Global HRAC MOA Classification Working Group Report
Version: June 2, 2020

Executive Summary

The Global Herbicide Resistance Action Committee (HRAC), supported by regional HRACs around the world, completed its updated to the mode of action classification system on March 1, 2020. Changes since the last update in 2010 include the addition of 14 new active ingredients, rationalization of chemical family names, and four new or updated modes of action: inhibition of fatty acid thioesterase (cinmethylin), inhibition of homogentisate solanesyltransferase (cyclopyrimorate), inhibition of solanesyl diphosphate synthase (aclonifen), and inhibition of serine-threonine protein phosphatase (endothall).

With this update, Global HRAC will transition from letter to number mode of action codes. Global HRAC believes a numerical code system is more globally relevant and sustainable compared to English/Latin letters. In geographies where the Latin alphabet is not used and/or where literacy rates are low, most everyone understands Hindu-Arabic numerals (including China). Global HRAC considered several numerical code options but in the end settled on alignment with the WSSA so that there is single numerical code shared by WSSA and Global HRAC.

Background

At the global HRAC meeting held May 2017 in Denver, Colorado USA, the current state of herbicide moa/chemical classification was discussed with a recommendation to update the mode of action classification, specifically:

1) Review and update the list of active ingredients (a.i.s) – including adding new ones
2) Update/revise MOA designations
3) Update/revise chemical classes
4) Recommend changes to the MOA classification code
5) Devise process for annual review and updates

Working Group

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The Working Group (WG) convened its kickoff meeting September 8, 2017.

The starting point for the list of herbicide a.i.s was provided by Ian Heap (Administrator of the herbicide resistance website weedscience.org) which was cross-referenced with the Pesticide Manual (BCPC), WSSA Herbicide Handbook and third-party reports such as Phillips McDougall for gaps and new market introductions. Evidence of commercialization was required for inclusion on the list. The final Master List includes ca. 357 herbicide a.i.s. The updated 2020 HRAC MOA poster is a subset of the Master List and includes 260 a.i.s. The WG reviewed all herbicides on the Master List.

Chemical family names

The purpose of a chemical name is to form groups (and where appropriate subgroups) that point the reader to the similarities and differences that exist among herbicides with the same mode of action. A guiding principle was that chemical family names should be as simple as possible, whenever possible and should not be so specific that they split similar herbicides into two or more different families. Herbicides with a high degree of structural novelty should be recognized by a novel chemical family name. Herbicides with a lower degree of structural novelty should be classified with existing chemical families whenever possible.

Naming should follow IUPAC nomenclature rules.

It is the WG's recommendation to avoid using a chemical family name when there is just one active in the family. "Other" may be appropriate when a MOA contains multiple a.i.s with no family groupings. This approach is consistent with the IRAC classification system.

Active ingredient name

The active ingredient name should be the most commercially relevant form (ester, salt, prodrug) e.g. quizalofop-P-ethyl. When an herbicide has more than one accepted common name, both will be listed.

New Mode of Action Codes

Global HRAC will transition from letter to numerical mode of action codes. Global HRAC believes a numerical code system is more global relevant and sustainable compared to an alphabetic code based on English/Latin letters. In geographies where the Latin alphabet is not used and/or where literacy rates are low, everyone understands Hindu-Arabic numerals (including China). Another concern about the English alphabet is that there are only 26 letters. Today we have 25 recognized modes of action including four new modes of actions since the last revision of our mode of action classification in 2010. Over the next 10 years we anticipate the addition of two to four new modes of action which will exceed the 26 letter maximum. Also, IRAC uses a numerical code and FRAC is transitioning from letters to numbers.

Global HRAC considered several numerical code options but in the end settled on alignment with the WSSA so that there is single numerical code shared by WSSA and Global HRAC. This decision facilitated the agreement that the WSSA and Global HRAC will support a common numerical code going forward.

