FRAC Code List ©*2022:
Fungal control agents sorted by cross-resistance pattern and mode of action
(including coding for FRAC Groups on product labels)

Disclaimer

The technical information contained in this publication is provided to CropLife International/RAC members, non-members, the scientific community, and a broader public audience.

While CropLife International and the RACs make every effort to present accurate and reliable information in the guidelines, CropLife International and the RACs do not guarantee the accuracy, completeness, efficacy, timeliness, or correct sequencing of such information. CropLife International and the RACs assume no responsibility for consequences resulting from the use of their information, or in any respect for the content of such information, including but not limited to errors or omissions, the accuracy or reasonableness of factual or scientific assumptions, studies or conclusions.

Inclusion of active ingredients and products on the RAC Code Lists is based on scientific evaluation of their modes of action; it does not provide any kind of testimonial for the use of a product or a judgment on efficacy. CropLife International and the RACs are not responsible for, and expressly disclaim all liability for, damages of any kind arising out of use, reference to, or reliance on information provided in the guidelines.

Listing of chemical classes or modes of action in any of the CropLife International/RAC recommendations must not be interpreted as approval for use of a compound in a given country. Prior to implementation, each user must determine the current registration status in the country of use and strictly adhere to the uses and instructions approved in that country.

INTRODUCTION

The following table lists 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 P, 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), 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.

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 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 "FUNGICIDE GROUP" code, e.g.

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 action gets clarified. These codes are not re-used for new groups; a note is added to indicate reclassification into a new code.

Last update: March 2022

Next update decisions: February 2023

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	octhilinone		
	A4 DNA topoisomerase type II (gyrase)	carboxylic acids	carboxylic acids	oxolinic acid	Bactericide. Resistance known. Risk in fungi unknown. Resistance management required.	31
	A5 inhibition of dihydroorotate dehydrogenase within *de novo* pyrimidine biosynthesis	DHODHI-fungicides	phenyl-propanol	ipflufenoquin	Medium to high risk.	52

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
B: Cytoskeleton and motor protein	B1 tubulin polymerization	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-phenyl carbamates. High risk. See FRAC Benzimidazole Guidelines for resistance management.	1
			thiophanates	thiophanate thiophanate-methyl		
	B2 tubulin polymerization	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 tubulin polymerization	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 *Fusarium graminearum*. 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 powdery mildews (*Blumeria* and *Sphaerotheca*) Medium risk. Resistance management required. Reclassified from U8 in 2018	50
			benzoylpyridine	pyriofenone		
	B7 tubulin dynamics modulator	pyridazine	pyridazine	pyridachlometyl	High risk.	53

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-dehydro-genase	SDHI (Succinate-dehydrogenase inhibitors)	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	isofetamid		
			pyridinyl-ethyl-benzamides	fluopyram		
			phenyl-cyclobutyl-pyridineamide	cyclobutrifluram		
			furan- carboxamides	fenfuram		
			oxathiin-carboxamides	carboxin oxycarboxin		
			thiazole-carboxamides	thifluzamide		
			pyrazole-4-carboxamides	benzovindiflupyr bixafen fluindapyr fluxapyroxad furametpyr inpyrfluxam isopyrazam penflufen penthiopyrad sedaxane		
			N-cyclopropyl-N-benzyl-pyrazole-carboxamides	isoflucypram		
			N-methoxy-(phenyl-ethyl)-pyrazole-carboxamides	pydiflumetofen		
			pyridine-carboxamides	boscalid		
			pyrazine-carboxamides	pyraziflumid		

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
C. respiration	C3 complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site *(cyt b gene)*	QoI-fungicides (Quinone outside Inhibitors)	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 Code 11 fungicides. High risk. See FRAC QoI Guidelines for resistance management.	11
			methoxy-acetamide	mandestrobin		
			methoxy-carbamates	pyraclostrobin pyrametostrobin triclopyricarb		
			oximino-acetates	kresoxim-methyl trifloxystrobin		
			oximino-acetamides	dimoxystrobin fenaminstrobin metominostrobin orysastrobin		
			oxazolidine-diones	famoxadone		
			dihydro-dioxazines	fluoxastrobin		
			imidazolinones	fenamidone		
			benzyl-carbamates	pyribencarb		
		QoI-fungicides (Quinone outside Inhibitors; Subgroup A)	tetrazolinones	metyltetraprole	Resistance not known. Not cross resistant with Code 11 fungicides on G143A mutants. High risk. See FRAC QoI Guidelines for resistance management.	11A

