Enhancing Chemical and Biological Diversity by Co-cultivation

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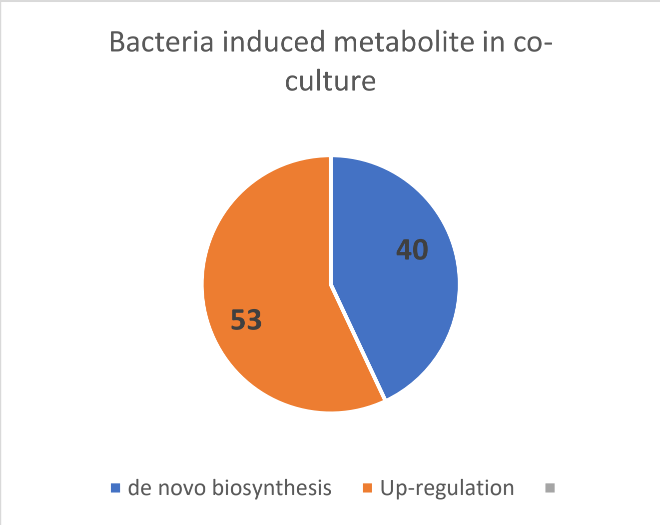
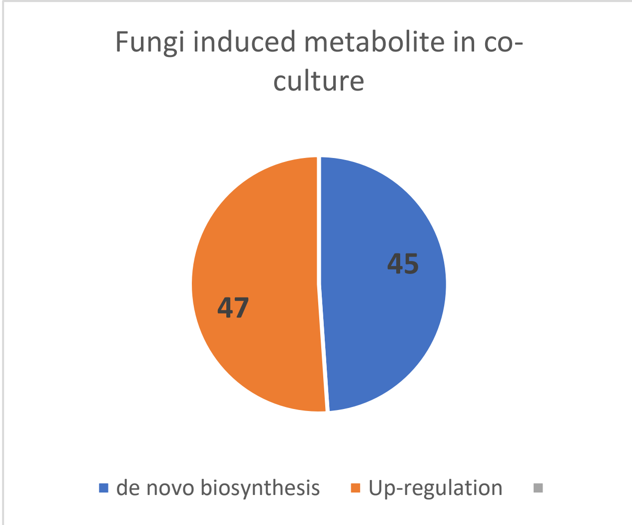

Bacteria induced metabolite in co-culture
40
53
de novo biosynthesis
Up-regulation


Fungi induced metabolite in co-culture
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de novo biosynthesis
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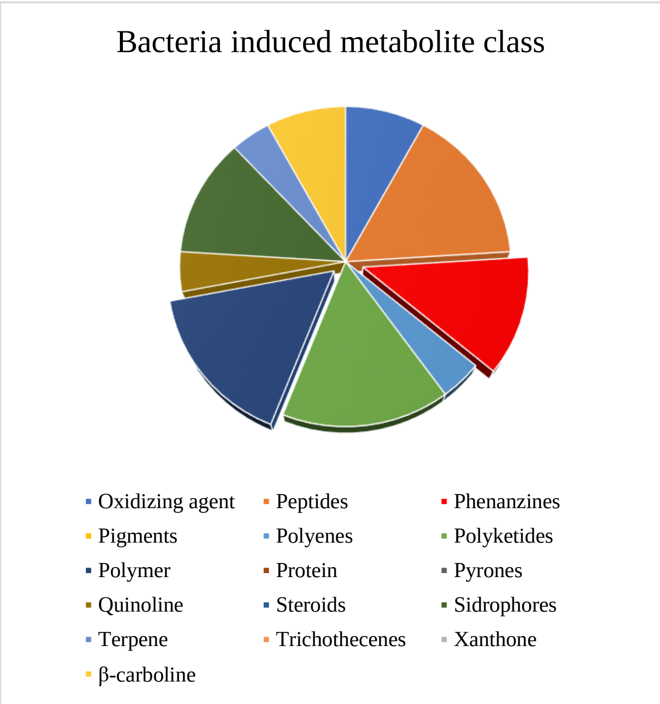
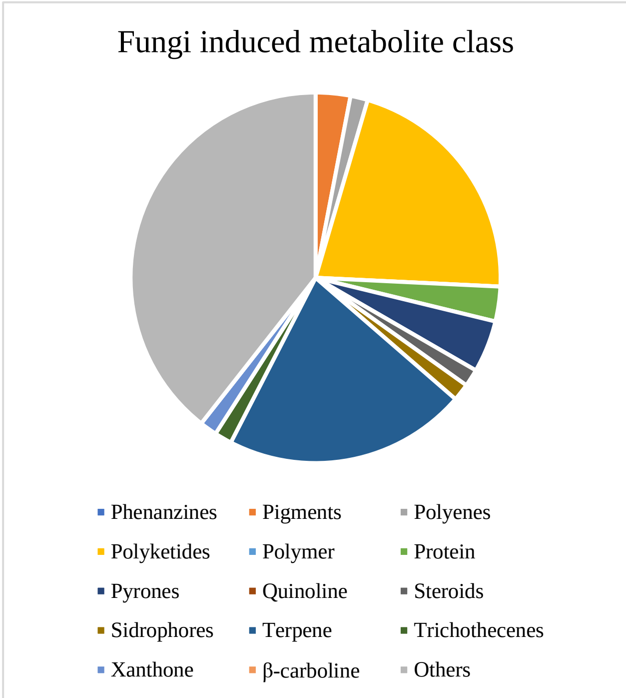

Bacteria induced metabolite class
Oxidizing agent
Peptides
Phenanzines
Pigments
Polyenes
Polyketides
Polymer
Protein
Pyrones
Quinoline
Steroids
Sidrophores
Terpene
Trichothecenes
Xanthone
β-carboline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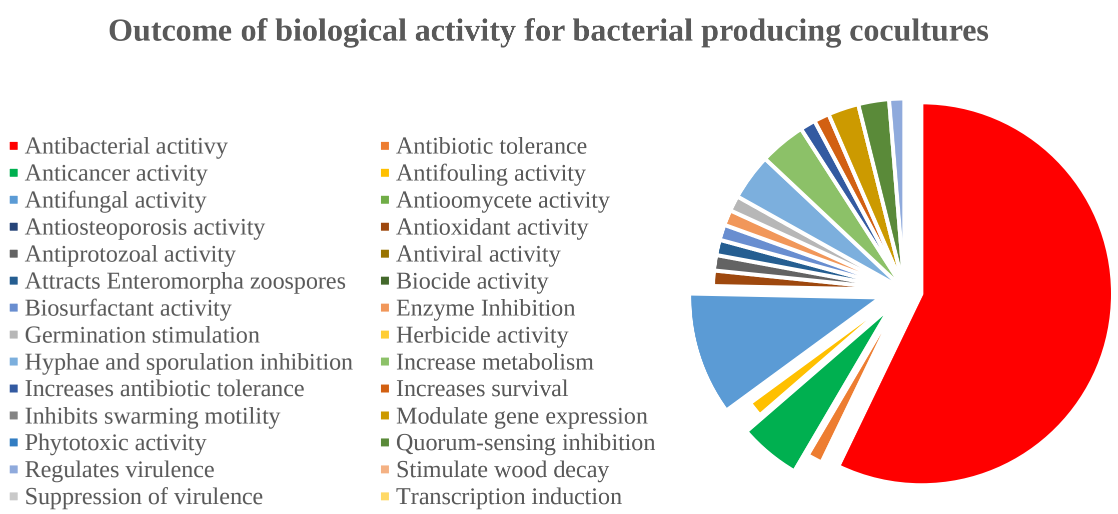
Others


