Appendix 7.
Classification of Herbicides According to Mode of Action

Farmers, advisors and researchers should know which herbicides are best suited to combat specific resistant weeds. To support the use of herbicides suitable for resistance management the enclosed classification of herbicides is proposed.

The herbicides are classified alphabetically according to their target sites, modes of action, similarity of induced symptoms or chemical classes.

If different herbicide groups share the same mode or site of action only one letter is used. In the case of photosynthesis inhibitors subclasses C_1, C_2 and C_3 indicate different binding behaviour at the binding protein D_1 or different classes. Bleaching can be caused by different ways. Accordingly subgroups F_1, F_2 and F_3 are introduced. Growth inhibition can be induced by herbicides from subgroups K_1, K_2 and K_3. Herbicides with unknown modes or sites of action are classified in group Z as "unknown" until they can be grouped exactly.

Classification of Herbicides

In order to avoid confusion with I and O categories J and Q are omitted. New herbicides will be classified in the respective groups or in new groups (R, S, T...).

Since the system was in part developed in co-operation with the "Weed Science Society of America (WSSA)" new herbicides should be categorized jointly by HRAC and WSSA.

For reference the numerical system of the WSSA is listed, too.

The aim of HRAC is to create a uniform classification of herbicide modes of action in as many countries as possible.

Such a classification system can be useful for many instances but there are cases where weeds exhibit multiple resistance across many of the groups listed and in these cases the key may be of limited value.

The system itself is *not* based on resistance risk assessment but can be used by the farmer or advisor as a tool to choose herbicides in different mode of action groups, so that mixtures or rotations of active ingredients can be planned.

The WSSA and HRAC systems differ in minor ways. Herbicides in *italics* are listed on the HRAC classification system but are not listed on the WSSA classification.

HRAC: Herbicide classification

HRAC Group	Mode of Action	Chemical Family	Active Ingredient	WSSA Group
A	Inhibition of acetyl CoA carboxylase (ACCase)	Aryloxyphenoxy-propionate 'FOPs'	clodinafop-propargyl cyhalofop-butyl diclofop-methyl fenoxaprop-P-ethyl fluazifop-P-butyl haloxyfop-R-methyl propaquizafop quizalofop-P-ethyl	**1**
		Cyclohexanedione 'DIMs'	alloxydim butroxydim clethodim cycloxydim *profoxydim* sethoxydim *tepraloxydin* tralkoxydim	
		Phenylpyrazoline 'DEN'	pinoxaden	
B	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	Sulfonylurea	amidosulfuron azimsulfuron bensulfuron-methyl chlorimuron-ethyl chlorsulfuron cinosulfuron cyclosulfamuron ethametsulfuron-methyl ethoxysulfuron flazasulfuron flupyrsulfuron-methyl-Na foramsulfuron halosulfuron-methyl *imazosulfuron* iodosulfuron mesosulfuron metsulfuron-methyl nicosulfuron *oxasulfuron* primisulfuron-methyl prosulfuron pyrazosulfuron-ethyl rimsulfuron sulfometuron-methyl sulfosulfuron thifensulfuron-methyl triasulfuron tribenuron-methyl trifloxysulfuron triflusulfuron-methyl *tritosulfuron*	**2**

HRAC Group	Mode of Action	Chemical Family	Active Ingredient	WSSA Group
		Imidazolinone	imazapic imazamethabenz-methyl imazamox imazapyr imazaquin imazethapyr	
		Triazolopyrimidine	cloransulam-methyl diclosulam florasulam flumetsulam *metosulam* *penoxsulam*	
		Pyrimidinyl(thio)benzoate	bispyribac-Na pyribenzoxim *pyriftalid* pyrithiobac-Na *pyriminobac-methyl*	
		Sulfonylaminocarbonyl-triazolinone	flucarbazone-Na propoxycarbazone-Na	
C1	Inhibition of photosynthesis at photosystem II	Triazine	ametryne atrazine cyanazine desmetryne *dimethametryne* prometon prometryne propazine simazine simetryne terbumeton terbuthylazine *terbutryne* trietazine	**5**
		Triazinone	hexazinone metamitron metribuzin	
		Triazolinone	amicarbazone	
		Uracil	bromacil *lenacil* terbacil	
		Pyridazinone	pyrazon = chloridazon	
		Phenyl-carbamate	desmedipham phenmedipham	
C2	Inhibition of photosynthesis at photosystem II	Urea	*chlorobromuron* chlorotoluron *chloroxuron*	**7**

HRAC Group	Mode of Action	Chemical Family	Active Ingredient	WSSA Group
		Urea (continued)	dimefuron diuron *ethidimuron* *fenuron* fluometuron (see F3) isoproturon *isouron* linuron methabenzthiazuron *metobromuron* metoxuron monolinuron *neburon* siduron tebuthiuron	
		Amide	propanil *pentanochlor*	
C3	Inhibition of photosynthesis at photosystem II	Nitrile	*bromofenoxim* bromoxynil ioxynil	**6**
		Benzothiadiazinone	bentazon	
		Phenyl-pyridazine	pyridate *pyridafol*	
D	Photosystem-I-electron diversion	Bipyridylium	diquat paraquat	**22**
E	Inhibition of protoporphyrinogen oxidase (PPO)	Diphenylether	acifluorfen-Na bifenox *chlomethoxyfen* *fluoroglycofen-ethyl* fomesafen *halosafen* lactofen	**14**
		Diphenylether	oxyfluorfen	
		Phenylpyrazole	*fluazolate* pyraflufen-ethyl	
		N-phenylphthalimide	cinidon-ethyl flumioxazin flumiclorac-pentyl	
		Thiadiazole	fluthiacet-methyl *thidiazimin*	
		Oxadiazole	oxadiazon oxadiargyl	
		Triazolinone	azafenidin *carfentrazone-ethyl* *sulfentrazone*	

