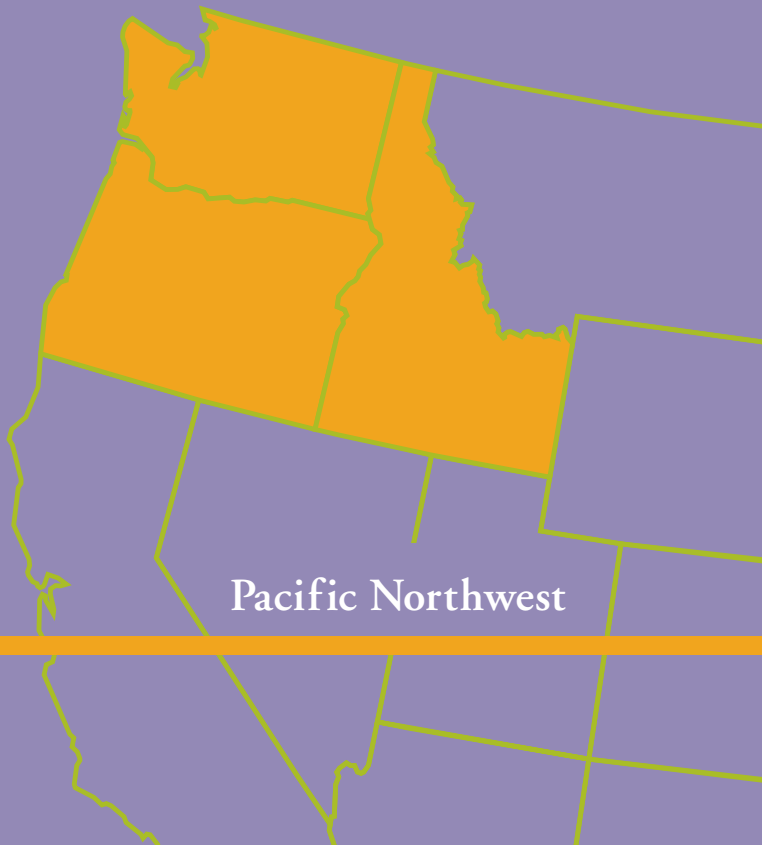




# Cereal Grass Weed Management and Stewardship



Pacific Northwest



# Cereal Grass Weed Management and Stewardship

## Objective

*The objective of this document is to provide a technical background for effective grass weed management in cereals for the Pacific Northwest (PNW). 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 labeled 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 PNW. Resistance in the PNW has been documented for both ACCase- and ALS-inhibiting herbicides.

In the PNW, ACCase-inhibitor herbicide resistance has been detected in wild oat (*Avena fatua*) and Italian (annual) ryegrass (*Lolium multiflorum*). ALS-inhibitor resistance has been confirmed in brome species (*Bromus* spp.). Jointed goatgrass (*Aegilops cylindrica*) may also become problematic as a result of limited available herbicide options (with over dependence on ALS-inhibitors). The key Syngenta wild oat and Italian ryegrass products are Axial™ (pinoxaden), Discover® (clodinafop-propargyl), Achieve® Liquid (tralkoxydim) and the broadleaf crop graminicide Fusilade® (fluazifop-P-butyl). 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



Italian Ryegrass



Downy Brome



Jointed Goatgrass

## 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 are affected. Unlike in Europe and Australia where metabolic resistance is widespread in several key grass species, it is relatively rare in North America.  
**Example:** Dinitroaniline (Treflan™) resistance in wild oat.

There are six to eight known resistant wild oat biotypes and three to four known resistant Italian ryegrass biotypes (see **Table 1**). The ACCase-inhibitor (Group 1) herbicides fall into three chemical classes: phenylpyrazolin (DEN), aryloxyphenoxy-propionates (FOP) and cyclohexanediones (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

Species	Biotypes	Resistance Type
<b>Wild oat</b>	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
<b>Italian ryegrass</b>	ACCcase-inhibitors: all FOPs and often tralkoxydim	Enhanced metabolism or target site
	ACCcase-inhibitors: all FOPs + DIMs	Target site
	ALS-inhibitors (sulfonylureas [SU])	Not determined

## Resistance Development

Repeated use of herbicides with the same mode of action 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.

