Review Article

Checklist of Ectomycorrhizae from Pakistan

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Abstract

This is the first attempt to make a comprehensive checklist of the ectomycorrhizae reported from Pakistan. Genera are arranged in alphabetical order (*Amanita*, *Boletus*, *Cantharellus*, *Clavariadelphus*, *Clitocybe*, *Cortinarius*, *Craterellus*, *Dermocybe*, *Descolea*, *Geastrum*, *Genea*, *Gomphus*, *Helvella*, *Hydnum*, *Inocybe*, *Lactarius*, *Lyophyllum*, *Peziza*, *Porphyrellus*, *Ramaria*, *Russula*, *Sarcodon*, *Suillus*, *Tomentella*, *Tuber*, *Tricholoma*), with species arranged alphabetically within each genus. Each species is given with its distribution and host. A total of twenty six (26) genera are presented.

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Introduction

Pakistan lies between latitudes 24-37°N and longitudes 61-75°E, comprising a wide variety of landscapes covering the total area of 796,095 km^2. Neighboring China is linked via the famous Silk Road, to the east, the area also adjoins the disputed territory of Kashmir and India and Afghanistan to the North-West, Iran in the South-West and the Arabian Sea to the South.[1] The land ranges from coastal areas to high peaks of the world providing the area a wide variation of climatic conditions. The Himalayan and Hindukush ranges are the most prominent features present on the face of the earth lies in the North and West of the Pakistan and Indus basin to the South. In this mountainous, plateau and plains complex, rich diversity of flora and fauna exists.[2]

About 3.5 % of the total land area of Pakistan is covered by forests.[3] In plains of Punjab with subtropical to semiarid climate, sub-tropical thorn forest of vegetation is represented by several species of deciduous and evergreen trees. Among these, *Populus euramericana* Guinie, *Salix babylonica* L., *S. tetrasperma* Roxb., *Dalbergia sissoo* Roxb., *Eucalyptus comendulensis* Dehnh. , *Morus alba* L. and *Acacia nilotica* (L.) Willd. ex Delile are among the dominant tree species. In temperate climate of Northern areas, Himalayan and Hindukush ranges are covered with dense forests of conifers along with scattered vegetation of deciduous trees. The dominant tree species are *Pinus wallichiana* A.B. Jackson, *Abies pindrow* Royle, *Cedrus deodara* (Roxb.) G. Don., *Picea smithiana* (Wall.) Boiss., *Juglans regia* L. *Salix* spp. and *Populus* spp.[4]

Ectomycorrhizal (ECM) fungi are a diverse functional group of mutulistic root symbionts that enhance host plant nutrient acquisition, protect against root disease, and mitigate the effects of abiotic stresses. [5,6] Previously this symbiotic relationship was considered to restrict only to temperate zones but recent studies have shown its existence in the tropical and subtropical areas as well. [7]

Thousands of ECM fungal species exist globally, but the estimate of species richness of these fungi varies widely. The manuscript in the form of a checklist is the first attempt in compilation of the available data on the ectomycorrhizae reported from Pakistan. The aim of this checklist is to summarize the currently known ectomycorrhizae from Pakistan. A total of twenty six (26) genera are presented represented. Up till now ninety five (95) ectomycorrhizae have been documented. Among these fifty seven (57) are identified and thirty eight (38) are given tentative names according to special nomenclature for ectomycorrhizae followed by the authors.

Materials and Methods

The checklist is based on consultation of all possible available literature to date. The fungal taxa are presented in alphabetical order followed by host symbiont, type of ectomycorrhizal system, habitat distribution and literature. For some ectomycorrhizal fungal taxa some information was not found in literature. Taxonomic position was confirmed by using Index Fungorum, (an online global fungal nomenclature) and Agerer [8] and recent monographs as well as particular articles on ectomycorrhizae.

