Mycorrhiza (1993) 3:123-136

Mycorrhiza

Distribution of vesicular-arbuscular mycorrhizae in the plants and rhizosphere soils of the tropical plains, Tamil Nadu, India

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Abstract. We examined 737 plant species from 121 families of angiosperms and four species of pteridophytes for mycorrhizal association. Only 372 species showed infection. Mycorrhizal colonization was recorded in 49% of the total flora. The quantum of colonization ranged from 10% to 90%. In all, 35 species exhibited mycorrhizal colonization higher than 75%. Of the four pteridophytes, *Isoetes coromandelina* showed mycorrhizal colonization by *Entrophospora schenckii* and *Glomus aggregatum* in its rhizosphere. For the first time in India, 102 of these species were reported to be mycorrhizal. *Glomus fasciculatum* (13.8%) and *G. aggregatum* (11%) were prevalent in the rhizosphere soils. *Acaulospora foveata* (0.2%), *A. longula* (0.5%) and *Glomus hoi* (0.9%) were the least represented as mycorrhizal spores. A total of 40 vesicular-arbuscular mycorrhizal fungal species belonging to *Acaulospora*, *Entrophospora*, *Gigaspora*, *Glomus*, *Sclerocystis* and *Scutellospora* were isolated from the rhizosphere soils of different ecosystems.

Key words: Soil type - Profile - Tropical plains - Rhizosphere - Vesicular-arbuscular mycorrhizal fungi - Root colonization

Introduction

The tropical forests of India have received almost no attention from mycorrhizologists, although of all microorganisms mycorrhizae in tropical forests must profoundly influence soil fertility and thus the growth and development of plants (Mahadevan et al. 1989). According to Shamsuddin (1979), 99 of 200 species of Malaysian forest trees screened had mycorrhizal associations. De Alwis and Abeynayake (1980) reported endotrophic mycorrhizae in 53 out of 63 tree species examined. The occurrence of mycorrhizal fungi in the tropical forest trees of Tamil Nadu was reported by Mohankumar and Mahadevan (1987). They found mycorrhizal associations in 131 out of 178 species. In Point Calimere reserve forest (Thanjavur district), Kannan and Lakshminarasimhan (1989) reported that 48 plant species belonging to 38 families differed in their mycorrhizal associations. They were classified following Thapar and Khan (1973) into nonmycorrhizal (18 species), occasional mycorrhizal (5 species) and consistently mycorrhizal (25 species).

Research on floristics and endomycorrhizal occurrence in natural ecosystems is especially limited in the coastal regions of tropical countries (Mahadevan et al. 1989). Investigations of this type are not only of great botanical interest but are also of importance in social forestry and land reclamation (Ragupathy and Mahadevan 1991). We made a detailed floristic and endomycorrhizal survey in Thanjavur district, Tamil Nadu, India.

Materials and methods

Study site

Thanjavur district, with a vast expanse of rice fields and fruit orchards, is a coastal district of Tamil Nadu lying 185 m above mean sea level between 9°50′ and 11°50′ N latitude and 78°45′ and 79°50′ E longitude. It includes an area of 8280 km^2 and is bounded to the north by South Arcot and Tiruchirapalli districts; the latter also forms the western border. It is flanked to the south by Pudukkottai district and the Palk strait, and to the east by the Bay of Bengal. The coastal stretch extends about 216 km (Fig. 1). The district is divided into three distinct areas, the deltaic region, the upland area or nondeltaic region, and the salt swamp.

Sampling

For each species, the feeder roots were collected by digging and given the number of the herbarium specimen. Root samples were collected from seedlings of all the tree species. When seedlings were not available, the root samples were collected directly from the tree itself after tracing the root up to the base of the trunk. Roots were fixed in formaldehyde/acetic acid (Johansen 1940).

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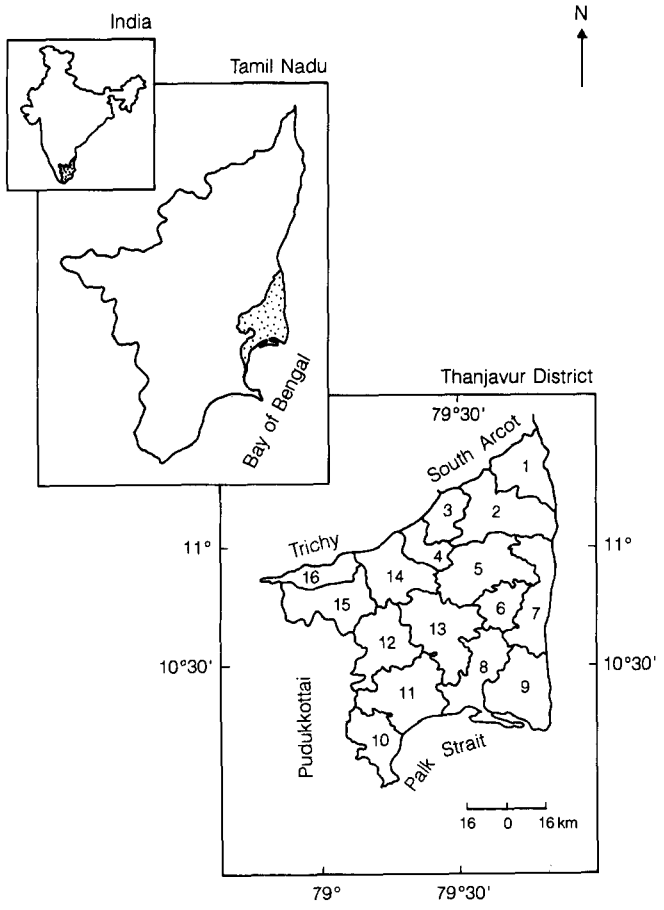

