



Cereal Grass Weed Management and Stewardship



Northern Plains

Objective

The objective of this document is to provide a technical background for effective grass weed management in cereals for the Northern Plains (NP). This document provides recommended Best Management Practices (BMPs) for effective weed control and the management of weed resistance. These BMPs assist in developing appropriate crop and herbicide rotation programs for product stewardship at the local level.

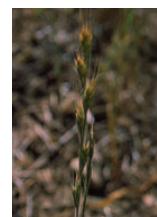
Background

Herbicide performance is affected by many factors including correct timing, use of correct labelled rates, proper use of adjuvants and effective spray application. In limited cases, weed control failures are related to herbicide resistance. Herbicide resistance is the inherited ability of a weed to survive a rate of herbicide that would normally kill it. A low incidence of grass weed resistance is present in the cereal growing regions of the NP. Grass weed resistance in the NP has been documented with ACCase-inhibitor (Group 1 mode of action) and ALS-inhibitor (Group 2 mode of action) herbicides, as well as mitotic inhibitor and lipid synthesis inhibitor herbicides.

In the NP, ACCase-inhibitor herbicide resistance has been detected in wild oat (*Avena fatua*), green foxtail (*Setaria viridis*), purple robust foxtail (*Setaria viridis* var. *robusta-purpurea*), giant foxtail (*Setaria faberi*) and Persian darnel (*Lolium persicum*). Resistance to ALS-inhibitor herbicides has been confirmed in wild oat, giant foxtail, green foxtail and yellow foxtail (*Setaria glauca*). The key Syngenta wild oat and foxtail products are Axial™ (pinoxaden), Discover® NG (clodinafop-propargyl) and Achieve® Liquid (tralkoxydim). Syngenta graminicides Fusilade® (fluazifop-P-butyl) and Fusion® (fluazifop-P-butyl + fenoxypop) can be used in broadleaf crops to control these same grass weeds. A list of products used for control of the species referred to above, together with details regarding mode of action and herbicide class, is provided in Appendix 1.



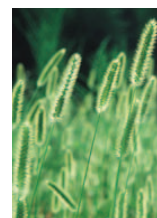
Wild Oat in Wheat



Persian darnel



Green foxtail



Yellow foxtail

Resistance Types

- 1) **Target site resistance.** This type of resistance affects the site of activity of a group of herbicides with the same mode of action and results in high-level resistance. Herbicides with different modes of action remain effective, and therefore, resistant biotypes can be managed. **Example:** ALS-inhibitor resistant kochia.
- 2) **Enhanced metabolism (metabolic resistance).** Weeds can develop the ability to detoxify herbicides. A key feature of metabolic resistance is that herbicides with different modes of action can be affected. Unlike in Europe and Australia where metabolic resistance is widespread in several key grass species, it has not been documented widely in North America. **Example:** Dinitroaniline (Treflan™) resistance in wild oat.

There is one or more known resistant biotypes of key grass weed species in the Northern Plains (see Table 1). The ACCase-inhibitor (Group 1) herbicides fall into three chemical classes: phenylpyrazolin (DEN), aryloxyphenoxy-propionate (FOP) and cyclohexanedione (DIM). Note that within the Group 1 herbicides, multiple types of target-site resistance exist. A grass species may be resistant to a FOP (Discover, Puma®) and not to a DEN (Axial) or DIM (Achieve Liquid).

Table 1. Known resistant grass biotypes in North America

Species	Biotypes	Resistance Type
Wild oat	ACCcase-inhibitors: all FOPs	Target site
	ACCcase-inhibitors: all FOPs + DIMs	Target site
	ALS-inhibitors	Not determined
	Dinitroanilines	Not determined
	Triallate and/or difenzoquat	Metabolic
	ACCcase-inhibitors (FOP), ALS-inhibitors (imidazolinone) and often triallate	Metabolic
Green foxtail	ACCcase: all FOPs and DIMs	Target site
	ALS-inhibitors	Not determined
	Dinitroanilines +/- ACCcase inhibitors (FOP)	Multiple: target site + metabolic
Yellow foxtail	ALS-inhibitor	Not determined
	PSII inhibitor	Target site
Giant foxtail	ACCcase-inhibitors: all FOPs + DIMs	Target site
	PSII inhibitor	Target site
	ALS-inhibitors (sulfonylureas [SU], imidazolinone)	Not determined
Purple robust foxtail	ACCcase-inhibitors: all FOPs + DIMs	Not determined
Persian darnel	ACCcase-inhibitors: FOPs +/- DIMs	Not determined

Resistance Development

Repeated use of herbicides with the same mode of action and target site can lead to the selection of resistant weeds. The development and spread of herbicide resistance is also influenced by agronomic practices, together with environmental effects and genetic diversity in weed populations.