Although moving to a universal numerical code is a positive step forward, it does not mean Global HRAC will immediately replace our current letter codes. Countries currently using letters will require a long transition period for education and communication before a change to numbers can be implemented. Regional HRACs will lead this action working with private and government stakeholders. Global HRAC is committed to help the regions facilitate the transition by supporting education and policy needs. In the meantime, Global HRAC will continue to support legacy letter-based codes.

Note: Moving forward with a new code will fix a problematic issue with the legacy letter code, namely divergent modes of action identified by the same letter. The legacy HRAC system includes multiple modes of action that share a common letter (C, F, or K) and differentiated by a number e.g. F1, F2, F4. This suggests, incorrectly, that modes of action sharing the same letter are similar and not suitable to mix or rotate for resistance management.

Revised Herbicide MOA Classification – MASTER LIST

HRAC/WSSA Group 1, HRAC Legacy Group A

Inhibition of Acetyl CoA Carboxylase

Active ingredients	Previous classification	New classification
alloxydim, butroxydim, clethodim, Cloproxydim, cycloxydim, profoxydim, sethoxydim, tepraloxydim, tralkoxydim	Cyclohexanediones (DIMs)	No change
clodinafop-propargyl, clofop-isobutyl, cyhalofop-butyl, diclofop-methyl, fenoxaprop-ethyl, fenthiaprop, fluazifop-butyl, haloxyfop-methyl, isoxapyrifop, metamifop, quizalofop-ethyl	Aryloxyphenoxy-propionates (FOPs)	No change
pinoxaden	Phenylpyrazoline	No change

The structures of both clethodim and sethoxydim on the 2010 poster are incorrect – the substituent on the dione is CH2CH(CH3)SEt. Corrected structures are in the updated 2020 poster.

HRAC/WSSA Group 2, Legacy HRAC Group B

Inhibition of Acetolactate Synthase

- Triazolopyrimidines contain two types of linkages. One of these linkage types involves a sulfone directly attached to the triazolopyrimidine ring while the other linkage type has a nitrogen directly attached to the triazolopyrimidine ring. In the revised classification system, these two types of chemical families are distinguished as Triazolopyrimidine Type 1 and Triazolopyrimidine Type 2.
- Change chemical family name pyrimidinyl (thio) benzoates to pyrimidinyl benzoates in order to create simpler name that captures only the key features common to all five a.i.s (bispyribac-sodium and pyriminobac-methyl do not contain a sulfide).
- Create a new family name "Sulfonanilides" for pyrimisulfan and triafamone. In the current system these a.i.s are inaccurately classified as benzoates and "Sulfonanilides" was the chemical class assigned to pyrimisulfan and triafamone in J. Pest Sci 2011, 36(2) 212-220.
- Simplify Sulfonylamino-carbonyl-triazolinones to "Triazolinones"

Active ingredients	Previous classification	New classification
bispyribac-sodium (and prodrug pyribenzoxim), pyriftalid, pyriminobac-methyl, pyrithiobac-sodium	Pyrimidinyl (thio) benzoates	Pyrimidinyl benzoates
pyrimisulfan, triafamone	Pyrimidinyl (thio) benzoates	Sulfonanilides
cloransulam-methyl, diclosulam, florasulam, flumetsulam, metosulam	Triazolopyrimidine	Triazolopyrimidine - Type 1
penoxsulam, pyroxsulam	Triazolopyrimidine	Triazolopyrimidine - Type 2
amidosulfuron, azimsulfuron, bensulfuron-methyl, chlorimuron-ethyl, chlorsulfuron, cinsulfuron, cyclosulfamuron, ethametsulfuron-methyl, ethoxysulfuron, flazasulfuron, flucetosulfuron, flupyrsulfuron-methyl-Na, foramsulfuron, halosulfuron-methyl, imazosulfuron, iodosulfuron-methyl-Na, mesosulfuron-methyl, metazosulfuron, metsulfuron-methyl, nicosulfuron, orthosulfamuron, oxasulfuron, primisulfuron-methyl, propyrisulfuron, prosulfuron, pyrazosulfuron-ethyl, rimsulfuron, sulfometuron-methyl, sulfosulfuron, triasulfuron, tribenuron-methyl, thifensulfuron-methyl, trifloxysulfuron-Na, triflusulfuron-methyl, tritosulfuron	Sulfonylureas	No change
imazamethabenz-methyl, imazamox, imazapic, imazapyr, imazaquin, imazethapyr	Imidazolinones	No change
flucarbazone-Na, propoxycarbazone-Na, thiencarbazone-methyl	Sulfonylamino-carbonyl-triazolinones	Triazolinones

