FIELD SURVEY OF EUCALYPT MYCORRHIZAE IN PAKISTAN

by

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Summary. *A survey was conducted to investigate into mycorrhizae in eucalypts introduced in different environments in Pakistan. All the 57 species examined were found capable of forming ectotrophic mycorrhizae. General structure of mycorrhizae encountered is the same as described for eucalypts growing in Australia. Based on their characteristics, three types of mycorrhizae were identified, viz., white nodular, white pyramidal and brown pyramidal. Of these, the last named was the most prevalent and was described.*

Introduction. Mycorrhizae are a common feature in the genus *Eucalyptus* and the phenomenon is wide-spread in its native habitat in Australia (Chilvers and Pryor, 1965). Being fast growing exotics, eucalypts have successfully been grown all over the world but instances of failures have also been encountered. Pryor (1956) has suggested that failures in the mediterranean countries may be due to the absence of suitable symobiotic fungi. Working with Renantherae group of eucalypts, Pryor (1956) has shown that mycorrhizal association is perhaps obligatory for their healthy growth.

In Pakistan, more than 100 species of eucalypts have been introduced (Khan, 1955), most of which are under trial at three silvicultural research stations—Pakistan Forest Institute (Peshawar), Jallo (Lahore) and Miani (Hyderabad). Each station has a distinct climate and soil. In the present study 57 species growing in these stations were examined.

Review of Literature. Chilvers and Pryor (1965) made an exhaustive survey of 152 species of eucalypts growing within the Australian capital territory or adjacent New South Wales for mycorrhizae. All these species had mycorrhizae associated with them. Since these species included representatives from 40 out of 47 taxonomic series listed by Blakely, they concluded that all species of *Eucalyptus* are capable of forming mycorrhizae.

Besides, they investigated the intensity of this phenomenon and its relation to the type of habitat. They found that the intensity of infection varied greatly and those conditions which favoured the accumulation of organic matter in the surface layers of well-dra ined soil or litter above the surface, were most conductive to mycorrhizal formation. Cool moist conditions were another factor for prominent formation. Following Harley (1959), who described beech mycorrhiza, they recognized sixkinds of roots or root systems: uninfected roots, superficial mycorrhizae, diffuse and pyramidal infected system, nodular

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infections, apically infected roots and unbranched lateral infections caused by the fungus, *Cenococcum graniforme*.

The identification of fungal symbiont in ecto-mycorrhizae is still an unsolved problem (Chilvers 1968). Zak (1971) while characterizing Douglas fir mycorrhizae has given a systematic and orderly key based on micro and macroscopic features. Further he suggested that regadless of completeness of fungus identification, each distinct and described mycorrhizae should be named and thereby accorded identity. He used the following plan:

Tree binomial	+	Fungus binomial
Tree binomial	+	Arbitrary designation of isolates
Tree binomial	+	Mantle colour and series number.

In Pakistan, Shuja (1971) reported mycorrhizae on a species of *Eucalyptus* and Khalique and Beg (1976) found that chloride type of salinity adversely affected the development of mycorrhiza on potted plants of *Eucalyptus camaldulensis*.

Method. The three research stations were visited in May, 1976. Five roots were dug from the upper soil surface down-wards to a depth of 15 cm. from each of three individual trees of each species. While sampling particular care was taken to keep soil lumps undisturbed alongwith roots. This material was put in plastic bags, tagged, brought to the laboratory at the Insitute and stored in an inchubator at 5°C.

Zak's (1971) method of mycorrhizal characterization was applied in the laboratory and microscopic and macroscopic features were studied. Four chemical reagents, i.e. $H_2 SO_4$ (concen), KOH (15%), $FeSO_4$ (concen.) and $NH_4 OH$ (concen.) were used to study colour change of mycorrhiza. A summary of observations is given in Appendix I.

Results. Three distinct types of eucalypt mycorrhizae were identified: white nodular, white pyramidal and brown pyramidal. White nodular was isolated only from 3 years old, vigorously growing potted plants of *E. camaldulensis*. (Fig. 1) White pyramidal was also rare, occurring on a few species and that too in association with brown pyramidal, in much less intensity. Since brown pyramidal was the most common, it was studied in detail. The observations follow:

Description. Appearance under stereomicroscope: Mycorrhizae appear as an open pyramidal system containing upto 50 pieces and look pale translucent yellow under reflected light when young. Mature mycorrhizae are darker owing to accumulation of tannin deposits in the epidermal cells. Hyphal out-growths from the mantle are rare but smooth rhizomorphs are always present frequently growing along the surface of long roots and connecting with the mantle at the base of mycorrhizal branches. Some time a stringy growth of hyphae may surround the long roots.

