

FRAC Code List ©*2019: Fungal control agents sorted by cross resistance pattern and mode of action (including FRAC Code numbering)

INTRODUCTION

The following table lists commercial fungicides, mainly for use in plant protection, according to their mode of action and resistance risk. The most important bactericides are also included. Grouping is considering the biochemical mode of action, but a main driver is to identify cross-resistance patterns between chemistries.

The Table headings are defined as:

MOA Code

Different letters (A to I, with added numbers) are used to distinguish fungicide groups according to their biochemical mode of action (MOA) in the biosynthetic pathways of plant pathogens. The grouping was made according to processes in the metabolism starting from nucleic acids synthesis (A) to secondary metabolism, e.g. melanin synthesis (I) at the end of the list, followed by host plant defence inducers (P), recent molecules with an unknown mode of action and unknown resistance risk (U, transient status, until information about mode of action and mechanism of resistance becomes available), and chemical multi-site inhibitors (M). Fungicidal compositions of biological origin are grouped according to the main mode of action within the respective pathway categories. A more recently introduced category “Biologicals with multiple modes of action” (BM) is used for agents from biological origin showing multiple mechanisms of action without evidence of a dominating mode of action.

Target Site and Code

If available, the biochemical mode of action is given. In several cases the precise target site may not be known, however, a grouping within a given pathway / functional cluster is still possible. Grouping can also be made due to cross resistance profiles within a group or in relation to other groups.

Group Name

The Group Names listed are based on chemical relatedness of structures which are accepted in literature (e.g. The Pesticide Manual). They are based on different sources (chemical structure, site of action, first important representative in group).

Chemical or Biological Group

Grouping is based on chemical considerations. Nomenclature is according to IUPAC and Chemical Abstract name. Taxonomic information may be used for agents of biological origin.

Common name

BSI/ISO accepted (or proposed) common name for an individual active ingredient expected to appear on the product label as definition of the product.

Comments on Resistance

Details are given for the (molecular) mechanism of resistance and the resistance risk. If field-resistance is known to one member of the Group, it is most likely but not exclusively valid that cross resistance to other group members will be present. There is increasing evidence that the degree of cross resistance can differ between group members and pathogen species or even within species. For the latest information on resistance and cross resistance status of a particular pathogen / fungicide combination, it is advised to contact local FRAC representatives, product manufacturer's representatives or crop protection advisors. The intrinsic risk for resistance evolution to a given fungicide group is estimated to be **low, medium or high** according to the principles described in FRAC Monographs 1, 2 and 3. Resistance management is driven by intrinsic risk of fungicide, pathogen risk and agronomic risk (see FRAC pathogen risk list).

Similar classification lists of fungicides have been published by T. Locke on behalf of FRAG – UK (Fungicide Resistance, August 2001), and by P. Leroux (Classification des fongicides agricoles et résistance, Phytoma, La Défense des Végétaux, No. 554, 43-51, November 2002).

FRAC Code

Numbers and letters are used to distinguish the fungicide groups according to their cross resistance behaviour. This code should be used to define the GROUP Number on product labels. The numbers were assigned primarily according to the time of product introduction to the market. The letters refer to P = host plant defence inducers, M = chemical multi-site inhibitors, U = unknown mode of action and unknown resistance risk, and BM = biologicals with multiple modes of action. Reclassification of compounds based on new research may result in codes to expire. This is most likely in the U – section when the mode of actions gets clarified. These codes are not re-used for new groups; a note is added to indicate reclassification into a new code.

Last update: February 2019

Next update decisions: January 2020

** Disclaimer*

The FRAC Code List is the property of FRAC and protected by copyright laws. The FRAC Code List may be used for educational purposes without permission from FRAC. Commercial use of this material may only be made with the express, prior and written permission of FRAC. Inclusion to the FRAC Code List is based on scientific evaluation of the mode of action of the active ingredients; it does not provide any kind of testimonial for the use of a product or a judgment on efficacy.