HRAC/WSSA Group 3, Legacy HRAC Group K1

Inhibition of Microtubule Assembly

Tebutam (previously included with Benzamides because of structural similarities) was reclassified as unknown.

Active ingredients	Previous classification	New classification
benefin=benfluralin, butralin, dinitramine, ethalfluralin, fluchloralin, isopropalin, nitralin, prodiamine, profluralin, oryzalin, pendimethalin, trifluralin	Dinitroanilines	No change
dithiopyr, thiazopyr	Pyridines	No change
butamifos, DMPA	Phosphoroamidates	No change
chlorthal-dimethyl=DCPA	Benzoic acid	No change
propyzamide=pronamide	Benzamides	No change

HRAC/WSSA Group 4, Legacy HRAC Group O

Auxin Mimics

Active ingredients	Previous classification	New classification
picloram, clopyralid, aminopyralid	Pyridine-carboxylates	No change
halauxifen, florpyrauxifen	None/new	Pyridine-carboxylates
triclopyr, fluroxypyr	Pyridine-carboxylates	Pyridyloxy-carboxylates
2,4,5-T, 2,4-D, 2,4-DB, clomeprop, dichlorprop, Fenoprop, mecoprop, MCPA, MCPB	Phenoxy-carboxylates	No Change
dicamba, chloramben, TBA	Benzoates	No change
quinclorac, quinmerac	Quinoline-carboxylates	No change
aminocyclopyrachlor	None	Pyrimidine-carboxylates
benazolin-ethyl	Other	No change
chlorfenac=fenac, chlorfenprop	Other	Phenyl carboxylates

There was a request to consider an additional level auxin herbicide mode of action segmentation based on differential binding to AFB/receptor proteins. The WG sees value in such a refinement, but did not feel there is sufficient data to support a recommendation at this time. This opinion is shared by Corteva the global leader on differential auxin chemistry signaling. Our recommendation was to postpone this action until more data is available.

HRAC/WSSA Group 5, Legacy HRAC Group C1, C2

Inhibition of photosynthesis at PS ll – D1 Serine 264 Binders

The recommendation was to combine subclasses 1 and 2. Subclasses C1 and C2 were created for resistance management since, at the time, there was no cross resistance between these subgroups. Today however there are no clear cross-resistance patterns between these subgroups to justify separation; one can find examples of biotypes resistant to ureas (current C2) and uracils (current C1), or biotypes resistant to triazines (current C1) and ureas but sensitive to other C1 compounds.

There is still no demonstrated cross-resistance between C1/C2 and C3 - mutations at the serine site (current C1/C2) produce biotypes that are sensitive (often hypersensitive) to histidine 215 site mutations (C3 herbicides). Therefore, the WG proposed going forward with two subclasses – identified as D1 Serine 264 binders (Group 5) and D1 Histidine 215 binders (Group 6).

