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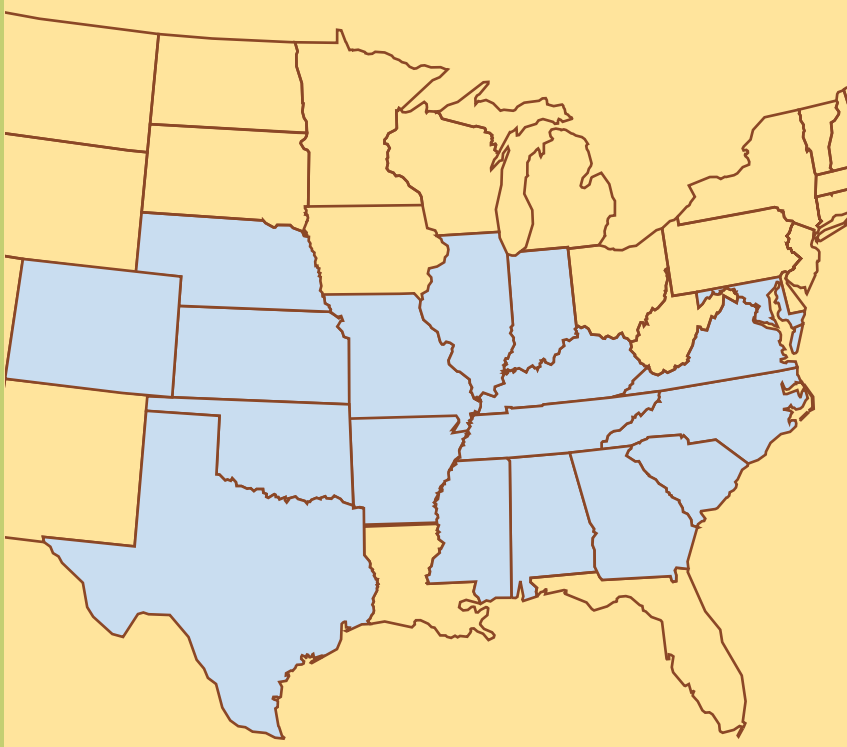
Cereal Grass Weed Management and Stewardship



Southern Field Crops &
Mid-Atlantic States

Objective

The objective of this document is to provide a technical background for effective grass weed management in cereals for the Southern and Mid-Atlantic States. 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 Southern and Mid-Atlantic States. Resistance in the Southern and Mid-Atlantic states has been documented with four herbicide modes of action: ACCase-inhibitors, ALS-inhibitors, photosystem II-inhibitors and dinitroanalines.

In the Southern and Mid-Atlantic states, ACCase-inhibitor herbicide resistance has been detected in Italian (annual) ryegrass (*Lolium multiflorum*) and perennial ryegrass (*Lolium perenne*). ALS-inhibitor resistance has been confirmed in Italian and perennial ryegrasses with at least one example of multiple resistance to ACCase-inhibitor and ALS-inhibitor herbicides in perennial ryegrass. In annual bluegrass (*Poa annua*), resistance has been reported to photosystem II-inhibitors and to dinitroanalines. Cheat (*Bromus secalinus*) may also become problematic as a result of over dependence on ALS-inhibitors. The key Syngenta products for control of Italian ryegrass and wild oat are Axial® (pinoxaden), Achieve® Liquid (tralkoxydim) and the broadleaf crop graminicides Fusilade® (fluazifop-P-butyl) and Fusion® (fluazifop-P-butyl + fenoxyprop). 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**.


Perennial ryegrass


Annual Bluegrass


Cheat


Italian ryegrass

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 redroot pigweed (*Amaranthus retroflexus*).

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 is relatively rare in North America. **Example:** ACCase-inhibitor and ALS-inhibitor resistance in wild oat.

There is one or more known resistant biotypes of key grass weed species in the Southern and Mid-Atlantic States (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 (Hoelon®, Fusilade) and not to a DEN (Axial) or DIM (Select®, Poast®).

Table 1. Known Resistant Italian Ryegrass and Wild Oat Biotypes in North America.

