

# FRAC España

Fungicide Resistance Action Committee



# ¿Qué es FRAC España?

- Grupo de trabajo para la prevención de resistencias a fungicidas
- Creado en 1988 como respuesta puntual a los problemas de resistencia en oidio de remolacha
- Se retoma la actividad en 2016
- Miembro de FRAC Internacional  
Constituido como grupo regional en el sur de Europa

# Miembros de FRAC ESPAÑA

ADAMA



- Asesora Científica: Dra. Dolores Fernández Ortuño,
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- Asociaciones: **Aepla** [www.aepla.es](http://www.aepla.es)
- Colaboradores externos: María Ortiz



# Objetivos

- Ofrecer conocimiento y recomendaciones científicas y difusión de estrategias para un buen manejo de los productos fungicidas y bactericidas, para prevenir el desarrollo de resistencias .
- Coordinación de todas las partes - Comunidad científica, Autoridades locales, Autoridades centrales y FRAC España- para diseñar una estrategia común en la prevención de resistencias a enfermedades de alto riesgo para la agricultura española y mediterránea
- Aprovechar la sinergia con IRAC España en su lucha para prevenir la resistencia a insecticidas

# ¿Por qué las estrategias anti-resistencias?

Más problemático aún en **Gestión Integrada de Plagas**:

- Menos productos compatibles
- Más dependiente de unos pocos productos eficaces
- Consecuencias más graves si uno deja de “funcionar”

Se recoge expresamente en la **Directiva de Uso Sostenible**

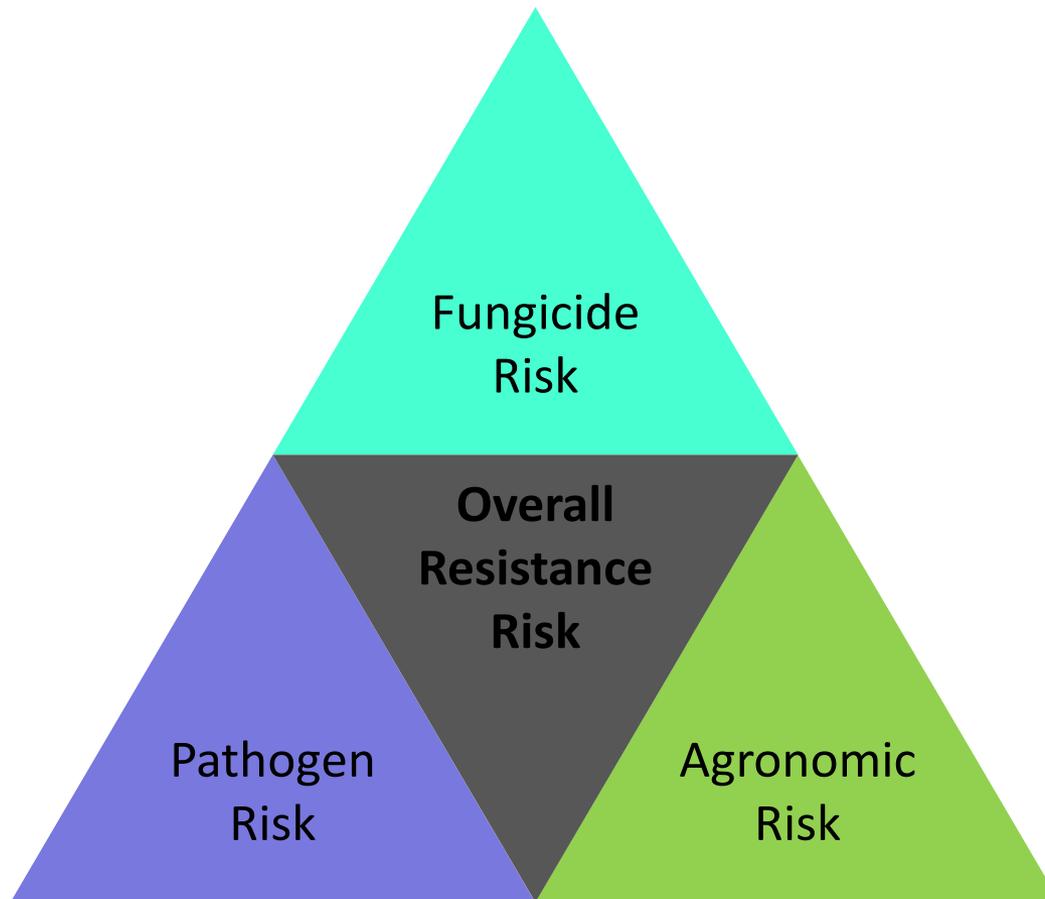
# Comité régional de FRAC INTERNATIONAL



 = Regional FRAC group

 = Associated Group (RAG)