A key factor in the development of resistant wild oat and Italian ryegrass biotypes in North America and the PNW 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). Evidence from the PNW indicates reduced efficacy of certain ALS-inhibiting herbicides. Additionally, Italian ryegrass has a higher propensity than wild oat to develop multiple resistance mechanisms; thus, careful management is required.

## 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 especially where weed infestations are high and 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.
- Ensure good coverage is achieved with proper spray volumes and calibrated equipment.
- Use multiple control tactics: make sequential applications and/or tankmixtures of herbicides with different modes of action, use pre-plant burndown applications of Touchdown® CT 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.
- Use the full, labeled rate of product with the recommended spray adjuvant.
- Avoid antagonism that may result from tankmixtures.
- Use a diverse crop/fallow rotation to extend the range of available herbicides and agronomic practices.
- Consider cultivation, fertilizer regimens, seeding rates and row widths that enhance crop competitiveness.
- Scout treated fields within three weeks of application to confirm that effective control has been achieved; re-treat with a different MOA/chemical class, if needed.
- 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, 3, 4). Recommendations in each table assume sensitive (non-resistant) weed populations. Each table details the recommended crop and herbicide rotations in the order of preferred choice. Follow either the primary or secondary options through the rotation scenarios. Rotation scenarios with weaker resistance management strategies are noted as “Higher Risk.”

Table 2. Wild oat, Non-irrigated crop systems

Scenario 1		
Year	Crop	Grass Herbicide
1	Winter wheat	<b>Primary option:</b> Axial or Discover Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops* <b>Secondary option:</b> Everest® or Osprey™ Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
2	Pulse	<b>Primary option:</b> Far-Go® Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops* <b>Secondary option:</b> Select® or Poast® Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
Scenario 2		
Year	Crop	Grass Herbicide
1	Winter wheat	<b>Primary option:</b> Discover Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops* <b>Secondary option:</b> Osprey, Everest** or Beyond™*** Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
2	Spring barley	<b>Primary option:</b> Axial, Achieve Liquid or Far-Go Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
	Spring wheat	<b>Primary option:</b> Axial, Achieve Liquid, Far-Go or Everest <b>Secondary option:</b> Axial or Achieve Liquid Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
3	Pulse	<b>Primary option:</b> Far-Go <b>Higher risk option:</b> Select or Poast Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
Scenario 3		
Year	Crop	Grass Herbicide
1	Winter wheat	<b>Primary option:</b> Osprey, Everest** or Beyond*** Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops* <b>Secondary option:</b> Discover Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
2	Spring barley	<b>Primary option:</b> Axial or Achieve Liquid Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops* <b>Secondary option:</b> Far-Go <b>Higher risk secondary option:</b> Axial or Achieve Liquid Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
	Spring wheat	<b>Primary option:</b> Axial, Discover or Achieve Liquid Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops* <b>Secondary option:</b> Far-Go <b>Higher risk option:</b> Axial or Achieve Liquid Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*

\* Not to exceed two applications of glyphosate products on any one acre in two seasons.

\*\* There is a 9-month rotational crop restriction to barley.

\*\*\* Clearfield® winter wheat.

Table 3. Italian ryegrass, Non-irrigated crop systems

Scenario 1		
Year	Crop	Grass Herbicide
1	Winter wheat	<b>Primary option:</b> Axiom*** followed by Osprey, Everest*** or Beyond**** Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops* <b>Secondary option:</b> Amber® and/or Axiom** followed by Axial, Achieve Liquid or Discover Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
2	Spring barley	<b>Primary option:</b> Axial or Achieve Liquid Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
	Spring wheat	<b>Primary option:</b> Axiom** followed by Axial, Achieve Liquid or Discover Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
3	Pulse	<b>Primary option:</b> Select <b>Higher risk option:</b> Poast Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
Scenario 2		
Year	Crop	Grass Herbicide
1	Winter wheat	<b>Primary option:</b> Axiom** followed by Osprey, Everest*** or Beyond**** <b>Secondary option:</b> Amber and/or Axiom** followed by Discover Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
2	Spring barley	<b>Primary option:</b> Axial or Achieve Liquid Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
	Spring wheat	<b>Primary option:</b> Discover, Axial or Achieve Liquid <b>Secondary option:</b> Axial or Achieve Liquid Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
Scenario 3 = Higher Risk		
Year	Crop	Grass Herbicide
1	Winter wheat	<b>Primary option:</b> Axiom** followed by Discover <b>Secondary option:</b> Axiom** followed by Osprey Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*
2	Pulse	<b>Primary option:</b> Non-FOP (Select, Poast) Touchdown or Gramoxone Max/Inteon and/or cultivation where needed between crops*

\* Not to exceed two applications of glyphosate products on any one acre in two seasons.