Fig. 1. Location of the study area. *1*, Sirkazhi; *2*, Mailaduthurai; *3*, Tiruvidaimarudur; *4*, Kumbakonam; *5*, Nannilam; *6*, Tiruvarur; *7*, Nagapattinam; *8*, Thiruturaipoondi; *9*, Vedharanyam; *10*, Pearavurani; *11*, Pattukottai; *12*, Orathanadu; *13*, Mannargudi; *14*, Papanasam; *15*, Thanjavur; *16*, Thiruvaiyaru

Soil collection

Soil samples of about 500 g were collected from the root region by digging to a depth of 10 cm with a trowel. For aquatic plants, sediments were collected into polythene bags, labelled and stored at 4° C until analysis.

Assessment of vesicular arbuscular mycorrhizal structure in roots

The quantum of vesicular-arbuscular mycorrhizal (VAM) association in each specimen was examined in the roots (Phillips and Hayman 1970) and calculated as

$$\text{Percent mycorrhizal association} = \frac{\text{No. of mycorrhizal-associated segments}}{\text{Total no. of segments scored}} \times 100$$

For nonpigmented roots

For each specimen, 100 feeder root pieces were thoroughly washed in tap water and boiled at 90° C for 1 h in 10% KOH. The segments were washed in distilled water, acidified by immersing for 5 min in 5 N HCl, and stained in 0.05% trypan blue or cotton blue in lactophenol; the excess stain was removed in clear lactophenol. Root segments were mounted temporarily on slides in acetic acid : glycerol (1 : 1 v/v) and the edges of the cover slips were sealed with DPX mountant.

For pigmented roots

Root segments were suspended in 10% KOH, heated to 90° C, boiled for 2 to 3 h and washed in alkali. To decolorise the pigments, the segments were immersed in an alkaline solution of hydrogen peroxide until bleached. They were rinsed thoroughly in distilled water, acidified in 5 N HCl, stained and mounted on slides.

Collection of mycorrhizal spores from soil samples

Mycorrhizal spores were obtained by wet sieving after an initial 710-μm sieve and decanting from 100-g soil samples (Gerdemann and Nicolson 1963). Spores were collected in specimen tubes from the 250-, 150-, 106-, 75-, and 45-μm sieves but not from the 710-μm sieve. They were identified according to Schenck and Pere'z (1987) and Raman and Mohankumar (1988).

Results

Mycorrhizal association

A variety of vegetation and soil types exist in Thanjavur district. Depending upon the vegetation cover, moisture, salinity, colour and nature of the soil, nine distinct soil types are recognized: sandy, red, cultivated, wet, grassland, forest, mangrove, brackish and aquatic sediments (Nair et al. 1980). The distribution of VAM fungi in these soils is not abundant but provides a general idea of the occurrence of VAM fungi.

Of the six genera from the families of Acaulosporaceae, Gigasporaceae and Glomaceae including 136 species, 40 species were isolated from rhizosphere soils of plants growing in Thanjavur district (Table 1). The data on the occurrence of dominant VAM fungi for each species are presented in Table 2.

There was little variation in spore distribution and number between coastal sandy soil and river sandy soil. The principal VAM species in both soils were *Gigaspora albida* and *G. gigantea, Glomus aggregatum*, *G. ambisporum*, *G. fasciculatum* and *G. heterosporum*, *Scutellospora heterogama* and *S. nigra*, and *Sclerocystis pachycaulis.*

Cultivated soils. Much of the land area in the district is cultivated for rice (*Oryza sativa*) and sugar cane (*Saccharum officinarum*). The major species of VAM fungi in these soils were *Gigaspora albida* and *G. aggregatum*, *Glomus ambisporum*, *G. intraradices*, *G. fasciculatum*, *G. occulatum*, *G. microaggregatum* and *G. reticulatum*, among which *G. intraradices* was more frequent than other VAM species.