List of ectomycorrhizae from Pakistan

Division Ascomycota

Genus *Genea*

1. **Mycobiont:** *G. verrucosa* Vittad.
   Phytobiont: *Populus ciliata* Wall. ex Royle
   Root tip morphology: Simple, irregular to monopodial pinnate
   Distribution: Pakistan KPK, Khanspur-Ayubia
   Literature: [9]
2. **Mycobiont:** *G. hispidula* Berk. et. Br.
   Phytobiont: *Salix babylonica*
   Root tip morphology: Simple or irregularly pinnate
   Distribution: Pakistan KPK, Khanspur-Ayubia
   Literature: [10]

Genus *Helvella*

3. **Mycobiont**: *H. crispa* Bull.
   Phytobiont: *Abies pindrow*
   Root tip morphology: Dichotomous
   Distribution: Pakistan; Khanspur
   Literature: [11]

Genus *Peziza*

4. **Mycobiont:** *Peziza* sp.
   Phytobiont: *Cedrus deodara*
   Root tip morphology: Dichotomus to coralloid
   Genbank Accession No.: JN836754

Distribution: Pakistan; KPK, Ayubia National Park
Literature: [12]

5. **Mycobiont:** *P. michelii* (Boud.) Dennis
Phytobiont: *Alnus nitida* (Spach) Endl.Gen.
Root tip morphology: Simple
Genbank Accession No.: JN836749
Distribution: Pakistan; KPK, Khanspur-Halipad
Literature: [13]

Genus *Tuber*

6. **Mycobiont:** *T. aestivum* **(**Wulfen**)** Spreng**.**
Phytobiont: *Salix* sp.
Root tip morphology: Simple, irregular
Distribution: Pakistan; KPK, Nathia gali
Literature: [10]

Division Basidiomycota

Genus *Amanita*

7. **Mycobiont**: *A. cinnamomescens* Tulloss, S. H. Iqbal & Khalid
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-Pinnate
Distribution: Pakistan; Khyber Pakhtunkhwa (KPK); Khanspur-Ayubia
Literature: [11]

8. **Mycobiont**: *A. flavipes* S. Imai
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-Pinnate
Distribution: Pakistan; KPK; Khanspur-Ayubia; Natia gali; Kuza gali
Literature: [11]

9. **Mycobiont**: *A. flavoconoides* nom. prov.
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomous
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [11]

10. **Mycobiont:** *A. pakistanica* Tulloss, S.H. Iqbal & Khalid
Phytobiont: *Pinus wallichiana*
Root tip morphology: Densely dichotomous to coralloid
Distribution: Pakistan; KPK; Khanspur-Ayubia; Natia gali
Literature: [11]

11. **Mycobiont**: *A. rubescens* Pers.
Phytobiont: *Picea smithiana*
Root tip morphology: Monopodial-Pinnate
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [11, 14]

12. **Mycobiont**: *A. pak3* nom. prov.
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomous to coralloid
Distribution: Pakistan; KPK; Kaghan, Dist. Sheran, Kaghan valley
Literature: [11]

13. **Mycobiont**: *A. vaginata* (Bull.) Lam.
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomous to coralloid
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [11]

Genus *Boletus*

14. **Mycobiont**: *B. barrowsii* Thiers & A.H. Sm.
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-Pinnate
Distribution: Pakistan; KPK; Nathiagali
Literature: [11]

15. **Mycobiont**: *B. calopus* Pers.
Phytobiont: *Abies pindrow*
Root tip morphology: Simple to Monopodial-Pinnate
Distribution: Pakistan; KPK; Khanspur-Ayubia; Nathia gali; Sheran
Literature: [11]

16. **Mycobiont**: *B. edulis* Bull.
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-Pinnate
Distribution: Pakistan; KPK; Khanspur-Ayubia; Kuza gali; Khaira gali
Literature: [11]
17. **Mycobiont**: *B. reticulates* Schaeff.
Phytobiont: *Abies pindrow*
Root tip morphology: Simple to Monopodial-Pinnate
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [11]
18. **Mycobiont**: *B. rubellus* Krombh.
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomus
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [11]

Genus *Cantharellus*

19. **Mycobiont**: *C. cibarius* Fr.
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomous to coralloid
Distribution: Pakistan; KPK; Dunga gali, Nathia gali, Kuza gali, Sheran-Kaghan valley
Literature: [11, 15]

Genus *Clavariadelphus*

20. **Mycobiont**: *C. truncatus* Donk
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomous
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [11]