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	QiI - 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. No spectrum overlap with the Oomycete-fungicides cyazofamid and amisulbrom	21
			sulfamoyl-triazole	amisulbrom		
			picolinamides	fenpicoxamid florylpicoxamid		
	C5 uncouplers of oxidative phos-phorylation		dinitrophenyl-crotonates	binapacryl meptyldinocap dinocap	Resistance not known. Also acaricidal activity.	29
			2,6-dinitro-anilines	fluazinam	Low risk. However, resistance claimed in *Botrytis* in Japan.	
			(pyr.-hydrazones)	(ferimzone)	Reclassified to U 14 in 2012.	
	C6 inhibitors of oxidative phos-phorylation, 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 QoI 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) *(cgs gene)*	AP - fungicides (Anilino-Pyrimidines)	anilino-pyrimidines	cyprodinil mepanipyrim pyrimethanil	Resistance known in *Botrytis* and *Venturia*, sporadically in *Oculimacula*. Medium risk. See FRAC Anilinopyrimidine Guidelines for resistance management.	9
	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 (*P. glumae*) 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	quinoxyfen	Resistance to quinoxyfen known. Medium risk. Resistance management required. Cross resistance found in *Erysiphe (Uncinula) necator* but not in *Blumeria graminis*.	13
			quinazolinone	proquinazid		
	E2 MAP/Histidine-Kinase in osmotic signal transduction *(os-2, HOG1)*	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 *(os-1, Daf1)*	dicarboximides	dicarboximides	chlozolinate dimethachlone iprodione procymidone vinclozolin	Resistance common in *Botrytis* 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 quintozene (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)	Carbamates	carbamates	iodocarb propamocarb prothiocarb	Low to medium risk. Resistance management required.	28
	F5	formerly CAA-fungicides				
	F6 microbial disrupters of pathogen cell membranes	formerly *Bacillus amyloliquefaciens* strains (FRAC Code 44); reclassified to BM02 in 2020				
	F7 cell membrane disruption	formerly extract from *Melaleuca alternifolia* (tea tree oil) and plant oils (eugenol, geraniol, thymol) FRAC Code 46, reclassified to BM01 in 2021				
	F8 ergosterol binding	Polyene	amphoteric macrolide antifungal antibiotic from *Streptomyces natalensis* or *S. chattanoogensis*	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	oxathiapiprolin fluoxapiprolin	Resistance risk assumed to be medium to high (single site inhibitor). Resistance management required. (Previously U15).	49
	F10 interaction with lipid fraction of the cell membrane, with multiple effects on cell membrane integrity	protein fragment	polypeptide	polypeptide ASFBIOF01-02	Resistance not known.	51

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 *(erg11/cyp51)*	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 cyp51 (erg 11) gene, e.g. V136A, Y137F, A379G, I381V; cyp51 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	pyrifenox 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		
			triazolinthiones	prothioconazole		
	G2 Δ^{14}-reductase and $\Delta^{8}\rightarrow\Delta^{7}$-isomerase in sterol biosynthesis *(erg24, erg2)*	amines ("morpholines") (SBI: Class II)	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 *(erg27)*	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 *(erg1)*	(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 *Plasmopara viticola* but not in *Phytophthora infestans*. Cross resistance between all members of the CAA group. Low to medium risk. See FRAC CAA Guidelines for resistance management.	40
			valinamide carbamates	benthiavalicarb iprovalicarb valifenalate		
			mandelic acid amides	mandipropamid		
I: melanin synthesis in cell wall	I1 reductase in melanin biosynthesis	MBI-R (Melanin Biosynthesis Inhibitors – Reductase)	isobenzo-furanone	fthalide	Resistance not known.	16.1
			pyrrolo-quinolinone	pyroquilon		
			triazolobenzo-thiazole	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. Additional activity against bacteria and fungi through induction of host plant defence	16.3

MOA	TARGET SITE AND CODE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
P: host plant defence induction	P 01 salicylate-related	benzo-thiadiazole (BTH)	benzo-thiadiazole (BTH)	acibenzolar-S-methyl	Resistance not known.	P 01
	P 02 salicylate-related	benzisothiazole	benzisothiazole	probenazole (also antibacterial and antifungal activity)	Resistance not known.	P 02
	P 03 salicylate-related	thiadiazole-carboxamide	thiadiazole-carboxamide	tiadinil isotianil	Resistance not known.	P 03
	P 04 polysaccharide elicitors	natural compound	polysaccharides	laminarin	Resistance not known.	P 04
	P 05 anthraquinone elicitors	plant extract	complex mixture, ethanol extract (anthraquinones, resveratrol)	extract from *Reynoutria sachalinensis* (giant knotweed)	Resistance not known.	P 05
	P 06 microbial elicitors	microbial	bacterial *Bacillus* spp.	*Bacillus mycoides* isolate J	Resistance not known.	P 06
			fungal *Saccharomyces* spp.	*cell walls of Saccharomyces cerevisiae* strain LAS117		
	P 07 phosphonates	phosphonates	ethyl phosphonates	fosetyl-Al	Few resistance cases reported in few pathogens. Low risk. Reclassified from U33 in 2018	P07
				phosphorous acid and salts		
	P 08 salicylate-related	isothiazole	isothiazolylmethyl ether	dichlobentiazox	activates SAR both up- and downstream of SA. Resistance not known.	P 08