Table 1. Synoptic key characters of vesicular-arbuscular mycorrhizal species. H, Hyaline to white; Y, yellow brown to red brown to brown; Br, dark brown to black; U, usual color; O, occasional color

Species	Spore color			Spore or sporocarp size (μm)[a]	Wall no.	Wall thickness (μm)
	H	Y	Br	Suspensor diameter (μm)		
Acaulospora Gerd. & Trappe emend. Berch						
A. foveata Trappe & Jonos	U	O		—	185–310 (–410) × 215–350 (–480)	3	14–18
A. longula Spain & Schenck		O			(50–) 65–90 (–100)	5	2.5–5
Entrophospora Ames & Schneider							
E. colombiana Spain & Schenck		O	O	—	100–125	5	5–7
E. schenckii Sieverding & Toro	U	O		—	35–50 (60) 48–90 × 26–63	3	1.5–2.5
Gigaspora Gerd. & Trappe							
G. albida Schenck & Smith	O	U		35–50	150–300, 200 × 330, 225 × 252	1–5	4–15
G. gigantea (Nicol. & Gerd.) Gerd. & Trappe		U		40	170–450 × 200–500	2	4.5–6
Glomus Tul. & Tul.							
G. aggregatum Schenck & Smith emend. Koske	U	O		—	35–50 (–85) 100, 45–110, 42–80	1–2	2–6
G. albidum Walker & Rhodes	O			—	85–105	2	1–4
G. ambisporum Schenck & Smith		U	O	—	50 × 100	2–3	6–9
G. citricola Tang & Zang		O		—	80–90 (–100)	2	4–10
G. claroideum Schenck & Smith		U		—	60–95	1–2	(4.5) 7.5
G. clarum Nicol. & Schenck	O	U		—	68–120	2–5	5–25
G. deserticola Trappe et al.		O	U	—	54–115 × 30–120	1	3–17
G. etunicatum Becker & Gerd.		O		—	60–125	2	4–10
G. fasciculatum (Thaxter) Gerd. & Trappe emend. Walker & Koske	U	O		—	35–60 (105) 45–120	1–2	3–17
G. geosporum (Nicol. & Gerd.) Walker		U	O	—	100–250 × 50–185	3	5–18
G. heterosporum Smith & Schenck (formed singly in soil)		O	U	—	80–200 × 50–187	3	4–8
(clustered)			O	—	50–80 (–100)–(155)	2	3–6
G. hoi Berch & Trappe		U		—	50–170	2	5–7
G. intraradices Schenck & Smith		U		—	40 (50–90) 125	1–4	3–15
G. maculosum Miller & Walker	O	U		—	130–150	3	4–15
G. manihotis Howeler et al.	O	U		—	150–200 (234)	2	7–10 (30)
G. microaggregatum Koske et al.		U		—	15–17	1–2	< 1.2
G. microcarpum Tul. & Tul.		U	O	—	30–45 (–56)	1	4–10
G. monosporum Gerd. & Trappe		U		—	125–300	2	4–10
G. mosseae (Nicol. & Gerd.) Gerd. & Trappe		U		—	100–275	2	2–7
G. multicaule Gerd. & Bakshi		U		—	125 × 100	3	5–18
G. occultum Walker	U			—	25–100	1–2	2–3
G. pubescens Trappe & Gerd.	U			—	15–20	1	3
G. pulvinatum (Henn.) Trappe & Gerd.					52–100 × 55–90	1	2
G. pustulatum Koske et al.		U		—	100	2	—
G. reticulatum Bhatta. & Mukerji			U	—	100–150	2	10–12
G. segmentatum Trappe et al.	U			—	50–100 × 46–90	2	4–8
G. tenebrosum (Thaxter) Berch		U		—	200 (–250) × 205	1	10–15
Scutellospora Walker & Sanders							
S. fulgida Koske & Walker	U	O		20–45	150–200 × 150–200	3	7–9
S. gilmorei (Trappe & Gerd.) Walker & Sanders	U			27–35	200–300	6	15–18
S. heterogama (Nicol. & Gerd.) Walker & Sanders			U	20–40	159–250	4	6.5–10
S. nigra (Radhead) Walker & Sanders			U	40–60 × 80–100	297–500	2	7–10
S. pellucida (Nicol. & Schenck) Walker & Sanders	U			10–30	58–183 (–200)	6	6–18
Sclerocystis Gerd. & Trappe							
S. microcarpus Iqbal & Bushra		U		100–400	90–115 × 35–60	1	3.5–10–18
S. rubiformis Gerd. & Trappe		U		150 × 150	30–100 × 22–80	2	3.8–7

[a] The values in parentheses indicate the maximum size of the spores

Red soil. A few hillocks in northwest and west Thanjavur have red soil with the dominant VAM species *Glomus deserticola*, *G. geosporum*, *G. mosseae* and *G. microcarpum*, *Sclerocystis microcarpus* and *S. pakistanica; G. mosseae* was recorded particularly frequently.

Aquatic sediments. As floating plants also exhibited VAM infection, the aquatic sediments were collected and examined for VAM fungi. The common VAM fungi in the sediments were *Entrophospora colombiana*, *Glomus aggregatum*, *G. microaggregatum* and *G. pubescens*.