Mantle structure: Mantle is 30-40 u thick and composed of large diameter (5-10 u) hyphae throughout most of its depth. Outer layers are formed of compact felt prosen-

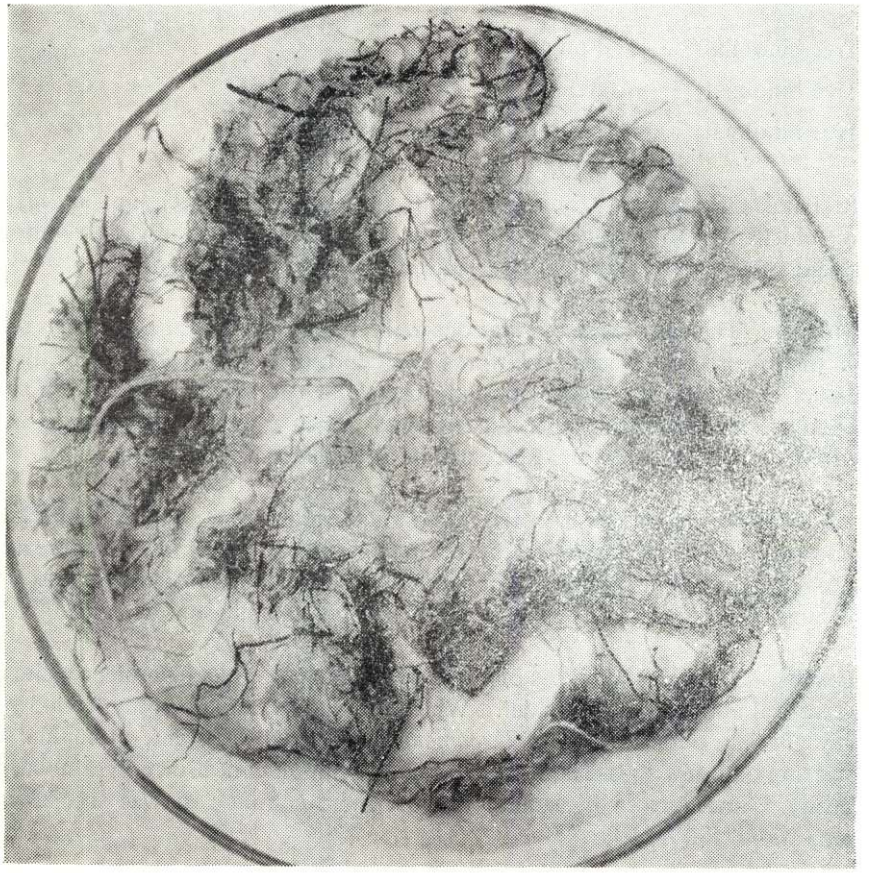

Fig. 1. Ecto-mycorrhizal nodules of E. camaldulensis.

