

**Table 1.** Listed below are common and trade names of select fungicides currently registered in the United States representing the major fungicide groups and chemistry within these groups (chemical group), plus the mobility, activity, and risk of resistance developing to these fungicides.

Group Code <sup>1</sup>	Group Name (Abbreviation) <sup>1</sup>	Chemical Group	Common Name	Example Trade Name	Mobility	Mode of Action of Fungicide	Risk of Resistance <sup>2</sup>
1	methyl benzimidazole carbamate (MBC)	benzimidazole	thiabendazole	Mertect	xylem mobile	inhibits tubulin formation in mitosis, broad-spectrum	high
		thiophanate	thiophanate-methyl	Topsin M, Cleary's 3336, Cercobin			
2	dicarboximide	dicarboximide	iprodione	Chipco, Meteor, Rovral, Iprodione Pro	localized penetrant/translaminar	MAP/Histidine-kinase in osmotic signal transduction	medium to high
3	demethylation inhibitor (DMI): SBI Class I	imidazole	triflumizole	Procure, Terraguard	xylem mobile	sterol biosynthesis inhibition, broad-spectrum	medium
		piperazine	triforine	Funginex, Saprol		sterol biosynthesis inhibition, narrow-spectrum	
		triazole	difenoconazole	Inspire Super, Stadium		sterol biosynthesis inhibition, broad-spectrum	
			flutriafol	Rhyme, Preemptor			
			metconazole	Quash			
			myclobutanil	Eagle, Rally			
			propiconazole	Banner Maxx, Honor Guard, Procure, Quilt			
			tebuconazole	Folicur, Toledo			
		tetraconazole	Mettle				
triazolinthione	prothioconazole	Proline, Prosaro, Stratego YLD					
4	phenylamide (PA)	acylalanine	mefenoxam, metalaxyl	Apron XL, Ridomil Gold, Subdue Maxx	xylem mobile	inhibits RNA synthesis, active on oomycetes	high
5	amines ("morpholines") (SBI: Class II)	piperidine	piperalin	Pipron	multi-site	sterol biosynthesis in membranes.	low to medium

7	succinate dehydrogenase inhibitors (SDHI)	oxathiin-carboxamide	carboxin	Vitavax	locally systemic	inhibits respiration (MET2, succinate dehydrogenase), activity includes basidiomycetes	medium to high
		pyrazole-4-carboxamides	fluxapyroxad	Merivon, Priaxor			
			penflufen	Emesto			
			penthioopyrad	Fontelis, Vertisan			
		pyridine-carboxamide	boscalid	Endura, Pristine			
pyridinyl-ethyl-benzamide	fluopyram	Luna					
9	anilinopyrimidine (AP)	anilinopyrimidine	cyprodinil	Inspire Super, Switch, Vanguard	locally systemic	methionine biosynthesis and hydrolytic enzymes	medium
			pyrimethanil	Scala			
11	quinone outside inhibitor (QoI)	methoxy-acrylate	azoxystrobin	Abound, Quadris, Heritage, Stadium	xylem mobile	inhibits respiration (MET-III, cytochrome bc <sub>1</sub> ), broad-spectrum	high
		dihydro-dioxazine	fluoxastrobin	Evito	locally systemic		
		imidazolinone	fenamidone	Reason			
		methoxy-carbamate	pyraclostrobin	Cabrio, Headline, Priaxor			
		oximino-acetate	kresoxim-methyl	Cygnus, Sovran			
			trifloxystrobin	Flint, Gem, Compass			
12	phenylpyrrole (PP)	phenylpyrrole	fludioxonil	Cannonball, Maxim, Medallion, Scholar, Stadium	contact	disrupts membrane integrity, broad-spectrum	low to medium
13	aza-naphthalene	aryloxyquinoline	quinoxifen	Quintec	contact, volatile	MAP/Histidine-kinase in osmotic signal transduction, active on powdery mildew	low to medium
14	aromatic hydrocarbon (AH)	aromatic hydrocarbon	quintozene	PCNB, Blocker	contact	thought to act on lipid peroxidation, active on basidiomycetes and some ascomycetes	low to medium
			dicloran	Botran	contact	acts on <i>Botrytis</i> , <i>Monilinia</i> , <i>Rhizopus</i> and <i>Sclerotinia</i>	low to medium
		1,2,4-triazazole	etridiazole	Koban, Terrazole, Truban	contact	curative and preventative control of soil borne diseases, especially oomycetes.	low to medium