Wet soil. Wet land hydrophytes are attached to the soil, usually in association with water, at least in the early part of their life. The common VAM fungi in these ar-

Table 2. Plant species screened for mycorrhizal associations

Plants[a]	Infection (%)	VAM species[b]
Annonaceae		
Annona squamosa L.	40	LAGR, LCLR
Polyalthia suberosa (Roxb.) Thw.	58	LABD, LRTC
P. longifolia (Sonner.) Thw.	23	LPBS, GABD
Menispermaceae		
Cissampelos pareira L. Var. *hirsuta*	—	—
Cocculus hirsutus (L.) Diels	53	GGGT, LAGR, LCTC
Pachygone ovata (Poir.) Miers ex Hook f.	63	GABD, LCTC, LPVN
Tinospora cordifolia (Willd.) Miers ex Hook. f. & Thoms.	40	ESHK, LABS, LMCC, LPBS
Nelumbonaceae		
Nelumbo nucifera Gaertn.	—	—
Nymphaea pubescens Willd.	—	—
Papaveraceae		
Argemone mexicana L.[c]	67	LABS, LHOI, LINR, LRTC
Cruciferae		
Brassica juncea (L.) Czern. & Coss.	—	LABS
Capparaceae		
Cadaba fruticosa (L.) Druce.	—	LGSP, LINR
C. trifoliata (Roxb.) Wight & Arn.[c]	38	LCTC, LHTS
Capparis brevispina DC.	—	—
C. rotundifolia Rottl.[c]	63	GABD, LHTS
C. sepiaria L.	—	LABD, LMNS
C. zeylanica L.	58	LAGR, SPCC
Crateva adansonii DC.	38	LCTC, LDST, LETC, LHOI
Maerua oblongifolia (Forsk.) A. Rich.[c]	62	LPST, LRTC, LTNB
Cleomaceae		
Cleome angustifolia Forsk.	68	LAGR, LABS, LFTC, SPCC
C. aspera Koen. ex. DC.	—	LABS, LCTC, LHOI
C. chelidonii L. f.[c]	40	LCLR, LOCT
C. gynandra L.	—	LHTS
C. monophylla L.	—	LINR, LMCC
C. viscosa L.	—	LMNS, LPST
Violaceae		
Hybanthus enneaspermus (L.) F. v. Muell	30	LDST
Flacourtiaceae		
Casearia elliptica Willd.[c]	23	LTNB, SPCC
C. esculenta Roxb.[c]	35	SPCC, CFLG
Polygalaceae		
Polygala arvensis Willd.[c]	53	LAGR, LINR
P. chinensis L.	82	LAGR, LINR
P. rosmarinifolia W. & A.	63	GABD, CGLM
Caryophyllaceae		
Polycarpaea corymbosa (L.) Lam.	43	LCLD, SRBF
var. *corymbosa*	55	LGSP, CPLC
var. *longipetala*		
Polycarpan prostratum (Forsk) Asch. & Schweinf.	—	—
Portulacaceae		
Portulaca oleracea L.	38	LFSC, LINR, SPCC
P. quadrifida L.	—	—
P. pilosa L.	—	LINR
Talinum portulacifolium (Forsk.) A. & S.	—	—
Tamaricaceae		
Tamarix indica Willd.	—	—
Elatinaceae		
Bergia ammanioides Roxb.	—	—
B. capensis L.	—	LOCT
Clusiaceae		
Calophyllum inophyllum L.	29	SPCC, CGLM
Garcinia spicata (W. &. A.) Hook. f.	20	SPCC, CGLM
Malvaceae		
Abutilon indicum L.	45	LCLR
Gossypium hirsutum L.	83	LINR
Hibiscus ovalifolius (Forsk.) Vahl	35	—
H. surattensis L.[c]	72	LAGR, CGLM
H. tiliaceus L.	—	—
H. vitifolius L.	54	—
Malvastrum coromandelianum (L.) Garcke	—	—
Pavonia zeylanica (L.) Cav.	—	LCTC, LABD
Sida acuta Burm. f.	—	—
S. cordata (Burm. f.) Borssum	62	LCLD
S. cordifolia L.	28	LCLD, LINR
S. schimperiana Hochst	—	LMRC
Thespesia populnea (L.) Soland ex Correa	—	LGSP, LMRC, LPST
Urena lobata L.	—	LPBS, LTNB
Sterculiaceae		
Guazuma ulmifolia Lam.	—	—
Melochia corchorifolia L.	13	LETC
Pentapetes phoenicea L.	—	—
Pterospermum canescens Roxb.[c]	63	LDST, LFSC, CGRG
Waltheria indica L.	—	LAGR, SMRC
Corchorus olitorius L.	32	LINR
C. urticifolius W. & A.	50	LPUN, SRBF
Grewia rhamnifolia Heyne ex Roth	—	—
Triumfetta pentandra A. Rich.	—	—
T. rotundifolia Lam.[c]	23	LMAG, LMSS
Linaceae		
Hugonia mystax L.	73	GABD, LAGR, LFSC, CHTG
Zygophyllaceae		
Tribulus terrestris L.	51	LPVN
Oxalidaceae		
Biophytum sensitivum (L.) DC.	—	LINR
Balsaminaceae		
Hydrocera triflora (L.) W. & A.	—	LOCT
Rutaceae		
Aegle marmelos (L.) Correa	—	LABS
Atlantia monophylla (L.) Correa	—	LABS, LFSC
Clausena dentata (Willd.) M. Roem.[c]	80	LABS, LCTC, LFSC
Glycosmis mauritiana (Lam.) Tanaka	60	LABS, LFSC, LCTC
Limonia acidissima L.	58	GABD

