 5	= 25.6	38.4	51.2	4/4.17	= 5.4/5.1	= 24/23	36/35	48/46	4.5	= 5.5	= 21.3	32	42.6	4.72	= 6.3	= 20.3	30.5	40.7	5	= 6.1	= 19.2	28.8	38.4
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Sharpen + MSO adjuvant (saflufenacil ¹⁴)	1 to 2 fl oz SC + 1 to 1.5 pt/A (0.36 to 0.72 oz)	Small broadleaf weeds.	Fallow and post-harvest.	Provides burndown control of small emerged broadleaf weeds. Apply when weeds are small and actively growing. Add UAN at 2 gal/100 gal. Sharpen has no grass activity. Planting interval is dependant on soil texture and OM. Refer to label for tank-mix options.																																			
Spartan Charge (carfentrazone ¹⁴ & sulfentrazone ¹⁴)	3.75 to 5.75 fl oz SE (0.16 to 0.25 oz & 1.48 to 2.26 oz)	Small-seeded broadleaf weeds.		Do not use on coarse texture soils or soil with <1.5% OM. Adjust rate for soil type and soil pH. Rainfall required for activation.																																			
Aim + MSO adjuvant (carfentrazone ¹⁴)	0.5 to 1 fl oz EC + 1 qt/A (0.128 to 0.256 oz)	Broadleaf weeds including pigweed and ALS kochia.	Weeds: Less than 2 inches tall.	Non-residual, contact herbicides that require >15 gpa and full sunlight. Apply paraquat with NIS at 1 qt/A. Do not use AMS replacement or water conditioner adjuvants with Liberty.																																			
Paraquat ²² + NIS	1.5 to 4 pt 2SL 1 to 2.7 pt 3SL (0.375 to 1 lb)	Emerged annual grass and broadleaf weeds.	Weeds: Small.																																				
Liberty 280 + AMS (glufosinate ¹⁰)	32 to 43 fl oz SL + 3 lb/A (0.58 to 0.79 lb)																																						
Thifen ² & Triben ² 4:1 ratio - Affinity T/M 3:1 ratio 2:1 ratio 1:1 ratio - Affinity B/S 1:4 ratio - Panoflex	0.4 to 0.67 oz 75DF 0.6 to 1 oz 50SG 0.3 to 0.5 oz 75DF 0.3 to 0.66 oz 75DF 0.25 to 0.5 oz 75DF 0.4 to 0.8 oz 50SG 0.3 to 0.6 oz 50SG	Provides a broader spectrum of control than either a.i. alone. Choose ratio based on prevalent weeds.	Any time after harvest until 60 days prior to planting crop.	Add NIS at 2 qt/100 gal water unless restricted by the tank-mix partner. Products containing tribenuron give season-long Canada thistle and perennial sowthistle control.																																			
2,4-D ⁴	1.5 to 4 pt 4EC/SL (0.75 to 2 lb)	Broadleaf weeds and suppression of Canada thistle.	POST.	Use the higher rate for perennial weeds.																																			
Dicamba ⁴	0.5 to 1 pt 4SL 3.2 to 6.4 fl oz 5SL (0.25 to 0.5 lb)			Soil residual from fall application may damage broadleaf crops seeded the next year. See page 6 for crop rotation restrictions																																			
Distinct (dicamba ⁴ & diflufenzopyr ¹⁹)	6 oz WDG (3 oz ae & 1.2 oz) Distinct at 6 oz WDG/A = 6 fl oz/A Clarity.			Add oil adjuvant at 1 to 2 pt/A + 28% UAN at 1.25 qt/A or AMS at 8.5 lb/100 gallons. Refer to label for tank-mix options. Allow 120 days before rotation to crops. Alfalfa, cereal grain crops, and soybeans may be planted 30 days after 1 inch of rain for rates at 4 oz/A or less.																																			

CHEMICAL FALLOW

For Future Planting of Registered Crops

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Curtail / generic clopyralid ⁴ & 2,4-D ⁴	4 pt SL (0.19 lb & 1 lb)	Broadleaf weeds including Canada thistle.	Canada thistle: Prior to bud stage.	Apply after a majority of rosettes have emerged.
Tordon 22K (picloram ⁴) RUP	0.25 to 0.5 pt SL (0.063 to 0.125 lb)	Annual weeds.	Weeds: Actively growing.	Refer to label for grazing and rotational restrictions. Do not rotate to corn or sorghum the following year. Rates greater than 0.5 pt/A should be used post-harvest when rotating to fallow the following year.
Tordon 22K (picloram ⁴) + 2,4-D ⁴ RUP	0.5 to 1 pt SL + 1 to 2 pt EC/SL (0.125 to 0.25 lb + 0.5 to 1 lb)	Perennial weeds.	Canada thistle: Prior to bloom. Field bindweed: Actively growing.	
Facet L + MSO adjuvant (quinclorac ^{4,0})	1.33 pt L + 1.5 pt/A (0.25 lb)	Field bindweed: Runners at least 4 inches long. May control foxtails, barnyardgrass, and volunteer flax.	Postharvest or in the spring prior to seeding of wheat including durum.	Add AMS at 2.5 lb/A or UAN at 1 gal/A. Apply after harvest but prior to frost. Use in a 3-year program with 0.33 lb DF/A the first year and 0.17 to 0.33 lb DF/A in following years.
Valor SX Valor EZ (flumioxazin ¹⁴)	2 to 4 oz WDG 2 to 4 fl oz SC (1.02 to 2.04 oz)	Most small- seeded broadleaf weeds. May suppress downy brome at 3 oz in no-till.	Post-harvest in fall until 30 days prior to planting. Refer to page 6.	Apply in fall with glyphosate or 2,4-D for control of emerged vegetation.

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs																																								
Glyphosate ⁹	0.75 to 1.5 lb ae See Remarks.	Annual and perennial grass and broadleaf weeds.	Preplant or any time prior to crop emergence.	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2"></th> <th style="text-align: center;">0.75 lb ae</th> <th style="text-align: center;">1.125 lb ae</th> <th style="text-align: center;">1.5 lb ae</th> </tr> <tr> <th style="text-align: left;">lb ae/gal</th> <th style="text-align: left;">lb ai/gal</th> <th colspan="3" style="text-align: center;">----- fl oz -----</th> </tr> </thead> <tbody> <tr> <td>3</td> <td>= 4</td> <td>= 32</td> <td>48</td> <td>64</td> </tr> <tr> <td>3.75</td> <td>= 5</td> <td>= 25.6</td> <td>38.4</td> <td>51.2</td> </tr> <tr> <td>4/4.17</td> <td>= 5.4/5.1</td> <td>= 24/23</td> <td>36/35</td> <td>48/46</td> </tr> <tr> <td>4.5</td> <td>= 5.5</td> <td>= 21.3</td> <td>32</td> <td>42.6</td> </tr> <tr> <td>4.72</td> <td>= 6.3</td> <td>= 20.3</td> <td>30.5</td> <td>40.7</td> </tr> <tr> <td>5</td> <td>= 6.1</td> <td>= 19.2</td> <td>28.8</td> <td>38.4</td> </tr> </tbody> </table> <p>Add AMS fertilizer at 8.5 lb/100 gal.</p>			0.75 lb ae	1.125 lb ae	1.5 lb ae	lb ae/gal	lb ai/gal	----- fl oz -----			3	= 4	= 32	48	64	3.75	= 5	= 25.6	38.4	51.2	4/4.17	= 5.4/5.1	= 24/23	36/35	48/46	4.5	= 5.5	= 21.3	32	42.6	4.72	= 6.3	= 20.3	30.5	40.7	5	= 6.1	= 19.2	28.8	38.4
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2,4-D ⁴	1.5 to 4 pt 4EC/SL (0.75 to 2 lb)	Annual broadleaf weeds, biennial thistles, and suppression of perennial broadleaf weeds.	Weeds: Emergence to bud stage.	Apply only registered brands in CRP. Do not graze animals for 7 days after application or within 3 days of slaughter.																																								
			Pasture grasses: After 5-leaf stage.	Do not apply after boot stage on grasses for seed production. Use 2 pt/A on annuals and gumweed and 4 pt/A on sages and other perennials. Controls buckbrush/western snowberry.																																								
Dicamba ⁴	0.5 to 4 pt 4SL 3.2 to 12.8 floz 5SL (0.25 to 2 lb)		Grasses: After 3-leaf stage of seedling grasses. Weeds: Prior to bud stage for thistles and knapweeds.	Add NIS for new seedings and oil adjuvant at 1 to 2 pt/A on mature stands. Rates greater than 1 pt/A may injure newly seeded grasses. Refer to label for grazing restrictions and tank mixtures with other herbicides.																																								
Dicamba ⁴ + 2,4-D ⁴	1 to 4 pt SL+ 2 pt 4EC/SL (0.5 to 2 lb + 1 lb)		Biennial thistles: Rosette stage.	Add NIS at 1 to 2 qt/100 gal water.																																								
Overdrive (dicamba ⁴ & diflufenzopyr ¹⁹)	6 oz WDG (3 oz & 1.2 oz)		Prior to bud stage for thistles and knapweeds.	Add NIS at 1 qt/100 gal water + 28% UAN at 1.25 qt/A or AMS at 17 lb/100 gallons. Canada thistle suppression only.																																								
Metsulfuron ²	0.1 to 1 oz DF (0.06 to 0.6 oz)	Season-long control of perennial sowthistle.	Fall or spring to early summer. Weeds: Less than 4 inches tall.	Add phenoxy type herbicide to small annual weeds or before thistle plants bolt. Add oil adjuvant at 1 to 2 pt/A. Add 2,4-D for Russian thistle control. Use Cimarron X-tra/generics for control of buckbrush and perennial species.																																								
Starane / generic fluroxypyr ⁴	0.5 - 0.67 pt 1.5EC 0.25-0.35 pt 2.8EC 3.75 - 5 oz 40WDG (1.5 to 2 oz)	Kochia and some broadleaf weeds.	Spring: Kochia less than 6 inches tall.	Will kill desirable legumes but controls kochia, including herbicide resistant kochia.																																								
Stinger / generic clopyralid ⁴	1/3 to 2/3 pt SL (2 to 4 oz)	Broadleaf weeds including Canada thistle and knapweeds.	Weeds: Actively growing and prior to bud stage for thistles and knapweeds.	Apply after most thistle shoots have emerged but before bud stage. Do not apply Curtail/generics to new grass seedings. Use lower rate for annual broadleaf weeds and higher rate for perennial thistles and knapweeds. Do not cut treated grass for hay within 30 days after application.																																								
Curtail / generic clopyralid ⁴ & 2,4-D ⁴	4 to 8 pt SL (1 to 2 oz & 0.19 to 0.38 lb)																																											
Crossbow (triclopyr ⁴ & 2,4-D ⁴) 	1 to 6 qt SL (0.25 to 1.5 lb & 0.5 to 3 lb)	Trees, brush and broadleaf weeds.	Spring: Prior to bud stage for thistles and knapweed. Fall: To rosettes.	Provides more consistent musk thistle and brush control (except buckbrush and western snowberry) than 2,4-D alone. Use highest rate for elm and Russian olive. Observe grazing and haying restrictions.																																								

CRP

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Milestone (aminopyralid ⁴)	3 to 7 fl oz SL (0.75 to 1.75 oz)	Most annual and perennial composite weeds, including wormwood and thistles - see label.	Spring: Rosette to bolting or in fall.	Apply up to 14 oz/A for spot treatment. Milestone can leave a residue for several years following application. Legume species are very susceptible. Refer to label for crop rotation restrictions if CRP breakout into cropland is planned.
Tordon (picloram ⁴)	0.25 to 0.5 pt SL (0.06 to 0.13 lb)	Annual broadleaf weeds.	Weeds: Small and actively growing.	Apply 0.25 to 0.5 pt/A for small annual weeds. Apply 2 pt/A for suppression and 4 pt/A as spot treatment to control perennial weeds.
	RUP 1 to 4 pt (0.25 to 1 lb)	Perennial broadleaf weeds and trees.	Emergence to bud stage.	Rates over 2 pt/A may suppress perennial grasses. Observe grazing restrictions. Apply with 2,4-D to provide cost-effective weed control. Tordon can leave a residue for several years following application. Refer to label for crop rotation restriction if CRP breakout into cropland is planned.
Plateau (imazapic ²)	4 to 12 fl oz SL for pasture, rangeland, native prairie restoration, and wildflower establishment. (1 to 3 oz)	Foxtail barley and annual and perennial broadleaf weeds including leafy spurge.	PRE or POST. Grasses: 7 to 10 days after planting. Weeds: Up to 6 inches tall. Early September to early October. Apply in mid-September for leafy spurge control.	Use on newly established or existing grass stands. Has PRE activity on annual weeds. Add MSO type adjuvant at 2 pt/A. 4 fl oz/A controls/suppresses annual weeds. 12 fl oz/A controls annual weeds plus leafy spurge and Russian knapweed. Rates above 8 fl oz/A can cause reduced grass production, especially cool-season grasses. Use lower rates in areas of low rainfall. High risk of injury to switchgrass. No grazing restrictions specified. Does not control absinth wormwood, Canada thistle, or spotted knapweed.

VEGETATION CONTROL FOR CRP BREAKOUT

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs																																																						
Glyphosate ⁹	0.75 to 1.5 lb ae See Remarks.	CRP vegetation and weeds.	14 to 21 days prior to tillage.	<table border="0"> <tr> <td></td> <td></td> <td></td> <td style="text-align: center;"><u>0.75 lb ae</u></td> <td style="text-align: center;"><u>1.125 lb ae</u></td> <td style="text-align: center;"><u>1.5 lb ae</u></td> </tr> <tr> <td></td> <td></td> <td></td> <td colspan="3" style="text-align: center;">----- fl oz -----</td> </tr> <tr> <td></td> <td><u>lb ae/gal</u></td> <td><u>lb ai/gal</u></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td>3 = 4 =</td> <td></td> <td style="text-align: center;">32</td> <td style="text-align: center;">48</td> <td style="text-align: center;">64</td> </tr> <tr> <td></td> <td>3.75 = 5 =</td> <td></td> <td style="text-align: center;">25.6</td> <td style="text-align: center;">38.4</td> <td style="text-align: center;">51.2</td> </tr> <tr> <td></td> <td>4/4.17 = 5.4/5.1 =</td> <td></td> <td style="text-align: center;">24/23</td> <td style="text-align: center;">36/35</td> <td style="text-align: center;">48/46</td> </tr> <tr> <td></td> <td>4.5 = 5.5 =</td> <td></td> <td style="text-align: center;">21.3</td> <td style="text-align: center;">32</td> <td style="text-align: center;">42.6</td> </tr> <tr> <td></td> <td>4.72 = 6.3 =</td> <td></td> <td style="text-align: center;">20.3</td> <td style="text-align: center;">30.5</td> <td style="text-align: center;">40.7</td> </tr> <tr> <td></td> <td>5 = 6.1 =</td> <td></td> <td style="text-align: center;">19.2</td> <td style="text-align: center;">28.8</td> <td style="text-align: center;">38.4</td> </tr> </table>				<u>0.75 lb ae</u>	<u>1.125 lb ae</u>	<u>1.5 lb ae</u>				----- fl oz -----				<u>lb ae/gal</u>	<u>lb ai/gal</u>					3 = 4 =		32	48	64		3.75 = 5 =		25.6	38.4	51.2		4/4.17 = 5.4/5.1 =		24/23	36/35	48/46		4.5 = 5.5 =		21.3	32	42.6		4.72 = 6.3 =		20.3	30.5	40.7		5 = 6.1 =		19.2	28.8	38.4
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Wheatgrasses may be controlled by glyphosate applied in the spring. However, smooth brome grass requires at least fall plus preplant spring applications of glyphosate and in-crop chemical and/or mechanical control. Add AMS at 8.5 lb/100 gal for improved control. Allow 14 to 21 days prior to tillage. Glyphosate provides greater Canada thistle control when fall-applied than spring-applied. Addition of 2,4-D or will increase alfalfa and sweet clover control but decrease grass control. Always add AMS to overcome antagonism of 2,4-D on grass control and improve control of perennial weeds, such as leafy spurge and Canada thistle. CRP grasses and forbs may become a problem in planted crop. A3-7 B8

GRASS ESTABLISHMENT

Herbicide	Product/A (ai/A)	Weeds	When to Apply	Remarks and Paragraphs
Glyphosate ⁹	0.75 to 1.5 lb ae See Remarks.	Emerged grass and broadleaf weeds.	Preplant or anytime prior to crop emergence.	Non-selective, non-residual translocated, foliar herbicide. Add AMS fertilizer at 8.5 lb/100 gal.
2,4-D ⁴ MCPA ⁴	0.5 to 1 pt 4EC/SL (0.25 to 0.5 lb)	Broadleaf weeds.	Grasses: After 5-leaf stage.	Use rates listed for establishing grasses.
Bromoxynil ⁶	1 to 2 pt EC (0.25 to 0.5 lb)		Grasses: Anytime after emergence.	Grass tolerance is excellent. Can be applied to grass-alfalfa mixtures. Registered CRP species include wheatgrasses (crested, tall, western, bluebunch, and intermediate), perennial ryegrass, fescue, Russian wildrye, and alfalfa. Most active in hot, sunny conditions.
Bromoxynil ⁶ & MCPA ⁴	1 to 2 pt 4EC 0.8 to 1.6 pt 5EC (0.25 to 0.5 lb & 0.25 to 0.5 lb)		POST: Grasses: 3-leaf stage or larger.	Refer to Buctril/bromoxynil section above for registered grass species. Consult label for list.
Starane Ultra / generic fluroxypyr ⁴	0.5 - 0.67 pt 1.5EC 0.25 - 0.35pt 2.8EC 3.75 - 5 oz 4WDG (1.5 to 2 oz)	Kochia and some broadleaf weeds.	Spring: Kochia less than 6 inches tall.	Will kill desirable legumes.

LAWN (Grass weed control)

Acclaim Extra (fenoxaprop), **Certainty** (sulfosulfuron), **Dimension/Ultra** (dithiopyr), **Drive** (quinclorac), **Pendulum** (pendimethalin), **Weed B Gon Max + Crabgrass Control**.

LAWN (Broadleaf weed control)

	MCP	2,4-D	dic	tric	other		MCP	2,4-D	dic	tric	other
Brush Killer	DCPP	+	+	-	-	Trimec 889	MCPA	+	+	-	-
Coolpower	MCPA	-	+	+	-	Trimec 1000	MCPP	+	+	-	-
Horsepower	MCPA	-	+	+	-	T-Zone/Foundation	-	+	+	+	sulf
Q4	-	+	+	-	quin+sulf	Turflon Ester	-	-	-	+	-
Spartan Charge	-	-	-	-	Carf+sulf	WBG/Chickweed, clover...	-	-	-	+	-
Speedzone	MCPP	+	+	-	Carfentrazone	WBG Weed + Crabgrass	MCPP	+	+	-	quin
Tenacity	-	-	-	-	Mesotrione	Weed Stop for Lawns 2X	MCPP	+	+	-	sulf
Trimec Classic	MCPP	+	+	-	-	WS for L + Crabgrass	-	+	+	-	sulf+quin

Abbreviation: dic=dicamba, diclo=dichlorprop, meso=mesotrione, quin=quinclorac, sulf=sulfentrazone, carf=carfentrazone, tric=triclopyr, WBG=Weed B Gon.

CRP BREAKOUT

R1. CRP breakout or vegetation management when breaking land out of CRP is difficult. Heavy vegetation produced from many years of growth without grazing or haying will make cultivation difficult. For most situations, haying in the summer will help remove much of the vegetation found in CRP. Burning may destroy standing plant residues but will not kill underground roots and is not recommended. Removing vegetation by burning may increase weed seed germination. Methods to control vegetation without destroying residues should be used to enhance soil quality and control erosion.

Cultivation alone will not give satisfactory control of CRP vegetation. A herbicide treatment applied several weeks prior to tillage will reduce the amount of vegetation. Fall-applied herbicides are needed if conventional tillage methods will be used to prepare a seedbed the following year. Fall application allows breakdown of foliage and root plant biomass. Cultivators and some tillage equipment tend to plug during spring tillage when a fall-applied herbicide is not used. Mechanical and cultural vegetation control methods should be followed by a vigorous weed control program the following spring. CRP grasses and forbs may become a problem in the planted crop. Seeding a broadleaf crop after CRP breakout will provide chemical control options not available in grass crops.

NDSU research found that glyphosate at 0.75 lb ae/A applied fall or spring gave less than 70% alfalfa and smooth brome control. Glyphosate at 1.5 lb ae/A applied in fall gave 98% early season alfalfa and smooth brome control but regrowth occurred by mid-summer. A fall application followed by a spring application of glyphosate each at 0.75 lb ae/A or a spring application of glyphosate at 1.5 lb ae/A was required for greater than 90% control of smooth brome. A spring application of glyphosate at 1.5 lb ae/A also provided over 90% alfalfa and smooth brome control. Tillage improved control of perennial regrowth (15 to 20% increase) from fall applications of glyphosate but did not improve control from spring applications.

*Or generic equivalent.

SPECIAL WEED PROBLEMS

North Dakota Noxious and Troublesome Weeds

www.ag.ndsu.nodak.edu/invasiveweeds/

Photographs and descriptions of weeds (except quackgrass) in this section can be found in NDSU Extension publication W-1411. Identification and control publications for specific invasive weeds can be found at <http://www.ag.ndsu.edu/publications/crops/weeds>.

By North Dakota Law, all land owners must control noxious weeds on their property.

Refer to the following Extension Circulars for additional information:

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* Weed is a North Dakota State Noxious Weed.	
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BINDWEED, FIELD

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
Glyphosate ⁹ + dicamba ⁴	Up to 1.5 lb ae + 1 pt 4SL (0.5 lb) See Remarks.	Preplant, fallow, post-harvest, and CRP.	Actively growing. Vines: At least 12 inches long. Apply at beyond full bloom.	Tankmixture provides less potential for soil residual than with higher rates of dicamba applied alone. Add AMS at 8.5 lb/100 gal.
Glyphosate ⁹ + 2,4-D ⁴	<0.38 lb + 1.5 pt 4EC/SL (0.75 lb)	Preplant, fallow, post-harvest.	Vines: 6 to 18 inches long.	Suppression in patches or individual plants. Allow at least 7 days between application and tillage. Control is reduced under dry conditions. Add AMS at 8.5 lb/100 gal.
2,4-D ⁴ amine or ester	1.5 to 2 pt 4SL (0.75 to 1 lb) 1.33 to 2 pt 4EC (0.66 to 1 lb)	Spring wheat and barley.	Crop: Tiller stage.	The high rate may injure crop but is beneficial in small areas to control bindweed. Does not provide long term control.
Express / generic tribenuron ² + 2,4-D ⁴ + dicamba ⁴	0.17 to 0.3 oz DF 0.25 to 0.5 oz SG + 0.5 pt 4EC/SL + 2 to 3 fl oz 4SL (0.125 to 0.25 oz + 0.25 lb + 1 to 1.44 oz)	Spring wheat including durum.	Crop: Tillering and before crop exceeds the 5-leaf stage.	Provides season-long control. 2,4-D enhances weed control and crop safety. Add NIS at 0.125% v/v.
Metsulfuron ² + 2,4-D ⁴ + dicamba ⁴	0.05 to 0.1 oz XP + 0.5 pt 4EC/SL + 2 to 3 fl oz 4SL (0.0375 to 0.075 oz + 0.25 lb + 1 to 1.44 oz)			Do not apply metsulfuron within 22 months from last metsulfuron treatment or on soils above a pH of 7.9. Refer to metsulfuron label for additional restrictions.
2,4-D ⁴	1 pt 4EC/SL (0.5 lb)	Corn.	Corn: 3 to 8 inches tall.	Use drop nozzles after corn is more than 8 inches tall. Provides field bindweed suppression only.
Dicamba ⁴	0.5 to 1 pt 4SL (0.25 lb)		Corn: See remarks.	Apply 0.5 to 1 pt/A up to 8 inches tall. Apply 0.5 pt/A post-direct from 8 inches to 36 inches tall or 15 days prior to tassel.
Glyphosate ⁹	1 to 1.5% solution or up to 3 lb ae See Remarks.	Patches in wheat, barley, oat, corn, soybean or trees.	Crop: Prior to heading or flowering. Bindweed: Bud to flowering stage.	Crop will be killed in treated area. Avoid drift or spraying tree foliage. Repeat applications are required for complete control. Apply to actively growing bindweed. Add AMS fertilizer at 8.5 lb/100 gal.
Facet L + MSO adjuvant (quinclorac ^{4,0}) Ransom and Richland counties	22 to 32 fl oz L + 2 pt (4 to 6 oz)	Fallow, post-harvest or preplant to wheat including durum.	In fall prior to a killing frost. Allow 30 days after tillage.	Plant wheat at least 1 inch deep. Add AMS at 2.5 lb/A or UAN at 1 gal/A. Refer to label for tank-mix rates in wheat and fallow.
2,4-D ester ⁴	2 to 4 pt 4EC (1 to 2 lb)	Fallow or post-harvest, and CRP.	Bindweed: Actively growing and regrowth 12 inches long to bud.	Apply only registered brands of 2,4-D in CRP. Cultivate fallow land until early July to achieve optimum growth at time of application. Spray in late August or September. Respray in following crop. Does not provide long term control.
Dicamba ⁴	2 to 4 pt 4SL (1 to 2 lb)			Mid to late fall treatments more effective than summer treatments. Rotate to wheat, corn, soybean or sorghum only. Crop injury may occur if the interval between application and planting is less than 45 days per pt/A dicamba used, excluding days when ground is frozen. Add oil adjuvant to improve control.

BINDWEED, FIELD cont.

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
Dicamba ⁴	4 to 16 pt 4SL (2 to 8 lb)	Patches or individual plants in CRP, pastures, fallow, and noncropland.	Bindweed: Actively growing and regrowth 12 inches long to bud.	Apply to foliage and/or soil. Consult label for grazing restrictions. Use low rate only in fall and high rates in dense or old stands. Add oil adjuvant to improve control.
Tordon 22K (picloram ⁴) + 2,4-D ⁴ RUP	2 to 4 pt SL + 1 to 2 pt 4EC/SL (0.5 to 1 + 0.5 to 1 lb)	Pasture, rangeland, CRP, and noncropland.		Picloram + 2,4-D is more cost-effective than picloram alone at higher rates. Consult reference for grazing restrictions.
Facet L + Overdrive + MSO adjuvant (quinclorac ^{4,0} + dicamba ⁴ & diflufenzopyr ¹⁹)	32 fl oz L + 6 oz WDG + 2 pt (6 oz + 3 oz & 1.2 oz)		Fall: Bindweed: In fall prior to a killing frost. At least 4 inches of stem.	
Perspective (aminocyclopyrachlor ⁴ & chlorsulfuron ²)	3 to 4.75 oz DF (1.2 to 1.9 oz & 0.5 to 0.75 oz)	Non-crop and wildlife habitats.	Actively growing in early summer or fall rosettes.	Use only in non-crop areas. Allow 365 days before grazing or haying. Do not apply near trees. Add NIS at 1 qt/100 gal or MSO at 1 gal/100 gal.

KNAPWEED, DIFFUSE AND SPOTTED AND YELLOW STARHISTLE

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
2,4-D ⁴ amine or ester	2 to 4 pt 4EC/SL (1 to 2 lb)	Fallow, post-harvest, CRP, pasture, and rangeland.	Rosette stage is preferred.	Several years of annual treatment are necessary. Use only registered 2,4-D brands for CRP.
Dicamba ⁴	2 to 4 pt 4SL (1 to 2 lb)		Bud to bloom is second best.	Plants are controlled slowly. Add NIS at 1 qt/100 gal water to improve consistency of control.
Tordon 22K (picloram ⁴) RUP	1 to 2 pt SL (0.25 to 0.5 lb)	CRP, pasture, rangeland, and noncropland.		Consult label for grazing restriction. Apply up to 2 pt/A broadcast and 4 pt/A for spot treatment.
Tordon 22K + (picloram ⁴) 2,4-D ⁴ amine / ester RUP	1 to 2 pt SL + 1 qt 4EC/SL (0.25 to 0.5 lb + 1 lb)			
Method (aminocyclopyrachlor ⁴)	4 to 8 fl oz SL (1 to 2 oz)	Noncropland and wildlife habitats.	Spring: Prior to flowering or fall rosettes.	Use only in noncropland. Allow 365 days before grazing or haying. Do not apply near trees. Apply Method with MSO at 1 gal/100 gal. Apply Perspective with NIS at 1 qt/100 gal or MSO at 1 gal/100 gal. Use lowest rate for yellow starthistle.
Perspective (aminocyclopyrachlor ⁴ & chlorsulfuron ²)	3 to 4.75 oz DF (1.2 to 1.9 oz & 0.5 to 0.75 oz)			
Plateau (imazapic ²)	6 fl oz SL (1.5 oz)	CRP, pasture, rangeland, and noncropland.	Rosette stage in the fall.	<u>For yellow starthistle only.</u> Do not apply more than 4 oz/A in CRP. Add MSO adjuvant at 1 qt/A + 28% UAN at 1 qt/A. Refer to label for restrictions.
Milestone (aminopyralid ⁴)	3 to 7 fl oz SL (0.75 to 1.75 oz)		Spring: Rosette to bolting. Fall: Rosettes.	Apply up to 14 fl oz/A for spot treatment. Use lower rates for yellow starthistle. Apply with NIS at 1 qt/100 gal. Refer to label for grazing restrictions.
Transline (clopyralid ⁴)	2/3 to 1 pt SL (4 to 6 oz)	Noncropland and right-of-way.	Rosette to bud stage.	Add NIS at 1 qt/100 gal water. Stinger is labeled for CRP.
Glyphosate ⁹	1.5 to 2.25 lb ae See Remarks.	Fallow and noncropland.	Bud to bloom stage - late summer to early fall.	Other vegetation will also be killed. Retreat the following spring with 2,4-D at 2 to 4 pt/A to control seedlings and escapes. Refer to label for adjuvant use. Add AMS at 8.5 lb/100 gal water.

KNAPWEED, RUSSIAN

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
Method (aminocyclopyrachlor ⁴)	8 to 12 fl oz SL (2 to 3 oz)	Noncropland and wildlife habitats.	Spring: Prior to flowering or fall rosettes.	Use only in noncropland. Allow 365 days before grazing or haying. Do not apply near trees. Apply Method with MSO at 1 gal/100. Apply Perspective with NIS at 1 qt/100 gal or MSO at 1 gal/100 gal.
Perspective (aminocyclopyrachlor ⁴ & chlorsulfuron ²)	3 to 4.75 oz DF (1.2 to 1.9 oz & 0.5 to 0.75 oz)			
Milestone (aminopyralid ⁴)	5 to 7 fl oz SL (1.25 to 1.75 oz)	CRP, pasture, rangeland, and noncropland.	Spring: Bud to flowering stage. Fall: Dormant plants.	Apply up to 14 oz/A for spot treatment. Apply with NIS at 1 qt/100 gal. Refer to label for grazing restrictions.
Plateau + MSO adjuvant (imazapic ²)	12 fl oz SL + 2 pt (3 oz)		Apply following several hard frosts (mid-October). Plants may be dormant with grey stems and no leaves. Application in mid-September or during flowering in mid-summer provides shorter-term control than late applications.	Rates above 8 fl oz/A can reduce grass production.
Tordon 22K (picloram ⁴)	RUP 3 to 4 pt SL (0.75 to 1 lb)			Consult label for grazing restriction. Apply up to 2 pt/A broadcast and 4 pt/A for spot treatment.

PURPLE LOOSESTRIFE OR LYTHRUM

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
Rodeo / generic 4 lb ae/gal glyphosate ⁹ approved for aquatic use	1 to 1.5 gal/100 gal 1.3 to 1.9 fl oz/gal water of a 4 lb/gal conc. (1 to 1.5% conc.)	Drainage and aquatic sites.	July to early September.	Use only registered 4 lb ae/gal glyphosate formulations. Add NIS approved for use in aquatic sites at 1 gal/100 gal water. Control seedlings using a 2,4-D formulation labeled for use near water. Biological control agents have been introduced for control.
Garlon 3A (triclopyr-amine ⁴) Vastlan (triclopyr-choline ⁴)	1 to 3 gal/100 gal water (3 to 9 lb) 4.5 to 6 qt/A (4.5 to 6 lb)			Add NIS. Minimize overspray to open water especially application along shore of flowing water. Does not affect cattail or desirable grass species. For backpack application add Vastlan at 1 to 1.5%.
Habitat (imazapyr ²)	1 pt SL (0.25 lb)		Plants actively growing.	Can be applied only by federal or state agency personnel trained in aquatic pest control. Will injure cattail.
Milestone (aminopyralid ⁴)	1 pt/100 gal SL (0.125% conc.)	Non-irrigation ditch banks, wildlife or natural areas, seasonally dry wetlands, including riparian areas.	July to early September.	Do not apply directly to water. Safe under or near many tree species. Apply with NIS at 1 qt/100 gal.
Capstone (triclopyr ⁴ & aminopyralid ⁴)	1 gal/100 gal SL (1% conc.)			
Biological Control	Insects			Two leaf feeding beetles (<i>Galerucella</i> spp.) have been successful in the state. Contact your local weed control officer or state APHIS officer in Bismarck.

QUACKGRASS

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
Glyphosate ⁹	0.75 lb	See label.	See label. Generally 6 to 12 inches tall	See label for registered uses, rates for different formulations, and application information.
Maverick² Olympus²	2/3 oz DF 0.6 to 0.9 oz WDG	- HRS wheat - Winter wheat		See label for registered uses, rates for different formulations, and application information.
SU herbicides² Accent/nicosulfuron Resolve/rimsulfuron Option/foramsulfuron	See label.	Registered crops.		See label for application information, adjuvants, and use information. Add MSO at 1.5 pt/A.
POST grass herbicides¹	See page 27.	Labeled broadleaf crops.		Add oil adjuvant at at 1 gal/100 gal water but not less than 1.25 pt/A.

SALT CEDAR

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
Arsenal (imazapyr ²)	1% solution to foliage or 2 qt/A aerial applied to foliage or 12 oz/gal as a cut stump treatment immediately after cutting.	Wildlife openings and wildlands.	August or September is best but can be applied anytime saltcedar is found. Plants should have green leaves (foliar application).	Thoroughly wet foliage. Do not cut down and remove for at least three years following foliar treatment or regrowth will occur. Add MSO adjuvant at 1 qt/A for foliar application or 0.5 to 1% for backpack sprayer. Avoid drift and contact with desirable plants. Do not contaminate surface water.
Garlon 4 (triclopyr-ester ⁴)	25% v/v + oil adjuvant (1 qt + 2 qt) (1 lb)	Non-cropland as basal bark or cut stump.	Treatment in late fall or early spring is best; otherwise any time when the bark is not frozen.	Do not spray over open water or irrigation ditches. Complete coverage around the trunk (Garlon only) or stump is required. Garlon 4A in oil can be applied up to 30 days after to cut stumps. Vastlan should be applied as soon as possible after cutting stumps (no effect as a bark treatment).
Vastlan (triclopyr-choline ⁴)	Undiluted	Cut stump only.		

SPURGE, LEAFY

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
2,4-D ⁴ amine or ester	2 to 4 pt 4EC/SL (1 to 2 lb)	CRP, pasture, and rangeland	Leafy spurge: Early bud stage and fall.	Apply both spring and fall for satisfactory control. Do not graze dairy cows for 7 days or beef cows for 3 days after treatment. Apply only registered 2,4-D brands in CRP.
Tordon 22K (picloram ⁴) + 2,4-D ⁴ ester or amine RUP	1 to 2 pt SL + 2 pt 4EC/SL (0.25 to 0.5 lb + 1 lb)	CRP, pasture, rangeland and roadsides.	Leafy spurge: Spring: True flower stage. Fall: 4 to 12 inch regrowth.	Tordon + 2,4-D at 1 pt/A + 2 pt/A is the most cost-effective treatment in NDSU data. Retreatment at the same rate will be necessary for several years regardless of herbicide or rate. Annual control was greater and years of retreatment needed were less with the 2 pt/A Tordon rate. Fall treatments should use 2 pt/A and apply for 3 to 5 years consecutively.
Tordon 22K + Plateau + 2,4-D ⁴ + MSO adjuvant (picloram ⁴ + imazapic ²) RUP	1 pt SL + 4 fl oz SL+ 1 qt 4EC/SL + 1 qt (4 oz + 1 oz + 1 lb)		Leafy spurge: True flower growth in spring.	Do not apply in fall. Addition of Plateau improves long-term leafy spurge control. 2,4-D is not required but does increase spectrum of weeds controlled. Follow labels of all herbicides used. Apply only in spring when plants are in true flower. Some grasses may show temporary stunting.
Tordon 22K + Overdrive (picloram ⁴ + dicamba ⁴ & diflufenzopyr ¹⁹) RUP	1 to 2 pt SL+ 4 to 6 oz WDG (4 to 8 oz + 2 to 3 oz & 0.8 to 1.2 oz)		Leafy spurge: Spring: True flower stage.	Add oil adjuvant to improve control. Overdrive improves long-term leafy surge control with spring but not fall application timing.
Dicamba ⁴	4 pt 4SL (2 lb)			Add oil adjuvant to improve control.
	4 to 16 pt 4SL (2 to 8 lb)	Patches or individual plants in CRP, pasture or noncropland.	Leafy spurge: Spring: True flower stage. Fall: 4 to 12 inch regrowth.	Consult label for grazing restrictions. Add oil adjuvant to improve control. Re-treatment necessary.
Tordon 22K (picloram ⁴) RUP	4 pt SL (1 lb)			Consult narrative for grazing restrictions.
Glyphosate ⁹	0.75 to 1.5 lb ae See Remarks.	CRP and trees.	Leafy spurge: After July 1 to actively growing plants.	Glyphosate is non-selective. Avoid spraying tree foliage. Retreat with 2,4-D at 2 to 4 pt/A following spring application to control seedlings and escapes. Add AMS at 8.5 lb/100 gal.
Facet L + MSO adjuvant (quinclorac ^{4,26}) Ransom and Richland counties	32 to 64 fl oz L+ 2 pt (6 to 12 oz)	CRP, pasture and rangeland.	Spring: True flower stage. Fall: 4 to 12 inches of regrowth.	Can be used near trees and in areas with sandy soils/high water tables. Tank-mix with Overdrive for long-term control. Allow 7 days before haying. There are no grazing restrictions.
Facet L + Overdrive + MSO adjuvant (quinclorac ^{4,0} + dicamba ⁴ & diflufenzopyr ¹⁹) Ransom and Richland counties	32 fl oz L + 6 oz WDG + 2 pt (6 + 3 oz & 1.2 oz)	Noncrop, pasture, rangeland, and wildlife habitats.	Spring: True flower. Fall: Prior to frost.	Allow 7 days before haying.
Krenite (fosamine)	12 to 16 pt (6 to 8 lb)	Noncropland, adjacent to water and trees.	Spring: True flower growth stage. Fall: Early.	Inconsistent control. Best control with high humidity and good soil moisture. Do not contaminate water during application.

SPURGE, LEAFY cont.

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
Rodeo / generic 4lb ae/gal glyphosate ⁹ approved for aquatic use	2 pt SL (0.75 lb)	Adjacent to water.	Mid-July to mid-September.	Use only registered glyphosate formulations. Add NIS approved for use near water at 2 to 4 qt/100 gal water. Subsequent years: Control seedlings with a 2,4-D formulation labeled near water.
2,4-D ⁴ amine	2 to 4 pt SL (1 to 2 lb)		Leafy spurge: Actively growing.	Use only 2,4-D formulations labeled for use in or near water, such as Agrilience "AgriSolutions 2,4-D Amine 4", Nufarm "Weedar 64", or Loveland "Savage" and "Amine 4 2,4-D".
Landmaster BW / generic glyphosate ⁹ & 2,4-D ⁴	54 fl oz 2.4 SL (0.38 & 0.63 lb)	Noncropland, pasture, and fallow.	Leafy spurge: Seed set stage or actively growing in fall.	Some grass injury and stunting may occur. Injury is greater with fall than spring treatments. Not to be used in consecutive years.
Method (aminocyclopyrachlor ⁴)	8 to 12 oz SL (2 to 3 oz)	Noncropland and wildlife habitats.	Spring: Prior to flowering or fall rosettes.	Use only in noncropland. Allow 365 days before grazing or haying. Do not apply near trees. Apply Method with MSO at 1 gal/100 gal. Apply Perspective with NIS at 1 qt/100 gal or MSO at 1 gal/100 gal.
Perspective (aminocyclopyrachlor ⁴ & chlorsulfuron ²)	4.75 to 6 oz DF (1.9 to 2.4 oz & 0.75 to 0.95 oz)			
Plateau + MSO adjuvant (imazapic ²)	8 to 12 fl oz SL + 2 pt (2 to 3 oz)	Pasture, new or existing grass plantings in cropland, CRP or noncropland.	Early to mid September.	May be used on CRP, pasture, rangeland, industrial sites, roadside right-of-way or noncropland. Rates above 8 fl oz can reduce grass production, especially cool season species. Safe under most tree species but will cause temporary yellowing of spruce candles. See label for additional information.
Plateau + Sharpen + NIS adjuvant (imazapic ² + saflufenacil ¹⁴)	4 to 6 fl oz SL+ 1 to 2 fl oz SC+ 1 qt/100 gallon (1 to 1.5 oz + 0.36 to 0.72 oz)	Noncropland and wildlife habitats.	Spring: True flower stage.	Allow 365 days before grazing or haying. Do not apply in the fall. Can also be applied with AMS. Substituting MSO adjuvant for NIS will injure grasses. See label for additional information.
Casoron 4G Norosac 10G (dichlobenil)	150 to 200 4G 60 to 80 lb 10G (6 to 8 lb)	Sensitive areas such as near trees or water where long residual herbicides cannot be used.	Leafy spurge: Late Nov. to early March - before emergence.	Season long suppression only. Must be applied before leafy spurge emerges. No POST control.
Overdrive + MSO adjuvant (dicamba ⁴ & diflufenzopyr ¹⁹)	6 oz WDG + 2 pt (3 oz & 1.2 oz)		Spring: True flower. Fall: Early to mid-September.	Do not allow spray to contact basal bark or tree leaves.
GrazonNext HL + Overdrive + MSO adjuvant (aminopyralid ⁴ & 2,4-D ⁴ + dicamba ⁴ & diflufenzopyr ¹⁹) Ransom and Richland counties	2.1 pt + 4 oz WDG + 2 pt (1.7 & 14 oz + 2 & 0.8 oz)		Somewhat less control than when mixed with Overdrive, but safe to use in areas with high water table.	
Cultivation		Cropland.	Leafy spurge: 2 to 4 inches tall.	Leafy spurge will not survive intensive tillage. Repeat when plants are 2 to 4 inches tall.
			Late fall.	Cultivate when plants are 3 to 6 inches tall on fallow or post-harvest in September and again in October.
Biological Control	Insects and Grazing	CRP, pasture, rangeland and noncropland.	See narrative.	Several insects are available. Sheep and goats can be used for management of leafy spurge infestations.

THISTLE, CANADA

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
Express / generic tribenuron ²	0.17 to 0.33 oz DF 0.25 to 0.5 SG	Wheat, barley and pasture.	Thistle: Rosette to pre-bud stage.	Add 2,4-D ester. Add NIS except when adding 2,4-D ester at 0.75 pt/A.
Thifen ² & Triben ² 4:1 ratio 75DF Affinity T/M 50SG 3:1 Audit 75DF 2:1 ratio 75DF 1:1 ratio 75DF Affinity B/S 50SG	0.4 to 0.67 oz DF 0.6 to 1 oz SG 0.3 to 0.5 oz DF 0.3 to 0.66 oz DF 0.25 to 0.5 oz DF 0.4 to 0.8 oz SG	Provides a broader spectrum of control than either a.i. alone. Choose ratio based on prevalent weeds.		
MCPA ⁴ or 2,4-D ⁴ amine or ester	1.5 pt 4SL (0.75 lb) 1.33 pt 4EC (0.66 lb)	Wheat and barley.	Crop: Tiller stage.	Patch spray at higher rates may injure crop but may provide greater thistle control. Small grains are more tolerant to MCPA than 2,4-D. Suppression only.
2,4-D ⁴ ester or amine	2 to 4 pt 4EC/SL (1 to 2 lb)	Fallow or post-harvest.	12 inches tall and actively growing.	Cultivate fallow until early July to achieve rosette stage at time of application. Spray in late August or September. Re-treatment necessary. Suppression only.
	3 to 4 pt 4EC/SL (1.5 to 2 lb)	CRP, pasture, and rangeland or trees.		Apply only registered 2,4-D brands in CRP. Refer to paragraph for livestock grazing restrictions. Use only amine formulation in trees. Suppression only.
Curtail M / generic clopyralid ⁴ &MCPA ⁴	1.75 to 2.33 pt SL (0.09 to 0.122 lb & 0.5 to 0.68 lb)	Wheat, barley, and CRP.	Crop: 3-leaf to jointing.	<u>Rosette technique</u> : Products containing glyphosate or clopyralid fall-applied to Canada thistle in the rosette stage provides greater control than when applied to bolting or flowering stems. Refer to paragraph T3 for control of Canada thistle using the rosette technique.
Curtail / generic clopyralid ⁴ & 2,4-D ⁴	2 pt SL (0.09 lb & 0.5 lb)		Crop: 4-leaf through jointing.	
	4 pt SL (0.19 lb & 1 lb)	Fallow.	Thistle: Rosette until prior to bloom.	
	4 to 6 pt SL (0.19 to 0.29 lb & 1 to 1.5 lb)	CRP and pasture.		
Stinger / generic clopyralid ⁴	0.25 to 0.67 pt SL (0.09 to 0.25 lb)	Sugarbeet, wheat, barley, oat, corn.	Thistles: Rosette to pre-bud stage.	High rates in pasture is expensive but more effective.
	0.67 to 1.3 pt SL (0.25 to 0.5 lb)	CRP, pasture and rangeland.		
Hornet (flumetsulam ² & clopyralid ⁴)	2 to 5 oz WDG (0.37 to 0.09 oz & 1 to 2.5 oz)	Corn.	Corn: Up to 24 inches tall. Use drop nozzles on 20 to 24 inch corn.	Add a oil adjuvant at 1 to pt/A. Refer to label for tank-mix options.
Dicamba ⁴	0.5 to 1 pt 4SL (0.25 to 0.5 lb)		Corn: POST up to 5 inches tall.	Do not apply more than 0.5 pt/A after corn is more than 5 inches tall. Can be applied 15 days prior to tasseling.
Distinct Overdrive (dicamba ⁴ & diflufenzopyr ¹⁹)	6 oz WDG (3 oz & 1.2 oz)	Corn, fallow, and noncropland.	Corn: 4 to 24 inches tall.	Distinct is labeled in cropland - allow 7 days before haying/grazing. Overdrive is labeled in CRP, pasture, rangeland, and noncropland. Add NIS at at 1 qt/100 gal water + 28% UAN at 1.25 qt/A or AMS at 8.5 lb/100 gal. Canada thistle suppression only.
Basagran ⁶	1 to 2 pt SL (0.5 to 1 lb)	Soybean and dry bean: Any stage. Field pea: More than 3 leaf pairs or 4 nodes.	Canada thistle: 6 to 8 inches tall.	Contact herbicide requiring thorough coverage. Apply in two sequential applications with MSO at 1.5 pt/A. <u>Rosette technique</u> : Repeated in-crop applications control Canada thistle during the growing season but allow fall rosette growth. Refer to paragraph T3 for control of Canada thistle using the rosette technique.

THISTLE, CANADA cont.