17	DMI: SBI Class III	hydroxyanilide	fenhexamid	Elevate, Decree	locally systemic	sterol biosynthesis inhibitor, <i>Botrytis, Monilina, Sclerotinia</i>	low to medium
19	polyoxin	peptidyl pyrimidine nucleoside	polyoxin D	Endorse, Oso, Ph-D	xylem mobile	single-site, inhibits chitin synthetase, acts on some fungi.	medium
21	quinone inside inhibitors (QiI)	cyano-imidazole	cyazofamid	Ranman	locally systemic	respiration complex III: cytochrome bc1 (ubiquinone reductase) at Qi site	medium to high (assumed)
22	benzamide	toluamide	zoxamide	Gavel, Zing!	locally systemic	cytoskeleton and motor proteins; acts on $\beta$ -tubulin assembly in mitosis	low to medium
24	hexopyranosyl antibiotic	hexopyranosyl antibiotic	kasugamycin	Kasumin	xylem mobile	protein synthesis, bactericide	medium
25	glucopyranosyl antibiotic	glucopyranosyl antibiotic	streptomycin	Agri-mycin 17, Agri-Step	xylem mobile	protein synthesis, bactericide	high
27	cyanoacetamide-oxime	cyanoacetamide oxime	cymoxanil	Curzate, Tanos	locally systemic	unknown mode of action, acts on oomycetes	low to medium
28	carbamate	carbamate	propamocarb	Banol, Previcur Flex	xylem mobile	lipid synthesis and membrane integrity; proposed to act on cell membrane permeability, fatty acids. Active on oomycetes	low to medium
29	QiI - fungicides (Quinone inside Inhibitors)	2,6-dinitroanilines	fluazinam	Omega	locally systemic	respiration: uncouples oxidative phosphorylation, broad-spectrum	low
30	organo tin compounds	tri-phenyl tin compound	triphenyltin hydroxide	Super Tin	contact	inhibitors of oxidative phosphorylation, ATP synthase	low to medium
33	phosphonate	ethyl phosphonates	fosetyl-aluminum	Aliette	amphi-mobile	unknown mode of action.	low
			phosphorous acid and salts	Alude, BioPhos, Phostrol, ProPhyt, etc.	amphi-mobile		
40	carboxylic acid amide (CAA)	cinnamic acid amide	dimethomorph	Forum, Stature, Zampro	localized penetrant/translaminar	cell wall biosynthesis in oomycetes	low to medium
			mandipropamid	Micora, Revus	locally systemic		
41	tetracycline antibiotic	tetracycline antibiotic	oxytetracycline	FireLine	amphi-mobile	protein synthesis, bactericide	high
43	benzamide	pyridinylmethyl-benzamide	fluopicolide	Presidio	locally systemic	delocalisation of spectrin-like proteins	not known (suspected)

44	microbial	<i>Bacillus</i> sp. and the fungicidal lipopeptides produced	<i>Bacillus subtilis</i> syn. <i>B. amyloliquefaciens</i> strain QST 713	Cease, Companion, Double Nickel, Serenade Opti	contact and induced resistance	microbial disrupters of pathogen cell membranes. Induced resistance	not known
45	QoSI fungicides (Quinone outside Inhibitor, stigmatellin binding type)	triazolo-pyrimidylamine	ametoctradin	Orvego, Zampro	locally systemic	complex III: cytochrome bc1 (ubiquinone reductase) at Qo site, stigmatellin binding sub-site	medium to high (assumed)
46	plant extract	terpene hydrocarbons and terpene alcohols	extract from <i>Melaleuca alternifolia</i> (tea tree)	Timorex Gold	contact	cell membrane disruption (proposed)	not known
P1	host plant defense inducers (SAR)	benzothiadiazole	acibenzolar-S-methyl	Actigard	amphi-mobile	activates plant's systemic acquired resistance (SAR) via salicylic acid pathway	not known
P5	plant extract	complex mixture, ethanol extract	extract from <i>Reynoutria sachalinensis</i> (giant knotweed)	Regalia	translaminar	host plant defence induction	not known
U6	phenyl-acetamide	phenyl-acetamide	cyflufenamid	Torino	locally systemic	unknown mode of action, active on powdery mildew	known
U8	aryl-phenyl-ketone	benzophenone	metrafenone	Vivando	locally systemic	actin disruption (proposed), active on powdery mildew	medium
U15	piperidinyl-thiazole-isoxazolines	piperidinyl-thiazole-isoxazolines	oxathiapiprolin	Orondis	xylem mobile	oxysterol binding protein (OSBP) inhibition (proposed)	medium to high (assumed)
M1	inorganic	inorganic	copper	Badge, Champ, Cueva, Kocide, Nordox	contact	disrupts function of enzymes and energy transport systems, membrane integrity; broad-spectrum	low
M2	inorganic	inorganic	sulfur	Microthiol Disperss, MicroSulf	contact	inhibits electron movement, thus interferes with cellular respiration	low
M3	dithiocarbamate	dithiocarbamate	mancozeb	Dithane, Manzate	contact	reacts with protein SH groups; broad-spectrum	low
			metiram	Polyram			
			thiram	Thiram	contact		
			ziram	Ziram			