Outcome of biological activity for bacterial producing cocultures
Antibacterial actitivy
Antibiotic tolerance
Anticancer activity
Antifouling activity
Antifungal activity
Antioomycete activity
Antiosteoporosis activity
Antioxidant activity
Antiprotozoal activity
Antiviral activity
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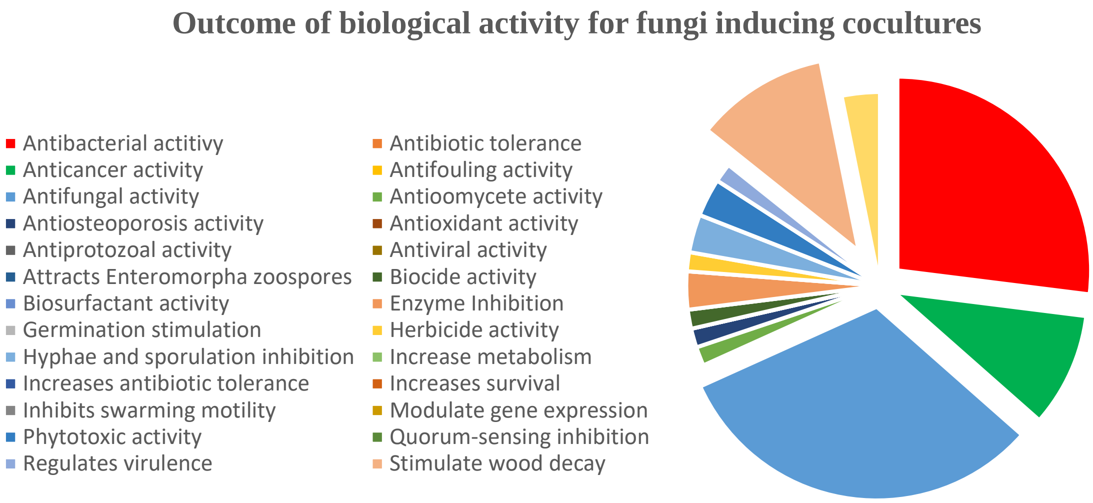
Biocide activity
Biosurfactant activity
Enzyme Inhibition
Germination stimulation
Herbicide activity
Hyphae and sporulation inhibition
Increase metabolism
Increases antibiotic tolerance
Increases survival
Inhibits swarming motility
Modulate gene expression
Phytotoxic activity
Quorum-sensing inhibition
Regulates virulence
Stimulate wood decay
Suppression of virulence
Transcription induction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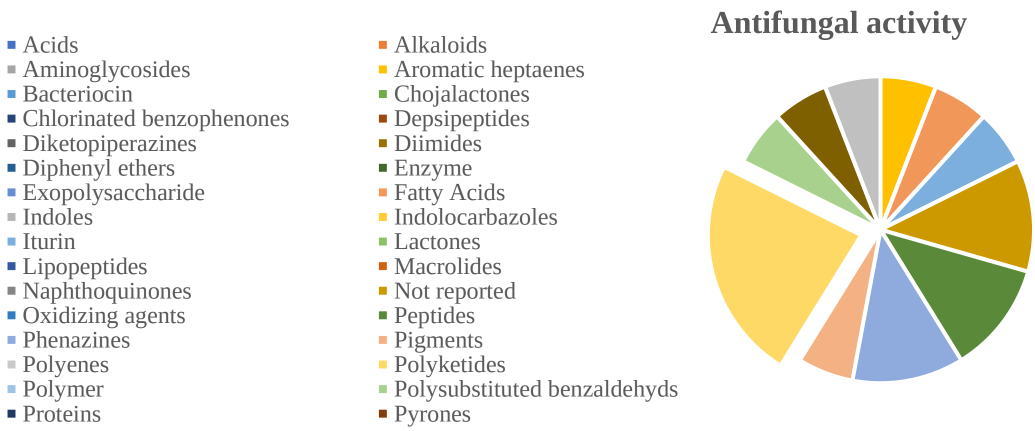
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Bacteriocin
Chojalactones
Chlorinated benzophenones
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Diketopiperazines
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Oxidizing agents
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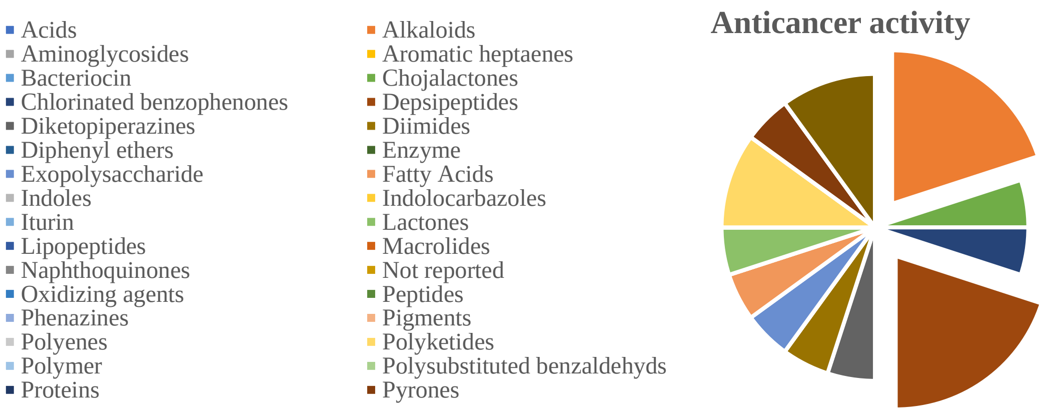
Polyenes
Polyketides
Polymer
Polysubstituted benzaldehyds
Proteins
Pyrones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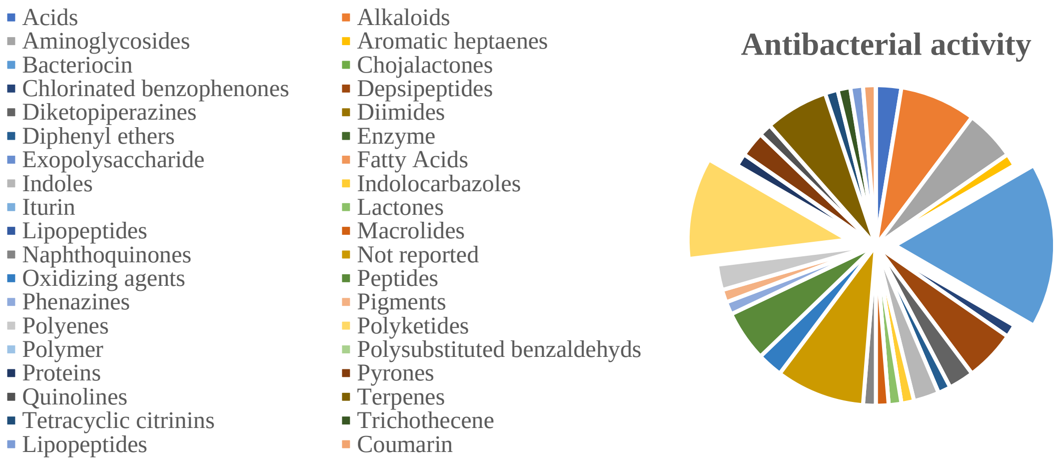
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Quinolines
Terpenes
Tetracyclic citrinins
Trichothecene
Lipopeptides
Coumarin

Type	Inducer microbe	Culture Medium	Challenge microbe	Compound	Compound class	Induction type	Biological activity	Reference
F/F	Serpula *lucrymans*	Solid	*Trichoderma* sp (3 isolates)	laccase	Enzymes	*de novo* biosynthesis	Stimulate wood decay	(Score et al. 1997)
B/F and B/B	*Bacillus* sp. S3, *B. pumilus* S8, *B. licheniformis* D1	Liquid	*Candida albicans, Yarrowia lipolytica, Pseudomonas aeruginosa, Bacillus pumilus*	not identified	Not identified	Up-regulation	Antifungal activity against *Y. lipolytica*	(Dusane et al. 2011)
B/B	S*treptomyces* sp (76 species)	Solid	*Bacillus subtilis* ATCC6633	not identified	Not identified	Up-regulation	Antibiotic activity	(Ueda et al. 2000)
F/F	*Acremonium* sp. Tbp-5	Solid	*Mycogone rosea* DSM 12973	acremostatins A–C	Lipoaminopeptides	*de novo* biosynthesis	No reports	(Degenkolb et al. 2002)
B/F	*Actinomyces levoris*	Solid	*Candida tropicalis*	levorin	Aromatic heptaene	*de novo* biosynthesis	Antifungal and antibiotic activity	(Yakovleva and Bulgakova 1978)
F/F	*Alternaria tenuissima*	Liquid and Solid	*Nigrospora sphaerica*	stemphyperylenol, alterperylenol	Polyketides	*de novo* biosynthesis	Stemphyperylenol shows antifungal activity	(Chagas et al. 2013)
F/F	*Antrodiella citrinella, Flammulina velutipes, Fomitopsis pinicola, Heterobasidion annosum, Junghuhnia collabens, Phlebia centrifuga, Phlebiopsis gigantea, Resinicium bicolor*	Solid	*Antrodiella citrinella, Flammulina velutipes, Fomitopsis pinicola, Heterobasidion annosum, Junghuhnia collabens, Phlebia centrifuga, Phlebiopsis gigantea, Resinicium bicolor*	laccase	Enzymes	Up-regulation/*de novo* biosynthesis	Stimulate wood decay	(Iakovlev and Stenlid 2000)

B/B	*Aspergillus austroafricanus*	Liquid	*Bacillus subtilis* or *Streptomyces lividans*	austramide, violaceol I, violaceol II, diorcinol	Diphenyl ethers	*de novo* biosynthesis/Up-regulation	Violaceol I-II has antibacterial active against *Staphylococcus aureus* (ATCC 700699); Diorcinol has moderate antibacterial activity against *B. subtilis.*	(Ebrahim et al. 2016)
F/B	*Aspergillus fumigatus*	Liquid	*Streptomyces rapamycinicus*	fumicyclines A-B	Meroterpenoids	*de novo* biosynthesis	Moderate antibacterial activity against *S. rapamycinicus.*	(König et al. 2013)
B/F or F/B	*Aspergillus fumigatus*	Solid	*Pseudomonas aeruginosa*	1-Hydroxyphenanzine, 1-methoxyphenazine, phenazine-1-sulfate, triacetylfusarinine C [Al3+] and triacetylfusarinine C [Fe3+], triacetylfusarinine C, fusarinine C and phenazine dimers	Phenanzines	Biotransformation	1-hydroxyphenanzine and 1-methoxyphenazine suppressed fungal growth; siderophores triacetylfusarinine C, triacetylfusarinine C [Al3+] and triacetylfusarinine C [Fe3+] stimulate the capturing of iron	(Moree et al. 2012)
F/B	*Aspergillus fumigatus*	Liquid	*Streptomyces bullii*	ergosterol, brevianamide F, spirotryprostatin A, 6-methoxy spirotryprostatin B, fumitremorgin C and its 12,13-dihydroxy derivative, fumitremorgin B, verruculogen, 11-O-methylpseurotin A, 11-O-methylpseurotin A2, emestrins A-B	Diketopiperazine alkaloids	*de novo* biosynthesis	High toxicity and antiparasitic activity against *Trypanosoma brucei brucei* and *Leishmania donovani* (except brevianamide F and 11-O-methylpseurotin A)	(Rateb et al. 2013)
F/B	*Aspergillus fumigatus*	Liquid	*Streptomyces peucetius*	Fumiformamide, N,N′-((1Z,3Z)-1,4-bis(4-methoxyphenyl)β-1,3-diene-2,3-diyl)diformamide, two known N-formyl derivatives and xanthocillin analogue BU-4704	Alkaloids	*de novo* biosynthesis	N,N′-((1Z,3Z)-1,4-bis (4-methoxyphenyl)β-1,3-diene-2,3-diyl) diformamide has cytotoxic activity	(Zuck et al. 2011)
F/B	*Aspergillus fumigatus* KMC-901	Liquid	*Sphingomonas sp* KMK-001	glionitrin A	Diketopiperazine alkaloid	*de novo* biosynthesis	Antibacterial activity against MRSA, antitumor activity against human cancer cell	(Park et al. 2009)