Active ingredients	**Previous classification**	**New classification**
atraton, atrazine, ametryne, aziprotryne=aziprotryn, chlorazine, CP 17029, cyanazine, cyprazine, desmetryne, dimethametryn, dipropetryn, eglinazine-ethyl, ipazine, methoprotryne=methoprotryn, procyazine, proglinazine-ethy, prometon, prometryne, propazine, sebuthylazine, secbumeton, simetryne, simazine, terbumeton, terbuthylazine terbutryne, trietazine	Triazines	No change
amicarbazone	Triazolinone	No change
ethiozin, hexazinone, isomethiozin, metamitron, metribuzin	Triazinones	No change
bromacil, isocil, lenacil, terbacil	Uracils	No change
chlorprocarb, desmedipham, phenisopham, phenmedipham	Phenylcarbamates	No change
brompyrazon, chloridazon=pyrazon	Pyridazinone	No change
benzthiazuron, bromuron, buturon, chlorobromuron, chlorotoluron, chloroxuron, difenoxuron, dimefuron, diuron, ethidimuron, fenuron, fluometuron, fluothiuron, isoproturon, isouron, linuron, metobenzuron, metobromuron, methabenzthiazuron, metoxuron, monolinuron, monuron, neburon, parafluron, siduron, tebuthiuron, thiazafluron	Ureas	No change
chloranocryl=dicryl, pentanochlor, propanil	Amides	No change

HRAC/WSSA Group 6, Legacy HRAC Group C3

Inhibition of photosynthesis at PS ll – D1 Histidine 215 binders

Active ingredients	Previous classification	New classification
bromofenoxim, bromoxynil, ioxynil	Nitriles (also Uncouplers “M”)	No change
pyridate	Phenyl-pyridazines	No change
bentazon	Benzothiadiazinone	No change

HRAC/WSSA Group 9, Legacy HRAC Group G

Inhibition of Enolpyruvyl Shikimate Phosphate Synthase

Active ingredients	Previous classification	New classification
glyphosate	Glycines	No change

HRAC/WSSA Group 10, Legacy HRAC Group H

Inhibition of Glutamine Synthetase

Active ingredients	Previous classification	New classification
glufosinate-ammonium, bialaphos=bilanafos	Phosphinic acids	No change

HRAC/WSSA Group 12, Legacy HRAC Group F1

Inhibition of Phytoene Desaturase

Three new classes were proposed: Phenyl ethers, N-Phenyl heterocycles, and Diphenyl heterocycles.

Activeingredients	Previous classification	New classification
picolinafen, diflufenican	pyridine carboxamides	Phenyl-ethers
beflubutamid	Other	Phenyl-ethers
flurochloridone	Other	N-Phenyl heterocycles
norflurazon	Pyridazinone	N-Phenyl heterocycles
fluridone, flurtamone	Other	Diphenyl heterocycles

HRAC/WSSA Group 13, Legacy HRAC Group F4

Inhibition of Deoxy-D-Xylulose Phosphate Synthase (usually referred to as DXP in literature)

Active ingredients	Previous classification	New classification
clomazone	None	Isoxazolidinone
bixlozone	None/New	Isoxazolidinone

HRAC/WSSA Group 14, Legacy HRAC Group E

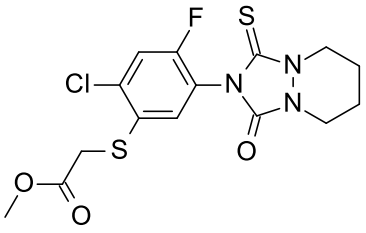
Inhibition of Protoporphyrinogen Oxidase

The proposed classification reduces number of families and recognizes a common group (N-Phenyl) for many PPO herbicides separated by novel heterocycles.

- Oxadiazolone is aligned with IUPAC nomenclature rules.
- Fluthiacet-methyl is a prodrug with the (primary) active form an N-Phenyl imide.