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
Pleiospermium alatum (Wall. ex W. & A.) Swingle	—	LCTC
Toddalia asiatica (L.) Lam.	73	LAGR, LFSC, LCTC
Murraya koenigii (L.) Spreng.	—	—
M. paniculata (L.) Jac.	15	LABS, LCTC
Ochnaceae		
Ochna obtusata DC. var. obtusata[c]	38	GABD, LTNB
var. *gamblei*	42	LETC, CARG
Burseraceae		
Commiphora caudata (W. & A.) Engl.	53	LAGR, LDST
Meliaceae		
Aglaia elaeagnoidea (Juss.) Benth.	—	—
Azadirachta indica A. Juss.	23	LMCC, LPST, SRBF
Walsura trifoliata (A. Juss.) Harms[c]	38	LAGR, LFSC
Flindersiaceae		
Chloroxylon swietenia DC.[c]	64	LHOI, LMSS, CPLC
Olacaceae		
Olax scandens Roxb.[c]	12	—
Opiliaceae		
Cansjera rheedii Gmel.[c]	—	LFSC, SPCC
Icacinaceae		
Pyrenacantha volubilis Wight[c]	37	LTNB
Celastraceae		
Cassine glauca (Rottb.) Kuntze	30	GGGT, CNGR
Maytenus emarginata (Willd.) Ding Hou	—	LAGR, LFSC, LHTS
Pleurostylia opposita (Wall.) Alston	43	GABD, LDST
Salacia chinensis L.	—	—
Rhamnaceae		
Colubrina asiatica (L.) Brongn.	—	LFSC, LHTS
Scutia myrtina (Burm. f.) Kurz	—	LINR
Ziziphus mauritiana Lam.	30	LMNS, SPCC
Z. oenoplia (L.) Mill.	42	LABD
Vitaceae		
Cayratia pedata (Lam.) Juss. ex Gagnep.	—	LMNS
Cissus quadrangularis L.	73	LAGR, LINR
C. vitiginea L.	20	LPST, LFLG
Cyphostemma setosum (Roxb.) Alston	—	—
Sapindaceae		
Allophylus serratus (Roxb.) Kurz	12	LRTC
Cardiospermum canescens Wall.	—	—
C. halicacabum L.	—	LETC, LFSC
Dodonaea angustifolia L. f.	80	LAGR, LFSC, CHTG
Lepisanthes tetraphylla (Vahl) Radlk[c]	20	CNGR, SPKS
Sapindus emarginatus Vahl	—	—
Anacaridaceae		
Lannea coromandelica (Houtt.) Merr.	23	LGSP
Anacardium occidentale L.	—	—
Mangifera indica L.	93	LFSC

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
Papilionaceae		
Abrus precatorius L.	23	LAGR, LINR
Aeschynomene aspera L.	—	ESHK, LCLR
A. indica L.	20	LCLR, LCRD
Alysicarpus monilifer (L.) DC.	80	LMSS, LPST
A. rugosus (Willd.) DC.	—	—
A. vaginalis (L.) DC.	61	LAGR, LFSC, GABD
Arachis hypogaea L.	90	LAGR, LFSC, LINR
Atylosia scarabaeoides (L.) Benth.[c]	45	LMSS, SPKS
Butea monosperma (Lam.) Taub.	31	LAGR, LFSC
Cajanus cajan (L.) Mill.	53	LFSC, LMSS
Canavalia lineata DC.[c]	73	LAGR, GGGT, CHTG
C. virosa (Roxb.) W & A.[c]	50	KINR
Clitoria ternatea L.	15	—
Crotalaria angulata Mill.[c]	80	LMRC, LPVN
C. juncea L.	—	LFSC, LINR
C. laburnifolia L.	43	LMNS, LRTC
C. linifolia L. f.[c]	90	LMSS, LSGT
C. nana Burm. f.	—	ESHK, LCLR, LCRD
C. pallida Dryand.	60	LAGR, CFLG, CHTG
C. paniculata Willd.[c]	30	LABS, SPKS, SRBF
C. quinquefolia L.	43	ECLB, LCLR
C. retusa L.[c]	56	LHTS, CGLM, CPLC, SPKS
C. verrucosa L.	24	LAGR, LINR
Cyamopsis tetragonoloba (L.) Taub.	—	LCLR, LINR
Dalbergia lanceolaria L.	—	LETC, SMRC
D. sissoo Roxb.	92	LFSC
Derris scandens (Roxb.) Benth.	—	ECLB, LMRC
D. trifoliata Lour.	—	—
Desmodium biarticulatum (L.) F. V. Muell.[c]	80	LAGR, LFSC, SPKS
D. dichotomum (Willd.) DC.	—	LINR
D. gangeticum (L.) DC.	—	LPBS, CPLC
D. tortuosum (Sw.) DC.[c]	23	LMAG, GABD
D. triflorum (L.) DC.	60	CGLM, CFLG, CHTG, SPKS
Eleiotis sororia DC.[c]	48	LINR, LMSS
Erythrina variegata L.	—	CHTG
Galactia tenuiflora W. & A.	67	LGSP, LSGT
Gliricidia sepium (Jacq.) Kunth ex Walp.	28	LAGR, LINR
Indigofera aspalathoides Vahl ex DC.	80	LAGR, LFSC, SPCC
I. glabra L.	—	LMCL, LPBS
I. hirsuta L.[c]	36	LHOI, CPLC
I. linnaei Ali	—	GABD, LABS
I. trita L. f.	—	LMNH, CPLC
I. vicioides Jaub. & Spach.[c]	57	LHTS
Lablab purpureus (L.) Sweet	41	LFSC
Mucuna pruriens (L.) DC.	43	LAGR, LHTS, CGLM, SPCC
Pongamia pinnata (L.) Pierre	—	LAGR, SPCC
Pseudarthria viscida (L.) W. & A.	—	CPLC
Pycnospora lutescens (Poir.) Schind.	65	LMSS, LSGT, SRBF
Rhynchosia minima (L.) DC.	—	—