# ¿Por qué las estrategias anti-resistencias?



- Combined Risk includes Agronomic Risk

# Clasificación FRAC. Modos de Acción

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
H: cell wall biosynthesis	H3	Formerly glucopyranosyl antibiotic (validamycin)			reclassified to U18	26
	H4 chitin synthase	polyoxins	peptidyl pyrimidine nucleoside	polyoxin	Resistance known. Medium risk. Resistance management required.	19
	H5 cellulose synthase	CAA-fungicides (Carboxylic Acid Amides)	cinnamic acid amides	dimethomorph flumorph pyrimorph	Resistance known in <i>Plasmopara viticola</i> but not in <i>Phytophthora infestans</i> . Cross resistance between all members of the CAA group. <b>Low to medium risk.</b> See FRAC CAA Guidelines for resistance management.	40
			valinamide carbamates	benthiavalicarb iprovalicarb valifenalate		
mandelic acid amides			mandipropamid			

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
	unknown	cianoacetamide-oxime	cianoacetamide-oxime	cymoxanil	Resistance claims described. Low to medium risk. Resistance management required.	27
	unknown	phosphonates	ethyl phosphonates	fosetyl-Al	Few resistance cases reported in few pathogens. Low risk.	33
				phosphorous acid and salts		

## Recursos en internet:

[www.frac.info](http://www.frac.info)

- **Póster de Modos de Acción y Estructura química**
- **Lista de Modos de acción**
- **Evaluación del riesgo del patógeno a la aparición de resistencias**
- **Otros recursos bibliográficos**

# Mode of Action of Fungicides

FRAC classification on mode of action 2017 ([www.frac.info](http://www.frac.info))

## A: Nucleic Acid Synthesis

<b>A1: RNA polymerase I</b> # 4: 1% fungicides (Benzimidazoles) 	<b>A2: adenosin-deaminase</b> # 6: typically diamine pyrimidines 
<b>A3: DNA/ RNA synthesis (prop.)</b> # 32: heteroaromatics 	<b>A4: DNA topoisomerase type II (gyrase)</b> # 51: carboxylic acids 

## B: Cytoskeleton and Motor Proteins

<b>B1: &gt; 6-tubulin assembly in mitosis</b> # 1: MBC Fungicides (= glycidyl benzimidazole Carbamates) 	<b>B2: &gt; 6-tubulin assembly in mitosis*</b> # 10: hydroxy carboximides 
<b>B3: &gt; 8-tubulin assembly in mitosis</b> # 22: benzamides and thiazole carboxamides 	<b>B4: cell division (prop.)</b> # 20: phenylamides 
<b>B5: delocalisation of spectrin-like proteins</b> # 43: benzamides # 45: benzimidazoles # 47: cyanopyridines 	<b>B6: actin/myosin/ fibrothin function e.g. in vesicle trafficking</b> # 47: cyanopyridines 

## C: Respiration

<b>C1: inhibition of complex I</b> NADH Oxidoreductase # 29: pyridinones, pyrazoles, pyrimidines 	<b>C2: inhibition of complex II: succinate dehydrogenase</b> # 7: SDH (succinate dehydrogenase) inhibitors 
<b>C3: inhibition of complex III</b> cytochrome bc1 (ubiquinol oxidase) at Qo site # 11: Qo inhibitors (Qo-type quinone inhibitors) 	<b>C4: inhibition of complex III</b> cytochrome bc1 (ubiquinol oxidase) at Qi site # 2: Qi inhibitors (Qi-type quinone inhibitors) 

## C: Respiration

<b>C1: inhibition of complex I</b> NADH Oxidoreductase # 29: pyridinones, pyrazoles, pyrimidines 	<b>C2: inhibition of complex II</b> cytochrome bc1 (ubiquinol oxidase) at Qo site # 11: Qo inhibitors (Qo-type quinone inhibitors) 	<b>C3: inhibition of complex III</b> cytochrome bc1 (ubiquinol oxidase) at Qi site # 2: Qi inhibitors (Qi-type quinone inhibitors) 	<b>C4: inhibition of complex III</b> cytochrome bc1 (ubiquinol oxidase) at Qi site # 2: Qi inhibitors (Qi-type quinone inhibitors) 	<b>C5: inhibitors of oxidative phosphorylation, ATP synthase</b> # 30: organo tin 
<b>C6: uncouplers of oxidative phosphorylation</b> # 34 	<b>C7: ATP production (prop.)</b> # 38: thioamides, carbamates 			

