Additional File 1

Table S1. List of beneficial endophytic microbes associated with various medicinal plants and their plant growth promoting (PGP) and antimicrobial properties

S. No.	Endophytes	Host Plant	Plant Part	PGP/ Antimicrobial Properties	References
1.	*Bacillus cereus* and *B.subtilis*	*Teucrium polium* L.	Leaves	Production of indole-3- acetic acid (IAA), ammonia and phosphate solubilization trait	[50]
2.	*B. subtilis, Agrobacterium tumefaciens, Bacillus* sp., *Pseudomonas putida,* and *Pseudomonas* sp.	*Casia tora*	Root	Synthesis of IAA, ammonia, siderophores, HCN and solubilization of phosphate	[51]
3.	*Paenibacillus* sp.	*Tridax procumbens*	Root	Production of secondary metabolites, IAA, siderophores, ACC deaminase, biosurfactant and phosphate solubilization	[52]
4.	*B. cereus* (ECL1), *B. thuringiensis* (ECL2), *Bacillus* sp. (ECL3), *B. pumilis* (ECL4), *P. putida* (ECL5), and *Clavibacter michiganensis* (ECL6) *Achromobacter xiloxidans,*	*Curcuma longa* L.	Rhizome	Production of IAA, siderophore and phosphate solubilization	[53, 54]

	Alcaligenes sp., *Bacillus pumilus*				
5.	*Enterobacter* sp., *Rahnella* sp., *Rhodanobacter* sp., *Pseudomonas* sp., *Stenotrophomonas* sp., *Xanthomonas* sp. and *Phyllobacterium* sp.	*Ipomoea batatas* L.	Stem	Production of IAA, nitrogen fixation and stress tolerance	[55]
6.	*B. subtilis* and *B. thuringiensis*	*Glycine max* L.	Seed	Increase in nodule number per plant, increased soybean weight	[56]
7.	*Pseudomonas* sp.	*Zingiber officinale*	Rhizome	IAA, ACC deaminase and siderophore production	[57]
8.	*Achromobacter xiloxidans*; *Alcaligenes* sp., *B. pumilus*	*Helianthus annus* L.	Root	Positive catalase and oxidase activities, phosphate solubilization	[58]
9.	*Bacillus* sp., *Sphingopyxis* sp.	*Fragaria ananassa*	Meristematic tissue	Indole acetic acid production, solubilization of inorganic phosphate	[59]
10.	*B. subtilis* OS-11	*Ocimum sanctum*	Leaves	Increase in the content of essential oil, enhancement of plant growth	[60]
11.	*Bacillus* sp. and *Enterobacter* sp.	*Phoenix dactylifera* L.	Seed	ACC deaminase, IAA production, ammonia production, ferric iron chelation, solubilization of potassium, phosphorus and zinc	[61]
12.	*Psuedomonas resinovorans, Paenibacillus polymaxa*, and *Acenitobacter calcoaceticus*	*Gynura procumbens*	Leaves	Production of cytokinin compounds	[62]
13.	*Pseudomonas* sp. Ph6- gfp	*Trifolium pratense* L.	Root	Degradation of phenanthrene, a toxic	