							lines HCT-116, A549, AGS, and DU145	
F/F	*Aspergillus giganteus*	Liquid	*Aspergillus niger*	antifungal protein (AFP)	Protein	Down-regulation	Antifungal protein (AFP) has antifungal activity against various filamentous fungi	(Meyer and Stahl 2003)
F/F	*Aspergillus giganteus*	Liquid	*Fusarium* oxysporum	antifungal protein (AFP)	Protein	Up-regulation	Antifungal protein (AFP) has antifungal activity against various filamentous fungi	(Meyer and Stahl 2003)
F/F	*Aspergillus nidulans*	Liquid	Actinomycetes (58 soil-dwelling bacteria) and *Escherichia coli*	orsellinic acid, lecanoric acid, F-9775A and F-9775B	Archetypal polyketides and pentacyclic triterpenes	*de novo* biosynthesis	F-9775A and F-9775B has antiosteoporosis activity; orsellinic acid has antimicrobial activity; lecanoric acid inhibits ATP synthesis and electron transfer and has antimicrobial activity	(Schroeckh et al. 2009)
B/F and B/B	*Bacillus pumilus*	Liquid	Serratia *marcescens*, *Bacillus pumilus* or *Bacillus licheniformis*	not identified	Not identified	Up-regulation	Increase in biosurfactant activity	(Dusane et al. 2011)
B/B	*Bacillus amyloliquefaciens* LBM 5006	Liquid	*Escherichia coli* ATCC 25922	peptides	Bacteriocin/peptide	*de novo* biosynthesis	Antibacterial activity	(Benitez et al. 2011; Chanos and Mygind 2016)
B/F	*Bacillus amyloliquefaciens*	Solid	*Aspergillus fumigatus* and *Aspergillus niger*	Iturin	Lipopetides	*de novo* biosynthesis	Antifungal activity	(Moree et al. 2013)
B/B	*Bacillus cereus* UW85	Liquid	*Cytophaga-Flavobacterium* (CF)	peptidoglycan from vegetative cells	Polymer	Up-regulation	Increase the growth of CF bacteria	(Peterson et al. 2006)
B/B	*Bacillus* isolate strain UA-094	Liquid	*Bacillus* isolate strain UA-086	indole and cyclo(Phe-Pro) diketopiperazine	Indole and diketopiperazine	Up-regulation	Antibacterial activity	(Trischman et al. 2004)
B/B	*Bacillus subtilis*	Solid	*Streptomyces griseus*	lactonase-homologous Protein	Protein	*de novo* biosynthesis	Antibacterial activity: inhibits development and	(Schneider et al. 2012)

							streptomycin production in *S. griseus*.	
B/B	*Bacillus subtilis*	Solid	*Streptomyces coelicolor* and *Streptomyces avermitilis*	bacillaene	Polyene	Up-regulation	Delays the production of pigmented antibiotics in *S. coelicolor;* Antibiotic activity against *S. avermitilis* (inhibits the growth).	(Straight et al. 2006; Butcher et al. 2007)
B/B	*Bacillus subtilis*	Liquid	*Streptomyces coelicolor*	surfactin	Lipopeptide surfactant	Up-regulation	Inhibition of aerial hyphae and sporulation of *S. coelicolor*	(Straight et al. 2006)
F or B/B	*Bacillus subtilis, Escherichia coli, Saccharomyces cerevisiae*	Liquid	*Myxococcus xanthus* (proteobacterium)	peptidoglycan	Polymer	Up-regulation	Induction of rippling (ondulatory movement) in *M. xanthus*	(Berleman et al. 2006)
B/F and B/B	*Bacillus* sp. S3, *B. pumilus* S8, *B. licheniformis* D1, and *Serratia marcescens* V1	Liquid	*Candida albicans, Yarrowia lipolytica, Pseudomonas aeruginosa* and *Bacillus pumilus*	not identified	Not identified	Up-regulation	Antibacterial activity against *P. aeruginosa* and *B. pumilus*	(Dusane et al. 2011)
B/B	*Bacillus* sp. S3	Liquid	*Pseudomonas aeruginosa*	not identified	Not identified	Up-regulation	Quorum-sensing inhibition	(Dusane et al. 2011)
B/P	bacterial biofilms	Liquid	*Enteromorpha (*green seaweed)	N-acylhomoserine lactone (AHL)	Quroum sensing fatty acid (DSF)	Up-regulation	AHL attracts *Enteromorpha* zoospores	(Joint et al. 2002)
F/F	*Bionectria ochroleuca*	Solid	*Trichophyton rubrum*	4″-hydroxysulfoxy-2,2″-dimethylthielavin P	Polyketide	*de novo* biosynthesis	No reports	(Bertrand et al. 2013)

F/F	*Botrytis cinerea*	Solid	*Candida albicans, Aspergillus fumigatus, Colletotrichum acutatum, Fusarium proliferatum,* and *Magnaporthe grisea*	11-hydroxy-dehydro-botrydienol, botrytisic acid A, botrytisic acid B, dehydro-botrydienol, 3-hydroxy-4-oxocyclofarnesa-2,5,7,9-tetraen-11,8-olide, norbotrydialone acetate, botrydienal phytotoxin, 10-oxo-dehydro-dihydro-bodtrydial, hydratedbotryenalol, and dehydro-botrydienal, 2-(-hydroxy-5-methoxyphenoxy)acrylic acid, integrastin B, palmarumycin C15, australifungin, botryendial phytotoxin, cissetin, 3-O-acetyl-botcineric acid, equisetin, enniantin I, enniantin G, 11,12-hydroxy-eudesm-4-en-3-one, cordyol C, illudin C3, illudinic acid, integrastin B, 7-chrolo-6-methoxymellein, cis-4-hydroxy-6-deoxy-scytalone or xylarine, citreoviridin licicolinic acid A, 4-hydroxy-5-methylmellein, chaetoxanthone C, Cordyol C, mycorrhizin A, palmarumycins C7 and C15, chaetoxanthone C, diorcinol, destruxin A1/A4, antibiotic FR-49175, bis-dethio-bis-methyl-thio-gliotoxin, 3-hydroxymellein, 3,4-dihydro-3,8-dihydroxy-3-methyl-1H2-benzopyran-1-one, pleuromutilin, cyclopiazonic acid	Fatty acids, enniantins, and others	Up-regulation/*de novo* biosynthesis	Antifungal activity and cytotoxicity	(Serrano et al. 2017)

F/F	*Serpula lacrymans* and *Coniophora puteuna*	Solid	*Trichoderma* spp and *Scytalidium* FY	peroxidase	Enzymes	Up-regulation	Stimulate wood decay	(Score et al. 1997)
F/F	*Coniophora puteuna*	Solid	*Scytalidium* FY	laccase	Enzymes	Up-regulation	Stimulate wood decay	(Score et al. 1997)
B/F	*Burkholderia cenocepacia*	Liquid	*Candida albicans* and *Xanthomonas campestris* pv. campestris	cis-2-dodecenoic acid (BDSF)	α,β Unsaturated fatty acid (DSF)	Up-regulation	BDSF restores the biofilm and extracellular polysaccharide production phenotypes of *X. campestris* and inhibits *C. albicans* germ tube formation.	(Boon et al. 2008)
B/B and B/P	*Burkholderia gladioli*	Liquid	*Burkholderia seminalis* and orchid	extracellular polysaccharides	Polysaccharides	Up-regulation	Polysaccharide alters hormone metabolism	(Araújo et al. 2016)
B/F	*Burkholderia gladioli*	Solid	*Rhizopus microsporus*	enacyloxin Iia, iso-enacyloxin Iia, enacyloxin IIIa and iso-enacyloxin IIIa	Polyketides	*de novo* biosynthesis	Antifungal and antibacterial activity	(Ross et al. 2014)
F/F	*Candida albicans*	Solid	*Trichophyton rubrum, Trichophyton mentagrophytes, Trichophyton terrestre* and *Microsporum gypseu*m. (other common dermatophytes)	(3R,6E)-2,3-dihydrofarnesol (R-DHF) and (2E,6E)-farnesol (F-ol)	Acyclic sesquiterpenes	*de novo* biosynthesis/Up-regulation	F-ol and R-DHF has inhibitory effects on *Trichophyton rubrum, Trichophyto mentagrophytes, Microsporum canis* and *Epidermophyton floccosu.*	(Brasch et al. 2014)
F/B	*Candida albicans*	Liquid	*Pseudomonas aeruginosa*	farnesol	Sesquiterpene	Up-regulation	Reduces levels of quinolone and pyocyanin from *Pseudomonas* and inhibits swarming motility in *P. aeruginosa*	(Cugini et al. 2007; McAlester et al. 2008)
F/B	*Candida albicans*	Liquid	*Pseudomonas aeruginosa*	not identified	Not identified	Up-regulation	Inhibits virulence in *Pseudomonas aeruginosa*	(Lopez-Medina et al. 2015)
F/F	*Ceriporiopsis subvermispora*	Solid	*Pleurotus ostreatus*	laccase, manganese peroxidase and lignin-degrading enzymes	Enzymes	Up-regulation	Stimulate wood decay	(Chi et al. 2007)