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
A: nucleic acids metabolism	A1 RNA polymerase I	PA – fungicides (PhenylAmides)	acylalanines	benalaxyl benalaxyl-M (=kiralaxyl) furalaxyl metalaxyl metalaxyl-M (=mefenoxam)	Resistance and cross resistance well known in various Oomycetes but mechanism unknown. High risk. See FRAC Phenylamide Guidelines for resistance management	4
			oxazolidinones	oxadixyl		
			butyrolactones	ofurace		
	A2 adenosin-deaminase	hydroxy-(2-amino-) pyrimidines	hydroxy-(2-amino-) pyrimidines	bupirimate dimethirimol ethirimol	Medium risk. Resistance and cross resistance known in powdery mildews. Resistance management required.	8
	A3 DNA/RNA synthesis (proposed)	heteroaromatics	isoxazoles	hymexazole	Resistance not known.	32
			isothiazolones	ochthilnone		
	A4 DNA topoisomerase type II (gyrase)	carboxylic acids	carboxylic acids	oxolinic acid	Bactericide. Resistance known. Risk in fungi unknown. Resistance management required.	31

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
B: Cytoskeleton and motor protein	B1 β-tubulin assembly in mitosis	MBC - fungicides (Methyl Benzimidazole Carbamates)	benzimidazoles	benomyl carbendazim fuberidazole thiabendazole	Resistance common in many fungal species. Several target site mutations, mostly E198A/G/K, F200Y in β-tubulin gene. Positive cross resistance between the group members. Negative cross resistance to N-Phenylcarbamates. High risk. See FRAC Benzimidazole Guidelines for resistance management.	1
			thiophanates	thiophanate thiophanate-methyl		
	B2 β-tubulin assembly in mitosis	N-phenyl carbamates	N-phenyl carbamates	diethofencarb	Resistance known. Target site mutation E198K. Negative cross resistance to benzimidazoles. High risk. Resistance management required.	10
	B3 β-tubulin assembly in mitosis	benzamides	toluamides	zoxamide	Low to medium risk. Resistance management required.	22
		thiazole carboxamide	ethylamino-thiazole-carboxamide	ethaboxam		
	B4 cell division (unknown site)	phenylureas	phenylureas	pencycuron	Resistance not known.	20
	B5 delocalisation of spectrin-like proteins	benzamides	pyridinylmethyl-benzamides	fluopicolide fluopimomide	Resistant isolates detected in grapevine downy mildew. Medium risk. Resistance management required.	43
	B6 actin/myosin/fimbrin function	cyanoacrylates	aminocyanoacrylates	phenamacril	Resistance known in <i>Fusarium graminearum</i> . Target site mutations in the gene coding for myosin-5 found in lab studies. Medium to high risk. Resistance management required.	47
aryl-phenyl-ketones			benzophenone	metrafenone	Less sensitive isolates detected in wheat powdery mildew. Medium risk. Resistance management required.	
	benzoylpyridine	pyriofenone	Reclassified from U8 in 2018	50		

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE	
C. respiration	C1 complex I NADH Oxido-reductase	pyrimidinamines	pyrimidinamines	diflumetorim	Resistance not known.	39	
		pyrazole-MET1	pyrazole-5-carboxamides	tolfenpyrad			
		quinazoline	quinazoline	fenazaquin			
	C2 complex II: succinate-dehydrogenase	SDHI (Succinate-dehydrogenase inhibitors)	phenyl-benzamides	phenyl-benzamides	benodanil flutolanil mepronil	Resistance known for several fungal species in field populations and lab mutants. Target site mutations in sdh gene, e.g. H/Y (or H/L) at 257, 267, 272 or P225L, dependent on fungal species. Resistance management required. Medium to high risk. See FRAC SDHI Guidelines for resistance management.	7
			phenyl-oxo-ethyl thiophene amide	phenyl-oxo-ethyl thiophene amide	isofetamid		
			pyridinyl-ethyl-benzamides	pyridinyl-ethyl-benzamides	fluopyram		
			furan- carboxamides	furan- carboxamides	fenfuram		
			oxathiin- carboxamides	oxathiin- carboxamides	carboxin oxycarboxin		
			thiazole- carboxamides	thiazole- carboxamides	thifluzamide		
			pyrazole-4- carboxamides	pyrazole-4- carboxamides	benzovindiflupyr bixafen fluindapyr fluxapyroxad furametpyr inpyrfluxam isopyrazam penflufen penthioapyrad sedaxane		
			N-cyclopropyl-N-benzyl-pyrazole- carboxamides	N-cyclopropyl-N-benzyl-pyrazole- carboxamides	isoflucypram		
			N-methoxy-(phenyl-ethyl)-pyrazole- carboxamides	N-methoxy-(phenyl-ethyl)-pyrazole- carboxamides	pydiflumetofen		
			pyridine- carboxamides	pyridine- carboxamides	boscalid		
	pyrazine- carboxamides	pyrazine- carboxamides	pyraziflumid				
	C3 complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (<i>cyt b gene</i>)	QoI-fungicides (Quinone outside Inhibitors)	methoxy-acrylates	methoxy-acrylates	azoxystrobin coumoxystrobin enoxastrobin flufenoxystrobin picoxystrobin pyraoxystrobin	Resistance known in various fungal species. Target site mutations in cyt b gene (G143A, F129L) and additional mechanisms. Cross resistance shown between all members of the QoI group. High risk. See FRAC QoI Guidelines for resistance management.	11
			methoxy-acetamide	methoxy-acetamide	mandestrobin		
			methoxy-carbamates	methoxy-carbamates	pyraclostrobin pyrametostrobin triclopyricarb		
			oximino-acetates	oximino-acetates	kresoxim-methyl trifloxystrobin		
			oximino-acetamides	oximino-acetamides	dimoxystrobin fenaminstrobin metominostrobin orysastrobin		
			oxazolidine-diones	oxazolidine-diones	famoxadone		
dihydro-dioxazines			dihydro-dioxazines	fluoxastrobin			
Imidazolinones			Imidazolinones	fenamidone			
benzyl-carbamates			benzyl-carbamates	pyribencarb			

