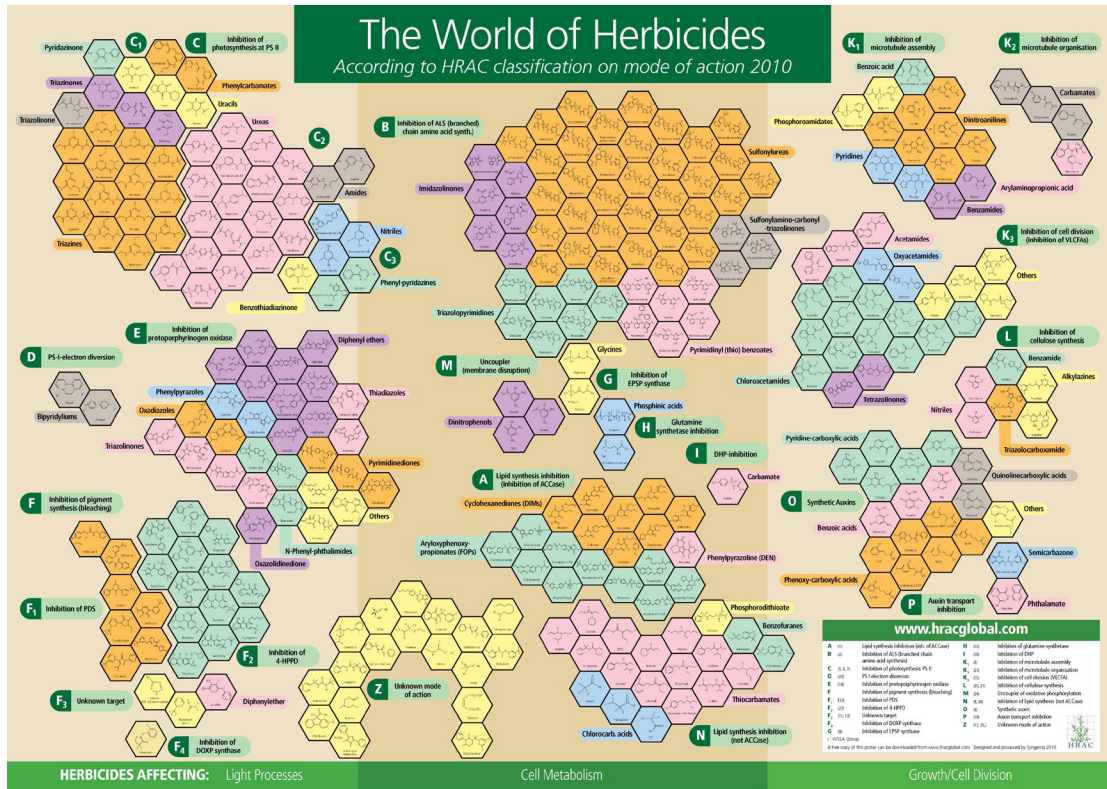


# The new HRAC Mode of Action Classification System for Herbicides

HRAC Europe 2021

# The „old“ HRAC-Classification System



- Letter-Codes for the classification of herbicides (*Mode of Action*)
- Established in the 1980th by the Herbicide Resistance Action Committee (HRAC)
- Different classification systems in North America and Australia
- Classification according to symptoms or chemical structure
- Diverse interpretation of letter-codes with sub-groups
  - C ➔ Inhibition of photosystem PSII, but with different (C1-C3) binding sites
  - F ➔ „Bleacher“-compounds with different effects and (F1-F4) binding sites
  - K ➔ „Growth inhibition“ with different effects and (K1-K3) binding sites