M4	phthalimide	phthalimide	captan	Captan	contact	combines with thiols (SH groups); broad-spectrum	low
M5	chloronitrile	chloronitrile	chlorothalonil	Bravo, Daconil 2787, Echo, Initiate	contact	acts on fungal respiration via thiol, broad-spectrum	low
M12	biopesticide	polypeptide plant extract (lectin)	BLAD – extract from cotyledons of lupine plants	Fracture	contact	multiple effects on cell wall, ion membrane transporters, chelating effects	low
NC	inorganic	inorganic	mineral oil	JMS Stylet-oil, SunSpray Ultra-Fine	contact	destroys pathogen cell walls, interferes with fungus attaching to plant	low
NC	biopesticide	aldehyde	cinnamaldehyde	Vertigo	contact	biofungicide, algacide	low
NC	biopesticide	natural material	hydrogen dioxide	Oxidate	contact		low
NC	biopesticide	natural material	kaolin clay	Surround	contact	forms physical barrier to organisms, suppresses powdery mildew	low
NC	biopesticide	natural material	botanical oil (clove, garlic peppermint, rosemary, thyme, etc.)	BacStop, Organocide, Promax, Sporan, ThymeGuard, Trilogy	contact	destroys pathogen cell walls, interferes with fungus attaching to plant	low
NC	biopesticide	natural material	citric acid	Procidic	contact and systemic		low
NC	biopesticide	natural material	potassium bicarbonate	Armicarb, Kaligreen, MilStop	contact	upsets potassium ion balance in powdery mildew fungal cells, cell wall collapses	low
NC	biopesticide	natural material	potassium silicate	Sil-Matrix	contact	desiccates fungal cells, interacts with plant cuticle forming physical barrier	low
NC	biopesticide	natural material	Rhamnolipid biosurfactant	Zonix	contact	ruptures cell membrane of zoospores	low
NC	biopesticide	bacterial	<i>Bacillus amyloliquefacinens</i>	Double Nickel, Ethos XB	contact	<i>Bacillus</i> lipopeptides disrupt cell membrane by insertion	low
NC	biopesticide	bacterial	<i>Bacillus subtilis</i>	Cease, Companion, Prevont, Serenade	contact	<i>Bacillus</i> lipopeptides disrupt cell membrane by insertion	low
NC	biopesticide	bacterial	<i>Streptomyces lydicus</i>	Actinovate	N/A	competitive exclusion, direct effect on pathogen via siderophores and chitinase	low

NC	biopesticide	bacterial	<i>Streptomyces griseoviridis</i>	Mycostop	N/A	competitive exclusion, direct effect on pathogen via siderophores and chitinase	low
NC	biopesticide	fungal	<i>Aspergillus flavus</i>	AF-36	N/A	competitive exclusion; competitive colonizer of cotton flowers. Displaces other <i>A. flavus</i> in the soil surface.	low
NC	biopesticide	fungal	<i>Coniothyrium minitans</i>	Contans	N/A	pathogenic; colonizes and kills sclerotia of <i>Sclerotinia</i> spp.	low
NC	biopesticide	fungal	<i>Gliocladium catenulatum</i>	Prestop, Primastop	N/A	antagonistic, competitive exclusion	low
NC	biopesticide	fungal	<i>Gliocladium virens</i>	SoilGard	N/A	antagonistic, competitive exclusion	low
NC	biopesticide	fungal	<i>Trichoderma asperellum</i> and <i>T. gamsii</i>	Bio-Tam	N/A	antagonistic, competitive exclusion	low
NC	biopesticide	fungal	<i>Trichoderma virens</i> and <i>T. harzianum</i>	RootShield Plus WP	N/A	antagonistic, competitive exclusion	low
NC	biopesticide	viral PIP	Papaya Ringspot Virus Coat Protein	'Rainbow' papaya variety	N/A	plant incorporated protectant	low

<sup>1</sup> Group codes, names, and abbreviations used by FRAC as part of the pesticide classification system developed for pesticide resistance management labeling (web site 1). Fungicide groups are excluded that do not have a product registered in the U.S. Biopesticide group name added to this table.

<sup>2</sup> Risk of resistance is considered high when mode of resistance is known (or suspected) to be qualitative or some pathogens have already developed resistance within a few years under commercial use, medium when mode of resistance is quantitative, and low when the fungicide has multi-site activity. Entries in this column were assigned by FRAC (web site 1).

Labels for fungicides registered in the U.S. are accessible at web site 9.