HRAC Group	Mode of Action	Chemical Family	Active Ingredient	WSSA Group
		Oxazolidinedione	*pentoxazone*	
		Pyrimidindione	*benzfendizone* butafenacil	
		Other	*pyraclonil* *profluazol* flufenpyr-ethyl	
F1	Bleaching: Inhibition of carotenoid biosynthesis at the phytoene desaturase step (PDS)	Pyridazinone	norflurazon	**12**
		Pyridinecarboxamide	diflufenican picolinafen	
		Other	beflubutamid fluridone flurochloridone flurtamone	
F2	Bleaching: Inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	Triketone	mesotrione sulcotrione	**27**
		Isoxazole	*isoxachlortole* isoxaflutole	
		Pyrazole	benzofenap pyrazolynate pyrazoxyfen	
		Other	*benzobicyclon*	
F3	Bleaching: Inhibition of carotenoid biosynthesis (unknown target)	Triazole	amitrole (in vivo inhibition of lycopene cyclase)	**11**
		Isoxazolidinone	clomazone	**13**
		Urea	fluometuron (see C2)	
		Diphenylether	aclonifen	
G	Inhibition of EPSP synthase	Glycine	glyphosate *sulfosate*	**9**
H	Inhibition of glutamine synthetase	Phosphinic acid	glufosinate-ammonium *bialaphos = bilanaphos*	**10**
I	Inhibition of DHP (dihydropteroate) synthase	Carbamate	asulam	**18**
K1	Microtubule assembly inhibition	Dinitroaniline	benefin = benfluralin	**3**

HRAC Group	Mode of Action	Chemical Family	Active Ingredient	WSSA Group
		Dinitroaniline (continued)	*butralin* *dinitramine* ethalfluralin oryzalin pendimethalin trifluralin	
		Phosphoroamidate	*amiprophos-methyl* *butamiphos*	
		Pyridine	dithiopyr thiazopyr	
		Benzamide	propyzamide = pronamide *tebutam*	
		Benzoic acid	DCPA = chlorthal-dimethyl	**3**
K2	Inhibition of mitosis / microtubule organisation	Carbamate	*chlorpropham* *propham* carbetamide	**23**
K3	Inhibition of VLCFAs (see Remarks) (Inhibition of cell division)	Chloroacetamide	acetochlor alachlor butachlor	**15**
			dimethachlor dimethanamid metazachlor metolachlor *pethoxamid*	
			pretilachlor propachlor *propisochlor* thenylchlor	
		Acetamide	*diphenamid* napropamide *naproanilide*	
		Oxyacetamide	flufenacet mefenacet	
		Tetrazolinone	fentrazamide	
		Other	anilofos *cafenstrole* *piperophos*	
L	Inhibition of cell wall (cellulose) synthesis	Nitrile	dichlobenil *chlorthiamid*	**20**
		Benzamide	isoxaben	**21**
		Triazolocarboxamide	*flupoxam*	
		Quinoline carboxylic acid	quinclorac (for monocots) (also group O)	**26**

HRAC Group	Mode of Action	Chemical Family	Active Ingredient	WSSA Group
M	Uncoupling (Membrane disruption)	Dinitrophenol	*DNOC* *dinoseb* dinoterb	**24**
N	Inhibition of lipid synthesis - not ACCase inhibition	Thiocarbamate	butylate cycloate *dimepiperate* EPTC esprocarb molinate *orbencarb* pebulate prosulfocarb thiobencarb = benthiocarb *tiocarbazil* triallate vernolate	**8**
		Phosphorodithioate	bensulide	
		Benzofuran	*benfuresate* ethofumesate	
		Chloro-Carbonic-acid	*TCA* *dalapon* *flupropanate*	**26**
O	Action like indole acetic acid (synthetic auxins)	Phenoxy-carboxylic-acid	clomeprop 2,4-D 2,4-DB dichlorprop = 2,4-DP MCPA MCPB mecoprop = MCPP = CMPP	**4**
		Benzoic acid	chloramben dicamba TBA	
		Pyridine carboxylic acid	clopyralid fluroxypyr picloram triclopyr	
		Quinoline carboxylic acid	quinclorac (also group L) quinmerac	
		Other	benazolin-ethyl	
P	Inhibition of auxin transport	Phthalamate Semicarbazone	naptalam diflufenzopyr-Na	**19**
R	….	…	…	
S	…	…	…	

.	…	…	…	
HRAC Group	**Mode of Action**	**Chemical Family**	**Active Ingredient**	**WSSA Group**
Z	Unknown Note: While the mode of action of herbicides in Group Z is unknown it is likely that they differ in mode of action between themselves and from other groups.	Arylaminopropionic acid	Flamprop-M-methyl /-isopropyl	**25**
		Pyrazolium	difenzoquat	**26**
		Organoarsenical	DSMA MSMA	**17**
		Other	*bromobutide* *(chloro)-flurenol*	**27**
			cinmethylin	
			cumyluron	
			dazomet	
			dymron = daimuron *methyl-dimuron= methyl-dymron* *etobenzanid* fosamine *indanofan* metam *oxaziclomefone* *oleic acid*	
			pelargonic acid pyributicarb	

Remarks:
According to information and comments following herbicides are classified in the January 2005 version in HRAC (WSSA) groups:

B (2): cancelled: #9; #9; procarbazone
Approved ISO name: propoxycarbazone

E (14): cancelled: pyrazogyl
Approved name: pyraclonil

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