• Last revision in 2010

## ➔ Revision of the HRAC-Classification System in 2020

# Revisions in the HRAC-Classification System



## 1. Change from a letter to a numerical system

HRAC (WSSA)	Legacy HRAC	MoA description	HRAC (WSSA)	Legacy HRAC	MoA description
1	A	Inhibition of Acetyl CoA Carboxylase (ACCase)	19	P	Auxin transport inhibitor
2	B	Inhibition of Acetolactate Synthase (ALS)	22	D	PSI - Electron diversion
3	K1	Inhibition of microtubule assembly	23	K2	Inhibition of microtubuli organisation
4	O	Auxin mimics	24	M	uncoupler
5	C1, C2	Inhibition of Photosynthesis II - Serine 264	27	F2	Inhibition of Hydroxyphenyl Pyruvate Dioxygenase (HPPD)
6	C3	Inhibition of Photosynthesis II - Histidin 215	28	--	Inhibition of Dihydroorotate Dehydrogenase
9	G	Inhibition of Enolpyruvyl Shikimate Phosphate Synthase (EPSPS)	29	L	Inhibition of Cellulose Synthesis
10	H	Inhibition of Glutamin Synthetase	30	Q	Inhibition of Fatty Acid Thioesterase (FAT)
12	F1	Inhibition of the Phytoene Desaturase (PDS)	31	R	Inhibition of Serine Threonine Protein Phosphatase
13	F4	Inhibition of Deoxy-D-Xyulose Phosphate Synthase (DOXP)	32	S	Inhibition of Solanesyl Diphosphate Synthase (SDS)
14	E	Inhibition of Protoporphyrinogen Oxidase (PPO)	33	T	Inhibition of Homogentisate Solanesyltransferase
15	K3, (N)	Inhibition of Very Long Chain Fatty Acids (VLCFAs)	34	F3	Inhibition of Lycopene Cyclase
18	I	Inhibition of Dihydropteroate Synthase (DHP)	∅	Z, (N)	unknown

(N) = group N was deleted and integrated in either group 15 (K3) or ∅ (Z)

### Advantages:

- Future-proofness: Cessation of limit based on number of letters
- Consistency: Common system with Australia and North America
- Applicability: Usage also in regions with different writing systems, e.g., Asia

### Gentle transition from the „old“ to the „new“ system

- Retention of the „old“ letter-codes
- Allocation of letter-codes for new modes of action (up to and including update 2020)
- No new letter-codes for new modes of action starting from 2021 (e.g., 28 – Inhibition of Dihydroorotate-Dehydrogenase in 2021)

## 2. Consideration of new findings on the modes of action of active ingredients

### 1. New HRAC-groups:

- **30 (Q) - Inhibition of Fatty-Acid-Thioesterase (FAT): cinmethylin**
- **31 (R) - Inhibition of Serin-Threonin-Protein-Phosphatases: endothall**
- **32 (S) - Inhibition of Solanesyl-Diphosphat-Synthase (SDS): aclonifen**
- **33 (T) - Inhibition of Homogentisate-Solanesyl-Transferase (HST): cyclopyrimorate**
- **28 (-) - Inhibition of Dihydroorotate-Dehydrogenase: tetflupyrolimet**  
(new in 2021 without allocation of a letter-code)

### 2. Deletion of HRAC-groups

- **N (Inhibition of Lipid-Synthesis, non-ACCase):**
  - **Prosulfocarb, tri-allate, ethofumesate, i.a. → 15 (K3) – Inhibition of Very-long-chain-fatty acid (VLCFA)**
  - **Dalapon, i.a. → 0 (Z) – unknown mode of action**

### 3. Renaming of HRAC-groups

- **F3 (Bleacher with unknown mode of action) renamed in „Inhibition of Lycopene-Cyclase“ → HRAC: 34**
  - **Amitrol the only remaining active ingredient in F3**
  - **Aclonifen → 32 (S) – Inhibition of Solanesyl-Diphosphat-Synthase (SDS)**