Species	Biotypes	Resistance Type
Italian ryegrass	ACCase-inhibitors: all FOPS and often tralkoxydim	Enhanced metabolism or target site
	ACCase-inhibitors: all FOPS + DIMS	Target site
	ALS-inhibitors (sulfonylureas [SU])	Not determined
Wild oat	ACCase-inhibitors: all FOPS	Target site
	ACCase-inhibitors: all FOPS + DIMS	Target site
	ALS-inhibitors	Not determined
	Dinitroanilines	Not determined
	Triallate and/or difenzoquat	Metabolic
	ACCase-inhibitors FOP, ALS-inhibitors (imidazolinone) and often triallate	Metabolic

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 Italian ryegrass and wild oat biotypes in North America and the Southern and Mid-Atlantic states has been the heavy reliance and frequent use of the FOP and DIM classes of ACCase-inhibitors in cereal ***and*** broadleaf crops (**Appendix 1**). A similar over-reliance on ALS-inhibiting herbicides has resulted in the development of resistance to this herbicide mode of action. 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 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 Inteon™ and/or cultivation in the fallow portion of the crop rotation
- Avoid the repeated use of herbicides within the same mode of action 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/fallow 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 three weeks following application to confirm that effective control has been achieved; re-treat with a different mode of action/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 2-5**). Recommendations in each table assume sensitive (non-resistant) weed populations. Each table details examples of crop rotations that utilize herbicides with different herbicide modes of action.

Table 2. Winter wheat – Italian ryegrass – Southern Region

Scenario 1		
Year	**Crop**	**Grass Herbicide**
1 **Spring** **Fall**	Soybean Fallow	Touchdown[1,2], Sequence®[1,2], Dual Magnum®, Prefix™ or PROWL® Gramoxone Inteon or Touchdown[1]
2 **Spring** **Fall**	Soybean Wheat	Touchdown[1,2], Sequence[1,2], Dual Magnum, Prefix or PROWL Axial
3 **Spring** **Fall**	Soybean Fallow	Touchdown[1,2], Sequence[1,2], Dual Magnum, Prefix or PROWL Gramoxone Inteon or Touchdown[1]
4 **Spring** **Fall**	Corn Wheat	Bicep II Magnum®, Dual II Magnum®, Lexar®, Lumax®, Touchdown[1,3], Sequence[1,3], Expert®[1,3], NorthStar®, Guardsman Max®, Accent® or Steadfast® **Primary option:** Osprey™ or Finesse® **Secondary option:** Axial
Scenario 2		
Year	**Crop**	**Grass Herbicide**
1 **Spring** **Fall**	Corn Wheat	Bicep II Magnum, Lexar, Dual II Magnum, Lumax, Touchdown[1,3], Sequence[1,3], Expert[1,3], NorthStar, Guardsman Max, Accent or Steadfast Axial
2 **Spring** **Fall**	Soybean Fallow	Touchdown[1,2], Sequence[1,2], Dual Magnum, Prefix or PROWL Gramoxone Inteon or Touchdown[1]
3 **Spring** **Fall**	Corn Fallow	Bicep II Magnum, Dual II Magnum, Lexar, Lumax, Touchdown[1,3], Sequence[1,3], Expert[1,3], NorthStar, Guardsman Max, Accent or Steadfast Gramoxone Inteon or Touchdown[1]
4 **Spring** **Fall**	Soybean Fallow	Touchdown[1,2], Sequence[1,2], Dual Magnum, Prefix or PROWL Gramoxone Inteon or Touchdown[1]
Scenario 3		
Year	**Crop**	**Grass Herbicide**
1 **Spring** **Fall**	Soybean Wheat	Touchdown[1,2], Sequence[1,2], Dual Magnum, Prefix or PROWL Axial
2 **Spring** **Fall**	Soybean Fallow	Touchdown[1,2], Sequence[1,2], Dual Magnum, Prefix or PROWL Gramoxone Inteon or Touchdown[1]
3 **Spring** **Fall**	Rice Fallow	Stam™, PROWL, Command®, Regiment™, Newpath™ (Clearfield®-tolerant rice only) or Facet® Gramoxone Inteon or Touchdown[1]
Scenario 4		
Year	**Crop**	**Grass Herbicide**
1	Winter Wheat	Axial, Amber® followed by Axial or Axial + Amber tankmix Touchdown[1] or Gramoxone Inteon for burndown
2	Winter Wheat	Osprey Touchdown[1] or Gramoxone Inteon for burndown

[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] Preplant/pre-emergence to all soybeans; post-emergence to glyphosate-tolerant soybeans only.

[3] Preplant/pre-emergence to all corn; post-emergence to glyphosate-tolerant corn only.