Active ingredients	Previous classification	New classification
acifluorfen, bifenox, chlomethoxyfen, chlornitrofen, fluorodifen, fluoroglycofen-ethyl, fluoronitrofen, fomesafen, lactofen, nitrofen, oxyfluorfen	Diphenyl ethers	No change
pyraflufen-ethyl	Phenylpyrazoles	No change
oxadiargyl, oxadiazon	Oxadiazoles	N-Phenyl-oxadiazolones
azafenidin, carfentrazone-ethyl, sulfentrazone	Triazolinones	N-Phenyl-triazolinones
fluthiacet-methyl	Thiadiazoles	N-Phenyl-imides (procide)
butafenacil, saflufenacil	Pyrimidinediones	N-Phenyl-imides
pentoxazone	Oxazolidinediones	N-Phenyl-imides
chlorphthalim, cinidon-ethyl, flumiclorac-pentyl, flumioxazin, flumipropyn	N-Phenyl-phthalimides	N-Phenyl-imides
trifludimoxazin, tiafenacil	New	N-Phenyl-imides
pyraclonil	Other	No change

The active form of fluthiacet is shown below:



HRAC/WSSA Group 15, Legacy HRAC Group K3

Inhibition of Very Long Chain Fatty Acids

Active ingredient additions and deletions: (1) Reclassify the acetamides: diphenamid, naproanilide, and napropamide as unknown since recent evidence demonstrates these a.i.s are not VLCFA inhibitors[1], (2) Reclassify the thiocarbamates and benzofurans (previously classified as "Lipid Synthesis Inhibition – not ACCase") to "Inhibition of VLCFA" since reports point to this as the MOA for thiocarbamates and benzofurans[2]. New chemical classification naming conventions:

- The thioacetamide group highlights the similarity that the structures of anilofos and piperophos share with chloracetamide and oxyacetamide chemical families (by giving them a name that draws the reader's attention to the similarity without being overly complex and specific e.g. dithiophosphate acetamides). However, the name "thioacetamide" could be misleading in that it represents an acetamide where the O atom has been substituted with a S atom i.e. CH3C(=S)NH2. Other names such as mercaptoacetamides, thioglycolic acids, and (dialkyl) dithiophosphates were viewed as too specific/complex, so the WGs recommendation was to add "alpha" to the name. The decision to incorporate "alpha" for the thioacetamide chemical family led to the recommendation to use the alpha nomenclature for the chloroacetamides and the oxyacetamide chemical families as well.
- Azolyl carboxamide best represented the primary functional group heterocycle-C(O)NR'R'' over other possible names such as N-carboxamides, N-carboxamide heterocycles, and carbamoyl heterocycles.
- Isoxazolines and oxiranes nomenclature makes clear that pyroxasulfone, fenoxasulfone, indanofan and tridiphane are not closely related by structure to the "acetamides"

Active ingredients	**Previous classification**	**New classification**
cafenstrole, fentrazamide, ipfencarbazone	Other and tetrazolinone	Azolyl-carboxamides
anilofos, Piperophos	Other	α-Thioacetamides
pyroxasulfone, fenoxasulfone	Others	Isoxazolines
indanofan, tridiphane	Unknown, other	Oxiranes
acetochlor, alachlor, allidochlor=CDAA, butachlor, butenachlor, delachlor, diethatyl-ethyl, dimethachlor, dimethenamid, metazachlor, metolachlor, pethoxamid, pretilachlor, propachlor, propisochlor, prynachlor, thenylchlor	Chloroacetamides	α-Chloroacetamides
mefenacet, flufenacet	Oxyacetamides	α-Oxyacetamides

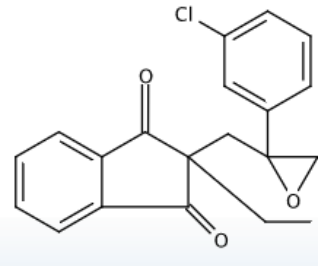
HRAC/WSSA Group 15 Continued

Active ingredients	Previous classification	New classification
butylate, cycloate, dimepiperate, EPTC, esprocarb, molinate, orbencarb, pebulate, prosulfocarb, thiobencarb=benthiocarb tiocarbazil, tri-allate, vernolate	Thiocarbamates	No change
benfuresate, ethofumesate	benzofurans	No change

[1]Yang *et al*. Pest Manag Sci 2010 66:794-800. Report found no evidence that diphenamid and napropamide inhibited VLCFA. No evidence to support naproanilide.