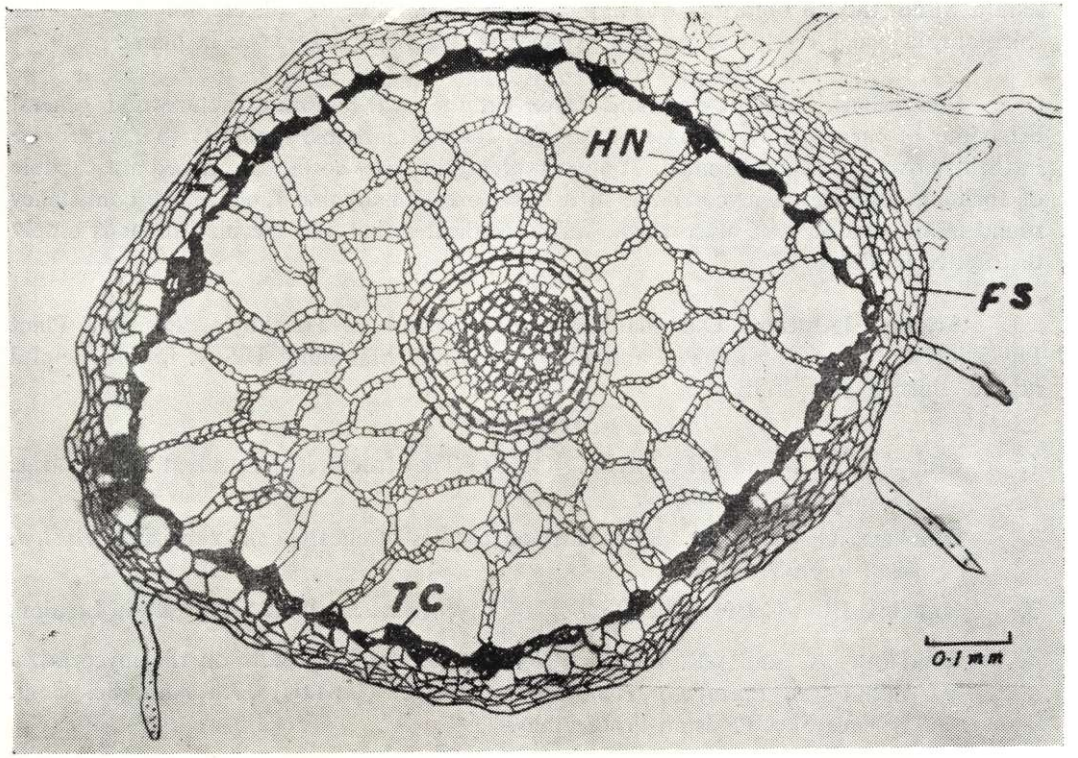

Fig. 2. Transverse section through fully differentiated region of mycorrhiza. FS, fungal sheath; HN, hartig net; TC, tannin cells.

chyma becoming irregular synchymatous with depth. Hyphal walls are thin, not exceeding 0.3 u but heavily ornamented with hard glassy spheres of secreted material 0.2-4 u in diameter. Hyphae are subdivided into short cells between 15 and 25 u long by septa containing prominent dolipores. Clamp connections appear to be absent.

Hartig net: It consists of thin hyphae, 3-4 u in diameter.

Rhizomorphs and external hyphae: Rhizomorphs range upto 120 u in diameter. Spherical globules are distributed all over the hyphal surfaces. There is no tissue differentiation within the rhizomorphs. Clamp connections are absent. There are also smaller rhizomorphs which consist of parallel hyphae ranging from 3.5—5.5 u in diamter.

Conclusions. The observations made on the distribution, structure and general behaviour of eucalypt mycorrhizae in Pakistan show remarkable similarity to mycorrhizae in their native Australian habitats. It appears that all species so far introduced are capable of forming ectotrophic mycorrhizae in association with suitable fungi. The consistency found in the anatomy of mycorrhizae further indicates that the specific fungus is amply distributed in all habitats.

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References

1. CHILVERS, G.A. and L.D. PRYOR. (1965) The structure of Eucalypt mycorrhizae. *Aust. J. Bot*, 13, 245-59.
2. CHILVERS, G.A. (1968) Some distinctive types of eucalypt mycorrhizae. *Aust. J. Bot.* 16, 49-70.
3. HARLEY, J.L. (1959) The Biology of Mycorrhizae. Leonard Hill Ltd., London.
4. KHALIQUE, A. and A.R. BEG. (1976) The effect of soil salts on the mycorrhizal nodules in *Eucalyptus camaldulensis* Dehn. (URDU) 17th Ann. Sc. Conf. Science Soc. Pakistan-Proceedings.
5. KHAN, M.I.R. (1955) The genus *Eucalyptus*, its past and future in West Pakistan. *Pakistan J.For.* 5(4): 202-215.
6. PENFOLD, A.R. and J.L. WILL, (1961) The Eucalyptus. Leonard Hill Ltd., London.
7. PRYOR, L.D. (1956) Chlorosis and lack of vigour in seedlings of Renantherous species of *Eucalyptus* caused by lack of mycorrhizae *Proc. Linn. Soc. N.S.W.* 81-91.
8. SHUJA, N. *et al.* (1971) Mycorrhizal associations in some angiosperm trees around New University Campus, Lahore. *Pakistan J.For.* 21(4): 367-73.
9. ZAK, B. (1971). Characterization and identification of Douglas Fir Mycorrhizae. Proc. Ist American Conf. on mycorrhizae Urbana, 1969. Miscellaneous Publication 1189. USDA. Forest Service, pp. 38-53.