Table 3. **Winter wheat – Italian ryegrass – Delmarva Region**

Scenario 1		
Year	**Crop**	**Grass Herbicide**
1 Spring	Corn	Bicep II Magnum, Dual II Magnum, Lexar, Touchdown[1] (glyphosate-tolerant corn only), Guardsman Max, Princep or Steadfast ATZ
Fall	Wheat	Axial
2 Spring	Soybean	Touchdown[1] (glyphosate-tolerant soybeans only), Dual Magnum, Prefix or PROWL
Fall	Fallow	Gramoxone Inteon or Touchdown[1]
3 Spring	Corn	Bicep II Magnum, Dual II Magnum, Lexar, Touchdown[1] (glyphosate-tolerant corn only), Guardsman Max, Princep or Steadfast ATZ
Fall	Wheat	Axial or Osprey
4 Spring	Soybean	Touchdown[1] (glyphosate-tolerant soybeans only), Dual Magnum, Prefix, PROWL, Lorox® or Sencor®
Fall	Fallow	Gramoxone Inteon or Touchdown[1]
Scenario 2		
Year	**Crop**	**Grass Herbicide**
1 Spring	Corn	Bicep II Magnum, Dual II Magnum, Lexar, Touchdown[1] (glyphosate-tolerant corn only), Guardsman Max, Princep or Steadfast ATZ
Fall	Wheat	Axial
2 Spring	Snapbeans	Dual Magnum or Treflan™
Fall	Fallow	Gramoxone Inteon or Touchdown[1]
3 Spring	White potato	Dual Magnum, Outlook®, Sencor or PROWL
Fall	Wheat	Osprey
4 Spring	Soybean	Touchdown[1] (glyphosate-tolerant soybeans only), Dual Magnum, Prefix or PROWL, Lorox or Sencor
Fall	Wheat	Axial

[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.

Table 4.

Recommended herbicide rotations for selected crops grown in rotation with winter wheat treated with a Group 1 herbicide (Axial) in the Delmarva region. Rotation scenarios with weaker resistance management strategies are noted as "higher risk."

Note: Touchdown, Gramoxone Inteon, and/or cultivation should be utilized as needed between crops as additional tools to manage herbicide-resistant weeds. Avoid using more than two applications of glyphosate products on any one acre in two seasons.

Crop	Grass Herbicide
Corn	Bicep II Magnum, Dual II Magnum, Lexar, Touchdown[1] (glyphosate-tolerant corn only), Guardsman Max, Princep or Steadfast ATZ
Soybean	Touchdown[1] (glyphosate-tolerant soybeans only), Dual Magnum, Prefix or PROWL, Lorox or Sencor
Cotton	Touchdown[1] (glyphosate-tolerant cotton only), Dual Magnum, PROWL, Treflan or Ignite® (glufosinate-tolerant cotton only)
Snap bean	Dual Magnum or Treflan
White Potato	Dual Magnum, Outlook, Sencor or PROWL
Squash	**Primary option:** Strategy
Cucumber	**Primary option:** Curbit®, Command or Strategy **Secondary option (higher risk):** Select
Melons	**Primary option:** Strategy or Command **Secondary option (higher risk):** Select
Tomato *(transplanted)*	**Primary option:** Treflan, Tillam or Sencor **Secondary option (higher risk):** Select
Peppers *(transplanted)*	**Primary option:** Treflan or Dual Magnum (check local label recommendations) **Secondary option (higher risk):** Select

[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.

Table 5. **Winter Wheat – Wild Oat – Southern Region**

Scenario 1		
Year	**Crop**	**Grass Herbicide**
1	Winter Wheat	Axial or Achieve Liquid Touchdown[1] or Gramoxone Inteon for burndown
2	Winter Wheat	Osprey Touchdown or Gramoxone Inteon for burndown
3	Cotton	Dual Magnum, PROWL, Touchdown[3] or Sequence[3]
Scenario 2		
Year	**Crop**	**Grass Herbicide**
1	Wheat	Axial or Achieve Liquid
2	Corn	Bicep II Magnum, Dual II Magnum, Lexar, Lumax, Touchdown[1,2], Sequence[1,2], Expert[1,2], NorthStar, Guardsman Max, Accent or Steadfast
3	Grain Sorghum	Bicep II Magnum or Dual Magnum plus AAtrex® fb Peak® or Peak + AAtrex

[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] Preplant/pre-emergence to all corn; post-emergence to glyphosate-tolerant corn only.

[3] Preplant/pre-emergence to all cotton; post-emergence to glyphosate-tolerant cotton only.

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 different modes 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-inhibitor 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 weed 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 and follow all product label use directions.)