Resistance of wild oat and foxtail species to ACCase and ALS inhibitors in the NP is due to a combination of target site and enhanced metabolism, whereas the mechanism of Persian darnel resistance to ACCase inhibitors has not been ascertained. A key factor in the development of resistant biotypes in North America and the NP has been the frequent use of the FOP class (and some of the DIM class) of ACCase inhibitors in cereal *and* broadleaf crops (Appendix 1). Applying a herbicide at rates below the label recommendation is also a key contributing factor to the development of weed resistance.

Resistance Management Guidelines for Cereal Grass Weeds

Many factors affect the performance of herbicides under field conditions. The following Best Management Practices should be implemented even when resistance has not been confirmed.

- Maintain accurate spray records in cereal and rotational crops
- Apply post-emergence herbicides to small, actively growing weeds
- Use the full labelled herbicide rate with the recommended spray adjuvant
- Ensure good coverage is achieved with proper spray volumes and calibrated equipment
- Use multiple control tactics: sequential applications and/or tankmixtures of herbicides at full label rates with different modes of action, pre-plant burndown applications of Touchdown® or Gramoxone Max®/Gramoxone Inteon™ and/or cultivation in the fallow portion of the crop rotation
- Avoid the repeated use of herbicides within the same Mode of Action (MOA) and chemical class in successive seasons either in cereal crops or rotational crops
- To avoid antagonism, use only registered tankmix partners
- Use a diverse crop rotation to extend the range of available herbicides and agronomic practices
- Consider cultivation, fertilizer regimes, seeding rates and row widths that enhance crop competitiveness
- Scout treated fields within 3 weeks following application to confirm that effective control has been achieved; re-treat with a different MOA/chemical class if needed
- Where possible, rogue or destroy, mechanically or with non-selective herbicides, patches of suspected resistant plant escapes
- Minimize weed seed movement between fields by way of tires, machinery, straw, manure, irrigation water, etc.
- Re-evaluate the effectiveness of the combined strategies annually

Resistance Management Strategies

Resistance management strategies should be designed specifically for each cropping system and target weed species (see Tables 2 and 3). Recommendations in each table assume sensitive (non-resistant) weed populations. Rotation scenarios with weaker resistance management strategies are noted as “Higher Risk.”

Table 2. Best herbicide resistance management practice recommendations for crop rotation scenarios.

Follow either the primary or secondary options through the rotation scenario.

Note: Touchdown, Gramoxone Max, Gramoxone Inteon and/or cultivation should be utilized as needed between crops as additional tools to manage herbicide-resistant weeds.

Do not exceed two applications of glyphosate products on any one acre in two seasons.

Scenario 1		
Year	Crop	Grass Herbicide
1	Spring wheat	Primary option: Axial or Discover NG Secondary option: Buckle®, Everest®, Silverado® or Olympus™
2	Pulse	Primary option: Eptam®, PROWL®, Far-Go®, Treflan or Sonalan™ Secondary option: Group 1, non-FOP products (Select®, Poast®) Higher risk option: Group 1 FOP products (Assure® II)
Scenario 2		
Year	Crop	Grass Herbicide
1	Spring wheat	Primary option: Axial or Discover NG Secondary option: Everest, Silverado or Beyond®*
2	Corn (RR™ or Conventional)	Primary option: LUMAX®, Bicep II MAGNUM®, Dual II MAGNUM®, Atrazine, Steadfast®, Accent® or Option® Secondary option: LUMAX, Bicep II MAGNUM, Dual II MAGNUM, Atrazine or Touchdown ¹ (glyphosate-tolerant corn only)
3	RR soybeans	Primary option: Touchdown ¹ (tankmix Fusilade or Fusion for volunteer corn control) Secondary option: Raptor®, Extreme® or PROWL
	Conventional soybeans	Primary option: Treflan, Sonalan or PROWL Secondary option: Fusion, Fusilade, Select, Poast or Rezult®

* Clearfield winter wheat.