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
R. viscosa (Roth.) DC.	—	LHTS, LMSS
Rothia indica (L.) Druce	—	LCLR, LCRD
Sesbania sesban (L.) Merr.	—	LPSI, LMCL
Stylosanthes fruticosa (Retz.) Alston	30	CNGR
Tephrosia purpurea (L.) Pers.	20	LAGR, LFSC, GABD
T. villosa (L.) Pers.	50	ALGL, LCLR
Vitna unguiculata (L.) Walp.		
sub. *unguiculata*	58	GABD, LMSS
sub. *cylindrica* (L.) Eselt.	60	LHTS, SPCC
V. radiata (L.) Wilczek	30	LABS, LCLR
V. mungo (L.) Hepper	—	LCTC, LFSC
Zornia diphylla (L.) Pers.	40	LAGR, LFSC
Z. gibbosa Span.	—	LCLR, LMSS
Caesalpiniaceae		
Bauhinia racemosa Lam.[c]	70	LHTS, CFLG, SPCC
B. tomentosa L.	—	—
B. variegata L.	—	—
C. coriaria (Jacq.) Willd.[c]	47	LMNH, CHTG
Caesalpinia bonduc (L.) Roxb.	—	LFSC, CFLG, CGLM
Cassia alata L.	—	LMCL, LPBS
C. auriculata L.	34	LAGR, LCLR, LHTS
C. fistula L.	70	GGGT, LDST
C. italica (Mill.) Lam. ex Andr.[c]	88	LMSS, LPVN
C. occidentalis L.	63	LFSC, LHTS
C. pumila Lam.	—	LCLR, LCRD
C. roxburghii DC.	40	GABD, LFSC
C. siamea Lam.	50	LINR, LMCL
C. tora L.	—	LETC
Parkinsonia aculeata L.[c]	40	—
Tamarindus indica L.	34	LAGR
Mimosaceae		
Acacia auriculiformis A. Cunn. ex Benth.	—	GABD
Acacia caesia (L.) Willd.[c]	23	LMSS
A. leucophloea (Roxb.) Willd.	50	—
A. minutifolia Ragu. et al.[c]	86	LAGR, LMRC
A. nilotica (L.) Willd.	58	LCTC, LFSC
A. polycantha Willd.	43	LFSC, LHTS
A. tanjorenis Ragu. et al.[c]	78	GGGT, LCLR
Albizia amra (Roxb.) Boivin.	60	GGGT
A. lebbeck (L.) Willd.	80	LAGR, SPCC
A. odoratissima (L.f.) Benth.	—	LINR, LPBS
Desmanthus virgatus Willd.[c]	75	LABS, LINR
Dichrostachys cinerea (L.) W. & A.	48	LAGR, LCLR
Leucaena latisiliqua (L.) Gillis	38	LMRC, SPCC, LSGT
Mimosa pudica L.	80	LABS, LPST
Neptunia oleracea Lour.	—	LCLR
Pithecellobium dulce (Roxb.) Benth.	—	LCTC, SRBF
Prosopis chilensis (Molina) Stuntz.	60	LABS, LFSC, LHTS
P. cineraria (L.) Druce	23	GABD, LPBS
Vahliaceae		
Bistella dichotoma (Murr.) Bullock	20	GGGT, CHTG
B. digyna Retz.	—	LCLR
Droseraceae		
Drosera indica L.[c]	52	GABD, LFSC

