

USING HERBICIDE SITE OF ACTION FOR REDUCING THE RISK OF DEVELOPING HERBICIDE-RESISTANT WEEDS

Weed Facts WF-14



Reducing the risk for developing herbicide-resistant weed populations requires incorporating a number of guidelines in managing your fields. These guidelines include:

- Spray only when necessary
- Use alternative methods of control whenever possible such as mechanical cultivation or delayed planting (row crops), mowing (forage crops), and using weed-free crop seeds
- Rotate crops and their accompanying herbicides' site of action
- Limit number of applications of herbicide(s) with same site of action in a given growing season
- Use mixtures or sequential herbicide treatments having different sites of action that will control the weeds of concern
- Scout fields after herbicide application to detect weed escapes or shifts
- Clean equipment before leaving fields infested with or suspected to have resistant weeds

Rotating herbicides with differing sites of action is important for minimizing the risk of developing herbicide-resistant weeds. However, information on herbicide site of action is often not printed on herbicide labels and thus is difficult to obtain. The following tables are designed to assist with herbicide selection based on herbicide site of action.

Below (Table A) is a list of important herbicide groups for agronomic crops grown in the Mid-Atlantic region. To reduce the risk of developing herbicide resistant weeds, **avoid repeated use of herbicides with the same site of action**. Note that more than one herbicide family may have the same site of action.

A list of common pre-package herbicide mixture and their components is contained in Table B. Be sure to know the site of action for all the herbicides included in the pre-package mixture.

Table A: Important herbicide groups for corn, soybean, small grain, commercial vegetable and forage.

Herbicide class	Site of action	Family	Active ingredient	Trade name	WSSA group ¹
Plant growth regulators	IAA-like	phenoxy	2-4-D	various	4
			2,4-DB	Butyrac	
			MCPA	various	
		benzoic acid	dicamba	Banvel, Clarity	4
		carboxylic acid (pyridines)	aminopyralid	Milestone	4
			clopyralid	Stinger	
			fluroxypyr	Starane, Vista	
			picloram	Tordon	
			triclopyr	Garlon, Remedy	
Auxin transport inhibitor	IAA transport	semicarbazone	diflufenzopyr	none	19
		phthalamate	naptalam	Alanap	19

Herbicide class	Site of action	Family	Active ingredient	Trade name	WSSA group ¹			
Amino acid biosynthesis	ALS-enzyme	imidazolinone	imazamethabenz imazamox imazapic imazapyr imazaquin imazethapyr	Assert Raptor, Beyond Plateau Arsenal Scepter Pursuit	2			
		sulfonylamino-carbonyl-triazolinones	flucarbazone propoxycarbazone thiencarbazone	Everest Olympus none	2			
Amino acid biosynthesis	ALS-enzyme	sulfonylurea	chlorimuron chlorsulfuron foramsulfuron halosulfuron iodosulfuron mesosulfuron metsulfuron nicosulfuron primisulfuron prosulfuron rimsulfuron thifensulfuron sulfosulfuron triasulfuron tribenuron	Classic Glean, Telar Option Permit, Sandea Autumn Osprey Ally, various Accent Beacon Peak Resolve Harmony SG Maverick Amber Express	2			
			triazolopyrimidine (sulfonamides)	cloransulam flumetsulam	FirstRate Python	2		
			EPSP-enzyme	amino acid derivative	glyphosate	Roundup, Touchdown	9	
			Fatty acid (Lipid) biosynthesis inhibitors	ACCase	aryloxyphenoxy propionates	diclofop fenoxaprop fluazifop quizalofop	Hoelon none Fusilade Targa, Assure II	1
					cyclohexanediones	clethodim sethoxydim tralkoxydim	Select Poast, Poast Plus Achieve	1
phenylpyrazolin	pinoxaden	Axial			1			
Seedling growth inhibitors (Root)	Microtubule inhibitors	dinitroanilines	benefin ethalfuralin pendimethalin trifluralin prodiamine	Balan Curbit, Sonalan Prowl, Pendulum Treflan, various Barricade	3			
		pyridazines	dithiopyr	Dimension	3			
		Unknown	none	DCPA	Dacthal	3		
Seedling growth inhibitors (Shoot)	Unknown	chloroacetamides	acetochlor alachlor dimethenamid metolachlor pronamide propachlor	Harness, Topnotch Breakfree, Degree Lasso, Micro-Tech Outlook Dual, Cinch Kerb Ramrod	15			
			acetamides	napropamide	Devrinol	15		
			oxyacetamides	flufenacet	Define	15		

Herbicide class	Site of action	Family	Active ingredient	Trade name	WSSA group ¹
Photosynthesis inhibitors (mobile 1)	Lipid synthesis inhibitors	thiocarbamates	butylate cycloate EPTC vernolate	Sutan Ro-Neet Eptam, Eradicane Vernam	8
		none	bensulide	Prefar	8
	Photosystem II	phenylcarbamates	phenmedipham	Spin-Aid	5
		triazines	ametryn atrazine prometon simazine	Evik Atrazine Pramitol Princep	5
		triazinones	hexazinone metribuzin	Velpar Metribuzin	5
uracils	terbacil	Sinbar	5		
Photosynthesis inhibitors (mobile 2)	Photosystem II	ureas	diuron linuron tebuthiuron	Karmex Lorox Spike	7
Photosynthesis inhibitors (non-mobile)	Photosystem II	benzothiadiazole	bentazon	Basagran	6
		nitriles	bromoxynil	Buctril	6
		phenyl-pyridazine	pyridate	Tough	6
Cell membrane disrupters	PPO (protoporphyrinogen oxidase)	diphenyl ethers	acifluorfen	Blazer	14
			fomesafen	Reflex, Flexstar	
			lactofen	Cobra	
			oxyfluorfen	Goal	
		N-phenyl-phthalimides	flumiclorac flumioxazin fluthiacet	Resource Valor, Chateau Cadet	14
oxadiazole	oxadiazon	Ronstar	14		
triazolinone	carfentrazone sulfentrazone	Aim Authority, Spartan	14		
Pigment inhibitors	Photosystem I	bipyridyliums	paraquat	Gramoxone	22
	PDS (carotenoid biosynthesis)	pyridazinone	norflurazon	Solicam	12
	HPPD (hydroxy-phenyl-pyruvate-dioxygenase)	triketone	mesotrione tembotrione topramezone	Callisto Laudis Impact	27
Phosphorylated amino acid (N metabolism disrupter)	Glutamine synthetase	amino acid derivative	glufosinate	Ignite, Finale	10
Cell wall biosynthesis inhibitor	Synthesis - site B	benzamide	isoxaben	Gallery	21
	Unknown	quinoline carboxylic acid	quinclorac	Paramount	26