¹ Follow the 2-1-2 glyphosate resistance management strategy: No more than 2 applications of glyphosate in 1 field over a 2-year period.

continued

Table 2. continued

Scenario 3		
Year	Crop	Grass Herbicide
1	Spring wheat	<p>Primary option: Axial or Discover NG</p> <p>Secondary option: Silverado², Everest³, Olympus or Beyond*</p>
2	Sugar beets	<p>Primary option: Eptam, Far-Go or Ro-Neet®</p> <p>Secondary option: Select or Poast</p> <p>Higher risk option: Group 1 FOP product (Assure II)</p>
3	Corn (RR or Conventional)	<p>Primary option: LUMAX, Bicep II MAGNUM, Dual II MAGNUM, Atrazine, Steadfast, Accent or Option</p> <p>Secondary option: LUMAX, Bicep II MAGNUM, Dual II MAGNUM, Atrazine or Touchdown¹ (glyphosate-tolerant corn only)</p>
4	RR soybeans	<p>Primary option: Touchdown¹</p> <p>Secondary option: Raptor, Extreme, Select or PROWL</p>
	Conventional soybeans	<p>Primary option: Treflan, Sonalan, Prowl or Group 1 non-FOP product (Select, Poast, Rezult)</p> <p>Secondary option: Fusilade or Fusion</p>
Scenario 4		
Year	Crop	Grass Herbicide
1	Winter wheat	<p>Primary option: Achieve Liquid, Axial or Discover NG</p> <p>Secondary option: Everest, Osprey™, Olympus or Silverado</p>
2	Pulse	<p>Primary option: Eptam, Far-Go, Sonalan, Treflan or PROWL</p> <p>Secondary option: Group 1 non-FOP product (Select, Poast)</p> <p>Higher risk option: Group 1 FOP product (Assure II)</p>

* Clearfield winter wheat.

¹ Follow the 2-1-2 glyphosate resistance management strategy: No more than 2 applications of glyphosate in 1 field over a 2-year period.

² Ten-month rotation to sugar beets.

³ Nine-month rotation to sugar beets.

Table 3.

Recommended herbicide rotations for selected crops grown in rotation with spring wheat treated with a Group 1 herbicide (Achieve Liquid, Axial, Discover NG or Puma) in the Northern Plains.

Note: Touchdown, Gramoxone Max, Gramoxone Inteon and/or cultivation should be utilized as needed between crops as additional tools to manage herbicide-resistant weeds. Do not exceed two applications of glyphosate products on any one acre in two seasons.

Rotational Crop	Grass Herbicide
Spring barley	Primary option: Buckle or Far-Go
Spring wheat	Primary option: Far-Go followed by Everest, Silverado or Olympus
Winter wheat	Primary option: Far-Go, Buckle, Olympus or Osprey
Sunflower	Primary option: Beyond (IMI SF only), Sonalan, Treflan, Eptam or PROWL Secondary option: Assert® Higher risk option: Select
Dry beans	Primary option: Sonalan, Treflan, Eptam or PROWL Secondary option: Raptor Higher risk option: Select
Potatoes	Primary option: Eptam, Sencor®, PROWL or Matrix® (suppression) in tankmixture with Dual MAGNUM® Secondary higher risk option: Select
RR Canola	Primary option: Sonalan or Treflan followed by glyphosate Secondary option: Touchdown ¹
LL Canola	Primary option: Sonalan or Treflan followed by Liberty® Secondary option: Liberty

¹ Follow the 2-1-2 glyphosate resistance management strategy: No more than 2 applications of glyphosate in 1 field over a 2-year period.

Managing Resistance

In the event of suspected ACCase-inhibitor resistance to a Syngenta product, contact a Syngenta representative who will collect seed samples and have them tested. If ACCase-inhibitor resistance is confirmed in a weed population:

- Use as diverse a crop rotation as possible and herbicides with a different mode of action
- Where ACCase-inhibitor resistance has been characterized as FOP only, DEN or DIM chemistry will still be effective in rotation with other modes of action
- Make use of rotations based around herbicides with alternate modes of action (see Appendix 1)
- Do not use a mode of action change as the sole resistance management strategy
- Do not overuse the ALS inhibiting herbicides because of high potential for resistance development
- Do not combine low rates of multiple mode of action groups as this will expedite the development of resistance

Appendix 1:

Herbicides for grass weed control in the cereal growing regions of the United States (note: not all products are registered in all states—consult local weed control/crop protection guides for more information).