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
Rhizophoraceae		
Ceriops tagal (Perr.) Robins.	—	—
Rhizophora apiculata Blume	—	—
Combretaceae		
Combretum albidum G. Don[c]	38	LMSS, LPST
Lumnitzera racemosa Willd.	—	—
Quisqualis indica L.	30	SPCC
Terminalia crenulata Roth	52	LCTC, CGRG
T. catappa L.	13	LABS
Myrtaceae		
Eucalyptus longifolia Link & Otto	65	LFSC, CFLG, SRBF
Psidium guajava L.	43	LFSC, SPCC
Syzygium cumini (L.) Skeels	—	LAGR, LFSC, GABD
Barringtoniaceae		
Barringtonia acutangula (L.) Gaertn.	—	—
Melastomataceae		
Memecylon edule Roxb.	—	GABD, LAGR, LFSC, SPKS, SPCC
Lythraceae		
Ammania baccifera L.	18	LCLR, LPBS
A. octandra L.f.	—	LCRD
Lawsonia inermis L.	10	GGGT
Nesaea brevipes Koehne	23	ECLB, LCRD
N. lanceolata (Heyne ex Clarke) Koehne	18	ECLB, LCLR, LCRD
Rotala rossa (Poiret.) C. Cook	—	ESHIC, LCLR
R. verticillaris L.	—	ESHK, LCLR
Onagraceae		
Ludwigia adscendens (L.) Hara	38	ECLB, LCLR
L. hyssopifolia (G. Don) Exell	—	LINR
L. perennis L.	23	ECLB, LCTC
Turnera ulmifolia L.	45	LHTS
Passifloraceae		
Passiflora foetida L.	20	LPVN, LTNB
Caricaceae		
Carica papaya L.	58	LFSC, SPCC
Cucurbitaceae		
Benincasa hispida (Thunb.) Cogn.	28	LFSC
Citrullus colocynthis (L.) Schrader	61	LABS, SPCC
C. lanatus (Thunb.) Matsum. & Nakai	46	GABD, LAGR
Coccinia grandis (L.) Voigt	15	—
Ctenolepsis garcinii (Burm. f.) Clarke	86	LFSC, CHTG, SPCC
Cucumis melo L.	37	LINR, GABD
Cucurbita maxima Duch. ex Lam.	—	—
Diplocyclos palmatus (L.) Jaffrey	—	—
Kedrostis foetidissima (Jacq.) Cogn.	25	LMSS
Lagenaria siceraria (Molina) Standl.	15	LINR
Luffa cylindrica (L.) Roem.	51	LFSC
Momordia charantia L.	—	—
M. dioica Roxb. ex Willd.[c]	—	LETC, LFSC
Mukia maderaspatana (L.) M. Xoem.	13	ALGL
Trichosanthes cucumerina L.[c]	72	GGGT, LFSC, CHTG
T. tricuspidata Lour.	28	GABD, CHTG

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
Cactaceae		
Opuntia dillenii (ker Gawl.) Haw.	67	GABD, LPST
Aizoaceae		
Sesuvium portulacastrum (L.) L.	—	—
Trianthema triquetra Rottl. ex Willd.	—	—
Zaleya decandra (L.) Burm. f.	38	LCTC, LETC
Molluginaceae		
Gisekia pharnaceoides L.[c]	57	LAGR, LFSC, SPCC
Glinus lotoides L.	27	LMCL, LOCT
G. oppositifolius (L.) DC.	—	LINR
Mollugo cerviana (L.) Ser.	25	GABD, LHTS, CFLG
M. nudicaulis Lam.	20	LETC, LINR
M. pentaphylla L.	15	LMNS, LPST
Umbelliferae		
Centella asiatica (L.) Urban	70	LFSC, LMSS
Alangiaceae		
Alangium salviifolium (L. f.) Wang.	14	LMSS
Rubiaceae		
Benkara malabarica (L.) Trivn.	38	LFSC, LMCC, SPCC, CNGR
Canthium dicoccum (Gaertn.) Teijsm & Binn.	30	LAGR, LHTS
var, *dicoccum*	43	LFSC, GABD
var. *umbellata*		
C. parviflorum Lam.	47	LGSP, LMCC
Catunaregam spinosa (Thunb.) Tirven.	38	LRTC, CHTG
Dentella repens (L.) Forst.	60	LAGR, LOCT
D. serpyllifolia Wall. ex Airy-Shaw[c]	60	LAGR, LOCT
Hedyotis aspera Heyne ex Roth	—	LHOI, LPBS
H. brachiata W. & A	—	GABD, LINR
H. corymbosa (L.) Lam.	12	LSGT
H. graminifolia L. f.	—	LRTC, LMCC
H. herbacea L.	—	LCLR, LCRD
H. puberula (G. Don.) Arn.	30	LOCT, LPST
H. trinervia (Retz.) Roem. & Schult.	—	LMNS, LPBS
Ixora pavetta Andr	51	LABS, LPST
Knoxia sumatrensis (Retz.) DC.	—	LMRC, SPKS
Mitragyna parvifolia (Roxb.) Korth.	24	ALGL, LRTC
Morinda pubescens Smith	60	LABD, LCTC, LFSC
Pavetta indica L.	—	LFSC
Spermacoce articularis L. f.	62	LAGR, LFSC
S. hispida L.	40	LAGR, LFSC, SPCC
Tarenna asiatica (L.) Kuntze	71	LMSS, SRBF
Thecagonum biflorum (L.) Babu	—	LINR
Asteraceae		
Acanthospermum hispidum DC.	90	LAGR, LFSC, GABD, SPCC
Ageratum conyzoides L.	13	LCLR, LOCT
Blainvillea acmella (L.) Philipson[c]	42	LHTS
Blumea bifoliata (L.) DC.	—	LGSP
B. obliqua (L.) Druce	—	LABD
Eclipta prostrata (L.) L. Mant.	20	LCLR, LMCC
Emilia sonchifolia (L.) DC.	—	LHTS, LMRC
Epaltes divaricata (L.) Cass.	—	—
Erigeron sublyratus DC.	—	—
Glossocarida bosvallea (L. f.) DC.	—	—