B/B	Diaminopimelic acid-peptidoglycan producing bacteria	Liquid	*Bacillus subtilis*	Peptidoglycan and disaccharide tripeptides (muropeptide fragments of the cell wall)	Polymers	Up-regulation	Germination stimulation of dormant *Bacillus subtilis* spores	(Shah et al. 2008)
F/B	*Emericella* sp strain CNL-878	Liquid	*Salinispora arenicola* strain CNH-665	emericellamides A and B	Cyclic depsipeptide	Up-regulation	Emericellamide A has moderate antibacterial activity against MRSA and weak cytotoxicity against the human colon carcinoma cell line HCT-116; Emericellamide B was slightly weaker than 1.	(Oh et al. 2007)
F/B	*Chaetomium* sp. (endophytic fungus)	Solid	*Bacillus subtilis*	3- and 4-hydroxybenzoic acid methyl esters, acremonisol A, SB236050, SB238569, isosulochrin, protocatechuic acid methyl ester, shikimeran A, bipherin A, chorismeron, quinomeran and serkydayn	Polyketides, dibenzoic acid, α pyrone and quinolinic alkaloids	Up-regulation/*de novo* biosynthesis	Increase in antibacterial activity and cytotoxicity.	(Akone et al. 2016)
B/B	*Escherichia coli*	Liquid	*Salmonella typhimurium*	indole	Alkaloid	Up-regulation	Increase antibiotic tolerance (carbenicillin and ciprofloxacin) in *Salmonella typhimurium*	(Vega et al. 2013)
F/F	*Eutypa lata*	Solid	*Botryosphaeria obtusa*	O-methylmellein, 4-hydroxy-8-O-methylmellein and 5-hydroxy-8-O-methylmellein	Polyketides (mycoalexins)	Up-regulation/*de novo* biosynthesis	Non-hydroxylated derivative have antifungal and phytotoxic activity	(Glauser et al. 2009)
F/F	*Alternaria tenuissima*	Solid	*Fusarium culmorum* and *Fusarium graminearum*	alternariol, alternariol monomethyl ether, altenuen	Mycotoxins	Down-regulation	Not reported	(Müller et al. 2012)

F/F	*Fusarium culmorum* and *Fusarium graminearum*	Solid	*Alternaria tenuissima*	Deoxynivalenol and zearalenone	Trichothecene and Polyketide	Up-regulation	Deoxynivalenol has antibacterial activity; zearalenone shows cytochrome P450 3A4 inhibition	(Müller et al. 2012)
F/B	*Fusarium oxysporum* MSA35 *(*wild-type strain)	Liquid	*Serratia* sp *and Achromobacter* sp	isocaryophyllene, α-humulene, cyclocaryophyllan-4-ol	Sesquiterpenes	Up-Regulation	Antimicrobial activity of isocaryophyllene.	(Minerdi et al. 2009)
F/F	*Fusarium oxysporum* MSA35 *(*wild-type strain)	Liquid	*F. oxysporum* f. sp. lactucae (pathogenic strain)	isocaryophyllene, α-humulene, cyclocaryophyllan-4-ol	Sesquiterpenes	Up-Regulation	Suppression of virulence in pathogenic *F. oxysporum*	(Minerdi et al. 2009)
F/F	*Fusarium oxysporum* SIN2	Solid	*Sarocladium* cf. strictum SIN29	fusaric acid	Picolinic acid analogue	Up-regulation	Increase *Fusarium oxysporum* virulence	(Bohni et al. 2016)
F/B	*Fusarium pallidoroseum*	Liquid	*Saccharopolyspora erythraea*	N-demethylophiosetin, pallidorosetin A, pallidorosetin B, equisetin, ophiosetin	Decalin-type tetramic acid analogues	*de novo* biosynthesis	No reports	(Whitt et al. 2014)
F/B	*Fusarium tricinctum*	Solid	*Bacillus subtilis*	ateropyrone, enniantin B, B1 and A1; fusaristatin A; macrocarpon C; (−)-citreoisocoumarin; 2-(carboxymethylamino)benzoic acid and (−)-citreoisocoumarinol	Pyrone/Depsipeptides/lipopeptide/Coumarin	Up-regulation/*de novo* biosynthesis	Enniantin B1 and A1 have antibacterial activity against *Bacillus subtilis, Staphylococcus aureus* (MRSA and MSSA), *Streptococcus pneumoniae*, and *Enterococcus faecali;* lateropyrone displayed antibacterial activity against *B. subtilis, S.aureus, S. pneumoniae and E. faecalis*	(Ola et al. 2013)
F/F	*Fusarium tricinctum*	Liquid	*Fusarium begoniae*	subenniatin A-B	Depsipeptides	*de novo* biosynthesis	Inactive in cytotoxic and antibacterial bioassays	(Wang et al. 2013b)

F/F	*Gloeophyllum abietinum*	Liquid and solid	*Heterobasidion annosum*	oosponol, oospoglycol, melledonal A, melledonal C	Polyketides and Sesquiterpenes	Up-regulated	Antibacterial activity	(Sonnenbichler et al. 1994)
B/F	*Gluconobacter* sp.W-315	Liquid	*Neurospora crassa* or *Aspergillus oryzae*	enacyloxin IIa	Polyketide	*de novo* biosynthesis	Antibacterial activity	(Watanabe et al. 1982)
B/B	group A streptococcus (GAS)	Solid	group B streptococcus (GBS)	short hydrophobic peptides (SHP2/3)	Peptides	Up-regulation	Stimulate RovS-mediated gene regulation in GBS	(Cook et al. 2013)
B/B	group B streptococcus (GBS)	Solid	group A streptococcus (GAS)	short hydrophobic peptides (SHP1520)	Peptides	Up-regulation	Modulate Rgg2/3-regulated gene expression in GAS.	(Cook et al. 2013)
B/F	Gut microbiota	Liquid	*Candida albicans*	peptidoglycans	Polymer	Up-regulation	Increases hyphal development of the polymorphic fungal pathogen *C. albicans*	(Xu et al. 2008)
B/B	*Lactobacillus helveticus* M92, *Lactobacillus plantarum* L4, *Enterococcus faecium* L3	Liquid	*Lactococcus lactis* subsp. Lactis LMG 9450	not identified	Bacteriocin	Up-regulation	Antibiotic activity	(Kos et al. 2011; Chanos and Mygind 2016)
B/F	*Lactobacillus kefiranofaciens*	Liquid	*Saccharomyces cerevisiae*	kefiran	Bacteriocin (exopolysaccharide)	Up-regulation	Used as a thickener, stabilizer, emulsifier, fat substitute or gelling agent; also has antitumor activity	(Cheirsilp et al. 2003)
B/F	*Lactobacillus kefiranofaciens*	Liquid	*Saccharomyces cerevisiae*	kefiran	Bacteriocin (exopolysaccharide)	Up-regulation	Used as a thickener, stabilizer, emulsifier, fat substitute or gelling agent; also has antitumor activity	(Tada et al. 2007)
B/B	*Lactobacillus paracasei*	Liquid	*Bacillus subtilis* ATCC 11774	paracin 1.7	Bacteriocin	Up-regulation	Broad-spectrum antibacterial activity	(Ge et al. 2014; Chanos and Mygind 2016)
B/B	*Lactobacillus plantarum* DC400	Liquid	*Lactobacillus sanfranciscensis* DPPMA174 and *Pediococcus pentosaceus* 2XA3	plantaricin A	Bacteriocin (pheromone)	*de novo* biosynthesis	Antibacterial activity	(Di Cagno et al. 2009; Chanos and Mygind 2016)
B/B	*Lactobacillus plantarum* KLDS1.0391	Liquid	*L. helveticus* KLDS1.0737, *Enterococcus faecium* KLDS4.0352, *Lactobacillus reuteri* KLDS1.0737,	plantaricin MG	Bacteriocin	Up-regulation	Antibacterial activity	(Man et al. 2012; Chanos and Mygind 2016)

			Enterococcus faecalis KLDS4.0313					
B/B	*Lactobacillus acidophilus La-5*	Liquid	*Streptococcus thermophilus* STY-3; *Lactobacillus delbrueckii* subsp. bulgaricus LBY-2; *L. delbrueckii* subsp. bulgaricus CECT 400;*L. delbrueckii* subsp. lactis CECT 282 and *Lactobacillus sakei* subsp. sakei CECT 906	lactacin B	Bacteriocin	*de novo* biosynthesis/Up-regulation	Antibacterial activity	(Tabasco et al. 2009; Chanos and Mygind 2016)
B/B	*Lactobacillus acidophilus* N2 (NCFM)	Liquid	*L. delbrueckii, L. helveticus, L. casei, L. fennentum, L. plantarum, L. viridescens, Streptococcus pyogenes, Staphylococcus aureus, Staphylococcus epidermidis, Bacillus cereus, Listeria monocytogenes*	lactacin B	Bacteriocin	*de novo* biosynthesis/Up-regulation	Antibacterial activity	(Barefoot et al. 1994; Chanos and Mygind 2016)
B/B	*Lactobacillus plantarum* J23	Liquid	*L. lactis, L. hilgardii, P. pentosaceus, L. lactis, L. brevis, L. fermentum, L. hilgardii, L. paracasei, L. pentosus, L. plantarum), L. sakei, L. mesenteroides, P. acidilacti, P. Parvulus, P. pentosaceus*	Not identified	Bacteriocin	*de novo* biosynthesis	Antibacterial activity against *Oenococcus oeni*, and a range of *Lactobacillus* and *Pediococcus* species	(Rojo-Bezares et al. 2007; Chanos and Mygind 2016)