				metabolite	[63]
14.	*Acinetobacter* sp. ALEB16	*Atractylodes lancea*	Leaves	Accumulation of plant volatile oils and induction in abscisic acid and salicylic acid production	[64]
15.	*Bacillus thuringiensis* GDB-1	*Pinus sylvestris*	Root	ACC deaminase activity, IAA and siderophore production along with phosphate solubilization trait	[65]
16.	*Bacillus subtilis* HYT- 12-1	*Lycopersicum esculentum*	Seed	IAA production; phosphate solubilization; siderophores production; nitrogen fixation and ACC deaminase activity	[66]
17.	*Achromobacter xylosoxidans* strain AUM54	*Catharanthus roseus*	Root	ACC deaminase activity, increased plant ethylene levels and increased antioxidative enzyme	[67]
18.	*Bacillus megaterium, Bacillus pumilus, Bacillus licheniformis, Micrococcus luteus, Paenibacillus* sp.*, Pseudomonas* sp.*,* and *Acinetobacter calcoaceticus*	*Plectranthus tenuiflorus*	Root, stem, and leaves	Production of extracellular enzymes	[68]
19.	*Bacillus amyloliquefaciens* ES-2	*Scutellaria baicalensis*	Root	Production of secondary metabolites with broad-spectrum antibacterial and antifungal activities	[69]
20.	*Serratia nematodiphila* LRE07*, Enterobacter aerogenes* LRE17*, Enterobacter* sp. LSE04 and	*Solanum nigrum* L.	Root, stem, and leaves	ACC deaminase, indole acetic acid, siderophore and phosphate solubilizing activity	[70]

	Acinetobacter sp. LSE06				
21.	*Acinetobacter* sp., *Agrobacterium* sp., *Bacillus* sp., *Brevibacillus* sp., *Burkholderia* sp., *Curtobacterium* sp., *Erwinia* sp., *Lactococcus* sp., *Pantoea* sp., and *Pseudomonas* sp.	*Eucalyptus* sp.	Stem	Production of new metabolites and enzymes and control of plant diseases	[71]
22.	*Arthrobacter* sp. SMR3, *B. subtilis* SMR15	*Papaver somniferous*	Root, leaves, capsule and seeds	Benzylisoquinoline alkaloid (BIA) biosynthesis, IAA production, ACC deaminase production	[72]
23.	*Alcaligenes faecalis* subsp. faecalis str. S8	*Withania somnifera*	Stem and fruit	Production of IAA and phosphate solubilization	[73]
24.	*B. subtilis* LK14	*Moringa peregrine*	Bark	Phosphate solubilization, ACC deaminase and acid phosphatase activity	[74]
25.	*Paenibacillus validus, Lysinibacillus fusiformis, B. licheniformis, Pseudomonas putida, Microbacterium oleivorans,* and *Serratia plymutica*	*Citrus sinensis*	Root	Phosphate solubilization, siderophore production, nitrogen fixation, IAA synthesis, production of antibiotic and lytic enzymes (chitinase), induction of systemic resistance through salicylic acid production	[75]
26.	*Bacillus* sp., *Pseudomonas* sp.	*Bauhinia purpurea*	Stem, leaves and flower	Appreciable antioxidant and antimicrobial activity	[76]
27.	*Acinetobacter* sp. ACMS25 and *Bacillus* sp. PVMX4	*Phyllanthus amarus*	Root	Phosphate solubilization, IAA production, siderophore production, ACC deaminase activity and	[77]

				production of hydrolytic enzymes like cellulose, protease, pectinase	
28.	*Azotobacter* sp., *Azotobacter vinelandii, Azotobacter chroococcum*	*Vigna radiata*	Root and leaves tissues	IAA production, phosphate solubilizing activities	[78]
29.	*Bacillus* sp., *Enterobacter* sp. and *Sporosarcina aquimarina*	*Avicennia marina*	Pneumato-phores	Production of siderophore, phosphate solubilization and IAA production	[79]
30.	*Pseudomonas fluorescens* G10 and *Microbacterium* sp. G16	*Brassica napus*	Root	Production of IAA, siderophores and ACC deaminase resulting in increased biomass production	[80]
31.	*Burkholderia phytofirmans*	*Allium Cepa*	Root	ACC deaminase activity	[81]
32.	*Acetobacter diazotrophicus*	*Saccharum officinarum*	Stem	Nitrogen fixation ability	[82]
33.	*Bacillus subtilis*	*Morus alba*	Root, stem and leaves	Reduced bacterial wilt	[83]
34.	*Burkholderia cepacia, Rhizobium* sp., *Klebsiella* sp., *Gluconacetobacter diazotrophicus, Herbaspirillum seropedicae, Pantoea agglomerans, Azospirillum* sp., *Bacillus* sp., and *Enterobacter* sp.	*Zea mays*	-	Growth enhancement	[84]
35.	*Bacillus megaterium*	*Zea mays*	Root, stem and leaves	-	[85]
36.	*Burkholderia vietnamiensis*	*Saccharum officinarum*	Root	Growth enhancement and increased	[86]