[2]Magnucka *et al*. Pest Management Sci. 2009 65(10) 1065-1070; Baldwin et al. J Experimental Botany 2003 54 (385) 1289-1294; Barrett et al Biochemical Soc Transactions 1994 22(3) 260S; Abulnaja et al Phytochemistry 1992 31(4) 1155-1159; Lechelt-Kunze *et al*. Pest Management Sci 2003 59(8) 847-856

The Indanofan structure in the 2010 poster is not correct. The correct structure is shown as follows:



HRAC/WSSA Group 18, Legacy HRAC Group I

Inhibition of Dihydropteroate Synthase

Active ingredients	Previous classification	New classification
asulam	Carbamate	No change

HRAC/WSSA Group 19, Legacy HRAC Group P

ATI – Auxin transport inhibition

- Naptalam and diflufenzopyr (DFFP) are structurally similar - ortho-substituted benzoic acid vs an ortho substituted pyridine carboxylic acid. The new chemical family name "Aryl carboxylates" was created.
- *The recommendation to exclude chlorflurenol, cyclanilide and flurenol was followed since these compounds are not herbicides or ATIs. Early work at Sandoz with cyclanilde showed different symptomology than known ATIs (i.e. contact necrosis vs epinasty) like TIBA, NPA and DFFP, and it was very weak in a competitive NPA binding assay. It appears to have a direct interaction with ethylene, but the interaction with auxins appears to be indirect, if any. Chlorflurenol and flurenol are growth inhibitors with symptomology related to growth inhibition and necrosis rather than epinasty – MOA appears to be related to ABA / ethylene regulation than ATI.*

Active ingredients	Previous classification	New classification
naptalam, DFFP	Phthalamate and Semicarbazone	Aryl-carboxylates

HRAC/WSSA Group 22, Legacy HRAC Group D

PS-I electron diversion

The class name was changed to pyridiniums, not pyridyliums, as this is aligned with IUPAC nomenclature. Cyperquat has a single N^+ so the name pyridiniums is preferred over bipyridiniums.

Active ingredients	Previous classification	New classification
cyperquat, diquat, morfamquat, paraquat	Bipyridyliums	Pyridiniums

HRAC/WSSA Group 23, Legacy HRAC Group K2

Inhibition of Microtubule Organization

Flamprop-m was reclassified as unknown.

Active ingredients	Previous classification	New classification
barban, carbetamide, chlorbufam, chlorpropham, propham, swep	Carbamates	No change

HRAC/WSSA Group 24, Legacy HRAC Group M

Uncouplers

Active ingredients	Previous classification	New classification
dinosam, dinoseb, DNOC, dinoterb, etinofen, medinoterb	Dinitrophenols	No change

HRAC/WSSA Group 27, Legacy HRAC Group F2

Inhibition of Hydroxyphenyl Pyruvate Dioxygenase

Active ingredients	Previous classification	New classification
mesotrione, sulcotrione, tembotrione, tefuryltrione, bicyclopyrone, fenquinotrione	Triketones	No change
benzobicyclon	Other	Triketone (procide)
benzofenap, pyrasulfotole, topramezone, pyrazolynate, pyrazoxyfen, tolpyralate	Pyrazoles	No change (pyrazoles). *Note: Benzofenap, pyrazolynate and pyrazoxyfen will be identified as procides.*
isoxaflutole	Isoxazoles	No change (isoxazoles) - procides

HRAC/WSSA Group 29, Legacy HRAC Group L

Inhibition of Cellulose Synthesis

Active ingredients	Previous classification	New classification
Flupoxam	Triazolocarboxamide	Triazolecarboxamide
Isoxaben	Benzamide	No change
Triaziflam, indaziflam	Alkylazines	No change
Dichlobenil, chlorthiamid	Nitriles	No change

HRAC/WSSA Group 30, Legacy HRAC Group Q

Inhibition of Fatty Acid Thioesterase[1] – New updated

Cinmethylin was previously incorrectly assigned as an inhibitor of tyrosine aminotransferase.