## 3. Inclusion of new active ingredients

e.g., halauxifen, tolpyralate, bixlozone

## 4. Revision of chemical family names according to IUPAC-standard

Changes for important active ingredients in Europe

HRAC-group	HRAC-group		chemical family name "old"	active substance (example)	chemical family name "new"
	new	old			
2	B		Pyrimidinyl (thio) benzoates	bispyribac-sodium	Pyrimidinyl benzoates
			Triazolopyrimidine	florasulam	Triazolopyrimidine type I
				pyroxsulam, penoxsulam	Triazolopyrimidine type II
			Sulfonylamino-carbonyl-triazolinones (SACT)	propoxy-carbazon-NA, thiencarbazone-ethyl	Triazolinones
4	O		<i>none/new</i>	halauxifen, floryprauxifen	Pyridine-carboxylates
			Pyridine-carboxylates	fluroxypyr, triclopyr	Pyridyloxy-carboxylates
12	F1		Pyridine-carboxamides	diflufenican, picolinafen	Phenyl-ethers
			other	beflubutamide	
			other	flurochloridone	
13	F4		<i>none/new</i>	clomazone, bixlozone	Isoxazolidinone
14	E		Triazolinones	carfentrazone-ethyl	N-Phenyl-triazolinones
			N-Phenyl-phthalimides	flumioxazin	N-Phenyl-imides
15	K3		Chloroacetamides	dimethachlor, DMTA-p, metazachlor, s-metolachlor, pethoxamid	$\alpha$ -Chloroacetamides
			Oxyacetamides	flufenacet	$\alpha$ -Oxyacetamides
30	Q		<i>none/new</i>	cinmethylin	Benzyl ether
32	S		<i>none/new</i>	aclonifen	Diphenylether

**Chemical family** names provide an indication of comparable chemical structures within a mode of action group.

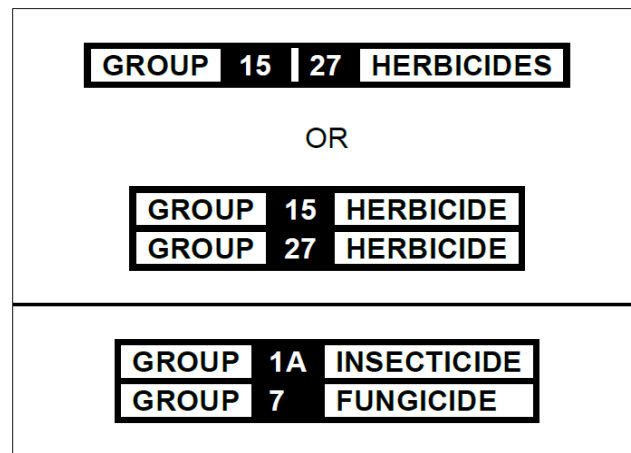
The **active ingredient name** relates to the most commercially relevant form (e.g. ester, salt) to avoid duplication due to several forms available on the market.

## Handling of the integration of active ingredients „old“ HRAC-group N in the HRAC-group 15 (K3)

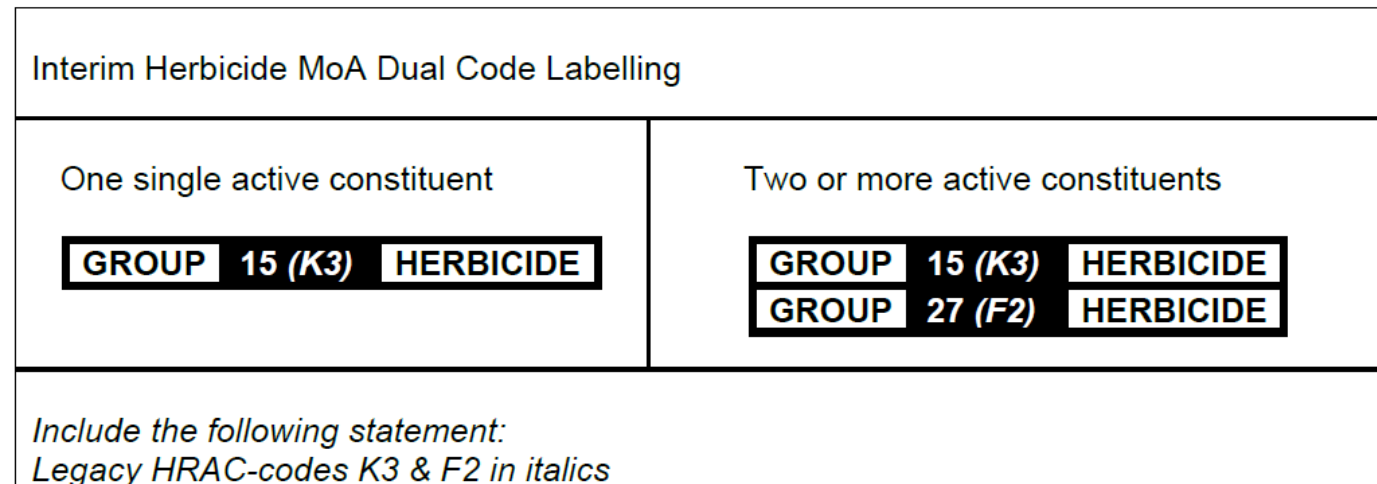
- Affected active ingredients: e.g., prosulfocarb, tri-allate, ethofumesate (former HRAC-group N)
- 15 (K3) – Inhibition of Very-long-chain-fatty acid (VLCFA)
  - Multi-enzyme systems with different elongases (*different to the inhibition of ACCase or ALS!*)
  - Binding sites of enzyme(s) to active ingredients not yet described
  - Indication on „multi-site“-effects with complex substance-specific effects on different elongases
  - Low incidence of resistances worldwide, especially in Europe
  - Occurring resistances mostly non-target site based (metabolic resistances)
- Combinations and spray sequences of former group N and K3 products have been used for years without any problems as part of resistance management strategies
- Further investigations are necessary to elucidate the mode of action
- A review of group 15 (K3) might be required