				yield	
37.	*Pseudomonas* sp.	*Populus* sp.	Root, stem and leaves	Ability to degrade 2,4-dichlorophenoxyacetic acid (2,4-D)	[87]
38.	*Gluconacetobacter diazotrophicus, Herbaspirillum seropedicae, Herbaspirillum rubrisubalbicans, Azospirillum amazonense, Burkholderia tropica*	*Saccharum officinarum*	Root	-	[88]
39.	*Gluconacetobacter diazotrophicus, H. seropedicae, Herbaspirillum rubrisubalbicans, A. amazonense* and *Burkholderia* sp.	*Saccharum officinarum*	Root and shoot	Growth enhancement and increased nitrogen content	[89]
40.	*Klebsiella aerogenes, B. subtilis*	*Bacopa monnieri*		Enhancement in plant biomass and Bacoside A content	[19]
41.	*Sphingomonas* sp., *Pseudomonas* sp., *Lasiodiplodia theobromae, Penicillium digitatum, Aspergillus awamori, Trichoderma harzianum, Aspergillus flavus, Cladosporium herbarum*, *A. niger*, *Monascus* sp., *Penicillium citrinum*,	*Solanum nigrum* L.	Stem, leaves and fruit	-	[90, 91, 92, 93]

	and *Penicillium chrysogenum*				
43.	*Aspergillus* sp., *Cladosporium* sp.	*Calotropis procera*	Root, stem and leaves	Antimicrobial and antioxidant activities	[94]
44.	*Alternaria porri, Aspergillus flavipes, Fusarium oxysporum, Nigrospora sphaerica, A. niger, Curvularia lunata, Colletotrichum falcatum, Phomopsis archeri, Pestalotiopsis sydowiana, Phoma exigua,* and *Leptospharulina chartarum*	*Calotropis. Gigantean*	Stem, leaves and flower	-	[95]
46.	*Delftia tsuruhatensis , Pseudomonas frederiksbergensis, Agrococcus lahaulensis, Arthrobacter, B. siamensis, B. tequilensis, B. zhangzhouensis, Chryseobacterium cucumeris, Kocuria polaris* and *Sphingomonas genera*	*Scrophularia striata*	Root, stem and leaves	Antibacterial activity against plant pathogens	[96]
47.	*Pseudomonas* sp. and *Bacillus* sp.	*Aloe barbadensis*	Root, stem and leaves	-	[97]
48.	*P. aeruginosa, P. putida, B. megaterium, Arthrobacter* sp., *Micrococcus* sp.,	*Piper nigrum* L.	Root and stem	Antagonistic activity against *Phytophthora capsici*	[98]

	Curtobacterium sp.				
49.	*Erwinia* sp., *Pseudomonas* sp., *B. megaterium*, *B. chosinensis*, and *Microbacterium trichothecenolyticum*	*Medicago sativa* L.	Root	-	[99, 100]
50.	*B. siamensis*	*Coriandrum sativum*	-	Increased root length, shoot length, and dry weight	[101]
51.	*Micrococcus luteus* and *Lysinibacillus fusiformis*	*Panax quinquefolius*	Stem	Enhanced seedling biomass	[102]
52.	*Bacillus* and *Paenibacillus* sp.	*Curcuma longa*	Rhizome	Increased root length, shoot length, and root number	[103]
53.	*Bacillus* sp.	*Curcuma longa*	Rhizome	Induced host disease resistance	[104]
54.	*Pseudomonas aeruginosa*	*Anredera cordifolia*	Leaves	Production of proteases, amylase, esterase, and cellulose enzymes	[105]
55.	*B. subtilis*	*Pseudobrickellia brasiliensis*	Stem and leaves	Protease and esterase activity	[106]
57.	*P. aeruginosa*	*Achyranthes aspera*	Leaves	Improved plant biomass and antioxidant activity	[107]