B/B	*Lactobacillus plantarum* NC8	Liquid	*Bacillus cereus, Enterococcus faecalis, E. Faecium, L. acidophilus, L. brevis, L. bulgaricus, L. casei, L. fermentum, L. helveticus, L. hilgardii, L. reuteri, L. sake, L. salivarius, L. lactis, L. mesenteroides, Listeria innocua, P. pentosaceous, Staphylococcus carnosus, Streptococcus thermophilus*	plantaricin NC8	Bacteriocin (Class Iib)	Up-regulated	Antibacterial activity	(Maldonado et al. 2004; Chanos and Mygind 2016)
B/B	*Lactococcus lactis* sub sp. Lactis	Liquid	*Yarrowia lipolytica*	nisin	Bacteriocin (Polycyclic peptide)	Up-regulation	Antibacterial activity	(Ariana and Hamedi 2017)
B/F	*Lactococcus lactis* subsp. lactis ATCC 11454	Liquid	*Saccharomyces cerevisiae*	nisin	Bacteriocin (Polycyclic peptide)	Up-regulation	Antibacterial activity	(Liu et al. 2006)
B/F	*Lactococcus lactis* subsp. lactis ATCC11454	Liquid	*Kluyveromyces marxianus*	nisin	Bacteriocin (Polycyclic peptide)	Up-regulation	Antibacterial activity	(Shimizu et al. 1999)
B/B	*Leuconostoc citreum* GJ7	Liquid	*Lactobacillus plantarum* KFRI 464, *Lactobacillus delbrueckii* KFRI 347 and *Leuconostoc mesenteroides* KCTC 1628	kimchicin G7	Bacteriocin	Up-regulation	Antibacterial activity	(Chang et al. 2007; Chanos and Mygind 2016)
F/B	*Libertella* sp	Liquid	Antibiotic-resistant marine a-proteobacterium	libertellenones A–D	Diterpenoids	*de novo* biosynthesis	Antitumoral activity against HCT-116 human adenocarcinoma cell line (libertellenone D is the most potent).	(Oh et al. 2005)
F/F	*Aspergillus* sp. (mangrove epiphytic)	Liquid	*Aspergillus* sp. (mangrove epiphytic)	aspergicin, neoaspergillic acid, ergosterol	Alkaloids and Steroid	*de novo* biosynthesis	Aspergicin, neoaspergillic acid show antibacterial activity against selected Gram bacteria.	(Zhu et al. 2011)
F/F	Mangrove fungi strain No. K38	Liquid	Mangrove fungi strain No. E33	8-hydroxy-3-methyl-9-oxo-9H-xanthene-1-carboxylic acid methyl ether	Xanthone derivative	*de novo* biosynthesis	Antifungal activity against *Gloeasporium musae* and *Peronophthora cichoralearum*	(Li et al. 2011)

F/F	*Phomopsis* sp K38 (mangrove fungi)	Liquid	*Alternaria* sp E33 (mangrove fungi)	cyclo-(L-leucyl-trans-4-hydroxy-L-prolyl-D-leucyl-trans-4-hydroxy-L-proline)	Cyclopeptide (cyclic tetrapeptide)	*de novo* biosynthesis	Antifungal activity against *Gaeumannomyces graminis*, *Rhizoctonia cerealis*, *Helminthosporium sativum* and *Fusarium graminearum*	(Li et al. 2014)
F/F	*Phomopsis* sp K38 (mangrove fungi)	Liquid	*Alternaria* sp E33 (mangrove fungi)	cyclo (D-Pro-L-Tyr-L-Pro-L-Tyr) and cyclo (Gly-L-Phe-L-Pro-L-Tyr)	Cyclopeptide (cyclic tetrapeptide)	*de novo* biosynthesis	Moderate antifungal activity against *C. albicans*, *G. graminis*, *R. cerealis*, *H. sativum* and *F. graminearum*, Cyclo (Gly-L-Phe-L-Pro-L-Tyr) was more active than cyclo (D-Pro-L-Tyr-L-Pro-L-Tyr).	(Huang et al. 2014)
F/F	*Phomopsis* sp K38 (mangrove fungi)	Liquid	*Alternaria* sp E33 (mangrove fungi)	(-)-byssochlamic acid bisdiimid	Diimide derivative	*de novo* biosynthesis	(-)-byssochlamic has weak cytotoxic activity against Hep-2 and HepG2 cells.	(Li et al. 2010)
F/F	*Phomopsis* sp K38 (mangrove fungi)	Liquid	*Alternaria* sp E33 (mangrove fungi)	ethyl 5-ethoxy-2-formyl-3-hydroxy-4-methylbenzoate	Polysubstituted benzaldehyde derivative	*de novo* biosynthesis	Antifungal activity against *Fusarium graminearum*, *Gloeosporium musae*, *Rhizoctonia solani Kuhn* and *Phytophthora soja*.	(Wang et al. 2013a)
F/F	*Marasmius pallescens*	Solid and Liquid	*Marasmiellus troyanus*	laccase and manganese peroxidase activity	Enzymes	Up-regulation	Stimulate wood decay	(Ferreira Gregorio et al. 2006)
B/B	Marine bacteria	Solid	85 other marine isolates	not identified	Not identified	Up-regulation	Antibacterial activity	(Long and Azam 2001)
B/B	*Prochlorococcus* strain MIT9313 and MED4 (marine cyanobacterium)	Liquid	heterotrophic marine bacteria	not identified	Not identified	Up-regulation/*de novo* biosynthesis	Not reported.	(Sher et al. 2011)
B/B	*Micromonospora* spp., *Verrucosispora* spp., *and Solwaraspora* spp. (marine bacteria)	Liquid	*Mycobacterium* sp. WMMA-183 and *Rhodococcus* sp. WMMA-185 (marine mycolic acid-containing bacteria)	not identified	Not identified	Up-regulation/*de novo* biosynthesis	Antibacterial activity	(Adnani et al. 2015)
F/F	Marine-derived mangrove endohytic fungi Strain n. 1924	Liquid	Marine-derived mangrove endohytic fungi Strain n. 3893	cyclo(phe-phe)dipetide and 6-methylsalicylic acid	Peptide and beta-hydroxy acid	*de novo* biosynthesis	6-methylsalicylic acid has biocide activity against pests *Heliothis armigera* Huhner and *Sinergasilus spp.*	(Zhu et al. 2007)

F/F	*Monascus* sp	Solid and Liquid	*Saccharomyces cerevisiae* and *Aspergillus oryzae*	not identified	Pigment	Up-regulation	Overproduction of hydrophobic substances to block enzyme attack (defense mechanism)	(Shin et al. 1998)
F/F/F/F/F	*Ovadendron sulphureoochraceum, Ascochyta pisi, Emericellopsis minima, Cylindrocarpon destructans* and *Fusarium oxysporum*	Liquid	*Ovadendron sulphureoochraceum, Ascochyta pisi, Emericellopsis minima, Cylindrocarpon destructans* and *Fusarium oxysporum*	lateritin	N-methylated peptide (depsipeptide)	*de novo* biosynthesis	Antitumoral activity against human cancer cell lines pancreas BXPC-3, breast MCF-7, CNS SF268, lung NSC H460, colon KM20L2 and prostate DU145); antibacterial activity against *Micrococcus luteus, S. aureus, E. faecalis* and *S. pneumoniae;* antifungal activity against *Candida albicans*	(Pettit et al. 2010)
F/F	*Paraconiothyrium SSM001* (Taxus endophyte)	Liquid	*Alternaria* and *Phomopsis (*bark fungi)	taxol	Diterpenoid	Up-regulation	Anticancer activity	(Soliman and Raizada 2013)
F/F	*Penicillium citrinum*	Liquid	*Beauveria feline*	citrifelins A–B	Citrinin adducts with a unique tetracyclic framework	*de novo* biosynthesis	Citrifelins A and B have antibacterial activity against *E. coli, S. aureus, A. hydrophilia, V. parahemolyticus, V. harveyi, E. tarda, V. alginolyticus*, and *V. anguillarums.*	(Meng et al. 2015)
F/F	*Penicillium fuscum*	Liquid	*Penicillium camembertii/clavigerum*	berkeleylactones A−H, macrolides A26771B, patulin, and citrinin	16-membered-ring macrolides	*de novo* biosynthesis	Berkeleylactone A has potent antibacterial and antifungal activities against four MRSA, *Bacillus anthracis*, *Streptococcus pyogenes*, *Candida albicans*, and *Candida glabrata*	(Stierle et al. 2017)
B/F	*Penicillium pinophilum* FKI-5653	Liquid	*Trichoderma harzianum* FKI-5655	secopenicillide C, penicillide, MC-141, pestalasin A and stromemycin	Lactones	Up-regulation	Penicillide acts as antibiotic, plant growth inhibitor, mycotoxin, acyl-CoA-cholesterol acyltransferase inhibitor; anticancer and cytotoxic, non-peptidic oxytocin receptor antagonist and calpain inhibitor.	(Nonaka et al. 2011)

F/B	*Penicillium* sp DT-F29	Solid	*Bacillus* sp B31	verruculogen TR-2; 12-hydroxyverruculogen TR-2; 12b-hydroxy-13a-methoxyverruculogen TR-2; 12b-hydroxy-13a-ethoxyverruculogen TR-2; 12b-hydroxy-13a-butoxyethoxyverruculogen TR-2; 12a-hydroxy-13a-prenylverruculogen TR-2; spirotryprostatin C; cycloprostatin C; 12,13-dihydroxyfumitremorgin C; cyclotryprostatin B;, hydrocycloprostatin A; hydrocycloprostatin B; neofipiperzine C; fumitremorgin B; prenylcycloprostatin B; 25-hydroxyfumitremorgin B; 13-prenyl fumitremorgin B; 12b-hydroxy-13a-butoxyethoxyfumitremorgin B; 12b-hydroxy-13a-methoxyverruculogen B; fumitremorgin A; 26a-hydroxyfumitremorgin A; 25-hydroxyfumitremorgin A, and diprostatin A	2,5-diketopiperazines	*de novo* biosynthesis/Up-regulation	2,5-DKPs show bromodomain-containing protein 4 (BRD4) inhibitory activities; fumitremorgin B is a potential BRD4 inhibitor	(Yu et al. 2017)
F/B	*Pestalotia* sp	Liquid	Antibiotic-resistant marine a-proteobacterium	pestalone	Chlorinated benzophenone	*de novo* biosynthesis	Moderate antitumoral activity against human tumor cell lines; antibacterial activity against MRSA and vancomycin-resistant *Enterococcus faecium*	(Cueto et al. 2001)
F/F	*Phlebia radiata, Phlebia rufa, Coriolus versicolor, Stereum hirsutum, Phanerochaete velutina* and *Hypholoma fasciculare*	Solid	*Phlebia radiata, Phlebia rufa, Coriolus versicolor, Stereum hirsutum, Phanerochaete velutina* and *Hypholoma fasciculare*	phenoloxidase	Enzymes	Up-regulation/*de novo* biosynthesis	Stimulate wood decay	(White and Boddy 1992)
O/ Oomycetes	*Phytophthora nicotianae*	Liquid	*Phytophthora nicotianae*	mating hormones α1 and α2	Hormones	*de novo* biosynthesis	Induction of sexual reproduction in the opposite mating type	(Ojika et al. 2011)
B/F	*Pseudomonas aeruginosa*	Solid	*Candida albicans*	5-methyl-phenazinium-1-carboxylate (5MPCA)	Phenazines derivative (red pigment)	*de novo* biosynthesis	Redox-active antifungal activity	(Gibson et al. 2009)
B/B	*Pseudomonas aeruginosa*	Liquid	*Enterobacter* sp	pyocyanin	Phenazine derivative	*de novo* biosynthesis	Antibacterial activity	(Angell et al. 2006)