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
			Prosulfuron	Peak	Cereals, Sorghum
			Mesosulfuron-methyl	Osprey, Silverado™	Wheat
			Metsulfuron + chlorsulfuron	Finesse	Wheat, Barley
			Foramsulfuron	Option®	Corn
			Nicosulfuron	Accent, Steadfast	Corn
			Rimsulfuron	Matrix®, Steadfast	Corn
			Nicosulfuron + rimsulfuron + atrazine	Basis Gold®, Steadfast ATZ	Corn
			Sulfosulfuron	Maverick®	Cereals
			Primisulfuron + dicamba	NorthStar	Corn
		Imidazolinone (IMI)	Imazamethabenz-methyl	Assert®	Cereals
			Imazamox	Beyond®, Raptor®	Clearfield crops (IMI-resistant), Soybean, Dry beans, Dry peas
			Imazethapyr	Pursuit®, Extreme®	Soybean, Beans, Peas
			Imazethapyr	Newpath	Clearfield rice
			Imazaquin	Scepter®	Soybean
		Pyrimidinylthiobenzoate	Bispyribac-sodium	Regiment	Rice
		Sulfonylamino-carbonyl-triazolinone	Flucarbazone-sodium	Everest®	Wheat
			Propoxycarbazone-Na	Olympus™	Wheat

*Group identifiers in parentheses are the HRAC classification codes

continued

[1] For use in several broadleaf crops.

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
			Simazine	Princep	Corn
		Triazinone	Metribuzin	Sencor	Broad range
			Metribuzin + flufenacet	Axiom®	Corn, Soybean
7 (C2)	(as above)	Amide/anilide	Propanil	STAMPEDE™	Cereals
			Propanil	Stam	Rice
		Urea	Linuron	Lorox	Broad range
22 (D)	PSI electron diversion	Bypyridilium	Paraquat	Gramoxone Inteon	Non-crop
			Diquat dibromide	Reglone®	Desiccant
28 (F2)	Inhibition of HPPD	Triketone	Mesotrione	Callisto®, Lumax, Lexar, Camix®	Corn
		Isoxazole	Isoxaflutole	Balance®	Corn
11 (F3)	Inhibition of carotenoid biosynthesis	Isoxazolidinone	Clomazone	Command	Broad range
9 (G)	Inhibition of EPSPS	Glycine	Glyphosate (+/or imazethapyr, +/or *S*–metolachlor, +/or atrazine)	Touchdown, Roundup®, Extreme, Sequence, Expert	Roundup Ready® (RR™) crops, Non-RR crops
10 (H)	GS inhibition	Phosphinic acid	Glufosinate-ammonium	Liberty®, Finale®, Ignite	Liberty Link® crops
3 (K1)	Inhibition of microtubule assembly	Dinitroaniline (DNA)	Trifluralin	Treflan, Buckle®	Broad range
			Pendimethalin	PROWL	Broad range
			Ethalfluralin	Sonalan™	Broad range
			Ethalfluralin + clomazone	Strategy	Broadleaf crops[1]
23 (K3)	Inhibition of cell division and very long chain fatty acids	Chloracetamide	*S*-Metolachlor (+/or atrazine, +/or mesotrione)	Dual II Magnum, Dual Magnum, Bicep II Magnum, Camix, Lumax, Lexar	Corn
			S-Metolachlor + fomesafen	Prefix	Soybean
			Acetochlor (+ atrazine, EPTC, etc.)	Surpass™, Harness®, Doubleplay®, TopNotch™	Corn
			Dimethenamid-P	Outlook	Broad range
			Dimethenamid-P + atrazine	Guardsman Max	Corn, Sorghum
			Alachlor	IntRRo®	Soybean, other crops
8 (N)	Inhibition of lipid biosynthesis	Thiocarbamate	Triallate	Far-Go®, Buckle	Cereals
			EPTC	Eptam	Broadleaf crops[1]
			Cycloate	Ro-Neet®	Broadleaf crops[1]
			Pebulate	Tillam	Broadleaf crops[1]
		Benzofuran	Ethofumesate	Nortron®	Broadleaf crops[1]
4 (O)	Synthetic auxin	Quinoline carboxylic acid	Quinclorac	Facet	Rice
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 Center at 866-SYNGENTA (866-796-4368).

Discover NG is currently registered in MN, MT, ND and SD on all types of wheat (including durum). Discover NG may be used on wheat (including durum) in ID, OR, WA 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) registrations and 2(ee) recommendations in your possession in order to use Discover NG, and you must comply with all of the limitations for use set forth in the 24(c) and 2(ee) registrations. As of the date of printing, a Section 24(c) application is pending for Discover NG on wheat (including durum) in UT.

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.

AAtrex, Balance, Bicep II Magnum, Expert, Guardsman Max, Gramoxone Inteon, Harness, Hoelon, IntRRo, Lexar, Lumax, Surpass and TopNotch are Restricted Use Pesticides.

GS 406.70110 SCP 040-00030-A

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