## D: Amino Acid and Protein Synthesis

<b>D1: methionine biosynthesis (cys gene) (prop.)</b> # 8: 8-azolo-pyrimidines (= 4R fungicides) 	<b>D2: protein synthesis</b> # 23: enopyranteronic acid 	<b>D3: protein synthesis</b> # 24: hexopyranol antibiotics 
<b>D4: protein synthesis</b> # 25: glycosylamyl antibiotics 	<b>D5: protein synthesis</b> # 41: tetraoxane antibiotics 	

## E: Signal Transduction

<b>E1: signal transduction (mechanism unknown)</b> # 13: azanaphthalenes 	<b>E3: osmotic signal transduction</b> MAP / histidine kinase (os-1, Daff1) # 2: dicarboximides 
<b>E2: osmotic signal transduction</b> MAP / histidine-kinase (os-2, HOG1) # 12: phenylamides (PP- fungicides) 	

## F: Lipid Synthesis or Transport / Membrane Integrity or Function

<b>F2: phospholipid biosynthesis</b> # 6: phosphorodithioloates & dithioloates 	<b>F3: lipid peroxidation (prop.)</b> # 14: aromatic hydrocarbons & heteroaromatics 	<b>F4: cell membrane permeability, fatty acids (prop.)</b> # 28: carbamates 	<b>F6: microbial disruptors of pathogen cell membranes</b> # 44: Microbial (Bacillus sp.) 
<b>F7: cell membrane disruption (prop.)</b> # 46: plant extract 	<b>F8: ergosterol binding</b> # 48: polyene 	<b>F9: lipid homeostasis and transforstorage</b> # 49: GDSLIP Glycosylase binding protein homologue inhibition 	

## G: Sterol Biosynthesis in Membranes

<b>G1: C14-demethylase in sterol biosynthesis (erg11/cyp51)</b> # 3: C14-demethylase (ergosterin/terbufosin) inhibitors (SBI: Class I) 	<b>G2: 14-reductase and 14-17-isomerase in sterol biosynthesis (erg2, erg 24)</b> # 6: Anilines/Morpholines (= SBI: Class II) 
<b>G3: keto reductase in C4-de-methylation (erg27)</b> # 17: SBI: Class III 	<b>G4: squalene epoxidase in sterol biosynthesis (erg3)</b> # 19: SBI: Class IV 

## H: Cell Wall Biosynthesis

<b>H4: chitin synthase</b> # 19: Polyoxins 	<b>H5: cellulose synthase</b> # 49: Carboxylic Acid Derivatives (CAR Fungicides) 
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## P: Host Plant Defence Induction

<b>P01: salicylic pathway</b> benzothiazole BTH 	<b>P02: salicylic pathway</b> benzothiazole BTH 	<b>P03: thiazolidine carboxamide</b> 	<b>P04: polyphenols</b> 	<b>P05: plant extract</b> 
<b>P06: salicylic pathway</b> benzothiazole BTH 	<b>P07: salicylic pathway</b> benzothiazole BTH 			

## M: Chemicals with Multi-Site Activity

<b>M01: organics</b> 	<b>M02: organics</b> 	<b>M03: organics</b> 	<b>M04: organics</b> 	<b>M05: organics</b> 
<b>M06: organics</b> 	<b>M07: organics</b> 	<b>M08: organics</b> 	<b>M09: organics</b> 	<b>M10: organics</b> 

## Unknown Mode of Action

<b>U01: unknown mode of action</b> 	<b>U02: unknown mode of action</b> 	<b>U03: unknown mode of action</b> 	<b>U04: unknown mode of action</b> 	<b>U05: unknown mode of action</b> 
<b>U06: unknown mode of action</b> 	<b>U07: unknown mode of action</b> 	<b>U08: unknown mode of action</b> 	<b>U09: unknown mode of action</b> 	<b>U10: unknown mode of action</b> 

## NC: Not Classified

<b>NC: Not Classified</b> 
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**Legend:**