\*\* If registered.

\*\*\* There is a 9-month rotational crop restriction to barley.

\*\*\*\* Clearfield winter wheat.

Table 4. Wild oat, Irrigated crop systems

Scenario 1		
Year	Crop	Grass Herbicide
1	Spring wheat	<b>Primary option:</b> Achieve Liquid, Axial or Discover <b>Secondary option:</b> Far-Go
	Spring barley	<b>Primary option:</b> Achieve Liquid or Axial <b>Secondary option:</b> Far-Go
2	Spring wheat	<b>Primary option:</b> Far-Go <b>Secondary option:</b> Axial, Discover or Achieve Liquid
	Spring barley	<b>Primary option:</b> Far-Go <b>Secondary option:</b> Axial or Achieve Liquid
3	Potatoes	<b>Primary option:</b> Sencor® or Matrix® (suppression), in tankmixture with Dual MAGNUM®
Scenario 2		
Year	Crop	Grass Herbicide
1	Barley	<b>Primary option:</b> Axial, Achieve Liquid or Far-Go
	Wheat	<b>Primary option:</b> Discover, Axial or Achieve Liquid
2	Potatoes	<b>Primary option:</b> Eptam® or Sencor in tankmixture with Dual MAGNUM
3	Sugar beets	<b>Primary option:</b> Non ACCase-inhibitor (non-FOP preceeding Discover), Eptam (if not used in prior crop), Ro-Neet®, Treflan (suppression) in tankmixture with Dual MAGNUM

## Managing Resistance

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

- Do not use a FOP
- 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
- In the event of confirmed ACCase-inhibitor target site resistance to DIM or DEN chemistry, do not apply any ACCase-inhibiting herbicides
- Make use of rotations based around herbicides with alternate modes of action (see Appendix 1)
- Use as diverse a crop rotation as possible and herbicides with a different mode of action
- Do not overuse the ALS-inhibiting herbicides because of high potential for resistance development

## 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	Wheat
			Fenoxaprop-P-ethyl	Puma	Cereals
			Diclofop-methyl	Hoelon®	Cereals
			Fluazifop-P-butyl	Fusilade, Fusion®	Broadleaf crops <sup>1</sup>
			Quizalofop-P-ethyl	Assure®	Broadleaf crops <sup>1</sup>
		Cyclohexanedione (DIM)	Tralkoxydim	Achieve Liquid	Cereals
			Clethodim	Select	Broadleaf crops <sup>1</sup>
			Sethoxydim	Poast	Broadleaf crops <sup>1</sup>
		Phenylpyrazolin (DEN)	Pinoxaden	Axial	Cereals
2 (B)	ALS inhibition	Sulfonylurea (SU)	Triasulfuron	Amber	Cereals
			Mesosulfuron-methyl	Osprey, Silverado®	Wheat
			Foramsulfuron	Option®	Corn
			Nicosulfuron	Accent®	Corn
			Rimsulfuron	Matrix	Corn
			Nico. + rim. + atrazine	Basis Gold®	Corn
			Sulfosulfuron	Maverick®	Cereals
		Imidazolinone (IMI)	Imazamethabenz-methyl	Assert®	Cereals
			Imazamox	Beyond, Raptor®	Clearfield crops (IMI-resistant), Soybean, Dry beans, Dry Peas
			Imazethapyr	Pursuit®	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.

<sup>1</sup> For use in several broadleaf crops.