Appendix I

SPECIES OF *EUCALYPTUS* EXAMINED AND CHARACTERS OF THEIR MYCORRHIZAE

Name of species	Locality[1]	Characters of mycorrhizae[2]						Chemical reagent colour reaction			
		Form	Individual element	Colour of mantle	Texture of mantle	Surrounding hyphae	Rhizomorphs	H_2SO_4 conc.	KOH 15%	$FeSO_4$ conc.	NH_4OH conc.
1	2	3	4	5	6	7	8	9	10	11	12
ochrophloia	PFI	S	Sn	YB	G	—	+	B	—	—	—
crebra	PFI	S	Sn	YB	G	—	+	B	LB	—	—
	Jallo	S	Sn	LGr	G	—	+	B	LB	—	—
grandis	PFI	S	Sn	W	G	—	+	W	—	LY	—
		S	Sn	Br	G	—	+	LBr	—	—	—
rudis	PFI	S	Sn	YB	G	—	+	GrY	—	—	—
	Jallo	S	Sn	W	G	—	+	YBr	—	—	—
		S	Sn	Br	G	—	+	LBr	B	—	—
	Miani	S	Sn	W	G	—	+	—	—	—	—
		S	Sn	Br	G	—	+	LBr	—	—	—
microtheca	PFI	S	Sn	LB	G	—	+	Y	—	—	—
	Jallo	S	Sn	LGr	G	—	+	—	Br	—	DBr
	Miani	S	Sn	LBr	G	—	+	PBr	—	—	—
citriodora	PFI	S	Sn	W	G	—	+	—	LY	LY	—
		S	Sn	Br	G	—	+	Or	—	—	—

1. PFI Pakistan Forest Institute Peshawar.
   Jallo Lahore.
   Miani Hyderabad

2. B Black -(ish)
   Br Brown -(ish)
   D Dark
   G Gray
   L Light
   P Pale
   Or Orange
   S Simple
   Sn Sinuous
   Y Yellow -(ish)
   W White
   + Present
   — None
   G Glabrous

1	2	3	4	5	6	7	8	9	10	11	12
	Jallo	S	Sn	LGr	G	—	+	—	DBr	—	DBr
	Miani	S	Sn	Br	G	—	+	LBr	PBr	—	—
melanophloia	PFI	S	Sn	W	G	—	+	—	—	—	—
	Miani	S	Sn	Br	G	—	+	Or	—	—	—
largiflorens	PFI	S	Sn	LBr	G	—	+	Or	—	—	—
	Miani	S	Sn	LBr	G	—	+	YBr	—	—	—
leucoxylon	PFI	S	Sn	W	G	—	+	—	—	—	—
		S	Sn	Br	G	—	+	LBr	—	—	—
redunca	PFI	S	Sn	Br	G	—	+	LBr	—	—	—
cladocalyx	PFI	S	Sn	LBr	G	—	+	—	—	—	—
	Jallo	S	Sn	Br	G	—	+	—	—	—	—
	Miani	S	Sn	LBr	G	—	+	—	—	—	—
amplifolia	PFI	S	Sn	Br	G	—	+	—	—	—	DBr
	Jallo	S	Sn	LBr	G	—	+	B	Br	Br	Br
woodwardi	PFI	S	Sn	Br	G	—	+	—	B	B	—
maculata	PFI	S	Sn	Br	G	—	+	DBr	—	—	—
mysore hybrid	PFI	S	Sn	Br	G	—	+	—	—	—	—
	Jallo	S	Sn	Br	G	—	+	Or	—	—	—
	Miani	S	Sn	LBr	G	—	+	—	—	—	—
blakelyi	PFI	S	Sn	Br	G	—	+	PBr	—	—	—
	Jallo	S	Sn	Br	G	—	+	Or	—	—	—
leptoflaba	PFI	S	Sn	YBr	G	—	+	—	DBr	—	—
	Miani	S	Sn	DBr	G	—	+	LBr	—	—	—
polycarpa	PFI	S	Sn	Br	G	—	+	—	DBr	—	—
fruticetorum	PFI	S	Sn	Br	G	—	+	Or	—	—	—
albens	PFI	S	Sn	Br	G	—	+	LBr	—	—	—
	Miani	S	Sn	W	G	—	+	—	—	—	—
		S	Sn	Br	G	—	+	LBr	—	—	—
saligna	PFI	S	Sn	YBr	G	—	+	—	DBr	Br	—
	Jallo	S	Sn	LBr	G	—	+	—	Br	DBr	—

