

A: Nucleic Acids Metabolism

A1: RNA polymerase I
4: PA-fungicides (PhenylAmides)

A2: adenosine-deaminase
8: hydroxy (2-amino)-pyrimidines

Group 4

A3: DNA / RNA synthesis (prop.)
32: heteroaromatics

A4: DNA topoisomerase type II (gyrase)
31: carboxylic acids

Group 32

FRAC Classification of Fungicides

Fungal control agents by cross resistance pattern and mode of action 2020 (www.frac.info)

B: Cytoskeleton and Motor Proteins

B1: > β-tubulin assembly in mitosis
1: MBC fungicides (= Methyl Benzimidazole Carbamates)

B2: > β-tubulin assembly in mitosis*
10 N-phenyl carbamates

B4: cell division (unknown site)
20 phenylureas

Group 1

B3: > β-tubulin assembly in mitosis
22 benzamides and thiazole carboxamides

B5: delocalisation of spectrin-like proteins
43 benzamides

B6: actin/myosin/fimbrin function
47 cyanoacrylates

50 aryl-phenyl-ketones

Group 22

C: Respiration

C2: complex II: succinate-dehydrogenase
7 SDHI (Succinate Dehydrogenase Inhibitors)

Group 7

C: Respiration

C1: complex I NADH Oxido-reductase
39 pyrimidinamines, pyrazole-MET1, quinazoline

C4: complex III cytochrome bc1 (ubiquinone reductase) at QI site
21 QI fungicides (Quinone Inside Inhibitors)

C7: ATP transport (proposed)
38 thiophene- carboxamides

C8: inhibition of complex III cytochrome bc1(ubiquinone reductase) at Qo site (stigmatellin binding site)
45 QoI-fungicide (stigmatellin binding)

Group 39

C5: uncouplers of oxidative Phosphorylation
29

C6: inhibitors of oxidative phosphorylation, ATP synthase
30 organo tins

Group 29

C3: complex III cytochrome bc1 (ubiquinone reductase) at Qo site (cyt b gene)
11 QoI fungicides (Quinone outside Inhibitors)

C9: inhibition of complex III cytochrome bc1(ubiquinone reductase) at Qo site (cyt b gene)
11 QoI fungicides (Quinone outside Inhibitors); Subgroup A

Group 11

D: Amino Acid and Protein Synthesis

D1: methionine biosynthesis (cgs gene) (proposed)
9 Anilino-Pyrimidines (AP fungicides)

D2: protein synthesis (ribosome, termination step)
23 enopyranonic acid

D3: protein synthesis (ribosome, initiation step)
24 hexopyranosyl antibiotics

D4: protein synthesis (ribosome, initiation step)
25 glucopyranosyl antibiotics

D5: protein synthesis (ribosome, elongation step)
41 tetracycline antibiotics

Group 9

E: Signal Transduction

E1: signal transduction (mechanism unknown)
13 azanaphthalenes

E2: osmotic signal transduction > MAP / histidine- kinase (os-2, HOG1)
12 phenylglyrrols (PP-fungicides)

E3: osmotic signal transduction > MAP / histidine kinase (os-1, Daf1)
2 dicarboximides

Group 13

F: Lipid Synthesis or Transport / Membrane Integrity or Function

F2: phospholipid biosynthesis > methyltransferase
6 phosphorothiolates & dithiolanes

F3: cell peroxidation (prop.)
14 aromatic hydrocarbons & heteroaromatics

F4: cell membrane permeability, fatty acids (prop.)
28 carbamates

F7: cell membrane disruption
46 plant extract

F8: ergosterol binding
48 polyene

F9: lipid homeostasis and transfer/storage
49 OSBPI Oxyester binding protein homologue inhibition

Group 6

I: Melanin Synthesis in Cell Wall

I1: reductase in melanin biosynthesis
16.1 Melanin Biosynthesis Inhibitors: Reductase (MBI-R)

I2: dehydratase in melanin biosynthesis
16.2 Melanin Biosynthesis Inhibitors: Dehydratase (MBI-D)

I3: polyketide synthase in melanin biosynthesis
16.3 Melanin Biosynthesis Inhibitors: Polyketide synthase (MBI-P)

Group 16.1

G: Sterol Biosynthesis in Membranes

G1: C14-demethylase in sterol biosynthesis (erg11/cyp51)
3 DMIs (Demethylation Inhibitors) (SBI : Class I)

G2: Δ¹⁴-reductase and Δ⁸->Δ⁷-isomerase in sterol biosynthesis (erg2, erg 24)
5 Amines ("Morpholines") (SBI : Class II)

G3: 3-keto reductase in C4-de-methylation (erg27)
17 (KRI fungicides KetoReductase Inhibitors) (SBI : Class III)

G4: squalene epoxidase in sterol biosynthesis (erg1)
18 (SBI : Class IV)

Group 3

H: Cell Wall Biosynthesis

H4: chitin synthase
19 Polyoxins

H5: cellulose synthase
40 Carboxylic Acid Amides (CAA fungicides)

Group 19

P: Host Plant Defence Induction

P1: salicylate related
#P01 benzothiazole BTH

P2: salicylate related
#P02 benzothiazole

P3: salicylate related
#P03 thiazazole carboxamide

P4: polysaccharide elicitors
#P04 polysaccharide

P5: anthraquinone elicitors
#P05 plant extract

P6: microbial elicitors
#P06

P7: phosphonates
#P07 phosphonates

NC : Not Classified

Group P01

M: Chemicals with Multi-Site Activity

Cu copper preparations (Group M01)

S Sulphur (Group M02)

Group M05 chlorothalonil

Group M08 anilazine

Group M09 dithianon

Group M12 thiocarbamates

Group M10 chinomethional

Group M06 tolyfluanid

Group M11 fluorelmid

Group M03 thiram

Group M04 folpet

Group M07 guazatine

Group M01

Unknown Mode of Action

Group 27 cymoxanil

Group 34 teclothalam

Group 35 triazoxide

Group 36 flusulfamide

Group 37 diclomezone

Group 06 cyflufenamid

Group U13 flutriafol

Group U14 ferimzone

Group U16 tebufoquin

Group U17 picarbutrazox

Group U18 validamycin

Group U12 dodine

Group 27

BM: Biologicals with Multiple Modes of Action

BM 02: microbial (living microbes or extract, metabolites)

BM 01: plant extract

Group BM 02