*continued*

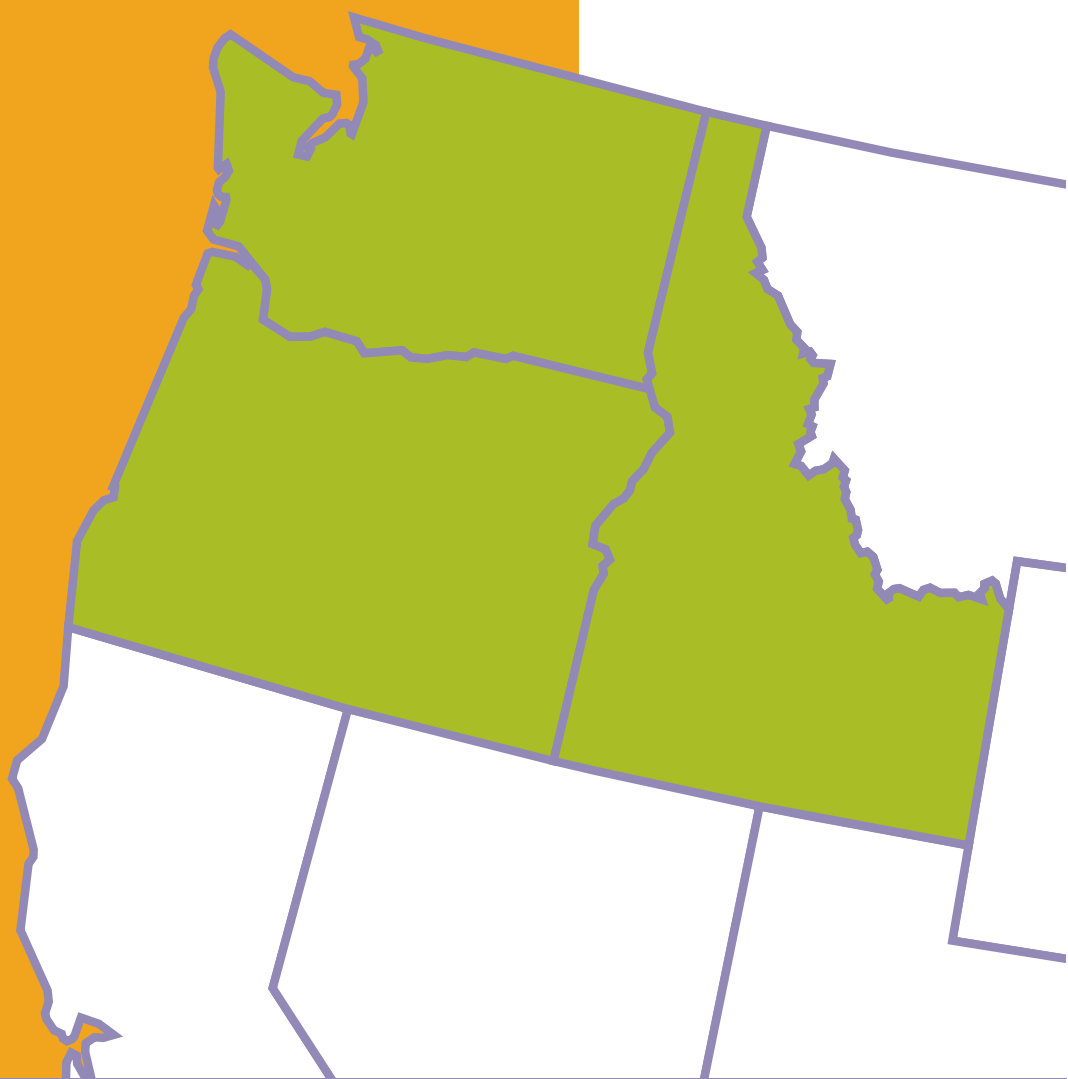
## Appendix 1 *continued*

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®	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	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 (Bicep) II MAGNUM, Bicep®, 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	Cereals
			EPTC	Eptam	Corn
		Benzofuran	Ethofumesate	Nortron®	Broadleaf crops <sup>1</sup>
8 (Z)	Unknown	Pyrazolium	Difenzoquat-methyl sulfate	Avenge®	Cereals

\* Group identifiers in parentheses are the HRAC classification codes.

<sup>1</sup> For use in several broadleaf crops.

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



Discover 2EC is currently registered in MN, MT, ND and SD on all types of wheat (including durum). Discover 2EC may be used on wheat (including durum) in ID, OR, WA, UT and WY in accordance with the Special Local Needs provisions of the EPA under the 24(c) registrations and 2(ee) recommendations. You must have a copy of the approved 24(c) registration and 2(ee) recommendations in your possession in order to use Discover 2EC, and you must comply with all of the limitations for use set forth in both the 24(c) registration and the 2(ee) recommendation.

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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