1	2	3	4	5	6	7	8	9	10	11	12
kitsoniana	PFI	S	Sn	YBr	G	—	+	—	DBr	—	—
kondirinensis	PFI	S	Sn	LBr	G	—	+	—	—	—	DBr
botryoides	PFI	S	Sn	YBr	G	—	+	—	Br	Br	Br
	Miani	S	Sn	Br	G	—	+	LBr	—	—	Y
torelliana	PFI	S	Sn	LBr	G	—	+	YBr	Br	YBr	Br
sideroxylon	PFI	S	Sn	YBr	G	—	+	—	Br	—	—
argillacea	PFI	S	Sn	Br	G	—	+	Or	LBr	—	—
	Miani	S	Sn	W	G	—	+	—	LBr	LY	—
		S	Sn	Br	G	—	+	LBr	—	—	—
populnea	PFI	S	Sn	Br	G	—	+	LBr	—	—	—
salubris	PFI	S	Sn	LBr	G	—	+	Y	—	—	—
hemiphloia	PFI	S	Sn	YBr	G	—	+	—	LBr	—	—
	Jallo	S	Sn	W	G	—	+	—	—	—	—
		S	Sn	Br	G	—	+	—	B	—	—
tereticornis	PFI	S	Sn	DBr	G	—	+	Or	—	YBr	—
	Jallo	S	Sn	LBr	G	—	+	Or	DBr	Gr	—
campaspe	PFI	S	Sn	W	G	—	+	—	—	—	—
		S	Sn	LBr	G	—	+	PBr	Br	—	—
siderophloia	PFI	S	Sn	W	G	—	+	—	YBr	—	—
		S	Sn	LBr	G	—	+	—	—	Gr	DBr
	Miani	S	Sn	W	G	—	+	—	—	—	—
		S	Sn	Br	G	—	+	—	B	B	B
stricklandi	PFI	S	Sn	Br	G	—	+	YBr	B	—	—
occidentalis	PFI	S	Sn	PBr	G	—	+	—	Y	YBr	—
viminalis	PFI	S	Sn	LBr	G	—	+	—	DBr	DBr	—
camphora	PFI	S	Sn	LBr	G	—	+	—	—	—	—
largiflorens	PFI	S	Sn	Br	G	—	+	LBr	—	Or	—
oleosa	PFI	S	Sn	DBr	G	—	+	Y	—	—	—
bicostata	PFI	S	Sn	DBr	G	—	+	Gr	—	—	—
intermedia	PFI	S	Sn	LBr	G	—	+	Y	—	—	—

1	2	3	4	5	6	7	8	9	10	11	12
polyanthemos	PFI	S	Sn	Br	G	—	+	LBr	B	B	B
dealbata	PFI	S	Sn	Br	G	—	+	—	—	—	—
	Jallo	S	Sn	W	G	—	+	B	Br	PBr	LBr
		S	Sn	Br	G	—	+	B	DBr	Gr	B
microcorys	PFI	S	Sn	Br	G	—	+	—	DBr	DBr	DBr
gomphocephla	PFI	S	Sn	Br	G	—	+	LBr	DBr	DBr	DBr
robusta	PFI	S	Sn	Br	G	—	+	LBr	—	—	—
	Miani	S	Sn	Br	G	—	+	Or	—	—	—
pallidifolia	PFI	S	Sn	Br	G	—	+	LBr	DBr	DBr	DBr
lededopholia	Miani	S	Sn	W	G	—	+	Gr	PY	—	—
torquata	Miani	S	Sn	Br	G	—	+	LBr	—	—	—
camaldulensis	PFI	S	Sn	Br	G	—	+	—	—	—	—
		Nodular	Sn	W	G	—	+	B	—	—	—
	Jallo	S	Sn	Br	G	—	+	—	DBr	—	—
	Miani	S	Sn	LBr	G	—	+	—	Br	Br	Br
pellita	Miani	S	Sn	W	G	—	+	—	—	—	—
		S	Sn	Br	G	—	+	Or	DBr	DBr	—
microcarpa	Miani	S	Sn	Br	G	—	+	LBr	Or	—	—
alba	Miani	S	Sn	LBr	G	—	+	—	—	—	DBr
nubilis	Miani	S	Sn	GrB	G	—	+	LGr	Br	—	B
paniculata	Jallo	S	Sn	Br	G	—	+	—	B	—	—
	PFI	S	Sn	LBr	G	—	+	Y	—	B	—
astringens	Miani	S	Sn	Br	G	—	+	LBr	—	—	—
ochrophloia	Miani	S	Sn	Br	G	—	+	LBr	—	—	—