Genus *Clitocybe*

21. **Mycobiont**: *C. cf. infundibuliformis* (Scaeff.) Fr.
Phytobiont: *Abies pindrow*
Root tip morphology: Simple
Distribution: Pakistan; KPK; Khanspur-Ayubia**,** Nathia gali
Literature: [11]

Genus *Cortinarius*

22. **Mycobiont**: *C. hinnuleus* Fr.
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-Pinnate to Monopodial-Pyramidal
Distribution: Pakistan; KPK; Kuza gali, Dunga gali, Nathia gali, Sheran-Kaghan valley
Literature: [11]

Genus *Craterellus*

23. **Mycobiont**: *C. tubaeformis* (Fr.) Quél.
Phytobiont: *Populus ciliata*
Root tip morphology: Dichotomous to coralloid
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [9]

Genus *Descolea*

24. **Mycobiont**: *D. flavoannulata* (Lj.N. Vassiljeva) E. Horak
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-Pinnate to Monopodial-Pyramidal
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [11, 16]

Genus *Dermocybe*

25. **Mycobiont**: *D. cinnamomea* (L.: Fr.) Wünscne
Phytobiont: *Salix herbacea* L.
Root tip morphology: Simple irregular
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [10]

Genus *Geastrum*

26. **Mycobiont**: *G. triplex* Jungh.
Phytobiont: *Picea smithiana*
Root tip morphology: Simple to irregularly pinnate
Distribution: Pakistan; Hazara District Mukshpuri
Literature: [11]

Genus *Gomphus*

27. **Mycobiont**: *G. floccosus* (Schwein.) Singer
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomous
Distribution: Pakistan; Khanspur-Ayubia
Literature: [11]

Genus *Hydnum*

28. **Mycobiont**: *H. repandum* L.
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-Pinnate to Monopodial-Pyramidal
Distribution: Pakistan; Khanspur-Ayubia, Nathia gali, Kuza gali
Literature: [11]

Genus *Inocybe*

29. **Mycobiont**: *I. nitidiuscula* (Britzelm.) Lapl.
Phytobiont: *Alnus nitida*
Root tip morphology: Dichotomous
Distribution: Pakistan; Jhika gali, Koza gali
Literature: [17]

Genus *Lactarius*

30. **Mycobiont**: *L. hatsudake* Nobuj. Tanaka
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-Pinnate
Distribution: Pakistan; Khanspur-Ayubia, Nathia gali, Khaira gali
Literature: [11]

31. **Mycobiont**: *L. deliciosus* (L.) Gray
Phytobiont: *Pinus wallichiana, Salix babylonica*
Root tip morphology: Dichotomous
Distribution: Pakistan; Khanspur-Ayubia, Lahore, Nathia gali; Sheran-Kaghan valley
Literature: [11, 10]

32. **Mycobiont**: *L. sanguifluus* (Paulet) Fr.
Phytobiont: *Juglans regia*, *Pinus wallichiana*, *Quercus incana* Bartram
Root tip morphology: Dichotomous
Genbank Accession No.: HE615155, HF559374, HF559375, HF549576
Distribution: Pakistan; Abbotabad; Khanspur-Ayubia, Kuzah gali
Literature: [18]

Genus *Lyophyllum*

33. **Mycobiont**: *L. decastes* (Fr.) Singer
Phytobiont: *Abies pindrow*
Root tip morphology: Irregularly-Pinnate to Monopodial-Pinnate
Distribution: Pakistan; Khanspur-Ayubia, Nathia gali; Sheran-Kaghan valley
Literature: [11]

Genus *Porphyrellus*

34. **Mycobiont**: *P. porphyrosporus* (Fr. & Hök) E.-J. Gilbert
Phytobiont: *Cedrus deodara*
Root tip morphology: Dichotomous
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [11]

Genus *Ramaria*

35. **Mycobiont**: *R. aurea* (Schaeff.) Quél.
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-Pinnate
Distribution: Pakistan; KPK; Kuza gali, Dunga gali
Literature: [11]