B/F	*Pseudomonas aeruginosa*	Liquid	*Candida albicans*	N-3-oxo-dodecanoyl-L-Homoserine lactone (3-oxo-C12HSL)	Fatty acid (DSF)	Up-regulation	Prevents *Candida* morphology switch from yeast to hyphal (filamentous) growth.	(Cugini et al. 2007; McAlester et al. 2008)
B/B or F	*Pseudomonas aeruginosa*	Liquid	*Escherichia coli, Klebsiella pneumoniae, Proteus mirabilis, Streptococcus pyogenes, Bacillus subtilis, Staphylococcus aureus* and *Candida albicans*	cis-2-decenoic acid	a,b Unsaturated fatty acid (DSF)	Up-regulation	Induces the dispersion of biofilm microcolonies on the challenged microbes	(Davies and Marques 2009)
B/B	*Pseudomonas aeruginosa*	Solid	*Staphylococcus aureus*	4-hydroxy-2-heptylquinoline-N-oxide (HQNO)	Quinoline	*de novo* biosynthesis	Suppression of *S. aureus* respiration, protecting *S. aureus* from death by commonly used aminoglycoside antibiotics; Selection of typical *S. aureus* small-colony variants (SCVs), which are stable aminoglycoside resistance and persistence in chronic infections	(Hoffman et al. 2006)
B/B	*Rhodococcus fascians* (multi-antibiotic resistant mutant)	Liquid	*Streptomyces padanus*	rhodostreptomycin A-B	Aminoglycosides	Gene transfer	Antibacterial activity.	(Kurosawa et al. 2008)
F/F	*Schizophyllum commune*	Solid	*Hypholoma fasciculare*	indigo and indirubin	Pigments	Up-regulation	Indirubin is a potent inhibitors of cyclin dependent kinases and has antiviral, antibacterial and antifungal activityes	(Menezes et al. 2015)
B/B	*Actinokineospora* sp. EG49 (sponge-associated Actinomycetes)	Liquid	*Nocardiopsis* sp. RV163 (sponge-associated Actinomycetes)	N-(2-hydroxyphenyl)-acetamide, 1,6-dihydroxyphenazine and 5a,6,11a,12-tetrahydro-5a,11a-dimethyl[1,4]benzoxazino[3,2-b][1,4]benzoxazine	Angucycline, diketopiperazine and β-carboline	Up-regulation/*de novo* biosynthesis	1,6-dihydroxyphenazine has antibacterial activity against *Bacillus sp*. P25 and *Actinokineospora sp*. EG49 and antiprotozoal activity against *Trypanosoma brucei*	(Dashti et al. 2014)
B/B	*Stenotrophomonas maltophilia*	Liquid	*Pseudomonas aeruginosa*	cis-11-methyl-2-dodecenoic acid	a,b Unsaturated fatty acid (DSF)	Up-regulation	Stimulates biofilm filamentation, increases levels of a number of proteins with roles in bacterial stress tolerance and increased tolerance to	(Fouhy et al. 2007; Ryan et al. 2008)

							polymyxins of *P. aeruginosa*	
B/B	*Streptococcus mutans*	Solid/Liquid	*Streptococcus sanguinis*	mutacins	Bacteriocin	Up-regulation	Antibacterial activity against *Streptococcus sanguinis*.	(Kreth et al. 2005)
B/B	*Streptococcus oligofermentas*	Solid/Liquid	*Streptococcus mutans* (major caries-causing pathogen)	hydrogen peroxide (H2O2)	Oxidizing agent	Up-regulation	Antibacterial activity against *Streptococcus mutans*	(Tong et al. 2007)
B/F	*Streptococcus oralis*	Liquid	*Actinomyces naeslundii* T14V	autoinducer 2	Furanosyl borate diester	Up-regulation	Induces biofilm growth in commensal bacteria	(Rickard et al. 2006)
B/B	*Streptococcus sanguinis*	Solid/Liquid	*Streptococcus mutans* (major caries-causing pathogen)	hydrogen peroxide (H2O2)	Oxidizing agent	Up-regulation	Antibacterial activity against *Streptococcus mutans*.	(Kreth et al. 2005)
B/B	*Streptomyces bikiniensis*	Solid	*Salmonella dusseldorf*	streptomycin	Aminoglycoside	Up-regulation	Antibacterial activity against against *Salmonella dusseldorf*.	(Turpin et al. 1992)
B/B	*Streptomyces cinnabarinus* PK209	Liquid	*Alteromonas* sp. KNS-16	lobocompactol	Diterpene	*de novo* biosynthesis	Antifouling activity against macroalgae *Ulva* and *Navicula*; antioxidant and anticancer activity.	(Cho and Kim 2012)
B/B	*Streptomyces cinnamoneus* NBRC 13823	Liquid	*Tsukamurella pulmonis* (mycolic acid-containing bacteria)	arcyriaflavin E	Indolocarbazole alkaloid	*de novo* biosynthesis	Citotoxicity	(Hoshino et al. 2015c)
B/B	*Streptomyces coelicolor*	Solid	*Streptomyces coelicolor*, *Amycolatopsis* sp., *Streptomyces* sp., *Streptomyces viridochromogenes*	four new acyl-desferrioxamines	Hydroxamic acid	Up-regulated/*de novo* biosynthesis	Antibacterial activity	(Traxler et al. 2013)
B/B	*Streptomyces endus* S-522	Liquid	*Tsukamurella pulmonis* S-522 or *Corynebacterium glutamicum* (mycolic acid-containing bacteria)	alchivemycin A	Polycyclic polyketide	*de novo* biosynthesis	Antibacterial activity against *Micrococcus luteus*	(Onaka et al. 2011)

B/B	*Streptomyces lividans* TK23	Liquid	*Tsukamurella pulmonis*, *T. pseudospumae*, *T. spumae* , *T. strandjordii*, *Corynebacterium glutamicum*, *C. efficiens*, *Rhodococcus erythropolis*, *R. coprophilus*, *R*, *wratislaviensis*, *R*, *zopfii*, *Gordonia rubripertincta*, *G. bronchialis*, *Nocardia farcinica*, *N. asteroides*, *Mycobacterium smegmatis*, *M. chlorophenolicum*, *Williamsia muralis* and *Dietzia cinnamea*	actinorhodin and undecylprodigiosin	Benzoisochromanequinone polyketide (red pigment)	*de novo* biosynthesis	Indicator of secondary metabolism	(Onaka et al. 2011)
B/B	*Streptomyces lividans* TK24	Solid	*Salmonella dusseldorf*	not identified	Not identified	Up-regulation	*Streptomyces lividans* increased the survival of *Salmonella dusseldorf*	(Turpin et al. 1992)
F/F	*Streptomyces nodosus* strain 258	Liquid	*C. brumptii*, *C. parapsilosis*, *P. lactosa*, *R. anrantica*, *R. rubra*, *Cryptococcus neoformans*, *C. albicans*, *C. krusei*, *C. tropicalis*, *C. puleherimma* and *C. utilis*	amphotericin B	Polyene	Up-regulation	Antifungal activity	(Yakovleva and Bulgakova 1978)
B/B	*Streptomyces* sp CJ-5	Liquid	*Tsukamurella pulmonis* TP-B0596 (mycolic acid-containing bacteria)	chojalactones A–C	butanolide chojalactones with unusual γ-butyrolactone scaffolds	*de novo* biosynthesis	Chojalactones A and B showed moderate cytotoxicity against P388 cells.	(Hoshino et al. 2015b)
B/B	*Streptomyces* sp NZ-6	Liquid	*Tsukamurella pulmonis* TP-B0596 (mycolic acid-containing bacteria)	niizalactams A–C	Di- and tricyclic macrolactams	*de novo* biosynthesis	Did not show antimicrobial activity or cytotoxicity.	(Hoshino et al. 2015a)

B/B	*Streptomyces sp.* strain B033	Liquid	*Burkholderia vietnamiensis* ATCC BAA-248, *Brucella neotomae* ATCC 23459, *Yersinia pestis* A1122 and *Xanthomonas axonopodis* ATCC 8718 (pathogenic strains of the phylum *Proteobacteria).*	resistomycin	Aminoglycosides	*de novo* biosynthesis	Increase in antibacterial activity.	(Carlson et al. 2015)
B/B	*Streptomyces* sp. Mg1	Solid	*Bacillus subtilis*	surfactin hydrolase	Enzymes	Biotransformation	Increase in surfactin hydrolase activity (detoxification).	(Hoefler et al. 2012)
B/B	*Streptomyces* sp. strain PTY087I2	Liquid	*Bacillus subtilis*, MSSA, MRSA and *Pseudomonas aeruginosa (*human pathogens)	granaticin, granatomycin D, and dihydrogranaticin B	Naphthoquinone	Up-regulation	Antibacterial activity against the all gram positive human pathogens used in these experiments	(Sung et al. 2017)
F/B	*Streptomyces* spp.	Liquid	*Bacillus subtilis*	staurosporine	Indolocarbazole alkaloid	Up-regulation	Antibacterial activity and protein kinase inhibition; Germination stimulation of dormant *Bacillus subtilis* spores	(Shah et al. 2008)
B/B	*Streptomyces tenjimariensis*	Liquid	23 different marine bacteria	istamycins A–B	Aminoglycosides	Up-regulation	Antibacterial activity against competitor colonies	(Slattery et al. 2001)
B/B	*Symbiobacterium thermophilum*	Liquid	*Bacillus* sp	2,2-bis(3 -indolyl)indoxyl and 1,1-bis(3 -indolyl)ethane	Indole	*de novo* biosynthesis	Antibacterial activities against *Staphylococcus aureus* and *Bacillus subtilis*	(Watsuji et al. 2007)
F/F	*Trichoderma harzianum* SIWT 25	Solid	*Serpula lacrymans* and *Coniophora puteuna*	tyrosinase	Enzymes	Up-regulation	Stimulate wood decay	(Score et al. 1997)
F/F	*Trametes versicolor*	Liquid	*Pleurotus ostreatus*	laccase	Enzymes	Up-regulation	Stimulate wood decay	(Baldrian 2004)