➔ As part of resistance management, HRAC continuous to support the previous practice of using combinations or spray sequences consisting of products from the former groups N and K3 (now 15).

- Collaboration between CropLife International and RACs
- More uniform and more visible identification of the mode of action groups on the product labels
- Uniform system for all indications
- For herbicides, dual-code-labelling with new + old HRAC-groups is possible



Single labelling with new HRAC-code



Dual-code-labelling with new and old HRAC-code

- Conversion of the HRAC Mode of Action classification from a letter to a numerical system
- The „old“ letter-based system is still valid!
  - ➔ Transition phase for the changeover to the new system
  - ➔ The new CLI label-icon for the mode of action groups supports the simultaneous use of old and new HRAC-Codes
- Assignment of numerical codes only for all new modes of action from 2021 onwards (no new letter-codes!)
- The revision in 2020 includes:
  - Designation of new HRAC groups for new modes of action
  - Re-classification of active ingredients based on new knowledge
  - Inclusion of new active ingredients
  - Adaptation of the chemical family names to the IUPAC nomenclature
- Inclusion of active substances from the HRAC-group N into group 15 (K3)
  - ➔ Previously carried out combinations / spray sequences with products of former groups N and K3 (now 15) are further supported by HRAC



[www.hracglobal.com](http://www.hracglobal.com)

- [Actual poster „HRAC Herbicide Mode of Action Classification 2021](#)
- [2020 Review of the Herbicide MoA Classification](#)

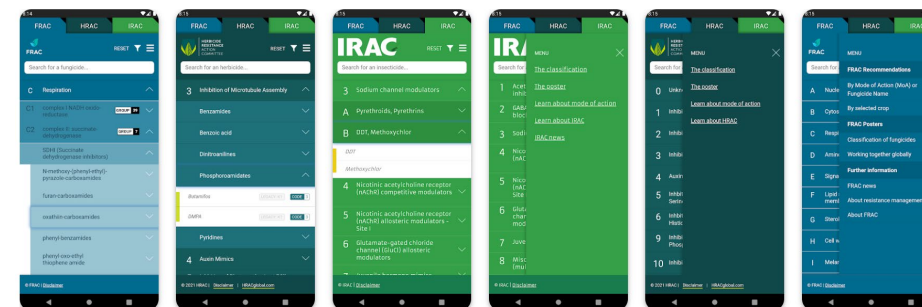


[www.hracglobal.com/europe/](http://www.hracglobal.com/europe/)



- [Resistance Management Stewardship](#)
- [Mode of Action Labelling Guidance April 2021](#)

## New **Global Resistance Management App** Get the **FRAC / HRAC / IRAC MoA - Posters to Go!**



### Global RAC's

Smartphone App for checking the Mode of Action of fungicidal, herbicidal and insecticidal active ingredients