36. **Mycobiont**: *R. stricta* (Pers.) Quél.
Phytobiont: *Abies pindrow*
Root tip morphology: Irregularly pinnate to Monopodial-Pinnate
Distribution: Pakistan; KPK; Kuza gali, Dunga gali
Literature: [11]

Genus *Russula*

37. **Mycobiont**: *R. ahmadiana* nom. prov.
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-Pinnate to Monopodial-pyramidal
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [11]
38. **Mycobiont**: *R. amethystina* Quél.
Phytobiont: *Picea smithiana*
Root tip morphology: Monopodial-Pinnate
Distribution: Pakistan; Fairy meadows, Baltistan
Literature: [11]
39. **Mycobiont**: *R. brevipes* Peck
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomous
Distribution: Pakistan; KPK; Khanspur-Ayubia, Kuza gali, Nathia gali
Literature: [19]
40. **Mycobiont:** *R. foetens* Pers.
Phytobiont: *Populus ciliata*, *Salix tetrasperma*
Root tip morphology: Irregular to monopodial pinnate
Distribution: KPK, Khanspur-Ayubia
Literature: [9, 10]
41. **Mycobiont**: *R. himalensis* nom. prov.
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-pinnate to Monopodial-pyramidal
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [11]
42. **Mycobiont:** *R. livescens* (Batsch) Bataille
Phytobiont: *Cedrus deodara*
Root tip morphology: Dichotomus
Genbank Accession No: JN836753
Distribution: Pakistan; KPK, Ayubia National Park
Literature: [12]
43. **Mycobiont**: *R. pakistanica* nom. Prov.
Phytobiont: *Abies pindrow, Populus ciliata*
Root tip morphology: Monopodial-pyramidal; Simple irregular
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [9, 11]
44. **Mycobiont**: *R. sardonia* Fr.
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-pinnate
Distribution: Pakistan; KPK; Kuza gali, Nathia gali
Literature: [11]
45. **Mycobiont**: *R. velanovskyi* Melzer & Zvára
Phytobiont: *Picea smithiana*
Root tip morphology: Monopodial-pinnate to Monopodial-pyramidal
Distribution: Pakistan; Northern areas, Fairy meadows
Literature: [11]
46. **Mycobiont**: *R. pak1* nom. prov.
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-pyramidal
Distribution: Pakistan; KPK; Kuza gali, Nathia gali; Sheran-Kaghan valley
Literature: [11]
47. **Mycobiont**: *R. pak2* nom. prov.
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-pinnate
Distribution: Pakistan; KPK; Khanspur-Ayubia, Murree Hills
Literature: [11]

Genus *Sarcodon*

48. **Mycobiont**: *S. atroviridis* (Morgan) Banker
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial-pyramidal

Distribution: Pakistan; Khanspur-Ayubia, Nathia gali, Kuza gali
Literature: [11]

Genus *Suillus*

49. Mycobiont: *S. brevipes* (Peck) Kuntze
Phytobiont: *Quercus incana*
Root tip morphology: Monopodial pinnate
Distribution: Pakistan; KPK, Khanspur
Literature: [20]

50. Mycobiont: *S. flavidus* (Fr.) J. Presl
Phytobiont: *Pinus wallichana*
Root tip morphology: Dichotomus
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [21]

51. Mycobiont: *S. sibiricus* (Singer) Singer
Phytobiont: *Pinus wallichiana*, *Salix alba*
Root tip morphology: Dichotomous-coralloid, Monopodial pinnate
Genbank Accession No.: JN119748, JN119749, JN119750, JN119752
Distribution: Pakistan; KPK; Khanspur-Ayubia, Khera gali, Kuza gali
Literature: [11, 20]

52. Mycobiont: *S. tomentosus* (Kauffman) Singer
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomous-coralloid
Distribution: Pakistan; KPK; Nathia gali
Literature: [11]

Genus *Tomentella*

53. Mycobiont: *T. pilosa* (Burt) Bourdot & Galzin
Phytobiont: *Populus ciliata*
Root tip morphology: Monopodial pinnate to monopodial pyramidal
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [9]

54. Mycobiont: *T. subtestacea* Bourdot & Galzin
Phytobiont: *Populus ciliata*
Root tip morphology: Simple, irregular to monopodial pinnate
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [9]