¹WSSA group is a system of classifying herbicides developed by the Weed Science Society of America, based on mode and site of actions, to help understand and plan for resistance management. The reference for this table is: E. James Retzinger and Carol Mallory-Smith. 1997. Classification of Herbicides by Site of Action for Weed Resistance Management Strategies. Weed Technology volume 11, pages 384 to 393.

Table B: Common pre-pack or premix herbicides for crops in the Mid-Atlantic region. The WSSA mode of action (MOA) numbers are the WSSA group numbers (right-hand column of Table A) for herbicide site of action.

Pre-packaged herbicide	Constituent products	WSSA MOA #'s	Pre-packaged herbicide	Constituent products	WSSA MOA #'s
Authority Assist	Authority, Pursuit	14, 2	Journey	Plateau, glyphosate	2, 9
Authority First	Authority, FirstRate	14, 2	Keystone	Harness, atrazine	15, 5
Authority MTZ	Authority, Metribuzin	14, 5	Latigo	Banvel, 2,4-D	4, 4
Axiom	Define, Metribuzin	15, 5	Lexar	Dual, Callisto, atrazine	15, 27, 5
Basis	Resolve, Harmony SG	2, 2	Lightning	Pursuit, Arsenal	2, 2
Bicep II Magnum	Dual, atrazine	15, 5	Lumax	Dual, Callisto, atrazine	15, 27, 5
Boundary	Dual, Metribuzin	15, 5	Marksman	Banvel, atrazine	4, 5
Breakfree ATZ	Breakfree, atrazine	15, 5	Milestone VM Plus	Milestone, Remedy Ultra	4, 4
Bullet	Micro-Tech, atrazine	15, 5	NorthStar	Banvel, Beacon	4, 2
Callisto Xtra	Callisto, atrazine	27, 5	Olympus Flex	Olympus, Osprey	2, 2
Canopy	Classic, Metribuzin	2, 5	OpTill	Sharpen, Pursuit	14, 2
Canopy EX	Classic, Express	2, 2	Overdrive	Banvel, diflufenzopyr	4, 19
Capreno	Thiencarbazone, Laudis	2, 27	PastureGard	Remedy, Vista	4, 4
Cimarron Max	metsulfuron, Banvel, 2,4-D	2, 4, 4	Prefix	Dual, Reflex	15, 14
Cimarron Plus	metsulfuron, Telar	2, 2	Rage D-Tech	Aim, 2,4-D	14, 4
Cinch ATZ	Cinch, atrazine	15, 5	Resolve Q	Resolve, Harmony SG	2, 2
Crossbow	Remedy, 2,4-D	4, 4	Sahara	Arsenal, Karmex	2, 7
Degree Xtra	Degree, atrazine	15, 5	Sequence	Dual, glyphosate	15, 9
Distinct	Banvel, diflufenzopyr	4, 19	Shotgun	atrazine, 2,4-D	5, 4
Envive	Classic, Harmony SG, Valor	2, 2, 14	Sonic	Authority, FirstRate	14, 2
Expert	Dual, atrazine, glyphosate	15, 5, 9	Spartan Charge	Aim, Spartan	14, 14
Extreme	Pursuit, glyphosate	2, 9	Spirit	Peak, Beacon	2, 2
Finesse	Glean, Ally	2, 2	Status	Banvel, diflufenzopyr	4, 19
Finesse Gr & BL	Glean, Everest	2, 2	Steadfast	Accent, Resolve	2, 2
Flexstar GT	Flexstar, glyphosate	14, 9	Steadfast ATZ	Accent, Resolve, atrazine	2, 2, 5
ForeFront R&P	Milestone, 2,4-D	4, 4	Storm	Basagran, Blazer	6, 14
Fultime	Topnotch, atrazine	15, 5	Strategy	Command, Curbit	13, 3
Fusion	Fusilade, fenoxaprop	1, 1	SureStart	Harness, Python, Stinger	15, 2, 4
Gangster	Valor SX, FirstRate	14, 2	Synchrony XP	Classic, Harmony SG	2, 2
Guardzman Max	Outlook, atrazine	15, 5	TripleFlex	Harness, Python, Stinger	15, 2, 4
Halex GT	Dual, Callisto, glyphosate	15, 27, 9	Valor XLT	Valor SX, Classic	14, 2
Harmony Extra	Harmony SG, Express	2, 2	Verdict	Sharpen, Outlook	14, 15
Harness Xtra	Harness, atrazine	15, 5	Weedmaster	Banvel, 2,4-D	4, 4
Hornet WDG	Python, Stinger	2, 4	Yukon	Sandea, Banvel	2, 4

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