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
Glyphosate ⁹	Up to 2.25 lb ae. See Remarks.	Patches in corn, wheat, oat or soybean.	Prior to heading or flowering.	Rosette technique: Glyphosate or clopyralid fall-applied to Canada thistle in the rosette stage provides greater control than when applied to bolting or flowering plants. Refer to paragraph T3 for control of Canada thistle using the rosette technique. Add AMS fertilizer at 8.5 lb/100 gal. Crop will be killed in treated area.
	Refer to label.	RR Corn: Up to 30 inches tall/6 collars. RR Soybean: Emerge to 14 day PHI. RR canola: Prior to bolting.		
	Up to 2.25 lb ae. See Remarks.	Preharvest wheat, corn, soybean, field pea, and lentil.	Crop seed is physiologically mature. Thistle: At or beyond bud stage.	
		Fallow or post-harvest.	Canada thistle: Rosette or beyond bud stage.	Avoid spraying tree foliage.
		CRP, noncropland and around trees.		
Dicamba ⁴	2 to 4 pt 4SL (1 to 2 lb)	Fall or post-harvest.	Thistle: At least 6 inches tall. Most effective when thistle is in the rosette stage.	May be applied at a lower rate with 2,4-D or glyphosate to reduce soil residue. Add oil adjuvant at 1 to 2 pt/A.
	1 pt 4SL (0.5 lb)	CRP, pasture and rangeland.	Thistle: Rosette to 12 inches tall.	Consult label for grazing restrictions. Add oil adjuvant at 1 to 2 pt/A. Mow in noncrop or cultivate in fallow until early July to achieve rosette stage at time of application, followed by spray in late August or September. Retreatment necessary. Refer to label for additional information.
	4 to 8 pt 4SL (2 to 4 lb)	Patches in CRP, pastures, fallow and noncropland.	Spring. Thistle: Rosette to prebud stage. Fall: Rosette following light frost but prior to a killing frost.	
Transline (clopyralid ⁴)	0.67 to 1.3 pt SL (0.25 to 0.5 lb)	Pasture, rangeland, and noncropland.		Add oil adjuvant at 1 to 2 pt/A. Observe grazing restriction for lactating animals.
Overdrive + MSO adjuvant (dicamba ⁴ & diflufenzopyr ¹⁹)	6 oz WDG + 2 pt/A (3 oz & 1.2 oz)	Trees.		Do not allow spray to contact basal bark or tree leaves. Mid-summer mowing promotes active growth for effective fall control of rosettes.
Milestone (aminopyralid ⁴)	5 to 7 fl oz SL (1.25 to 1.75 oz)	CRP, pasture, rangeland, and noncropland.		Apply up to 14 oz/A for spot treatment. Use low rate in fall, in low density stands, or areas with good grass stands. Fall application is more consistent than spring. Provides good control when applied in late-fall to freeze-up. Refer to label for grazing restrictions. Commercial mixture with 2,4-D available (GrazonNext HL) to increase spectrum of weed control.
Chlorsulfuron ² & Metsulfuron ⁴	0.5 to 2 oz DF (0.188 to 0.75 oz & 0.15 to 0.6 oz)			Apply oil adjuvant at 1 to 2 pt/A.
Tordon 22K (picloram ⁴)	0.5 to 2 pt SL (0.125 to 0.5 lb)	CRP, pasture, rangeland and fallow.	Thistle: At least 12 inches tall and actively growing.	Retreat at the same rate the following year. Add 2,4-D at 1 qt/A with Tordon at 1 pt/A to improve control. Mid-summer mowing promotes active growth for fall treatment. Mid-September is optimum fall application time and control decreases thereafter. Refer to label for additional information.
		RUP	Patches in CRP and pasture.	Thistle: Actively growing.
Method (aminocyclopyrachlor ⁴)	8 to 12 oz SL (2 to 3 oz)	Noncropland and wildlife habitats.	Actively growing in early summer or fall rosettes.	Use only in noncropland. Allow 365 days before grazing or haying. Do not apply near trees. Apply Method with MSO at 1 gal/100 gal. Apply Perspective with NIS at 1 qt/100 gal or MSO at 1 gal/100 gal. Only use helicopter for aerial application on rights-of-ways. Read label for other restrictions.
Perspective (aminocyclopyrachlor ⁴ & chlorsulfuron ²)	3 to 4.75 oz DF (1.2 to 1.9 oz & 0.5 to 0.75 oz)			

THISTLE, BIENNIAL: BULL, MUSK, AND PLUMELESS

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
2,4-D ⁴	3 to 4 pt 4EC/SL (1.5 to 2 lb)	CRP, pasture, rangeland, and noncropland. (Refer to Remarks and Paragraphs for restrictions)	Late-fall or early spring when thistles are in the seedling to rosette stage. Biennial thistles reproduce only by seed, so control prior to flowering will eventually eradicate infestations. Consult respective label for grazing restrictions.	Apply only registered 2,4-D brands in CRP.
2,4,D ⁴ + dicamba ⁴	2 pt 4EC/SL + 1 to 4 pt (1 lb + 0.5 to 2 lb)			Add oil adjuvant at 1 to 2 pt/A.
Chlorsulfuron ² & Metsulfuron ²	0.5 to 2 oz DF (0.188 to 0.75 oz & 0.15 to 0.6 oz)			Add oil adjuvant at 1 to 2 pt/A.
Dicamba ⁴	1 to 2 pt 4SL (0.5 to 1 lb)			Add oil adjuvant at 1 to 2 pt/A. Use high rate for patch treatment.
Curtail / generic clopyralid ⁴ & 2,4-D ⁴	4 to 6 pt SL (0.19 to 0.29 lb & 1 to 1.5 lb)			See remarks for Redeem below.
Glyphosate ⁹	Up to 2.25 lb ae See Remarks.			Non-selective, non-residual, foliar herbicide. Refer to label for adjuvant use. Add AMS fertilizer at 8.5 lbs/100 gal.
Milestone (aminopyralid ⁴)	3 to 5 fl oz SL (0.75 to 1.25 oz)		Spring: Rosette to bolting plants. Fall: Seedlings and rosette plants.	Use higher rate on plants in late-bolt to flowering growth stages and/or dense stands. Commercial mixture with 2,4-D available (GrazonNext HL) to increase spectrum of weed control. Apply with NIS at 1 qt/100 gal. Refer to label for grazing restrictions.
Overdrive (dicamba ⁴ & diflufenzopyr ¹⁹)	6 oz WDG (3 oz & 1.2 oz)			Labeled only in noncropland. Add oil adjuvant at 1 to 2 pt/A.
Transline (clopyralid ⁴)	0.33 to 1.33 pt SL (0.125 to 0.5 lb)	Pasture, rangeland, and noncropland		Very effective but more expensive than other treatments.
Tordon 22K (picloram ⁴) RUP	0.5 to 2 pt SL (0.125 to 0.5 lb)		Use high rate for patch treatment. Apply up to 2 pt/A broadcast and up to 4 pt/A for spot treatment.	
Tordon 22K (picloram ⁴) + 2,4-D ⁴ RUP	1 + 2 pt 4EC/SL (0.125 + 1 lb)		Apply only registered 2,4-D brands in CRP.	
Method (aminocyclopyrachlor ⁴)	4 to 8 fl oz SL (1 to 2 oz)	Noncropland and wildlife habitats.	Spring: Prior to flowering or fall rosettes.	Use only in noncropland. Allow 365 days before grazing or haying. Do not apply near trees. Apply Method with MSO at 1 gal/100 gal. Apply Perspective with NIS at 1 qt/100 gal or MSO at 1 gal/100 gal.
Perspective (aminocyclopyrachlor ⁴ & chlorsulfuron ²)	1.75 to 2.75 oz DF (0.7 to 1.1 oz & 0.3 to 0.4 oz)			

TOADFLAX, DALMATIAN AND YELLOW

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
Plateau + MSO adjuvant (imazapic ²)	12 fl oz SL + 2 pt (3 oz)	CRP, pasture, rangeland, and noncropland.	After hard frost when 25% of foliage is necrotic.	FOR DALMATIAN TOADFLAX ONLY. Applications prior to hard frost may result in poor control. Retreat as necessary.
Chlorsulfuron ²	2 to 3 oz DF (1.5 to 2.25 oz)	Pasture and noncropland.	PRE to early POST.	FOR DALMATIAN TOADFLAX ONLY. Apply at >25 gpa. Add oil adjuvant at 1 to 2 pt/A. Retreat as necessary.
Tordon 22K (picloram ⁴) RUP	1 to 2 qt SL (0.5 to 1 lb)	CRP, pasture, rangeland, and noncropland.	Toadflax: Actively growing through full bloom.	Use maximum rate for yellow toadflax. Apply 2 pt/A for broadcast and 4 pt/A for spot spray. Retreat as necessary.
Tordon 22K + Overdrive (picloram ⁴ + dicamba ⁴ & diflufenzopyr ¹⁹) RUP	1 to 2 qt SL + 6 to 8 oz WDG (0.5 to 1 lb + 3 to 4 oz & 1.2 to 1.6 oz)		Yellow toadflax: Mid-summer during flowering or in fall prior to frost.	Add oil adjuvant at 1 to 2 pt/A. Overdrive added to Tordon greatly improves long-term yellow toadflax control. Use higher rates for yellow toadflax.
Method (aminocyclopyrachlor ⁴)	4 to 8 oz SL (1 to 2 oz)	Noncropland and wildlife habitats.	Best in June prior to flowering. Late season application is less effective.	Use only in noncropland. Control of yellow toadflax decreases the later applications are made in the season. Allow 365 days before grazing or haying. Do not apply near trees. Apply Method with MSO at 1 gal/100 gal. Apply Perspective with NIS at 1 qt/100 gal or MSO at 1 gal/100 gal.
Perspective (aminocyclopyrachlor ⁴ & chlorsulfuron ²)	3 to 4.75 oz DF (1.2 to 1.9 oz & 0.5 to 0.75 oz)			

WORMWOOD, ABSINTH

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
2,4-D ⁴	4 pt 4EC/SL (2 lb)	CRP, pasture, rangeland, noncropland, trees, fallow, or post-harvest.	Apply in early spring and fall when plants are at least 12 inches tall and actively growing. Plants can be mowed in early to mid-summer to promote active regrowth prior to fall treatment.	Apply only registered 2,4-D brands in CRP. Plants are controlled slowly. Do not graze dairy cows for 7 days after treatment. Use amine formulation near trees.
Dicamba ⁴	1 to 2 pt 4SL (0.5 to 1 lb)			DO NOT apply near trees. Apply with oil adjuvant at 1 to 2 pt/A. Observe grazing restrictions.
Curtail / generic cloprralid ⁴ & 2,4-D ⁴	2 pt SL (0.09 lb & 0.5 lb)	Cropland.		Do not apply to new seedlings of grass. Do not cut treated grass for hay within 30 days PHI. Consult label for grazing restrictions.
	4 to 8 pt SL (0.19 to 0.38 lb & 1 to 2 lb)	CRP, pasture, rangeland and noncropland.		0.5 pt/A is the most cost-effective. Apply 4 pt/A for spot treatment. Refer to paragraph for grazing restriction. Use high rate for dense stands.
Tordon 22K (picloram ⁴) RUP	0.5 to 2 pt SL (0.125 to 0.25 lb)			0.5 pt/A is the most cost-effective. Apply 4 pt/A for spot treatment. Refer to paragraph for grazing restriction. Use high rate for dense stands.
Glyphosate ⁹	Up to 1.125 lb ae. See Remarks.	Trees, noncropland, fallow or post-harvest.		Avoid spraying tree foliage. Add AMS fertilizer at 8.5 lbs/100 gal. Use high rates for dense stands.
Milestone (aminopyralid ⁴)	6 to 7 oz SL (1.5 to 1.75 oz)	CRP, pasture, rangeland and noncropland.	Early spring or fall. Mow plants prior to fall application.	Use higher rate when plants are taller than 12 inches. Commercial mixture with 2,4-D available (GrazonNext HL) to broaden spectrum of weed control. Apply with NIS at 1 qt/100 gal. Refer to label for grazing restrictions.
Chaparral (aminopyralid ⁴ & metsulfuron ²)	3 to 3.3 oz DF (1.6 to 1.7 oz & 0.28 to 0.31 oz)		Early spring to plants 12 inches tall or less.	
Method (aminocyclopyrachlor ⁴)	4 to 8 oz SL (1 to 2 oz)	Noncropland and wildlife habitats.	Actively growing in early summer or fall rosettes.	Use only in noncropland. Allow 365 days before grazing or haying. Do not apply near trees. Apply Method with MSO at 1 gal/100 gal. Apply Perspective with NIS at 1 qt/100 gal or MSO at 1 gal/100 gal.
Perspective (aminocyclopyrachlor ⁴ & chlorsulfuron ²)	3 to 4.75 oz DF (1.2 to 1.9 oz & 0.5 to 0.75 oz)			

HOUNDSTONGUE

Herbicide	Product/A (ai/A)	Weed Location	When to Apply	Remarks and Paragraphs
2,4-D ⁴	2 pt 4EC/SL (1 lb)	CRP, pasture, rangeland, and noncropland.	May to mid-June	Apply only registered 2,4-D brands in CRP. First-year rosettes are more susceptible.
Metsulfuron ² + oil adjuvant	1 to 2 oz XP + 1 to 2 pt (0.6 to 1.2 oz)	CRP, pasture, rangeland, and noncropland.		Can be applied throughout the growing season. First-year rosettes are more susceptible.
Plateau + MSO adjuvant + 28% UAN (imazapic ²)	8 to 12 fl oz SL + 1.5 pt + 1 qt (2 to 3 oz)	CRP, pasture, rangeland, and noncropland.		Controls plants when applied PRE or POST

PALMER AMARANTH

Palmer amaranth is in the pigweed (Amaranth) family, is native to the southwestern United States and has moved to many parts of the country including Iowa, Minnesota, North Dakota and South Dakota. Palmer amaranth grows rapidly and can grow to a height of 8 to 10 feet in certain environments. Palmer amaranth is difficult to identify in the seedling stage because it looks similar to four other amaranth species found in North Dakota: redroot pigweed, Powell amaranth, smooth pigweed and waterhemp. There are several characteristics that differentiate the amaranth species. Presence of hair: Redroot pigweed has fine, dense hairs. Powell and smooth pigweed hairs are less dense than redroot. The fine hairs will be most noticeable on the stems towards the newest growth. Palmer and waterhemp have no hair. Leaf shape: Palmer amaranth leaves are wider and ovate to diamond-shaped compared to other amaranth species. Petiole length: The petiole is the stem-like structure that connects the leaf blade to the main stem. In Palmer amaranth the petioles (especially on older leaves) will be as long (or longer) than the leaf blade itself. Flowering structure: Palmer amaranth females have a long main terminal seed head that can reach up to 3 feet long. Palmer amaranth female seed heads also have stiff, sharp bracts that give the seed heads a prickly feel when touched. NDSU Extension developed a website, <https://www.ag.ndsu.edu/palmeramaranth.com> to assist stakeholders so they may learn more about Palmer amaranth and how to identify it. An additional resource is <https://www.ag.ndsu.edu/publications/crops/identification-biology-and-control-of-palmer-amaranth-and-waterhemp-in-north-dakota/w1916.pdf> "Identification, Biology, and Control of Palmer amaranth and waterhemp in North Dakota. Palmer amaranth has been introduced into North Dakota through many different methods. Used equipment, custom combines, contaminated millet seed, and contaminated grain screenings have all introduced Palmer amaranth into different counties in the state. It is important to verify there is no Palmer amaranth seed present on or in equipment, seed, or feed from areas of the country where Palmer amaranth is endemic.

SHELTERBELT WEED CONTROL

Extension Bulletin W-1097, "Weed Control in Tree Plantings" provides additional information.

Read and follow label directions. Most herbicides can injure trees if applied in a manner inconsistent with label directions. Only use herbicide formulations that are labeled in shelterbelts and only as described on the label. Eliminate perennial weeds prior to planting trees. Refer to label for application method (broadcast, over-the-top, directed), timing (spring or fall), and tolerant and susceptible tree species.

Herbicide	Product/A (ai/A)	Remarks
Alion (indaziflam ²⁹)	5 to 6.5 fl oz EC (0.065 to 0.085 lb)	Residual , soil-applied herbicide. Apply PRE in a broadcast, or directed application to soil when around desirable tree species. Adjust rate for soil type. Refer to label for additional information.
Casoron (dichlobenil)	100 to 200 lb 4G (4 to 8 lb)	Volatile, especially on wet soil. Preemergence herbicide for control of annual and perennial weeds in new plantings established at least 4 weeks. Most effective when applied in November or March just before rain or snow to activate and move dichlobenil into the soil.
Fusilade DX (fluazifop-P ¹)	1 to 1.5 pt EC (0.25 to 0.38 lb)	Translocated, postemergence, non-residual herbicide for control of annual and perennial grasses. Spot spray or apply over-the-top of woody species. Add oil additive at 1 qt/A.
Glyphosate ⁹	2% solution or Up to 1.125 lb ae See Remarks.	Non-selective, non-residual, translocated, postemergence herbicide. Effective on annual and perennial plants. Directed spray only. Add AMS at 8.5 lb/100 gal. Avoid contact to desirable species. A4-7 A16 X1
Goal (oxyfluorfen ¹⁴)	5 to 10 pt 1.6EC 4 to 8 pt 2XL (1 to 2 lb)	Residual, preemergence or contact herbicide for control of broadleaf weeds including kochia and some grass weeds. <u>General</u> : Do not incorporate in soil. Apply POST with NIS at 0.25% v/v. Can be applied with a residual herbicide or as a split application. <u>Conifers</u> : Apply pre-transplant, POST or POST-directed prior to bud-break or after new foliage has hardened off. <u>Hardwoods</u> : Apply pre-transplant or POST-directed prior to bud-break. Spray only the base of deciduous trees and <u>not over- the-top</u> . If a non-dormant application is required, apply after new foliage has expanded and hardened off and NOT during periods of new growth. Avoid direct or indirect spray contact with foliage of deciduous trees.
Karmex/Direx (diuron ⁵)	2.5 to 5 lb DF (2 to 4 lb)	Preemergence herbicide for plantings established at least one year. Apply as directed spray. Tolerance of labeled species is fair to very good. Do not use on light soil or in low, wet areas.
Plateau (imazapic ³)	8 to 12 fl oz SL (2 to 3 oz ae)	Add MSO at 2 qt/A. Controls many broadleaf weeds including leafy spurge. Can spray in and around tree species. Do not use on new plantings or seedling trees. Fall treatment will kill lilac and will cause temporary yellowing of spruce candles. Higher rates will reduce grass stands. Refer to label for list of tolerant tree species. Use caution on trees not listed on label.
Segment/Vantage (sethoxydim ¹)	1.5 to 2.5 pt Segment 2 to 3 pt Vantage	Translocated, postemergence, non-residual herbicide for control of annual and perennial grasses. Spot spray or apply over-the-top of most woody species. Add oil additive at 1 qt/A.
Princep / generic simazine ⁵	2 to 4 qt L 2.2 to 4.4 lb DF (2 to 4 lb)	Use only on tree plantings at least three years old. Preemergence herbicide that is most effective on annual broadleaf weeds. For adequate annual grass control apply with a preemergence, residual grass herbicide. Apply in fall or spring in full or split-rate applications. Use high rate in fine textured soils. Refer to label for list of registered tree species.
Rely 280 + AMS (glufosinate ¹⁰)	48 to 82 fl oz SL + 3 lbs/A (0.88 to 1.5 lb)	Non-selective, non-residual, contact herbicide. Directed application only. Controls many annual and perennial weeds. Use 1.7 fl oz/gal for spot application. Use 48 fl oz/A for weeds <3 inches, 56 fl oz/A for weeds <6 inches, and 56-82 fl oz/A for weeds >6 inches + tillered grasses.
Transline / generic clopyralid ⁴	0.25 to 0.67 pt SL (0.1 to 0.25 lb ae)	Safe to only some conifer species. Translocated, postemergence, broadleaf herbicide. Effective on weeds in the legume, smartweed (polygonum) and sunflower (composite) families. Provides excellent control of Canada thistle and knapweeds. Apply to actively growing weeds.
Stomp Pendulum (pendimethalin ³)	2 to 4 qt EC 3.3 to 6.6 lb WDG (2 to 4 lb)	Preemergence herbicide for residual control of annual grasses and some small-seeded broadleaf weeds. Apply before bud break to avoid potential growth suppression. Apply with preemergence broadleaf herbicide for broad spectrum annual weed control.
Treflan / generic trifluralin ³	1 to 2 pt EC (0.5 to 1 lb) 80 lb 5G (4 lb)	Apply PPI for new plantings or established trees. Gives season-long control of many annual grasses and some broadleaf weeds. Does not control weeds in the sunflower, legume or mustard family. Poor perennial weed control but may suppress field bindweed. Cultivation may be required for broadleaf weed control the first season. Apply with a residual preemergence broadleaf herbicide for broad-spectrum weed control.
2,4-D ⁴ amine	1 to 2 qt 4EC/SL (1 to 2 lb ae)	Translocated, postemergence, broadleaf herbicide. Directed application only. Used to reduce infestations of perennial weeds. Broadleaf plants and deciduous trees very sensitive. Avoid drift to desirable species. Use only amine formulations. Use low pressure, coarse spray droplets and apply only in calm weather.

TOTAL VEGETATION WEED CONTROL

Apply herbicides to bare soil rather than dead plants will improve herbicide performance. Add glyphosate to kill existing vegetation if present. Apply high rates followed by lower rates in subsequent years will generally give satisfactory extended control. For short term bare-ground control, non-residual herbicides can be applied several times per year. General precautions when using soil sterilant are:

1. Do not move treated soil and avoid applying where wind or water will move the treated soil.
2. Avoid spray drift. Apply during low wind, reduce spray pressure, and select nozzles that produce larger droplets.
3. Do not apply where roots of desirable vegetation may extend into the treated area.
4. Be familiar with and know the risks of the product to be applied.
5. Use a combination of herbicides with different modes of action to avoid resistant weeds.

Herbicide	Product/A (lb ai/A)	Remarks												
EsplAnade (indaziflam ²⁹ & diquat ²² & glyt ⁹)	8 to 16 fl oz	Spray when weeds are small and actively growing, temperatures above 60° F, and sunny. Re-treat hard-to-kill weeds 2 weeks after first application. Disturbing the soil weed preventative barrier may reduce the effectiveness of this product. Rain 30 minutes after application will not wash away effectiveness. Requires precipitation for soil activation. Long residual. A17												
Diuron ⁵	1 to 8 gal/5 to 15 lb (4 to 32 lb)	Refer to label for use in irrigation ditches. Higher rates needed for perennial grasses and broadleaf weeds. Deep rooted perennials will require retreatment. Long residual. A17												
Glyphosate ⁹	Up to 1.5 lb ae See Remarks.	Non-selective, non-residual , translocated herbicide. Effective on annual and perennial grass and broadleaf plants. Add 2,4-D or dicamba for broad-spectrum weed control. Add AMS at 8.5 lbs/100 gal. A4-6 T10												
Hyvar X Hyvar X-L (bromacil ⁵)	3 to 15 lb DF 0.75 to 6 gal L (2.4 to 12 lb DF 1.5 to 12 lb L)	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;"></td> <td style="width: 33%; text-align: center;">Annual weeds</td> <td style="width: 33%; text-align: center;">Perennial weeds</td> <td style="width: 33%; text-align: center;">Woody plants</td> </tr> <tr> <td>Hyvar X</td> <td style="text-align: center;">3 to 6 lb DF</td> <td style="text-align: center;">7 to 15 lb</td> <td style="text-align: center;">7 to 15 lb</td> </tr> <tr> <td>Hyvar X-L</td> <td style="text-align: center;">1 to 3 gal/A</td> <td style="text-align: center;">3 to 6 gal/A</td> <td style="text-align: center;">3 to 6 gal/A</td> </tr> </table> Apply PRE or EPOST. Non-corrosive and non-volatile. Refer to label for tank-mix options. Bromacil can move horizontally in soil after application. Long residual.		Annual weeds	Perennial weeds	Woody plants	Hyvar X	3 to 6 lb DF	7 to 15 lb	7 to 15 lb	Hyvar X-L	1 to 3 gal/A	3 to 6 gal/A	3 to 6 gal/A
	Annual weeds	Perennial weeds	Woody plants											
Hyvar X	3 to 6 lb DF	7 to 15 lb	7 to 15 lb											
Hyvar X-L	1 to 3 gal/A	3 to 6 gal/A	3 to 6 gal/A											
Krovar I / generic bromacil ⁵ & diuron ⁵	6 to 16 lb DF (4.8 to 12.8 lb)	Apply PRE for annual weeds. Requires moisture for activation. Refer to label for registered tank-mixes. Bromacil can move horizontally in soil after application. Long residual.												
Krovar I + Perspective (bromacil ⁵ & diuron ⁵ + acpc ⁴ & chlorsulf ²)	6 lb DF + 11 oz DF (2.4 + 2.4 lb + 4.4 oz + 1.8 oz)	Add MSO adjuvant at 1 to 2 pt/A. Apply PRE for control of annual grass and broadleaf weeds. Requires moisture for activation. Add glyphosate if emerged grass and broadleaf weeds are present. Bromacil can move horizontally in soil after application. Long residual.												
Landmark MP (sulfometuron ² & chlorsulfuron ²)	1 pkg/5 A DF to 1 pkg/2.5 A DF (1.5 to 3 oz)	Apply PRE to EPOST for broadleaf weeds. Will control/suppress leafy spurge. May be applied with Krovar I DF or Hyvar X to control ALS resistant weeds. Long residual.												
Liberty 280 (glufosinate ¹⁰)	3 to 5 pt SL (0.88 to 1.46 lb)	Non-selective, non-residual contact herbicide for use in non-crop and farmsteads. Use 4 fl oz/gal for spot application. Apply with AMS at 3 lb/A. B9												
Oust (sulfometuron ²)	2 to 4 oz XP (1.5 to 3 oz)	Use high rate in high moisture areas except in residential properties. Will control leafy spurge at 3 oz/A. Do not spray near water. Long residual.												
paraquat ²² RUP	2 to 2.7 ptSL (0.75 to 1 lb)	Non-selective, non-residual , contact herbicide. Controls only top-growth of perennial species. Add NIS and repeat application as necessary. Avoid drift and contact with desirable species.												
Plateau (imazapic ²)	8 to 12 fl oz SL (2 to 3 oz ae)	Add MSO at 2 pt/A. Controls many broadleaf weeds including leafy spurge. Use up to 12 fl oz in combination with other total vegetation control herbicides. T16												
Pramitol 25E (prometon ⁵)	5 to 10 gal EC (10 to 15 lb)	Use 5 to 7.5 gal/A for annual and susceptible perennial weeds and 7.5 to 10 gal/A for hard-to-kill perennial weeds. Apply before weeds emerge or EPOST. Long residual.												
Spike (tebuthiuron ⁵)	1.25 to 5 lb 80DF (1 to 4 lb)	For long-term woody plant and some broadleaf weed control. Avoid application in areas with surface or high water tables. Do not exceed 4 lb ai/A in a three year period. See label for specific species controlled and grazing and haying restrictions. Long residual.												
Throttle (chlorsulf&sulfomet & sulfentrazone ¹⁴)	12.5 oz DF (1.125 oz & 2.25 oz & 6 oz)	Provides residual PRE and POST control of annual weeds and POST control of perennial weeds. Long residual.												

TROUBLESOME WEEDS IN PASTURE, RANGELAND, AND NONCROPLAND

Weed	Herbicide	Product/A	Remarks and Paragraphs
Buckbrush/ West. snowberry	2,4-D ⁴ amine or ester Chlorsulf ² &Metsulf ^{2*} + oil adj. Chaparral ^{2,4}	2 to 3 qt 4EC/SL 2 oz DF + 1 to 2 pt/A 2 to 3 oz	Apply 2,4-D in spring only. Apply anytime during the growing season. Apply in spring to early summer. The addition of 2,4-D increases control at lower use rates.
Baby's breath	Metsulf ^{2*} + Dicamba ⁴ +oil adj.	0.3 to 0.6 oz DF + 1 pt 4S+1-2 pt/A	Best when applied from bolting to pre-flower.
Black henbane	Metsulfuron ^{2*} + oil adjuvant Dicamba ⁴ or Tordon ⁴ + oil adj	0.5 to 1 oz DF + 1 to 2 pt/A 1 to 3 pt 4SL + 1 to 2 pt/A	Apply herbicides during rosette to early flower. Tordon at 1 to 2 pt: Mix with 2,4-D at 1 to 2 pt/A.
Burdock	2,4-D ⁴ amine or ester Chlorsulf ² &Metsulf ^{2*} + oil adj. Dicamba ⁴ + oil adjuvant	1 qt 4EC/SL 0.25 to 0.5 oz DF + 1 to 2 pt/A 1 pt 4SL + 1 to 2 pt/A	Early summer prior to flowering.
Curly dock	Chlorsulf ² &Metsulf ^{2*} + oil adj. Dicamba ⁴ + oil adjuvant Metsulfuron ^{2*} + oil adjuvant Starane ⁴ 1.5/2.8EC/40DG Tordon ⁴ + 2,4-D ⁴ RUP	0.25 to 0.5 oz DF + 1 to 2 pt/A 0.5 to 1 pt 4 SL + 1 to 2 pt/A 0.1 oz + 1 to 2 pt/A 0.67 pt / 0.35 pt / 5 oz 0.5 to 1 pt + 1 to 2 pt 4EC/SL	Early spring to bolting is best. Herbicides will control curly dock when treated later in the summer but will need higher rates.
Dame's rocket	2,4-D ⁴ or MCPA ⁴ + oil adj. Metsulfuron ^{2*} + oil adj.	1 to 1.5 pt + 1 to 2 pt/A 1 oz + 1 to 2 pt/A	Apply in fall to rosette or early spring prior to bolting. Avoid spraying tree bark or foliage.
Foxtail barley	Plateau ² + MSO + 28% UAN	8 to 12 fl oz + 1.5 pt + 1 qt	
Goldenrod	2,4-D ⁴ amine or ester Chlorsulf ² &Metsulf ^{2*} + oil adj. Metsulfuron ^{2*} + oil adjuvant Tordon ⁴ + 2,4-D ⁴ RUP	3 to 6 pt 4EC/SL 1 oz DF + 1 to 2 pt/A 0.33 to 0.5 oz + 1 to 2 pt/A 1 pt + 1 qt 4EC/SL	Mid-June through flowering when plants are not stressed.
Gumweed	2,4-D ⁴ amine or ester Chlorsulf ² &Metsulf ^{2*} + oil adj. Metsulfuron ^{2*} + oil adjuvant	1.5 to 2 pt 4EC/SL 1 oz DF + 1 to 2 pt/A 1 oz + 1 to 2 pt/A	Early spring when plants are not stressed.
Halogeton	2,4-D ⁴ amine or ester Metsulfuron ^{2*} + oil adjuvant Plateau ² + MSO + 28% UAN	1 to 2 pt 4EC/SL 0.75 oz DF + 1 to 2 pt/A 1 to 3 oz + 1.5 pt + 1 qt	2,4-D: Apply very early in spring prior to flowering. Escort: Apply to actively growing plants. Apply PRE to POST. Use higher rates for POST.
Hoary cress	Metsulfuron ^{2*} + oil adj.	1 oz + 0.25% v/v + 1 to 2 pt/A	Apply in spring prior to flowering. Difficult-to-control perennial requiring followup treatments.
Mint	Chlorsulf ² &Metsulf ^{2*} + oil adj. Dicamba ⁴ + 2,4-D ⁴ + oil adj. Metsulfuron ^{2*} + oil adjuvant Tordon ⁴ + 2,4-D ⁴ RUP	1 oz DF + 1 to 2 pt/A 1 pt 4S + 1 qt 4EC/SL + 1 to 2 pt/A 1/3 to 1/2 oz + 1 to 2 pt/A 1 pt + 1 qt 4EC/SL	Apply mid-June through flowering when plants are not stressed.
Poison ivy	Crossbow ^{4,4} Garlon ⁴ 3A or 4	1.5 gal 3 to 4 pt or 2 to 3 pt	Apply to plants actively growing.
Prick. pear cactus	Tordon ⁴ RUP	2 pt	Apply late-spring to early summer.
Ragweed	Chlorsulf ² &Metsulf ^{2*} + oil adj. Tordon ⁴ + 2,4-D ⁴ RUP	0.25 oz DF + 1 to 2 pt/A 1 pt + 1 qt 4EC/SL	Apply mid to late summer.
Sagebrush, fringed	2,4-D ⁴ ester Chlorsulf ² &Metsulf ^{2*} + oil adj. Tordon ⁴ RUP	2 to 4 pt 4EC/SL 1 oz DF + 1 to 2 pt/A 1 to 2 pt	Best when applied in May. Plants should be leafed out and growing in good moisture conditions.
Sagebrush	2,4-D ⁴ ester	2 to 4 pt 4EC/SL	
Sagewort, Green	2,4-D ⁴ ester Tordon ⁴ + 2,4-D ⁴ RUP	4 pt 4EC/SL 1 pt + 1 qt 4EC/SL	
Swamp smartweed	Dicamba ⁴ + oil adjuvant Metsulfuron + oil adjuvant Tordon ⁴ + 2,4-D ⁴ RUP Weedmaster ^{4,4*}	0.5 to 1 pt 4SL + 1 to 2 pt/A 0.1 oz + 1 to 2 pt/A 1 pt + 1 qt 4EC/SL 1 pt	Apply to plants 1 to 4 inches tall. Apply in mid to late summer.
Trees, volunteer	Crossbow ^{4,4} Tordon+2,4-D+Remedy ⁴ RUP	2% solution or 2 gal/A 2% or 1 pt + 1 qt 4EC/SL + 1 pt	Add NIS at 0.5% v/v. Apply after tree leaves have fully expanded.
Wild licorice	Milestone ⁴ Transline ⁴	7 pt/A 1 pt /A	Apply when plants are actively growing.

* Or generic equivalent

TROUBLESOME WEEDS IN CROPLAND AND OTHER AREAS

Weed	Herbicide	Product/A	Remarks and Paragraphs
Alfalfa	2,4-D ⁴ + Dicamba ⁴ + MSO Stinger ^{4*} or Curtail ^{4,4*} +MSO	2 pt 4EC/SL+0.5 pt+1.5 pt/A 0.67 pt or 4 pt + 1.5 pt/A	Roundup / generics (2 to 4 pt/A) is less effective.
Buffalobur	Dicamba ^{4*} + MSO adjuvant	0.5 pt 4SL + 1.5 pt/A	Cobra, 2,4-D, MCPA, and Pursuit are less effective.
Cleavers/Catch-weed bedstraw	Starane ^{4*} 1.5/2.8EC/40DG Affinity ^{2,2*} + NIS Orion ^{2,4} + NIS	0.67 pt / 0.35 pt / 5 oz DF or SG - See label for rate. 17 oz	Liberty is less effective. Apply Affinity and Orion with NIS at 1 qt/100 gal water.
Cattail	Glyphosate ⁹ (only 4 lb ae/gal no adjuvant formulations)	4.5 pt of 4 lb ae/gal conc.	Add approved NIS at 1 qt/100 gal water. Apply at early to full bloom stage = late July to mid August. A3-8
	Arsenal ² + MSO adjuvant Raptor ² + MSO adjuvant	2 to 4 pt (1% v/v solution) 4 to 5 fl oz + 1.5 pt/A	Apply to cattail with green foliage/after leaf elongation. May require retreatment.
Curly dock	Stinger ^{4*} or Curtail [*] Express ^{2*} + oil adjuvant Harmony ^{2*} + oil adjuvant	0.67 pt or 2 pt 0.5 oz SG + 1.5 pt/A 0.9 oz SG + 1.5 pt/A	Stinger/Curtail has crop rotation restrictions. Add MSO at 1.5 pt/A. Apply to small plants. SU mixtures of thifensulfuron & tribenuron are also effective.
Common milkweed	Roundup ^{9*} + NIS + AMS Express ^{2*} + 2,4-D ⁴ +Banvel ^{4*}	2%+1 qt/100 gal+8.5 lbs/100 0.33 oz DF + 0.75 pt + 2 fl oz	Glyt - Suppression only. Will require retreatment. A3-8 Exp+2,4-D+Banvel - Apply high rates for spot treatment.
Dandelion	2,4-D ⁴ + MSO Stinger ^{4*} Dicamba ⁴ + MSO Express ^{2*} + MSO Glyphosate ⁹ + NIS + AMS Callisto or Impact or Laudis ²⁷	2 to 4 pt + 1.5 pt/A Refer to premix label. 0.5 pt 4SL. Apply with 2,4-D DF or SG - See label for rate. 1 to 3 lb ae 3 fl oz or 0.75 fl oz or 3 fl oz	2,4-D - Best control when applied in fall. Stinger - Apply premixes - Curtail and WideMatch. Banvel - Residue may injure next crop to be planted. Express - Partial control. Apply with 2,4-D. Roundup - Best control when applied in fall. Callisto/others - Partial control. Add MSO at 1.5 qt/A.
Equisetum (Horsetail) (Scouring rush)	MCPA ⁴ + MSO Permit ² + MSO Python ² + MSO Remedy/Garlon ⁴ + MSO Glean ^{2*} + MSO	1 qt/A 4EC/SL + 1.5 pt/A 1.33 oz DF + 1.5 pt/A 1.33 oz DF + 1.5 pt/A 2 qt + 1 to 1.5 pt/A 3 oz DF + 1.5 pt/A	Glyphosate is less effective. Retreatment necessary. Permit - Apply two applications each at 1.33 oz/A. Python - Apply with oil adjuvant PRE or POST. Remedy/Garlon and MCPA - Apply fall or spring. Glean/Telar/Oust - Will result in total vegetation control.
False chamomile	SUs ² / Orion + adj. Glyphosate ⁹ + NIS + AMS Valor ¹⁴ (Fall applied)	See label + NIS or oil adj. 1 qt + 1 qt/100 + 8.5 lbs/100 2 to 3 oz WDG	SU herbicides - Oil adjuvant will increase control. Roundup - Avoid spraying desirable vegetation. A3-8 PRE activity.
Flax, volunteer	Cobra / Blazer + oil adjuvant Elevore + MSO Flexstar ¹⁴ /Reflex ¹⁴ + oil adj. Facet L ^{4,0} + MSO Pursuit ² + Sencor ^{5*} (PRE) Starane ^{4*} 1.5/2.8EC/40DG Affinity ^{2*} + NIS Express ^{2*} + 2,4-D ⁴ + NIS	See label + 1 to 2 pt/A 1 fl oz + 1.5 pt/A 0.5 to 0.75 pt + 1 to 2 pt/A 0.33 oz DF + 1.5 pt/A 1 to 2 fl oz + 0.375 0.67 pt / 0.35 pt / 5 oz DF or SG - See label for rate. DF or SG + 0.75 pt 4EC/SL	Apply to flax < 3inches tall. Elevore - see label for crop rotation restrictions. Apply to small plants. Use only east of Hwy 281. Facet - see label for crop rotation restrictions. Add oil adjuvant at 1 to 2 pt/A Starane - No adjuvant needed. Affinity - Add NIS at 1 qt/100 gal water. Express - Add NIS at 1 qt/100 gal water.
Hemp dogbane	2,4-D ⁴ + Banvel ^{4*} + MSO Dicamba ⁹ + NIS + AMS	1 to 2 pt 4EC/SL + 1.5 pt 2% v/v 4SL	Banvel at 2 pt/A may will injure some crops planted the next year. A3-8
Horseweed (Marestail)	2,4-D ⁴ + MSO Callisto / Impact / Laudis ²⁷ FirstRate ² + MSO Hornet ^{2,4} + MSO Python ² + MSO Spartan ¹⁴ + MSO Valor ¹⁴ + MSO	1 to 2 pt + 1.5 pt/A 3 fl oz / 0.75 fl oz / 2 to 3 fl oz 0.3 oz WDG + 1.5 pt/A 3 to 4 oz WDG + 1.5 pt/A 1 oz WDG + 1.5 pt/A 3 to 6 fl oz + 1.5 pt/A 2 to 3 oz WDG + 1.5 pt/A	2,4-D (preplant) to some labeled crops is effective. Callisto/Impact/Laudis - Add MSO at 1.5 pt/A Roundup, atrazine, paraquat are less effective. Pursuit and Harmony are not effective. Most herbicides listed have rotational crop restrictions. Follow label guidelines. Python/Spartan/Valor = PRE control. Will not control emerged plants.
Nightflowering catchfly/ White cockle	Tribenuron + NIS Trib + thifensulfuron ^{2*} + NIS Huskie ^{6,27} (not confirmed)	DF or SG - See label for rate. DF or SG - See label for rate. 15 fl oz	Add NIS at 1 qt/100 gal water. Apply to small plants. Add NIS at 1 qt/100 gal water. Apply to small plants. Huskie also controls other cockle species.
Sowthistle (Ann. or perennial)	Ally ^{2*} + MSO Express ^{2*} + MSO	1/10 oz DF + 1.5 pt/A DF or SG - See label for rate.	Apply with 2,4-D or Banvel. 2,4-D, Banvel, Curtail, and Roundup applied alone are less effective.
Waterpod	2,4-D ⁴ , Pursuit ² or SUs ²	See label.	See Pursuit label for crop rotation restrictions.
Wild cucumber	Dicamba ⁴ + MSO Glyphosate ⁹ + NIS + AMS	0.5 4SL + 1.5 pt/A 1 qt/A + 1 qt/100+8.5 lbs/100	Banvel may injure or kill trees. Mechanical control or handweed is best. Banvel may injure trees. A3-8
Yellow nutsedge	Permit ² + MSO Basagran ⁵ + MSO	0.67 fb 0.67 oz + 1.5 pt/A 1.5 pt fb 1.5 pt + 1.5 pt/A	Pursuit, Dual, Roundup are less effective. Permit may injure crops planted the following years.

* Or generic equivalent

GENERAL INFORMATION

Refer to web version of the ND Weed Control Guide at: www.ndsu.edu/weeds for additional general information:

- Field investigation of crop injury
- Herbicide + Insecticide/Fungicide/Fertilizer
- Herbicide storage temperatures

A1. PPI AND PRE HERBICIDES

Incorporation of herbicides

Good weed control with PPI and PRE herbicides depends on many factors, including rainfall after application, soil moisture, soil temperature, soil type and weed species. For these reasons, PRE herbicides applied to the soil surface sometimes fail to control weeds. Herbicides that are incorporated into the soil surface usually require less rainfall after application for effective weed control than unincorporated herbicides. A rotary hoe or harrow will activate PRE herbicides under dry conditions and control small weeds emerging through a PRE herbicide.

Many factors influence the activity and performance of soil-applied herbicides. Factors that should be considered are: rate too low for soil type, high weed pressure, weeds not listed on label, poor control in wheel tracks, cloddy soil, wet soil, amount of previous crop residue, dry weather, poor incorporation, improper setting of incorporation implement, herbicide resistant weeds, incorporation too shallow or deep, incorporation speed too slow, worn sweeps on cultivator, single pass instead of two pass incorporation, and second incorporation deeper than first. Consider these possibilities before poor weed control is attributed only to the herbicide.

Buckle, Eptam, Far-Go, Ro-Neet, Sonalan, and Treflan* require incorporation. Eptam, Far-Go, and Ro-Neet must be incorporated immediately (within minutes) after application. Treflan incorporation may be delayed up to 24 hours if applied to a cool, dry soil and if wind velocity is less than 10 mph. Sonalan incorporation may be delayed up to 48 hours. Prowl* is labeled only PPI in soybean, dry beans, and pulse crops and labeled PRE, not PPI, on corn. Dual*, Harness/Surpass*, and Outlook* may be used PRE but shallow PPI improves weed control, particularly on fine textured soils. Incorporation of Dual*, and Nortron* may be delayed several days. Incorporation of Eradicane and Eptam can be delayed up to 4 hours when applied with liquid fertilizer and the same day when impregnated on dry bulk fertilizer. Ro-Neet can be incorporated up to 4 hours after application and up to 8 hours when impregnated on dry fertilizer.

Perform a second tillage at right angles to the initial incorporation if a disk or field cultivator is used. The second incorporation will incorporate any herbicide remaining on the soil surface and provide more uniform distribution in the soil, thereby improving weed control and reducing crop injury.

A2. SOIL ORGANIC MATTER TEST

Soil-applied herbicides are adsorbed and inactivated by soil constituents in the following order: organic matter>clay>silt>sand. Adjust herbicide rates for soil type and organic matter content. Most soil-applied herbicides require higher rates to be effective in high organic matter soils, but crop safety may be marginal on low organic matter soils. Linuron activity requires low organic matter. Far-Go, Treflan* and most POST herbicides are affected only slightly by organic matter levels. Organic matter levels should be determined on each field where organic-matter-sensitive herbicides are to be used. Organic matter levels change very slowly, and testing once every 5 years should be adequate.

*Or generic equivalent.

A3. POST APPLIED HERBICIDES

Weed control from POST herbicides is influenced by rate, weed species, weed size, and climatic conditions. Labeled rates will be effective under favorable conditions and when weeds are small and actively growing. Use the highest labeled rates under adverse conditions and for well established weeds.

Sunlight inactivates some herbicides by the ultraviolet (UV) spectrum of light. Treflan* and Eptam degradation is minimal when incorporated soon after application. "Dim" herbicides (Achieve, Select*, and Poast) are highly susceptible to UV light and will degrade rapidly if left in nonmetal spray tanks for an extended period of time or if applied during mid-day. To avoid UV breakdown, apply soon after mixing and add an effective oil adjuvant which speeds absorption.

Ideal temperatures for applying most POST herbicides are between 65 and 85 F. Speed of kill may be slow when temperatures remain below 60 F. Some herbicides may injure crops if applied above 85 F or below 40 F. Avoid applying volatile herbicides under conditions where vapors and particle drift may injure susceptible crops, shelterbelt trees, or farmsteads.

Temperatures following herbicide application influence crop safety and weed control. Crops metabolize herbicides but metabolism slows during cool or cold conditions, which extends the amount of time required for plants to degrade herbicides. Rapid degradation under warm conditions allow plants to escape herbicide injury. Herbicides may be sprayed following cold night-time temperatures if day-time temperatures warm to at least 60 degrees.

Some "Fop" ACCase herbicides (fenoxaprop) are more effective during cold/cool temperatures and are much less effective when grass weeds are drought stressed. Other ACCase herbicides, such as Assure II*, Poast, and Select* control grasses best in warm weather when grasses are actively growing. ALS grass herbicides in wheat generally provide more consistent and greater grass control in warm, dry conditions compared with cool, wet conditions. Cool or cold conditions at or following application of ACCase herbicides may increase injury to wheat. Wild oat is a cool season grass but green and yellow foxtail are warm season grasses and may stop growing under cold conditions, resulting in poor control. Weeds are controlled most effectively when plants are actively growing.

Cold temperatures and freezing conditions following application of ALS herbicides, Buctril*, and metribuzin may increase crop injury with little effect on weed control. Delay applying fenoxaprop, ALS herbicides, and metribuzin until daytime temperatures exceed 60F and after active plant growth resumes.

Basagran*, Cobra, Flexstar, Liberty, Ignite, paraquat*, Reflex, and Ultra Blazer are less likely to cause crop injury when cold temperatures follow application but less weed control may result.

2,4-D, MCPA, Banvel*, Starane*, Stinger*, and glyphosate (resistant crops) have adequate crop safety and provide similar weed control across a wide range of temperatures, but weed death is slowed when cold temperatures follow application.

Dew may increase absorption and weed control by hydrating leaf cuticle but may reduce weed control if spray run-off occurs. Rainfall shortly after POST herbicide application reduces weed control because herbicide is washed off the leaves before absorption is complete (See the rainfast interval chart on the next page).

*Or generic equivalent.

Minimum Interval Between Application and Rain for Maximum POST Weed Control.

Herbicide	Time Intrvl.	Herbicide	Time Intrvl.
Acuron/Flexi	4 hr	MCPA ester	1 hr
Aim	1 hr	Milestone	4 hr
Alluvex	6-8 hr	Olympus	4 hr
Ally*/Escort*	4 hr	OpenSky	4 hr
Armezon	1 hr	Orion	4 hr
Armezon Pro	1 hr	Osprey	4 hr
Assure II / Targa	1 hr	Panoflex	4 hr
Atrazine*	4 hr	paraquat*	0.5 hr
Axial Star	1 hr	Permit	4 hr
Axial XL	0.5 hr	Perspective	6-8 hr
Basagran/bentazon*	4-8 hr	Plateau	1 hr
Betamix*	6 hr	Poast	1 hr
Beyond	1 hr	PowerFlex HL	4 hr
Bromoxynil*	1 hr	Pursuit	1 hr
Cadet	4 hr	Quelex	4 hr
Callisto	1 hr	Raptor	1 hr
Callisto GT	6-8 hr	Realm Q	4 hr
Capreno	1 hr	Redeem	2 hr
Cobra	0.5 hr	Reflex	2 hr
Curtail* / M*	6-8 hr	Reglone	0.5 hr
Dicamba	6-8 hr	Remedy	6-8 hr
DiFlexx/Duo	4 hr	Require Q	4 hr
Diquat*	0.5 hr	Resicore	6-8 hr
Discover NG	0.5 hr	Resolve*/Q	4 hr
Engenia	4 hr	Resource	1 hr
Enlist Duo	1 hr	Revulin Q	4 hr
Everest 3.0 / Sierra	1 hr	Rimfire Max	4 hr
Express*	4 hr	Select*/Max	1 hr
Extreme	1 hr	Sharpen	1 hr
Facet L	6 hr	Sinate	4 hr
Fenoxaprop	1 hr	Solstice	4 hr
FirstRate	2 hr	Spartan Charge	1 hr
Flexstar	1 hr	Starane*/Flex	4 hr
Flexstar GT 3.5	6-12 hr	Starane NXT*	1 hr
Fusilade DX	1 hr	Status	4 hr
Glyphosate(Full adjuv.)	6-12 hr	Stinger*	6-8 hr
Glyphosate (Partial adj.)	6-12 hr	SU herbicides	4 hr
Glyphosate (No adjuv.)	6-12 hr	Supremacy	2 hr
GoldSky	4 hr	Talinor	1 hr
Halex GT	1 hr	Tordon 22K	6-8 hr
Harmony*	4 hr	Ultra Blazer	4 hr
Hornet / Stanza	2 hr	UpBeet	6 hr
Huskie / Complete / FX	1 hr	Varisto	4 hr
Impact	1 hr	Varro	1 hr
Impact Core	1 hr	Weedmaster*	6-8 hr
Instigate	4 hr	WideMatch*	6 hr
Laudis	1 hr	Wolverine Advanced	1 hr
Liberty/Rely 280	4 hr	Xtendimax	4 hr
Lumax EZ	4 hr	Zidua Pro	1 hr
Luxxur	4 hr	2,4-D amine	4-8 hr
Marvel	1 hr	2,4-D ester	1 hr
MCPA amine	4-6 hr		

A4. GLYPHOSATE

1. Use full rates that will kill weeds. Commercial glyphosate formulations contains 3 to 5 lbs acid equivalent (4 to 6.1 lb active ingredient) per gallon. Refer to the end of section A4 for rates based on formulation. Dead weeds do not produce seed or contribute to glyphosate resistance. Reduced glyphosate rates will amplify low-level resistance in weed progeny. Lambsquarters, waterhemp, horseweed (marestail), ragweed, and kochia have low-level resistance and require at least a full or elevated glyphosate rate. A reduced glyphosate rate may cause temporary injury symptoms allowing plants to recover, resume growth, and produce seed. Progeny from recovered plants will have a higher level of resistance and require higher herbicide rates to give the same level of control than parental plants. Surviving plants will contribute seed to the seed bank possessing amplified level of resistance. Refer to General Weed Management Guidelines in Section X1 - Herbicide Resistant Weeds.

2. Apply to small, actively growing annual plants. This early timing will not coincide with the preferred timing of early bud to early flower for most perennial weeds. Usually larger and older annual plants can be more difficult to control.

3. To optimize glyphosate phytotoxicity from sequential applications, delay the second application until new growth appears (>10-14 days).

4. Delay tillage at least 1 day after treating annual weeds and 3 days after treating perennial weeds for greater weed control from increased glyphosate absorption and translocation.

5. Low water volume (gpa) will enhance glyphosate activity. Low water volume produces spray droplets with high glyphosate concentration that results in greater absorption. Low spray volume also reduces the concentration of antagonistic salts in water that can interact with glyphosate. Low gpa produces small drops which may increase risk of damaging drift.

6. Glyphosate is very water soluble. High water solubility causes slow absorption through waxy plant cuticles. High air humidity increases glyphosate absorption and activity by hydrating leaf cuticle. Glyphosate activity also increases when plants are growing under good soil moisture. Inversely, weed control is reduced under low humidity and when weeds are drought stressed.

7. Always add reputable surfactant (NIS) to glyphosate unless prohibited by the label. Glyphosate absorption into plant tissue is slow and generally only 20-40% in most weed species. Add NIS at 1 qt/100 gal water to full adjuvant load formulations, 1 to 2 qt/100 gal water to partial adjuvant formulations, and 2 to 4 qt/100 gal water v/v to glyphosate formulations with no adjuvant. NIS may also increase retention of spray droplets and improve control of hard-to-wet species such as lambsquarters, and most grasses. Not all surfactants are equal - use reputable adjuvants.

8. Most oil adjuvants (COC) antagonize glyphosate - See #6. Most herbicides applied with glyphosate are lipophilic (oil soluble). These include Group 1, 2, 4, 5, 14, 15, and 27 herbicides (See X1). Oil adjuvants (COC and MSO) greatly enhance oil soluble herbicides but antagonize glyphosate. NIS + AMS enhance glyphosate phytotoxicity more than other additives, are less effective with oil soluble herbicides, and will only partially overcome oil adjuvant antagonism of glyphosate. MSO based 'high surfactant oil concentrate' adjuvants (HSMOC-see page 128) contain a higher concentration of surfactant than COC and MSO and enhance oil soluble herbicides without decreasing glyphosate activity. Most COC/petroleum based 'high surfactant oil concentrate' (HSPOC)

adjuvants are inferior to HSMOC adjuvants and usually do not perform differently than common COC or petroleum oil adjuvants.

9. Apply oil adjuvants on an area basis (i.e. pt/A) rather than a volume basis (1% v/v/1 qt / 100 gal of water). HSMOC adjuvants are commercially recommended at half the POC and MSO rate (0.5% v/v vs 1% v/v). HSMOC adjuvants applied at full rates and on an area basis (1 to 1.5 pt/A) rather than on a volume basis (0.5% v/v spray water) will provide greater herbicide enhancement and more consistent weed control. HSMOC applied on a volume basis at low gpa does not contain enough oil adjuvant to optimize glyphosate and POST herbicides.

10. Always add AMS to glyphosate. AMS enhances glyphosate absorption and translocation and deactivates antagonistic hard water salts (Na, Ca, Mg, Fe). As spray droplet water evaporates, sulfate from AMS binds with antagonistic salts and prevents binding with glyphosate. In addition, ammonium from AMS binds with glyphosate resulting in greater absorption and weed control. Nitrogen (ammonia) enhances glyphosate resulting in greater weed control in good and adverse growing conditions and even in the absence of antagonistic salts in water (See Section A6). AMS can be added at any time during spray tank loading when applying glyphosate but should be added first if applying several active ingredients in the tank with glyphosate. Allow granular AMS to dissolve before application or use a liquid formulation.

11. Glyphosate labels suggest AMS at 8.5 to 17 lb/100 gallons of water. However, analysis of water across the U.S. show 4 to 6 lbs/100 gal of AMS are adequate to overcome most hard water. Add AMS at a minimum of 1 lb/A if using greater than 12 gpa spray volume or 8.5 lb/100 gallons of water. The following equation can be used to calculate the amount of AMS needed to overcome antagonistic ions in the spray solution: $lbs\ AMS/100\ gal = (0.002\ X\ ppm\ K) + (0.005\ X\ ppm\ Na) + (0.009\ X\ ppm\ Ca) + (0.014\ X\ ppm\ Mg) + (0.042\ X\ ppm\ Fe)$.

The formula does not account for cationic minerals (Ca) on leaf surfaces (lambsquarters, sunflower, velvetleaf, others) that can antagonize glyphosate. Refer to A6. Water in Montana and western ND and SD can have hardness levels of 1600 to 2500 ppm and require AMS at 17 lb/100 gal water. Determine water quality to determine minimum AMS rate. If using adjuvants called "Water Conditioning", or "AMS Replacement" adjuvants, use only those containing at least 4 lbs of AMS/100 gallons of water at their recommended rates. Data show generally less control from these AMS replacement adjuvants as compared to AMS at 8.5 lb/100 gal + NIS at 0.25% v/v.

12. Applying contact herbicides (Group 10, 14, and 22 - see X1) with glyphosate may result in antagonism and reduced weed control, especially of large weeds, winter-annual, biennial and perennial weeds. Contact herbicides cause rapid wilting and desiccation before the systemic glyphosate is absorbed reducing uptake and translocation within the plant. Contact herbicides may quickly kill small and susceptible weeds but regrowth of large weeds may be noticeable only a few days after application. Some contact herbicides that may antagonize glyphosate include: Group 10, 14, and 22. High spray water volumes may overcome some antagonism.

13. Cold weather is a stress to plants. Generally, weed control from glyphosate applied during or after cold weather may be the same as when applied in warm weather but the end result (weed control) may take longer. However, cold weather may decrease glyphosate activity on certain weeds. Ideal temperatures for applying POST herbicides are between 65 and 85 F. Speed of kill will be slower during cold weather. Use higher rates to overcome reduced control from cold temperatures before or after application.

Glyphosate applied during cold weather, to large weeds, and weeds with low-level resistance will result in less weed control. AMS enhances weed control and can partially overcome reduced control of stressed plants.

Research data show wide temperature fluctuations (>15 F) 1 to 2 days before and after application are more likely to reduce weed control than consistently cool or cold temperatures. Wide temperature fluctuations can likely explain many situations where weed control is poor due to cold weather, especially with lambsquarters.

14. Excessive dew on plant foliage at application may reduce weed control by diluting the glyphosate concentration in spray droplets and negate the effect of low spray volume at application. Glyphosate absorption in plants is slow which partially explains the 6 to 12 hour rainfast period. Allow a 6 to 12 hour rainfast period for all glyphosate formulations regardless of label statements. Research has consistently shown increased glyphosate activity in humid conditions when leaf cuticles are hydrated. Dew on leaves will hydrate leaf cuticles and facilitate absorption.

15. Glyphosate is not deactivated by sunlight. However, time of day application studies show that activity of glyphosate is greatest when applied in full sunlight after 10:00 am and before 6:00 pm.

16. Use drift management techniques. Glyphosate is a non-selective, non-residual, translocated, foliar herbicide. Glyphosate can cause severe injury or death of plants intercepting even a small amount of active ingredient in down-wind spray droplet drift. Several drift reducing nozzles (example, Turbo Tee-Jet) can reduce drift without reducing phytotoxicity. Do not use 'thickener' drift reducing adjuvants that negatively alter the spray pattern and reduce herbicide activity.

17. Glyphosate is not volatile and does not produce fumes or vapor after application. Off-target movement of glyphosate from wind or during temperature inversions is in the form of droplets or particle drift, not volatility.

18. Tolerant plants escape phytotoxicity by metabolizing herbicides, except glyphosate. Plant metabolism slows during cool or cold conditions extending the amount of time required to degrade most herbicides. Plants do not metabolize glyphosate and absorbed glyphosate will remain in the plant until warm temperatures cause plants to resume translocation of glyphosate to growing points via the phloem.

19. Glyphosate can be applied in the fall after several frosts and will result in excellent control of annual, biennial, and perennial weeds. However, plant tissue must be green or purple and leaves firmly attached to the stem to absorb and translocate the herbicide. Do not apply glyphosate to desiccated plant tissue from low freezing temperatures. Fall application to new plant growth is required for optimum herbicide activity.

20. Glyphosate is deactivated by strong adsorption to soil (including dust) and organic matter. Slow absorption allows glyphosate on the plant leaf surface to be inactivated by dust present either on the leaf surface or transported by wind. This applies also to using slough or river water for spraying. The addition of NIS or AMS will not overcome inactivation. Placing nozzles before or after wheels may reduce inactivation from dust. Applying glyphosate perpendicular to the previous application or shifting the sprayer to one side of the previous path may also reduce inactivation by dust.

A4 - GLYPHOSATE (cont.)