- C: Respiration
- C2: Inhibition of complex II by succinate dehydrogenase
- C3: Inhibition of complex III by cytochrome bc1 complex
- C4: Inhibition of complex III by cytochrome bc1 complex
- C5: Inhibition of complex III by cytochrome bc1 complex
- C6: Inhibition of complex III by cytochrome bc1 complex
- C7: Inhibition of complex III by cytochrome bc1 complex
- C8: Inhibition of complex III by cytochrome bc1 complex
- C9: Inhibition of complex III by cytochrome bc1 complex
- C10: Inhibition of complex III by cytochrome bc1 complex
- C11: Inhibition of complex III by cytochrome bc1 complex
- C12: Inhibition of complex III by cytochrome bc1 complex
- C13: Inhibition of complex III by cytochrome bc1 complex
- C14: Inhibition of complex III by cytochrome bc1 complex
- C15: Inhibition of complex III by cytochrome bc1 complex
- C16: Inhibition of complex III by cytochrome bc1 complex
- C17: Inhibition of complex III by cytochrome bc1 complex
- C18: Inhibition of complex III by cytochrome bc1 complex
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- C25: Inhibition of complex III by cytochrome bc1 complex
- C26: Inhibition of complex III by cytochrome bc1 complex
- C27: Inhibition of complex III by cytochrome bc1 complex
- C28: Inhibition of complex III by cytochrome bc1 complex
- C29: Inhibition of complex III by cytochrome bc1 complex
- C30: Inhibition of complex III by cytochrome bc1 complex
- C31: Inhibition of complex III by cytochrome bc1 complex
- C32: Inhibition of complex III by cytochrome bc1 complex
- C33: Inhibition of complex III by cytochrome bc1 complex
- C34: Inhibition of complex III by cytochrome bc1 complex
- C35: Inhibition of complex III by cytochrome bc1 complex
- C36: Inhibition of complex III by cytochrome bc1 complex
- C37: Inhibition of complex III by cytochrome bc1 complex
- C38: Inhibition of complex III by cytochrome bc1 complex
- C39: Inhibition of complex III by cytochrome bc1 complex
- C40: Inhibition of complex III by cytochrome bc1 complex
- C41: Inhibition of complex III by cytochrome bc1 complex
- C42: Inhibition of complex III by cytochrome bc1 complex
- C43: Inhibition of complex III by cytochrome bc1 complex
- C44: Inhibition of complex III by cytochrome bc1 complex
- C45: Inhibition of complex III by cytochrome bc1 complex
- C46: Inhibition of complex III by cytochrome bc1 complex
- C47: Inhibition of complex III by cytochrome bc1 complex
- C48: Inhibition of complex III by cytochrome bc1 complex
- C49: Inhibition of complex III by cytochrome bc1 complex
- C50: Inhibition of complex III by cytochrome bc1 complex

**FRAC**  
FUNGICIDE RESISTANCE ACTION COMMITTEE

↓ Fungicide Classes *	↓ Fungicide Risk	Combined Risk			↓ Agronomic Risk
benzimidazoles dicarboximides phenylamides QoI fungicides SDHI fungicides**	high = 6	6 3 1.5	12 6 3	18 9 4.5	high = 1 medium = 0.5 low = 0.25
SBI fungicides anilinopyrimidines phenylpyrroles	medium = 4	4 2 1	8 4 2	12 6 3	high = 1 medium = 0.5 low = 0.25
multi site fungicides (e.g. dithiocarbamates) MBI-R inhibitors SAR inducers	low = 1	1 0.5 0.25	2 1 0.5	3 1.5 0.75	high = 1 medium = 0.5 low = 0.25
Pathogen risk →		low = 1	medium = 2	high = 3	
Pathogen groups * →		seed borne pathogens (e.g. <i>Pyrenophora</i> sp. <i>Ustilago</i> sp.) soil-borne pathogens (e.g. <i>Phytophthora</i> sp.) rust fungi <i>Rhizoctonia</i> sp. <i>Fusarium</i> sp. <i>Sclerotinia</i>	<i>Erysiphe necator</i> <i>Gibberella fujikuroi</i> <i>Oculimacula</i> sp. <i>Rhynchosporium secalis</i> <i>Pyrenophora teres</i> <i>Septoria tritici</i> <i>Sclerotinia homoeocarpa</i> <i>Monilinia</i> sp. <i>Cercospora</i> sp. <i>Phoma</i> sp. <i>infestans</i>	<i>Blumeria graminis</i> <i>Botrytis cinerea</i> <i>Plasmopara viticola</i> <i>Magnaporthe grisea</i> <i>Venturia inaequalis</i> <i>Mycosphaerella fijiensis</i>	

## Riesgo de aparición de resistencias

# Preocupaciones

- La presión de la *food chain* en el número de trazas de residuos, está desencadenando un mal uso de los productos, con más aplicaciones de las indicadas, con poca rotación de mismos, etc.
- En contra de los principios de la Directiva de Uso Sostenible, se están aumentando el número de aplicaciones con los mismos productos.
- La evaluación comparativa puede impactar en un menor abanico de soluciones para un correcto manejo del fenómeno de las resistencias, lo cual a la larga puede significar una falta de control y mayor/mal uso de productos.
- Siguen apareciendo nuevos patógenos que suponen una amenaza a los protocolos de Gestion Integrada de Plagas.

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