Active ingredients	Previous classification	New classification
cinmethylin, methiozolin	None/Other	Benzyl ether

[1]Campe, R. *et al* A new herbicide site of action: Cinmethylin binds to acyl-ACP thioesterase and inhibits plant fatty acid biosynthesis. Pestic. Biochem. Physiol. 2018 https://doi.org/10.1016/j.pestbp.2018.04.006

HRAC/WSSA Group 31, Legacy HRAC Group R

Inhibition of serine-threonine protein phosphatase – New updated

Active ingredients	Previous classification	New classification
endothall	Other	No change

Bajsa *et al*. Validation of serine/threonine protein phosphatase as the herbicide target site of endothall. Pestic. Biochem. Physiol. **2012**, 102, 38-44, doi:10.1016/j.pestbp.2011.10.007.

HRAC/WSSA Group 32, Legacy HRAC Group S

Inhibition of Solanesyl Diphosphate Synthase (SDS) - New updated

SDS inhibition, like HST is a new mode of action to the classification system. Recommendation is to position SDS on the poster with HPPD, PDS, and DOXP as all produce bleaching symptoms and all are involved in carotenoid/plastoquinone biosynthesis.

Active ingredients	Previous classification	New classification
aclonifen	Unknown	Diphenylether

Kahlau *et al*. Aclonifen targets solanesyl diphosphate synthase, representing a novel mode of action for herbicides. Pest Manag. Sci. **2020**, in press.

HRAC/WSSA Group 33, Legacy HRAC Group T

Inhibition of homogentisate solanesyltransferase (HST) - New

HST inhibition is a new mode of action to the classification system. The recommendation is to position HST on the poster with HPPD, PDS, and DOXP as all produce bleaching symptoms and all are involved in carotenoid/plastoquinone biosynthesis.

Shino, M., et al. Action mechanism of bleaching herbicide cyclopyrimorate, a novel homogentisate solanesyltransferase inhibitor. J. Pestic. Sci., 43, 233–239, DOI: 10.1584/jpestics.D18-008.

Active ingredients	Previous classification	New classification
cyclopyrimorate	New	Phenoxypyridazine

HRAC/WSSA Group 34, Legacy HRAC Group F3

Inhibition of Lycopene Cyclase

Active ingredients	Previous classification	New classification
amitrole	Triazole	No Change

HRAC/WSSA Group Ø, Legacy HRAC Group Z

Unknown Mode of Action

Active ingredients
bromobutide, cacodylic acid, CAMA, cumyluron, difenzoquat, DSMA, dymron=daimuron, etobenzanid, fosamine, methyldymron, monalide, MSMA, oleic acid, oxaziclomefone, pelargonic acid, pyributicarb, quinoclamine, diphenamid, naproanilide, napropamide
Flamprop-m, tebutam,
Dalapon, flupropanate, TCA,
Bensulide, mefluidide, perfluidone

Eliminated Modes of Action

1) Lipid Synthesis Inhibition – not ACCase. (former HRAC N and WSSA 8). Thiocarbamates and benzofuranes transferred to VLCFA inhibition. N chlorocarbonic acids (dalapon, flupropanate, TCA) and bensulide reclassified as Unknown, since there is no evidence to support VLCFA inhibition, or any other target for these herbicides.
2) Bleaching Unknown (former HRAC F3 and WSSA 11). Amitrole reclassified as Lycopene cyclase inhibitor. Fluometurone is also an inhibitor of photosynthesis at PS ll.