21. Do not apply glyphosate brands formulated with surfactant (partial or full adjuvant formulations) to bodies of water because surfactant components are toxic to fish and aquatic life. Only no-adjuvant formulations, such as Aquamaster, Rodeo, and some 4 lb ae/gal formulations of glyphosate can be applied to water. An approved NIS surfactant at 1 gal/100 gal water must be added to no-adjuvant glyphosate formulations for adequate weed control. Refer to the Adjuvant Section, on page 128 for a list of NIS adjuvants registered for use in water.

22. Glyphosate has been reported to inhibit manganese (Mn) uptake in plants from soil. Glyphosate is a strong nutrient chelator and can immobilize micronutrients through enzyme inhibition and reduce micronutrient efficiency. These responses have only been seen in micronutrient deficient soils and can be managed by applying micronutrients as warranted by soil test analysis and fertilizer recommendation.

23. Glyphosate does not require low spray solution pH. Generally, efficacy of glyphosate is equal across normal water pH used for herbicide application. A theory has been promoted that at low spray solution pH, glyphosate and other weakly acidic herbicides would be more lipophilic (nonpolar) and more readily absorbed across nonpolar plant cuticles. Some adjuvants for glyphosate formulations lower pH but glyphosate is soluble at low pH and maintains efficacy. Adding acidifiers with the purpose of lowering the pH of spray solutions containing glyphosate is unjustified. Most AMS replacement adjuvants (see Adjuvant Compendium on page 128-130) used at 2 qt/100 gal water reduce spray solution pH which may prevent some binding of glyphosate with antagonistic minerals in spray water. However, they do not contain sulfate to bind with cationic minerals and do not contain ammonia which binds with glyphosate and is required for glyphosate optimization. "Acidic AMS Replacement" adjuvants (see page 129) contain AMADS or monocarbamide dihydrogen sulfate (urea + sulfuric acid), can reduce spray solution pH to ~2 to reduce cation antagonism, and can optimize glyphosate similar to AMS but only when applied at a minimum of 2 qt/100 gal water. Refer to #1 on page 131 - "Understanding a water quality analysis report" for additional information on spray solution pH.

24. Potassium (K) salt formulations of glyphosate may negatively interact with dma (dimethyl amine) salt formulations of 2,4-D in the spray tank resulting in precipitation. Conditions that increase the risk of precipitation are application in low gpa, using cold water, and using high herbicide rates. This is an example of two dissimilar salts causing physical incompatibility and possibility of reduced weed control. Another example of negative herbicide salt interaction is grass antagonism from tank-mixing glyphosate-ipa (isopropyl amine) and 2,4-D-dma (dimethyl amine). Landmaster BW, a mixture glyphosate-ipa and 2,4-D-ipa avoided this antagonism by containing the same salt (ipa) for both herbicides.

Partial List of Registered Glyphosate Products in ND:

Trade Name	Manufacturer	Glyphosate salt	lb ae/gal	lb ai/gal	Adjuvant Load*
Abundit Edge	Corteva	K	4.5	5.5	Full
Accord	Corteva	ipa	4	5.4	None
AquaNeat	Nufarm	ipa	4	5.4	None
Buccaneer	Tenkoz	ipa	3	4	Partial
Buccaneer Plus	Tenkoz	ipa	3	4	Full
Buccaneer 5	Tenkoz	ipa	3.7	5	Partial
Buccaneer 5 Extra	Tenkoz	ipa	4	5.4	Partial
Cornerstone 5 Plus	Winfield United	ipa	4	5.5	Full
Credit / 41	NuFarm	ipa	3	4	Partial
Credit / 41 Extra	NuFarm	ipa	3	4	Full
Credit Xtreme	NuFarm	ipa & K	2.5 + 2	5.83	Full
Duramax	Corteva	dma	4	5.07	Full
Durango DMA	Corteva	dma	4	5.07	Full
Extra Credit 5	NuFarm	ipa	3.7	5	Partial
Glyphogan	ADAMA	ipa	3	4	Partial
Gly Star 5 Extra	Albaugh	ipa	4	5.4	Full
Gly Star Gold	Albaugh	ipa	3	4	Full
Gly Star Original	Albaugh	ipa	3	4	Partial
Gly Star Plus	Albaugh	ipa	3	4	Full
Helosate Plus/Ad	Helm Agro	ipa	3	4	Full
Helosate 75SG	Helm Agro	-	68.9%	75.7%	Partial
Honcho K6	Bayer	ipa	4.5	5.5	Partial
Imitator DA	Drexel	di-ammon	3	3.6	Full
Imitator Plus	Drexel	ipa	3	4	Full
Mad Dog	Loveland	ipa	3	4	Partial
Mad Dog Plus	Loveland	ipa	3	4	Full
Mad Dog 5.4	Loveland	ipa	4	5.4	Partial
Makaze	Loveland	ipa	3	4	Full
Rodeo	Corteva	ipa	4	5.4	None
RT 3	Bayer	K	4.5	5.5	Full
RU PowerMax	Bayer	K	4.5	5.5	Full
RU PowerMax 3	Bayer	K	4.8	5.88	Full
RU/Private labels	Various	ipa	3	4	Partial
RU WeatherMax	Bayer	K	4.5	5.5	Full
Showdown	Helena	ipa + NH ₄	2.7 + 0.3	3.64	Full

*Unless prohibited add NIS to commercial glyphosate formulations as follows:
 Full adjuvant load = add NIS at 1 qt/100 gal water.
 Partial adjuvant load = add NIS at 1 to 2 qt/100 gal water.
 No adjuvant load = add NIS at 2 to 4 qt/100 gal water.

Table. Actual glyphosate product rates based on acid equivalent (ae) and active ingredient (ai) formulation concentrations - Refer to page 4 for more information.

lb ae	lb ai	0.75 ae	1.125 ae	1.5 ae	2.25 ae	3 ae
----- fl oz/A -----						
3	= 4	= 32	48	64	96	128
3.75	= 5	= 25.6	38.4	51.2	76.8	102.4
4	= 5.4	= 24	36	48	72	96
4.17	= 5.1	= 23	34.5	46	69	92.1
4.5	= 5.5	= 21.3	32	42.6	64	85
4.72	= 6.3	= 20.3	30.5	40.7	61	81.4
4.8	= 5.88	= 20	30	40	60	80
5	= 6.1	= 19.2	28.8	38.4	57.6	76.8

A5. SPRAY ADJUVANTS

Spray adjuvants generally consist of surfactants, oils and fertilizers.

Surfactants (nonionic surfactants = NIS) are used at 0.25 to 1% v/v (1 to 8 pt/100 gal of spray solution) regardless of spray volume. NIS rate depends on the amount of active ingredient in the formulation, plant species and herbicides used. The main function of a NIS is to increase spray retention, but at a lesser degree, may increase herbicide absorption. When a range of surfactant rates is given, the high rate is for use with low herbicide rates, drought stress and tolerant weeds, or when the surfactant contains less than 90% active ingredient. Surfactants vary widely in chemical composition and in their effect on spray retention, deposition, and herbicide absorption.

Silicone surfactants reduce spray droplet surface tension, which allow the liquid to run into leaf stomata ("stomatal flooding"). This entry route into plants is different than adjuvants that aid in absorption through the leaf cuticle. Rapid entry of spray solution into leaf stomata from use of silicone surfactants often does not result in improved weed control. Silicone surfactants are weed and herbicide specific, just like other adjuvants.

Oils generally are used at 1 to 2 pt/A or at 1% v/v (1 gal/100 gal of spray solution) depending on herbicide and oil. Oil additives increase herbicide absorption and spray retention. Oil adjuvants are petroleum (PO) or methylated vegetable or seed oils (MSO) plus an emulsifier for dispersion in water. The emulsifier, the oil class (petroleum, vegetable, etc.), and the specific type of oil in a class all influence effectiveness of an oil adjuvant. Oil adjuvants enhance POST herbicides more than NIS and are effective with all POST herbicides except Liberty and will antagonize Roundup. The term crop oil concentrate (COC) is used to designate a petroleum oil concentrate but is misleading because the oil type in COC is petroleum and not a crop vegetable oil.

MSO adjuvants greatly enhance POST herbicides much more than NIS and PO adjuvants. MSO adjuvants are more aggressive in dissolving leaf wax and cuticle resulting in faster and greater herbicide absorption. The greater herbicide enhancement from MSO adjuvants may occur more in low humidity/low rainfall environments where weeds develop a thicker cuticle. MSO adjuvants cost 2 to 3 times more than NIS and PO adjuvants. The added cost of MSO and increased risk of crop injury when used at high temperatures have deterred people from using this class of adjuvants.

Some herbicide labels restrict use of oil adjuvants and recommend only NIS alone or combined with nitrogen based fertilizer solutions. Follow label directions for adjuvant selection. Where labels allow use of oil additives, PO or MSO adjuvants may be used.

NDSU research has shown wide difference in adjuvant enhancement of herbicides. However, in many studies, no or small differences occur depending on environmental conditions at application, growing conditions of weeds, rate of herbicide used, and size of weeds. For example, under warm, humid conditions with actively growing weeds, NIS + nitrogen fertilizer may enhance weed control to the same level as oil adjuvants. The following are conditions where MSO type additives may give greater weed control than other adjuvant types:

1. Low humidity, hot weather, lack of rain, and drought-stressed weeds or weeds not actively growing due to some stress condition.
2. Weeds larger than recommended on the label.
3. Herbicides used at reduced rates.
4. Target weeds that are somewhat tolerant to the herbicide.
5. When university data supports reduced herbicide rates.

Oil adjuvant applied on a volume or area basis
Labels of many POST herbicides recommend oil adjuvants at 1% v/v. At water volume of 15 or 20 gallons per acre (GPA), 1% oil adjuvant will provide a minimum adjuvant concentration (1% v/v PO in 17 gpa = 1.4 pt/A). The optimum rate of a PO is 2 pt/A. State surveys show common spray volumes are 10 gpa or lower. PO at 1% v/v in 8.5 gpa = 0.68 pt/A and does not provide a sufficient amount of oil adjuvant. Further, in aerial applications at 5 GPA, PO at 1% v/v will not provide sufficient adjuvant. For example, Pursuit and Raptor labels require oil adjuvants to be added at 1.25% v/v or 1.25 gal/100 gal water for aerial application at 5 GPA.

Some herbicide labels contain information on adjuvant rates for different spray volumes. To insure sufficient adjuvant concentration, add oil adjuvant at 1% v/v but no less than 1.25 pt/A at all spray volumes. Surfactant at 0.25 to 1% v/v water is sufficient across all water volumes.

High surfactant oil concentrates (HSOC) were developed to enhance lipophilic herbicides without antagonizing glyphosate. HSOC adjuvants contain at least 50% w/w oil plus 25 to 50% w/w surfactant, are PO or MSO based, and are usually applied at ½ the oil adjuvant rate (area basis). Glyphosate must be applied with other herbicides to control glyphosate tolerant weeds and crops and to delay resistant weeds. Glyphosate is highly hydrophilic, is enhanced by NIS and nitrogen fertilizer surfactant type adjuvants, and is antagonized by oil adjuvants. Postemergence herbicides preferred by growers to mix with glyphosate to increase weed control are lipophilic (Select, Banvel, Laudis, others) and require oil adjuvants for optimum herbicide enhancement. Surfactants are less effective in enhancing lipophilic herbicides. Oil adjuvants, including PO and MSO adjuvants, may antagonize glyphosate. NDSU research has shown wide variability among PO based HSOC adjuvants with many performing no different than common PO adjuvants. However, MSO based HSOC adjuvants enhance both glyphosate and the lipophilic herbicide. MSO based HSOC adjuvants can enhance lipophilic herbicides more than PO based HSOC, MSO and PO adjuvants.

Some water pH modifiers are used to lower (acidify) spray solution pH because many insecticides and some fungicides degrade under high water pH. Most solutions are not high or low enough in pH for important herbicide breakdown in the spray tank. A theory has long been postulated that acidifying the spray solution results in greater absorption of weak-acid-type herbicides. pH-reducing adjuvants (water conditioners/AMS-replacement) were developed under this belief. However, low pH is not essential to optimize herbicide absorption.

Many herbicides are formulated as various salts, which are absorbed as readily as the acid. Salts in the spray water may antagonize formulated salt herbicides. In theory, acid conditions would convert the herbicide to an acid and overcome salt antagonism. However, herbicides in the acid form are less water soluble than in salt form. An acid herbicide with pH modifiers may precipitate and plug nozzles when solubility is exceeded, such as with high herbicide rates in low water volumes. Antagonism of herbicide efficacy by spray solution salts can be overcome without lowering pH by adding AMS or, for some herbicides, 28% UAN.

Acidic AMS replacement (AAR) adjuvants (see page 130) contain adjuvants including monocarbamide dihydrogensulfate (urea and sulfuric acid) and some adjuvants in this class are similar to NIS + AMS in enhancing glyphosate and other weak-acid herbicides. The sulfuric acid forms sulfate when reacting with water and can prevent herbicide antagonism with salts in water. The conversion of

urea to ammonium is slow but the ammonium formed can partially enhance herbicides. AAR adjuvants must be applied at 1% v/v or greater to achieve the same level of herbicide enhancement as AMS.

A6. SPRAY CARRIER WATER QUALITY

Minerals, clay, and organic matter in spray carrier water can reduce the effectiveness of herbicides. Clay inactivates paraquat, diquat, and glyphosate. Organic matter inactivates herbicides. Hard water cations or micronutrients such as calcium, magnesium, manganese, sodium, and iron reduce efficacy of all weak-acid herbicides (Group 1, 2, 4, 6, 9, 10, 14, 19, and 27). Cations antagonize weak acid herbicides by binding form salts (e.g. glyphosate-Ca) that are not readily absorbed by plants. The antagonism is related to the salt concentration.

ND water often contains a combination of sodium, calcium, magnesium, and iron and these cations generally are additive in the antagonism of herbicides. Water in ND, SD, and MT is often high in sodium bicarbonate which does not normally occur in other areas of the U.S. Calcium levels above 150 ppm and sodium bicarbonate levels above 300 ppm in spray water can reduce weed control in all situations. Water with 1600 ppm sodium bicarbonate can occur in ND, but total hardness levels can exceed 2,500 ppm.

Ammonium nitrogen increases effectiveness of most weak-acid herbicides formulated as a salt. Fertilizers should always be used with herbicides unless prohibited by label. Ammonium ions greatly enhance herbicide absorption and phytotoxicity even in the absence of antagonistic salts in the spray carrier. However, enhancement of POST herbicides from ammonium is most pronounced when spray water contains large quantities of antagonistic cations. Herbicide enhancement by nitrogen compounds appears in most weed species but especially in those that accumulate salts on or in leaf tissue (lambsquarters, velvetleaf, and sunflower).

AMS enhances phytotoxicity and overcomes salt antagonism for weak-acid herbicides formulated as a salt (listed above). The antagonism may be overcome by increasing the glyphosate concentration relative to the cation content or by adding AMS and some water conditioners to the spray solution. Effective water conditioners include EDTA, citric acid, AMS, and some acidic AMS replacements. Of these, AMS has been the most widely adopted. When added to a spray solution, the ammonium (NH_4^+) ion complexes with the glyphosate molecule and reduces glyphosate interaction with the hard-water cations. The sulfate ion complexes with the hard-water cations (e.g. calcium sulfate), causing the salt to precipitate from solution. This combined effect increases absorption and efficacy. Natural sulfate in water can be disregarded but can reduce antagonism if the sulfate concentration is at least three times the calcium concentration. 28% UAN does not contain sulfate and does not condition water by precipitating cations/calcium antagonism of glyphosate.

AMS is recommended at 8.5 to 17 lb/100 gal spray volume (1 to 2%) on most glyphosate labels. However, AMS at 4 lb/100 gal (0.5%) is adequate to overcome most salt antagonism but more than 4 lb/100 gal may be required to fully optimize herbicides. Use at least 1 lb/A of AMS when spray volume is more than 12 gpa. The amount of AMS needed to overcome antagonistic ions can be determined as follows: $\text{Lbs AMS/100 gal} = (0.002 \times \text{ppm K}) + (0.005 \times \text{ppm Na}) + (0.009 \times \text{ppm Ca}) + (0.014 \times \text{ppm Mg}) + (0.042 \times \text{ppm Fe})$. This does not account for antagonistic minerals on or in the leaf tissue in species like lambsquarters, sunflower, and velvetleaf which may require additional AMS.

Commercial liquid solutions of AMS contain ~3.4 lbs of AMS per gallon. For 8.5 lbs of AMS/100 gallons of water add 2.5 gallons of liquid AMS solution. Generally, 4 gal of 28% UAN/100 gal of spray is adequate. AMS or 28% UAN does not preclude the need for an oil adjuvant with lipophilic herbicides. AMS and 28% UAN enhance herbicide control of most weeds even without antagonistic salts. Nitrogen fertilizer/surfactant blends may enhance weed control of most herbicides formulated as a salt.

The analysis may report salt levels in ppm or grains. To convert from grains to ppm, multiply by 17 (Example: 10 grains calcium X 17 = 170 ppm calcium). AMS at 2% (17 lb/100 gallons water) will overcome antagonism from the highest calcium and/or sodium concentrations in water. However, AMS at 4 lb/100 gal is adequate for most water sources. Iron is the most antagonistic to many herbicides but not abundant in water.

Water conditioner adjuvants are liquid for user preference, applied at low use rates, may contain no or very little AMS, may lower spray solution, and are advertised to replace AMS, and thus are also called AMS replacement adjuvants. Pesticide applicators prefer the convenience of low use rate water conditioners, but performance is not equal to AMS. Glyphosate plus commercial water conditioner products that included AMS at the equivalent rate of 2.5% v/v can give similar control to 8.5 lbs/100 gal AMS. Commercial water conditioners that do not provide an equivalent amount of AMS are often no better than glyphosate alone.

Acidic AMS replacement (AAR) adjuvants have been developed for use with glyphosate and other weak acid herbicides. Claims have been made to enhance herbicide activity, and negate the effects of antagonistic salts in spray water and the antagonism from micronutrient solutions added for crop health. Most adjuvants in this class contain monocarbamide dihydrogen sulfate or AMADS (urea plus sulfuric acid) which lowers spray solution pH to 1.4 to 3. The low pH is below the pKa of postemergence herbicides causing most herbicide molecules to be in the acid state which results in fewer molecules binding to positively charged salts.

Some water conditioner adjuvants and acidic AMS replacement adjuvants (AAR) are marketed to modify spray water pH, but low pH is not required for herbicide efficacy. The type of acid or components of buffering agents and the specific herbicide all need to be considered before using pH-modifying agents. Several commercial AAR adjuvants applied with glyphosate in distilled water were tested and ranked as follows: surfactant + AMS > AMS > NIS + AAR. Generally, AAR adjuvants applied with glyphosate in 1000 ppm hard water (Ca and Mg) gave similar weed control as when applied in distilled water supporting the theory of non-binding herbicide molecules when pH is below the pKa of the herbicide.

Low spray volumes (5 to 10 gpa) have been equally or more effective than higher spray volumes for many herbicides. Low spray volume increases efficacy of most systemic POST herbicides because it reduces the ratio of antagonistic cations to herbicide molecules in the spray solution. Low spray volumes also increase efficacy because of higher herbicide concentration in the spray deposit (NDSU Pile Theory). Contact herbicides (Group 6, 10, 14, and 22) require higher spray volume for adequate and thorough coverage to enhance control.

Low spray volumes usually imply use of low-volume nozzles that produce small droplets which can increase off-target movement. However, drift-reducing nozzles have been developed that produce large droplets at low volume. In low spray volumes, larger droplets produced by drift-reducing nozzles have been equally effective as small droplets with several translocating herbicides. However, coarse or larger droplets may be less phytotoxic than fine and medium size droplets for most POST herbicides.

A7. SPRAY AND VAPOR DRIFT

Risk of off-target herbicide movement and injury to non-target plants depends on the susceptibility of the plant to the applied herbicide. 2,4-D, MCPA, dicamba, glyphosate, and ALS herbicides have the greatest potential for damaging non-target plants.

Wind velocity and direction: Apply when wind direction is away from susceptible plants, during low wind speed, and in the absence of temperature inversions.

Boom height: Adjust boom as close to the target as possible while maintaining uniform spray coverage. Choose nozzles with a wide angle as opposed to narrow angle nozzles.

Spray shields: Cones around nozzles reduce drift by 25 to 50% and spray shields that enclose the entire boom reduce drift by 50 to 85%. Spray shields should not be used as a substitute for other drift control techniques but as a supplement to drift reduction.

Drift control: Reduce drift by increasing droplet size, reducing spray pressure, using drift reduction nozzles, adding drift reducing additives that do not increase spray viscosity, and orienting nozzles rearward on aircraft.

Drift-reducing nozzles: Sprayer nozzles designed to reduce spray drift increase spray droplet size and reduce the number of small droplets (fines). Two primary types of drift-reducing nozzles have pre-orifice and air-induction (venturi) designs.

Herbicide formulation: Some herbicides have been formulated to reduce drift. Amine formulated herbicides are less volatile than ester formulations. 2,4-D is formulated as an acid, ester, and various amine salt (e.g. dimethyl amine (dma)). 2,4-D has been formulated as a choline salt for use in Enlist soybean and is the least volatile formulation. Likewise, dicamba has been formulated as a dma salt (Banvel) and a comparatively less volatile diglycol amine (dga) salt (Clarity). Dicamba has been formulated as a bis(3-aminopropyl)methylamine (bapma) salt for use in RU Xtend soybean and is the least volatile formulation.

2,4-D resistant (Enlist) soybean and dicamba resistant (RU Xtend) soybean have been developed with Best Management Practices (BMP) to reduce risk of off-target movement. These include course to ultra coarse droplet size, buffer zones to susceptible plants, low volatile herbicide formulations, low boom height, and wind speed between 3 and 10 mph. Use only low volatile herbicide formulations that have been registered on each crop technology. Soybean is approximately 100 times more susceptible to dicamba than 2,4-D. Off-target movement as well as proper tank clean-out are important factors to consider for soybean safety.

Do not use AMS with any formulation of dicamba. Ammonium significantly increases the volatility of dicamba and reduces the effect of low-volatile DGA and BAPMA formulations of dicamba.

A proportion of the spray volume will be deposited on the soil surface. Unabsorbed dicamba on plant tissue or on the soil surface can volatilize as temperatures increase and after dew or small rain events solubilize dicamba crystals. Multiple volatilization events can occur several days and weeks after application.

A8. SPRAYER CLEANOUT

Herbicides may adsorb to the spray tank, hoses, nozzles, screens, and filters requiring thorough cleaning. Adsorbed herbicide may remain tightly adsorbed in sprayers through water rinsing and even through several tank-loads of other herbicides. Through subsequent sprayer applications including an oil adjuvant, nitrogen solution, or basic pH blend adjuvant may cause the herbicide to desorb, disperse into the spray solution, and damage susceptible crops. Highly active herbicide residues that persist in sprayers and cause crop injury include dicamba and ALS herbicides. Herbicides attached to all tank and sprayer components must be desorbed and the residue removed in a cleaning process. Sprayer cleanout procedures are given on herbicide labels and should be followed. The following procedure illustrating a thorough sprayer cleanout procedure is effective for most herbicides:

- Step 1.** Drain tank and rinse tank with clean water. Spray rinse.
 - Step 2.** Fill the sprayer tank with clean water and label identified
 - Step 3.** Allow solution to set for 8 hours.
 - Step 4.** Spray the cleaning solution through the booms.
 - Step 5.** Clean nozzles, screens, and filters. Rinse the sprayer to
- Common types of cleaning solutions are chlorine bleach (lowers pH), ammonia (increases pH), and commercially formulated tank cleaners. Never mix chlorine bleach and ammonia as a dangerous gas will be released. Read herbicide label for recommended tank cleaning solutions and procedures.

SPRAYER CLEANING SOLUTIONS FOR HERBICIDES:

Water: Extreme, Glyphosate, Lightning, Raptor, SG formulations.

Bleach: Laudis.

Ammonia or commercial tank cleaner + water:

2,4-D, Assure II, Basagran*, Bromoxynil*, Cadet, Callisto, Cobra, Dicamba, Extreme, FirstRate, Fusilade DX, Gramoxone*, Harmony DF*, Harness*, Hornet, Metolachlor*, Metsulfuron*, Paraquat*, Permit, Prowl*, Pursuit, Python, Raptor, Reflex, Rimsulfuron*, Resource, Select*, Stinger*, Surpass*, Targa*, Thifensulfuron, Tribenuron*, Treflan*, Ultra Blazer, and Valor.

Detergent or commercial tank cleaner + water:

Aim, Atrazine*, Clarity*, Flexstar, Liberty 280, Metribuzin*, Poast, and Status.

A9. MIXING INSTRUCTIONS:

Some herbicide labels list a specific mixing sequence. Formulation codes follow the categories in parenthesis. In absence of specific directions follow adding pesticide formulations to a tank partially filled with water follows the **A.P.P.L.E.S.** method:

Agitate

Powders soluble (dry fertilizers, SG, SP)

Powders dry (DF, WDG, WP)

Liquid flowables and suspensions (ASC, F, ME, SC, SE)

Emulsifiable concentrates (EC, EW, OD)

Solutions (S, SL)

Each ingredient must be uniformly mixed before adding the next component, e.g., a soluble powder must be completely dissolved before adding the next component. Adjuvants are added in the same sequence as pesticides, e.g., ammonium sulfate is a soluble powder, oil adjuvants are emulsifiable concentrates; and most surfactants are solutions. Within each group, usually add the pesticide before the adjuvant, e.g., a soluble-powder pesticide before ammonium sulfate.

A10. WICK APPLICATION

Weed control programs may leave tall weeds that are above the crop canopy. The crop may be beyond the stage of POST herbicide timing with no effective chemical options. Wick application with glyphosate at a 25 to 50% solution will control most annual weeds and suppress perennial weeds. Wick applicators are

commercially available or instructions for building a wick applicator can be found on the web.

Add NIS at 0.5 to 1% to all glyphosate mixtures. Position the applicator above the crop canopy. Keep absorbate material moist but not saturated to dripping. Travel at a speed to sufficient to moisten weed foliage and avoid spatter. Drops from the wick or dislodged from weeds "whipping" back from the application bar will cause crop death or severe injury. Quackgrass, kochia, redroot pigweed, and soybean can exude glyphosate through roots, and kill susceptible plants/crops through root exchange. Wick application in non-crop and cover crops may control many species. Tall broadleaf and grass weeds can be controlled leaving low canopy turnip, radishes and other broadleaf cover crop species. Use only registered glyphosate formulations.

A11. BACKPACK SPRAYER CALIBRATION

No-Math Version:

- Step 1. Mark a calibration plot 18.5 foot wide X 18.5 feet long.
- Step 2. Spray the plot uniformly with water while recording the number of seconds required to spray the plot.
- Step 3. Spray into a bucket for the same number of seconds.
- Step 4. Measure the collected volume of water in fluid ounces.
- Step 5. The number of ounces collected equals the number of gallons per acre the sprayer is delivering.

Hand-held Sprayers:

Spray coverage should be uniform and the foliage of target plants should be wet but not to the amount of spray solution run-off.

Hand-held sprayers should be calibrated by:

- 1) spraying a known area using water following a standard, reproducible procedure
- 2) measuring the amount of water applied
- 3) calculating gallons per acre (gpa).

For example, 0.75 gallon on 500 sq ft is the same as 65 gallons per acre: 43,560 sq ft per acre / 500 sq ft x 0.75 gallon = 65 gpa.

The desired rate in lb/A or pt/A can be used to calculate the amount of herbicide to add to the spray solution.

If 3 pt/A is desired: 3 pt/A / 65 gpa = 0.046 pt or 0.73 fl oz or 1.5 tbs/gal of spray solution (16 fl oz = 1 pt, 2 Tbsp = 1 fl oz).

Assume a spray volume of 50 to 70 gpa when calibration is not performed and spray does not run off plant leaves. Actual volume applied can vary with the type of sprayer, spray pressure, and technique of the applicator, so calibration is strongly encouraged.

Some herbicide labels specify a percent solution for use in hand-held sprayers. The following chart provides mixing instructions to obtain solutions of varying percent concentrations on a volume/volume basis:

Desired solution volume	% concentration of herbicide				
	0.5	1.0	1.5	2.0	5.0
gallons	Amount of herbicide to add, fl oz				
1	0.6	1.3	1.9	2.6	6.4
2	1.3	2.6	3.8	5.2	12.8
5	3.2	6.4	9.6	12.8	32.0
10	6.4	12.8	19.2	25.6	64.0
100	64.0	128.0	192.0	256.0	640.0
1 pt = 16 fl oz	16 Tbls = 1 cup				
1 Tbls = 3 tsp	1 fl oz = 30 mls				
1 Tbls = 15 ml	1 fl oz = 2 Tbls				

A12. CALCULATING HERBICIDE MIXTURES

Boom Spraying:

Mix to calibrated rate of gallons/A output of spray unit being used.

For handgun & backpack applications:

For 50 gpa application rate unless otherwise calibrated.

2 qt/A rate=1.28 fl oz x # of gal water= fl oz of herbicide for mixture

Example: For a 3 gallon backpack: 1.28 x 3 = 3.84

1 pt/A rate=0.32 fl oz x # of gal water= fl oz of herbicide for mixture

Example: For a 3 gallon backpack: 0.32 x 3 = 1 fl oz herbicide

1 qt/A rate=0.64 fl oz x # of gal water= fl oz of herbicide for mixture

Example: For a 3 gallon backpack: 0.64 x 3 = 2 fl oz herbicide

2,4-D

1 qt/A rate = 0.64 fl oz/gal water; 2 qt/A rate = 1.28 fl oz/gal water

3 gallon backpack: 2 fl oz (1 qt/A rate) / 4 fl oz (2 qt/A rate)

15 gallon sprayer: 9.5 fl oz (1 qt/A rate) / 19 fl oz (2 qt/A rate)

Pro-rate herbicide rate for different spray volumes.

Curtail (clopyralid + 2,4-D) or Redeem/Garlon (triclopyr)

2 qt/A rate = 1.28 fl oz/gal water

3 gallon backpack: 4 fl oz

15 gallon sprayer: 19 fl oz

Pro-rate herbicide rate for different spray volumes.

Banvel or Clarity (dicamba)

1 pt/A rate = 0.32 fl oz/gal water, 1 qt/A rate = 0.64 fl oz/gal water

3 gallon backpack: 1 fl oz (1 pt/A rate) / 2 fl oz (1 qt/A rate)

15 gallon sprayer: 5 fl oz (1 pt/A rate) / 10 oz (1 qt/A rate)

Pro-rate herbicide rate for different spray volumes.

Milestone (aminopyralid)

4 to 6 fl oz/A rate = 0.12 fl oz/gal water

3 gallon backpack: 0.36 fl oz

15 gallon sprayer: 1.8 fl oz

Pro-rate herbicide rate for different spray volumes.

Escort (metsulfuron) or Telar (chlorsulfuron)

2 to 3 oz DF/A = 0.33 oz DF/gal water

3 gallon backpack: 1 oz DF + 0.5% v/v NIS

10 gallon sprayer: 3.2 oz DF + 0.5% v/v NIS

Pro-rate herbicide rate for different spray volumes.

TORDON 22K (picloram)

1 qt/A rate = 0.64 fl oz/gal water, 2 qt/A rate = 1.25 fl oz/gal water

3 gallon backpack: 2 fl oz (1 qt/A rate): 4 fl oz (2 qt/A rate)

15 gallon sprayer: 9.5 fl oz (1 qt/A rate): 19 fl oz (2 qt/A rate)

Pro-rate herbicide rate for different spray volumes.

TORDON 22K + 2,4-D

1 pt/A Tordon 22K + 1 qt/A 2,4-D = 0.33 fl oz + 0.67 fl oz/gal water

3 gallon backpack: 2 fl oz 2,4-D + 1 fl oz Tordon 22K

15 gallon sprayer: 10 fl oz 2,4-D + 5 fl oz Tordon 22K

Pro-rate herbicide rate for different spray volumes.

Adjuvants and Rates

Apply adjuvants 1 to 2 pt/50 gal water if recommended.

For product names and types refer to page 126.

3 gallon backpack: 1 fl oz

10 gallon sprayer: 3.2 fl oz

Pro-rate adjuvants for different spray volumes.

ANNUAL WEED CONTROL

S1. Wild buckwheat is weed in broadleaf row crops and there are few effective chemical control options. Wild buckwheat disrupts swathing and combining by wrapping around the crop and becoming entangled on the sides of the header. Herbicide resistance has not been documented but high populations and natural tolerance to glyphosate may increase its prevalence in locations of high glyphosate use. Wild buckwheat is a problem in small grains because of tolerance to both 2,4-D and MCPA. These herbicides kill other competitive weeds while allowing wild buckwheat to increase. High 2,4-D rates may control buckwheat but are not normally used because of crop injury risk. Control of wild buckwheat with glyphosate depends on application rate, plant size, environment, and water quality. Early wild buckwheat germination, lack of soil-applied foundation herbicides, delayed POST applications until most weeds have emerged, and only one glyphosate application to large wild buckwheat plants are all factors that result in inadequate control. Reduced glyphosate rates may kill small wild buckwheat plants and temporarily suppress the growth of others. Applying glyphosate at 0.75 lb. ae/A and buckwheat growing in adverse conditions may result in erratic control. Refer to the following sources for biology and management of wild buckwheat:

<http://www.extension.purdue.edu/extmedia/GWC/GWC-10-W.pdf>

S2. Downy and Japanese brome has increased because of reduced tillage practices, renewed interest in winter wheat, and lack of proper identification. Bromes typically germinate from late August to early October and mature in early July. Bromes can establish in early spring and still be very competitive with cereals. Lack of control can result in rapid invasion through prolific seed production. Bromes are drought tolerant and strongly compete with crops. Bromes mature and desiccate early in the summer and dry plant material promote wildfires. Tillage is a very effective control method. Japanese brome is often easier to control with herbicides than downy brome. Fall herbicide treatments are more effective than spring treatments on fall-emerged plants while allowing chemical control before spring crop planting. Glyphosate is very effective on young brome plants but will not prevent new plants from emerging. Olympus, PowerFlex, Goldsky, Rimfire Max, and Beyond can be used in spring and winter wheat. Relying on herbicides after spring wheat emergence is not recommended as the downy brome will be at an advanced growth stage and will still produce seed.

S3. Foxtail is most competitive when small grains are seeded late and soil temperatures are warm for foxtail germination and rapid growth. Fields regularly chisel plowed generally have more foxtail than moldboard plowed fields. Moldboard plowing buries the foxtail seed, which prevents emergence and reduces viable seed for subsequent years. Foxtail may not decrease wheat and barley yields but high foxtail infestations can cause harvest problems (especially when straight combining) and dockage at the elevator. Herbicide treatment for foxtail may not be warranted when foxtail infestations are less than 30 plants/sq ft and when foxtail emerges after the crop is in the 3- to 4-leaf stage because the crop can compete with emerging foxtail. This is especially true for barley. Chemical control is warranted when the foxtail population is over 100 plants/sq ft. Foxtail also may contribute to moisture stress and cause yield loss under drought conditions. For high foxtail infestation emerging with the crop harrow or rotary hoeing as soon as possible. Harrowing or rotary hoeing is not effective once foxtail has 2 to 3 leaves. Small grains can be harrowed or rotary hoed until the 3- to 4-leaf stage with little effect on yield. Apply effective herbicides if a harrow or rotary hoe is not an option. Control of low foxtail populations is optional but seed may contribute to weed infestations in subsequent crops.

S4. Narrowleaf hawksbeard is a problem weed in Canada and Montana, but has infested many fields in northwest ND. Narrowleaf hawksbeard is a winter annual or annual that reproduces by seed. It resembles perennial sowthistle with yellow flower heads but does not have only a single stem and leaves are at the base of the plant. It germinates primarily in the spring and fall from late August through early November. It grows 2 to 3 feet tall from a taproot and all parts of the plant exude a milky sap. Flower heads are 1/2 to 3/4 inches in diameter. Each plant is capable of producing over 49,000 seeds and seeds are dispersed by wind. It is a common contaminant in alfalfa seed. No dormant period is required for germination. It is listed as noxious weed in Manitoba. Control measures should begin in the fall at the rosette stage. Herbicides with good activity on narrowleaf hawksbeard include 2,4-D (1 pt, lower rates not as effective), Glyphosate (1.125 lb ae/A), Express, glyphosate + Express, glyphosate + dicamba, or glyphosate + Sharpen. For residual control, consider Glyphosate + Valor + 2,4-D applied in the fall. Fall-applied herbicides are more effective than spring-applied. Spring-applied herbicides that are effective include glyphosate, Express, Sharpen, Curtail, WideMatch, and Liberty. Narrowleaf hawksbeard should be controlled in the rosette stage. Control is much more difficult after the plant starts to bolt. Tillage will effectively control narrowleaf hawksbeard. In wheat, several options are available for hawksbeard control such as Affinity BS + 2,4-D, GoldSky, Starane Flex + 2,4-D, Quelex, Talinor, Huskie, Kochiavore, and others.

S5. Horseweed (marehail) a winter annual or summer annual. Horseweed seed germinates shortly after soil contact, thrives in no-till systems, and tillage only 0.5 inch deep can kill emerging populations. Horseweed forms a basal rosette after emergence in the fall and bolts in the spring growing to a height up to 6 feet. Horseweed can germinate in the spring. Horseweed seed has pappus like dandelion seed and can travel for several miles. Reduced tillage, wind dispersal, and herbicide resistance from overuse of glyphosate and other herbicides make control difficult. Horseweed is resistant to glyphosate, paraquat, atrazine, and ALS herbicides. Control horseweed in no-till soybean prior to planting. Soybeans planted before in mid-May will require a residual herbicide to control later emerging plants. This strategy will reduce the need for POST herbicide treatments which are less effective. The following principles are important in horseweed control programs:

- Include 2,4-D ester in preplant treatments in corn and soybean.
- Apply herbicides before horseweed plants are 4 to 6 inches tall.
- Fall-applied herbicides may not control spring-emerging plants.
- Spring applications should include a residual herbicide.

Refer to the following sources for biology and management of horseweed:

<http://www.extension.purdue.edu/extmedia/GWC/GWC-9-W.pdf>

S6. Kochia is an exceptionally competitive weed and a few uncontrolled plants can cause severe yield loss. Kochia is resistant to 2,4-D and MCPA due to resistance from repeated use and near eradication of susceptible kochia biotypes over 7 decades of use. 2,4-D and MCPA does not translocate readily in kochia. Stinger is not effective. ALS resistance in kochia occurred soon after introduction of SU herbicides in the late 1980s. All kochia is considered ALS resistant.

Kochia is resistant to Group 2, 4, and 9. Group 14 resistance is suspected leaving few herbicides for weed control, especially in soybean and legume crops. Spartan PRE and Flexstar POST can control kochia but may result in Group 14 resistance. Kochia population have already been documented surviving dicamba and Starane (fluoxypr). Long-term kochia control will require using sustainable cultural and chemical weed management strategies. Refer to paragraph S7 (Lambsquarters) for other cultural practices to use for kochia management.

Soil-applied herbicides with activity on kochia are: acetochlor (suppression), Acuron/Flexi, Anthem, atrazine, Balance Flexx, Boundary, Callisto/Xtra, dicamba, Fierce EZ, Gangster, Lumax, metribuzin, Nortron, Prefix (restricted geography), Sharpen, Verdict, and Zidua. Soil-applied Spartan gives good to excellent kochia control if activated but Valor is less effective and has less soil residue to control later flushes. DNA herbicides do not control kochia.

Post-applied herbicides with activity on small (<3 inches tall) kochia include: Aim (less than 2 inches), Acuron/Flexi/GT, atrazine, Buctril, dicamba, Flexstar/Reflex, Huskie/Complete/FX, Impact + atrazine, Laudis + atrazine, Liberty, Lumax, paraquat, Starane (including all premixes), and Status.

Sequential applications of the Dry Bean Tank-Mix as listed in the dry bean section will also control kochia. Applications must be made to small weeds (<2") and use of MSO adjuvant is required. For other effective herbicides for kochia control see the weed rating chart in the back of the weed guide.

Most kochia seed dies after 1 year and less than 5% can germinate in the second growing season. This is the most critical weakness in kochia biology. Application of this short seed life means two or three years of excellent season-long control can reduce kochia populations. Plant 1 planter width of corn or sunflower around the perimeter of the fields to prevent kochia plants from other areas from rolling across your field.

S7. Lambsquarters is a member of the goosefoot family which also includes kochia, Russian thistle, and sugarbeet. Lambsquarters is a summer annual that can emerge throughout the summer, with peak emergence in mid to late spring. A lambsquarters plant can produce more than 70,000 seeds. Brown seeds germinate readily, while black seeds are more dormant. Seed dormancy is mainly responsible for survival. Seed can remain viable in the soil for several decades but light, wide day and night temperature fluctuations, and nitrate in the soil increase seed germination. There are at least 16 *Chenopodium* (Goosefoot) species that are confused with lambsquarters, including *Atriplex* species, and spreading orach.

There are many effective PRE herbicides in all crops which is the most effective control practice recommended. All POST herbicides give erratic control. Glufosinate is generally poor on lambsquarters.

Lambsquarters has become resistant to triazine herbicides since the early 1970s and resistance to ALS herbicides in the 1990s. Glyphosate resistance has been suspected for many years as lambsquarters has become more prevalent. Lambsquarters size at application also affects common lambsquarters response to glyphosate. Poor management decisions and unfavorable weather have caused inconsistent lambsquarters control with glyphosate. Differences in glyphosate sensitivity have been documented in several states. Lambsquarters is considered the most 'hard-to-wet' broadleaf species with spray droplets. Without an effective surfactant and an adequate surfactant concentration many spray droplets bounce off lambsquarters leaves and are not retained. Many glyphosate formulation claim to be 'full-load' adjuvant formulations and do not recommend additional NIS which may cause inconsistent herbicide response. NDSU research has shown wide variability among surfactants in enhancing lambsquarters control from glyphosate. In general, adding more surfactant enhances control of lambsquarters, grasses, and other 'hard-to-wet' species. Use NIS at 0.5 to 1% v/v for no-load, 0.25 to 0.5% v/v for partial-load, and 0.25% v/v for full load glyphosate formulations.

Lambsquarters populations have survived glyphosate applied at 1 lb ae/A and the resistant trait was passed on to the next generation. Other populations may require a glyphosate rate of 2 to 4 times the labeled rate of 0.75 lb. ae/A. Cultural practices that help control common lambsquarters include anything that makes the crop more competitive and reduces the success of the weed. Such practices include selecting crops with quick emergence, altering planting dates relative to weed emergence, planting to narrow rows and using higher seeding rates for greater crop competition, placing fertilizer with the crop (not the weed), and implementing crop rotations that discourage summer annual weed success. Late seeding in particular can give some control because common lambsquarters tends to germinate early in the season and those seedlings are killed through soil preparation or with a burndown herbicide. Delayed planting crop may not yield as well as earlier planting, especially for full-season crops like corn. Crop rotation interrupts pest life cycles and allows alternative tillage and herbicide options. When following corn or soybean with a fall- or spring-seeded small grain, common lambsquarters may not emerge, compete, or set seed the year of the cereal grain. In addition, because common lambsquarters seeds persist in the soil, removing escapes before seed set is useful for long-term management. Clean up tillage, mowing, or an effective herbicide application after cereal grain harvest can often prevent seed production. Alternatively, underseeding a legume cover or forage crop in the small grain, or after harvest, can compete effectively with common lambsquarters if the grain and cover crops are dense and vigorous. Mechanical weed control operations, such as rotary hoeing and row cultivating, can help reduce herbicide dependence and effectively control seedling weeds. Because common lambsquarters seedlings are very small and fragile, and the seeds germinate in response to soil disturbance, stirring the top 1 to 2 inches of soil is highly effective at controlling emerging seedlings during the first 4 to 6 weeks after planting. Row cultivators must be used when weeds are small. The potential to use in-crop cultivation depends on tillage system in corn, and on tillage system and row spacing in soybean. Refer to the weed rating chart in the back of the weed guide for effective herbicides for lambsquarters control.

S8. Nightshades thrive in high rainfall and human activity associated with crop production like moving tillage and harvesting equipment from field to field or planting crop seed contaminated with nightshade seed. Birds and wildlife consume nightshade berries and can transport seed through droppings. Four nightshade species are found in North Dakota: black nightshade, eastern black nightshade, hairy nightshade, and cutleaf nightshade. Hairy nightshade is the only species densely covered with small hairs. The berries of cutleaf and hairy nightshade remain green at maturity. Only the underneath side of black and eastern black nightshade leaves are black or dark-purple and berries turn black or dark purple at maturity. Eastern black nightshade is very difficult to distinguish from black nightshade before berry formation. Eastern black nightshade forms berries in umbrella-like clusters with berry stems arising from a common point, the calyx of eastern black nightshade is the smallest of the four, and the lobes of the calyx recurve away from the berry. Black nightshade and hairy nightshade berries connect in a racemose fashion (similar to grapes). The calyx of black nightshade is mid-size and the lobes extend outward, while the calyx of hairy nightshade is large and encloses half the berry. It has been reported that leaves from eastern black nightshade plants are translucent and leaves from black nightshade are opaque when held to sunlight.

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Nightshade emergence may continue from June through September and is strongly influenced by moisture. Rain events cause multiple flushes of nightshade, so plants can emerge even after normal crop spraying is complete. Hairy nightshade emerging in early fall can produce viable seed before frost while eastern black nightshade requires a longer growing season. Nightshade can compete after crops form a shaded canopy. Consequently, growth of nightshade can accelerate after small grain harvest, which exposes nightshade to sunlight. Nightshade seeds become viable shortly after berry formation and seeds can remain viable in soil for 15 years when deeply buried. Studies show that one nightshade plant can produce 178,000 seeds under competitive situations or 800,000 without competition. Therefore, successful nightshade management requires prevention of seed production.

Nightshade plants remain green after several frosts and can cause harvest problems. Berries are poisonous and the juice from ruptured berries can stain crop seed and glue nightshade seed and dirt to harvested seed. In addition, dry nightshade berries are similar in size to soybean or field pea seed and are difficult to separate. Nightshade can be spread to other fields by equipment and contaminated seed used for planting. Nightshade biotypes are tolerant to many classes of herbicides, including SUs (except Express). Eastern black nightshade resistance to imidazolinone herbicides has been documented in North Dakota. Thus, herbicides may remove competing broadleaf weeds allowing nightshades to proliferate.

Only a few residual soil herbicides, e.g. Balance Flexx, Extreme, Gangster, Pursuit, Python, Spartan, and Valor control nightshade flushes and may leave a residue the following year. Nightshade can be controlled in herbicide resistant crops (Clearfield, Liberty Link, and Roundup Ready). Basagran may control hairy nightshade but not eastern black nightshade. Black nightshade is more tolerant to some herbicides (Matrix) than eastern black nightshade. Flexstar/Reflex gives poor hairy nightshade control. Refer to pages 114 to 119 for chemical control options. Other options for nightshade management include planting of uncontaminated seed, using crop rotations, multiple herbicide applications to control late flushes, and inter-row cultivation.

S9. Common ragweed is an annual, composite weed species that is common in eastern and central ND. A single common ragweed plant can produce up to 64,000 seeds. Common ragweed emerges early in the growing season and germination ceases in early July when hot temperatures arrive. Common ragweed biotypes resistant to Group 2 and 9 are common and Group 14 resistance is quickly increasing. Special management of common ragweed in all crops is necessary to maintain effective control with herbicides into the future.

To successfully manage common ragweed apply soil-residual herbicides at 100% of the maximum rate followed by the most effective POST herbicide at maximum labeled rates in all crops. It can be managed with only POST herbicides in corn and cereal crops but difficult in broadleaf crops. Apply the maximum rate of soil-residual herbicides when planting conventional soybean or where glyphosate-resistance is present at a high frequency.

Refer to the following sources for biology and management of common ragweed: Weed Control Guide pages 22-23, 30-31.

S10. Giant ragweed is a member of the composite family, has a summer annual life cycle, produces up to 5,000 seeds per plant, and produces greater than a billion pollen grains/plant. Giant ragweed is a very large and fast growing plant capable of growing

to a height of 17 feet making it a very competitive broadleaf weed species. It emerges early spring and continues through early August making control difficult. Giant ragweed is found predominately along river bottoms and field perimeters, although it is becoming more frequent across fields. Giant ragweed seed can easily be moved by water and machinery, especially a combine. Giant ragweed seeds can persist in the soil for > 5 years. Rapid growth, extended germination, fewer herbicides to effectively control it, and the selection of herbicide resistant biotypes makes control difficult. Biotypes have developed resistance to Group 2, 9, and 14 herbicides with resistance to all three mechanisms of action possible. The only way to effectively manage giant ragweed is to apply soil-applied herbicides after planting tilled fields and prior to planting no-tillage fields.

In no-tillage fields, apply non-selective herbicides in addition to a soil-residual herbicide prior to planting. Apply POST herbicides before plants are 3 inches tall and scout 7 to 14 days later to determine the need for a second POST application. Fewer herbicides effectively control giant compared to common ragweed.

S11. Waterhemp is in the pigweed (Amaranth) family, has a summer annual life cycle, is dioecious (male and female flowers found on separate plants), and has stems and petioles with little to no hair compared to redroot pigweed and Powell amaranth. The leaves are longer, narrower, and waxier (looks shinier) than other pigweed species. Waterhemp can easily produce 300,000 seeds per plant, up to 5 million seeds per plant, and usually produces 1.5 times more seed than other pigweed species of similar size. Seed can remain viable in the soil for at least 4 years and maybe longer causing rapid changes in population density when large quantities of seed are allowed to reach maturity. Waterhemp seeds can easily be distributed by water and machinery, but also likely by fowl and animals. Waterhemp emergence begins late-April to mid-May and continues through early August. Waterhemp is a moderate competitor, capable of reducing corn, soybean, and sugarbeet yield by 15, 44, and 70%, respectively. Waterhemp is established in eastern ND and western MN.

Waterhemp is resistant to Group 2, 4, 5, 9, 14, 15, and 27 herbicides as well as multiple-resistant (combinations of more than one of these mechanisms of action) biotypes. Because of the presence of herbicide-resistant biotypes, wide genetic diversity, late emergence, rapid growth, increased leaf waxes, and high plant densities, waterhemp is difficult to manage. Apply effective soil-applied herbicides followed by effective POST herbicides to small (1 to 3 inch) waterhemp. Choose residual POST herbicides to improve season long control. Utilize row-crop cultivation and hand-weeding as necessary to achieve zero tolerance (100% weed control) so as to not increase the frequency of single and multiple herbicide-resistant biotypes.

Refer to the following sources for biology and management of waterhemp: Weed Control Guide pages 22-23, 30-31.

S12. Biennial wormwood plants in ND emerge throughout the spring and summer, behave like an annual species, and produce up to 1 million seeds/plant. B. wormwood seeds are very small and can be dispersed easily by wind, water, and all human-related operations. B. wormwood thrives in undisturbed (no- or minimum-till) areas, low areas, and areas where soil may remain wet for extended periods of time. Consequently, with every rain event a new flush of wormwood seedlings may appear.

Biennial wormwood survives most PPI, PRE, and POST herbicides and is misidentified as common ragweed. Also, biennial wormwood can emerge late after most POST herbicides have been applied. Rescue treatments with herbicides that control common ragweed, such as Ultra Blazer and FirstRate, have little or no effect on

wormwood. Wormwood plants can grow six feet tall with a woody stem that averages 1 to 2 inches in diameter and can impede grain harvest, including damage to harvesting equipment.

Biennial wormwood is difficult to control because of an extended emergence period and tolerance to many PPI, PRE (Harness*/Surpass*, Dual*, Prowl, Sonalan, and Treflan*) and POST (most ALS herbicides, Cobra, Flexstar/Reflex, and Ultra Blazer) herbicides used in row crops. Sencor*, Huskie, Python, Spartan, Valor, and Wolverine provide residual biennial wormwood control. Growth regulator herbicides of 2,4-D, dicamba, Curtail*/M*, Hornet, Status, Stinger*, Widematch* and the non-selective herbicides Liberty and glyphosate control wormwood. However, biennial wormwood can emerge after most non-residual POST herbicides have been applied and produce seed the same season.

Basagran may not control wormwood with one application. Wormwood becomes tolerant to herbicides as plant size increases requiring application to small plants. Basagran applied with MSO and in repeat applications to small plants will improve control.

S13. Wild oat is difficult to eradicate because the seeds shatter before crops are harvested and because seed dormancy causes delayed germination. Wild oat is a cool season plant and seeds germinate in the spring and fall when favorable temperature and moisture conditions exist. Cultural approaches available for wild oat control in small grains include delayed small grain seeding, post seeding cultivation, and competitive crops. The most practical cultural method of wild oat control is delayed small grain seeding, which involves early soil cultivation to stimulate wild oat germination followed by tillage or chemical control to kill emerged wild oat prior to crop seeding. Delayed seeding may cause a significant wheat yield reduction when compared with early seeding.

Other cultural control practices are planting competitive crops like barley and rye. Wild oat eradication is not practical or economically sound; therefore, a combination of cultural and chemical control methods should be used to manage wild oat populations and minimize yield losses.

Apply POST wild oat herbicides to wild oat and crops at precise leaf stages. Early application may result in better yield because of less competition with the crop, but later flush of wild oat may require a second application. In general, any population warrants chemical control to prevent yield losses and reduce seed production. Wheat yield reduction from foxtail and wild oat competition in NDSU research follows.

Grass Weed Competition in Wheat

Weeds/sq. yard	Foxtail	Wild oats
% wheat yield reduction		
10	0	8-9%
50	4-5%	18%
75	6-7%	25%
100	8-9%	34%
150	15%	40%

*Or generic equivalent.