55. Mycobiont: *Tomentella* sp.1
Phytobiont: *Cedrus deodara*
Root tip morphology: Dichotomus
Genbank Accession No.: JN836750
Distribution: KPK, Ayubia National Park
Literature: [12]

56. Mycobiont: *Tomentella* sp.2
Phytobiont: *Cedrus deodara*
Root tip morphology: Dichotomus
Genbank Accession No.: JN836751, JN836752
Distribution: Pakistan; KPK, Ayubia National Park
Literature: [12]

Genus *Tricholoma*

57. Mycobiont: *T. aurantium* (Schaeff.) Ricken
Phytobiont: *Abies pindrow*
Root tip morphology: Monopodial pinnate to monopodial pyramidal
Distribution: Pakistan; KPK; Khanspur-Ayubia
Literature: [11, 15]

Unidentified ectomycorrhizae

58. Mycobiont: *Fagirhiza satifera*
Phytobiont: *Populus euramericana*
Root tip morphology: Simple, irregular to monopodial pyramidal
Distribution: Pakistan; Punjab, Lahore
Literature: [9]

59. **Mycobiont:** *Piceirhiza obscura*
Phytobiont: *Salix babylonica*
Root tip morphology: Simple, irregular to monopodial pinnate
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [9]
60. **Mycobiont:** *Pinirhiza aggregata*
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomus to coralloid
Distribution: Pakistan; Sakesar hills
Literature: [22]
61. **Mycobiont:** *P. alba*
Phytobiont: *Pinus roxburghii*
Root tip morphology: Dichotomus
Distribution: Pakistan; Punjab, Lahore.
Literature: [23]
62. **Mycobiont:** *P. argentiana*
Phytobiont: *Pinus roxburghii*
Root tip morphology: Dichotomus to irregularly pinnate
Distribution: Pakistan; Sakesar hills
Literature: [22]
63. **Mycobiont:** *P. citrina*
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomus
Distribution: Pakistan; Sakesar hills
Literature: [22]
64. **Mycobiont:** *P. dichotoma*
Phytobiont: *Pinus roxburghii*
Root tip morphology: Dichotomus
Distribution: Pakistan; Sakesar hills
Literature: [22]
65. **Mycobiont:** *P. elongata*
Phytobiont: *Pinus roxburghii*
Root tip morphology: Dichotomus
Distribution: Pakistan; Sakesar hills
Literature: [22]
66. **Mycobiont:** *P. grainulata*
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomus
Distribution: Pakistan; Sakesar hills
Literature: [22]
67. **Mycobiont:** *P. irregulata*
Phytobiont: *Pinus wallichiana*
Root tip morphology: Dichotomus to irregularly pinnate
Distribution: Pakistan; Sakesar hills
Literature: [22]
68. **Mycobiont:** *P. monopodata*
Phytobiont: *Pinus roxburghii*
Root tip morphology: Monopodial pinnate
Distribution: Pakistan; Sakesar hills
Literature: [22]
69. **Mycobiont:** *P. nigra*
Phytobiont: *Pinus roxburghii*
Root tip morphology: Simple to dichotomous
Distribution: Pakistan; Sakesar hills
Literature: [22]
70. **Mycobiont:** *P. pinnata*
Phytobiont: *Pinus roxburghii*
Root tip morphology: Irregularly pinnate to monopodial pinnate
Distribution: Pakistan; Sakesar hills
Literature: [22]
71. **Mycobiont:** *P. reticulata*
Phytobiont: *Pinus roxburghii*
Root tip morphology: Dichotomus to irregularly pinnate
Distribution: Pakistan; Sakesar hills
Literature: [22]
72. **Mycobiont:** *P. sakesarina*
Phytobiont: *Pinus roxburghii*
Root tip morphology: Dichotomus
Distribution: Pakistan; Sakesar hills
Literature: [22]
73. **Mycobiont:** *P. smoothiana*
Phytobiont: *Pinus roxburghii*
Root tip morphology: Dichotomus
Distribution: Pakistan; Sakesar hills
Literature: [22]
74. **Mycobiont:** *P. spinulata*
Phytobiont: *Pinus roxburghii*
Root tip morphology: Simple to dichotomus
Distribution: Pakistan; Sakesar hills
Literature: [22]
75. **Mycobiont:** *P. variegata*
Phytobiont: *Pinus roxburghii*
Root tip morphology: Dichotomus
Distribution: Pakistan; Sakesar hills
Literature: [22]
76. **Mycobiont:** *Populinirrhiza copperina*
Phytobiont: *Populus ciliata*
Root tip morphology: Simple to monopodial pinnate
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [24]
77. **Mycobiont:** *P. khanspurensis*