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
C: respiration (continued)	C4 complex III: cytochrome bc1 (ubiquinone reductase) at Qi site	Qil - fungicides (Quinone inside Inhibitors)	cyano-imidazole	cyazofamid	Resistance risk unknown but assumed to be medium to high (mutations at target site known in model organisms). Resistance management required.	21
			sulfamoyl-triazole	amisulbrom		
			picolinamides	fenicoxamid		
	C5 uncouplers of oxidative phosphorylation		dinitrophenyl-crotonates	binapacryl meptyldinocap dinocap	Resistance not known. Also acaricidal activity.	29
			2,6-dinitro-anilines	fluazinam	Low risk. However, resistance claimed in <i>Botrytis</i> in Japan.	
			(pyr.-hydrazones)	(ferimzone)	Reclassified to U 14 in 2012.	
	C6 inhibitors of oxidative phosphorylation, ATP synthase	organo tin compounds	tri-phenyl tin compounds	fentin acetate fentin chloride fentin hydroxide	Some resistance cases known. Low to medium risk.	30
	C7 ATP transport (proposed)	thiophene-carboxamides	thiophene-carboxamides	silthiofam	Resistance reported. Risk low.	38
	C8 complex III: cytochrome bc1 (ubiquinone reductase) at Qo site, stigmatellin binding sub-site	QoSI fungicides (Quinone outside Inhibitor, stigmatellin binding type)	triazolo-pyrimidylamine	ametoctradin	Not cross resistant to Qol fungicides. Resistance risk assumed to be medium to high (single site inhibitor). Resistance management required.	45
	D: amino acids and protein synthesis	D1 methionine biosynthesis (proposed) (<i>cgs</i> gene)	AP - fungicides (Anilino-Pyrimidines)	anilino-pyrimidines	cyprodinil mepanipirim pyrimethanil	Resistance known in <i>Botrytis</i> and <i>Venturia</i> , sporadically in <i>Oculimacula</i> . Medium risk. See FRAC Anilinopyrimidine Guidelines for resistance management.
D2 protein synthesis (ribosome, termination step)		enopyranuronic acid antibiotic	enopyranuronic acid antibiotic	blasticidin-S	Low to medium risk. Resistance management required.	23
D3 protein synthesis (ribosome, initiation step)		hexopyranosyl antibiotic	hexopyranosyl antibiotic	kasugamycin	Resistance known in fungal and bacterial (<i>P. glumae</i>) pathogens. Medium risk. Resistance management required.	24
D4 protein synthesis (ribosome, initiation step)		glucopyranosyl antibiotic	glucopyranosyl antibiotic	streptomycin	Bactericide. Resistance known. High risk. Resistance management required.	25
D5 protein synthesis (ribosome, elongation step)		tetracycline antibiotic	tetracycline antibiotic	oxytetracycline	Bactericide. Resistance known. High risk. Resistance management required.	41