S14. Powell amaranth is in the pigweed (Amaranth) family, is native to the southwestern United States, but it is common throughout the United States including North Dakota. Seedling characteristics that are very similar to redroot pigweed include small fine hairs found throughout the plant along rough leaf and stem surfaces. First leaves are more tapered and pinched toward the end. Powell amaranth grow erect from 4 to 6 feet. The inflorescence is several long, narrow clusters of both male and female flowers interspersed with spiny green bracts. Inflorescence is less branched than redroot pigweed or smooth pigweed. Branches of the flowering structure are usually 4 to 8 inches long. There is no known herbicide resistance Powell amaranth in ND, although there is some evidence to suggest that redroot pigweed is more susceptible to glyphosate than Powell amaranth.

S15. Barnyardgrass is becoming more problematic to control across North Dakota. It generally thrives in wet areas, but also grows abundantly in low pH soils. Some barnyardgrass populations escape POST herbicides due to a later emergence pattern. It is generally more tolerant to glyphosate than other grasses in North Dakota, and higher rates should be used accordingly. Globally, barnyardgrass is one of the worst weeds for developing herbicide resistance. We do not suspect herbicide resistance in North Dakota barnyardgrass populations at this time.

PERENNIAL WEED CONTROL

T1. Field bindweed. Facet L (quinclorac) is the most effective herbicide for field bindweed control. Apply in fallow, postharvest, or preplant in spring prior to seeding wheat, including durum. Wheat and sorghum have a 0 hour plant back restriction. Apply in fall prior to a killing frost to bindweed at least 4 inches long. For best long-term bindweed control, make yearly fall applications of Facet at 28 to 32 fl oz/A. Use the higher rates for dense populations or large plants. Apply with MSO adjuvant at 1 to 1.5 pt/A plus UAN at 1 gal/A to bindweed at least 4 inches long.

T2. Curly dock is a perennial broadleaf weed in the buckwheat family. It typically grows in moist soils, in areas such as roadside ditches, wetlands, and low-lying areas in cropland and pastures. The plant has a large, fleshy, yellow-orange colored taproot. The plant grows initially as a rosette (like a dandelion) and eventually produces an erect stem that ranges from 1- to 3-feet tall. Flowers are green and are present primarily during early summer. It reproduces primarily from seed (range of 100 to over 60,000 seeds per plant) but can also emerge from root fragments. Seedlings emerge from late spring through early fall. Perennial regrowth begins in April to May from taproots. The plant turns rusty-brown at maturity. Tillage that completely destroys the taproot will control curly dock. Mowing will prevent seed production and reduce top growth. Spring application of labeled herbicides will control seedling plants. Herbicide application in the fall is the best timing for controlling perennial (established) plants. Herbicides that contain glyphosate (>1.25 lb ae/A at bud to early flower stage or in the fall after a light frost); thifensulfuron (> 0.33 oz ai/A); tribenuron (>0.1875 oz ai/A) plus thifensulfuron, 2,4-D, or MCPA; aminopyralid; bromoxynil; or clopyralid can effectively control curly dock. Other SU herbicides, Callisto, Huskie, Laudis, Liberty, and Sharpen can suppress curly dock. See herbicide labels for use, application rates and procedures, crop rotation restrictions, etc.

T3. Canada thistle is a major problem in ND due to reduced tillage, wet weather, lack of persistent control strategies, and expense of control. NDSU research has shown that Stinger* and Curtail* provide the best long-term Canada thistle control in crop. Glyphosate alone or with 2,4-D gives good control applied pre- and post-harvest. However, control is reduced under dry conditions. Dicamba and Express* give only season-long control. In small grains, applying Express* plus 2,4-D* and dicamba enhances control. 2,4-D applied at jointing followed by Curtail* applied post-harvest to rosette thistle provides good long-term control. Pre-harvest glyphosate treatments also give good control. glyphosate applied alone is similar in control to Curtail* but provides less control than glyphosate plus 2,4-D.

Stinger*, Curtail*, glyphosate, and 2,4-D have the greatest activity on Canada thistle in annual cropping systems. Highest rates should be used without interfering with next years cropping pattern. Apply high rates of herbicides to patches before thistle infestations increase. Timing is a critical factor. Herbicides applied after a light frost may enhance control but application to leaf tissue destroyed by frost may result in less control due to lack of herbicide uptake.

Tillage can be a critical factor. Delaying tillage 1 to 2 weeks after application in late fall increases control and may add an additional 30 to 40% control for herbicide treatments that gave 30 to 50% control without tillage. If lower herbicide rates or less effective herbicides are used, tillage is very important. If tillage is not planned, implement a program of multiple applications of the most effective herbicides at the highest rates practical. Spray rosettes of actively growing plants using the rosette technique described below.

Milestone effectively controls Canada thistle, but is labeled only on noncropland, such as pastures, rangeland, and CRP. Milestone is

generally safe around most tree species except those in the legume family and can be used near but not in streams and ditches with flowing water.

Rosette Technique. The rosette technique maximizes long-term Canada thistle control by encouraging root buds to break dormancy but not initiate flowering. These vegetative shoots provide better absorption, translocation, and activity than flowering shoots. Greatest control occurs when herbicides are applied in the fall to new growth of Canada thistle in the rosette stage. Periodic tillage in fallow controls Canada thistle shoots and other weeds until mid July when the day-length is less than 15 hours. Canada thistle shoots that emerge when day-length is less than 15 hours do not bolt but remain in the rosette growth stage. Apply glyphosate, Stinger*, Curtail*, or WideMatch* to rosettes in late September or early October. For in-crop control, use herbicides and between-row tillage to prevent bolting. Continue cultivation until canopy closure in soybean and until early July in corn. Apply effective post-harvest herbicides until early October. Herbicides fall-applied to rosette Canada thistle provide greater control and root kill compared with treating bolted thistle.

T4. Rough cinquefoil can develop as an annual, biennial, or short-lived perennial. Rough cinquefoil leaves are alternate and compound with 3 leaflets at the end of a petiole. Individual leaflets have serrated margins. Stipules are at the base of the petiole where it attaches to the stem. Rough cinquefoil has yellow flowers with 5 petals and plants are often confused with wild strawberry, which has more smooth leaf margins. Chemical control of rough cinquefoil in cropland is limited. Glyphosate at 0.75 lb ae/A provides fair to good control and tank mixing with Sharpen in a burndown did not improve control. Wheat or row-crop herbicide labels do not list cinquefoil. Some Trimec labels for lawns list cinquefoil as controlled, but can not confirm control. In non-cropland, use Tordon, Milestone, 2,4-D, or Ally for control or suppression. High rates are required restricting cropland use.

T5. Dandelion is a simple perennial weed that is most associated with undisturbed sites such as lawns, road ditches, and minimum- and no-tillage fields. The plant is easily recognized for its bright yellow flowers on a leafless stem that turn into a fluffy round ball when seeds reach maturity and that are dispersed by wind currents. Above-ground foliage is arranged as a rosette (many leaves on a very short stem). Long-established dandelion have a large and deep taproot with multiple dormant buds that grow any time a root is damaged by herbicide or cut. Dandelion is extremely difficult to control because of extended germination from early spring into the fall. Dandelion over-winter and grow from rootstock. Dandelion growing from seed generally does not emerge until later spring or early summer after POST herbicides have been applied. Manage dandelion with tillage and herbicides, including glyphosate, Express, 2,4-D, or dicamba applied in late fall. Spring applications can control dandelion, but are not as effective as fall applications. Post-harvest applications typically provide better control than pre-harvest applications. Do not tank mix glyphosate with Group 14 herbicides such as Sharpen, Spartan, Valor, or Aim if dandelion is a primary target for weed control because these herbicides will reduce glyphosate absorption resulting in reduced dandelion control. Refer to the following sources for biology and management of dandelion: Paragraph B2.

T6. Common milkweed has become a weed problem in cultivated cropland due to an extensive deep root system, insulating winter snow, moist to wet summer conditions, tolerance to many commonly used herbicides, reduced tillage, and lack of human persistence in control measures. Common milkweed is tolerant to most herbicides. Control requires multiple herbicide applications. Preventing establishment and spread of milkweed patches requires continuous scouting and persistent control efforts.

Prevent seed production. Milkweed seed is highly viable and will germinate readily. Pappus on seeds allows long-distance travel and is

responsible for establishment. Common milkweed seedlings becomes perennial (capable of reproducing from underground roots) approximately 3 weeks after emergence. New shoots develop from established roots and begin emerging in late April and grow more rapidly than spring seeded crops. Milkweed control is expensive. Individual plants and small patches are easier and less expensive to treat than entire fields. Patch spraying covers only a fraction of the area of a broadcast application. Patch spraying allows use of higher herbicide rates with less expense than broadcast spraying.

Common milkweed control and management.
NDSU Research. Herbicides applied in June.

Herbicide	Rate	Months after application	
		3 mo.	12 mo.
	pt/A	--- % control ---	
2,4-D ester*	4	36	48
Dicamba	2	71	61
Dicamba + 2,4-D	0.5 + 2	26	15
Curtail	4	13	6
Glyphosate	1.5 lb ae	56	99

Express* + 2,4-D + dicamba controls only top-growth.

Glyphosate at 1.5 lb ae/A applied preharvest will reduce milkweed densities 85 to 95% compared to in-crop applications, which reduce milkweed densities by less than 40%. Apply herbicides when milkweed is in the late-bud to flowering stage and actively growing. Control patches when small. Patch-spray glyphosate at 1.5 to 2 lb ae/A. Apply glyphosate with AMS at 8.5 lb/100 gallons of water.

T7. Fall-applied herbicides can be effective for controlling perennial weeds provided most stem and leaf tissue has not been killed by frost. Weeds such as field bindweed, leafy spurge and Canada thistle should have 6 to 12 inches or more of stem or rosette tissue before treatment for adequate leaf area to absorb the herbicide. Good leafy spurge control can be expected through mid-October with auxin herbicides even after several light frosts when the leaves are green or red and still firmly attached to the stem. Milestone provides superior control to Tordon when applied in late fall (October).

T8. Mowing or tillage is a good means of reducing perennial weed seed production. If fall herbicide applications are planned, mowing or tillage should be discontinued early enough to allow adequate plant regrowth. Post-harvest treatments can be applied when weed growth is about 1 foot tall. Preharvest herbicide treatment should precede harvest by at least 5 days to allow adequate herbicide translocation in perennial weeds. Fortunately the minimum PHI for many preharvest treatments meets or exceeds this guideline.

PERENNIAL WEEDS IN CROPS

T9. Perennial weed control systems in crops should include in-crop (conventional and particularly Roundup Ready crops if available), preharvest, and postharvest herbicide applications. Regardless of application, retreatment once or twice per year will be required for successful control of perennial weeds. Once large patches are controlled, seedlings will require treatment annually with registered in-crop herbicides. Glyphosate use in Roundup Ready corn, soybean, canola, and sugarbeet is a very effective system to control perennial weeds. NDSU research has shown good control of established Canada thistle patches with glyphosate applied preharvest. For postharvest herbicide applications to be effective, treatment of new plant growth is required. Tillage combined with any herbicide treatment enhances control. Tables for each crop or perennial weed listed in this guide gives most effective herbicide choices, rates, and application information.

T10. Glyphosate at 0.75 to 1.5 lb ae/A applied as a spot treatment will give season-long control of most perennial weeds in wheat, barley, oat, corn, and soybean. glyphosate is non-selective and will kill crop in the treated area. Avoid drift outside the target area. Glyphosate is non-residual so plants may emerge after treatment and unaffected rhizomes or roots from perennials will continue to grow. See label or tables for application stage and rates. Glyphosate at 0.75 lb ae/A applied preharvest gives good Canada thistle and quackgrass control. When tillage is used after harvest, glyphosate will give greater Canada thistle control when applied preharvest than post-harvest.

PERENNIAL WEEDS IN PASTURES (See Z1 for haying and grazing restrictions)

T11. 2,4-D ester or amine at 2 to 4 pt/A controls many perennial weeds in pastures. Some perennials such as fringed sagebrush and western snowberry (buckbrush) are controlled with one application and perennials such as Canada thistle, field bindweed, and leafy spurge require retreatment annually. 2,4-D can be used where Tordon cannot, but avoid drift onto susceptible plants. Hi-Dep allows use at spray volumes as low as 1 gpa by ground or 0.5 gpa by air.

2,4-D formulations registered for use in water include Agriliance "AgriSolutions 2,4-D Amine 4", UAP "Savage" and "Amine 4 2,4-D Weed Killer", Nufarm "Weedar 64", Van Diest "Cornbelt 4 lb Amine" and "Cornbelt Navigate", and Helena "Opti-Amine". Use only 2,4-D formulations registered for use near or in water. Refer to 2,4-D labels for registered use and information.

T12. Crossbow (triclopyr & 2,4-D) at 1 to 6 qt/A can be applied to grass pastures for broadleaf weed and brush control. Crossbow plus 2,4-D generally provides better musk thistle and brush control than 2,4-D alone. Do not graze lactating dairy animals or harvest hay from treated areas for 1 year after application. Do not graze beef animals within 3 days of slaughter during the first year after treatment.

T13. Dicamba at 1 to 2 pt/A will suppress some perennials, especially field bindweed and weeds resistant to 2,4-D. Dicamba can be applied in 1 to 5 gpa in pasture, rangeland, and fallow. When applying dicamba at 2 pt/A or less, use 0.5% v/v surfactant or AMS at 2 to 6 lb/100 gal of spray solution. Long-term control generally is achieved with 4 to 16 pt/A but the high rates are economical only for spot treatment. Dicamba has a shorter soil residual than Tordon, but should not be applied where desirable plants may be damaged by herbicide leached to the root system. The label indicates the required delay between treatment and grazing of dairy animals or cutting for hay but varies with rate from 7 to 90 days.

T14-19 - PERENNIAL WEED CONTROL

T14. Escort* (metsulfuron) at 0.1 to 0.3 oz 75DF/A or **Cimarron** products (metsulfuron & chlorsulfuron) can be applied in rangeland, grass pastures, and non-cropland for control of noxious and troublesome weeds. Spot treat at higher rates when practical. Spray foliage for thorough coverage but not to run-off. Add a NIS at 0.25 to 0.5% v/v or PO at 1% v/v. Use of NIS may cause temporary yellowing, stunting, and suppression of head development in annual and perennial grasses. To avoid grass injury, do not apply to desirable grasses under stress, nor to grasses grown for seed. Products with 2,4-D, dicamba, and many other herbicides increase control and reduce risk of resistant weeds. Some brands of Ally* at 1 to 1.5 oz DF/A can be applied by air (helicopter and fixed wing) for weed control to utility and pipeline right-of-ways, military installations, and rangeland and pasture.

T15. Milestone (aminopyralid) at rates up to 14 oz/A per annual growing season may be applied as a spot treatment to not more than 50% of an area. Milestone has no grazing or haying restrictions but allow 3 days for animals to graze in untreated areas before transferring them to areas with sensitive broadleaf plants. May be applied to waters edge and in seasonally dry wetlands. Do not apply directly to water or to areas where surface water is present. Milestone can be applied to the soil under the canopy of several trees. Refer to label for list of tree species. Apply only as a directed spray under the canopy. Do not apply Milestone over-the-top of any tree. Legume plant and tree species are very susceptible to Milestone.

T16. Plateau (imazapic) with MSO adjuvant at 1 qt/A and UAN at 1 qt/A applied from early September to mid-October controls many grass and broadleaf weeds, including foxtail and leafy spurge in right-of-ways, pasture, rangeland, and CRP. Warm- season grasses are more tolerant than cool-season grasses. Highest rate provides longer control but increases grass injury. Plateau does not control absinth wormwood. Plateau does not injure desirable forage grasses or some broadleaf species including lead plant (*Amorpha canescens*), purple prairie clover (*Dalea purpurea*), prairie wild rose (*Rosa arkansana*), willow, (*Salix species*), and wild raspberry (*Rubus species*).

T17. Tordon (picloram) at 4 to 8 pt/A applied as a spot treatment controls broadleaf perennial weeds such as leafy spurge, common milkweed, field bindweed, Canada thistle, and Russian knapweed on rangelands and permanent grass pastures. Tordon at 1 to 2 pt/A applied POST will suppress growth of perennial broadleaf weeds. Retreatment at the same rates is necessary the following year. The most cost-effective broadcast spring-applied treatment for leafy spurge control is Tordon at 1 pt/A plus 2,4-D* at 2 pt/A applied annually for 3 to 5 years. Do not apply Tordon with dry fertilizers.

Tordon is a restricted pesticide because it is toxic to most broadleaf plants. Spray drift will damage broadleaf crops and plants. Tordon is water soluble and may leach in the soil; consequently, do not apply in areas where a sandy porous surface and substrata overlay ground water 10 feet or less below the surface. Tordon must not be allowed to drift into surface water (including wells), irrigation water and drainage ditches or near shelterbelts, shrubs, or trees.

Do not cut grass for feed within 2 weeks after treatment at Tordon rates greater than 2 pt/A. Tordon is excreted in the urine which restricts transfer of livestock from treated grass areas onto sensitive broadleaf crop areas for 12 months after application without first allowing 7 days of grazing on untreated grass. When the Tordon rate exceeds 2 pt/A, the total area treated should not exceed 25% of a land owner's acreage found in any particular

watershed.

T18. Mixture of Tordon + Plateau applied in June has provided greater leafy spurge control than Tordon + 2,4-D. Use of 2,4-D with Tordon + Plateau is not necessary but will increase the spectrum of broadleaf weeds controlled. Research by NDSU has shown improved leafy spurge control both in-season and the season following application when Tordon and Plateau are used.

Treatment	Product/A	Months after application		
		3	12	15
		----- % control -----		
Tordon + 2,4-D	1 pt + 1qt	75	48	0
Tordon + 2,4-D + Plateau + MSO	1 pt+1 qt + 4 oz+1 qt	92	83	75

MSO adjuvant is required.

Do not apply after July 1.

Bromegrass species occasionally have shown short-term injury.

T19. NRCS Policy on Noxious Weed Control in CRP.

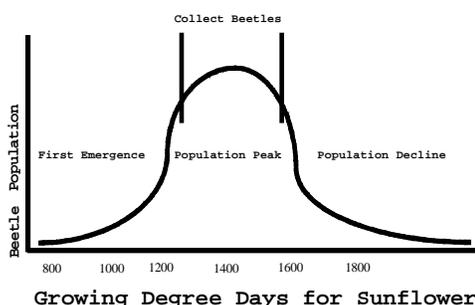
Taken from ND NRCS Exhibit 3, 2-CRP Manual, para. 210.

Established CRP Stands: Policy requires that no clipping or spraying of entire fields should be done during the primary nesting period (April 15 to August 1) for normal weed control. If noxious weeds are present and the critical control period for the weed falls in the primary nesting period, spot treatment of weeds is allowed. Herbicides chosen should maintain the grass and legume mixture. If this is not possible, control of the noxious weeds is a priority over maintaining legumes in the mix. Always notify your local USDA Service Center before making any herbicide applications.

New CRP Stands: Policy requires that weeds (noxious, common, volunteer grain, etc.) be controlled in CRP. Clipping and/or spraying during establishment should be used to control weed growth and reduce competition for the new seedlings. Clipping and/or spraying may be done at any time during the establishment period. If noxious weeds are present, control of noxious weeds is a priority over maintaining legumes in the mix. If the legume is killed after spraying and before the grass/alfalfa stand is established then a legume must be reseeded. Once the stand is established follow the above guidelines for established CRP stands. Always notify your local USDA Service Center before making any herbicide applications.

*Or generic equivalent.

T20. Leafy spurge. Eight insect species have been released in North Dakota for biological control of leafy spurge. **Flea beetles** (*Aphthona* spp.) have been the most effective insects due to root feeding by larvae, rapid establishment, and increase after introduction, and ease in capture to transport to additional locations. Flea beetles are distributed through the ND Biological Control Program. Contact your county weed officer or board member for information. Release flea beetles on a well-drained south-facing slope with a moderate density of leafy spurge (60 to 90 plants/square yard) with minimal grass cover. Do not collect or move flea beetles, cultivate, burn site, or apply insecticide within 0.25 mile of release site for 3 to 5 years to allow establishment. During establishment, landowners should prevent expansion of the leafy spurge infestation by treating uninfested perimeters with herbicides. The best time to collect and distribute flea beetles is between 1000 to 1500 accumulated growing degree days (AGDD) for sunflower. Scout for establishment when the total AGDD for sunflower reaches 1100 to 1200. Flea beetle density prior to 1200 and after 1600 AGDD is low.



Use an insect sweep net to collect beetles to estimate density. Collect beetles from 10:00 am to 3:00 pm, greater than 70 F, little or no wind, sunny skies, and when leafy spurge foliage is dry. Sweep 5 times over an area of 1 m². Count the number of flea beetles by removing excess trash and non-flea beetle insects and pour beetles into a graduated container. Every 10 ml of flea beetles is approximately 1000 individuals.

Redistribute flea beetles to other leafy spurge infestations when 500 to 1000 beetles per 5 minute sweeping period are collected. Over-harvest of beetles is not possible because many flea beetles fall to the ground prior to being swept or are on the soil surface laying eggs. Redistribute flea beetles in a small area of 10 ft² or less. A successful release should result in 50 or more flea beetles in 5 sweeps the summer following release. If densities are less than 50 flea beetles/5 sweeps then re-infest the site with additional flea beetles. A portion of the release area can be treated with picloram plus 2,4-D (2 pt + 2 pt) from early to mid-September to reduce leafy spurge density and increase insect establishment.

Research at North Dakota University has shown greater leafy spurge control when herbicides are combined with flea beetles compared to either used alone. Contact your county weed officer for date, time, and location of flea beetle collection in your area and information on purchasing collection equipment. An instructional video is available from the North Dakota Department of Agriculture, "[How To Raise Leafy Spurge Flea Beetles](#), North Dakota's Biological Control Program".

Leafy spurge gall midge (*Spurgia esulae*) prevents galled stems from flowering, thereby decreasing seed production. The gall midge generally infests only part of a leafy spurge population so seed production is reduced but not eliminated. A second control method is needed to reduce the original infestation and prevent spread by roots and seeds of plants not galled.

Research at NDSU has shown that the leafy spurge gall midge is compatible with herbicide treatment in an integrated leafy spurge management program. Herbicides such as Tordon or 2,4-D should be applied at the optimum growth stage for leafy spurge control. Some of the area (perhaps 15 to 25%) must be left untreated to sustain the insect population. This integrated program may be most useful near wooded areas or rough terrain. Consult NDSU Ext. Service Circulars W-866, Integrated Management of Leafy Spurge; W-1088 Leafy Spurge Biology, Ecology, and Management W-1183; and Leafy Spurge Control Using Flea Beetles, for further details.

Grazing. Sheep and goats provide an alternative to herbicides for controlling leafy spurge top-growth in pasture and rangeland with large infestations or along waterways and tree areas. Grazing alone reduces but does not eliminate leafy spurge infestation. Grazing slows the spread and allows grasses to be grazed by livestock. Grazing should be started in spring when plants first emerge. Divide infested areas into sections so animals can repeatedly graze new growth. NDSU research has shown that grazing leafy spurge with goats followed by a fall-applied herbicide treatment provided more rapid and better long-term leafy spurge control than either method used alone. Consult NDSU Ext. Service Circular W-866, Integrated Management of Leafy Spurge, for details.

Recommended stocking rates vary with terrain, leafy spurge density, and rainfall during the growing season. Sheep should be grazed at about 3 to 6 head/A/month or 1 to 2 ewes/A. Angora goats should be grazed at 12 to 16 goats/A/month or 3 to 4 goats/A. Grazing with goats controls leafy spurge with little utilization of the grass species. The stocking rate will decline over time as the leafy spurge infestation is reduced. Animals should be contained for 3 to 5 days so viable seed can pass through the digestive system before they are moved to non-infested areas. Which animal to utilize will depend on a land manager's specific conditions, such as fencing, availability of animals, need to overwinter, and prevailing markets at the time. Consult NDSU Extension Service Circular R-1093, Controlling Leafy Spurge Using Goats and Sheep, for further details.

T21. Purple loosestrife. Three insect species have been released into North Dakota for purple loosestrife control. The insects and plant parts attacked are:
Galerucella pusilla - a leaf-feeding beetle
Galerucella calmariensis - a leaf-feeding beetle
Hylobius transversovittatus - a root-mining weevil
 Biological agents hold promise for large infestations, thereby reducing the spread from neighboring states. However, purple loosestrife infestations in North Dakota are very small and isolated and **should be controlled by chemical and/or mechanical methods**. Biological control agents for purple loosestrife may not work well in urban areas because mosquito spraying severely reduces populations of biocontrol agents.

*Or generic equivalent.

HERBICIDE-RESISTANT WEEDS

X1. Herbicide resistance occurs with repeated use of a specific herbicide or a combination of herbicides for control of weed species that contain some plants in the population with resistant genes. The resistant type will increase with each use of the herbicide(s) because the gene pool in the field will shift from susceptible to resistant. This shift may be permanent, assuming that the resistant type plants are equally "fit" in the cropping environment. Use of one herbicide from a group with one mechanism of action may give resistance to other herbicides with the same mechanism of action. However, weed specificity for resistance is known for different herbicides within a mechanism of action group. For example, if a wild oat population is resistant to one ACCase inhibitor herbicide, other ACCase inhibitor herbicides may or may not provide control.

Weed populations with wide genetic diversity may develop resistance rapidly, especially for herbicides with a single mechanism of action. Large plant numbers, prolific seed production, high rates of weed migration/spread, and diverse environmental conditions may contribute to high genetic diversity. For example, kochia developed resistance rapidly in North Dakota to SU herbicides because of genetic diversity and the single mode of action (ALS inhibition). Weeds may vary in resistance to herbicides of the same mechanism of action group, especially if the herbicides are from different chemical classes. For example, weeds resistant to SU herbicides may or may not be cross-resistant to the Imi class of ALS inhibitors. Weeds may also vary in resistance to herbicides of the same chemical class, depending on their specific resistance mutation(s). Table X1 lists herbicides within various mode of action groups as a guide for possible cross resistance.

Types of Resistance

Altered target site - Genetic mutations within a herbicide site of action can prevent complete herbicide interaction with binding sites, allowing the target-site protein to remain functional. The incomplete inhibition of the altered site of action may result in little to no observed plant injury. Where the herbicide has such little inhibitory effect on the site of action, plants may survive greater than 10 times the normal herbicide rate (considered high-level resistance). Mechanisms of action where high-level resistance is most often seen include ACCase, ALS, and photosystem II inhibitors. However, target-site alterations may only partially reduce a herbicide's inhibitory effect. Such are considered low-level resistance because plants are unlikely to survive greater than 10 times the normal use rate. Plants with low-level target-site resistance may sometimes be controlled when the herbicide is applied to small plants at high-end label rates. Examples of low-level resistance due to target-site alterations include common ragweed resistant to PPO inhibitors, and goosegrass and some ryegrass resistant to glyphosate.

Altered herbicide metabolic processes - Plants prevent herbicide toxicity by rapid degradation. Corn degrades atrazine by this mechanism. This type of resistance is more complex than altered site-of-action type resistance because it involves several plant processes. Plants with altered metabolism resistance can degrade several unrelated herbicides of different modes of action through multiple genes controlling metabolic processes.

Plant injury may occur because plants can not rapidly degrade absorbed herbicide, causing this mechanism to be considered low-level resistance. Therefore increasing the herbicide rate to smaller plants may control more plants. Examples of altered herbicide metabolism include some ryegrass resistant to ACCase, ALS, and photosystem II inhibitors, and velvetleaf resistant to atrazine.

Metabolic resistance is believed to be present in many other weed species.

Herbicide sequestration / Altered herbicide localization - Nearly all plants with this type of resistance are injured shortly after the herbicide application because the movement of herbicide is either impeded, moved away from the target site, or moved to a location where it is ineffective. This may be at the whole-plant or cellular level. Herbicide sequestration is considered low-level resistance because increasing rates applied to smaller plants increases mortality. Examples of herbicide sequestration include biotypes of glyphosate-resistant horseweed, ryegrass, common and giant ragweed, and weed biotypes resistant to paraquat. Variable lambsquarters control may result from limited glyphosate translocation.

Target-site amplification - Some glyphosate-resistant kochia, Palmer amaranth, and waterhemp express increased levels of herbicide-susceptible EPSPS target-site protein. These plants can have up to 100 copies or more of the EPSPS gene, and produce more target-site enzyme than glyphosate can fully inhibit.

Cross and Multiple Resistance

A plant with a single resistance mechanism that survives treatment with chemicals within the same mechanism of action is cross resistant to those chemicals. Resistance that develops to one ALS herbicide chemistry often confers cross resistance to other ALS herbicide chemistries. In some cases, resistance that develops to a SU confers cross resistance to imidazolinones.

A plant with two or more resistance mechanisms that survives treatment with different chemicals within a different mechanism of action has multiple resistance, example: a kochia plant that survives SU and atrazine has multiple resistance.

Herbicide-resistant weed species in ND:

(#) = Herbicide mode of action.

- **ACCase inhibitor herbicides (1):** wild oat and green foxtail.
- **ALS inhibitor herbicides (2):** green foxtail, E. black nightshade, kochia, marshelder, mustard, ragweed, redroot/Powell pigweed, Palmer amaranth, waterhemp, and wild oat.
- **Mitotic inhibitor (3):** green foxtail - Treflan, Sonalan, Prowl.
- **Growth regulator (4):** kochia - 2,4-D and dicamba, Starane
- **Photosystem II inhibitor (5, 7):** kochia, Palmer amaranth.
- **EPSP synthase inhibitor (9):** Horseweed (marestail), kochia, common ragweed, Palmer amaranth, and waterhemp.
- **PPO inhibitor (14):** ragweed.

Multiple Resistance:

Green foxtail - Group 1 + 2	Kochia - Group 2 + 4 + 9
Palmer amaranth - Group 2+5+9	Ragweed - Group 2 + 9 + 14
Waterhemp - Group 2 + 9	Wild oat - Group 1 + 2, 8 + 15

Herbicide-resistant weed species in other U.S. states:

- **ACCase inhibitor herbicides (1):** Barnyardgrass, yellow foxtail.
- **ALS inhibitor (2):** Yellow foxtail, giant foxtail, lambsquarters, sunflower, cocklebur, and Russian thistle.
- **Growth regulator (4):** Wild mustard, field bindweed, Palmer amaranth, and waterhemp.
- **Photosystem II Inhibitor (5):** Yellow foxtail, redroot pigweed, Powell amaranth, lambsquarters, common ragweed, velvetleaf, and waterhemp.
- **EPSP Synthase Inhibitor (9) (glyphosate):** Russian-thistle.
- **Glutamine synthetase (10) (glufosinate):** Italian ryegrass, Palmer amaranth.
- **PPO inhibitor (14):** Palmer amaranth and waterhemp.
- **Very Long Chain Fatty Acid Inhibitor (15):** Palmer amaranth and waterhemp.
- **HPPD inhibitor (27):** Palmer amaranth and waterhemp.

Multiple Resistance:

Waterhemp - Group 2 + 4 + 5 + 9 + 14 + 27.
Horseweed (marestail) and kochia - Group 2 + 9.
Common ragweed, and giant ragweed:
Group 2 + 9 or Group 2 + 14 or Group 2 + 9 + 14.
Palmer amaranth: Group 2 + 4 + 5 + 9 + 27 or Group 2 + 3 + 9 + 14 + 15

Weeds expressing some natural tolerance to glyphosate:

Cinquefoil, clover, lambsquarters, common mallow, dandelion, galinsoga, horseweed (marestail), kochia, nightshade, nutsedge, Pennsylvania pellitory, prickly lettuce, purslane speedwell, smartweed, velvetleaf, waterhemp, wild buckwheat.

Weeds expressing some natural tolerance to glufosinate (Liberty): grasses, lambsquarters, yellow nutsedge.

For a comprehensive list of resistant weeds in North Dakota, U.S., and world see web site: www.weedscience.com

GENERAL WEED MANAGEMENT STRATEGIES:

The following strategies should be effective in reducing problems with herbicide tolerant and resistant weed biotypes, but no single strategy is likely to be totally effective.

Weed resistance in weeds **cannot** be prevented, but can be delayed. Herbicide rotations, management, and tillage will only delay resistance by the length of time the selection pressure for a given herbicide is removed by an alternative control method. Resistance may occur first in fields where repeated use of a single mode of action herbicide is used in a growing season or across several growing seasons. The gene pool does not revert back in absence of the original selection, except when the resistant plants are poorly fit. Fitness has not been greatly different for resistant and susceptible biotypes and should not be relied upon for resistance management.

Integrated weed management uses multiple strategies to manage weed populations including the following:

- \$ Scouting, proper weed identification, and weed mapping.
- \$ Use crop canopy/competition to improve weed control.
- \$ Use weaknesses in the biology of weed species which include traits, life cycles, and ecology.
- \$ Judicious use of and multiple approaches with herbicides.
- \$ Use mechanical weed control as appropriate.
- \$ Regular evaluation and adjustments of weed management strategies.

1. Scout fields before and soon after herbicide application. Correctly identify weeds. Use effective herbicides, handweeding, cultivation/tillage, and other methods of weed control to kill weeds that escape or germinate after chemical application. Scout fields at the end of the season and draw field maps to denote locations of weed species, weed density, and weed escapes. Save maps as a field record.

2. Diversified crop sequences with different life cycles e.g. winter annual crops (winter wheat), perennial crops (alfalfa) and summer annual crops (spring wheat, corn or beans) results in different planting and harvest times, more herbicide options, and decreased risk of herbicide resistant weeds.

3. Consider weed biology and ecology. Use tillage, crop sequence, soil fertility, planting date, crop competition, weed seed longevity, and response to herbicides to increase successful weed management.

4. "Don't forget the PRE". Apply effective PRE herbicides at full rates and include multiple mechanisms of action. PRE herbicides will reduce weed emergence and allow flexibility in POST herbicide timing. Residual PRE herbicides applied to soil and early POST (if labeled) will suppress weed emergence through canopy closure, particularly those with a long germination pattern (waterhemp). Use PRE herbicides that will effectively control problem weeds.

5. Apply effective POST herbicides. Apply herbicides that include multiple mechanisms of action in tank-mix or in sequential applications. Two or more herbicides in mixture must have activity against potentially resistant weeds to be effective. Herbicides in most commercial mixtures do not target the same weed species. Effective tank-mixtures on weeds will reduce selection of herbicide-resistant biotypes more successfully than rotating herbicide modes of action. Antagonism may occur with some mixtures, especially between contact and systemic herbicides.

6. Use high herbicide rates and effective adjuvants. Full rates kill weeds with low-level resistance and dead plants cannot produce resistant progeny. Reduced rates allow plants with low-level resistance to survive, hybridize, and produce progeny with elevated resistance. Hybrid plants (>1 resistance gene) express a higher level of resistance and require even higher herbicide rates to kill the plant. Dead weeds means zero tolerance (no seed production, zero resistant progeny) and is effective resistance weed management.

7. Spray small annual weeds. Generally, small weeds (<3 inches) are more susceptible to herbicides than large weeds. Even weeds with low level herbicide resistance are more susceptible at 1 inch than at larger growth stages.

8. Practice Zero Tolerance. Scout fields after row closure and kill uncontrolled weeds. Seed from escaped weeds will contribute to the weed seedbank and will require diversified weed management strategies of mowing, cultivation/tillage, and hand weeding to achieve near 100% weed control. Timely cultivation can improve weed control and handpulling is effective for single plants or small patches.

9. Control weeds in field perimeters, down out, and non-crop areas. Weeds surviving a partial herbicide dose on field borders can be a repository for the introduction of resistant weeds into a field. Control weeds in all areas of the field where crop is not growing including field edges, fence lines, waterways, ditch banks, and areas where crop has either not been planted or has been destroyed.

10. Rotate herbicides with different mechanisms of action in consecutive years. Diverse crop rotations can introduce herbicides with different mechanisms of action to delay herbicide resistance. A mix of dead plants, unaffected plants, and plants showing intermediate responses indicate herbicide resistance has occurred.

11. Clean tillage and harvest equipment to ensure weed seed will not be transported between fields. This is particularly important in crops that are harvested with a platform header equipped combine.

12. Evaluate weed management at the end of each season and revise to improve weed control the next year.

For more information:

1. Documented herbicide resistant weeds, herbicide resistance education, and herbicide mode of action see: <http://wssa.net/weed/resistance/>

2. Take Action web site is an industry-wide partnership between university weed scientists, major herbicide providers and corn, cotton, sorghum, soybean, and wheat commodity organizations for effective weed management information and tools. <http://takeactiononweeds.com/>

X1. Herbicide Site of Action and Chemical Family for Resistant Weed Management

Site of Action	Common Name	Herbicide Trade name	Premix or Co-pack Trade names
ACCase Inhibitor (1) Aryloxyphenoxy propionic acid "Fop"	clodinafop-propargyl fenoxaprop-P ethyl fluzafop-P butyl quizalofop-P ethyl	Discover NG. Puma = Tacoma = Parity. Fusilade DX. Assure II = Targa.	- Wolverine Advanced. -
Cyclohexanedione "Dim"	clethodim sethoxydim	Select/Max = Volunteer = Intensity. Arrow, Clethodim, Section, Select Max, Shadow, Tapout, Vaquero. Poast.	- -
Phenylpyrazolin "Den"	pinoxaden	Axial XL.	Axial Star, Axial Bold
ALS Inhibitor (2) Imidazolinone "Imi"	imazamethabenz imazamox imazapic imazapyr imazethapyr	Assert. Beyond = Clearcast = Raptor. Cadre = Impose = Plateau. Arsenal = Habitat. Pursuit = Thunder.	- Varisto Journey. Sahara. Authority Assist, Extreme=Thunder Master, Lightning, Matador, Pummel, Torment, Zidua Pro.
Sulfonylurea "SU"	chlorimuron chlorsulfuron halosulfuron mesosulfuron metsulfuron nicosulfuron rimsulfuron sulfometuron sulfosulfuron thifensulfuron tribenuron triflusulfuron	Classic. Glean = Telar. Halomax = Herbivore = Permit = Sandea. Osprey. Ally=Escort=Patriot=Plotter=Rometsol. Accent Matrix = Resolve. Oust. Certainty (turf), Outrider. Harmony = Treaty = Volta. Express = Nuance = Victory. UpBeet.	Enlite, Valor XLT. Cimarron Max/X-tra, Perspective, Report Extra. - Rimfire Max. Accurate Extra, Ally Extra, Chaparral, Cimarron Max, Cimarron X- tra, Finesse, Report Extra, Travallas. Revolvuln Q Alluvex, Instigate, Prequel, Realm Q, Require Q, Resolve Q, Steadfast Q. - Accurate Extra, Agility, Affinity BS/TM, Afforia, Alluvex, Ally Extra, Basis, Harmony Extra, Nimble, Rapport BS/TM, Resolve Q, Sentrallas, Travallas, Treaty Extra. Accurate Extra, Afforia, Affinity/Rapport BS/TM, Agility, Ally Extra, Luxxur A, Harmony Extra, Nimble, Supremacy. -
Triazolopyrimidine "TPS"	cloransulam florasulam flumetsulam pyroxsulam	FirstRate. - Python. PowerFlex HL, Teammate.	Authority First=Sonic, Surveil. GoldSky, Orion, Starane Flex, Quelex. Hornet, SureStart II, TripleFlex II. GoldSky, OpenSky, PerfectMatch.
Triazolinone	flucarbazone propoxycarbazone thiencarbazone	Everest 3.0, Pre-Pare, Sierra. Olympus. Varro	Rimfire Max. Autumn Super, Capreno, Corvus, Huskie Complete, Luxxur B.
Microtubule Assembly Inhibitor (3) Dinitroaniline (DNA)	ethalfuralin pendimethalin trifluralin	Sonalan. Prowl/H20 = Acumen. Trifluralin = Treflan = Triflurex = Trust/others.	- Buckle.
Auxin Mimics (4) Phenoxy	2,4-D amine/ester 2,4-D-choline MCPA amine MCPA ester	2,4-D, others. - MCPA Amine, Rhomene, others. MCPA E, Rhonox, Sword, Wildcard.	See bromoxynil. Crossbow, Curtail, Grazon P+D = Gun Slinger, Landmaster BW, Weedmaster. Enlist Duo - CurtailM, Hat Trick, Orion, Weld
Benzoic acid	dicamba acid -bapma salt -dma salt -dga salt -Na salt -ipa salt -dea salt	Vision Engenia Banvel = Dicamba = Rifle. Clarity = Sterling Blue, DiFlexx, XtendiMax. Banvel SGF. Vision. -	Latigo - - DiFlexx Duo Agility, Distinct=Overdrive, Require Q, Status, Yukon. Fallow Star. Weedmaster = Banvel + 2,4-D = Brush = Outlaw.
Pyridine	aminopyralid clopyralid halauxifen-methyl picloram	Milestone. Clean Slate, Spur = Stinger = Reclaim = Transline. Elevore Tordon 22K = Triumph 22K.	Capstone, Chaparral, CleanWave. Curtail/M , WideMatch = Colt, Hat Trick, Hornet, Maverick, PerfectMatch, Resicore, SureStart, TripleFlex. Quelex, Pixxaro EC, Rezuvant Grazon P+D = GunSlinger, Surmount, Trooper Extra/Pro.
Pyridyloxy	fluroxypyr triclopyr	Starane = Comet. Starane Ultra = Vista XRT. Garlon = Remedy. Pathfinder II.	Axial Star, Colt+Salvo/Sword, Gold/OpenSky, Hat Trick, Huskie FX, PerfectMatch, Pixxaro EC, Supremacy, Starane Flex/ NXT, Colt, Sentrallas, Travallas, Trump Card = WideMatch = Weld. PastureGard, Vengeance Plus.
Pyrimidine	aminocyclopyrachlor	Method	Perspective, Streamline, Viewpoint.
Quinoline	quinclorac (dicots)	Facet=Quinstar=Quinclorac=.	-
Site of Action	Common Name	Herbicide Trade name	Premix or Co-pack Trade names
Photosystem II Inhibitor – Ser 264 (5) Triazine	atrazine simazine	Atrazine, others. Princep.	See 2,4-D, dicamba, bentazon, bromoxynil, glyphosate, acetochlor, dimethenamid-p, s-metolachlor + or - safener.
Triazinone	metribuzin	Dimetric = Glory = Metribuzin = Sencor = TriCor	Authority MTZ, Boundary=Tailwind, Matador.
Phenyl-carbamate	des/phenmedphm		Betamix

Ureas	diuron linuron tebuthiuron	Diuron = Direx = Karmex. Lorox = Linex = Linuron. Spike.	Krovar, Sahara, WeedBlast. - -
Photosystem II Inhibitor B – His 215 (6)	basagran	Basagran.	Storm, Varisto.
	bromoxynil	BroClean = Brox = Buctril = Moxy.	Huskie/Complete/FX, Talinor, Wolverine Advanced, Carnivore.
	Pyridate	Tough	-
EPSP Synthase Inhibitor (9)	glyphosate-ipa, K, dma, mea, (NH ₄) ₂	Roundup, several generics - see page 71.	Enlist Duo, Extreme, Landmaster BW, others.
Glutamine Synthetase Inhibitor (10)	glufosinate	Finale, Liberty, Rely.	-
Bleaching: DOXP Synthase Inhib. (13)	clomazone	Command	
PPO (Protox) Inhibitor (14) Diphenylether	acifluorfen fomesafen	Ultra Blazer. Fomesafen, Flexstar=Rumble, Reflex=TopGun.	Storm. Flexstar GT 3.5, Marvel, Prefix=Vice.
	lactofen oxyfluorfen	Cobra, Phoenix. Goal = Collide.	Stellar. -
N-phenylimide	flumiclorac flumioxazin	Resource. Valor=Brdstar=Chateau=Encompass=Outflank=Panther = Payload = Tuscany.	- Afforia, Fierce, Surveil, Enlite.
	fluthiacet-methyl saflufenacil tiafenacil	Cadet. Sharpen. Reviton.	- Anthem/Max, Marvel. Verdict, Zidua Pro. -
Oxadiazolone	oxadiargyl	Raft, Topstar.	-
Phenylpyrazole	pyraflufen	ET, Vida.	-
Triazolinone	carfentrazone sulfentrazone	Aim = Quicksilver. Spartan = Blanket = Portfolio.	Spartan Charge, Anthem Flex Authority Assist/Elite/MTZ/First/Supreme, BroadAxe XC,
Very Long Chain Fatty Acid Inhibitor (15) Acetamide	acetochlor	Harness = Confidence. Surpass = Breakfree = Volley. Degree, TopNotch, Warrant.	Imperium, Breakfree ATZ Lite=Keystn LA=Volley ATZ Lite, Resicore, SureStart=TripleFlex.
	alachlor dimethenamid-P metolachlor meto + safener S-metolachlor S-meto + safener	Alachlor, Lasso, others. Outlook = Commit = Establish. Parallel PCS, Stalwart. Dual II, Me-Too-Lachlor, Parallel, Stalwart C. Dual Magnum, Brawl, Charger Max. Dual II Magnum, Brawl II, Cinch.	- Armezon Pro, Commit, Establish, Verdict. Matador. Parallel Plus, Stalwart Xtra. Boundary=Tailwind, BroadAxe XC, Prefix=Vice, Sequence. Acuron/Flexi, Bicep, Brawl, Charger, Cinch, Halex GT, Lumax.
Isoxazoline	pyroxasulfone	Zidua.	Anthem/Max/ATZ/Flex, Fierce, Zidua Pro
Thiocarbamate	cycloate EPTC triallate	Ro-Neet SB. Eptam. Far-Go.	- Imperium. Buckle.
Benzofuran	ethofumesate	Nortron = Ethofumesate 4SC = Ethotron.	
Auxin Inhibitor (19)	diflufenzopyr	-	Distinct, Overdrive, Status.
Photosystem I Inhibitor (22)	diquat	Reglone = Diquat.	-
	paraquat	Firestorm, Gramoxone SL, Parazone.	-
Bleaching: HPPD Inhibition(27) Triketone	bicyclopirones mesotrione	- Callisto = Tenacity.	Acuron/Flexi/GT, Talinor Acuron/Flexi/GT, Callisto/GT/Xtra, Halex GT, Instigate, Lumax EZ, Realm Q, Resicore, Revulin Q.
	tembotrione	Laudis.	Capreno, DiFlex Duo.
Isoxazole	isoxaflutole	Balance Flexx.	Corvus, Prequel.
Pyrazole	pyrasulfotole tolpyralate	- Shieldex	Huskie/Complete/FX, Wolverine Advanced. Katagon, Restraint
	topramezone	Impact = Armezon.	Armezon Pro, Impact Core, ImpactZ
Cellulose Inhib. (29)	indaziflam	Alion	-
Fatty Acid Thioesterase (30)	cinmethylin	-	-
	methiozolin	-	-
Unknown (0)	quinclorac (grass)	Facet.	-

Adapted from WSSA Herbicide Classification System For Resistant Weed Management. Weed Technol. 17:606-608.

HERBICIDE CARRYOVER

Y1. Herbicide persistence into the next growing season may restrict rotational crops. The following information discusses herbicide degradation for some chemistries known to carryover.

General Rules For Herbicide Breakdown

1. Many herbicides are broken down in soil by microbial decomposition. In addition, SUs and triazines are broken down by chemical reactions like acid hydrolysis.
2. Herbicide molecules must be free from binding to soil particles or organic matter for soil microorganisms to degrade.
3. Most herbicide molecules are more tightly adsorbed to soil particles in dry soils than moist soils.
4. Chemical degradation of herbicides in soil is affected by soil pH. Acid hydrolysis nearly ceases at soil pH above 6.8.

Effect of pH on Herbicide Activity and Persistence

Negative charges (-) on soil particles and organic matter adsorb positive-charged (+) compounds or substances. Soil pH influences adsorption and availability of the following herbicides by determining the electrical charge of the herbicide molecules: Imidazolinones, SUs, Triazines, and Triazolopyrimidines (TPS).

Molecules become (-) charged when a proton is removed or become (+) charged when a proton is added. Most herbicides become (+) charged in acid (H+) pH conditions. Positively charged herbicide molecules are adsorbed to the (-) charges on soil particles soil particles.

Y2. Breakdown of Imidazolinone (Imi), TPS Herbicides, and some HPPD herbicides (Callisto).

In general, breakdown occurs by soil microbes and **breakdown occurs more rapidly and herbicide activity increases as soil pH increases**. Rate of breakdown decreases in dry conditions. Imi and TPS herbicides are:

1. Broken down by microbes - not broken down by hydrolysis.
2. Not degraded in anaerobic (waterlogged soil) conditions.
3. Not volatile, not photodegraded, not leached beyond 12 inches.
4. Weakly bound to soil but strongly bound to OM.
5. Adsorbed more strongly as soil dries and through time. Imi herbicides molecules adsorb to OM in dry soil but can desorb and go into soil solution in wet/moist soil allowing molecules to become free for plant uptake and microbial breakdown. For sensitive crops like sugarbeet, the adsorption and desorption process may occur over several years causing crop injury from herbicide residues that become available after moisture events.
6. Negatively (-) charged, not adsorbed, and free for plant uptake and microbial degradation at soil pH >6.5 for Imi herbicides and pH >7 for TPS herbicides.
7. Strongly bound to OM at pH <6.5 for Imi herbicides and pH <7 for TPS herbicides. For Imi herbicides: Amount adsorbed changes little from 6.5 to 8. At soil pH <6.5, pH reduction as small as 0.2 pH units can **DOUBLE** the amount adsorbed.

Large variation in pH can exist in the same field. In low pH, residues of Imi herbicides can injure sensitive plants for many years.

In summary, activity and degradation of Imi and TPS herbicides increase as soil pH increases. Herbicide adsorption increases as OM matter increases and as soil pH decreases. All factors increasing microbial activity also increase herbicide degradation (warm, moist soils). Degradation increases in soils with pH above 6.5 (Imi) or 7 (TPS) because herbicide molecules are not adsorbed and are in soil solution for plant uptake and microbial breakdown.

Y3. Breakdown of SU Herbicides (with exceptions):

In general, most SU herbicides are broken down by acid hydrolysis and can leave a residue in soil for more than one year. The chemical reaction ceases at soil pH above 6.8.

Exceptions: Express*, Harmony*, Option, and UpBeet are rapidly broken down by soil microbes. Permit and Resolve*/Matrix* are broken down faster by hydrolysis as pH moves above and below pH of 7.0. Herbicide breakdown is slowest in neutral soil pH of 7.0.

Most SU herbicides are:

1. Not leached, nor volatile, nor broken down by photodegradation.
2. Affected by pH. Water solubility increases as pH increases.
3. Broken down primarily by acid hydrolysis. Microbial degradation is very slow.
4. Non-microbial hydrolysis for most residual SU herbicides ceases at soil pH above 6.8.
5. SU herbicides are undissociated (neutral charge) at pH less than 7.0 and are adsorbed to soil and OM. As soil pH increases above 7.0 molecules are (-) charged, are in a free form, do not bind with (-) charged soil particles, and are available for plant uptake. **Even at low pH ranges, SU herbicides are so biologically active at low concentrations that plant response may still occur.**

SU herbicides carryover more in high pH soils (above 6.8) because acid hydrolysis ceases above that level. Hydrolysis is minimally affected by soil moisture, organic matter, soil texture, soil microbes, and soil compaction or aeration. Hydrolysis is affected by soil temperature and soil pH. As temperature increases and pH decreases below 6.8, hydrolysis increases.

Y4. Breakdown of Triazine Herbicides

Triazines are degraded by hydrolysis similar to SU herbicides. Therefore, the same factors affecting SU breakdown also affect breakdown of triazine herbicides - See Y3. Some slight differences are noted below. Triazine herbicides are:

1. More active in high pH soils.
2. Broken down by photodegradation only when herbicide remains on soil surface for extended periods.

Triazine molecules are (+) charged at soil pH < 7.5. Positive charged triazine molecules bind to (-) charges on soil and OM making them unavailable for plant uptake and microbial breakdown. This is why pH sensitive herbicides like atrazine and Sencor* can be used with less risk of crop injury in low pH soils. However, as pH fluctuates across the field, herbicide availability may be radically altered ranging from complete crop safety and erratic weed control at low pH to crop injury and adequate weed control at high pH.

At high soil pH, the opposite reaction occurs. At soil pH > 7.5, triazine herbicide molecules donate protons (H⁺) resulting in (H + OH = H₂O) so the molecules have a net neutral charge, which do not bind to soil particles and OM, and are free for plant uptake and microbial decomposition.

Y5. Persistence of phytotoxic levels of a herbicide for more than 1 year can be a problem with some herbicides. Herbicide residues are most likely to occur following years with low rainfall because chemical and microbial activity needed to degrade herbicides are limited in dry soil. Crop damage from herbicide residues can be minimized by applying the lowest herbicide rate required for good weed control, by using band rather than broadcast applications, and by moldboard plowing before planting the next crop. Moldboard plowing reduces phytotoxicity of some herbicides by diluting the herbicide residue in a large volume of soil. Moldboard plowing is effective in reducing the residual effects of atrazine, Nortron, Prowl, Sencor*, Sonalan, and Treflan*.

*Or generic equivalent.

Y6. Herbicide residues often can be detected by bioassay. Representative soil samples of the whole field are obtained by sampling many places to the depth of the tillage layer. A soil sample free of herbicide residues can serve as the untreated check. The samples should be dried and the clods broken so that the largest particles are no larger than a wheat kernel. Prepare two or more samples of untreated check soil and the test soil in pots or other containers with holes in the bottom for water drainage.

The crop to be grown in the field should be used as one bioassay species. Alfalfa and canola also should be planted as an additional bioassay species because of their relative sensitivity to many residual herbicides. Plant seeds of large-seeded crops like corn or soybean at 1 seed per 1 to 2 square inches, or seeds of small-seeded crops like cereals or flax at about 1 seed/sq inch. Water as needed but do not over-water. Thin plant stands when seedlings are 2 to 3 inches tall to allow sufficient space for adequate growth. Position containers in direct sunlight and maintain temperature at 70 to 75 F. Observe the plants 2 to 3 weeks after emergence. Record visible and physical measurements such as plant height and leaf length for abnormalities.

Symptoms of some herbicides like atrazine and metribuzin do not develop until 2 to 3 weeks after emergence. Observe roots of plants grown in root inhibiting herbicides, such as dinitroanilines. Window bioassay does not provide accurate information for ALS herbicide carryover.