WSSA Group*	Mode of Action	Class	Active Ingredient	Key Products	Key Crops
1 (A)	ACCase inhibition	Aryloxyphenoxy-Propionate (FOP)	Clodinafop-propargyl	Discover NG	Wheat
			Fenoxaprop-P-ethyl	Puma	Cereals
			Diclofop-methyl	Hoelon®	Cereals
			Fluazifop-P-butyl	Fusilade, Fusion	Broadleaf crops ¹
			Quizalofop-P-ethyl	Assure	Broadleaf crops ¹
		Cyclohexanedione (DIM)	Tralkoxydim	Achieve Liquid	Cereals
			Clethodim	Select	Broadleaf crops ¹
			Sethoxydim	Poast, Rezult	Broadleaf crops ¹
		Phenylpyrazolin (DEN)	Pinoxaden	Axial	Cereals
2 (B)	ALS inhibition	Sulfonylurea (SU)	Triasulfuron	Amber®	Cereals
			Mesosulfuron-methyl	Osprey, Silverado®	Wheat
			Foramsulfuron	Option	Corn
			Nicosulfuron	Accent, Steadfast	Corn
			Rimsulfuron	Matrix, Steadfast	Corn
			Nicosulfuron + rimsulfuron + atrazine	Basis Gold®	Corn
			Sulfosulfuron	Maverick®	Cereals
			Imidazolinone (IMI)	Imazamethabenz-methyl	Assert
		Imazamox		Beyond, Raptor®	Clearfield crops (IMI-resistant), Soybean, Dry beans, Dry Peas
		Imazethapyr		Pursuit®, Extreme	Soybean, Beans, Peas
		Imazaquin		Scepter®	Soybean
		Sulfonylamino-carbonyl-triazolinone	Flucarbazone-Na	Everest	Wheat
			Propoxycarbazine-Na	Olympus	Wheat

*Group identifiers in parentheses are the HRAC classification codes

¹ For use in several broadleaf crops.

continued

Appendix 1 *continued*

WSSA Group*	Mode of Action	Class	Active Ingredient	Key Products	Key Crops
5 (C1)	Inhibition of photosynthesis at PSII	Triazine	Atrazine	AAtrex®	Corn
		Triazinone	Metribuzin	Sencor	Broad range
			Metribuzin + flufenacet	Axiom®	Corn, Soybean
7 (C2)	(as above)	Amide/anilide	Propanil	STAMPEDE™	Cereals
22 (D)	PSI electron diversion	Bypyridilium	Paraquat	Gramoxone Max/Inteon	Non-crop
			Diquat dibromide	Reglone®	Desiccant
28 (F2)	Inhibition of HPPD	Triketone	Mesotrione	Callisto™, LUMAX®	Corn
		Isoxazole	Isoxaflutole	Balance®	Corn
9 (G)	Inhibition of EPSPS	Glycine	Glyphosate	Touchdown, Roundup®, Extreme	Roundup Ready® (RR) crops, Non-RR crops
10 (H)	GS inhibition	Phosphinic acid	Glufosinate-ammonium	Liberty, Finale®	Liberty Link® crops
3 (K1)	Inhibition of microtubule assembly	Dinitroaniline (DNA)	Trifluralin	Treflan, Buckle	Broad range
			Pendimethalin	PROWL	Broad range
			Ethalfuralin	Sonalan	Broad range
23 (K3)	Inhibition of cell division and very long chain fatty acids	Chloracetamide	Metolachlor (+/or atrazine, +/or mesotrione)	Dual II MAGNUM, Dual MAGNUM, Bicep II MAGNUM, LUMAX, Camix®	Corn
			Acetochlor (+ atrazine, EPTC, etc.)	Surpass™, Harness®, Doubleplay®, TopNotch™	Corn
			Dimethenamid-P	Outlook®	Corn
			Alachlor	Lasso®	Corn
8 (N)	Inhibition of lipid biosynthesis	Thiocarbamate	Triallate	Far-Go, Buckle	Cereals
			EPTC	Eptam	Broadleaf crops ¹
			Cycloate	Ro-Neet	Broadleaf crops ¹
		Benzofuran	Ethofumesate	Nortron®	Broadleaf crops ¹
8 (Z)	Unknown	Pyrazolium	Difenzoquat-methyl sulfate	Avenge®	Cereals

*Group identifiers in parentheses are the HRAC classification codes

¹ For use in several broadleaf crops.

For more information, visit the Syngenta Crop Protection Web site at www.syngentacropprotection.com, the FarmAssist Web site at www.farmassist.com/crops/cereals or call the Syngenta Customer Resource Center at 866-SYNGENTA (866-796-4368).

Discover NG is registered for use on all types of wheat (including durum) in MN, MT, ND and SD.

Do not apply Achieve Liquid on spring wheat in MN, SD or east of Hwy 281 in ND. Do not apply Achieve Liquid in the following ND counties: Dickey, Eddy, Foster, LaMoure, Ramsey, Stutsman and Towner. Use of Achieve Liquid in these areas may result in crop injury to spring wheat.

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