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
E: signal transduction	E1 signal transduction (mechanism unknown)	aza-naphthalenes	aryloxyquinoline	quinoxifen	Resistance to quinoxifen known. Medium risk. Resistance management required. Cross resistance found in <i>Erysiphe (Uncinula) necator</i> but not in <i>Blumeria graminis</i> .	13
			quinazolinone	proquinazid		
	E2 MAP/Histidine-Kinase in osmotic signal transduction (<i>os-2, HOG1</i>)	PP-fungicides (PhenylPyrroles)	phenylpyrroles	fenpiclonil fludioxonil	Resistance found sporadically, mechanism speculative. Low to medium risk. Resistance management required.	12
E3 MAP/Histidine-Kinase in osmotic signal transduction (<i>os-1, Daf1</i>)	dicarboximides	dicarboximides	chlozolate dimethachlone iprodione procymidone vinclozolin	Resistance common in <i>Botrytis</i> and some other pathogens. Several mutations in OS-1, mostly I365S. Cross resistance common between the group members. Medium to high risk. See FRAC Dicarboximide Guidelines for resistance management.	2	

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
F: lipid synthesis or transport / membrane integrity or function	F1	formerly dicarboximides				
	F2 phospholipid biosynthesis, methyltransferase	phosphoro-thiolates	phosphoro-thiolates	edifenphos iprobenfos (IBP) pyrazophos	Resistance known in specific fungi. Low to medium risk. Resistance management required if used for risky pathogens.	6
		dithiolanes	dithiolanes	isoprothiolane		
	F3 cell peroxidation (proposed)	AH-fungicides (Aromatic Hydrocarbons) (chlorophenyls, nitroanilines)	aromatic hydrocarbons	biphenyl chloroneb dicloran quintozone (PCNB) tecnazene (TCNB) tolclofos-methyl	Resistance known in some fungi. Low to medium risk. Cross resistance patterns complex due to different activity spectra.	14
		heteroaromatics	1,2,4-thiadiazoles	etridiazole		
	F4 cell membrane permeability, fatty acids (proposed)	carbarnates	carbarnates	iodocarb propamocarb prothiocarb	Low to medium risk. Resistance management required.	28
	F5	formerly CAA-fungicides				
	F6 microbial disrupters of pathogen cell membranes	microbial	<i>Bacillus</i> sp. and the fungicidal lipopeptides produced	<i>Bacillus amyloliquefaciens</i> strain QST 713	synonyms for <i>Bacillus amyloliquefaciens</i> are <i>Bacillus subtilis</i> and <i>B. subtilis</i> var. <i>amyloliquefaciens</i> (previous taxonomic classification). Resistance not known. Induction of host plant defence described as additional mode of action for strain QST 713 and FZB24	44
				<i>Bacillus amyloliquefaciens</i> strain FZB24		
				<i>Bacillus amyloliquefaciens</i> strain MBI600		
<i>Bacillus amyloliquefaciens</i> strain D747						
F7 cell membrane disruption	plant extract	terpene hydrocarbons, terpene alcohols and terpene phenols	extract from <i>Melaleuca alternifolia</i> (tea tree)	Resistance not known.	46	
			plant oils (mixtures): eugenol, geraniol, thymol			
F8 ergosterol binding	polyene	amphoteric macrolide antifungal antibiotic from <i>Streptomyces natalensis</i> or <i>S. chattanoogensis</i>	natamycin (pimaricin)	Resistance not known. Agricultural, food and topical medical uses.	48	
F9 lipid homeostasis and transfer/storage	OSBPI oxysterol binding protein homologue inhibition	piperidinyl-thiazole-isoxazolines	oxathiapirolin	Resistance risk assumed to be medium to high (single site inhibitor). Resistance management required. (Previously U15).	49	