Field Bioassay Instructions: Plant several strips of desired crops across the field perpendicular to the direction the suspect herbicide was applied. Strips should be spaced to represent different field conditions (texture, pH, and drainage). If no visible signs of injury, stand reduction, or yield reduction occur, then the field can be seeded with the desired crop the next growing season. Do not plant if injury occurs and the bioassay must be repeated the next growing season to determine the safety of the crop to existing residues.

Y7. Atrazine* at rates over 0.38 lb ai/A generally has residue the year following application to corn in North Dakota. If soil moisture is deficient, atrazine may cause injury to susceptible crops the following year. Corn and millet are tolerant to atrazine while other crops vary in susceptibility. The approximate ranking of crops from most to least tolerant is corn, sorghum, millet, flax, soybean, barley, wheat, oat, sunflower, canola/mustard, alfalfa, and sugarbeet.

Y8. Balance Flexx (isoxaflutole) may have a residue the following year. Breakdown is primarily by microbial activity. Risk of Balance carryover increases as precipitation occurring during the growing season decreases. Balance becomes more active as soil texture becomes more coarse and organic matter decreases.

Y9. Dicamba at rates greater than 1.5 pt/A may remain as a residue in soil. Most grass and broadleaf crops can be planted 4 months or more after application at 1 pt/A. Refer to specific dicamba label for crop rotation restrictions. The approximate ranking of crops from most to least tolerant is corn, barley, wheat, oat, flax, potato, buckwheat, soybean, dry edible bean, sunflower, and sugarbeet.

*Or generic equivalent.

Y10. Flexstar/Reflex (fomesafen) at 0.75 to 1 pt/A may have a residue the year following application to soybean, dry bean, or potato. Most crops can be planted the next growing season except canola, crambe, flax, safflower, sugarbeet, and sunflower. Fomesafen is weakly adsorbed by OM but mobility and amount available for plant uptake increases as soil pH increases above 6.5. Degradation is through soil microbes and under anaerobic conditions. Conditions that inhibit microbial activity also reduce fomesafen breakdown. Cold or dry conditions after application reduce rate of breakdown. Northern production areas, like ND, have a shorter growing season and the soil temperature is colder for longer periods of time, which limits breakdown. Late applications in beans decreases the amount of time that breakdown can occur.

Ways to reduce risk of fomesafen carryover include lower application rates, banded herbicide applications, and tillage to dilute herbicide residues. The approximate ranking of non-labeled crops from most to least tolerant is cereals, potato, oil-seed rape/canola, field corn, sunflower, sugarbeet, sorghum, and alfalfa.

Y11. Metribuzin* may not have residue the following year at 0.25 lb ai/A, but rates over 0.5 lb ai/A may damage susceptible crops the next year. The approximate ranking of crops from most to least tolerant is potato, soybean, dry edible bean, corn, barley, wheat, oat, sunflower, flax, and sugarbeet.

Y12. Nortron* (ethofumesate) often has a residue the year following use on sugarbeet. The approximate ranking of crops from most to least tolerant is sunflower, dry beans, soybean, corn, barley, and wheat. Moldboard plowing usually will eliminate crop injury. Nortron should be applied in a band to reduce cost and reduce potential crop injury from residues the following year.

Y13. Sonalan (ethalfluralin), **Prowl/Prowl H₂O** (pendimethalin), and **Treflan*** (trifluralin) are similar herbicides called dinitroanilines. Under dry soil conditions these herbicides can persist in soil for more than 1 year. Sonalan has less soil residue than Treflan* and Prowl. Land treated with Sonalan in the spring may be planted to any crop the next year except sugarbeet. Sunflower, soybean, potato, and dry edible bean are quite tolerant of dinitroaniline herbicides. The approximate ranking of other crops from most to least tolerant is soybean, flax, alfalfa, barley, wheat, corn, oat, and sugarbeet.

Y14. Spartan (sulfentrazone) residue may remain in soil the following season. Most grass and broadleaf crops can be planted the following year except canola, crambe, lentil, and sugarbeet. Spartan is degraded by soil microbes, is not affected by sunlight, and is not volatile. Precipitation after PRE application activates the herbicide by moving it into the soil where microbial degradation can occur. Spartan solubility increases as soil pH increases above 6.5, as soil texture changes from fine to coarse, and as OM decreases. As Spartan solubility increases availability for plant uptake increases, weed control increases, and risk of crop injury increases. The approximate ranking of crops from most to least tolerant is soybean, flax, chickpea, mint, sunflower, potato, field pea, dry edible beans, safflower, crambe, canola, lentil, and sugarbeet.

*Or generic equivalent.

Y15. Crop Rotation Restrictions for North Dakota

Herbicide	Alf- alfa	Bar- ley	Can- ola	Corn	CRP grss	Dry bean	Field pea	Flax	Oat	Edibl Leg. ¹	Pot- ato	Saff lowr	Soy- bean	Sgr- beet	Sun- flwr	HRS/ Drum
	----- months after application (d = days) -----															
Acuron/Flexi	18/10	4	18	0	18	18	18	18	10	18	10	18	10	18	18	4
Acuron GT	10a	4.5	18	0	18	18	18	18	4.5	18	10	18	10	18	18	4.5
Ally Extra (e) (0.3 oz/A)	22e	10	22	22	6	22e	22e	22	10	22e	22	10	22	22b	10	1/10
Anthem/Max	10	11	18	0	18	11	6-8	18	11	6-8 ¹	4	18	0	15	4	4
Anthem Flex (r)	10	11	18	0	18	11	6	18	11	6	4	18	0	12	4	1
Armezon/Pro	9	3/4n	9	0	18	9n	9	18	3/4n	18	9	18	9	18	9	3/4n
Atrazine* (0.38 lb ai)	NCS	NCS	NCS	0	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	10	NCSb	NCS	NCS
(0.38-0.5 lb ai)	2CS	NCS	2CS	0	2CS	2CS	2CS	NCS	2CS	2CS	NCS	2CS	10	2CSb	2CS	2CS
(0.5-1 lb ai)	2CS	2CS	2CS	0	2CS	2CS	2CS	2CS	2CS	2CS	2CS	2CS	10	2CSb	2CS	2CS
Authority Assist	12	9.5	40b	10	12	4	4	26	18	4/12 ¹	26	18	0	40b	18	4
Authority Elite	12	4.5	12	10	12	0	0	12	12	0/12 ¹	4	12	0	36b	0	4.5
Authority First/Sonic	12	12	24	10	30b	12	12	30b	12	30b	18	30b	0	30b	30b	4
Authority MTZ	12	4	24	10	12	12	18	18	18	18	12	18	0	24b	12	4
Authority Supreme (r)	12	11	24	10	18	9	0	0	12	9	4	18	0	24	0	4
Autumn Super (i)	18	9j	18	1	18	18	18	18	18	18	18	18	2	24	18	3
Balance Flexx (j)	10	6	18	0	18	18	18	18	6	18	6	6	6	18	10	6
Banvel* (0.5 lb ai)	NCS	3d/oz	NCS	NCS	0h	NCS	NCS	NCS	3d/oz	NCS	NCS	NCS	45 d	NCS	NCS	3d/oz
(>0.5 lb ai)	NCS	NCS	NCS	NCS	0h	NCS	NCS	NCS	NCS	NCS	NCS	NCS	90 d	NCS	NCS	3d/oz
Beyond	9	18t	18	8.5	9	0	0	18	9	9	18t	18	0	18t	9	3
Boundary	4.5	8	12	4	12	12	8	12	12	12	0	12	0	18	12	8
BroadAxe XC	12	4.5	12	10	12	12	0	12	12	0/12 ¹	4	12	0	36b	0	4.5
Capreno (i)	18	10	18	0	18	18	18	18	18	18	18	18	10	18	18	4
Callisto/GT	10	4	10	0	18	18	10g	0	0	18	10	18	10	18	10	4
Callisto Xtra	NCS	NCS	NCS	0	18	18	18g	NCS	18	18	NCS	18	NCS	18	NCS	NCS
Clarity* (0.5 lb ai)	4	22 d	4	4	0h	4	4	4	22 d	4	4	4	4	4	4	22 d
(>0.5 lb ai)	6	44 d	6	6	0h	6	6	6	44 d	6	6	6	6	6	6	44 d
Corvus (i)	17	9	17	0	17	17	17	17	17	17	17	17	9	17	17	4
Curtail*/M*	10.5m	1	5	1	1	10.5m	18	5	1	18	18	10.5m	10.5m	5	10.5m	1
DiFlexx Duo	10	4	10	0	4	10	10	18	18	18	10	18	6	10	10	4
Everest* soil pH: <8/>8	11/18	9	9	11	NCS	9	11/18	9	18/24	11/24a	9	9	9	9	4	0
Extreme	4	18	40b	8.5	4	4	4	26	18	4	26	18	0	40b	18	0/4
Facet L	24b	10	10	10	10	24b	24b	24b	10	24b	24b	24b	10	24b	10	0
Far-Go	NCS	0	NCS	NCS	NCS	NCS	NCS	NCS	18	NCS	NCS	NCS	NCS	NCS	NCS	0
Fierce EZ	10	11	12	7d/1	18	10.5	2	18	11	11	4	18	0	12	4	1
Fierce MTZ/Kyber	10	11	18	7d/1	18	12	2	18	11	12/6a	9	18	0	18	12	8a
FirstRate	9	12	18	9	18	9	9	18	9	18	18	18	0	30b	30b	4
Flexstar/GT 3.5	18	4/9a	18	10/18a	18	0	12	18	4/9a	12	0	18	0	18	18	4/9a
Halex GT	10	4.5	12	0	18	18	10g	12	4.5	18	10	18	10	18	10	4.5
Harness*	9	NCS	NCS	0	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	4
Huskie/FX	4c	0.25	9	9	B	9	9	9	0.25	9/18 ¹	9	9	4	9	9	0.25
Huskie Complete	9c	9	9	9	18b	9	9	9	9	9/18 ¹	18b	18b	9	9	9	3
Impact	9	3	9	0	18	18n	18n	9	3	18	9	18	9	18	9	3
Instigate	18	18	18	0	18	18	18	10	18	18	10	18	10	18	10	9
Laudis	10	4	10	0	18	10g	10	18	4	18	10	18	8	10g	10	4
Liberty 280	6	2.33	0	0	2.33	6	6	6	2.33	6	2.33	6	0	0	6	2.33
Lumax EZ (<3 pt/A)	18	4.5	18	0	18	18	18	18	NCS	18	18	18	NCS	18	18	NCS
Marvel	18	4	18	10	18	0	10	18	4	18	0	18	0	18	18	4
Matrix*	12	9/18p	18	0	18	10	18	18	9	18	0	18	4	18	10	9

Herbicide	Alf- alfa	Bar- ley	Can- ola	Corn	CRP grss	Dry bean	Field pea	Flax	Oat	Edibl Leg. ¹	Pot- ato	Saff lowr	Soy- bean	Sgr- beet	Sun- flwr	HRS/ Drum
	----- months after application (d = days) -----															
Metribuzin* (u)	4	8u	12	4	4	12	8	12	12	8	12	12	4	18	12	8u
Milestone (b)	36b	B	24b	12b	B	B	B	B	B	B	B	B	B	B	B	B
Nortron*	12	12	12	12	12	12	12	12	12	12	12	12	12	0	12	12
Olympus (0.2-0.4 oz)	B	10	10	10	10	10	10	B	24	10	B	B	10	10	10	0/9
Osprey	10	1	10	12	10	3	3	10	10	10/3 ¹	10	10	3	10	1	0.25
PerfectMatch	10.5	9	9	9	9	10.5	10.5	9	9	18	18	10.5	10.5	9	10.5	1
Permit*	9	2	15	1	2	0	9	B	2	9	9	B	9	36	18	2
Plateau	36	24	48b	36	0	36	36	36	24	36	48b	36	18	48b	36	12
PowerFlex HL	9	9	9	9	9	9	9	9	9	9	9	9	5	9	9	1
PrePare	NCS	9	9	NCS	NCS	9	11	9	18	24	9	9	9	9	9	0/4
Prequel	10j	9	18	0	18	18j	18	18	9	18	6	18	10	18j	18	9
Prowl EC / H2O	NCS	NCS	NCS	0s	NCS	0	0	NCS	NCS	0	0	NCS	0	2CS	0	NCS
Pursuit	4	18	40b	8.5	4	4	0	26	18	0	26	18	0	40b	18	4
Quelex	9	0	9	3	3	9	9	9	3	9/15	15	9	3	15	3	0
Raptor/Beyond	9	18t	18	8.5	9	0	0	18	9	9	18t	18	0	18t	9	3t
Realm Q	18	9	18	0	18	18	18	10	9	18	10	18	10	18	10	9
Reflex	18	4	18	10	18	0	12	18	4	12	0	18	0	18	18	4
Require Q/Resolve Q	18	9	18	0	18	10	10	10	9	18	0	18	10	18	10	9
Resicore	10.5	10.5	18	0	18	18	18	18	10.5	18	18	18	10.5	18	10.5	4
Revulin Q	18	10	10	0	18	18	18	10	10	18	10	18	10	18	10	10
Rimsulfuron*(1ozDF/A)	10j	9	10j	0	18	10	18	18	9	18	0	18	10	10j	10	9
Sharpen (1 fl oz) (v)	4	0	4	0	4	4	0	4	0	0/1 ¹	4	4	0-1	4	4	0
(2 fl oz) (v)	5	0	5	0	5	5	0	5	0	0/2 ¹	5	5	1-2	5	5	0
(3 fl oz) (v)	6	0	6	0	6	6	2	6	0	2/3 ¹	6	6	2-3	6	6	0
Shieldex	9	3	9	0	12	9	9	9	3	12	9	12	9	18	9	3
Sinate	9	3	9/18a	0	18	18	9/18a	9/18a	3	18	9	18	9	18	9	3
Solstice	10	4	10	0	18	18	10g	0	0	18	10	18	10	18	10	4
Sonalan	NCS	NCS	0	NCS	13w	0	0	NCS	NCS	0	NCS	NCS	0	2CS	0	NCS
Spartan Charge	12	4	24	4	12	0	0	0	12	0/12 ¹	4	12	0	24b	0	4
Spartan Elite	12	4.5	12	10	12	0	0	12	12	0/12 ¹	4	12	0	36b	0	4.5
Starane Flex	9	0	9	3	0	9	9	9	0	9	9	9	9	9	9	0
Status (h)	4	4	4	0.25	4	4	4	4	4	4	4	4	4	4	4	1
Stinger*/Stinger HL	10.5	0	0	0	0	10.5m	18	0	0	18	18	10.5m	10.5m	0	10.5m	0
SureStart II	18	NCS	26b	0	26b	12/18	NCS	26b	NCS	NCS	18	26b	NCSj	26b	18	4
Surpass*	9	NCS	NCS	0	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	4
Surveil	12	B	B	9	9	9	9	9	9	9	18	B	0	30b	30b	3
Talinor (a)	9	1	9	0	18	9/15a	10	9	3	15	9	18	10	15	9	1
Tordon (1.5 oz)	2CS	NCS	2CS	2CSx	1	2CS	2CS	NCS	NCS	2CS	2CS	2CS	2CS	2CS	2CS	NCS
Travallas (e)	22	1day	12	12	B	22	12	12	B	22	B	B	12	B	12	1day
Treflan* (y)	0	NCS	0	NCS	18/21	0	0	0	18	0	0	0	0	2CS	0	NCS
TripleFlex II	18	NCS	26b	0	26b	12/18	NCS	26b	NCS	NCS	18	26b	NCSj	26b	18	4
Valor / Chateau										See page 6						
Varisto	9	18t	18	8.5	9	0	9	18	9	9	18t	18	0	18t	9	3
Varro	9	9	9	9	9	9	9	9	9	9	18b	9	3	9	9	3
WideMatch*	10.5	0	4	0	0	10.5	10.5z	4	0	18	18	10.5	10.5	0	10.5	0
Wolverine Advanced	4c	1	9	9	B	9	9	9	1	9/18 ¹	9	9	4	9	9	1
Zidua										See page 6						
Zidua Pro	10	18	40b	8.5	40	11	6	26	18	6	26	18	0	40b	18	4

*Or generic equivalent. ¹ Edible legumes = chickpea (garbanzo bean)/lentil.

NCS = Next cropping season after herbicide application. 2CS = Second cropping season after herbicide application. MAA = months after application.

Herbicides that allow most crops to be planted the year following application:

2,4-D, 2,4-DB, acetochlor, Affinity, Afforia, Aim, Alluvex, Axial, Basagran, Betamix, Buctril, Cadet, Cobra, Discover, diquat, Dual, DiFlexx, Engenia, Enlist Duo, Eptam, Express, glyphosate, GoldSky, Harmony, LeadOff, Liberty, Linuron*, MCPA, OpenSky, Orion, Outlook, paraquat, POST grass herbicides, PowerFlex, Resource, Ro-Neet, Sentrallas, Sharpen, Starane/NXT, Status, Storm, Supremacy, Teammate, Ultra Blazer, UpBeet, Verdict (v), Vida, Warrant, Xtendimax.

Field Bioassay Instructions - Refer to label or paragraph Y6 in the narrative section.

- a** Refer to label - restrictions may be adjusted based on herbicide rate, rainfall, tillage, soil type, soil pH, bioassay, and ND 24(c) labels.
- B or b** = Bioassay. Do not plant until field bioassay indicates it is safe. Crop rotation after atrazine* is rate and soil pH dependent.
Python, Hornet, and SureStart/TripleFlex = 26 month rotation + successful field bioassay.
FirstRate = 30 month rotation + successful field bioassay. Pursuit = 40 month rotation + successful field bioassay.
- c** Requires thorough tillage and 12 inches of rain.
- d** days
- e** These rotation intervals apply only to 0.3 oz/A. Dry pea, dry bean, lentil, and alfalfa can be planted after 10 months if soil pH is 6.8 or lower, or 22 months if soil pH is 6.9 to 7.9. Canola, corn, flax, soybean, and potato require 22 months and 18 inches precipitation. Above soil pH 7.9, soil bioassay must be performed.
- g** Cumulative precipitation between application and planting of rotational crops is 20 inches. Soil pH >6. No HPPD herbicide applied the previous year. For Laudis only: Cumulative precipitation of 20 inches. 10 MAA rotation interval applies to all dry bean types except red kidney and cranberry (18 MAA). Thorough tillage must precede planting of sugarbeet.
- h** Any rotational crop may be planted 120 days following application of dicamba at 1.5 pt/A or less, excluding days when ground is frozen. For all crops and rates greater than 1.5 pt/A allow 45 days per 1 pt/A of dicamba used excluding days when ground is frozen.
- i** Crops with a 9 or 10 month rotation restriction require 15 inches of cumulative precipitation after application. Crops with an 17 or 18 month rotation restriction require 30 inches of cumulative precipitation after application. Soil at 7.5 pH or above require crop rotation to be extended from 9 or 10 months to 17 or 18 months and from 17 or 18 months to 24 months.
- j** Requires 15 inches of cumulative precipitation during the growing season following application. An 18 month restriction applies to Prequel and rimsulfuron* applied above rates indicated or if drought follows application. Refer to label if higher rates are used.
- m** Do not plant dry bean, dry pea, soybean or sunflower for 18 months on soil with less than 2% OM and rainfall less than 15 inches during the 12 MAA OR may be planted 12 MAA if risk of injury is acceptable. Perform a field bioassay prior to planting for areas that receive less than 15 inches of rainfall and have less than 2% OM. Do not plant lentil, potato or any other broadleaf crop grown for seed for 18 months unless risk of injury is acceptable.
- n** Alfalfa, canola, dry pea, dry bean, potato, soybean, and sunflower can be planted 9 months after applying Armezon Pro at 20 fl oz/A or less or Armezon at 0.74 fl oz or less. Small grains can be planted 3 months after applying Armezon and 4 months after Armezon Pro.
- p** Barley can be planted 9 months after application in Cass, Grand Forks, Pembina, Towner, Traill, and Walsh counties of ND.
In all other counties of ND allow an 18 month rotation restriction before planting barley.
- r** Rotation interval is dependent on rate.
- s** Corn can be planted only if Prowl*/H20 are applied PRE. DO NOT APPLY PPI.
- t** Rotation to barley is: 9 months if (>18 inches water + >6.2 soil pH) or (moldboard plow with <18 inches water or <6.2 soil pH) or 18 months if (<18 inches water or soil pH <6.2).
Rotation to potato is: 9 months: soil pH >6.2 and rainfall is >18 inches/year or 18 months: soil pH <6.2 OR rainfall is <18 inches/year
Rotation to sugarbeet: 18 months: soil pH >6.2 or 26 months if soil pH is <6.2.
Rotation to non-Clearfield wheat west of Highway 83: 3 months if >10 inches water AND pH>6.2. 15 months if <10 inches water OR pH<6.2. East of Highway 83, wheat injury can occur if <10 inches of water.
- u** Must add 2 months if soil pH is 7.5 or above. Wheat and barley can be planted 4 MAA following dry pea, lentil or soybean.
- v** Do not include time when soil is frozen. Sunflower and safflower are the most sensitive crops.
For Verdict: Fall seeded cereals can be planted 4 months after application. All crops can be planted the spring following application.
- w** CRP grasses may be planted 13 MAA but a field bioassay must be performed prior to planting CRP grasses. The manufacturer assumes no liability for injury. Fall is recommended as the best time to plant CRP grasses.
- x** Do not plant corn or sorghum until soil samples analyzed for Tordon residue indicates no detectable levels present.
Restriction is based on non-legal herbicide residue that may be found in corn and sorghum and not on crop safety.
- y** Oats, sorghum, and annual or perennial grass crops may be planted at least 12 MAA in areas that received 20 inches or more of precipitation during the growing season. CRP grasses may be planted 18 MAA if Treflan* is spring-applied or 21 MAA if fall-applied.
- z** For rotation to field pea in 10.5 months, precipitation must be greater than 7 inches during the 10.5 months following application and greater than 5.5 inches of precipitation from June 1 to August 31 following application. Otherwise allow 18 months.

*Or generic equivalent.

Y16. Herbicide residue and fall cover crop establishment.

Late summer/ fall-seeded cover crops promote soil health, protect water quality, and enhance wildlife habitat. Cover crop response to spring-applied herbicides is limited but crop tolerance research is ongoing at several academic institutions. Herbicides labels may be expanded to consider soil residue effects on establishment of cover crops. Refer to pages 100 to 104 for current data base. Use rotational restrictions of common crops or herbicide effectiveness on common weeds with close relatives of fall seeded cover-crops:

- Use alfalfa for other legumes/pulse species.
- Use canola/mustard for Cruciferae species: radishes and turnips.
- Use small grains and wild oat for other grass species.

Greater flexibility is provided where the cover crops is only used for conservation practices. However, the grower assumes all risk if the herbicide interferes with the establishment of the cover crop. Consider soil type, soil pH, and precipitation patterns on herbicide degradation. In general, herbicides with crop rotation restrictions of 4 months or less should be safe to most cover crops as they have half-lives of 30 days or less. This information was adapted from information developed by Dr. Bill Curran and Dr. Dwight Lingenfelter, Pennsylvania State University.

Residues may accumulate in cover crops that may be fed to animals as forage and consumed by humans. Follow rotational restriction on labels when planting cover crops that may be grazed or harvested for forage to avoid illegal residues.

Herbicide rate, half-life values, and comments.

Herbicide	Rate/A	Half-lives (days ¹)	Comments
2,4-D	0.5 to 1 pt	7	Allow 30 days prior to planting broadleaf crops.
Dicamba	0.5 to 1 pt	5 to 14	Allow 45 days/pt as a general rule for dicamba degradation.
Dual II Magnum	1 to 2 pt	15 to 50	Ryegrass may be more susceptible than other crops.
Flexstar	0.75 to 1 pt	100	Small-seeded legume and brassica crops may be more susceptible than other crops.
Glyphosate	32 to 48 fl oz	47	-
Liberty	22 to 36 fl oz	7	-
Spartan	4.5 to 12 fl oz	36	Small-seeded legume and brassica crops may be more susceptible than other crops.
Valor	2 to 3 oz	12-18	Small-seeded legume and brassica crops may be more susceptible than other crops.

¹ Note: In general, herbicides with half-lives of 30 days or less should allow planting of cover crops after 4 months. Estimates derived from the WSSA Herbicide Handbook, 2014.

Risk of cover crop injury based on highest damage recorded at 5 ND locations in 2016-2017.

Herbicide*	Radish	Turnip	Field pea	Lentil	Flax	Oat	Barley	Dwarf Essex Rape
Dicamba	MR	HR	LR	MR	MR	LR	MR	MR
Everest	MR	MR	LR	MR	LR	LR	LR	MR
Goldsky	MR	MR	LR	LR	MR	LR	LR	LR
Huskie	LR	LR	LR	LR	MR	LR	LR	MR
PowerFlex	LR	LR	LR	MR	MR	LR	LR	MR
Quelex	MR	MR	LR	LR	LR	LR	LR	LR
Supremacy	LR	LR	LR	LR	LR	LR	LR	LR
Varro	MR	LR	LR	LR	LR	LR	MR	LR
WideMatch	MR	MR	HR	HR	LR	LR	LR	MR
2,4-D	MR	LR	LR	LR	LR	LR	LR	MR

* or generic herbicide.

Key: LR - low risk - 0 to 20% injury, MR - medium risk = 21 to 50% injury, HR - high risk = 51 to 100 injury, Strike through = severe injury. Products were chosen due to known residual activity. Other products may be safe for cover crops. This list is not all-inclusive. Most instances of medium or high risk were observed in only one environment. Most combinations were LR in most environments. High OM, high rainfall, tillage, low pH, and other factors will reduce the risk of herbicide carryover to cover crops. If cover crops will be grazed or harvested in some way (including haying), refer to label regarding grazing restrictions.

Reference for additional information include:

'Herbicide Rotation Restrictions in Forage and Cover Cropping Systems'

<http://wcws.cals.wisc.edu/new-fact-sheet-herbicide-rotation-restrictions-in-forage-and-cover-cropping-systems/>

by the University of Wisconsin, June, 2014. It contains tables summarizing rotation restriction intervals in months along with specific restrictions for forages grown after commonly used herbicide applications in small grains, soybean, and corn.

Risk of cover crop injury due to soybean herbicides with soil residual, Carrington and Fargo, 2016-20.¹

Risk of cover crop injury									
Site-years	Herbicide	Barley	Winter rye	Field pea	Flax	Radish	Turnip	Lentil	Rapeseed/Canola
Soil									
6	Sencor 75 DF	Low	Low	Low	Low	Medium	Medium	Low	Low
6	Spartan 4F	Low	Low	Low	Low	High	Medium	Medium	Medium
6	Valor SX	Low	Low	Low	Low	High	High	Low	High
6	Zidua SC	Low	Low	Low	Low	Medium	Low	Low	Medium
5	Pursuit	Low	Low	Low	High	High	High	Low	Low
POST									
5	Engenia (dicamba)	Low	Low	Low	Low	Low	Low	Low	Low
6	Flexstar	Low	Low	Low	Low	High	Medium	Low	Medium
3	Liberty 280	Low	Low	Low	Low	Low	Low	Low	Low
2	Raptor	Low	Low	Low	Low	Low	Low	Low	Low

¹Low risk = 0-20% injury; Medium risk = 21-50% injury; and High risk = >50% injury. Greatest injury recorded for each treatment was used to determine risk level. Herbicides were applied at normal rates and timings for soybean. Cover crops were planted generally late August to early September. Initial visual evaluation of injury (biomass and/or stand reduction) was generally in late September and 3-4 months after application of herbicides.

Y17. Herbicide residue analysis for soil, water, and plant tissue.

The following list shows laboratories that can analyze for herbicide residues:

A & L Great Lakes Lab 3505 Conestoga Drive, Fort Wayne, IN 46808 219-483-4759, http://www.algreatlakes.com
AgSource Harris Laboratories 300 Speedway Circle, Lincoln, NE 68502 402-476-0300, http://www.agsource.com
Agvise Laboratories PO Box 510, 604 Hwy 15, Northwood, ND 58267 701-587-6010, www.agviselabs.com 902 13 th St N, Benson, MN 56215, 320-843-4109
APT Labs Inc. 1050 Spring St., Reading, PA 19610 610 375-3888, www.aptlabsinc.com
Carbon Dynamics Institute, LLC 2835 Via Verde Dr, Springfield, IL 62703-4325 217-585-8340 Specialize Group 4 residue analysis
Columbia Food Laboratories, Inc. 12423 NE Whitaker Way Portland, OR 97230 503-695-2287, www.columbiafoodlab.com/ info@columbiafoodlab.com (Can test plant tissue).
Hazelton Environmental Services 525 Science Drive, Madison, WI 53711 608-232-3300
Matrix Sciences 21830 SW Alexander Lane Sherwood, OR 97140 503-626-1973 www.matrixsciences.com
Midwest Laboratories 13611 B Street, Omaha, NE 68144 402-334-7770, www.midwestlabs.com
Minnesota Valley Testing Laboratories, Inc. Iowa, Minnesota, North Dakota 800-782-3557, www.mvtil.com
Montana State Analytical Laboratory McCall Hall, PO Box 173620 Montana State University, Bozeman, MT 59717 406 994-3383, Heidi Hickes
SGS Brookings Rose Neal, Agricultural Services, Analytical Scientist 241 34 th Ave, Brookings, SD 57006 605-692-7611 x294 rose.neal@sgs.com www.sgs.com/agriculture
South Dakota Agriculture Laboratories, Brookings Biospace Dr. Regina Wixon, regina.wixon@sdaglabs.com 1006 32 nd Ave #103 / #105, Brookings, SD 57006-4728 605-692-7325, www.sdaglabs.com

Collecting tissue samples and interpreting residue test results.

- Contact a lab from Y17
- Contact the lab to determine:
 - quantity of plant material needed testing
 - plant tissue collection and packaging instructions
 - if the lab can test for the suspect herbicide
 - testing for more than one herbicide will cost additional money
- Collect plant tissue samples <2 weeks after the drift event
- Collect samples from actively growing parts of the plant (i.e. for soybeans, collect the top 2-3 nodes)
- Collect plant samples from the field which has not been injured. It may be difficult to determine meaningful conclusions from a tissue test without a sample taken from non-injured plants. To avoid contamination collect non-injured plant samples first followed by plant samples from damaged areas. Collecting additional samples from the field in areas between the injured and non-injured parts can be beneficial but cost prohibitive for residue analysis.
- Send plant samples to the lab as quickly as possible for testing or freeze samples quickly after sampling to prevent plant tissue and herbicide degradation. Follow instructions from laboratory.
- Herbicide residue analysis results will come back as a concentration in leaf tissue, either ppm or ppb. The number have little meaning without a check to compare to (see #5).
- The residue analysis results only support evidence of chemical injury. Tissue tests alone are not strong evidence of causality.
- Grain can also be sent for herbicide analysis. Similar procedures should be used including the use of a 'untreated/check' sample that is herbicide free.
- Significantly higher concentrations of herbicide than uninjured plant samples indicates damage. If similar concentrations may mean no herbicide damage but visual symptoms (and yield damage) may still indicate otherwise.

Susceptibility of crops to soil residue - most to least tolerant:

- Chlorimuron:** soybean > wheat > oat > corn > sorghum > sunflower > alfalfa > canola > sugarbeet.
- Clomazone:** soybean > corn > sorghum = sunflower > alfalfa = wheat = oat.
- Dinitroaniline:** soybean > alfalfa > wheat > corn > sorghum > oat > annual rye.
- Imazethapyr:** soybean > alfalfa > corn > wheat > oat > sunflower > sorghum > canola > sugarbeet.
- Atrazine:** corn > sorghum > millet > flax > soybean > barley > wheat > oat > sunflower > canola/mustard > alfalfa > sugarbeet.

Amount of herbicide active ingredient from a postemergence application to cause injury:

- Glyphosate on soybean = 10% of x rate (0.75 lb ae/A)
- Glyphosate on corn = 1% of x rate (0.75 lb ae/A)
- Dicamba on soybean = 0.005% of x rate (0.5 lb ae/A)
- Dicamba on soybean: Residue levels of dicamba in soybean tissue does not predict yield loss because of environmental factors, stage of growth at time of exposure, continued metabolism of dicamba in soybean plants, and exudation of dicamba from roots into soil. Soybean tissue may show no dicamba residue in plants tissue if not collected soon after exposure. Soybean plants exposed to dicamba and glyphosate at or near reproductive stages will cause more damage and risk of yield loss than exposure during the vegetative growth. Soybean injury and yield loss will be greater under drought stress conditions.

Herbicide residue levels in soil to cause injury.

Herbicide	Crop	ppm	ppb
Atrazine	Alfalfa	0.04-0.1	40-100
	Sugarbeet	<0.005	<5
	Soybean	0.15-0.25	150-250
	Oat	0.06-0.15	60-150
Classic	Wheat	0.075-0.18	75-180
		3 inch sample (No-till)	6 inch sample (moldboard plow)
	Alfalfa/Oat	<0.17 ppm	<0.08 ppm
Command	Corn	>0.35 ppm	>0.17
	Soybean	0.17-0.35 ppm	0.08-0.17 ppm
	Alfalfa/Wheat	0.05-0.2	50-200
Dinitroaniline	Corn	0.015-0.1	15-100
	Sugarbeet	0.1-0.2	100-200
Pursuit	Wheat	0.05-0.1	50-100
	Corn	0.2-0.3	200-300
	Sorghum	<0.01-0.03	10-30
Pursuit	Soybean	0.004-0.015	4-15
	Sugarbeet	<0.001	<1
	1 ppm = 1,000 ppb. *Safe values for herbicide residues differ by soil type and pH because of differences in availability in soil. Low-range values are for coarse textured soils with low levels of organic matter, higher values are for fine textured soils with high organic matter.		

Dicamba residue levels in plant tissue and visual injury symptoms to cause seed yield loss.

Herbicide	Crop	ppm	ppb	Injury	Yield loss
Dicamba	Dry bean	0.03-0.20	30-200	20-35%	>=25%
	Field pea	0.02-0.03	20-30	10-25%	>= 6%
Data is from one herbicide exposure and is not representative of multiple exposures. The higher values of concentration and visible injury represent dicamba applied alone. Dicamba applied with glyphosate can cause visible injury and reduced yield at lower concentrations in the rate range listed. Residue levels will be greater the closer plant foliage is sampled to the exposure event. Residue levels do not predict yield loss because of environmental factors, stage of growth at time of exposure, continued metabolism of dicamba, and possible exudation of dicamba. Dry bean plants exposed to dicamba at or near reproductive stages will cause more damage and risk of yield loss than exposure during the vegetative growth. Dicamba injury as dead growing points, aborted flowers, and empty or mis-figured pods will determine amount of yield loss. Visual injury is more predictive of yield loss than a tissue test. A tissue test can confirm if a herbicide active ingredient is present in plants rather than predict the extent of damage.					

Pinto bean response to low doses of dicamba, Carrington, ND, 2015-18.

Treatment ^a		Plant		Seed	
Herbicide	Rate	Biomass reduction ^b	Physiological maturity	Yield	Germination ^c
	lb ae/A	%	day of year	lb/A	%
untreated check	x	0	243	2,300	87
dicamba	0.00044	19	256	1,970	86
	0.0044	31	271	1,280	67
	0.044	48	280	150	26
LSD (0.05)		10	12	790	32

^aApplication at bud- to early bloom-stage plants. Rate as Xtendimax: 0.00044=0.019 fl oz/A; 0.0044=0.19 fl oz/A; 0.044=1.9 fl oz/A.

^bVisually evaluated 21 days after treatment.

^cData from three site-years.

Glyphosate residue levels in plant tissue is not an accurate method to predict crop yield loss. Dry bean plants exposed to glyphosate at or near reproductive stages will cause more damage and risk of yield loss than exposure during the vegetative growth. Damage to reproductive tissue will determine degree of yield loss.

Pinto bean response to low doses of glyphosate, Carrington, ND, 2015-18.

Treatment ^a		Plant		Seed	
Herbicide	Rate	Biomass reduction ^b	Physiological maturity	Yield	Germination ^c
	lb ae/A	%	day of year	lb/A	%
untreated check	x	0	243	2,300	87
glyphosate	0.00088	6	242	2,160	86
	0.0088	11	253	1,790	89
	0.088	32	279	860	57
LSD (0.05)		10	12	790	NS

^aApplication at bud- to early bloom-stage plants. Rate as Roundup Powermax: 0.00088=0.025 fl oz/A; 0.0088=0.25 fl oz/A; 0.088=2.5 fl oz/A.

^bVisually evaluated 21 days after treatment.

^cData from three site-years.

Publications on Herbicide Injury Symptoms:

A-1085 Herbicide Mode of Action and Sugarbeet Injury Symptoms
NDSU Extension

Web sites:

Herbicide Mode of Action and Injury Symptoms (U of MN):

z.umn.edu/cropinjury

Herbicide Mode of Action Symptoms, U of WI

Dicamba Injury to Soybean, U of WI

Z1. Restrictions on Grazing/Feeding/Haying of Crops Treated with Herbicides.

Herbicide	Crop	Time Interval
DAA = days after application WAA = Weeks after appl.		
Acetochlor	Corn	No restriction
Acuron/Flexi	Corn	45 DAA
Aim	Grasses	No restriction
Anthem	Field corn forage Sweet corn forage Corn grain/stover Soybean	30 DAA 40 DAA 70 DAA Not allowed
Armezon/Pro	Corn	45 DAA
Assure II	Enlist field corn Sugar Beet tops	30 DAA 60 DAA
Atrazine	Corn Roadsides (hay)	21 DAA Not Allowed
Authority Assist/First/MTZ	Soybean	Not Allowed
Authority Elite	Soybean Sunflower Dry pea, chickpea	30 DAA Not Allowed Forage 60, hay 120 DAA
Axial Bold/Star/XL	Wheat & Barley	30 DAA
Balance Flexx	Cover Crop Corn forage	Not Allowed 45 DAA
Basagran	Corn Soybean	12 DAA 30 DAA
Beyond	Clearfield Wheat	No restriction
Boundary	Soybean Soybean post-directed	40 DAA Not Allowed
BroadAxe XC	Soybean Sunflower	30 DAA Not Allowed
Bromoxynil	Alfalfa spring-applied Alfalfa fall-applied Corn CRP Small Grain	30 DAA 60 DAA 30 DAA Not Allowed 45 DAA
Bromoxynil + MCPA	Small Grain	45 DAA
Cadet	Corn grain or stover Field corn forage Sweet corn forage Soybean	70 DAA 30 DAA 40 DAA Not Allowed
Callisto	Corn Oats	45 DAA 30 DAA
Capreno	Corn	45 DAA
Chateau	Alfalfa	25 DAA
Corvus	Corn forage	45 DAA
Curtail	Small Grain	7-14 DAA
Curtail M	Small Grain	45 DAA
Defol 750	Corn Dry Bean Soybean Sunflower	14 DAA Not Allowed Not Allowed 14 DAA

Herbicide	Crop	Time Interval
Dicamba	Corn Small Grain: - Hay harvest - Lactating dairy animals (grazing) - Non-Lactating Animals (grazing)	≥ Milk Stage 37 DAA 7 DAA No Restriction
Diflexx/Duo	Corn	45 DAA
Discover NG	Small Grains	30 DAA
Dual II Magnum	Corn Soybean (PRE) Soybean (POST) Sunflower	30 DAA 30 DAA Not Allowed Not Allowed
Eptam	Alfalfa Dry Bean	14 DAA 45 DAA
Everest 3.0	Wheat	30 DAA
Extreme	RR Soybean	Not Allowed
Far-Go	Small Grain	Not Allowed
Fenoxaprop	Small Grain	60 DAA
Fierce EZ	Soybean	21 DAA
Fierce MTZ	Soybean	40 DAA
Flexstar	Soybean	Not Allowed
Goldsky	Small Grain: - Graze - Hay	7 DAA 28 DAA
Halex GT	Corn	45 DAA
Huskie/FX	Small grain	25 DAA
Huskie Complete	Small Grain: -Graze or forage -Cut for hay	25 DAA 30 DAA
Impact	Corn	45 DAA
Laudis	Corn	45 DAA
Liberty	Canola Soybean	Not Allowed Not Allowed
Lumax EZ	Corn	45 DAA
Marvel	Soybean	Not Allowed
Matrix	Corn	30 DAA
MCPA (may vary by label)	Alfalfa Flax Dry Pea Small grain CRP	7 DAA 7 DAA Not Allowed 7 DAA Not allowed
Metribuzin	Alfalfa Alfalfa & Grasses Barley Chickpeas Corn Fallow Grass Establishment Lentil Field Pea Soybean Wheat	28 DAA 42 DAA After maturity 40 DAA 60 DAA Not Allowed 28 DAA 40 DAA 40 DAA 40 DAA 14 DAA
Olympus	Wheat	No restriction

Herbicide	Crop	Time Interval
Orion	Small Grain	7 DAA
Outlook	Corn Cool-season grass Warm-season grass Soybean	40 DAA 60 DAA 30 DAA Not Allowed
Panoflex	Forage	7 DAA
Paraquat	Alfalfa Corn Field Pea Dry Bean Chickpea Faba bean Lentil Soybean Sunflower	42 DAA 7 DAA 7 DAA 7 DAA 7 DAA 7 DAA 7 DAA Not Allowed 7 DAA
Permit	Corn CRP	30 DAA No Restriction
Poast	Alfalfa:Undried Forage Corn Dry Bean Field Pea Flax Lentil Potato Sugar Beet Sunflower Soybean	7 DAA No Restriction No Restriction No Restriction No Restriction Not Allowed Not Allowed No Restriction Processed meal only Only processed meal from seed and hay allowed
Powerflex	Wheat	7 DAA
Prowl	Corn Forage grasses Alfalfa/grass mix Grass Straw Safflower Soybean Sunflower	21 DAA No Restriction 14 DAA No Restriction Not Allowed No Restriction Not Allowed
Pursuit	Alfalfa Soybean	30 DAA Not Allowed
Python	Corn Soybean	45 DAA Not Allowed
Quelex	Small Grain - Graze - Hay	7 DAA 21 DAA
Reflex	Corn Dry Bean Soybean	Not Allowed Not Allowed Not Allowed
Resolve	Corn	30 DAA
Revolin Q	Corn	45 DAA

Herbicide	Crop	Time Interval
Roundup Powermax (Glyphosate)	Alfalfa: - 44 oz/A or less - >44 fl oz - Dormant alfalfa - Spot Treatment RR Alfalfa RR Corn - Preharvest RR Corn - Postharvest CRP (≤ 2 qt/A) Feed Barley & Wheat: - Preharvest - Postharvest Grass Seed Production PP, PRE, Renov ≤ 2 qt PP, PRE, Renov > 2 qt Pastures: PP, PRE, Renov ≤ 2 qt PP, PRE, Renov > 2 qt Spot Treatment Postemergence ≤ 2 qt Soybean preharvest: >22 fl oz ≤ 22 fl oz RR Soybean: -Preharvest (≤ 22 oz) Oilseed crops: -Preharv & Postharv Vines and hay of dry bean, dry pea, chickpea, and lentil Rangeland (≤ 2 qt/A)	36 hours Not allowed 36 hours 3 DAA 5 DAA 7 DAA 7 DAA No Restriction 7 DAA 7 DAA No Restriction 8 WAA No Restriction 8 WAA 7 DAA No Restriction 25 DAA 14 DAA 14 DAA 7 DAA Not allowed No Restriction
Select	Alfalfa Soybean	15 DAA Not Allowed
Sentrallas	Grazing/Forage	7 DAA
Sequence	Corn Legume vegetables Soybean: - PP, PRE - POST Sunflower	30 DAA Not Allowed 30 DAA Not Allowed Not Allowed
Sharpen	Alfalfa/Grass dormant Corn Dry Bean Preharvest Field Pea vines Grass Forage/Pasture Legumes PP, PRE Small Grain straw Soybean Preharvest	28 DAA 80 DAA Not Allowed No Restriction No Restriction 65 DAA No Restriction Not Allowed
Sinate	Corn	60 DAA
Sonalan	Canola Field Pea	Not Allowed Not Allowed

Herbicide	Crop	Time Interval
Sierra	Wheat	30 DAA
Sonic	Soybean	Not Allowed
Spartan/Charge	Forage	Not Allowed
Spartan Elite	Soybean Sunflower Dry pea, chickpea, dry bean	30 DAA Not Allowed Forage 60, hay 120 DAA
Starane Ultra	Small grain Corn, Field Corn, Sweet CRP Grass seed/forage/hay	7 DAA 47 DAA 31 DAA Not Allowed No Restriction
Starane Flex	Small Grain	7 DAA
Starane NXT	Corn Grass Seed Production Small Grain	45 DAA Not Allowed 45 DAA
Stinger	Corn CRP Small Grains - Hay	40 DAA No Restriction 7 DAA Not Allowed
Storm	Soybean	Not Allowed
Supremacy	Small Grain: - Straw	Not Allowed No Restriction
Surveil	Soybean	Not Allowed
Talinor	Small Grain: - Graze/hay - Straw	30 DAA 60 DAA
Targa	Grass Seed Production	Not Allowed
Teammate	Small Grain: - Graze - Hay	7 DAA 28 DAA
Thistrol	Field Pea	Not Allowed
Travallas	Grazing/Forage Hay	7 DAA 30 DAA
Treflan	Alfalfa	21 DAA
Ultra Blazer	Soybean	Not Allowed
Valor	Soybean Wheat: >5" height	Not Allowed No Restriction
Varisto	Soybean	30 DAA
Varro/Luxxur	Wheat: - Graze - Hay	7 DAA 30 DAA
Verdict	Corn Soybean	80 DAA Not Allowed
Warrant	Corn Soybean Sugarbeet	40 DAA Not Allowed 70 DAA
Widematch	Corn Small Grain	47 DAA 7 DAA
Wolverine Advanced	Wheat, Barley -straw	25 DAA 57-60 DAA
Xtendimax	Xtend Soybean	Permitted
Zidua	Wheat	7 DAA

Herbicide	Crop	Time Interval
Zidua Pro	Soybean	Not Allowed
2,4-D (Labels vary)	Soybean Corn Fallow, stubble	Not Allowed 7 DAA 7 DAA
2,4-DB	Alfalfa - Established - Seedling Soybean	30 DAA 60 DAA 60 DAA

Grazing and Haying Restrictions for Herbicides Used in Pasture and Rangeland.

Herbicide ¹	Lactating dairy animals		All animals except lactating dairy animals		
	Before grazing	Before hay harvest	Before Grazing ⁹	Before hay harvest	Removal before slaughter
	----- days after application -----		----- days after application -----		
Amber	0	30	0	30	0
Cimarron Max*	7	-	0	37	30
Cimarron Xtra*	0	0	0	0	0
Crossbow	Next season	Next season	0 ²	14	3
Curtail*	14	7	0	7	7 ³
Dicamba ¹					
Up to 1 pt	7	37	0	0	30
Up to 2 pt	21	51	0	0	30
Up to 4 pt	40	70	0	0	30
Up to 16 pt	60	90	0	0	30
Escort*	0	0	0	0	0
Facet L	No grazing restrictions. Allow 7 days before haying.				
Glyphosate ¹					
Pre/Renovation - < 2.25 lb ae/A	No restriction	No restriction	No restriction	No restriction	No restriction
- > 2.25 lb ae/A	8 weeks	8 weeks	8 weeks	8 weeks	8 weeks
Spot Spray - Bayer ⁶	7	7	7	7	7
- Generics	14	14	14	14	14
Broadcast (8-11 fl oz)	No restriction	No restriction	No restriction	No restriction	No Restriction
Grazone P+D	7	30	0	30	3
Landmaster BW* ⁵	7	30	0	30	3
Method	Do not graze or feed		Do not graze or feed		-
Milestone	0	0	0	0	0
paraquat* ⁴	1 month	1 month	1 month	1 month	0
Perspective	Do not graze or feed		Do not graze or feed		-
Plateau	0	7	0	7	0
Rave	7	0	0	0	0
Spike ⁷	0	1 year	0	1 year	0
Stinger*	0	0	0	0	0
Telar* (<0.3 oz/A)	0	0	0	0	0
Tordon 22K ⁸	14	1 qt =14, <1qt=0	0	1 qt =14, <1qt=0	3
2,4-D/MCPA ¹ (labels vary)	7-14	7-30	0-7	7-30	3-7

*Or generic equivalent.

¹These are from Roundup Powermax label. Check specific label containing the same active ingredients for restrictions and uses.

²One year if more than 1.5 gallons/A is used.

³Withdrawal not needed if 2 weeks or more of time elapsed since application.

⁴Restrictions based on degree of new seedlings established before grazing. Suggested at least 6 inches of grass or legume growth.

⁵No restrictions if 10% or less of the area is treated.

⁶Do not treat more than one-tenth of any given acre at one time with spot or wiper application. Remove livestock before application.

⁷If no more than 20 lb/A is used.

⁸Remove livestock to untreated grass pastures for 7 days before transferring livestock to broadleaf or pasture areas. Removal before slaughter statement only applies to animals grazing treated forage for 2 weeks immediately after application.

⁹Some labels do not specify a grazing restriction.

Control of Volunteer Glyphosate Resistant (GR) Crops

PRE Control of volunteer GR canola:

>90% PRE = Acuron/Flexi, Authority Assist (7-9 fl oz), Authority First/MTZ/Elite/BroadAxe XC (20-26 fl oz = 75-85%), Balance Flexx, Fierce, FirstRate, Instigate, Realm Q (POST), Resolve Q, Sharpen (2-3 fl oz), Sonic, SureStart (2 pt), Surveil, Verdict.

<70% PRE = Anthem, Authority Assist (6 fl oz), Authority MTZ, Boundary, Metribuzin, Sharpen (1 fl oz), SureStart II (1.5-2 pt), Spartan, Valor, Zidua.

POST Control of volunteer GR canola:

>90% POST = Most ALS herbicides. SureStart II (1.5-2 pt), Teammate (3-leaf).

<70% POST = Aim, Cadet, Basagran >6-leaf, Cobra, Harmony*, Realm Q, Resolve Q, Sharpen >bolting, Talinor, Ultra Blazer >3-leaf.

		Canola - Pre	Canola - 3-leaf	Canola - 6-leaf	Canola - begin bolt	Canola - begin flower	Corn - 10-18 inches	Corn - 18-24 inches	Corn - 24-40 inches	Soybean - V2-V3	Soybean - V4-V6
**See section below table for more herbicides											
POST Grass Herbicides*											
Assure II* / Fusilade DX	3 - 5 fl oz	N	N	N	N	N	E	E	G-E	N	N
Select*	3 - 6 fl oz	N	N	N	N	N	G-E	P-G	P-F	N	N
Select Max	6 - 9 fl oz	N	N	N	N	N	G-E	P-F	P	N	N
Broadleaf Herbicides											
Armezon/Impact + atrazine	0.5 fl oz+0.38 lb ai	E	E	E	F	P	N	N	N	P	P
atrazine* + oil adjuvant	0.38 lb ai	E	G-E	P	N	N	N	N	N	E	P
	0.5 lb ai	E	G-E	G	P	P	N	N	N	E	F
Bromoxynil & MCPA*	0.8 pt	-	E	F-G	-	-	N	N	N	E	E
Callisto + atrazine (3/8 lb ai)	3 fl oz	E	E	E	E	E	N	N	N	P	P
Capreno + atrazine (3/8 lb ai)	3 fl oz	-	E	G-E	-	-	N	N	N	G	G
Curtail*	0.25 - 0.5 pt	-	G-E	F-G	-	-	N	N	N	F-G	P-F
Dicamba	4 - 12 fl oz	N-P	P	P	P	P	N	N	N	E	E
Express*	0.167 oz DF/0.25 oz SG	-	E	G-E	F-G	F	P	P	P	P	P
Extreme*	1.5 pt	E	E	G-E	P	P	F-G	F	P	N	N
FirstRate/Sonic	0.2 - 0.3 oz	E	E	F-E	P-F	F	-	-	-	N	N
Flexstar + MSO	0.38 - 0.75 pt	-	E	E	E	E	N	N	N	N	N
Harmony	0.33 oz DF / 0.5 oz SG	-	E	G-E	P	P	N	N	N	N	N
Hornet	1 - 2 oz	P-F	G-E	F-E	-	-	N	N	N	E	F
Huskie/Complete/FX	11-15/13.7/13.5-18 fl oz	-	E	E	E	E	N	N	N	G	G
Laudis + atrazine (3/8 lb ai)	3 fl oz	-	E	E	E	F	N	N	N	G	G
Liberty + AMS	32 - 43 fl oz	N	E	G-E	P-F	P	N	N	N	G	F-G
MCPA*	1 pt	P	E	E	G-E	G	N	N	N	G	F
Permit	1.5 oz	E	E	E	-	-	N	N	N	E	G
B-mix*+Nortron*+UpBeet+ MSO**	1.4 pt+0.23 pt+0.25 oz	-	P-F	N-P	N	N	P-F	N-P	N-P	F	N-P
Pursuit* + MSO	2 fl oz	G-E	E	G-E	P	P	G	F	P	N	N
Raptor + MSO	1 - 2 fl oz	-	E	G-E	P-F	P	P-F	P	N-P	N	N
	4 fl oz	-	E	E	G	F	G-E	F	P	N	N
Status	2.5 oz	N	F	P	N	N	N	N	N	E	G-E
	4 oz	N	G	F	P	P	N	N	N	E	E
Stinger* + oil adjuvant	1 - 2 fl oz	N	N	N	N	N	N	N	N	F-G	F
	3 - 4 fl oz	N	N	N	N	N	N	N	N	E	G-E
Varisto + MSO	11 -16 fl oz	-	E	E	G	F	P-F	P	N-P	N	N
	21 fl oz	-	E	E	E	E	G-E	F	P	N	N
UpBeet + MSO**	0.5 to 1 oz	-	G	N-P	N	N	P-F	N-P	N-P	F	N-P
WideMatch*	0.13 - 0.25 pt	N	P	P	N	N	N	N	N	F-E	P-G
Wolverine Advanced	1.7 pt	-	E	E	E	E	E	E	E	G	G
2,4-D*	0.5 pt	N	G	P	N	N	N	P	P	P	P
	1 pt	N	E	E	G-E	P	N	P	P	-	-

*Or generic equivalent.