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	cyanoacetamide-oxime	cyanoacetamide-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	tecloftalam (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 *Sphaerotheca*. Resistance management required	U 06
	cell membrane disruption (proposed)	guanidines	guanidines	dodine	Resistance known in *Venturia inaequalis.* Low to medium risk. Resistance management recommended.	U 12
	unknown	thiazolidine	cyano-methylene-thiazolidines	flutianil	Resistance in *Sphaerotheca* and *Podosphaera xanthii*. Resistance management required.	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
Not specified	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)	Also applies to organic copper complexes	M 01
		inorganic (electrophiles)	inorganic	sulphur		M 02
		dithiocarbamates and relatives (electrophiles)	dithio-carbamates and relatives	amobam 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	generally considered as a low risk group without any signs of resistance developing to the fungicides.	M 05
		sulfamides (electrophiles)	sulfamides	dichlofluanid tolylfluanid		M 06
		bis-guanidines (membrane disruptors, detergents)	bis-guanidines	guazatine iminoctadine		M 07
		triazines (unspecified mechanism)	triazines	anilazine		M 08
		quinones (anthraquinones) (electrophiles)	quinones (anthraquinones)	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	M 12

MOA	TARGET SITE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
BM: Biologicals with multiple modes of action: Plant extracts	multiple effects on ion membrane transporters; chelating effects	plant extract	polypeptide (lectin)	extract from the cotyledons of lupine plantlets ("BLAD")	Resistance not known. (previously M12).	BM 01
	affects fungal spores and germ tubes, induced plant defense	plant extract	phenols, sesquiterpenes, triterpenoids, coumarins	extract from *Swinglea glutinosa*	Resistance not known.	
	cell membrane disruption, cell wall, induced plant defense mechanisms	plant extract	terpene hydrocarbons, terpene alcohols and terpene phenols	extract from *Melaleuca alternifolia* (tea tree oil)	Resistance not known. (previously F7)	
				plant oils (mixtures): eugenol, geraniol, thymol		

MOA	TARGET SITE	GROUP NAME	CHEMICAL OR BIOLOGICAL GROUP	COMMON NAME	COMMENTS	FRAC CODE
BM: Biologicals with multiple modes of action: Microbial	multiple effects described (examples, not all apply to all biological groups): competition, mycoparasitism, antibiosis, membrane disruption by fungicidal lipopeptides, lytic enzymes, induced plant defence	microbial (strains of living microbes or extract, metabolites)	fungal *Trichoderma* spp.	*T. atroviride* strain I-1237 strain LU132 strain SC1 strain SKT-1 strain 77B		BM 02
				T. asperellum strain T34 strain kd		
				T. harzianum strain T-22		
				T. virens strain G-41		
			fungal *Clonostachys* spp.	*C. rosea* strain J1446 strain CR-7	nomenclature change from *Gliocladium catenulatum* to *Clonostachys rosea*	
			fungal *Coniothyrium* spp.	*C. minitans* strain CON/M/91-08		
			fungal *Hanseniaspora* spp.	*H. uvarum* strain BC18Y	Resistance not known.	
			fungal *Talaromyces* spp.	*T. flavus* strain SAY-Y-94-01		
			fungal *Saccharomyces* spp.	*S. cerevisae* strain LAS02 strain DDSF623		
			bacterial *Bacillus* spp.	*B. amyloliquefaciens* strain QST713 strain FZB24 strain MBI600 strain D747 strain F727 strain AT-332	*Bacillus amyloliquefaciens* reclassified from F6, Code 44 in 2020 synonyms for *Bacillus amyloliquefaciens* are *Bacillus subtilis* and *B. subtilis* var. *amyloliquefaciens* (previous taxonomic classification).	
				B. subtilis strain AFS032321 strain Y1336 strain HAI-0404		
			bacterial *Erwinia* spp. (peptide)	PHC25279		
			bacterial *Gluconobacter* spp.	*G. cerinus* strain BC18B		
			bacterial *Pseudomonas* spp.	*P. chlororaphis* strain AFS009		
			bacterial *Streptomyces* spp.	*S. griseovirides* strain K61		
				S. lydicus strain WYEC108		