F/F	*Trametes versicolor*	Solid	*Stereum gausapatum, Daldinia concentrica, Bjerkandera adusta, Fomes fomentarius* and *Hypholoma fasciculare* (five other wood decay fungi)	laccase and manganese-repressed peroxidase (MRP)	Enzymes	Up-regulation	Stimulate wood decay. Laccase acts to oxidise a variety of phenolic compounds and aromatic diamines; peroxidases utilise hydrogen peroxide (H_2O_2) to catalyse the oxidation of a range of organic and inorganic compounds.	(Hiscox et al. 2010)
F/F	*Trametes versicolor*	Solid	*Ganoderma applanatum*	(N-(4-methoxyphenyl)formamide 2-O-β-D-xyloside and N-(4-methoxyphenyl)formamide 2-O-beta-D-xylobioside), 3-phenyllactic acid, gluconic acid and orsellinic acid	Xylosides and Carboxylic acids	Up-regulation/*de novo* biosynthesis	N-(4-methoxyphenyl)formamide 2-O-beta-D-xylobioside) has potential to enhance the cell viability of human immortalized bronchial epithelial cell line of Beas-2B	(Yao et al. 2016)
F/F	*Trametes versicolor* and *Pleurotus ostreatus*	Liquid	*Trichoderma harzianum*, bacteria and yeasts (soil microbes)	laccase	Enzymes	Up-regulation	Stimulate wood decay	(Baldrian 2004)
B/B	*Escherichia coli* P5v (transformed bacteria engineered to provide DHS precursor)	Liquid	*Escherichia coli* (transformed strains engineered with 3AB synthase and the DHS transporter to provide 3AB)	3-amino-benzoic acid (3AB)	Organic Acid	Up-regulation	3AB is an important building block molecule for biosynthesis of several natural products	(Zhang and Stephanopoulos 2016)
F/P	*Trichoderma atroviride*	Liquid	*Arabidopsis thaliana* seedlings	Indole–acetic acid-related indoles	Indoles	Up-regulation	Stimulatory effect on plant growth	(Salas-Marina et al. 2011)
F/F	*Trichoderma harzianum*	Solid	*Moniliophthora roreri*	T39 butenolide, harzianolide, sorbicillinol	Lactones	*de novo* biosynthesis	T39 butenolide and harzianolide have antifungal activity against phythopathoges.	(Tata et al. 2015)
F/F	*Trichoderma* sp	Liquid	*Lentinula edodes*	β-mannosidase and laccase	Enzymes	Up-regulation	Stimulate wood decay. Lowering of Mn-dependent peroxidase activity	(Savoie and Mata 1999)
F/F	Unidentified Fungi (strain Nos. 1924)	Liquid	Unidentified Fungi (strain Nos. 3893)	marinamide (4-(2-pyrrolyl)-1-isoquinolone-3-carboxylic acid) and methyl ester marinamide (methyl 4-(2-pyrrolyl)-1-isoquinolone-3-carboxylate)	Alkaloids	*de novo* biosynthesis	Antibacterial activity against *E. coli*, *Pseudomonas pyocyanea*, and *S. aureus;* Antitumoral activity against tumor cell lines	(Zhu et al. 2007; Zhu et al. 2013)

B/B	Unidentified surface-associated marine bacteria	Liquid	*Staphylococcus aureus, Pseudomonas aeruginosa* or *Escherichia coli* (human pathogens)	not identified	Not identified	Up-regulation	Antibacterial activity	(Mearns-Spragg et al. 1998)
F/F	*Trametes versicolor*	Liquid	*Trichoderma harzianum (*soil fungus and biocontrol organism)	laccase and cellobiase	Enzymes	Up-regulation	Stimulate wood decay	(Freitag and Morrell 1992)
B/F	*Xanthomonas campestris* pv. campestris	Liquid	*Candida albicans* and *Xanthomonas campestris pv. Campestris*	cis -11-methyl-2-dodecenoic acid	a,b Unsaturated fatty acid (DSF)	Up-regulation	Regulates virulence in *X. Campestris;* Regulates morphological transition and virulence by *C. albicans*	(Wang et al. 2004)
B/B	*Xylella fastidiosa*	Liquid	*Methylobacterium mesophilicum*	not identified	Not identified	Up-regulation	*X. fastidiosa* down-regulate genes related to growth and up-regulate genes related to energy production, stress, transport, and motility,	(Dourado et al. 2015)
F/B	*Fusarium oxysporum* f. sp. radicis-lycopersici (soil-borne fungus)	Liquid	*Pseudomonas chlororaphis* strain PCL1391	fusaric acid	Polyketide	Up-regulation	Represses the production of signal N-hexanoyl-L-homoserine lactone (C6-HSL).and phenazine-1-carboxamide	(van Rij et al. 2005)
F/B	*Fusarium oxysporum*	Liquid	*Pseudomonas fluorescens* CHA0 (biocontrol strain)	fusaric acid	Polyketide	Up-regulation	Suppress 2,4-diacetylphloroglucinol (2,4-DAPG) production in strain CHA0	(Notz et al. 2002)
F/B	*Fusarium oxysporum*	Liquid	*Pseudomonas fluorescens*	Enzyme	Enzymes	Up-regulation	Degrade 2,4-DAPG into less toxic derivatives monoacetyl-phloroglucinol and phloroglucinol	(Schouten et al. 2004)
F/F	biocontrol agent *Trichoderma harzianum* M10	Liquid	endophyte *Talaromyces pinophilus* F36CF	harziaphilic acid	tetramic acid derivative	*de novo* biosynthesis	Harziaphilic acids did not affect viability of colorectal cancer and healthy colonic epithelial cells, but selectively reduced cancer cell proliferation.	(Vinale et al. 2017)
F/F	biocontrol agent *Trichoderma harzianum* M10	Liquid	endophyte *Talaromyces pinophilus* F36CF	ferricrocin, coprogen B and dimerumic acid	siderophores	Up-regulation	-	(Vinale et al. 2017)

F/F	biocontrol agent *Trichoderma harzianum* M10	Liquid	endophyte *Talaromyces pinophilus* F36CF	3-O-methylfunicone and herquline B	γ-pyrone	Down-regulation	-	(Vinale et al. 2017)
F/B	*Aspergillus niger*	Liquid	*Streptomyces coelicolor*	cyclo(Phe-Phe) and 2-hydroxyphenylacetic acid	cyclic dipeptide	Up-regulation	-	(Wu et al. 2015)
F/B	*Aspergillus fumigatus*	Liquid	*Streptomyces rapamycinicus*	fumigermin	polyketide	*de novo* biosynthesis	Fumigermin inhibits germination of spores of the inducing S. rapamycinicus	(Stroe et al. 2020)
B/F	marine *Streptomyces*	Liquid	*Bacillus* strains	dentigerumycin E	cyclic hexapeptide incorporating three piperazic acids	*de novo* biosynthesis	Dentigerumycin E exhibited antiproliferative and antimetastatic activities against human cancer cells	(Shin et al. 2018)
F/B	*Fusarium tricinctum*	Solid	*Streptomyces lividans*	fusatricinones A–D (1), dihydrolateropyrone (2), zearalenone, (−)-citreoisocoumarin, macrocarpon C and 7-hydroxy-2-(2-hydroxypropyl)-5-methylchromone	naphthoquinone dimers (1), lateropyrone derivative (2)	*de novo* biosynthesis	-	(Moussa et al. 2019)
F/B	*Fusarium tricinctum*	Solid	*Streptomyces lividans*	lateropyrone, the enniatins B, B1 and A1, and fusaristatin A	Depsipeptides and lipopeptide	Up-regulation	-	(Moussa et al. 2019)
B/F	*Pseudomonas aeruginosa*	Solid	*Fusarium tricinctum*	2-heptyl- 4-hydroxy-quinolone (HHQ), phenazine-1-carboxylic acid (PCA) and phenazine-1-carboxamide (PCN)	quorum sensing molecule and phenazine alkaloids	*de novo* biosynthesis	-	(Moussa et al. 2020)
F/F	*Ustilago maydis*	solid	*Fusarium verticillioides*	Over 20 chromatographic peaks	-	*de novo* biosynthesis	*F. verticillioides* is a strong antagonist of *U. maydis* as its presence leads to large reductions in *U. maydis* biomass.	(Estrada et al. 2011)