**Two applications at 10 to 14 days interval.

Weed control ratings in this section are based on the following scale:

E = Excellent = 90 to 99% control

G = Good = 80 to 90% control

F = Fair = 65 to 80% control

P = Poor = 40 to 65% control

N = None = No control

“-“ = insufficient information

Herbicide Effectiveness, Residual Activity in Soil (soil-applied), and Persistence in Soil (POST applied)

The following ratings show relative herbicide effectiveness at labeled rates. Under favorable conditions control may be greater than indicated and under unfavorable conditions herbicides may give erratic results. Dry and cool weather increases herbicide persistence while wet and/or warm weather reduces herbicide persistence.

SOIL- APPLIED HERBICIDES*	Mode of Action**	Barnyardgrass	Brome, Downy	Foxtail, Green	Foxtail, Yellow	Quackgrass	Volunteer Cereals	Wild Oat	Buckwheat, Wild	Cocklebur, Common	Horseweed (Marestail)	Kochia	Lambsquarters
Acetochlor	15	E	P-F	G-E	G-E	N	P	P-F	P	P	N-P	P-F	F-E
Acuron	5,15,27,27	E	G	E	E	N	P	P	G-E	E	G-E	E	E
Acuron Flexi	15,27,27	E	F	E	E	N	P	P	P	G	G-E	G-E	E
Afforia	2,2,14	N	F-G	P	P	N	N	N	P-F	N	F-E	F-G	G-E
Atrazine* (0.38 lb ai/A)	5	P	G	P	P	N	F-G	F-G	P	N	-	F	F
Atrazine* (0.5 - 0.75 lb ai/A)	5	F	G-E	P	P-F	P	G-E	G-E	G-E	F-G	-	G-E	E
Authority Assist	2,14	P	F-G	P	P	N	N	N	P	P	F	E	E
Auth. Elite/BroadAxe XC	14,15	P-E	P-F	F-E	F-E	N	P-F	P-F	P-G	P	F-G	E	E
Authority First / Sonic	2,14	N	F-G	P	P	N	N	N	P	E	P-E	E	E
Authority MTZ	5,14	P-F	F-G	P-F	P-F	N	P	P	F-G	P-F	F	E	G-E
Balance Flexx	27	E	-	E	F-G	P	N	N	N	P	G-E	G-E	E
Boundary	5,15	F-G	-	F-E	F-E	N	P	P	F-G	P	F	F-G	G
Callisto	27	N	-	N	N	N	N	N	N	P	G-E	P	E
Corvus	2,27	E	G	G-E	G	-	P	F-G	P	F	G	E	E
Dicamba	4	N	N	N	N	N	N	N	E	E	F-E	E	G
Dual/II/Magnum*	15	P-E	P-F	F-E	F-E	N	P	P-F	N-P	N	N	N-P	P-F
Eptam	8	E	-	E	E	F-G	G	G-E	F	P	N	P	F
Fierce EZ	14,15	G	G-E	E	G-E	N	N	P	P-F	P	F-G	F-E	F-E
Fierce MTZ/Kyber	5,14,15	G	G-E	E	G-E	N	N	P	F-G	P-F	F-G	F-E	F-E
Lumax EZ	5,15,27	G	G	G-E	G-E	N	P	P	G-E	F-G	E	E	E
Metribuzin*	5	P-F	F-G	P-F	P-F	N-P	P-G	N	F-G	P-F	F	F-G	P-F
Nortron/Ethotron	8	P	-	F-G	F-G	P	E	G	F-G	P	-	F-G	F
Olympus	2	F	F-G	P	P	P	N	F-G	P	-	N	P ¹	P
Outlook*	15	G-E	P-G	G-E	G-E	N	F-G	P	N	N	N	N	F-G
Permit*	2	N	-	N	N	N	N	N	N	E	P ¹	N ¹	G-E
PrePare	2	P-F	N-P	G-E	P-F	N	N	F-G	-	P	N	F-G ¹	F
Prequel	2,27	E	-	G-E	G-E	N	G-E	G-E	N	G-E	G-E	G	G-E
Prowl*/Sonalan*/Treflan*	3	E	F-G	E ¹	E	N	N-P	P	P	N	N	P	F-G
Resicore/Maverick	4,15,27	E	P-F	G-E	G-E	N	P	N	G-E	G-E	G-E	P-F	E
Rimsulfuron*	2	G	-	G	F-G	N	G	F	P	F	P ¹	G ¹	F
Ro-Neet	8	E	-	E	E	P	G-E	G	P-F	P	-	P	F-G
Sharpen (1 fl oz/A)	14	N	N	N	N	N	N	N	P-G	P	P-G	P-F	P-F
Sharpen (2-3 fl oz)	14	N	N	N	N	N	N	N	G-E	G	G-E	E	E
Spartan/Charge	14/14	N	F-G	P	P	N	N	N	P-F	P	F	F-E	G-E
SureStart II/TripleFlex II	2,4,15	E	-	E	E	N	G	P	E	E	G-E	G-E ¹	E
Surveil	2,14	N	F-G	P	P	N	N	N	P-F	E	F-E	F-E	F-E
Valor*	14	N	F-G	P	P	N	N	N	P-F	N	F-E	F-G	G-E
Verdict (10-18 fl oz)	14,15	F-G	P-G	G-E	G-E	N	F	P	G-E	G	G-E	E	E
Warrant	15	E	-	G-E	G-E	N	P	P	N	N	P	P	F
Zidua/Anthem/Perpetuo	15/14	E	F-G	G-E	G-E	N	N	F-E	P	P	N-P	F	P
Zidua Pro	2/15/ 14	E	F-G	E	E	N	P-F	F-E	G-E	G-E	F	F-E	E

PPI = Preplant Incorporated, Pre = Preemergence. Shallow PPI = greater and more consistent weed control compared to PRE.

*Or generic equivalent. **Numbers represent herbicide mode of action from a numerical classification system.

¹Except where resistant populations have developed.

Weed control ratings in this section are based on the following scale:

E = Excellent = 90 to 99% control P = Poor = 40 to 65% control
 G = Good = 80 to 90% control N = None = No control
 F = Fair = 65 to 80% control "-" = insufficient information

Residual Weed Activity:

S = Short = 0 to 2 weeks
 M = Medium = 2 to 6 weeks
 L = Long = 6 to 12 weeks
 VL = Very long = >12 weeks

Herbicide persistence ratings are for residues present 12 months after application:

O = Often S = Seldom N = None

SOIL- APPLIED HERBICIDES*	Lanceleaf Sage	Mallow, Common	Marshelder	Mustard, Wild	Mustard, Wntr. Annual	Nightshade, E/Black	Nightshade, Hairy	Pigweed, Redroot	Waterhemp / Palmer	Prickly Lettuce	Ragweed, Common	Smartweed, Annual	Sunflower	Thistle, Russian	Wormwood, Biennial	Thistle, Canada	Residual weed activity
Acetochlor	N	N	P	F	-	F-G	F-G	G-E	F-E	-	N-P	P	N-P	F	N	N	S-M
Acuron	G	-	E	E	E	E	E	E	E	G-E	E	E	E	E	G-E	N	L
Acuron Flexi	G	-	E	E	E	E	E	E	E	G-E	E	E	E	E	G	N	M
Afforia	N	E	P	G-E	G-E	E	G-E	G-E	G-E	F-G	N-P	F	P	F-G	G	N	M
Atrazine* (0.38 lb ai/A)	G	-	F	G	G	F	F	F	P-F	-	P	F	F	G	G	N	M
Atrazine*(0.5 - 0.75 lb ai)	E	-	E	E	E	E	E	E	G	E	E	E	G	E	E	N	L
Authority Assist	-	F	P-G	E	E	E	E	E	F-E	P	N	G-E	P	G-E	G-E	N	L
Auth. Elite/BroadAxe XC	N	-	P-G	P	P	G-E	F-G	G-E	G-E	P	N	G-E	N	G-E	F-G	N	M-L
Authority First / Sonic	E	-	E	E	E	E	E	E	F-E	-	G-E	E	E	G-E	G	N	L
Authority MTZ	F-G	F-G	E	G-E	G-E	G-E	F-G	E	F-E	G-E	F-G	G-E	P-F	G-E	G-E	N	M-L
Balance Flexx	-	N	G	E	G-E	G-E	G-E	E	G	G-E	G-E	F-G	P	G	G-E	N	M
Boundary	F	F	G-E	G-E	G-E	P	P	G-E	G-E	G-E	P-F	G	P	G-E	G-E	N	M
Callisto	-	-	E	E	E	E	E	E	G-E	-	G	E	E	-	-	N	M
Corvus	-	-	G-E	E	G-E	G-E	G-E	E	E	G-E	G-E	G-E	F	F	G-E	N	M
Dicamba	P-F	P	E	P	P	E	E	G	F-G	G-E	E	E	G-E	G	G-E	F-G	S
Dual/II/Magnum*	N	-	N	N	-	N	N	F-G	F-G	N	N	N	N	P	N	N	S-M
Eptam	N	P-G	P	P	P	F	F	G	G	P	F	P	N	P	N	N	S
Fierce EZ	-	E	P	G-E	G-E	G-E	F-E	G-E	G-E	F-G	F-G	F-G	P	G-E	G-E	N	M
Fierce MTZ/Kyber	-	E	E	G-E	G-E	G-E	F-E	G-E	G-E	G-E	F-G	G	P-F	G-E	G-E	N	M
Lumax EZ	G	-	E	E	G-E	E	E	E	G-E	G-E	G-E	G-E	G-E	G-E	G-E	N	L
Metribuzin*	F	-	E	G-E	G-E	P	P	G-E	F-G	G-E	P-F	G	P-F	G-E	G-E	N	M
Nortron/Ethotron	-	P	P	P-F	-	F-G	F-G	G-E	F-G	-	P	G-E	P	F-G	-	N	L
Olympus	-	-	-	G	G	P	P	P	N	P	P	P	P	P	-	N	L
Outlook*	N	N	N	P-F	-	F-G	F-G	G-E	G	-	N	N	N	P-F	N	N	S-M
Permit*	-	-	-	E	E	N	N	F-E	N	-	E	E	-	N	N	N	M
PrePare	N	F	-	-	G	G	G	G	N	P	N	F-G	N	F	P	N	M
Prequel	-	-	F-G	E	E	G-E	G-E	G-E	G	G-E	G-E	F-G	P-F	P-F	G-E	N	M
Prowl*/Sonalan*/Treflan*	N	-	N	N	P	N-P	N-P	E	G-E	N	N	P	N	F-G	N	N	VL
Resicore/Maverick	-	-	E	E	E	E	E	E	G-E	-	E	E	E	-	E	N	M
Rimsulfuron*	N	-	N	F	-	P	P	E	N	-	F	P	F	P	N	N	M
Ro-Neet	N	F-G	P	P	P	F-G	F-G	G	F-G	P	F	P	N	P	-	N	S
Sharpen (1 fl oz/A)	-	P-G	-	P-G	P-G	P-G	-	F-G	F	P	F	F	P-G	P-G	P-G	N	S
Sharpen (2-3 fl oz/A)	-	G-E	-	E	E	G-E	-	E	G-E	G-E	G-E	E	G-E	E	E	N	M
Spartan/Charge	N	-	P-G	P	P	E	F-G	F-E	F-E	P	N	G-E	N	G-E	G	N	L
SureStart II/TripleFlex II	G	-	E	E	E	G-E	G-E	G-E	P	G-E	F-G	G-E	E	F-G	E	F	M
Surveil	E	-	E	E	E	G-E	G-E	G-E	G	F-E	F-G	G-E	E	G-E	G	N	L
Valor*	N	E	P	G	G	E	G-E	G-E	G-E	F-G	N-P	F	P	F-G	G	N	M
Verdict (10-18 fl oz)	-	G-E	-	E	E	G-E	-	E	E	G-E	G-E	E	G-E	E	E	P	M
Warrant	N	-	N	P	-	F-G	F-G	G-E	G	-	N	N	N	N	N	N	S-M
Zidua/Anthem/Perpetuo	-	-	P	P	-	F-G	F-G	G	G	-	P-F	F	N	F	F	N	M-L
Zidua Pro	-	-	E	E	E	E	E	E	G-E	-	F-G	E	F-G	E	E	N	L

*Or generic equivalent.

¹Except where resistant populations have developed.

POST- APPLIED HERBICIDES*	Mode of Action	Barnyardgrass	Brome, Downy	Foxtail, Green	Foxtail, Yellow	Quackgrass	Volunteer Cereals	Wild Oat	Buckwheat, Wild	Cocklebur, Common	Horseweed (Marestail)	Kochia	Lambsquarters
Affinity BS* (1:1) + 2,4-D	2,2,4	N	N	N	N	N	N	N	G-E	G	F ¹	E ¹	E
Thifen&Triben* (2:1) + 2,4-D	2,2,4	N	N	P	P	N	N	N	G-E	E	F ¹	E ¹	E
Audit* (3:1) + 2,4-D	2,2,4	N	N	P	P	N	N	N	G-E	E	F ¹	E ¹	E
Affinity TM* (4:1) + 2,4-D	2,2,4	N	N	P	P	N	N	N	G-E	E	F ¹	E ¹	E
Aim	14	N	N	N	N	N	N	N	P	P	N	F-E	F-G
Armezon/Pro + atrazine	5,27	E	F-G	G-E	G-E	-	-	-	E	E	G	E	E
Assure II / Targa	1	E	P-E	E	F-G	E	E	G-E ¹	N	N	N	N	N
Atrazine (0.38 lb ai/A)	5	F	F-G	F	F	N	F	F	G-E	P	G	E	E
Atrazine (0.5 - 0.75 lb ai/A)	5	F-G	G	F	F-G	P	F-G	F-G	E	G	E	E	E
Axial Star	1,4	G-E	N	E	G-E	N	N	E ¹	P	E	-	E	N
Axial XL/Bold	1	G-E	N	E	G-E	N	N	E ¹	N	N	N	N	N
Basagran*	6	N	N	N	N	N	N	N	P-G	G-E	P-F	P-E	F-E
Betamix	5,5	P	N	F	F	N	N	N	F	P-F	-	F-G	G
Betamix + Nortron	5,8	P	N	F-G	F-G	N	N	N	F-G	F	-	F-G	G-E
Bromoxynil*	6	N	N	N	N	N	N	N	G-E	E	F	G-E	G
Bromoxynil & MCPA*	4,6	N	N	N	N	N	N	N	G-E	E	F-G	G-E	E
Cadet	14	N	N	N	N	N	N	N	N-P	N	N	P-F	F-G
Callisto	27	N	-	N	F	N	N	N	P	E	F-G	P-F	E
Callisto Xtra	5,27	N	F-G	N	F	N	N	N	G-E	E	E	E	E
Capreno + atrazine	2,5,27	G	G	G	G	N	F-G	G-E	G	G-E	G	G-E	E
Cobra/Phoenix	14	N	N	N	N	N	N	N	P	G-E	N	P-F	N
Curtail* / M*	4,4	N	N	N	N	N	N	N	G	E	G	P	G
Dicamba ² (1-4 oz ai/A)	4	N	N	N	N	N	N	N	E	E	F-E	G-E ¹	G-E
Dicamba ² (8 oz ai/A)	4	P	N	P	P	N	P	P	E	E	G-E	E ¹	E
DiFlexx ²	4	N	N	N	N	N	N	N	E	E	G	G-E	E
DiFlexx Duo ²	4,27	E	F-G	F	G-E	N	N	N	E	E	G-E	E	E
Discover NG	1	E	N	E	G-E	P	N	E ¹	N	N	N	N	N
Enlist Duo ²	4,9	E	G-E	E	E	E	E	E	P-G	E	G-E ¹	F-E ¹	E
Everest 3.0/Sierra	2	P	P-F	E	P-G	P	N	G-E ¹	F	N	N	N	P
Express*	2	N	N	N	N	N	N	N	P	N-F	N ¹	E ¹	P-F
Express* + 2,4-D	2,4	N	N	N	N	N	N	N	F	G	G ¹	E ¹	E
Extreme*	2,9	E	G-E	E	E	E	E	E	G	E	E ¹	E	G
Fenoxaprop*	1	E	N	E	E	N	N	E ¹	N	N	N	N	N
FirstRate	2	N	-	N	N	N	N	N	P-F	E	G-E ¹	P ¹	P
Flexstar	14	N	N	P-F	P-F	N	N	N	P	G-E	N-P	G-E	P-F
Flexstar GT	14	E	G-E	E	E	E	E	E	P-G	E	P-G	G-E ¹	G-E
Fusilade DX	1	E	F-G	G-E	G-E	G	E	E ¹	N	N	N	N	N
Glyphosate ²	9	E	G-E	E	E	E	E	E	P-G	E	G-E ¹	F-E ¹	P-E ¹
Goal/Collide	14	P	N	P	P	P	P	F-G	G-E	E	-	G-E	G
GoldSky	2,4	G-E	F-G	F-G	G-E	F	-	G-E	G-E	G-E		G-E	G-E
Halex GT	9,15,27	E	G	E	E	E	E	E	P-G	E	G-E ¹	E	E
Harmony* (1/12 oz)	2	N	N	N	N	N	N	N	N	N	N	N	F-G
Harmony* (0.3 to 0.6 oz)	2	N	N	N	N	N	N	N	G-E	P	N	N	E
Hornet	2,4	N	-	N	N	N	N	N	F-G	E	E	F-G ¹	P-F
Huskie	6,27	N	N	N	N	N	N	N	E	E	G-E	G-E	E
Huskie Complete	2,6,27	G-E	F	F-G	F-G	P	N	G-E	E	E	G-E	G-E	E
Huskie FX	4,6,27	N	N	N	N	N	N	N	E	E	G-E	E	E
Impact/Core + atrazine	5,27	E	F-G	G-E	G-E	-	-	-	E	E	G-E	E	E
Laudis + atrazine (3/8 lb ai)	5,27	E	F-G	F	G-E	-	-	P-F	E	E	G-E	E	E
Liberty	10	E	-	E	F-G	P	F-G	G-E	E	E	F-G	E	F-G
Lumax EZ (3 pt)	5,15,27	N	F-G	N	F	N	N	N	E	G	G-E	E	E
Luxxur	2,2	G-E	F	G-E	G-E	P	N	G-E	P	F	N	E ¹	F-G

POST- APPLIED HERBICIDES* (cont.)	Lanceleaf Sage	Mallow, Common	Marshelder	Mustard, Wild	Mustard, Wntr. Annual	Nightshade, E/Black	Nightshade, Hairy	Pigweed, Redroot	Waterhemp / Palmer	Prickly Lettuce	Ragweed, Common	Smartweed, Annual	Sunflower	Thistle, Russian	Wormwood, Biennial	Thistle, Canada	Herbicide Persistence
Affinity BS*(1:1) + 2,4-D*	F-G	F	E	E	E	F-G	F-G	G	F-G	G-E ¹	G ¹	G	G	E ¹	F-G	G-E	N
Thif & Trib*(2:1) + 2,4-D*	G-E	F	E	E	E	F-G	F-G	E	F-G	E ¹	E ¹	E	G-E	E ¹	F-G	G	N
Audit* (3:1) + 2,4-D*	G-E	F	E	E	E	F-G	F-G	E	F-G	E ¹	E ¹	E	G-E	E ¹	F-G	G	N
AffinityTM*(4:1) + 2,4-D*	G-E	F	E	E	E	F-G	F-G	E	F-G	E ¹	E ¹	E	G-E	E ¹	F-G	G	N
Aim	-	-	P	P	P	N-P	N-P	G	F-G	P	N	N	P	F	-	N	N
Armezon/Pro + atrazine	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	G	S
Assure II / Targa	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Atrazine (0.38 lb ai)	E	-	G-E	P-G	P-G	G-E	G-E	E	F	E	P	G	F-E	E	-	N	S
Atrazine (0.5 - 0.75 lb ai)	E	-	E	G-E	G-E	E	E	E	G	E	F-G	E	G	E	-	P	S
Axial Star	-	F-G	P	P	P	P	P	N	N	E	E	N	E	P	N	N	N
Axial XL/Bold	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Basagran*	P	P	G-E	E	E	N	F-G	F-E	N-E	G	P-F	E	E	G	G-E	F-G	N
Betamix	P	P	G	G-E	-	F-G	F-G	G	F	-	F	F	P	P	P	N	N
Betamix + Nortron	P-F	N	G	G-E	-	G	G	G	F	-	F-G	F-G	P	P	P	N	S
Bromoxynil*	E	P	E	F-G	F-G	E	E	F	P-F	F-G	E	G-E	G-E	E	P-F	P	N
Bromoxynil & MCPA*	E	P	E	E	G-E	E	E	F-G	F-G	F-G	E	G	E	E	F	P-F	N
Cadet	-	-	-	-	-	-	-	F-G	P-G	-	N	-	-	-	-	N	N
Callisto	-	-	E	E	E	E	E	E	G-E	N	P	E	E	-	-	N	S
Callisto Xtra	E	G-E	E	E	E	E	E	E	E	E	F	E	E	E	E	P	S
Capreno + atrazine	-	F-G	G-E	E	E	E	G-E	E	E	G	G-E	E	E	E	G-E	F	O
Cobra/Phoenix	E	G-E	G	E	-	P	P	G-E	G	-	P-E	P	P-F	P	P	N	N
Curtail* / M*	F-G	F-E	E	E	E	E	E	P	P-G	E	E	E	E	G	E	G-E	S
Dicamba2 (1-4 oz ai/A)	F	P	E	P	P	G-E	G-E	P-G	P-G	G	E	E	E	F	G-E	F	S
Dicamba2 (8 oz ai/A)	F-G	P	E	P	P	E	E	F-E	P-E	E	E	E	E	F-G	E	F-G	S
DiFlexx2	G	P	E	P	P	G	G	P-G	P-G	G	E	E	E	F	G-E	F-G	S
DiFlexx Duo2	G	G	E	E	G-E	E	E	E	G-E	G-E	E	E	E	G-E	E	G	S
Discover NG	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Enlist Duo	E	P-F	E	E	G-E	P-G	P-G	E	F-E ¹	E	E	P-E	E	G	F-E	G-E	N
Everest 3.0/Sierra	N	N	N	E	E	E ¹	N	G-E	N	P	N	E	P-F	N	-	N	S
Express*	N	P-F	E	E	E	P-F	-	F-E	N	G ¹	N	F-G	F	E ¹	P-F	G	N
Express* + 2,4-D	F-G	F-E	E	E	E	F-G	F-G	G	F-G	G-E	G	G	F-G	E	F-G	G-E	N
Extreme*	E	G-E	E	E	E	E	E	E	P-E ¹	E	G-E ¹	P-E	E	G-E	P-E	G-E	O
Fenoxaprop*	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
FirstRate	P	-	E	G-E	P	N	N	P	N	-	E ¹	E	E	-	P	N	O
Flexstar	E	G-E	G-E	E	E	G-E	F-G	E	P-E	-	P-E	G-E	F	-	P	N	O
Flexstar GT	E	F-E	E	E	E	G-E	G	E	P-E	F-G	F-E	E	G-E	G	F-E	F-G	O
Fusilade DX	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Glyphosate2	E	P-G	G-E	G-E	G-E	P-G	P-G	E	P-G ¹	P-G	G-E ¹	P-E	G-E	G	F-E	G-E	N
Goal/Collide	E	-	-	F	F	G-E	G-E	E	G-E	G-E	G	F	F-E	G-E	G	N	N
GoldSky	-	F-G	-	E	G-E	G	G	G-E	G-E	G	F-G	G	G-E	F-G ¹	-	P-F	N
Halex GT	E	P-G	E	E	E	E	E	E	G-E ¹	F-G	E	E	E	G	E	G-E	S
Harmony* (1/12 oz)	N	N	N	E	P	N	N	G	N	P ¹	N	F-G	P	P ¹	N	N	N
Harmony* (0.3 - 0.6 oz)	N	F	G-E	E	G-E	N	N	G-E	P-E	G-E ¹	N	E	G-E	G-E ¹	N	N	N
Hornet	E	-	E	E	E	G-E	G-E	P-F	N	E	E	F-G	E	F-G	E	G-E	O
Huskie	E	G	E	E	G-E	E	E	E	E	F-G	E	G-E	E	E	G	F-G	S
Huskie Complete	E	G	E	E	G-E	E	E	E	E	F-G	E	G-E	E	E	G	F-G	S
Huskie FX	E	G	E	E	G-E	E	E	E	E	F-G	E	G-E	E	E	G	F-G	S
Impact/Core + atrazine	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	G	S
Laudis + atrazine	-	G	E	E	E	E	E	E	E	E	E	E	E	E	E	G	S
Liberty	E	G	E	E	G-E	G-E	G-E	E	F-E	G-E	G-E	E	E	G-E	E	P	N
Lumax EZ (3 pt)	E	-	E	E	E	E	E	E	E	E	E	E	E	E	E	P	S
Luxxur	P-F	-	E	E	E	P-F	P-F	F-G	F ¹	G ¹	N	F-G	F	E ¹	P-F	G	S

POST- APPLIED HERBICIDES* (cont.)	Mode of Action	Barnyardgrass	Brome, Downy	Foxtail, Green	Foxtail, Yellow	Quackgrass	Volunteer Cereals	Wild Oat	Buckwheat, Wild	Cocklebur, Common	Horseweed (Marestail)	Kochia	Lambsquarters
Outrider	2	-	F-G	P-F	P-F	G	N	E	N	-	F	P ¹	P
MCPA	4	N	N	N	N	N	N	N	N	G	F-G	N	E
Metribuzin*	5	F	N	F	F	P	P	-	P-F	P-F	P-F	P-F	F-G
OpenSky	2,4	G-E	F-G	F-G	G-E	F	-	G-E	G-E	G-E		G-E	G-E
Olympus	2	F	F-E	P-F ¹	P-F	F-G	N	G-E ¹	-	-	P	-	-
Orion	2,4	N	N	N	N	N	N	N	G	F-G	-	G ¹	E
Osprey	2	G	F-G	P-F ¹	P-F	N-P	N	G-E ¹	N	N	N	N	N
Paraquat	22	G	-	G	G	P	F-G	G	F	F-G	F-G	G-E	E
PerfectMatch	2,4	G-E	F-g	F-G	G-E	F	-	G-E	E	E	G-E	F-E ¹	G
Permit*	2	N	N	N	N	N	N	N	P	E	-	P ¹	N
Poast	1	E	P-G	E ¹	E	F	G-E	G-E ¹	N	N	N	N	N
PowerFlex	2	G-E	F-G	F	G	-	-	G-E	F-G	-	-	F ¹	G-E
Pursuit*	2	G	-	G ¹	F-G	N	G	F ¹	P	G-E	N	E ¹	P
Quelex	2,4	N	N	N	N	N	N	N	G-E	-	G-E	F	G-E
Raptor/Beyond	2	E	F-E	E ¹	G-E	F	G-E	E ¹	P	G-E	N	E ¹	P-F
Raze	2,4	G	F-G	E ¹	G	N-P	N	E ¹	F-G	E	N	E	P
Realm Q	2,27	G-E	-	G-E	G-E	G-E	G-E	G-E	P-F	E	F-G	P-F ¹	E
Reflex*	14	N	N	N	N	N	N	N	P	G	N-P	F-E	P
Require Q	2,4	G-E	-	G-E	G-E	G-E	G-E	G-E	G-E	E	F-G	G-E ¹	F-G
Resicore/Maverick	4,15,27	N	N	N	N	N	N	N	G-E	E	G-E	G-E	E
Resolve Q	2,2	G-E	-	G-E	G-E	G-E	G-E	G-E	P	N	N	E ¹	F-G
Resource	14	N	-	N	N	N	N	N	-	F	N	P	F-G
Revulin Q	2,27	G-E	-	G-E	G-E	G-E	G-E	G-E	P-F	E	F-G	P-F ¹	E
Rimfire Max	2,2	G	P-F	P-F ¹	P-F	F	N	G-E ¹	N	-	P	N	-
Rimsulfuron	2	G-E	-	G-E	G-E	G-E	G-E	G-E	N	N	N	E ¹	F
Select* / Select Max	1	E	P-E	E	E	G-E	E	E	N	N	N	N	N
Starane Ultra	4	N	N	N	N	N	N	N	P	E	-	F-E	N
Starane Flex	4	N	N	N	N	N	N	N	G	E	-	F-E	P
Starane NXT*	4,6	N	N	N	N	N	N	N	E	E	G-E	E	E
Status	4,19	P-F	N	P-F	P-F	N	P	P	E	E	G-E	G-E	E
Stinger* (<0.061 lb ai/A)	4	N	N	N	N	N	N	N	F	G-E	G	N	N
Stinger* (>0.061 lb ai/A)	4	N	N	N	N	N	N	N	F-G	E	G-E	N	P
Storm	6,14	N	N	P-F	P-F	N	N	N	P-F	F-G	N	P-E	F-E
Supremacy	2,2,4	N	N	P	P	N	N	N	E	E	F ¹	E	E
SureStart II/TripleFlex II	2,4,15	E	-	E	E	N	G	P	E	E	G-E	G-E ¹	E
Talinor	6,27	N	N	N	N	N	N	N	E	E	G-E	G-E	E
Teammate	2	G-E	F-G	F-G	G	F	N	G-E	F-G	-	-	F ¹	G
Ultra Blazer	14	N	N	P-F	P-F	N	N	N	P	F-G	N	P-E	N
UpBeet (0.5 to 1 oz/A)	2	N	N	F-G	F-G	N	N-P	N	F-G	P	-	F-E ¹	P
UpBeet + Betamix	2,5	P	N	F-G	F-G	N	P	N	F-G	F-G	-	E ¹	G-E
Varisto	2,6	E	F-E	E ¹	G-E	F	G-E	E ¹	P-G	E	N	E ¹	F-E
Varro	2	G-E	F	G-E	G	P	N	G-E	P-F	-	-	N	P
WideMatch*	4,4	N	N	N	N	N	N	N	E	E	G-E	F-E ¹	N-F
Wolverine Advanced	1,6,27	E	N	E ¹	E	N	N	E ¹	E	E	G-E	G-E	E
2,4-D2	4	N	N	N	N	N	N	N	P	G-E	F-E	P	E
2,4-DB/Butyrac	4	N	N	N	N	N	N	N	P	E	-	N	G-E

¹Herbicides will not control resistant biotypes or provide minimal control in tank-mix/premixes with alternative modes of action.

POST- APPLIED HERBICIDES* (cont.)	Lanceleaf Sage	Mallow, Common	Marshelder	Mustard, Wild	Mustard, W. Annual	Nightshade, E/Black	Nightshade, Hairy	Pigweed, Redroot	Waterhemp / Palmer	Prickly Lettuce	Ragweed, Common	Smartweed, Annual	Sunflower	Thistle, Russian	Wormwood, Biennial	Thistle, Canada	Herbicide Persistence
Outrider	-	N	-	E	E	-	-	P	N	-	-	-	E	-	P	N	O
MCPA	G-E	P	G	E	G-E	P-F	P-F	P-F	P	G	G	F	G	P	F-G	P-F	N
Metribuzin*	-	-	-	P-G	P-G	P	P	G	P-G	P-G	P-F	P-F	P-F	-	-	N	O
OpenSky	-	F-G	-	E	G-E	G	G	G-E	G-E	G	F-G	G	G-E	F-G ¹	-	P-F	N
Olympus	-	-	-	E	E	-	-	P-F	N	-	-	-	-	-	-	-	O
Orion	F-G	P	F-G	E	E	F	F	E	P	E	E	G	E	F-G ¹	G	F-G	N
Osprey	N	N	N	E	E	N	N	F	N	N	N	N	N	N	N	N	S
Paraquat	E	G	G	E	G	G-E	G-E	E	E	F-G	G-E	E	E	E	-	P	N
PerfectMatch	P-F	F-E	E	G-E	G	G-E	G-E	G-E	N	E	E	G	E	P	G	G-E	S
Permit	P	-	G-E	E	E	P	P	F	N	-	G-	F-G	E	-	P	N	O
Poast	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
PowerFlex	-	-	-	E	E	-	-	E	N	P-F	-	F	E	G	-	P-F	N
Pursuit*	E	P	E	E	E	E	E	E	N	E ¹	N	G	G-E	P-E ¹	N	N	O
Quelex	-	-	-	E	E	G-E	G-E	G-E	-	F	G-E	G-E	F	F	-	P-F	S
Raptor/Beyond	E	P	G-E	E	E	E	E	E	N	G ¹	N	G-E	E	G-E ¹	P	N-P	N
Raze	N	F-G	P	E	E	E	E	E	N	G-E	G-E	G	G-E	F	PG	N	S
Realm Q	-	-	E	E	E	E	E	E	G-E	N	P	E	E	-	-	N	S
Reflex*	E	-	G	E	E	G	P	G-E	G-E	-	P-E	G	P-F	-	P	N	O
Require Q	P-F	P-F	E	E	E	N	G-E	F-E	F-G	G-E	F	F-G	G-E	G	G-E	F-G	S
Resicore/Maverick	-	-	E	E	E	E	E	E	F-E	-	E	E	E	-	E	G-E	O
Resolve Q	-	P-F	-	E	E	G/N	P-F	F-E	N	P-F	F-G	F-G	P	P ¹	N	N	S
Resource	-	-	-	-	-	-	-	F-G	N-P	-	N-P	-	-	-	-	N	N
Revulin Q	-	-	E	E	E	E	E	E	G-E	N	P	E	E	-	-	N	S
Rimfire Max	N	N	-	E	E	-	-	P-F	N	-	-	N	-	-	-	-	S
Rimsulfuron	-	-	-	E	E	G/N	P-F	E	N	-	P	F	P	P ¹	N	N	S
Select* / Select Max	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Starane Ultra	-	F-G	P	P	P	P	P	N	N	E	E	N	E	P	N	N	N
Starane Flex	-	F-G	P	G	G	P	P	G-E	N	E	E	P	E	G ¹	N	N	N
Starane NXT*	E	F-G	E	E	E	E	G-E	P	P-F	G	E	E	E	G-E	P-F	P	N
Status	G	G	E	E	G	G	G	G-E	G-E	E	E	E	E	E	E	G	S
Stinger* (<0.061 lb ai/A)	P	F	G-E	N	N	G-E	G-E	N	N	G-E	F-E	G	G	P	G-E	F-G	S
Stinger* (>0.061 lb ai/A)	F	F-G	E	N	N	E	E	N	N	E	G-E	G-E	G-E	P-F	E	E	S
Storm	P-F	P	F-G	E	G-E	F-G	F-G	E	F-E	G	P-F	E	F-E	G	G-E	N	N
Supremacy	G-E	F-E	E	E	E	F-G	F-G	E	N	E ¹	E	E	E	E ¹	F-G	G	N
SureStart II/TripleFlex II	G	-	E	E	E	G-E	G-E	G-E	P	G-E	F-G	G-E	E	F-G	E	G-E	O
Talinor	E	G	E	E	G-E	E	E	E	E	F-G	E	G-E	E	E	F	F-G	S
Teammate	-	-	-	E	E	-	-	E	N	P-F	-	F	E	G	-	P-F	N
Ultra Blazer	P-F	N	F	E	-	F-G	F-G	E	G-E	-	N-F	E	P-F	G	P	N	N
UpBeet (0.5-1 oz)	N-P	G	N	G-E	G	F	F	F	F	N	F	F	N	N-P	N	N	N
UpBeet + Betamix	P-F	G-E	G	E	-	G	G	G-E	F	-	F-G	G	G	P	P	N	N
Varisto	E	P	E	E	E	E	E	E	N	G ¹	P-F	E	E	G-E ¹	G-E	F-G	S
Varro	N	-	-	G	F	-	-	F-G	F ¹	-	-	-	-	P	-	-	S
WideMatch*	F	F-E	E	P	P	G-E	G-E	P	N	E	G-E	G	E	P	E	G-E	S
Wolverine Advanced	E	G	E	E	G-E	E	E	E	G-E	F-G	E	G-E	E	E	G	F	S
2,4-D2	P-F	P	E	E	F-G	N-P	N-P	F-G	F	E	E	P	E	G	F-G	F	N
2,4-DB/Butyrac	-	-	-	P	P	-	-	P	N	-	P	P	-	P	-	N	N

* Or generic equivalent.

¹ Herbicides will not control resistant biotypes or provide minimal control in tank-mix/premixes with alternative modes of action.

² Weed control is dependent on rate, size of weeds, environmental conditions, and number of applications.

³ Waterhemp and Palmer ratings assume populations are ALS-resistant.

North Dakota Herbicide Compendium

The listings are approximate average retail prices for small quantities. Herbicide prices do not include cost of additives, surfactants, oils or application costs. Prices vary by location, wholesaler, bulk discounts, seasonal changes, quantities purchased and particular programs the manufacturing company offers. Consult local agricultural suppliers for exact price. 2022 prices generally increased and are much more volatile. Some 2022 product prices were not available at printing time, for which 2021 prices are shown and may not reflect current price.

Product ^{Site of action}	Company	Brand Equiv.	Active ingredients	Formulation	\$/Unit	Product/A			Cost \$/A		
						Low	Med	High	Low	Med	High
Aatrex 4L ⁵	Syngenta	-	atrazine	4L	15.10 gal	0.75 pt	1.5 pt	2 pt	1.40	2.80	3.80
Aatrex Nine-O ⁵	Syngenta	-	atrazine	90DF	4.10 lb	0.42 lb	0.56 lb	0.83 lb	1.70	2.30	3.40
Abundit Edge ⁹	Corteva	RU PM	glyphosate-k salt	4.5SL	31.00 gal	22 fl oz	32 fl oz	44 fl oz	5.30	7.80	10.70
Accent Q ²	Corteva	Accent	nicosulfuron + isoxadifen safener	54.5DF	20.00 oz	0.67 oz	1.25 oz	1.8 oz	13.40	25.00	36.00
Accurate Extra ^{2,2,2}	FMC	Ally Extra	thifensulf & triben & metsulfuron	37.50+18.75+15DF	4.30 oz	10 A/pk	-	5 A/pk	-	-	-
Acumen ³	Tenkos	Prowl	pendimethalin	3.3EC	31.50 gal	2.4 pt	3 pt	3.64 pt	9.50	11.80	14.30
Acuron ^{5,15,27,27}	Syngenta	-	atra&meto&meso&bicyclo&benox	1+2.14+0.24+.06ZC	71.50 gal	1.5 qt	2.25 qt	3 qt	26.80	40.20	53.60
AcuronFlex ^{15,27,27}	Syngenta	-	meto & meso & bicyclo & benox	2.86+0.32+.08ZC	89.30 gal	1.2 qt	-	2.25 qt	26.80	-	50.20
Acuron GT ^{9,15,27,27}	Syngenta	-	meto & meso & bicyclo & gly & benox	2.+0.2+0.095+2ZC	89.30 gal	1.2 qt	-	2.25 qt	26.80	-	50.20
Affinity BrdSpec ^{2,2}	FMC	-	thifensulfuron & tribenuron 1:1	25 + 25SG	10.60 oz	0.4 oz	0.6 oz	1 oz	4.20	6.40	10.60
Affinity Tank Mix ^{2,2}	FMC	-	thifensulfuron & tribenuron 4:1	40 + 10SG	8.80 oz	0.6 oz	0.75 oz	1 oz	5.30	6.60	8.80
Afforia ^{2,14,2}	Corteva	-	flumioxazin & thifensulf & triben	40.8 & 5 & 5SG	5.90 oz	2.5 oz	3 oz	3.75 oz	14.70	17.60	22.00
Agent	Winfield	Flexstar	fomesafen	1.88L	40 gal						
Aim EC ¹⁴	FMC	-	carfentrazone-ethyl	2EC	180.90 qt	1/2 fl oz	-	1 fl oz	2.80	-	5.70
Alion ²⁹	Bayer	-	indaziflam	1.67EC	14.10 fl oz	5 fl oz	5.75 fl oz	6.5 fl oz	70.50	81.10	91.70
Alluvex ^{2,2}	Corteva	-	thifensulfuron & rimsulfuron 1:1	16.7 + 16.7SG	5.40 oz	1.5 oz	-	1.5 oz	8.10	-	8.10
Ally XP ²	FMC	-	metsulfuron-methyl	60XP	7.90 oz	0.05 oz	0.1 oz	0.3 oz	0.40	0.80	2.40
AllyExtra SG ^{2,2,2}	FMC	-	thifensulf & triben & metsulf	27.3+13.6+10.9SG	7.90 oz	0.3 oz	-	0.5 oz	2.40	-	4.00
Amber ²	Syngenta	-	triasulfuron	75DF	11.50 oz	0.14 oz	0.28 oz	0.56 oz	1.60	3.20	6.40
Anthem ^{14,15}	FMC	-	fluthiacet & pyroxasulfone	0.0632 + 2.09SE	2.80 fl oz	5 fl oz	9 fl oz	13 fl oz	14.00	25.20	36.40
AnthemFlex ^{14,15}	FMC	-	carfentrazone & pyroxasulfone	0.267 + 3.733SE	661.70 gal	2 fl oz	4 fl oz	4.5 fl oz	10.30	20.70	23.30
AnthemMaxx ^{14,15}	FMC	-	fluthiacet & pyroxasulfone	0.126 + 4.174SC	824.90 gal	2.5 fl oz	4.5 fl oz	6.5 fl oz	16.10	29.00	41.90
Armezon ²⁷	BASF	Impact	topramezone	2.8SC	18.10 fl oz	0.33 fl oz	0.5 fl oz	0.75 fl oz	6.00	9.10	13.60
Armezon Pro ^{27,15}	BASF		topramezone & dimethenamid	0.1 + 5.25EC	147.60 gal	16 fl oz	20 fl oz	24 fl oz	18.40	23.10	27.70
Arrow ¹	ADAMA	Select	clethodim	2EC	73.50 gal	4 fl oz	6 fl oz	8 fl oz	2.30	3.40	4.60
Arsenal ²	BASF	-	imazapyr-ipa salt	2AS	70.00 gal	1 qt	2 qt	3 qt	17.50	35.00	52.50
Assure II ¹	AMVAC	-	quizalofop-ethyl	0.88EC	94.50 gal	4 fl oz	8 fl oz	10 fl oz	3.00	5.90	7.40
Atra-5 ⁵	Drexel	-	atrazine	5F	23.30 gal	0.75 pt	1.5 pt	2 pt	2.20	4.40	5.80
Atrazine 4L ⁵	Several	-	atrazine	4L	17.20 gal	0.75 pt	1.5 pt	2 pt	1.60	3.20	4.30
Atrazine 90DF ⁵	Several	-	atrazine	90DF	4.70 lb	0.42 lb	0.83 lb	1.11 lb	2.00	3.90	5.20
Audit 1:1 ^{2,2}	UPL	-	thifensulfuron & tribenuron 1:1	25 + 25XP	11.50 oz	0.4 oz	0.6 oz	1 oz	4.60	6.90	11.50
Audit 4:1 ^{2,2}	UPL	-	thifensulfuron & tribenuron 4:1	40 + 10XP	8.70 oz	0.6 oz	0.75 oz	1 oz	5.20	6.50	8.70
Authority Assist ^{2,14}	FMC	-	imazethapyr & sulfentrazone	0.67 + 3.33SC	2.80 fl oz	6 fl oz	7.5 fl oz	9 fl oz	16.60	20.80	24.90
Authority Edge ^{15,14}	FMC	-	pyroxasulfone & sulfentrazone	1.52 + 2.73 SC	505.50 gal	8 fl oz	11 fl oz	14 fl oz	31.60	43.40	55.30
Authority Elite ^{15,14}	FMC	BroadAxe	S-metolachlor & sulfentrazone	6.3 + 0.7EC	115.10 gal	20 fl oz	25 fl oz	32 fl oz	18.00	22.50	28.80
Authority First ^{2,14}	FMC	Sonic	cloransulam & sulfentrazone	7.9 + 62.1WDG	4.90 oz	4 oz	6 oz	8 oz	19.40	29.10	38.80
Authority MTZ ^{5,14}	FMC	-	metribuzin & sulfentrazone	27 + 18WDG	35.50 lb	8 oz	12 oz	15 oz	17.80	26.60	33.30
Authority Supreme ^{14,15}	FMC		pyroxasulfone & sulfentrazone	2.08 + 2.08SC	445.60 gal	5 fl oz	8 fl oz	11 fl oz	17.40	27.90	38.30
Autumn Super ^{2,2}	Bayer	-	iodosulfuron & thien carbazole	6 + 45WDG	24.50 oz	0.5 oz	-	0.5 oz	12.20	-	12.20
Avadex MA ¹⁵	Gowan	Far-Go	triallate	10G	1.40 lb	10 lb	12.5 lb	15 lb	14.40	17.90	21.50
Avalanche Ultra ¹⁴	Winfield	-	acifluorfen-Na salt	2SL	68.90 gal	1 pt	1.5 pt	2 pt	8.60	12.90	17.20
Axial Bold ^{1,1}	Syngenta	-	fenoxaprop & pinoxaden	0.457 + 0.228 EC	143.50 gal	15 fl oz	-	15 fl oz	16.80	-	16.80
Axial Star ^{4,1}	Syngenta	-	fluroxypyr & pinoxaden & safnr	0.73 + 0.42EC	140.70 gal	16.4 fl oz	-	16.4 fl oz	18.00	-	18.00
Axiom DF ^{5,15}	Bayer	-	metribuzin & flufenacet	13.6 + 54.4DF	31.30 lb	7 oz	13 oz	20 oz	13.70	25.40	39.10
Balance Flexx ²⁷	Bayer	-	isoxaflutole & cyprosulfamide	2SC	4.30 fl oz	3 fl oz	4.5 fl oz	6 fl oz	12.80	19.20	25.60
Basagran ⁶	Several	-	bentazon-Na salt	4SL	63.50 gal	1 pt	1.5 pt	2 pt	7.90	11.90	15.90
Basagran 5L ⁶	BASF	Basgran	bentazon-Na salt	5SL	69.60 gal	0.8 pt	1.2 pt	1.6 pt	7.00	10.40	13.90
Basis Blend ^{2,2}	Corteva	ResolveQ	rimsulfuron & thifen & isoxadifen	20 + 10SG	7.60 oz	1.25 oz	-	1.5 oz	9.60	-	11.50
Batalium II ^{2,6,4}	UPL	-	flucarbazone & bromoxy & fluroxy	0.25 + 2.34 + 0.88EC	188.10 gal	13.7 fl oz	-	13.7 fl oz	20.10	-	20.10
Beacon ²	Syngenta	-	primisulfuron-methyl	75DF	36.00 oz	0.38 oz	0.5 oz	0.76 oz	13.70	18.00	27.40
Bentazon ⁶	Willowood	Basagran	bentazon-Na salt	4SL	49.00 gal	1 pt	1.5 pt	2 pt	6.10	9.20	12.30
Beyond ²	BASF	Raptor	imazamox-NH ₄ salt	1SL	489.70 gal	2 fl oz	3 fl oz	4 fl oz	7.70	11.50	15.30
Bicep II Magnum ^{5,15}	Syngenta	-	atrazine & S-metolachlor	3.1 + 2.4SC	43.70 gal	2.1 qt	2.35 qt	2.6 qt	22.90	25.70	28.40

Product ^{Site of action}	Company	Brand Equiv.	Active ingredients	Formulation	\$/Unit	Product/A			Cost \$/A		
						Low	Med	High	Low	Med	High
Bicep Lite II Magnum ^{5,15}	Syngenta	-	atrazine & S-metolachlor	2.67 + 3.23L	59.00 gal	1.5 qt	1.9 qt	2.2 qt	22.10	28.00	32.50
Bison ^{6,4}	Winfield	Bronate	bromoxynil ester & MCPA ester	2 + 2EC	60.00 gal	1 pt	1.5 pt	2 pt	7.50	11.30	15.00
Blanket ¹⁴	Tenkos	Spartan	sulfentrazone	4L	200.00 gal	3 fl oz	4.5 fl oz	6 fl oz	4.70	7.00	9.40
Boundary ^{15,5}	Syngenta	-	S-metolachlor & metribuzin	5.25 + 1.25L	83.50 gal	1.2 pt	1.6 pt	2.45 pt	12.50	16.70	25.60
Brash ^{4,4}	Winfield	Weedmstr	2,4-D-dma & dicamba-dma salt	2.87 + 1SL	32.00 gal	0.5 pt	2 pt	4 pt	2.00	8.00	16.00
Brawl ¹⁵	Tenkos	Dual Mag	S-metolachlor	7.62EC	54.50 gal	1.33 pt	1.67 pt	2 pt	9.10	11.40	13.60
Brawl II ¹⁵	Tenkos	Dual II M	S-metolachlor & benoxacor safen	7.64EC	58.60 gal	1.33 pt	1.67 pt	2 pt	9.70	12.20	14.70
Breakfree ¹⁵	Corteva	Surpass	acetochlor & dichlormid safener	6.4EC	65.00 gal	1.5 pt	2 pt	2.25 pt	12.20	16.30	18.30
Breakfree NXT Lite ^{15,5}	Corteva	Harness X	acetochlor & atrazine	4.3 + 1.7L	35.70 gal	1.5 qt	1.8 qt	2.1 qt	13.40	16.00	18.70
BroadAxe XC ^{15,14}	Syngenta	Auth. Elite	S-metolachlor & sulfentrazone	6.3 + 0.7EC	113.10 gal	20 fl oz	25 fl oz	32 fl oz	17.70	22.10	28.30
Broclean ⁶	Loveland	Buctril	bromoxynil-ester	2EC	58.10 gal	1 pt	1.5 pt	2 pt	7.30	10.90	14.50
Bromac ^{6,4}	Loveland	Bronate	bromoxynil-ester & MCPA-ester	2 + 2EC	53.60 gal	1 pt	1.5 pt	2 pt	6.70	10.00	13.40
Bromac Advanced ^{6,4}	Loveland	Bron. Adv.	bromoxynil-ester & MCPA-ester	2.5 + 2.5EC	63.70 gal	0.8 pt	1.2 pt	1.6 pt	6.40	9.50	12.70
Brox ⁶	Albaugh	Buctril	bromoxynil-ester	2EC	52.50 gal	1 pt	1.5 pt	2 pt	6.60	9.80	13.10
Brox M ^{6,4}	Albaugh	Bronate	bromoxynil-ester & MCPA-ester	2 + 2EC	63.50 gal	1 pt	1.5 pt	2 pt	7.90	11.90	15.90
Brox M Ultra ^{6,4}	Albaugh	Bron. Adv.	bromoxynil-ester & MCPA-ester	2.5 + 2.5EC	60.00 gal	0.8 pt	1.2 pt	1.6 pt	6.00	9.00	12.00
Buccaneer/Plus ⁹	Tenkos	Roundup	glyphosate-ipa salt	3SL	22.00 gal	2 pt	3 pt	4 pt	5.50	8.30	11.00
Buckle ^{15,3}	Gowan	-	triallate + trifluralin	10 + 3	1.50 lb	10 lb	-	12.5 lb	15.00	-	18.80
Butyrac 200 ⁴	Albaugh	-	2,4-DB-dma salt	2SL	32.60 gal	2 pt	3 pt	4 pt	8.20	12.20	16.30
Cadet ¹⁴	FMC	-	fluthiacet-methyl	0.91EC	301.00 qt	0.4 fl oz	0.65 fl oz	0.9 fl oz	3.80	6.10	8.50
Callisto ²⁷	Syngenta	-	mesotrione	4SC	321.70 gal	2 fl oz	2.5 fl oz	3 fl oz	5.00	6.30	7.50
Callisto GT ^{27,9}	Syngenta	-	mesotrione & glyphosate	0.38 + 3.8SE	35.00 gal	2 pt	-	2 pt	8.80	-	8.80
Callisto Xtra ^{27,5}	Syngenta	-	mesotrione & atrazine	0.5 + 3.2SC	52.20 gal	15 fl oz	22 fl oz	24 fl oz	6.10	9.00	9.80
Candor ^{4,4}	Nufarm	Crossbow	triclopyr-bee & 2,4-D-bee	1 + 2SL	42.00 gal	1 qt	3 qt	6 qt	10.50	31.50	63.00
Capreno ^{27,2}	Bayer	-	tembo & thien carbazole & isox	2.88 + 0.57SC	4.90 fl oz	3 fl oz	-	3 fl oz	14.60	-	14.60
Capstone ^{4,4}	Corteva	-	aminopyralid-3ipNH ₄ & triclopyr	0.1 + 1SL	53.00 gal	4 pt	5 pt	6 pt	26.50	33.10	39.80
Carnivore ^{4,4,6}	Winfield	-	MCPA & fluroxypyr & bromoxynil	1.67+0.67+1.67EC	55.00 gal	1 pt	1.5 pt	2 pt	6.90	10.30	13.80
Casoron 4G ²⁹	UPL	-	dichlobenil	4G	3.20 lb	100 lb	150 lb	200 lb	320	480	640
Chaparral ^{4,2}	Corteva	-	aminopyralid-K salt+ metsulfuron	52.5 + 9.45DF	95.00 lb	1 oz	2 oz	3 oz	5.90	11.90	17.80
Charger Basic ¹⁵	Winfield	Dual Mag.	S-metolachlor	7.62EC	58.20 gal	1.33 pt	1.67 pt	2 pt	9.70	12.10	14.50
Charger Max ¹⁵	Winfield	Dual II M	S-metolachlor & benoxacor safen	7.64EC	62.40 gal	1.33 pt	1.67 pt	2 pt	10.40	13.00	15.60
Chateau ¹⁴	Valent	Valor	flumioxazin	51WDG	4.60 oz	1.5 oz	2 oz	2.5 oz	6.90	9.20	11.50
Chateau EZ ¹⁴	Valent	Valor EZ	flumioxazin	4 SC	-	1.5 oz	2 oz	2.5 oz	-	-	-
Cheetah ¹⁰	Nufarm	Liberty	glufosinate-NH ₄ salt	2.34SL	80.80 gal	29 fl oz	32 fl oz	43 fl oz	18.30	20.20	27.10
Cheetah Max ^{14,10}	Nufarm	-	fomesafen & glufosinate-NH ₄ salt	1 + 2SL	-	24 fl oz	-	24 fl oz	-	-	-
Cimarron Plus ^{2,2}	Bayer	-	chlorsulfuron & metsulfuron	15 + 48DF	6.50 oz	0.125 oz	1 oz	2 oz	0.80	6.50	13.00
Cinch ¹⁵	Corteva	Dual II M	S-metolachlor & benoxacor safen	7.64EC	107.50 gal	1.33 pt	1.67 pt	2 pt	17.90	22.40	26.90
Cinch ATZ Lite ^{5,15}	Corteva	Bicep II L	atrazine & S-metolachlor	2.67 + 3.23L	45.20 gal	1 qt	1.5 qt	1.9 qt	11.30	16.90	21.50
Clarity ⁴	BASF	-	dicamba-dga salt	4SL	92.50 gal	4 fl oz	8 fl oz	16 fl oz	2.90	5.80	11.60
Clash ⁴	Nufarm	Clarity	dicamba-dga salt	4SL	80.00 gal	2 fl oz	4 fl oz	8 fl oz	1.30	2.50	5.00
Clean Slate ⁴	Nufarm	Stinger	clopyralid-monoethanolamine salt	3SL	185.00 gal	1.3 fl oz	2.6 fl oz	0.25 pt	1.90	3.80	5.80
Cleanse ¹	Winfield	-	clethodim	2EC	66 gal	-	-	-	-	-	-
Cleansweep D ^{4,4,6}	Nufarm	-	fluroxypyr-e & 2,4-D-e & bromox	0.64 + 1.6 + 2EC	71.10 gal	1 pt	1.25 pt	1.5 pt	8.90	11.10	13.30
Cleansweep M ^{4,4,6}	Nufarm	-	fluroxypyr-e & MCPA-e & bromox	0.67+1.67+1.67 EC	88.40 gal	1 pt	1.5 pt	2 pt	11.00	16.60	22.10
CleanTraxx ^{1,14}	Corteva	-	penoxsulam & oxyfluorfen	0.083 + 3.93EC	0.00 gal	3pt	3.75 pt	4.5 pt	-	-	-
CleanWave ^{4,4}	Corteva	-	aminopyralid & fluroxypyr	0.08 + 1.12EC	65.10 gal	10 fl oz	12 fl oz	14 fl oz	5.10	6.10	7.10
Clethodim ¹	Several	Select	clethodim	2EC	64.50 gal	4 fl oz	6 fl oz	8 fl oz	2.00	3.00	4.00
Cobra ¹⁴	Valent	-	lactofen	2EC	207.80 gal	8 fl oz	10 fl oz	12.5 fl oz	13.00	16.20	20.30
Collide ¹⁴	UPL	Goal	oxyfluorfen	2EC	98.00 gal	4 pt	6 pt	8 pt	49.00	73.50	98.00
Colt AS ^{4,4}	Loveland	WideMatch	clopyralid-MEAsalt & fluroxypyr-e	0.75 + 0.75EC	56.00 gal	1 pt	1.25 pt	1.33 pt	7.00	8.80	9.30
Colt + Salvo ^{4,4}	Loveland	-	fluroxypyr-ester & 2,4-D-ester	0.75 + 3EC	48.20 gal	1 pt	1.33 pt	1.67 pt	6.00	8.00	10.10
Colt + Sword ^{4,4}	Loveland	-	fluroxypyr-ester & MCPA-ester	0.71 + 2.84EC	57.00 gal	1.125 pt	1.5 pt	2 pt	8.00	10.70	14.30
Comet ⁴	Nufarm	Starane	fluroxypyr-ester	1.5EC	78.00 gal	0.5 pt	0.67 pt	1 pt	4.90	6.50	9.80
Confidence ¹⁵	Winfield	Harness	acetochlor & safener	7EC	62.70 gal	1.25 pt	1.75 pt	2.25 pt	9.80	13.70	17.60
Confidence Xtra ^{15,5}	Winfield	Harness X	acet & dichlormid & atra	4.3 + 1.7F	38.50 gal	1.2 qt	1.5 qt	1.8 qt	11.60	14.40	17.30
Cornerstone/Plus ⁹	Winfield	Roundup	glyphosate-ipa salt	3SL	28.70 gal	2 pt	3 pt	4 pt	7.20	10.80	14.40
Corvus ^{27,2}	Bayer	-	isox&thien carbazole&cyprosulf	1.88 & 0.75SC	6.70 fl oz	3.3 fl oz	4.5 fl oz	5.6 fl oz	22.00	30.00	37.30
Credit 41 Extra ⁹	Nufarm	Roundup	glyt-ipa salt	3SL	15.00 gal	2 pt	3 pt	4 pt	3.80	5.60	7.50
Credit Xtreme ⁹	Nufarm	-	glyphosate-ipa & K salt	2.5 + 2 SL	18.00 gal	22 fl oz	32 fl oz	44 fl oz	3.10	4.50	6.20