Table S2. List of endophytes enhancing pharmaceutically important secondary metabolites in medicinal plants

S. No.	Endophyte	Host plant	Secondary plant metabolite/s	Reference
1.	*Colletotrichum gloeosporioides*	*Centella asiatica*	Asiaticoside	[154]
2.	*Fusarium* sp.	*Dracaena cochinchinensis*	Red resin	[155]
3.	*Piriformospora indica*	*Bacopa monnieri*	Bacoside	[156]
4.	*Phomopsis* sp.	*Euphorbia pekinensis*	Terpenoid	[157]
5.	*Piriformospora indica*	*Spilanthes calva*	Spilanthol	[158]
6.	*Sebacina vermifera*	*Linum album*	Podophyllotoxins	[159]
7.	*Fusarium mairei*	*Taxus chinensis*	Paclitaxel	[160]
8.	*Fusarium mairei*	*Taxus cuspidate*	Paclitaxel	[161]
9.	Endophytic fungus	*Catharanthus roseus*	Alkaloid	[162]

10.	*Piriformospora indica*	*Curcuma longa*	Curcumin and volatile oil	[163]
11.	*Ramularia* sp.	*Rumex gmelini Turcz*	Emodin	[164]
12.	*Fusarium* sp.	*Rumex gmelini Turcz*	Musizin, chrysophanol and physcion	[164]
13.	*Aspergillus oryzae*	*Rumex gmelini Turcz*	Resveratrol	[164]
14.	*Trimmatostroma* sp.	*Rhodiola crenulata*	Salidroside and tyrosol	[165]
15.	*Rhizophagus intraradices*	*Hypericum perforatum* L.	Hypericin and pseudohypericin	[166]
16.	*Piriformospora indica*	*Withania somnifera*	Withaferin A	[167]
17.	*CATDLF5 (Curvularia sp.) and CATDLF6 (Choanephora*	*Catharanthus roseus*	Serpentine	[17]

	infundibulifera)			
18.	*CATDS5 (Pseudomonas sp.)*	*Catharanthus roseus*	Ajmalicine	[17]
19.	*Burkholderia* sp.	*Artemisia annua*	Artemisinin	[168]
20.	*Gilmaniella* sp.	*Atractylodes lancea*	Ethylene	[169]
21.	*Chaetomium globosum & Colletotrichum gloeosporioides*	*Anoectochilus roxburghii*	kinsenoside	[170]
22.	*Pseudomonas fluorescens*	*Atractylodes lancea*	Essential oil	[171]
23.	*Paenibacillus polymyxa*	*Panax ginseng*	Ginsenoside	[152]

24.	*Bacillus subtilis*	*Ligusticum chuanxiong*	ligustrazine	[172]
25.	*Pseudonocardia* sp.	*Artemisia annua*	Artemisinin	[173]
26.	*Burkholderia* sp.	*Panax ginseng*	Ginsenoside Rg3	[129]
27.	*Ilyonectria liriodendra*	*Houttuynia cordata*	Chlorogenic acid, quercitrin α-pinene, β-pinene, camphene, β-myrcene, limonene, decanal, bornyl acetate, β-caryophyllene, 2-undecanone	[12]
28.	Arbuscular mycorrhiza fungi (AMF) and *Trichoderma konigii*	*Ocimum basilicum*	Ferulic acid, chicoric acid, and quercetin rutinoside	[174]
29.	*Mucor fragilis*	*Salvia miltiorrhiza*	Diterpenoides and phenolic acids	[11]