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
G: sterol biosynthesis in membranes	G1 C14- demethylase in sterol biosynthesis (<i>erg11/cyp51</i>)	DMI-fungicides (DeMethylation Inhibitors) (SBI: Class I)	piperazines	triforine	There are big differences in the activity spectra of DMI fungicides. Resistance is known in various fungal species. Several resistance mechanisms are known incl. target site mutations in <i>cyp51</i> (<i>erg 11</i>) gene, e.g. V136A, Y137F, A379G, I381V; <i>cyp51</i> promotor; ABC transporters and others. Generally wise to accept that cross resistance is present between DMI fungicides active against the same fungus. DMI fungicides are Sterol Biosynthesis Inhibitors (SBIs), but show no cross resistance to other SBI classes. Medium risk. See FRAC SBI Guidelines for resistance management.	3
			pyridines	pyrifenoxy pyrisoxazole		
			pyrimidines	fenarimol nuarimol		
			imidazoles	imazalil oxpoconazole pefurazoate prochloraz triflumizole		
			triazoles	azaconazole bitertanol bromuconazole cyproconazole difenoconazole diniconazole epoxiconazole etaconazole fenbuconazole fluquinconazole flusilazole flutriafol hexaconazole imibenconazole ipconazole mefentrifluconazole metconazole myclobutanil penconazole propiconazole simeconazole tebuconazole tetraconazole triadimefon triadimenol triticonazole prothioconazole		
				triazolinthiones		
	morpholines	aldimorph dodemorph fenpropimorph tridemorph		Decreased sensitivity for powdery mildews. Cross resistance within the group generally found but not to other SBI classes. Low to medium risk. See FRAC SBI Guidelines for resistance management.	5	
		piperidines				fenpropidin piperalin
		spiroketal-amines				spiroxamine
	G3 3-keto reductase, C4- de-methylation (<i>erg27</i>)	KRI fungicides (KetoReductase Inhibitors) (SBI: Class III)	hydroxyanilides	fenhexamid	Low to medium risk. Resistance management required.	17
			amino-pyrazolinone	fenpyrazamine		
	G4 squalene-epoxidase in sterol biosynthesis (<i>erg1</i>)	(SBI class IV)	thiocarbamates	pyributicarb	Resistance not known, fungicidal and herbicidal activity.	18
			allylamines	naftifine terbinafine	Medical fungicides only.	

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL 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. Low to medium risk. See FRAC CAA Guidelines for resistance management.	40
			valinamide carbamates	benthiavdicarb iprovaldicarb valifenalate		
mandelic acid amides			mandipropamid			
I: melanin synthesis in cell wall	I1 reductase in melanin biosynthesis	MBI-R (Melanin Biosynthesis Inhibitors – Reductase)	isobenzofuranone	fthalide	Resistance not known.	16.1
			pyrrolo-quinolinone	pyroquilon		
			triazolobenzothiazole	tricyclazole		
	I2 dehydratase in melanin biosynthesis	MBI-D (Melanin Biosynthesis Inhibitors – Dehydratase)	cyclopropane-carboxamide	carpropamid	Resistance known. Medium risk. Resistance management required.	16.2
			carboxamide	diclocymet		
			propionamide	fenoxanil		
	I3 polyketide synthase in melanin biosynthesis	MBI-P (Melanin Biosynthesis Inhibitors – Polyketide synthase)	trifluoroethyl-carbamate	tolprocarb	Resistance not known.	16.3

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
P: host plant defence induction	P 1 salicylate-related	benzo-thiadiazole (BTH)	benzo-thiadiazole (BTH)	acibenzolar-S-methyl	Resistance not known.	P 01
	P 2 salicylate-related	benzisothiazole	benzisothiazole	probenazole (also antibacterial and antifungal activity)	Resistance not known.	P 02
	P 3 salicylate-related	thiadiazole-carboxamide	thiadiazole-carboxamide	tiadinil isotianil	Resistance not known.	P 03
	P 4 polysaccharide elicitors	natural compound	polysaccharides	laminarin	Resistance not known.	P 04
	P 5 anthraquinone elicitors	plant extract	complex mixture, ethanol extract (anthraquinones, resveratrol)	extract from <i>Reynoutria sachalinensis</i> (giant knotweed)	Resistance not known.	P 05
	P 6 microbial elicitors	microbial	bacterial <i>Bacillus</i> spp.l	<i>Bacillus mycoides</i> isolate J	Resistance not known.	P 06
			fungal <i>Saccharomyces</i> spp.	cell walls of <i>Saccharomyces cerevisiae</i> strain LAS117		
P 7 phosphonates	phosphonates	ethyl phosphonates	fosetyl-Al	Few resistance cases reported in few pathogens. Low risk. Reclassified from U33 in 2018	P 07 (33)	
			phosphorous acid and salts			