Product ^{Site of action}	Company	Brand Equiv.	Active ingredients	Formulation	\$/Unit	Product/A			Cost \$/A		
						Low	Med	High	Low	Med	High
Crossbow ^{4,4}	Corteva	-	triclopyr-bee & 2,4-D-bee	1 + 2SL	51.20 gal	1 qt	3 qt	6 qt	12.80	38.40	76.80
Curtail ^{4,4}	Corteva	-	clopyralid-mea & 2,4-D-3ipa salt	0.38 + 2SL	58.10 gal	2 pt	2.67 pt	4 pt	14.50	19.40	29.00
Curtail M ^{4,4}	Corteva	-	clopyralid-acid & MCPAioester	0.42 + 2.35SL	66.50 gal	1.75 pt	2 pt	2.33 pt	14.60	16.60	19.40
Dacthal ³	AMVAC	-	DCPA	6F	193.30 gal	8 pt	10 pt	14 pt	193	242	338
Dacthal ³	AMVAC	-	DCPA	75WDG	22.00 lb	8 lb	10 lb	14 lb	176	220	308
Defol	Drexel	Na chlorat	Sodium chlorate	5SL	7.10 gal	4.8 qt	-	4.8 qt	8.50	-	8.50
Detonate ⁴	Tenkoz	Banvel	dicamba-dma salt	4SL	54.00 gal	4 fl oz	8 fl oz	16 fl oz	1.70	3.40	6.80
Diablo ⁴	Nufarm	Banvel	dicamba-dma salt	4SL	51.00 gal	4 fl oz	8 fl oz	16 fl oz	1.60	3.20	6.40
Dicamba ⁴	Several	Banvel	dicamba-dma salt	4SL	50.90 gal	4 fl oz	8 fl oz	16 fl oz	1.60	3.20	6.40
DiFlex ⁴	Bayer	Clarity	dicamba-dga & cyprosulfamide	4SC	215.10 gal	8 fl oz	12 fl oz	16 fl oz	13.40	20.20	26.90
DiFlex Duo ^{4,27}	Bayer	-	dic-dga & tembotrione & safener	1.86 + 0.27SC	99.70 gal	24 fl oz	32 fl oz	40 fl oz	18.70	24.90	31.20
Dimetric EXT ⁵	Winfield	Sencor	metribuzin	75DF	18.00 lb	0.25 lb	0.33 lb	0.5 lb	4.50	5.90	9.00
Dimetric ⁵	Winfield	Sencor	metribuzin	3F	72.10 gal	0.5 pt	0.67 pt	1 pt	4.50	6.00	9.00
Diquat ²²	Nufarm	Reglone	diquat-dibromide salt	2SL	65.40 gal	1 pt	1.5 pt	2 pt	8.20	12.30	16.40
Discover NG ¹	Syngenta	-	clodinafop & oil adjuvant	0.5EC	163.90 gal	12.8 fl oz	14.5 fl oz	16 fl oz	16.40	18.60	20.50
Distinct ^{4,19}	BASF	-	dicamba & diflufenzopyr	0.5 + 0.2WDG	41.40 lb	2 oz	4 oz	6 oz	5.20	10.40	15.50
Diuron ⁵	Several	-	diuron	80WDG	4.50 lb	0.75 lb	2 lb	6 lb	3.30	8.90	26.70
Dog Fight ^{2,9}	Loveland	Extreme	imazethapyr-acid & glyt-ipa salt	0.17 + 2SL	26.60 gal	1.5 pt	2.25 pt	3 pt	5.00	7.50	10.00
Double Header ^{15,27}	Loveland	-	acetochlor & mesotrione	3.2 + 0.38	47.50 gal	1.7 qt	2 qt	2.4 qt	20.20	23.80	28.50
Draft ^{2,2}	Rotam	Harm Extr	thifensulfuron & tribenuron	50 + 25DF	16.90 oz	0.3 oz	-	0.3 oz	5.10	-	5.10
Dual Magnum ¹⁵	Syngenta	-	S-metolachlor	7.62EC	81.10 gal	1.33 pt	1.67 pt	2 pt	13.50	16.90	20.30
Dual II Magnum ¹⁵	Syngenta	-	S-metolachlor & benoxacor safen	7.64EC	95.00 gal	1.33 pt	1.67 pt	2 pt	15.80	19.80	23.70
DuraCor ^{4,4}	Corteva	-	aminopyralid + florypyrauxifen	0.667 + 0.067SL	86.30 gal	12 fl oz	16 fl oz	20 fl oz	8.10	10.80	13.50
Duramax ⁹	Corteva	Rodeo	glyphosate-dma salt	4SL	30.00 gal	24 fl oz	36 fl oz	48 fl oz	5.60	8.40	11.30
Durango DMA ⁹	Corteva	Roundup	glyphosate-dma salt	4SL	30.40 gal	24 fl oz	36 fl oz	48 fl oz	5.70	8.50	11.40
Elevore ⁴	Corteva	-	halauxifen-methyl	0.572 EC	937.80 gal	1 fl oz	-	1 fl oz	7.30	-	7.30
Engenia ⁴	BASF	-	dicamba-BAPMA salt	5SL	114.00 gal	12.8 fl oz	19.2 fl oz	25.6 fl oz	11.40	17.10	22.80
Enlist Duo ^{9,4}	Corteva	-	glyphosate-dma & 2,4-D-choline	1.7 + 1.6SL	29.80 gal	3.5 pt	4 pt	4.75 pt	13.00	14.90	17.70
Enlist One ⁴	Corteva	-	2,4-D-choline	3.8SL	44.80 gal	1 pt	1.5 pt	2 pt	5.60	8.40	11.20
Eptam ¹⁵	Gowan	-	EPTC	7EC	53.30 gal	2.3 pt	4 pt	6.75 pt	15.30	26.60	44.90
Escort XP ²	Bayer	Ally	metsulfuron-methyl	60XP	6.60 oz	0.33 oz	1 oz	2 oz	2.20	6.60	13.10
Ethofumesate ¹⁶	Willowood	Nortron	ethofumesate	4SC	70.00 gal	6 pt	7 pt	7.5 pt	52.50	61.30	65.60
Ethotron ¹⁶	UPL	Nortron	ethofumesate	4EC	77.70 gal	6 pt	7 pt	7.5 pt	58.20	68.00	72.80
Everest 3.0 ²	UPL	-	flucarbazone-Na salt & safener	1.75OD	8.40 fl oz	1.5 fl oz	-	2 fl oz	12.60	-	16.80
EverPreX ¹⁵	Corteva	-	S-metolachlor	7.62 EC	66.00 gal	1.33 pt	1.67 pt	2 pt	11.00	13.80	16.50
Express SG ²	FMC	-	tribenuron-methyl	50SG	16.10 oz	1/4 oz	1/3 oz	1/2 oz	4.00	5.30	8.10
Extreme ^{2,9}	BASF	-	imazethapyr-acid & glyt-ipa salt	0.17 + 2SL	26.30 gal	1.5 pt	2.25 pt	3 pt	4.90	7.40	9.90
Facet L ^{4,0}	BASF	-	quinclorac	1.5L	119.20 gal	22 fl oz	32 fl oz	64 fl oz	20.50	29.80	59.60
Fallow Star ^{9,4}	Albaugh	Fallow Mst	glyt-ipa & dicamba-ipa salt	1.1 + 0.5SL	18.80 gal	22 fl oz	32 fl oz	44 fl oz	3.20	4.70	6.50
Far-Go EC ¹⁵	Gowan	-	triallate	4EC	60.40 gal	1 qt	1.25 qt	1.5 qt	15.10	18.90	22.60
Fierce EZ ^{14,15}	Valent	-	flumioxazin + pyroxasulfone	1.34 + 1.70 SC	537.00 gal	6 fl oz	6.75 fl oz	7.5 fl oz	25.20	28.32	31.47
Fierce MTZ ^{14,15,5}	Valent	-	flumioxazin&pyroxasulfone+metri	0.5+0.64+1.5 SC	233.80 gal	1 pt	1.25 pt	1.5 pt	29.20	36.50	43.80
Firestorm ²²	UPL	Paraquat	paraquat-dichloride	3SL	35.00 gal	2 pt	3 pt	4 pt	8.80	13.10	17.50
FirstRate ²	Corteva	-	cloransulam-methyl	84WDG	43.00 oz	0.3 oz	0.6 oz	0.75	12.90	25.80	32.30
Flexstar ¹⁴	Syngenta	-	fomesafen-Na salt & adjuvants	1.88SL	68.30 gal	0.5 pt	-	0.75 pt	4.30	-	6.40
Flexstar GT 3.5 ^{14,9}	Syngenta	-	fomesafen & glyt & adjuvants	0.56 + 2.26SL	45.20 gal	1.75 pt	-	2.68 pt	9.90	-	15.20
Foma 1.88 ¹⁴	Drexel	Flexstar	fomesafen-Na salt & adjuvants	1.88EC	33.00 gal	0.5 pt	-	0.75 pt	2.10	-	3.10
Foma 2.0 ¹⁴	Drexel	Reflex	fomesafen-Na salt	2EC	41.50 gal	0.5 pt	-	0.75 pt	2.60	-	3.90
FomAsate ^{14,9}	Drexel	Flexstr GT	fomesafen & glyt & adjuvants	0.56 + 2.26SL	25.00 gal	1.75 pt	-	2.68 pt	5.50	-	8.40
Fomesafen1.88 ¹⁴	Willowood	Flexstar	fomesafen-Na salt & adjuvants	1.88EC	36.10 gal	0.5 pt	-	0.75 pt	2.30	-	3.40
Framework ³	Winfield	Prowl	pendimethalin	3.3EC	34.00 gal	2.4 pt	3 pt	3.64 pt	10.20	12.80	15.50
Frequency ²⁷	BASF	Impact	topramezone	2.8SC	860.00 gal	1 oz	2 oz	4 oz	6.70	13.40	26.90
Full Deck ^{4,4,4}	Helena	-	MCPA & fluroxypyr & clopyralid	2.48+ 0.66 + 0.57SL	95.00 gal	1 pt	1.25 pt	1.5 pt	11.90	14.80	17.80
FulTime NXT ^{15,5}	Corteva	-	acetochlor & atrazine	2.4 ME + 1.6L	46.00 gal	2.5 qt	2.7 qt	3 qt	28.80	31.10	34.50
Fusilade DX ¹	Syngenta	-	fluazifop-P butyl	2EC	147.20 gal	6 fl oz	10 fl oz	12 fl oz	6.90	11.50	13.80
Garlon 4 Ultra ⁴	Corteva	-	triclopyr-ester	4EC	103.00 gal	1 qt	2 qt	4 qt	25.80	51.50	103
Glory ⁵	ADAMA	Sencor	metribuzin	75DF	66.50 gal	0.25 lb	0.33 lb	0.5 lb	3.10	4.20	6.20
Glyphogan/Plus ⁹	ADAMA	Roundup	glyphosate-ipa salt	3SL	18.00 gal	2 pt	3 pt	4 pt	4.50	6.80	9.00
GlyStar 5Extra ⁹	Albaugh	Rodeo	glyphosate-ipa salt	4SL	25.00 gal	24 fl oz	36 fl oz	48 fl oz	4.70	7.00	9.40

Product ^{Site of action}	Company	Brand Equiv.	Active ingredients	Formulation	\$/Unit	Product/A			Cost \$/A		
						Low	Med	High	Low	Med	High
GlyStar Gold ⁹	Albaugh	Roundup	glyphosate-ipa salt	3SL	18.00 gal	2 pt	3 pt	4 pt	4.50	6.80	9.00
GlyStar Original ⁹	Albaugh	Roundup	glyphosate-ipa salt	3SL	18.00 gal	2 pt	3 pt	4 pt	4.50	6.80	9.00
GlyStar Plus ⁹	Albaugh	Roundup	glyphosate-ipa salt	3SL	15.00 gal	2 pt	3 pt	4 pt	3.80	5.60	7.50
Goal ¹⁴	Corteva	Collide	oxyfluorfen	2EC	56.40 gal	4 pt	6 pt	8 pt	28.20	42.30	56.40
GoldSky ^{2,2,4}	Corteva	-	pyroxusulam&florasulam&flurox	0.11+0.018+0.71OD	153.60 gal	1 pt	-	1 pt	19.20	-	19.20
Gramoxone SL 3.0 ²²	Syngenta	Paraquat	paraquat-dichloride	3SL	26.80 gal	1.3 pt	2 pt	2.7 pt	4.40	6.70	9.00
Graslan L ^{4,4}	Corteva	Grazon	picloram-3ipa & 2,4-D-choline	0.81 + 3SL	42.00 gal	1.5 pt	2 pt	2.5 pt	7.90	10.50	13.10
GrazonNext ^{4,4}	Corteva	-	aminopyralid-3ipa + 2,4-D-3ipa	0.41 + 3.33SL	55.70 gal	1.5 pt	2 pt	2.6 pt	10.40	13.90	18.10
Grazon P+D ^{4,4}	Corteva	Graslan	picloram-3ipa & 2,4-D-3ipa	0.54 + 2SL	34.00 gal	2 qt	3 qt	4 qt	17.00	25.50	34.00
GunSlinger ^{4,4}	Albaugh	Grazon	picloram-3ipamine&2,4-D-3ipa	0.54 + 2 S	27.90 gal	2 qt	3 qt	4 qt	14.00	21.00	27.90
Habitat ²	BASF	Arsenal	imazapyr-ipa salt	2SL	130.00 gal	1 qt	2 qt	3 qt	32.50	65.00	97.50
Halex GT ^{27,9,15}	Syngenta	-	mesotrione & glyt-K & S-meto	4.39 SC (1:10:10)	55.50 gal	3 pt	3.6 pt	4 pt	20.80	25.00	27.80
Halomax ²	Aceto	Permit	halosulfuron-methyl	75DF	22.00 oz	0.67 oz	1 oz	1.33 oz	14.70	22.00	29.30
Harmony SG ²	FMC	-	thifensulfuron-methyl	50SG	36.70 oz	0.3 oz	0.45 oz	0.7 oz	11.00	16.50	25.70
Harness ¹⁵	Bayer	-	acetochlor & furilazole safener	7EC	86.10 gal	1.25 pt	1.75 pt	2.25 pt	13.50	18.80	24.20
Harness Max ^{15,27}	Bayer	-	acet & meso & furilazole safener	3.52 + 0.33EC	66.40 gal	40 fl oz	55 fl oz	88 fl oz	20.80	28.50	45.70
Harness Xtra ^{15,5}	Bayer	-	acet & furilazole & atrazine	4.3 + 1.7F	58.40 gal	1.2 qt	1.5 qt	1.8 qt	17.50	21.90	26.30
Harness Xtra 5.6L ^{15,5}	Bayer	-	acet & furilazole & atrazine	3.1 + 2.5F	52.80 gal	1.5 qt	1.7 qt	2.3 qt	19.80	22.40	30.40
Hat Trick ^{4,4,4}	Loveland	-	clop-mea&fluroxy-mhe&MCPAe	0.51 + 0.51 + 1.8EC	54.50 gal	1 pt	1.5 pt	2 pt	6.80	10.20	13.60
Helmquat ²²	Helm Agro	Gramoxon	paraquat-dichloride	3SL	41.40 gal	0.67 pt	1 pt	1.33 pt	6.70	10.30	14.00
Herbivore ²	Winfield	Permit	halosulfuron-methyl	75DF	16.80 oz	0.67 oz	1 oz	1.33 oz	11.30	16.80	22.40
Hornet ^{2,4}	Corteva	-	flumetsulam & clopyralid-K salt	18.5 + 60WDG	4.80 oz	2 oz	3 oz	4 oz	9.60	14.40	19.20
Huskie ^{6,27}	Bayer	-	brom & pyrasulfotole & mefenpyr	1.75 + 0.31EC	106.40 gal	11 fl oz	12.8 fl oz	13.7 fl oz	9.10	10.60	11.40
Huskie Complete ^{6,27,2}	Bayer	-	brom&pyrasulf&thiencarb&mfnp	1.46+0.26+0.042OD	186.90 gal	13.7 fl oz	-	13.7 fl oz	20.00	-	20.00
Huskie FX ^{6,27,4}	Bayer	-	brom&pyrasulf&fluroxy&mefenpyr	1.44 + 0.26 + 0.60EC	119.50 gal	13.5 fl oz	15.5 fl oz	18 fl oz	12.60	14.50	16.80
Hydrothol 191	UPL	Herb. 273	Endothall	2G	5.00 lb	-	-	-	-	-	-
Hyvar X-L ⁵	Bayer	-	bromacil	2SL	99.40 gal	1 gal	2 gal	3 gal	99	199	298
Impact ²⁷	AMVAC	Armezon	topramezone	2.8SC	21.90 fl oz	0.75 fl oz	1.38 fl oz	2 fl oz	16.43	30.11	43.80
Impact Core ^{15,27}	AMVAC	-	acetochlor & topramezone	7.08 + 0.071SC	95.80 gal	20 fl oz	30 fl oz	40 fl oz	15.00	22.50	29.90
ImpactZ ^{27,5}	AMVAC	-	topramezone & atrazine	0.26 & 4SC	187.10 gal	8 fl oz	-	10.7 fl oz	11.70	-	15.60
Impose ²	ADAMA	Plateau	imazapic-NH ₄ salt	2SL	1.80 fl oz	4 fl oz	8 fl oz	12 fl oz	7.30	14.70	22.00
Incinerate ²⁷	Winfield	Callisto	mesotrione	4SE	146.20 gal	2 fl oz	2.5 fl oz	3 fl oz	2.30	2.90	3.40
Instigate ^{2,27}	Corteva	Realm Q	rimsulfuron & mesotrione	4.17 + 41.67WDG	3.20 oz	5.25 oz	-	7 oz	16.50	-	22.10
Intensity ¹	Loveland	Select	clethodim	2EC	61.00 gal	4 fl oz	6 fl oz	8 fl oz	1.90	2.90	3.80
Intensity One ¹	Loveland	Select Max	clethodim	1EC	71.00 gal	6 fl oz	8 fl oz	12 fl oz	3.30	4.40	6.70
Interline ¹⁰	UPL	Liberty	glufosinate-NH ₄ salt	2.34SL	80.30 gal	22 fl oz	29 fl oz	36 fl oz	13.80	18.20	22.60
Karmex ⁵	ADAMA	Diuron	diuron	80XP	5.10 lb	2 lb	6 lb	8 lb	10.20	30.50	40.60
Kerb SC	Corteva	-	Pronamide	3.3SC	267.80 gal	2 pt	3.5 pt	5 pt	66.90	117	167
Keystone LA NXT ^{15,5}	Corteva	Harness	acetochlor & atrazine	4 + 1.5L	68.30 gal	1.33 qt	1.5 qt	1.8 qt	22.70	25.60	30.70
Kochiavore ^{4,6,4}	Winfield	-	2,4-De&bromox-e&fluroxypyr-e	1.67&1.67&0.67EC	76.80 gal	1 pt	-	1.5 pt	9.60	-	14.40
Krovlar I ^{6,5}	Bayer	-	bromacil & diuron	40 + 40DF	9.90 lb	6 lb	12 lb	16 lb	59	119	158
Kyber ^{14,5,15}	Corteva	-	flumiox & metrib & pyroxasulfone	0.5 + 1.5 + 0.64SC	218.40 gal	1 pt	-	1.5 pt	27.30	-	41
Landmaster BW ^{9,4}	Albaugh	-	glyphosate-ipa & 2,4-D-ipa salt	0.9 + 1.5SL	22.50 gal	27 fl oz	40 fl oz	54 fl oz	4.70	7.00	9.50
Latigo ^{4,4}	Helena	Weedmstr	dicamba-acid & 2,4-D-acid	1.8 + 2.4 SL	74.00 gal	0.33 pt	0.67 pt	1 pt	3.10	6.20	9.30
Laudis ²⁷	Bayer	-	tembotrione & isoxadifen safener	3.5 + 1.75SC	4.10 fl oz	3 fl oz	-	3 fl oz	12.20	-	12.20
Liberty 280 ¹⁰	BASF	-	glufosinate-NH ₄ salt	2.34SL	58.30 gal	29 fl oz	32 fl oz	43 fl oz	13.20	14.60	19.60
Linex ⁵	TKI	-	linuron	4L	108.10 gal	8 fl oz	12 fl oz	16 fl oz	6.80	10.10	13.50
Lorox ⁵	TKI	-	linuron	50DF	30.70 lb	1 lb	2 lb	3 lb	30.70	61.30	92.00
Lumax EZ ^{5,27,15}	Syngenta	-	atrazine & mesotrione & S-metol	0.94 + 0.25 + 2.5SE	66.80 gal	3 pt	4 pt	5 pt	25.00	33.40	41.70
Luxur A&B ^{2,2}	Bayer	-	tribenuron + thiencarb&mfnp	50SG+0.083 co-pack	1,361.00	80A/case			17.00	-	-
Mad Dog/Plus ⁹	Loveland	Roundup	glyphosate-ipa salt	3SL	13.00 gal	2 pt	3 pt	4 pt	3.30	4.90	6.50
Maestro 2EC ⁶	Nufarm	Buctril	bromoxynil-ester	2EC	63.50 gal	1 pt	1.5 pt	2 pt	7.90	11.90	15.90
Maestro 4EC ⁶	Nufarm	Buctril	bromoxynil-ester	4EC	111.00 gal	0.5 pt	0.75 pt	1 pt	6.90	10.40	13.90
Maestro Adv. ^{6,4}	Nufarm	Bron. Adv.	bromoxynil-ester & MCPA-ester	2.5 + 2.5EC	94.00 gal	0.8 pt	1.2 pt	1.6 pt	9.40	14.10	18.80
Maestro D ^{6,4}	Nufarm	-	bromoxynil-ester & 2,4-D-ester	2 + 1.9EC	75.00 gal	0.75 pt	1.33 pt	2 pt	7.00	12.50	18.80
Maestro MA ^{6,4}	Nufarm	Bronate	bromoxynil-ester & MCPA-ester	2 + 2EC	69.50 gal	1 pt	1.5 pt	2 pt	8.70	13.00	17.40
Makaze ⁹	Loveland	Roundup	glyphosate-ipa salt	3SL	14.30 gal	2 pt	3 pt	4 pt	3.60	5.30	7.10
Makaze Yield Pro ⁹	Loveland	-	glyphosate-ipa salt+IBA+cytokinin	3+0.005+0.0009SL	24.00 gal	2 pt	3 pt	4 pt	6.00	9.00	12.00
Marvel ^{14,14}	FMC	-	fomesafen & fluthiacet	2.88 + 0.12SC	168.90 gal	5 fl oz	6 fl oz	7 fl oz	6.60	7.90	9.20

Product ^{Site of action}	Company	Brand Equiv.	Active ingredients	Formulation	\$/Unit	Product/A			Cost \$/A		
						Low	Med	High	Low	Med	High
Matador ^{15,5,2}	Loveland	-	metochlr & metrib & imazethapyr	4 + 0.56 + 0.13SL	50.00 gal	2 pt	3 pt	4 pt	12.50	18.80	25.00
Matador S ^{15,5,2}	Loveland	-	metochlr & metrib & imazethapyr	3.38 + 0.75 + 0.17SL	60.00 gal	1.9 pt	-	2.4 pt	14.30	-	18.00
Matrix ²	Corteva	-	rimsulfuron	25DF	13.70 oz	1 oz	-	1.5 oz	13.70	-	20.60
Mauler ⁵	Valent	Sencor	metribuzin	4F	148.70 gal	6 fl oz	9 fl oz	12 fl oz	7.00	10.50	13.90
Maverick	Valent	-	clopyralid & pyrox & meso	0.523 + 0.69 + 0.825 SC	-l	14 floz	23 floz	32 floz	-	-	-
MCPA amine ⁴	Several	-	MCPA-amine	4SL	25.90 gal	0.4 pt	1 pt	2 pt	1.30	3.20	6.50
MCPA ester ⁴	Several	-	MCPA-ester	4EC	26.20 gal	0.5 pt	1 pt	2 pt	1.60	3.30	6.60
Mes-O-sate ^{27,9,15}	Drexel	Halex GT	mesotrione & glyt-K & S-meto	4.39 SC (1:10:10)	40.00 gal	3.6 pt	-	4 pt	18.00	-	20.00
MesoTryOne ²⁷	Drexel	Callisto	mesotrione	4SE	160.00 gal	2 fl oz	2.5 fl oz	3 fl oz	2.50	3.10	3.80
Me-Too-Lachlor ¹⁵	Drexel	Dual Mag.	metolachlor	8EC	40.00 gal	1.33 pt	1.67 pt	2 pt	6.70	8.40	10.00
Me-Too-Lachlor II ¹⁵	Drexel	Dual II M	metolachlor & benoxacor safen	7.8EC	40.00 gal	1.33 pt	1.67 pt	2 pt	6.70	8.40	10.00
Method ⁴	Bayer	-	aminocyclopyrachlor-K	2SL	4.80 fl oz	4 fl oz	8 fl oz	12 fl oz	19.00	38.00	57.00
Metribuzin ⁵	ADAMA	Sencor	metribuzin	75DF	23.60 lb	0.25 lb	0.33 lb	0.5 lb	5.90	7.80	11.80
Milestone / VM ⁴	Corteva	-	aminopyralid-3ipNH ₄ salt	2SL	331.70 gal	3 fl oz	5 fl oz	7 fl oz	7.80	13.00	18.10
Moxy ⁶	Winfield	Buctril	bromoxynil-ester	2EC	55.90 gal	1 pt	1.5 pt	2 pt	7.00	10.50	14.00
NextStep NG ¹	UPL	Discover	clodinafop & oil adjuvant	0.5EC	163.50 gal	12.8 floz	14.5 floz	16 fl oz	16.40	18.50	20.40
Nortron SC ¹⁶	Bayer	-	ethofumesate	4EC	107.90 gal	6 pt	7 pt	7.5 pt	81.00	94.40	101
Olympus ²	Bayer	-	propoxycarbazone-Na salt	70WDG	15.00 oz	0.4 oz	0.5 oz	0.6 oz	6.00	7.50	9.00
OpenSky ^{2,4}	Corteva	-	pyroxulam&fluroxyppyr	0.107+0.95SE	146.10 gal	1 pt	-	1.25 pt	18.30	-	22.80
Orion ^{2,4}	Syngenta	-	florasulam & MCPA-ehe	0.033 + 2.34EC	426.30 case	17 fl oz	-	40A/case			10.65
Osprey ²	Bayer	Silverado	mesosulfuron-methyl	4.5WDG	3.80 oz	3.2 oz	4 oz	4.75 oz	12.10	15.20	18.00
Oust XP ²	Bayer	-	sulfometuron-methyl	75XP	7.00 oz	2 oz	6 oz	8 oz	14.00	42.00	56.00
Oust Extra ^{2,2}	Bayer	-	sulfometuron & metsulfuron	56.25 + 15DF	6.00 oz	3 oz	4 oz	5 oz	18.00	24.00	30.00
Outflank ¹⁴	ADAMA	Valor	flumioxazin	51WDG	6.00 oz	1.5 oz	2 oz	3 oz	9.00	12.00	18.00
Outlaw ^{4,4}	Helena	Weedmstr	2,4-D-ehe & dicamba-acid	1.45 + 1.09SL	55.00 gal	1.5 pt	1.75 pt	2.75 pt	10.30	12.00	18.90
Outlook ¹⁵	BASF	-	dimethenamid-P	6EC	148.40 gal	10 fl oz	14 fl oz	18 fl oz	11.60	16.20	20.90
Outrider ²	Valent	Maverick	sulfosulfuron	75DF	15.70 oz	0.33 oz	0.50 oz	0.67 oz	5.20	7.90	10.50
Overdrive ^{4,19}	BASF	Distinct	dicamba-Na & diflufenzopyr-Na	50 + 20WDG	2.80 oz	4 oz	6 oz	8 oz	11.20	16.80	22.40
Palace ^{15,27}	Tenkoz	Zemax	S-metolachlor & mesotrione	3.34 + 0.33SC	52.50 gal	1.6 qt	2 qt	2.4 qt	21.00	26.30	31.50
Panoflex ^{2,2}	Corteva	-	thifensulfuron & tribenuron 1:4	10 + 40SG	9.70 oz	0.3 oz	0.45 oz	0.6 oz	2.90	4.40	5.80
Panther Pro ^{14,5,2}	Nufarm		flumioxazin&metri&imazethapyr	0.67 + 3 + 0.56SC	192.00 gal	12 fl oz	-	12 fl oz	18.00	-	18.00
Panther SC ¹⁴	Nufarm	Valor	flumioxazin	4SC	350.00 gal	1.5 fl oz	2 fl oz	3 fl oz	4.10	5.50	8.20
Parallel ¹⁵	ADAMA	Dual II	metolachlor & safener	7.8EC	60.00 gal	1.33 pt	1.67 pt	2 pt	10.00	12.50	15.00
Parallel PCS ¹⁵	ADAMA	Dual	metolachlor	8EC	43.70 gal	1.33 pt	1.67 pt	2 pt	7.30	9.10	10.90
Paraquat ²²	Willowood	Gramoxon	paraquat-dichloride	3SL	38.00 gal	0.67 pt	1 pt	1.33 pt	3.20	4.80	6.30
Parazone ²²	AMVAC	Gramoxon	paraquat-dichloride	3SL	37.90 gal	0.67 pt	1 pt	1.33 pt	3.20	4.70	6.30
Parity ¹	Tenkoz	Puma	fenoxaprop-P ethyl	1EC	147.00 gal	0.33 pt	0.4 pt	0.67 pt	6.10	7.40	12.30
Pathfinder II ⁴	Corteva	Garlon	triclopyr-acid/bee	0.75EC	62.20 gal	2.7 gal	8 gal	10.7 gal	168	498	666
Patriot ²	Nufarm	Escort	metsulfuron-methyl	60DF	3.00 oz	0.33 oz	1 oz	2 oz	1.00	3.00	6.00
Peak ²	Syngenta	-	prosulfuron	57DF	16.90 oz	0.25 oz	0.38 oz	0.5 oz	4.20	6.40	8.40
PerfectMatch ^{2,4,4}	Corteva	-	pyroxulam & clopyr & fluroxyppyr	1.66SE	150.10 gal	1 pt	-	1 pt	18.80	-	18.80
Permit ²	Gowan	-	halosulfuron-methyl	75DF	22.00 oz	0.67 oz	1 oz	1.33 oz	14.80	22.00	29.30
Perspective ^{4,2}	Bayer	-	aminocyclopyrachlor+chlorsulf	39.5 + 15.8DF	6.80 oz	3 oz	4.75 oz	8 oz	20.50	32.40	54.60
Phoenix ¹⁴	Valent	-	lactofen & adjuvants	2EC	215.70 gal	8 fl oz	10 fl oz	12.5 fl oz	13.50	16.90	21.10
Pin-Dee ³	Drexel	Prowl EC	pendimethalin	3.3EC	29.00 gal	2.4pt	3 pt	3.6 pt	8.70	10.90	13.10
Pixxaro EC ^{4,4}	Corteva	-	halauxifen-methyl & fluroxyppyr	0.1 + 2.33EC	150.40 gal	-	6 fl oz	-	-	7.10	-
Plateau ²	BASF	-	imazapic-NH ₄ salt	2SL	164.80 gal	4 fl oz	8 fl oz	12 fl oz	5.10	10.30	15.40
Plotter ²	Rotam	Ally	metsulfuron-methyl (cropland)	60DF	2.30 oz	0.05 oz	0.1 oz	0.3 oz	0.10	0.20	0.70
Poast ¹	BASF	-	sethoxydim	1.5EC	107.70 gal	0.5 pt	1 pt	1.5 pt	6.70	13.50	20.20
PowerFlex HL ²	Corteva	-	pyroxulam+cloquintocet safener	13.1WDG	109.00 lb	2 oz	-	2 oz	13.60	-	13.60
Pramitol EC ⁵	Several	-	prometon	25EC	41.40 gal	5 gal	7.5 gal	10 gal	207	310	414
Pramitol 5S ⁵	Several	-	prometon	5PS	3.70 lb	150 lb	200 lb	400 lb	550	733	1465
Prefix ^{15,14}	Syngenta	-	S-metolachlor & fomesafen	4.34 + 0.95EC	58.40 gal	1 pt	1.5 pt	2 pt	7.30	10.90	14.60
Pre-Pare ²	UPL	Everest	flucarbazone-Na salt	70WDG	22.30 oz	0.3 oz	-	0.3 oz	6.70	-	6.70
Prequel ^{2,27}	Corteva	-	rimsulfuron & isoxaflutole	15 + 30SG	7.90 oz	1.66 oz	2 oz	2.5 oz	13.10	15.80	19.80
Presidual ^{15,5}	Winfield	Boundary	S-metolachlor & metribuzin	5.25 + 1.25L	73.50 gal	1.2 pt	1.6 pt	2.45 pt	11.00	14.70	22.50
Primero ²	Rotam	Accent	nicosulfuron	75DF	12.10 oz	0.33 oz	0.5 oz	0.67 oz	4.00	6.00	8.10
Princep 4L ⁵	Syngenta	-	simazine	4L	25.10 gal	2 qt	3 qt	4 qt	12.60	18.80	25.10

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Princep Caliber 90 ⁵	Syngenta	-	simazine	90DF	5.70 lb	1.8 lb	3 lb	4.4 lb	10.30	17.10	25.10
Prowl H2O ³	BASF	-	pendimethalin	3.8ACS	47.60 gal	2.1 pt	2.6 pt	3 pt	12.50	15.50	17.80
Pruvin ²	ADAMA	Resolve	rimsulfuron	25SG	8.80 oz	0.75 oz	-	1 oz	6.60	-	8.80
Purestand ²	Nufarm	Ally	metsulfuron-methyl	60DF	5.80 oz	0.05 oz	0.1 oz	0.3 oz	0.30	0.60	1.70
Pursuit ²	BASF	-	imazethapyr-NH ₄ salt	2AS	428.30 gal	2 fl oz	2.5 fl oz	3 fl oz	6.70	8.40	10.00
Python ²	Corteva	-	flumetsulam	80WDG	16.50 oz	0.8 oz	1 oz	1.33 oz	13.20	16.50	22.00
Quelex ^{4,2}	Corteva	-	halauxifen & florasulam	0.1 + 0.1WDG	124.10 lb	0.75 oz	-	0.75 oz	5.80	-	5.80
Quik-Quat ²²	Drexel	Paraquat	paraquat-dichloride	3SL	35.00 gal	0.67 pt	1 pt	1.33 pt	2.90	4.40	5.80
Range Star ^{4,4}	Albaugh	Weedmstr	2,4-D-dea & dicamba-dea salt	2.87 + 1SL	35.80 gal	1 pt	2 pt	4 pt	4.50	9.00	17.90
Rapport BrdSpec ^{2,2}	Nufarm	Affinity BS	thifensulfuron & tribenuron 1:1	25 + 25DF	7.60 oz	0.4 oz	0.6 oz	1 oz	3.00	4.50	7.60
Rapport TankMix ^{2,2}	Nufarm	Affinity TM	thifensulfuron & tribenuron 4:1	40 + 10DF	5.80 oz	0.6 oz	0.75 oz	1 oz	3.50	4.40	5.80
Raptor ²	BASF	-	imazamox-NH ₄ salt	1SL	544.40 gal	3 fl oz	4 fl oz	5 fl oz	12.80	17.00	21.30
Realm Q ^{2,27}	Corteva	Instigate	rimsulfuron & meso. & isoxadifen	7.5+31.25SG	4.90 oz	4 oz	-	4 oz	19.60	-	19.60
Reflex ¹⁴	Syngenta	-	fomesafen-Na salt	2EC	58.00 gal	0.5 pt	0.75 pt	1 pt	3.60	5.40	7.20
Reglone ²²	Syngenta	-	diquat-dibromide salt	2SL	83.80 gal	1 pt	1.5 pt	2 pt	10.50	15.70	21.00
Relegate ⁴	Nufarm	Remedy	triclopyr-ester	4EC	55.00 gal	1 qt	1.5 qt	2 qt	13.80	20.60	27.50
Rely 280 ¹⁰	BASF	Liberty	glufosinate-NH ₄ salt	2.34SL	71.90 gal	48 fl oz	56 fl oz	82 fl oz	27.00	31.50	46.10
Remedy Ultra ⁴	Corteva	-	triclopyr-ester	4EC	69.70 gal	1 qt	1.5 qt	2 qt	17.40	26.20	34.90
Resicore ^{4,15,27}	Corteva	-	clopyralid & acetochlor & meso	0.19 + 2.8 + 0.3SC	67.80 gal	2.25 qt	2.5 qt	3 qt	38.20	42.40	50.90
Resolve Q ^{2,2}	Corteva	Alluvex	rimsulfuron & thifen & isoxadifen	18.4 + 4SG	9.40 oz	1 oz	-	1.25 oz	9.40	-	11.80
Resource ¹⁴	Valent	-	flumiclorac-ester	0.86SL	243.50 gal	2 fl oz	4 fl oz	6 oz	3.80	7.60	11.40
Reviton ¹⁴	Helm	-	tiafenacil	2.83SC	5.30 gal	1 fl oz	2 fl oz	3 fl oz	0.00	0.10	0.10
Revulin Q ^{2,27}	Corteva	-	nicosulfuron & meso. & isoxadifen	14.4 + 36.8SG	5.60 oz	3.4 oz	3.7 oz	4 oz	19.00	20.70	22.40
Rezuvant ^{4,4,1}	Corteva	-	halauxifen & fluroxypyr & pinox	0.035+0.869+0.42EC	143.00 gal	16.4 fl oz	-	16.4 fl oz	18.30	-	18.30
Rifle ⁴	Loveland	Banvel	dicamba-dma salt	4SL	52.00 gal	4 fl oz	8 fl oz	16 fl oz	1.60	3.30	6.50
Rifle D ^{4,4}	Loveland	Weedmstr	2,4-D-dea & dicamba-dea salt	2.87 + 1SL	32.50 gal	0.5 pt	2 pt	4 pt	2.00	8.10	16.30
Rimfire Max ^{2,2}	Bayer	-	propoxy-Na & meso & mefenpyr	4.76 + 1.91WDG	4.50 oz	3 oz	-	3 oz	13.40	-	13.40
Ringside ¹⁴	Tenkoz	Reflex	fomesafen-Na salt	2EC	38.00 gal	0.5 pt	0.75 pt	1 pt	2.40	3.60	4.80
Rodeo ⁹	Corteva	-	glyphosate-ipa salt	4SL	30.00 gal	24 fl oz	36 fl oz	48 fl oz	5.60	8.40	11.30
Ro-Neet SB ¹⁵	Helm Agro	-	cycloate	6EC	173.00 gal	4 pt	4.5 pt	5.33 pt	86.50	97.30	115
RT 3 ⁹	Bayer	Roundup	glyphosate-K salt	4.5SL	26.60 gal	22 fl oz	32 fl oz	44 fl oz	4.60	6.70	9.10
RU PowerMax ⁹	Bayer	Roundup	glyphosate-K salt	4.5SL	33.40 gal	22 fl oz	32 fl oz	44 fl oz	5.70	8.30	11.50
RU PowerMax 3 ⁹	Bayer	Roundup	glyphosate-K salt	4.8SL	-	20 fl oz	30 fl oz	40 fl oz	-	-	-
RU WeatherMax ⁹	Bayer	Roundup	glyphosate-K salt	4.5SL	47.00 gal	22 fl oz	32 fl oz	44 fl oz	8.10	11.70	16.10
Rugged ⁴	Winfield	2,4-D acid	2,4-D-acid	3.49EC	41.50 gal	0.67 pt	1.33 pt	2.5 pt	3.50	6.90	13.00
Rumble ¹⁴	ADAMA	Flexstar	fomesafen-Na salt & adjuvants	1.88EC	60.00 gal	0.5 pt	0.75 pt	1 pt	3.80	5.60	7.50
Saber ⁴	Loveland	2,4-D a	2,4-D-dma salt	3.8SL	25.50 gal	0.5 pt	1 pt	2 pt	1.60	3.20	6.40
Salvo ⁴	Loveland	2,4-D e	2,4-D-ester	5EC	36.00 gal	6.4 fl oz	9.6 fl oz	12.8 fl oz	1.80	2.70	3.60
Sandea ²	Gowan	Permit	halosulfuron-methyl	75DF	41.00 oz	0.67 oz	1 oz	1.33 oz	27.50	41.00	54.50
Scorch ^{4,4,4}	Nufarm	-	2,4-D & fluroxypyr & dicamba	3 + 0.75 + 1EC	74.50 gal	1 pt	2 pt	4 pt	9.30	18.60	37.30
Scout ¹⁰	Valent	Liberty	glufosinate-NH ₄ Salt	2.34 SL	45.00 gal	29 fl oz	32 fl oz	43 fl oz	10.20	11.30	15.10
Section ¹	Winfield	Select	clethodim	2EC	120.00 gal	4 fl oz	6 fl oz	8 fl oz	3.80	5.60	7.50
Section Three ¹	Winfield	Shadow	clethodim	3EC	76.80 gal	2.7 floz	5.33 floz	10.7 floz	1.60	3.20	6.40
Select Max ¹	Valent	-	clethodim	1EC	105.80 gal	8 fl oz	12 fl oz	16 fl oz	6.60	9.90	13.20
Sentrallas ^{2,4}	FMC	-	thifensulfuron & fluroxypyr	0.25 & 1.3OD	117.40 gal	7 fl oz	9 fl oz	14 fl oz	6.40	8.30	12.80
Sequence ^{9,15}	Syngenta	-	glyphosate-K salt & S-metolachlor	2.25 + 3SC	56.00 gal	1.5 pt	2.5 pt	3 pt	10.50	17.50	21.00
Shadow ¹	UPL	Select	clethodim	3EC	85.00 gal	2.7 floz	5.33 floz	10.7 floz	1.80	3.50	7.10
Sharpen ¹⁴	BASF	-	saflufenacil	2.85SC	746.50 gal	1 fl oz	2 fl oz	3 fl oz	5.80	11.70	17.50
Shieldex	Summit Agro	-	Tolpyralate	3.3SC	-	1 floz	1.175 floz	1.35 floz	-	-	-
Showdown ⁹	Helena	Roundup	glyphosate-ipa & NH ₄ salt	2.7 + 0.3SL	20.00 gal	22 fl oz	32 fl oz	44 fl oz	3.40	5.00	6.90
Shredder E-99 ⁴	Winfield	-	2,4-D-beester	6.1EC	38.10 gal	0.33 pt	0.67 pt	1.33 pt	1.60	3.20	6.30
Simazine L ⁵	Several	Princep	simazine	4L	20.70 gal	2 qt	3 qt	4 qt	10.40	15.50	20.70
Simazine DF ⁵	Several	Princep	simazine	90DF	4.20 lb	1.8 lb	3 lb	4.4 lb	7.50	12.60	18.40
Sinate ^{27,10}	AMVAC	-	topramezone & glufosinate	0.1 + 2.47SL	113.10 gal	21 fl oz	-	28 fl oz	18.60	-	24.70
Sinbar ⁵	TKI	-	terbacil	80WP	51.60 lb	0.5 lb	2 lb	4 lb	25.80	103	206
Sinister ¹⁴	Helena	Reflex	fomesafen-acid	2.87SL	132.30 gal	0.52 pt	-	0.52 pt	8.60	-	8.60
Smack Down ^{15,4,2}	Loveland	SureStart	aceto&clpyr&flumet&dichlormid	3.75+0.29+0.12SC	84.50 gal	1.5 pt	2 pt	3 pt	15.80	21.10	31.70
Solida ²	FMC	Matrix	rimsulfuron	25DF	18.00 oz	1 oz	-	1.5 oz	18.00	-	27.00

Product ^{Site of action}	Company	Brand Equiv.	Active ingredients	Formulation	\$/Unit	Product/A			Cost \$/A		
						Low	Med	High	Low	Med	High
Solstice ^{27,14}	FMC	-	mesotrione & fluthiacet	3.784 + 0.216SC	379.00 gal	2.5 fl oz	-	3 fl oz	7.40	-	8.90
Sonalan HFP ³	Gowan	-	ethalfluralin	3EC	45.60 gal	1.5 pt	3 pt	4.5 pt	8.50	17.10	25.60
Sonalan 10G ³	Gowan	-	ethalfluralin	10G	2.40 lb	6 lb	11.5 lb	17 lb	14.60	27.90	41.30
Sonic ^{2,14}	Corteva	Authrty 1st	cloransulam & sulfentrazone	7.9 + 62.1WDG	4.10 oz	4 oz	6 oz	8 oz	16.50	24.80	33.10
Spartan ¹⁴	FMC	-	sulfentrazone	4L	211.70 gal	3 fl oz	4.5 fl oz	6 fl oz	5.00	7.40	9.90
Spartan Charge ^{14,14}	FMC	-	carfentrazone & sulfentrazone	0.35 + 3.15SE	276.20 gal	3.75 fl oz	4.5 fl oz	5.75 fl oz	8.10	9.70	12.40
Spartan Elite ^{15,14}	FMC	BroadAxe	S-metolachlor & sulfentrazone	6.3 + 0.7EC	116.50 gal	20 fl oz	25 fl oz	32 fl oz	18.20	22.80	29.10
Spike ⁵	Corteva	-	tebuthiuron	80DF	8.50 lb	2.5 lb	3.75 lb	5 lb	21.30	31.90	42.50
SpitFire ^{4,4}	Nufarm	-	dicamba & 2,4-D	0.5 + 3.07SL	42.70 gal	1 pt	2 pt	4 pt	5.30	10.70	21.40
Spur ⁴	Albaugh	Stinger	clopyralid-monoea salt	3SL	185.00 gal	1.3 fl oz	2.6 fl oz	0.25 pt	1.90	3.80	5.80
Stalker ²	BASF	Arsenal	imazapyr-ipa salt	2SL	300.00 gal	48 fl oz	2 qt	3 qt	113	150	225
Starane Flex ^{2,4}	Corteva	-	florasulam & fluroxypyr	0.042 + 0.833EC	70.30 gal	13.5 fl oz	-	13.5 fl oz	7.40	-	7.40
Starane NXT ^{6,4}	Corteva	-	bromoxynil & fluroxypyr-ester	2.33 + 0.583EC	85.00 gal	14 fl oz	21 fl oz	27.4 fl oz	9.30	13.90	18.20
Starane Ultra ⁴	Corteva	-	fluroxypyr-ester	2.8EC	197.30 gal	0.25 pt	0.35 pt	0.54 pt	6.20	8.60	13.30
Status ^{4,19}	BASF	-	dic-Na&diflufenzpr-Na&isoxadifen	40 + 16WDG	4.10 oz	5 oz	7.5 oz	10 oz	20.60	30.80	41.10
Stealth ³	Loveland	Prowl	pendimethalin	3.3EC	37.20 gal	2.4 pt	3 pt	3.64 pt	11.20	14.00	16.90
Sterling Blue ⁴	Winfield	Clarity	dicamba-dga salt	4SL	54.80 gal	4 fl oz	8 fl oz	16 fl oz	1.70	3.40	6.90
Stinger ⁴	Corteva	Stinger	clopyralid-monoea salt	3SL	136.30 gal	1.3 fl oz	2.6 fl oz	0.25 pt	1.40	2.80	4.30
Stinger HL ⁴	Corteva	Stinger	clopyralid-dimethylamine salt	5SL	180.60 gal	0.78 fl oz	1.55 fl oz	0.15 pt	1.10	2.20	3.40
Storm ^{14,6}	UPL	-	acifluorfen & bentazon	1.33 + 2.67SL	93.90 gal	1 pt	1.5 pt	2 pt	11.70	17.60	23.50
Streamline ^{4,2}	Bayer	-	aminocyclopyrachlor + metsulf	39.5 + 12.6DF	7.00 oz	4.75 oz	7.5 oz	9.5 oz	33.30	52.50	66.50
Strut ⁴	Loveland	Clarity	dicamba-dga salt	4SL	52.00 gal	4 fl oz	8 fl oz	16 fl oz	1.60	3.30	6.50
Supremacy ^{4,2,2}	UPL	-	fluroxypyr & thifen & tribenuron	25 + 4.5 + 1.5WDG	1.80 oz	4 oz	5 oz	6 oz	7.20	9.00	10.80
SureStart II ^{15,4,2}	Corteva	-	aceto&clpyr&flumet&dichlormid	3.75+0.29+0.12EC	78.60 gal	1.5 pt	2 pt	3 pt	14.70	19.60	29.50
Surflan ³	UPL	-	oryzalin	4EC	52.00 gal	2 qt	3 qt	4 qt	26.00	39.00	52.00
Surpass NXT ¹⁵	Corteva	-	acetochlor & dichlormid safener	7EC	109.70 gal	1.5 pt	2.25 pt	3 pt	20.60	30.85	41.14
Surveil ^{14,2}	Corteva	Gangster	flumioxazin & cloransulm	36 + 12WDG	101.30 lb	2.1 oz	2.8 oz	4.2 oz	13.30	17.70	26.60
Sword ⁴	Loveland	-	MCPA ester	5.2EC	35.30 gal	3 fl oz	1 pt	2 pt	0.80	4.40	8.80
Tacoma ¹	Winfield	Puma	fenoxaprop-P ethyl	1EC	158.70 gal	0.33 pt	0.4 pt	0.67 pt	6.50	7.90	13.30
Tailwind ^{15,5}	ADAMA	Boundary	S-metolachlor & metribuzin	5.25 + 1.25L	65.20 gal	1.2 pt	1.6 pt	2.45 pt	9.80	13.00	20.00
Talinor ^{6,27}	Syngenta	-	bromoxynil & bicyclopyrone	1.46 + 0.31EC	98.10 gal	13.7 fl oz	-	18.2 fl oz	10.50	-	14.00
Tapout ¹	Helena	Select	clethodim	1EC	100.00 gal	4 fl oz	6 fl oz	8 fl oz	3.10	4.70	6.30
Targa ¹	Gowan	Assure II	quizalofop-ethyl	0.88EC	94.90 gal	7 fl oz	8 fl oz	10 fl oz	5.20	5.90	7.40
Tavium ^{4,15}	Syngenta	-	Dicamba-dga + VaporGrip + S-metolachlor	1.12 + 2.26 CS	51.00 gal	-	56.5 fl oz	-	22.50	22.50	22.50
Teammate ²	Corteva	-	pyroxulam & safener	21.5WDG	205.00 lb	1 oz	-	1 oz	12.80	-	12.80
TerraVue ^{4,4}	Corteva	-	aminopyralid & floryprauxifen	71+6WDG	-	2 oz	-	2.85 oz	-	-	-
Thistrol ⁴	Nufarm	-	MCPB	2EC	61.80 gal	2 pt	4 pt	6 pt	15.40	30.90	46.30
Thunder ²	Albaugh	Pursuit	imazethapyr-NH4 salt	2AS	300.00 gal	2 fl oz	2.5 fl oz	3 fl oz	4.70	5.90	7.00
Thunder Master ^{2,9}	Albaugh	Extreme	imazethapyr-acid & glyph-ipa salt	0.17 + 2SL	30.00 gal	1.5 pt	2.25 pt	3 pt	5.60	8.40	11.20
Top Gun ¹⁴	Loveland	Reflex	fomesafen-Na salt	2EC	45.00 gal	0.5 pt	0.75 pt	1 pt	2.80	4.20	5.60
Tordon 22K ⁴	Corteva	-	picloram-K salt	2SL	66.80 gal	1 pt	2 pt	4 pt	8.40	16.70	33.40
Torment ^{14,2}	ADAMA	-	fomesafen & imazethapyr	2 + 0.5	108.80 gal	0.75 pt	-	1 pt	10.20	-	13.60
Tough ⁶	Belchim	-	pyridate	5EC	230.80 gal	1.5 pt	-	1.5 pt	43.30	-	43.30
Transline ⁴	Corteva	Stinger	clopyralid-monea salt	3SL	193.30 gal	0.67 pt	1 pt	1.33 pt	16.20	24.20	32.10
Travallas ^{2,2,4}	FMC	-	metsulfuron & thifen & fluroxypyr	0.025&0.25&1.3OD	1.10 fl oz	7 fl oz	-	7 fl oz	7.80	-	7.80
Treaty ²	Nufarm	Harmony	thifensulfuron-methyl	75DF	9.50 oz	1/12 oz	0.3 oz	0.6 oz	0.80	2.90	5.70
Treaty Extra ^{2,2}	Nufarm	Harm. Extr	thifensulfuron & tribenuron	50 + 25DF	8.00 oz	0.15 oz	0.3 oz	0.6 oz	1.20	2.40	4.80
Treflan HFP ³	Gowan	-	trifluralin	4EC	23.50 gal	1 pt	2 pt	4 pt	2.90	5.90	11.70
Treflan TR-10 ³	Gowan	-	trifluralin	10G	1.90 lb	5 lb	10 lb	20 lb	9.40	18.80	37.70
TriCor 4F ⁵	UPL	Sencor	metribuzin	4F	76.00 gal	6 fl oz	8 fl oz	16 fl oz	3.60	4.80	9.50
TriCor 75DF ⁵	UPL	Sencor	metribuzin	75DF	14.20 lb	0.25 lb	0.33 lb	0.67 lb	3.60	4.70	9.50
Trifluralin EC ³	Several	Treflan	trifluralin	4EC	23.90 gal	1 pt	2 pt	4 pt	3.00	6.00	12.00
Trifluralin 10G ³	Albaugh	Treflan	trifluralin	10G	1.00 lb	5 lb	10 lb	20 lb	5.00	10.00	20.00
Triflurex ³	ADAMA	Treflan	trifluralin	4EC	24.60 gal	1 pt	2 pt	4 pt	3.10	6.20	12.30
Trimec Classic ^{4,4,4}	PBI	-	2,4-D-amine & MCPP & dicamba	3.32EC	43.00 gal	3.25 pt	3.8 pt	4.33 pt	17.50	20.40	23.30
TripleFlex II ^{15,4,2}	Bayer	SureStart	aceto&clpyr&flumet&furilazole	3.75+0.38+0.12SC	87.90 gal	1.5 pt	2 pt	3 pt	16.50	22.00	32.90
Trisidal ^{15,4,2}	Winfield	SureStart	aceto&clpyr&flumet&furilazole	3.75+0.38+0.12SC	56.20 gal	1.5 pt	2 pt	3 pt	10.50	14.00	21.10
Triumph 22K ⁴	Albaugh	Tordon	picloram-K salt	2SL	49.20 gal	1 pt	2 pt	4 pt	6.10	12.30	24.60
Trooper 22 K ⁴	Nufarm	Tordon	picloram-K salt	2SL	60.00 gal	1 pt	2 pt	4 pt	7.50	15.00	30.00