30.	*Staphylococcus sciuri* and *Micrococcus* sp.	*Catharanthus roseus*	Terpenoid indole alkaloids like vindoline, serpentine and ajmalicine	[175]
31.	Endophytic bacterial community	*Putterlickia retrospinosa* and *P. verrucosa*	Maytansine	[176]
32.	*Azotobactor chroococcum* CL13	*Curcuma longa*	Phenolic compounds, sesquiterpenoids and curcuminoids	[177]
33.	*Stenotrophomonas maltophilia* (N5-18)	*Pappaver sominiferum*	Morphine and total alkaloid	[178]
34.	*Gilmaniella* sp. AL12	*Atractylodes lancea*	Volatile content	[179]
35.	*Bradyrhizobium* sp.	*Crotalaria*	Antiherbivore, nematicide	[180]

36.	*Pantoea dispersa* and *Penicillium polonicum*	*Aquilaria malaccensis*	Agarospirol	[149]
37.	*Paenibacillus* sp.	*Populus* sp.	Threitol and asparagine	[181]
38.	*Enterobacter ludwigii*	*Vitis vinifera*	Vanillic acid	[182]
39.	Bacterial endophytes	*Vetiveria zizanioides*	Essential oil biogenesis	[151]
40.	*Pseudomonas aeruginosa* and *Pseudomonas pseudoalcaligenes*	*Hyptis suaveolens*	Essential oils	[183]
41.	*Bacillus amyloliquefaciens, Pseudomonas fuorescen, Alternaria alternata, Sclerotium rolfsii Aspergillus terreus, Penicillium oxalicum, Sarocladium kiliense*	*Withania somnifera*	Withanolide modulation	[184]

42.	*Bacillus* and *Enterobacter* sp.	*Thymus vulgaris*	Bioactive metabolites (benzene, 1,3-dimethyl-, p-xylene, dibutyl phthalate, bis (2-ethylhexyl) phthalate, and tetracosane)	[185]
43.	*Macrophomina pseudophaseolina* (SF2)	*Andrographis paniculata*	Andrographolide content	[186]
44.	*Fusarium redolens* (RF1), *Phialemoniopsis cornearis* (SF1), and *Macrophomina pseudophaseolina* (SF2)	*Coleus forskohlii*	Forskolin content	[147, 187]
45.	*Piriformospora indica*	*Coleus forskohlii*	p-cymene	[188]
46.	*Glomerella magna,*	*Lycoris radiata*	Alkaloides (narciclasine,	[39]

	Phyllosticta capitalensis, Stagonosporopsis cucurbitacearum, Stagonosporopsis ligulicola, Phyllosticta ophiopogonis and *Colletotrichum gloeosporioides*		lycorine, galanthamine and tazettine)	
47.	*Pseudomonas fluorescens*	*Atractylodes lancea*	Sesquiterpenoid	[189]
48.	*Aspergillus terreus, Penicillium oxalicum, Sarocladium kiliense* (endophytes) and, *Trichoderma viride* (biocontrol agent)	*Withania somnifera*	Withaferin A	[190]
49.	*Alcaligenes faecalis*	*Coleus forskohlii*	Forskolin	[186]

50.	*Chitinophaga* sp., *Allorhizobium* sp., *Duganella* sp., and *Micromonospora* sp.	*Alkanna tinctoria*	Alkannin and shikonin	[16]
51.	*Piriformospora indica*	*Centella asiatica*	Asiaticosides	[191]
52.	*Mycena* sp.	*Anoectochilus formosanus*	Flavonoid and kinsenoside	[153]
53.	*Bacillus subtilis* and *Klebsiella aerogenes*	*Bacopa monnieri*	Bacoside	[19]
54.	*Paenibacillus* sp.	*Bacopa monnieri*	Bacoside A	[18]
55.	Bacterial endophytes	*Echinacea purpurea*	Alkamides, volatile organic compounds (VOCs) and phenylpropanoid compounds	[192, 193]