Phytobiont: *Populus ciliata*
Root tip morphology: Simple to monopodial pinnate
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [25]

78. **Mycobiont:** *P. lusterata*
Phytobiont: *Populus ciliata*
Root tip morphology: Simple
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [23]
79. **Mycobiont:** *P. monopodata*
Phytobiont: *Populus ciliata*
Root tip morphology: Monopodial pinnate
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [23]
80. **Mycobiont:** *P. pinnata*
Phytobiont: *Populus ciliata*
Root tip morphology: Monopodial pinnate
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [24]
81. **Mycobiont:** *Populirhiza ayubiensis*
Phytobiont: *Populus ciliata*
Root tip morphology: Simple
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [9]
82. **Mycobiont:** *P. coratuberculata*
Phytobiont: *Populus ciliata*
Root tip morphology: Coralloid to tuberculate
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [9]
83. **Mycobiont:** *P. cystidiata*
Phytobiont: *Populus ciliata*
Root tip morphology: Dichotomous to coralloid
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [9]
84. **Mycobiont:** *P. dichotoma*
Phytobiont: *Populus ciliata*
Root tip morphology: Dichotomous
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [9]
85. **Mycobiont:** *P. epidermoida*
Phytobiont: *Populus ciliata*
Root tip morphology: Dichotomus
Distribution: Pakistan; KPK, Khaira gali
Literature: [26]
86. **Mycobiont:** *P. gigantica*
Phytobiont: *Populus ciliata*
Root tip morphology: Dichotomous to coralloid
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [9]
87. **Mycobiont:** *P. himalayensis*
Phytobiont: *Populus ciliata*
Root tip morphology: Dichotomus
Distribution: Pakistan; KPK, Khanspur
Literature: [26]
88. **Mycobiont:** *P. hyphaeata*
Phytobiont: *Populus ciliata*
Root tip morphology: simple irregular
Distribution: Pakistan; KPK, Nathia gali
Literature: [9]
89. **Mycobiont:** *P. lahorensis*
Phytobiont: *Populus euramericana, Salix babylonica*
Root tip morphology: Simple irregular
Distribution: Pakistan; Punjab, Lahore
Literature: [9, 10]
90. **Mycobiont:** *P. pakhtoonkhawansis*
Phytobiont: *Populus ciliata*
Root tip morphology: Dichotomous to coralloid
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [9]
91. **Mycobiont:** *P. triangularis*
Phytobiont: *Populus ciliata*
Root tip morphology: Dichotomous to coralloid
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [9]
92. **Mycobiont:** *Quercirrhiza summatriangularis*
Phytobiont: *Populus ciliata*

Root tip morphology: Simple to irregularly pinnate
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [9]

93. **Mycobiont:** *Q. tomentellocystidiata*
Phytobiont: *Populus euramericana*, *Salix babylonica*
Root tip morphology: Simple irregular to monopodial pyramidal
Distribution: Pakistan; Punjab, Lahore
Literature: [9, 10]
94. **Mycobiont:** *Salicirhiza gigantica*
Phytobiont: *Salix tetrasperma*
Root tip morphology: Dichotomous to coralloid
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [10]
95. **Mycobiont:** *S. khanspurensis*
Phytobiont: *Salix herbacea*
Root tip morphology: Simple irregular
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [10]
96. **Mycobiont:** *S. pakistanica*
Phytobiont: *Salix tetrasperma*
Root tip morphology: Simple irregular
Distribution: Pakistan; KPK, Khanspur-Ayubia
Literature: [10]

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Competing Interests
None declared.

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