Product ^{Site of action}	Company	Brand Equiv.	Active ingredients	Formulation	\$/Unit	Product/A			Cost \$/A		
						Low	Med	High	Low	Med	High
Trooper P+D ^{4,4}	Nufarm	Grazon	picloram-3ipa & 2,4-D-3ipa salt	0.54 + 2 S	25.00 gal	2 qt	3 qt	4 qt	12.50	18.80	25.00
Trump Card ^{4,4}	Helena	-	fluroxypyr-ester & 2,4-D-acid	0.66 + 2.65EC	75.00 gal	1 pt	2 pt	3 pt	9.40	18.80	28.10
Truslate ^{4,4}	Nufarm	WideMatch	clopyralid-mea & fluroxypyr-mhe	0.75 + 0.75EC	70.00 gal	0.75 pt	1 pt	1.33 pt	6.60	8.80	11.60
Truslate Pro ^{4,4,4}	Nufarm	-	clorpy-mea & flurox-mhe & MCPAe	0.5 + 0.64 + 1.75EC	71.00 gal	1 pt	1.5 pt	2 pt	8.90	13.30	17.80
Trust ³	Winfield	Treflan	trifluralin	4EC	29.10 gal	1 pt	2 pt	4 pt	3.60	7.30	14.60
Trycera ⁴	Helena	Garlon	triclopyr-acid	4EC	135.00 gal	1 qt	2 qt	4 qt	33.80	67.50	135
Tuscany SC ¹⁴	Nufarm	Valor	flumioxazin	4 SC	540.00 gal	2 fl oz	3 fl oz	4 fl oz	8.40	12.70	16.90
Ultra Blazer ¹⁴	UPL	-	acifluorfen-Na salt	2SL	60.90 gal	1 pt	1.5 pt	2 pt	7.60	11.40	15.20
Unison ⁴	Helena	Hardball	2,4-D-acid	1.74SL	40.00 gal	1 pt	1.75 pt	2.5 pt	5.00	8.80	12.50
UpBeet ²	FMC	-	triflusulfuron-methyl	50DF	19.60 oz	0.25 oz	0.3 oz	0.5 oz	4.90	5.90	9.80
Valor EZ ¹⁴	Valent	-	flumioxazin	4SC	5.00 fl oz	2 fl oz	2.5 fl oz	3 fl oz	9.90	12.40	14.90
Valor SX ¹⁴	Valent	-	flumioxazin	51WDG	3.70 oz	2 oz	2.5 oz	3 oz	7.40	9.20	11.10
Vanquish ⁴	Nufarm	-	dicamba-dga salt	4SL	85.00 gal	4 fl oz	8 fl oz	16 fl oz	2.70	5.30	10.60
Varisto ^{6,2}	BASF	-	bentazon & imazamox	4 + 0.19SL	148.90 gal	16 fl oz	21 fl oz	27 fl oz	18.60	24.40	31.40
Varro ²	Bayer	-	thiencarbazone & mefenpyr	0.083OD	248.50 gal	6.85 fl oz	-	6.85 fl oz	13.30	-	13.30
Vastlan ⁴	Corteva	Garlon	triclopyr-choline	4SL	97.50 gal	1 qt	2 qt	4 qt	24.40	48.80	97.50
Velossa ⁵	Helena	Velpar	hexazinone	2L	130.00 gal	2 pt	4 pt	6 pt	32.50	65.00	97.50
Velpar ⁵	TKI	-	hexazinone	2L	107.80 gal	2 pt	4 pt	6 pt	14.61	53.90	80.80
Verdict ^{14,15}	BASF	-	saflufenacil & dimethenamid-P	0.57 + 5EC	232.20 gal	10 fl oz	13 fl oz	16 fl oz	18.10	23.60	29.00
Verdure X ²²	Helm Agro	Reglone	diquat-dibromide salt	2SL	105.00 gal	1 pt	1.5 pt	2 pt	13.10	19.70	26.30
Victory ²	Nufarm	Express	tribenuron-methyl	75DF	9.00 oz	1/8 oz	1/6 oz	1/3 oz	1.10	1.50	3.00
Vida ¹⁴	Gowan	ET	pyraflufen-ethyl	0.208EC	3.80 fl oz	0.5 fl oz	2 fl oz	5.5 fl oz	1.90	7.60	20.90
Viewpoint ^{4,2,2}	Bayer	-	aminocycpyrchl&imazapyr&met	22.8 + 31.6 + 7.3DF	5.00 oz	13 oz	16 oz	18 oz	65.00	80.00	90.00
Vise ^{15,14}	ADAMA	Prefix	S-metolachlor & fomesafen	4.34 + 0.95EC	60.00 gal	1 pt	1.5 pt	2 pt	7.50	11.30	15.00
Vision ⁴	Helena	Banvel	dicamba-acid	3.8SL	94.00 gal	4 fl oz	8 fl oz	16 fl oz	2.90	5.90	11.80
Vista XRT ⁴	Corteva	Starane	fluroxypyr-ester	2.8AE	170.00 gal	6 fl oz	12 fl oz	22 fl oz	8.00	15.90	29.20
Volley NXT ¹⁵	Tenkoz	Surpass	acetochlor & dichlorimid safener	7EC	63.00 gal	1.5 pt	2.25 pt	3 pt	11.80	17.72	23.63
Volta ²	Rotam	Harmony	thifensulfuron-methyl	75DF	8.30 oz	1/12 oz	0.3 oz	0.6 oz	0.70	2.50	5.00
Volta Extra ^{2,2}	Rotam	Harm. Extr	thifensulfuron & tribenuron	50 + 25DF	9.30 oz	0.15 oz	0.3 oz	0.6 oz	1.40	2.80	5.60
Volunteer ¹	Tenkoz	Select	clethodim	2EC	65.00 gal	4 fl oz	6 fl oz	8 fl oz	2.00	3.00	4.10
Voucher ^{4,4}	Helena	Strn+Swd	MCPA-acid & fluroxypyr-ester	2.6 + 0.64SL	65.00 gal	1 pt	2 pt	3 pt	8.10	16.30	24.40
Warrant ¹⁵	Bayer	~Degree	acetochlor (microencapsulated)	3ME water based	34.90 gal	1.25 qt	1.5 qt	2 qt	10.90	13.10	17.50
Warrant Ultra ^{15,14}	Bayer	-	acetochlor & fomesafen	2.83 + 0.64EC	49.50 gal	48 fl oz	-	48 fl oz	18.60	-	18.60
Weed Blast ^{5,5}	Loveland	-	bromacil & diuron	4 + 4G	7.00 lb	40 lb	50 lb	60 lb	280	350	420
Weedone 638 ^{4,4}	Nufarm	-	2,4-D-acid & 2,4-D-ester	2.8EC	32.50 gal	0.67 pt	2 pt	3 pt	2.70	8.10	12.20
Weedmaster ^{4,4}	Nufarm	-	2,4-D-dea & dicamba-dea	2.87 + 1SL	40.30 gal	0.5 pt	2 pt	4 pt	2.50	10.10	20.10
Weld ^{4,4,4}	Winfield	-	MCPAe & fluroxypyr & clopyralid	1.75 + 0.64 + 0.5EC	64.60 gal	1 pt	1.5 pt	2 pt	8.10	12.10	16.20
Whiteout ⁴	Loveland	-	2,4-D-ehe (solventless)	5.64EC	22.00 gal	0.33 pt	0.67 pt	1.33 pt	0.90	1.80	3.70
WideARmatch ^{4,4,4}	Corteva	-	clopyralid & halauxifen & fluroxypyr	0.82 + 0.04 + 1.02EC	85.10 gal	14 fl oz	-	14 fl oz	9.30	-	9.30
WideMatch ^{4,4}	Corteva	-	clopyralid-mea & fluroxypyr-mhe	0.75 + 0.75EC	70.50 gal	0.75 pt	1 pt	1.33 pt	6.60	8.80	11.70
Wildcard ⁴	Helena	-	MCPA-ester	4EC	45.00 gal	0.5 pt	1 pt	2 pt	2.80	5.60	11.30
Wildcard Xtra ^{6,4}	Helena	Bronate	bromoxynil-ester & MCPA-ester	2 + 2EC	65.00 gal	0.75 pt	1 pt	1.5 pt	6.10	8.10	12.20
Wolverine Adv. ^{1,27,6}	Bayer	-	fenox&pyrasulf&bromox&mefenpr	0.4 & 0.13 & 1.05EC	104.60 gal	1.7 pt	-	1.7 pt	22.20	-	22.20
XtendiMax ⁴	Bayer	Clarity	dicamba-dga salt + VaporGrip	2.9SL	61.60 gal	22 fl oz	33 fl oz	44 fl oz	10.60	15.90	21.20
Yukon ^{4,2}	Gowan	-	dicamba-Na & halosulfuron-CH3	55 + 12.5 WDG	3.70 oz	4 oz	6 oz	8 oz	14.90	22.40	29.80
Zidua ¹⁵	BASF	-	pyroxasulfone	85WDG	10.80 oz	3 oz	4 oz	5 oz	32.50	43.40	54.20
Zidua SC ¹⁵	BASF	-	pyroxasulfone	4.17SC	692.90 gal	1.75 oz	4 oz	6.5 oz	9.50	21.70	35.20
Zidua Pro ^{2,14,15}	BASF	-	pyrox&saflufenacil&imazethapyr	2.28+0.48+1.33SC	481.00 gal	4.5 fl oz	-	4.5 fl oz	16.90	-	16.90
2,4-D Products ⁴	Several	-	2,4-D								
2,4-D amine ⁴				3.8SL	19.80 gal	0.5 pt	2 pt	4 pt	1.20	5.00	9.90
2,4-D ester ⁴				3.8EC	29.20 gal	0.5 pt	2 pt	4 pt	1.80	7.30	14.60
LV ester ⁴				5.7EC	36.60 gal	0.33 pt	2 pt	4 pt	1.50	9.10	18.30

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North Dakota Adjuvant Compendium

For other adjuvants: www.herbicide-adjuvants.com/

Nonionic Surfactant (NIS)			
Activator 90	Loveland	\$32/gal	0.25 to 0.5% v/v
APSA-80	Amway	\$32/gal	0.25 to 0.5% v/v
ChemSurf 90	Winfield United	\$32/gal	0.25 to 0.5% v/v
Haf-Pynt	Drexel	\$31/gal	0.25 to 0.5% v/v
Hypertonic	CHS	\$33/gal	0.25 to 0.5% v/v
Induce	Helena	\$31/gal	0.25 to 0.5% v/v
Insist 90 Plus	Wilbur-Ellis	\$-/gal	0.25 to 0.5% v/v
K-Tone	West Central	\$33/gal	0.25 to 0.5% v/v
Liberate LeciTech	Loveland	\$44/gal	0.25 to 0.5% v/v
Permeate (NPE-free)	Winfield United	\$42/gal	0.25 to 0.5% v/v
Prefer 90	West Central	\$33/gal	0.25 to 0.5% v/v
Preference	Winfield United	\$35/gal	0.25 to 0.5% v/v
R-11	Wilbur-Ellis	\$-/gal	0.25 to 0.5% v/v
Rainier EA	Wilbur-Ellis	\$-/gal	0.25 to 0.5% v/v
Surf-AC 910	Drexel	\$25/gal	0.25 to 0.5% v/v
Topsurf	Winfield United	\$18/gal	0.25 to 0.5% v/v
Tradition 93	Rosen's	\$-/gal	0.25 to 0.5% v/v
Vertex	Precision Labs	\$32/gal	0.25 to 0.5% v/v
Wet-Sol 99	Schaeffers	\$28/gal	0.25 to 0.5% v/v
Wetcit	Oro Agri	\$75/gal	0.25 to 0.5% v/v

NIS Approved for use in Water

Surfactants approved for use in bodies of water are

Activate Plus	Induce	Precise	Top Surf
AgriDex	Level 7	Preference	X-77
Class Act NG	Liberate L-Tech	R-11	Rainer-EA

Surfactant & Silicone

Freeway	Loveland	\$110/gal	0.75 to 2 pt/100 gal
Kinetic	Helena	\$115/gal	0.75 to 2 pt/100 gal
Sil-Fact	Drexel	\$45/gal	0.75 to 2 pt/100 gal
Silkin	Winfield United	\$100/gal	0.75 to 2 pt/100 gal
Speed	Precision Labs	\$135/gal	0.25 to 2 pt/100 gal
Sylcoat	Wilbur-Ellis	\$-/gal	0.75 to 2 pt/100 gal
Tacheon Duo	Precision Labs	\$79/gal	2 to 4 fl oz/A

Surfactant & Deposition/Retention (Drift Retardant)

Accudrop	Winfield United	\$80/gal	-
Cerium Elite	West Central		1 qt/100 gal
Fixate Pro	CHS	\$41/gal	1 qt/100 gal
MasterLock	Winfield United	\$41/gal	5 to 8 fl oz/A
Parachute II	West Central	\$55/gal	3 to 4 fl oz/A
Precise	Precision Labs	\$63/gal	1 to 2 pt/100 gal

Surfactant & Drift Retardant & Antifoam

Powerlock	Winfield United	\$55/gal	5 to 8 oz/A
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Surfactant & Nano-technology (carbon tubes)

Chem Xcel Gen 3	C&R Enterprise	\$63/gal	22-25 fl oz/gal herb
Nano Excel	Enviro Science	\$-/gal	2 to 8 fl oz/A
Nano-Revolution 3.0	Max Systems	\$145/gal	2 to 8 fl oz/A

Petroleum Oil Concentrate (POC/COC)

Agri-Dex	Helena	\$21/gal	1 to 2 pt/A
Crop Oil	West Central	\$14/gal	1 to 2 pt/A
Herbimax	Loveland	\$22/gal	1 to 2 pt/A
Peptoil	Drexel	\$12/gal	to 2 pt/A
Prime Oil	Winfield United	\$15/gal	1 to 2 pt/A
Protyx Aerial	Precision Labs	\$21/gal	0.5 pt/A
R-Way	Rosen's	\$-/gal	1 to 2 pt/A
ROC Crop Oil	Wilbur-Ellis	\$-/gal	1 to 2 pt/A
Vigor	Precision Labs	\$15/gal	1 to 2 pt/A

Crop (Soybean) Oil Concentrate

BeanOil	Drexel	\$15/gal	1 to 2 pt/A
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High Surfactant Petroleum Oil Concentrate (HSPOC)

Between	Winfield United	\$20/gal	1 to 2 pt/A
Covrex	West Central	\$24/gal	1 to 2 pt/A
Diplomat	Rosens	\$21/gal	1 to 2 pt/A
Exchange	Precision Labs	\$26/gal	1 to 2 pt/A
Hi-Load	Simplot	\$26/gal	1 to 2 pt/A
High Load	Wilbur-Ellis	\$-/gal	1 to 2 pt/A
High Mark	Loveland	\$26/gal	1 to 2 pt/A
Penetrec	CHS	\$24/gal	1 to 2 pt/A
Superb HC	Winfield United	\$25/gal	1 to 2 pt/A

Methylated Seed Oil (MSO)

Emulate	CHS	\$22/gal	1 to 2 pt/A
Exuro	Winfield United	\$23/gal	-
Fire-Zone	Helena	\$27/gal	1 to 2 pt/A
Hasten	Wilbur-Ellis	\$-/gal	1 to 2 pt/A
MES-100	Drexel	\$15/gal	1 to 2 pt/A
MSO Leci-Tech	Loveland	\$27/gal	1 to 2 pt/A
MSO Ultra	Precision Labs	\$26/gal	1 to 2 pt/A
Noble	Winfield United	\$23/gal	1 to 2 pt/A
Persist Ultra	J.R. Simplot	\$20/gal	1 to 2 pt/A
Premium MSO	Helena	\$20/gal	1 to 2 pt/A
Sundance II	Rosen's	\$21/gal	1 to 2 pt/A
Superspread MSO	Wilbur-Ellis	\$27/gal	1 to 2 pt/A
Upland MSO	West Central	\$22/gal	1 to 2 pt/A

MSO & Organosilicone Surfactant

Air Force	Winfield United	\$47/gal	4 to 6 fl oz/A
Dyne-Amic	Helena	\$57/gal	4 to 6 fl oz/A
Inergy	Winfield United	\$55/gal	4 to 6 fl oz/A
Persist Advanced	Precision Labs	\$100/gal	1 pt/100 gal
Sil-MES 100	Drexel	\$40/gal	4 to 6 fl oz/A
Syl-Tac	Wilbur-Ellis	\$-/gal	4 to 6 fl oz/A

MSO & Basic pH Blend

Entro	Various	\$28/gal	1 to 2 pt/A
Renegade EA	Wilbur-Ellis	\$-/gal	1 to 2 pt/A

MSO & Deposition/Retention (Drift Retardant)

StrikeLock	Winfield United	\$-/gal	0.5 to 1 pt/A
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MSO & Surfactant & Deposition/Retention (Drift Retardant)

Plexus	Rosen's	\$-/gal	10 to 12 fl oz/A
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High Surfactant Methylated Oil Concentrate (HSMOC)

Advatrol	West Central	\$37/gal	1 to 1.5 pt/A
Aggrestrol	CHS	-	1 to 1.5 pt/A
Cide Winder	Helena	\$42/gal	1 to 1.5 pt/A
Destiny HC	Winfield United	\$40/gal	1 to 1.5 pt/A
Duce	Helena	\$36/gal	1 to 1.5 pt/A
Glacier EA	Wilbur-Ellis	\$-/gal	1 to 1.5 pt/A
Hot MES	Drexel	\$20/gal	1 to 1.5 pt/A
Hybrid	Miller	\$35/gal	1 to 1.5 pt/A
Kixyt	Precision Labs	\$44/gal	1 to 1.5 pt/A
Penatrol	Wilbur-Ellis	\$-/gal	1 to 1.5 pt/A
Succeed Ultra	Winfield United	\$42/gal	1 to 1.5 pt/A
Top Shelf	Loveland	\$32/gal	1 to 1.5 pt/A

ADJUVANTS CONTAINING AMMONIUM
Ammonium sulfate (AMS) / Urea ammonium nitrate (UAN)

Fertilizer

AMS (Dry)	Various	\$0.35/lb	4 to 8.5 lb/100 gal
AMS (liquid)	Various	\$6-9/gal	2 to 4 qt/A
28% UAN/Bulk	Various	\$3-10/gal	2 to 4 qt/A

AMS & Surfactant (NIS)

Bronc Plus	Wilbur-Ellis	\$-/gal	2.5% v/v
Cayuse Plus	Wilbur-Ellis	\$-/gal	2 to 6 qt/100 gal
Class Act NG	Winfield United	\$13/gal	2.5% v/v
Class Act Flex	Winfield United	\$15/gal	1 to 4 % v/v
Deliver	Precision Labs	\$14/gal	2.5% v/v
Encloax	West Central		2.5% v/v
Impressive DB	Rosen's	\$1.25/lb	2.25 lb/A
Optify A20	Winfield United	\$10/gal	-
Optify L27	Winfield United	\$25/gal	-
Powerhouse	Rosen's	\$12/gal	5 to 10 qt/100 gal
Precinct II	West Central	\$13/gal	2.5% v/v
Re-Duce	Helena	\$12/gal	1% v/v
Surfate	Loveland	\$23/gal	1% v/v
Wheelhouse II	CHS	\$13/gal	2.5% v/v

AMS & Drift Retardant (Deposition)

Array	Rosen's	\$2.50/lb	9 lbs/100 gal
Lox Plus	Drexel	\$15/gal	1 to 2 gal/100 gal
StrikeZone MXD	Helena	\$5/gal	2 lb/100 gal
Vector	Rosen's	\$8/gal	2 lb/100 gal

AMS & Defoamer

AMS-Xtra	Drexel	\$4/gal	2.5 to 5% v/v
Omnix LDF	Precision Labs	\$9/gal	2.5 to 5% v/v

AMS & Deposition & Defoamer

AMS-Supreme	Drexel	\$15/gal	2.5 to 5% v/v
Border Xtra DF	Precision Labs	\$2/lb	18 lb/100 gal
Border Xtra 8L	Precision Labs	\$13/gal	2.5% v/v
Drift-Gard	Rosen's	\$-/gal	9 lb/100 gal

AMS & Surfactant & Deposition & Defoamer

Adium	West Central		2.5% v/v
AMS-All	Drexel	\$11/gal	1 to 5 gal/100 gal
Blue Diamond	NWC,Emerado	\$15/gal	1 to 2 qt/100 gal
Bronc Triple	Wilbur-Ellis	\$-/gal	2.4 qt/100 gal
Zenith	Rosen's	\$1.80/lb	1.5 to 2.25 lb/A

AMS & Surfactant & Paraffinic oil

Flame	Loveland	\$42/gal	0.5% v/v
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AMS & WCA* (AMS Replacement)

Bronc Max	Wilbur-Ellis	\$-/gal	0.5 to 1% v/v
Choice W-Master	Loveland	\$30/gal	0.5% v/v
Enact	Rosen's	\$25/gal	0.5% v/v
SeQuel	Helena	\$17/gal	1 to 5 pt/100 gal
Transport LpH	Precision Lab	\$20/gal	0.5% v/v

AMS & WCA* & Deposition

AMS 2000	Winfield United	\$1.25/lb	10 to 17 lb/100 gal
AmSol Plus	Winfield United	\$6/gal	2.5 gal/100 gal

AMS & WCA* & Deposition & Defoamer

Holzi	Drexel	\$1.60/lb	9 lb/100 gal
Stay Down	Rosen's	\$-/gal	5 lb/100 gal

AMS & WCA* & Surfactant & Deposition & Defoamer

Veracity	West Central	\$26/gal	3 qt/100 gal
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Basic pH Blend

Ascension	Wilbur-Ellis	\$-/gal	1% v/v
Axon	CHS	\$24/gal	1% v/v
Linkage	West Central	\$24/gal	1% v/v
Quad 7	Loveland	\$22/gal	1% v/v
Sequestra	Drexel	\$24/gal	1% v/v

Acidic AMS Replacement (contains AMADS)

AMADS - Monocarbamide dihydrogen sulfate = urea + sulfuric acid

Aduro	Winfield United	\$32/gal	4 pt/100 gal
Brimstone	Wilbur-Ellis	\$-/gal	4 pt/100 gal
Cynder	Wilbur-Ellis	\$-/gal	2 to 4 qt/A
ET-4000	MK Ag Service	\$31/gal	4 pt/100 gal
Fixate	CHS	\$32/gal	4 pt/100 gal
Gun Smoke	Loveland	\$40/gal	4 pt/100 gal
Hel-Fire	Helena	\$36/gal	4 pt/100 gal
Jackhammer	West Central	\$32/gal	4 pt/100 gal

Acidic WCA*

ET-4000	MK Ag Service	\$31/gal	4 pt/100 gal
Regulator 2.0	Max Systems	\$22/gal	2 to 4 qt/100 gal

Acidic WCA* & Surfactant & Base Oil

Simplyx	Precision Labs	\$40/gal	0.5 pt/A
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*Non ammonium / non-AMS water conditioning agent

MSO & Surfactant & WCA

Optify Z37	Winfield United	\$55/gal	--
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AMS & Surfactant & Deposition

Amsurf Xtra	Winfield United	\$9/gal	-
Optify D30	Winfield United	\$20/gal	--

ADJUVANTS CONTAINING NO AMMONIUM

WCA* / AMS Replacement

Choice Trio	Loveland	\$29/gal	0.5% v/v
Citron	Farm Direct	\$3.50/lb	2.2 lb/100 gal
Class Act Ridion	Winfield	\$-/gal	0.5 to 2% v/v
Cut-Rate	Wilbur-Ellis	\$-/lb	3 to 4 lb/100 gal
Optify XX	Winfield United	\$50/gal	-
Quest/Request	Helena	\$22/gal	0.5% v/v
Speedway	Winfield United	\$38/gal	0.5% v/v
Valcheck II	Winfield United	\$30/gal	-

WCA* & Surfactant

Flame	Loveland	\$42/gal	0.5% v/v
Jackhammer Elite	West Central	\$27/gal	2 qt/100 gal
Last Chance	West Central	\$-/gal	0.25 to 0.5% v/v
Last Chance Pro	West Central	\$-/gal	2 qt/100 gal
Level Best	CHS	\$-/gal	0.25 to 0.5% v/v
Level Best Pro	CHS	\$-/gal	2 qt/100 gal
Transport Ultra	Precision Labs	\$39/gal	0.25 to 0.75% v/v
Wheelhouse Pro	CHS	\$27/gal	2 qt/100 gal

WCA* & HSMOC

Tapran	West Central		1% v/v
Zaar	Helena	\$37/gal	1% v/v

WCA* & Surfactant & Deposition/Retention & Defoamer

Deppex	CHS	\$62/gal	2 qt/100 gal
Enerpex	West Central	\$62/gal	2 qt/100 gal
Strike Force	Loveland	\$65/gal	2.5 qt/100 gal
Taragon Elite	Precision Labs	\$45/gal	2 qt/100 gal
Taragon Xtra	Precision Labs	\$54/gal	2 qt/100 gal
Trapline Pro II	CHS	\$51/gal	2 qt/100 gal
Veracity Elite II	West Central	\$51/gal	2 qt/100 gal
Weather-Gard	Loveland	\$65/gal	2 qt/100 gal
Complete Leci-Tec			

WCA* & Deposition/Retention & Defoamer

AccuQuest WM	Helena	\$36/gal	1 to 3 qt/100 gal
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*Non ammonium / non-AMS water conditioning agent

WCA* & VRA & Surfactant & Deposition/Retention & Defoamer

Traplock	CHS		19.2 fl oz/A
Verasure	West Central		19.2 fl oz/A

Volatility Reducing Agent (VRA)

AEGOS	BASF		8 fl oz/A
VaporGrip Xtra	Several		20 to 32 fl oz/A

UTILITY ADJUVANTS

Deposition/Retention - Drift Retardants

Acuvant	CHS	\$58/gal	2 to 6 fl oz/A
Cognitive 1	West Central	\$34/gal	2 to 4 qt/100 gal
Corral Poly	Winfield United	\$25/qt	4 to 12 fl oz/100 gal
Crosshair	Wilbur-Ellis	\$-/gal	4 fl oz/A
Diligence-EA	Wilbur-Ellis	\$-/gal	1-2 oz/A
Direct	Precision Labs	\$34/qt	1 to 4 oz/100 gal
Downdraft	Winfield United	\$61/gal	-
Efficax	Wilbur-Ellis	\$-/gal	4 to 12 oz/A
In-Place	Wilbur-Ellis	\$-/gal	4 fl oz/pt-lb herbic
Intact	Precision Labs	\$45/gal	2 qt/100 gal
InterLock	Winfield United	\$60/gal	4 fl oz/pt-lb herbic
Lox	Drexel	\$25/gal	4 to 6 fl oz/A
Mediate	West Central	\$30/gal	1 to 3 qt/100 gal
Nexum	Precision Labs	\$45/gal	4 fl oz/A
Placement	Winfield United	\$45/gal	4 to 8 fl oz/A
Point Blank	Helena	\$42/qt	2 to 6 fl oz/100 gal
Petrichor	West Central	\$58/gal	2 to 6 fl oz/A
UltraLock	Winfield United	\$80/gal	-

Deposition/Retention & Defoamer

Compadre Leci-Tc	Loveland	\$58/gal	1 pt/100 gal
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Acidifying Agents

BS-500	Drexel	\$17/gal	2 to 4 pt/100 gal
Complete	Winfield United	\$44/gal	1 to 3 pt/100 gal
Denali EA	Wilbur-Ellis	\$-/gal	1 to 4 pt/100 gal
Indicate 5	Brandt	\$48/gal	2 to 4 pt/100 gal
Induce pH	Helena	\$37/gal	2 to 4 pt/100 gal
LI-700 Leci-Tech	Loveland	\$39/gal	2 to 4 pt/100 gal
New Balance	Precision Lab	\$44/gal	2 to 4 pt/100 gal
Sequestra	Drexel	\$24/gal	1 to 5 gal/100 gal
Tri-Fol	Wilbur-Ellis	\$-/gal	0.5 to 4 pt/100 gal

Compatibility Agents

Blendex	Helena	\$55/gal	1 to 5 pt/100 gal
CompatibilityAgent	West Central	\$35/gal	1 to 3 pt/100 gal
Complete	Winfield United	\$44/gal	1 to 3 pt/100 gal
Convert	Precision Labs	\$50/gal	1 to 6 pt/100 gal
EZ-Mix	Loveland	\$38/gal	1 to 4 pt/100 gal
Mix	Drexel	\$20/gal	1 to 4 pt/100 gal
Mix-All	Rosen's	\$45/gal	1 to 4 pt/100 gal
Stability	Wilbur-Ellis	-	1 to 3 pt/100 gal

Spray Tank Cleaners

Tank Cleaner	Various	\$12-25/qt	1 to 2 qt/100 gal
Tank Cleaner	Various	\$5-7/lb	1 to 2 lb/100 gal

Understanding a Water Quality Analysis Report

1. Water pH

Generally, the normal pH range of water used for application has little effect on herbicide efficacy. Carbamate and organophosphate insecticides quickly degrade through alkaline hydrolysis at water pH above 7. Water pH above 7 significantly increases degradation of Cobra, Resource, and Valor, however, these herbicides have very low water solubility and alkaline degradation would affect only the soluble fraction of the herbicide. Increasing water pH to 9 can reduce precipitation and nozzle plugging with the sugarbeet micro-rate treatment. Most sulfonylurea herbicides, POST HPPD herbicides, Select, Status, and Sharpen are more soluble at high pH and efficacy can be greater when applied in water with pH above 7. Some adjuvants marketed for glyphosate reduce water pH. Low pH forces some salt formulated herbicides into the acid state that may not be soluble in the amount of water being sprayed and thus plug nozzles and reduce efficacy. Herbicides need to be in solution for absorption into plant foliage. See #23 on page 73 for additional information.

2. Total Dissolved Solids and Electrical Conductivity

The major mineral constituents in Northern Plains water and their ionic charges are:

Cations (+ charge) = calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and iron (Fe).

Anions (- charge) = sulfate (SO₄), chloride (Cl), bicarbonate (HCO₃), and nitrate (NO₃).

The sum of all the minerals dissolved in a sample of water is normally referred to as the total dissolved solids (TDS). The higher the TDS, the more electric current water can conduct. Because of this characteristic, a measure of the electrical conductivity (EC) is often used to provide a quick, economical estimate of the TDS in water. If the EC is less than 500 umho/cm, water quality problems for herbicides are unlikely. Water EC values in ND and western U.S. run between 1000 and 2,500. Usually hardness and cation concentration, not TDS, are used to evaluate water quality on herbicide performance.

3. Hardness

Water hardness is caused by potassium, calcium, magnesium, and iron. These minerals can react and antagonize most all POST herbicides registered. Almost all POST herbicides are weak acid herbicides and can ionize (separate into neutral, + and - molecules) in acidic pH. Negative charged molecules can bind with cationic minerals resulting in antagonism. The ester formulations of growth regulator herbicides are oil soluble and do not react directly with the salts in the water. However, these oil type liquid herbicide formulations include an emulsifier to mix with water. Sometimes these emulsifiers when mixed in water with salts cause an oil-like scum or precipitate in the spray water reducing efficacy and plugging nozzles. Refer to pages 120 to 127 for a list amine or ester herbicide formulations.

Sodium contributes to water hardness but functions to soften water similar to home water softener systems. Hardness levels are reported in mg/L (ppm) of calcium carbonate (CaCO₃). Hardness values are calculated by adding meq/L of Ca and Mg then multiplying by 50. Hardness of individual cations can be confusing because they can be reported as milliequivalents/L (meq/L), milligrams per liter (mg/L), parts per million (ppm), or grains per U.S. gallon (gpg). The mg/L and ppm are considered equal, and 1 grain per gallon is equal to 17.1 mg/L or ppm.

To convert meq/L to ppm, multiply meq/L x atomic number of the atom: K meq/L x 39.102, Na x 22.991, Mg x 12.156, Ca x 20.04. Water hardness values in MT, ND, and MN run between 0 and 2,500 ppm. There are variations in water hardness classifications

but the following scale can be used:

Soft =	<75 ppm
Mod. hard =	75 – 150 ppm
Hard =	150 – 300 ppm
Very hard =	> 300 ppm

The amount of AMS needed to overcome antagonistic ions can be calculated as follows:

$$\text{Lbs AMS/100 gal} = (0.002 \times \text{ppm K}) + (0.005 \times \text{ppm Na}) + (0.009 \times \text{ppm Ca}) + (0.014 \times \text{ppm Mg}) + (0.042 \times \text{ppm Fe}).$$

This does not account for antagonistic minerals on the leaf surface on some species like lambsquarters, sunflower, and velvetleaf which may require additional AMS. Apply AMS at 8.5 lbs/100 gallons of water unless water hardness requires more.

4. Sodium Absorption Ratio

Water high in sodium, when added to clay soils, may have a detrimental effect. Excess sodium will attach to clay particles and displace other ions, namely chloride and sulfide. A high SAR may indicate a limited ability for plants to extract water from the soil. The adjusted SAR has reference to bicarbonates. Some water in the Northern Plains is very high in bicarbonates, which increases the SAR problem. Water quality standards for SAR are as follows:

Excellent =	<3
Good =	3 – 5
Permissible =	5 – 10
Doubtful =	10 – 15
Unsuitable =	>15

5. Residual Sodium Carbonate

Values greater than 0 increase the sodium hazard.

6. Bicarbonates

Since bicarbonate is anionic (-) it is always associated with a cation (+) like sodium or calcium to make sodium or calcium bicarbonate in ground water. The corresponding cation (Ca, Na) may have a greater role in herbicide antagonism than the bicarbonate. High sodium and sodium bicarbonate antagonism of herbicides is usually overcome by ammonia type adjuvants. Small amounts of antagonistic salts do not appear to reduce herbicide efficacy with full use rates. This is because the use rate was established for efficacy using various waters. However in principle to optimize herbicide efficacy, any amount of antagonistic salts will have some negative effect and to optimize efficacy for all conditions always apply AMS to overcome even low amounts of antagonistic salt.

Water with high bicarbonate levels may have low levels of other anions like chloride and sulfate. Calcium chloride is also antagonistic and spray water pH should be below 7. Bicarbonate levels greater than 500 ppm may reduce herbicide efficacy of Achieve, Poast, Select, MCPA amine, and 2,4-D amine. When using water with more than 500 ppm bicarbonates the high rate of these herbicides should be used and applied at the most susceptible weed stage for efficacy. Bicarbonate also increases water pH and high bicarbonate levels may also be associated with high water pH (See #1 above). Water bicarbonate levels in MT, ND, and MN range from 200 to 1,000 ppm.

Analysis of spray water sources can determine water quality effects on herbicide efficacy.

Water samples can be tested at:

USPS: NDSU Dept 7680, Fargo, ND 58108-6050,
UPS and Physical Address: NDSU Soil and Water Laboratory,
Waldron Hall 202, 1360 Bolley Dr. NDSU, Fargo, ND 58102.
701 231-7864.

Air Temperature Inversions

Since the 1990's, industry and the U.S. EPA have recognized that off-target movement of pesticides can be amplified by air temperature inversions. Thus, pesticide labeling often contains cautionary language regarding making applications when an air temperature inversion is or will be in place. This language has evolved in recent years to strong prohibitions regarding applications of certain pesticides during air temperature inversions. Recently introduced, low volatility formulations of dicamba, used in over the top applications to tolerant soybean varieties, are now specifying prohibitions of applications from two hours before sunset to one hour after sunrise as a means to further reduce the impact of air temperature inversions.

Air temperature inversions are an environmental phenomenon that have long been recognized to adversely impact the deposition of fine spray drops. Fine spray drops reach the target very slowly and this makes them more susceptible to lateral movement off target in light winds. Especially when they encounter dense, cooler air, near the ground, in an air temperature inversion. In addition, air stability near the earth surface allows for the accumulation of volatile pesticide molecules which may easily move down range in a light breeze to non-target sites. When this happens, sensitive plants and animals may be adversely impacted.

Multiple site observations of air temperature inversions have been collected in North Dakota since 2017. The data that has been collected demonstrates that air temperature inversion begin to build two to three hours before sunset and then begin to dissipate 30 to 120 minutes after sunrise. While air temperature inversions are typically associated with wind speeds of zero to three miles per hour, our observations indicate that significant inversion conditions can exist at much greater speeds. Air temperature inversions can be measured on most 24 hour days. However, there is wide variation regarding the intensity of inversions from day to day. Calm atmospheric conditions are usually associated with the most intense inversion observations.

A comprehensive explanation of air temperature inversions and their potential impact on pesticides can be found in the NDSU publication, "Air Temperature Inversions Causes, Characteristics and Potential Effects on Pesticide Spray Drift (AE1705 (Revised October 2019)). The publication is available on-line at: <https://tinyurl.com/NDSU-Inversion-AE1705>

Pesticide applicators now have excellent tools for identifying air temperature inversions. In North Dakota and in portions of Minnesota and Montana, NDSU operates the NDAWN Mesonet Weather System. Selected stations (159 as of December 2020) monitor actual air temperature inversion intensity by comparing air temperature at three meters and at one meter. Observations and recordings are made every five minutes and reported on the world wide web at: <https://ndawn.ndsu.nodak.edu> An Android and iPad app is available for reporting station readings and to send alerts when an inversion observation occurs. Details can be found here: <https://www.ndsu.edu/ndscoblog/?p=4031> Finally, Innoquest, a developer of application spray equipment accessories makes a hand-held tool for measuring air temperature inversions. You can find more information on their device here: <https://innoquestinc.com>

Delta T: A Tool for Pesticide Application Decision Making

Delta T is the temperature difference between a dry bulb (air temperature sensor exposed directly to the air) and a wet bulb (air temperature sensor enclosed in wetted material so that water is constantly evaporating from it and cooling the bulb). The higher the Delta T value, the drier the atmosphere is with greater potential to evaporate spray drops.

Delta T is the primary method by which applicators in Australia decide when and how to apply pesticides to improve efficacy and reduce spray drift. It originated in the early 1990's. It was designed in the era when the primary spray nozzle was a flat fan. Because these nozzles produce a relatively high proportion of fine spray drops, there was widespread concern, especially in the drier and hotter parts of Australia, that significant evaporation of these fine drops would lead to coverage/efficacy issues as well as increased spray drift. The Australian's also use relatively low Delta T values as an indication that an air temperature inversion is likely occurring and/or the humidity is so high that fine spray drops would have a tendency to move further down range.

The Delta T concept has gained some adoption in the arid portions of Western Canada. Weather instrumentation manufacturers in North America have also built a Delta T value into their devices. Kestrel Meters and Weather Flow both make instruments that report a Delta T value. In the United States, Delta T has not been widely used. It is not part of standard pesticide application curricula.

A typical flat fan spray nozzle set at 40 psi will produce 30% or more fine spray drops. All those drops are likely to evaporate before they hit the target with a Delta T value of 18 or more. That will result in coverage and efficacy issues. Further, because ALL the spray drops are shrinking because of evaporation, more and more of the spray will be subjected to wind movement and drift. The impact of evaporation on a spray application can be partially offset by increasing droplet size. Coarse or greater spray quality drops, those often produced by an Air Induction or a Turbo Teejet Induction nozzle, can be used up to a Delta T of 21.6. But after that, the evaporation rate becomes so problematic that applications are no longer recommended.

Just like other weather variables, Delta T will change throughout the day. Generally, in the early morning hours, the value will be low, but as the day warms, the number will rise. As evening and night sets in, the numbers will fall again. In North Dakota, Delta T values will generally be higher in the SW and lower in the NE region of the state (relatively warmer and drier climate versus a cooler and higher precipitation one).

Delta T is an excellent way to understand the impact of temperature and humidity on a spray drop. Delta T values are reported every five minutes through the North Dakota Agriculture Weather Network (NDAWN). They are located on the world wide web at: <https://ndawn.org>

Kochia – Weed of the Year

Kochia has been and remains one of the 10 worst weeds in ND from surveys conducted since 1978. The severe drought conditions from summer 2020 through 2021 were conducive for kochia to thrive across the entire state. A lot of kochia plants escaped management in 2021, resulting in an abundance of seed production that will be problematic during the 2022 growing season. Consider how the biology of kochia contributes to its persistence in weed management systems:

<p>Kochia emergence: - Seed dormancy: None (usually) - GDD required: <50 - Days to 95% emerge.: 2 weeks - Temperature range: 40 to 100 F - Maximum emergence depth: 3.25 in. - Calendar time span: March through July - Soil conditions: Fertile/saline/drought -Seedling frost tolerance: Lower teens -Rooting depth: Up to 16 ft in drought</p>	<p>Implications: Wide genetic diversity in kochia is expressed in highly variable phenotypes: green, red, and purple colored plants, tall and narrow plants, short and round plants, and plants with wide leaves, and narrow leaves. Wide genetic diversity caused ALS (Group 2) resistance kochia biotypes to develop in the late 1980s, a short time after ALS herbicides were developed. Most kochia emerges in a 2 to 3 week time span very early in the spring. However, early spring tillage and herbicide burndown practices have selected for later emerging kochia biotypes. As a result, multiple flushes of kochia now occur from April through July. Kochia is adapted to drought conditions and saline soil and grows mostly uninhibited as it lacks competition from other plant species.</p>
<p>Kochia biomass production: Ratio of seed mass per unit plant mass: Foxtail = 75, Lambsquarters = 150, Kochia = 500</p>	<p>Implications: Kochia has one of the highest seed to plant mass ratios. This allows plants to disseminate numerous seeds that are weakly attached to light, buoyant plants that roll (tumble weed) uninhibited across fields with the wind.</p>
<p>Kochia carbon assimilation pathway (C3 or C4): C4 (fixes 4 carbons vs. 3 during photosynthesis)</p>	<p>Implications: C4 carbon assimilation physiology allows rapid kochia growth in hot temperatures and in low moisture conditions.</p>
<p>Herbicide resistant kochia biotypes in ND: Group 2 (ALS) = Express, Raptor, Python, etc. Group 4 (Growth reg.) = 2,4-D, dicamba, Starane Group 5 (Photosynthetic inhibitor) = atrazine Group 9 (EPSPS inhibitor) = glyphosate The mechanism of glyphosate resistance in kochia is gene amplification (i.e. plants make multiple copies of the EPSPS gene). Gene amplification can produce kochia that cannot be controlled by practical rates of glyphosate. Multiple herbicide resistant kochia in ND: Group 2 + 4. Group 2 + 9. Group 2 + 4 + 9.</p>	<p>Implications: Wide genetic diversity in kochia allows resistant biotypes to develop from high herbicide selection pressure (frequent use of herbicides from one site of action). 2,4-D was registered in the mid 1940s. Use of 2,4-D over 70 years has gradually depleted susceptible biotypes leaving tolerant/resistant kochia biotypes that survive field rates of 2,4-D. Fluroxypyr (Starane) resistant kochia is from over-dependence on fluroxypyr in small grains and corn. A contrasting difference between 2,4-D and glyphosate resistance in kochia is the maximum 2,4-D rate of 1 pt/A in wheat compared to the high rates of glyphosate used in tolerant RUR crops (2.25 lbs ae/A). The 1 pt/A rate of glyphosate used in the 90s now requires 2 to 4 qt/A to achieve the same level of weed control. Resistance increases in each successive kochia generation compared to the previous generation.</p>
<p>Pollen: Type of pollination: Cross but able to self. Length of pollen viability: Up to 12 days</p>	<p>Implications: Pollen from herbicide resistant kochia plants can pollinate flowers on susceptible plants to make seed resistant to herbicides.</p>
<p>'The chink in the armor': SHORT seed viability. % seeds viable after 1 year = 5%, 2 years = 1%</p>	<p>Implications: Seed from most weeds remain viable in the soil for many years. Most kochia seed is non-viable after 1 or 2 years - see next section below.</p>

Crop Rotation: A crop rotation that includes a grass crop where many effective herbicides are registered can effectively control kochia and deplete the soil seed bank. Corn and small grains have the largest portfolio of herbicides to control kochia.

Chemical Control in Crops: The most effective chemical control strategy for kochia includes PRE followed by POST herbicides. Many PRE corn and soybean herbicides can effectively control kochia. Except for corn and small grains, all other crops have very few POST herbicides to effectively control kochia and timely POST applications to small plants are required for maximum activity.

Cover crops: NDSU research at the Carrington REC has demonstrated that a fall established cereal rye cover crop can help reduce kochia biomass the following spring. Kochia density was not affected by the presence of a cover crop, but the reduction in biomass helps slow growth rates and prolong the window to apply effective burndown herbicides.

Fall Residual Herbicide Applications: Ndsu research at the North Central REC has demonstrated that applications of herbicides applied in October, before the ground freezes, can provide residual control of kochia into May. Flumioxazin will generally provide control or suppression of kochia and allow rotational flexibility to many crops the following spring. Suppression of kochia will thin the population in the spring to enable better herbicide coverage of any burndown application prior to planting.

Herbicides for kochia control:

Corn: atrazine, dicamba, flumioxazin, fluroxypyr, isoxaflutole, mesotrione/tembotrione/topramezone + atrazine, pyroxasulfone, saflufenacil, and Liberty in Liberty Link corn.

Soybean: bentazon + MSO adjuvant (split applications- kochia must be <2" tall), flumioxazin, fomesafen, metribuzin, sulfentrazone, saflufenacil, Liberty (LL soybean), and approved dicamba products (Xtend soybean). Note that reliance on Enlist One or Enlist Duo alone in E3 soybean will not provide adequate control due to resistance/tolerance of 2,4-D and fairly widespread glyphosate resistance.

Dry bean: bentazon + MSO adjuvant (split applications- kochia must be <2" tall), fomesafen, sulfentrazone.

Small grains: carfentrazone (small), fluroxypyr, dicamba, bromoxynil, pyrasulfotole + bromoxynil, bicycloprone + bromoxynil. Note that fluroxypyr rates of 2 oz ai/A are desired for best kochia control. Many premixes contain reduced rates of fluroxypyr, and additional fluroxypyr can be added to raise the rate to 2 oz ai/A. NDSU recommends 3 different effect active ingredients applied to kochia <3" tall for optimal control in small grains.

Summary of new information in the 2022 Weed Control Guide:

www.ndsu.edu/weeds - Web version of ND Weed Control Guide.

HERBICIDE UPDATE:

Discontinued products: Fierce WDG (Fierce EZ is only formulation).

New products: Acuron GT, Chateau EZ, Maverick, Rezuvant, Shieldex

Removed/discontinued products: Betamix

Weed Guide Updates

- Revised fall burndown foliar and residual tables – page 7.
- Revised Treflan section in small grains – Page 9
- Revised small grain pre-harvest revised to state not for desiccation – Page 19.
- Revised Millet table to the small grains section – page 20.
- Revised sugarbeet section to remove Betamix. Added Section 18 label for Ultra Blazer, and 24(c) labels for Dual Magnum and Liberty.
- Revised Palmer amaranth paragraph to include information of populations imported on grain screenings – Page 75.
- Added barnyardgrass to annual weed control narrative (S15) – Page 91.

Roundup Xtend/Xtendflex soybean: Label information updated. Refer to Bayer, BASF, and Syngenta web sites for application information. Label changes for 2022 season are possible between time of print and spray season.

Crop rotation restrictions: updated for several herbicides - pages 6, 102-104.

Herbicide Resistant Weeds: updated X1 to reflect changes in WSSA mode of action numbers. Several chemical family and active ingredient reclassifications.

Herbicide Compendium: Herbicide compendium: Please note volatile market may/will change pricing throughout the year. Prices reflect average small quantity quotes received in November 2021.

Weed of the Year: Kochia - page 134

Quick Reference Information

1. NDSU Weed Science Home Page: www.ndsu.edu/weeds
2. <agdakota> list serve: Timely updates in pesticide registration and crop production information. To subscribe, send email to aimee.thapa@ndsu.edu
3. U.S. registered pesticide labels: www.cdms.net/manuf/manuf.asp
4. North Dakota Department of Agriculture registered pesticide database: www.nd.gov/ndda/pesticide-fertilizer-division/pesticide-registration
5. **Safety and Emergency Phone Numbers:**
 - ND Poison Control Line: 800-222-1222
 - ND Emergency Assistance Line: 800-472-2121
 - Report Pesticide Incident to NDDA: 701-328-2232

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For information regarding pesticide certification, contact the **North Dakota State University Extension Pesticide Program**

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Fargo, ND 58108-6050
Phone: 701-231-7180 or 231-6388
Fax: 701-231-5907
Email: NDSU.pesticide@ndsu.edu
www.ndsupesticide.org

For pesticide enforcement, compliance assistance, registration, and other regulatory issues, contact the **Agriculture Chemical Division at the North Dakota Department of Agriculture**

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