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
U: Unknown mode of action (U numbers not appearing in the list derive from reclassified fungicides)	unknown	cianoacetamide-oxime	cianoacetamide-oxime	cymoxanil	Resistance claims described. Low to medium risk. Resistance management required.	27
	formerly phosphonates (FRAC code 33), reclassified to P 07 in 2018					
	unknown	phthalamic acids	phthalamic acids	teclofthalam (Bactericide)	Resistance not known.	34
	unknown	benzotriazines	benzotriazines	triazoxide	Resistance not known.	35
	unknown	benzene-sulfonamides	benzene-sulphonamides	flusulfamide	Resistance not known.	36
	unknown	pyridazinones	pyridazinones	diclomezine	Resistance not known.	37
	formerly methasulfocarb (FRAC code 42), reclassified to M 12 in 2018					
	unknown	phenyl-acetamide	phenyl-acetamide	cyflufenamid	Resistance in <i>Sphaerotheca</i> . Resistance management required	U 06
	cell membrane disruption (proposed)	guanidines	guanidines	dodine	Resistance known in <i>Venturia inaequalis</i> . Low to medium risk. Resistance management recommended.	U 12
	unknown	thiazolidine	cyano-methylene-thiazolidines	flutianil	Resistance not known.	U 13
	unknown	pyrimidinone-hydrazones	pyrimidinone-hydrazones	ferimzone	Resistance not known (previously C5).	U 14
	complex III: cytochrome bc1, unknown binding site (proposed)	4-quinolyl-acetate	4-quinolyl-acetates	tebufloquin	Not cross resistant to QoI. Resistance risk unknown but assumed to be medium. Resistance management required.	U 16
	Unknown	tetrazolyloxime	tetrazolyloximes	picarbutrazox	Resistance not known. Not cross resistant to PA, QoI, CAA.	U 17
	Unknown (Inhibition of trehalase)	glucopyranosyl antibiotic	glucopyranosyl antibiotics	validamycin	Resistance not known. Induction of host plant defense by trehalose proposed (previously H3).	U 18

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
NC: not classified	unknown	diverse	diverse	mineral oils, organic oils, inorganic salts, material of biological origin	Resistance not known.	NC
M: Chemicals with multi-site activity	multi-site contact activity	inorganic (electrophiles)	inorganic	copper (different salts)	Generally considered as a low risk group without any signs of resistance developing to the fungicides.	M 01
		inorganic (electrophiles)	inorganic	sulphur		M 02
		dithiocarbamates and relatives (electrophiles)	dithio-carbamates and relatives	ferbam mancozeb maneb metiram propineb thiram zinc thiazole zineb ziram		M 03
		phthalimides (electrophiles)	phthalimides	captan captafol folpet		M 04
		chloronitriles (phthalonitriles) (unspecified mechanism)	chloronitriles (phthalonitriles)	chlorothalonil		M 05
		sulfamides (electrophiles)	sulfamides	dichlofluanid tolylfluanid		M 06
		bis-guanidines (membrane disruptors, detergents)	bis-guanidines	guazatine iminocadine		M 07
		triazines (unspecified mechanism)	triazines	anilazine		M 08
		quinones (anthraquinones) (electrophiles)	quinones (anthra-quinones)	dithianon		M 09
		quinoxalines (electrophiles)	quinoxalines	chinomethionat / quinomethionate		M 10
		maleimide (electrophiles)	maleimide	fluoroimide		M 11
		thiocarbamate (electrophiles)	thiocarbamate	methasulfocarb		Reclassified from U42 in 2018

MOA	TARGET SITE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
BM: Biologicals with multiple modes of action	multiple effects on cell wall, ion membrane transporters; chelating effects	plant extract	polypeptide (lectin)	extract from the cotyledons of lupine plantlets ("BLAD")	Resistance not known (previously M12).	BM 01
	multiple effects described: competition, mycoparasitism, antibiosis, lytic enzymes, induced resistance	microbial (living microbes or extract, metabolites)	fungal <i>Trichoderma</i> spp.	<i>Trichoderma atroviride</i> strain I-1237	Resistance not known	BM 02
				<i>Trichoderma atroviride</i> strain LU132		
				<i>Trichoderma atroviride</i> strain SC1		
				<i>Trichoderma asperellum</i> strain T34		
			fungal <i>Gliocladium</i> spp.	<i>Gliocladium catenulatum</i> strain J1446		
			bacterial <i>Streptomyces</i> spp.	<i>Streptomyces griseovirides</i> strain K61		