F/F	*Stereum hirsutum*	Solid	*Coprinus micaceus* and *Coprinus disseminatus*	-	-	Up-regulation	*S. hirsutum* mycelial fronts always overgrew those of *C. micaceus*, there were down-regulations of metabolites in the interaction zone, compared to monocultures of both *S. hirsutum* and *C. micaceus.*	(Peiris et al. 2008)
F/F	*Hypholoma fasciculare*	Solid	*Resinicium bicolor*	benzoic acid methyl ester, a benzyl alcohol, a quinolinium type compound and other volatiles	sesquiterpenes	*de novo* biosynthesis	two wood decay basidiomycete fungi	(Hynes et al. 2007)
F/F	*Rhodotorula glutinis* DBVPG 3853	Liquid	*Debaryomyces castellii DBVPG 3503*	β-carotene, torulene, torularhodin	carotenoid pigments	Up-regulation	-	(Buzzini 2001)
F/B	*Penicillium notatum*	Liquid	Cyanobacterium *Scytonema ocelutum*	*tolytoxin*	Phytoalexin	*de novo* biosynthesis	Antifungal	(Patterson and Bolis 1997)
B/F	*Streptomyces sp.* US80	Liquid	heat-killed fungi	irumamycin, X-14952 B and 17-hydroxy-venturicidin A	-	Up-regulation	Antifungal	(Fourati-Ben Fguira et al. 2008)
B/B	*Streptomyces sp. RKBH-B178*	Liquid	autoclaved *Mycobacterium smegmatis*	hydrazidomycin D	hydrazide	*de novo* biosynthesis	-	(Liang et al. 2019)
B/B	*Streptomyces sp. RKBH-B178*	Liquid	autoclaved *Pseudomonas aeruginosa*	Glucuronidated-PQS	glucuronidated analog of the pseudomonas quinolone signal (PQS)	*de novo* biosynthesis	-	(Liang et al. 2019)
B/B	*Bacillus cereus, Flavobacterium johnsoniae*, and *Pseudomonas koreensis*	Liquid	*Bacillus cereus, Flavobacterium johnsoniae*, and *Pseudomonas koreensis*	zwittermicin, petrobactin, derivatives of lokisin	sidephores	Up-regulation	Antibiotic	(Chevrette et al. 2022)

B/B	*Streptomyces hygroscopicus* HOK021	Liquid	*Tsukamurella pulmonis* TP-B0596	harundomycin A	conjugate between FabF inhibitor and catechol-type siderophore	*de novo* biosynthesis	Bifunctional Antibacterial Conjugate	(Asamizu et al. 2022)
F/F	*Aspergillus carneus* KMM 4638	Liquid	*Beauveria felina* (=*Isaria felina*) KMM 4639	asperflavinoids B, D and E	drimane-Type Sesquiterpenes	*de novo* biosynthesis	Cytotoxic	(Zhuravleva et al. 2022)
F/B	*Aspergillus nidulans*	Liquid	*Streptomycetes*	anhydrosepedonin (**1**) and antibiotic C (**2**)	iron-chelating tropolones and tripyrnidone	*de novo* biosynthesis and up-regulation	antibacterial	(Gerke et al. 2022)
F/F	*Alternaria*	Liquid	*Trichoderma atroviride*	alternariol	benzochromenone	Up-regulation	mycotoxin	(Tian et al. 2023)
F/F	Trichoderma *atr oviride*	Liquid	*Alternaria*	Hydroxylation of altern ariol (AOH-OH)	benzochromenone	Biotransform ation	-	(Tian et al. 2023)
B/F	*Streptomyces* sp 13F051	Liquid	*Leohumicola minima* 15S071	ulleungdolin	polyketide–peptide hybrid	*de novo* biosynthesis	-	(Hwang et al. 2022)
F/F	*Botrytis cinerea*	Liquid	*Pichia fermentans* (two strains), *Issatchenkia terricola* and *Wicker hamomyces anomalus.*	46 differentially secreted metabolites, including *trans*-cinnamic acid and the indole-3-carboxaldehyde	Phenylpropanoid and alkaloid	Up-regulation	Antifungal for biocontrol	(Fernandez-San Millan et al. 2022)
F/F	*Aspergillus oryz ae*	Solid	Zygosaccharomyces *rouxii*	l-Arginine and l-Glutamate increase and l-Isoleucine decreased	Aminoacids	Regulation	- fungal breakage rate increased - enzyme activity decreased	(Liu et al. 2022b)
F/F	*Trichoderma* strains	Liquid	*T richoderma* strains	Unkown	Unkown	Regulation	- synergistically promote plant growth - antagonistic activity against pathogens	(Liu et al. 2022a)
F/F	*Aspergillus nidulans*	Liquid	*Aspergillus fumigatus*	diphenyl ethers	polyketides	Up-regulation	Antibacterial	(Ninomiya et al. 2022)

F/F	*Aspergillus fumigatus*		*Aspergillus nidulans*	Unkown	siderophore	Up-regulation	-	(Ninomiya et al. 2022)
F/F	*Fusarium oxysporum* AB2	Liquid	*Epicoccum nigrum* TORT	Beauvericin	Depsipeptides	Up-regulation	insecticidal and antibacterial activities	(Vásquez-Bonilla et al. 2022)
F/F	*Azospirillum oryzae* NBT506	Liquid	*Bacillus velezensis* UTB96	Surfactin and indole-3-acetic acid (AA)	surfactin production, indole-3-acetic acid (IAA) production, phosphate solubilization and enzyme activities	Up-regulation	plant growth-promoting bacteria (PGPB)	(Bagheri et al. 2022)
F/F	*Aspergillus oryz ae*	Liquid	Zygosaccharomyces *rouxii*	Unkown	Unkown	Up-regulation	Antibacterial	(Liu et al. 2022c)
F/F	deep-sea-derived fungi *Penicilliu m crustosum* PRB-2	Solid	*Penicillium fellutanum* HDN14-323	penifellutins A (1), B (2), penifellutins C (3) and D (4),	Polyketides	*de novo* biosynthesis	-	(Yu et al. 2022)
F/B	*Aspergillus flavipes*	Solid	*Bacillus subtilis*	Taxol	-	Up-regulation	`Chemotherapy	(El-Sayed et al. 2021)
F/F	*Penicillium fuscum*	Solid	*P. camembertii/claviger um*	berkeleypenostatins A–G (1–7), berkeleylactones A–H, the known macrolide A26771B, citrinin, and patulin	macrolide	*de novo* biosynthesis and Up-regulation	Anticancer	(Stierle et al. 2021)
B/F	*Streptomyces lunalinharesii*	Solid	Phytopathogen *Rhizoctonia solani*	desferrioxamine E and anisomycin	siderophores	Up-regulation	-	(Maimone et al. 2021)
B/F	wild-type lactic acid bacteria	Liquid	auxotrophic *Sacchar omyces cerevisiae*	riboflavin and folate	B-group vitamins	Up-regulation	-	(Konstantinidis et al. 2021)
F/F	Marine *Aspergi llus terreus* C23-3	Liquid	Marine *Aspergillus. unguis* DLEP2008001	unguisin A, lovastatin, and nidulin and others	Multiple	Up-regulation	Antimicrobial	(Wang et al. 2022)

F/F	*Irpex lacteus*	Solid	*Nigrospora oryzae*	irperide	butenolide	*de novo* biosynthesis	Antifungal	(Wu et al. 2022)
F/F	*Alternaria, Botryosphaeria, Phoma* and *Talaromyces*	Solid	*Fusarium pseudograminearum* (Fp)	Unkown	Unkown	Unkown	Antifungal	(Zhao et al. 2022)
F/B	*Aspergillus sydowii*	Liquid	*Bacillus subtilis*	s (−)- (7S)- 10-hydroxysydonic acid, serine sydonate and macrolactin U'	-	Up-regulation	Antibacterial against Staphylococcus aureus	(Sun et al. 2022)
B/B	*Enterococcus faecium* 135	Liquid	*Ligilactobacillus salivarius* and *Limosilactobacillus reuteri*	bacteriocin-like inhibitory substances (BLIS)	Bacteriocin	Up-regulation	Antibacterial	(Piazentin et al. 2022)
B/B	*Streptomyces sp*	Liquid	*Achromobacter sp*	Ligiamycins A and B	Decalin-Amino-Maleimides	Up-regulation	-	(Lim et al. 2022)
F/F	*Cosmospora sp.*	Solid	Phytopathogen *Magnaporthe oryzae*	soudanones A, E, D (1-3) and their two new derivatives, soudanones H-I (4-5), the known isochromans, pseudoanguillosporins A and B (6, 7), naphtho-γ-pyrones, cephalochromin and ustilaginoidin G (8, 9), and ergosterol (10).	Isochromanones	*de novo* biosynthesis and Up-regulation	-	(Oppong-Danquah et al. 2022)
B/B	*Streptomyces sp*	Solid	*Pandoraea sp.*	Gwanakosides A and B	6-Deoxy-α-l-talopyranose-Bearing Aromatic Metabolites	*de novo* biosynthesis	Antibacterial	(Huynh et al. 2022)
B/B	Soil *Bacillus velezensis*	Solid	*Pseudomonas*	surfactin	lipopeptides	Up-regulation	- enhance motility - chemical trap to reduce the toxicity	(Andrić, S et al. 2021)

F/F	*Trametes coccinea* (F3)	Solid	*Leiotrametes lactinea* (F9) and *T. versicolor* (F1)	Melanin and laccase	Group of multicopper oxidases involved in detoxification of toxic compounds	Up-regulation	-	(Dullah et al. 2021)
F/F	*Talaromyces calidicanius*	Solid	*Aspergillus chevalieri*	Unkown	Unkown	Up-regulation	inhibiting the enzyme acetylcholinesterase	(de Oliveira et al. 2022)
F/B	*Aspergillus nidulans*	Liquid	*Streptomyces iranensis*	orsellinic acid, lecanoric acid, F-9775A and F-9775B	Archetypal polyketides and pentacyclic triterpenes	*de novo* biosynthesis	Arginine-derived polyketides serve as the bacterial signals	(Krespach et al. 2022)
B/F	*Paenibacillus peoriae strain M48F*	Solid	*Pleurotus ostreatus HK35* and *Pleurotus eryngii DSMZ 8264*	5-diisopropylpyrazine	VOC	Up-regulation	enhance mycelial growth	(Orban et al. 2023)
F/B	*Pleurotus ostreatus HK35* and *Pleurotus eryngii DSMZ 8264*	Solid	*Paenibacillus peoriae strain M48F*	β-bisabolene	sesquiterpenes	Up-regulation	fungal defense reaction	(Orban et al. 2023)
A/F	marine dinoflagellate *Prorocentrum lima*	Liquid	*Aspergillus pseudoglaucus*	okadaic acid and dinophysistoxin 1	Up-regulation	Up-regulation	Toxines	(Berry et al. 2022)

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