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
Grangea maderaspatana (L.) Poir[c]	38	LABD, LOCT
Launaea sarmentosa (Willd.) Sch.-Bip ex Kuntze	62	GABD, LFSC, CHTG
Parthenium hysterophorus L.	30	LAGR
Sonchus oleraceus L.	—	SMRC
Sphaeranthus amaranthoides Burm.	—	—
S. indicus L.	—	LMAG
Spilanthes calva DC.	—	LINR
Synederella nodiflora (L.) Gaertn.	—	LHTG
Tridax procumbens L.	60	CNGR, LMCL
Verbesina encelioides (Cav.) Benth. & Hook. f. ex Gray	36	LMNS, SPKS
Vernonia cinerea (L.) Less.	22	LPST
Vicoa indica (L.) DC.	30	LMNH, CGLM
Wedelia chinensis (Osbeck.) Merr.	—	—
Xanthium indicum Koen.	—	—
Goodeniaceae		
Scaevola plumieri (L.) Vahl	—	—
Sphenocleaceae		
Sphenoclea zeylanica Gaertn.	—	ESHK, LCLR
Plumbaginaceae		
Plumbago zeylanica L.	30	LMNS
Myrsinaceae		
Aegiceras corniculatus (L.) Blanco	—	—
Sapotaceae		
Madhuca longifolia (Koen.) Macbr.	—	LABS
Manilkara hexandra (Roxb.) Dubard	35	GGGT, LAGR, CFLG
Mimusops elengi L.	—	—
Ebenaceae		
Diospyros ebenum Koen.	—	—
D. ferra (Willd.) Bakh.	38	LAGR, LHTG
Oleaceae		
Jasminum angustifolium (L.) Willd.	20	LETC
Salvadoraceae		
Azima tetracantha Lam.	—	LMCC
Salvadora persica L. var. *wightiana*	—	—
Apocynaceae		
Carisia spinarum L.	—	LPVN
Cascabela thevetia (L.) Lippold	—	—
Catharanthus pusillus (Murr.) G. Don[c]	85	LINR, LPST
C. roseus (L.) G. Don	28	LGSP
Ichnocarpus frutescens (L.) R. Br.	—	—
Wrightia tinctoria (Roxb.) R. Br.	40	LFSC
Asclepiadaceae		
Calotropis gigantea (L.) R. Br.	38	LHTS
Caralluma adscendens (Roxb.) Haw.[c]	65	LABD, LDST
C. umbellata Haw.	41	LMAG, CPLC
Gymnema sylvestre (Retz.) R. Br.	—	—
Heterostemma tanjorense W. & A.	—	—
Leptadenia reticulata (Retz.) W. & A.	—	—
Pentatropis capensis (L. f.) Bullock	—	—
Pergularia daemia (Forskk.) Chiov.	—	—
Sarcostemma brunonianum W. & A.	—	—
S. intermedium Decne	—	—
S. secamone (L.) Bennet	—	
Tylophora indica (Burm. f.) Merr.	40	LDST
Wattakaka volubilis (L. f.) Stapf.	25	LABD, LPBS

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
Periplocaceae		
Hemidesmus indicus (L.) R. Br.	70	CHTG
Loganiaceae		
Strychnos lenticellata Hill	20	LMCL
Gentianaceae		
Canscora heteroclita (L.) Gilg	—	LCLR
Enicostema axillare (Lam.) Raynal	—	—
Exacum pedunculatum L.	58	LAGR, LFSC
Hoppea dichotoma Willd.	—	—
Menyanthaceae		
Nymphoides hydrophylla (Lour.) Kuntze	30	LCLR, LCRD
Hydrophyllaceae		
Hydrolea zeylanica (L.) Vahl	—	—
Boraginaceae		
Carmona retusa (Vahl)	23	GGGT
Coldenia procumbens L.	40	CGLM
Cordia obliqua Willd.	64	LSGT
Ehretia ovalifolia Wight	20	LHTS
E. pubescens Benth.	—	—
Heliotropium curassavicum L.	—	—
H. indicum L.	—	LETC
H. marifolium Retz.[c]	80	LFSC, LHTS
Heliotropium ovalifolium Forssk.	15	LMTC
H. subulatum (Hochst. ex Dc.) Vatke	—	LAGR, LMSS
H. zeylanicum (Burm. f.) Lam.[c]	65	LABD, LPST
Trichodesma indicum (L.) R. Br.	38	LDST
Convolvulaceae		
Cressa cretica L.	—	—
Evolvulus alsinoides (L.) L.	50	LHOI, CPLC
E. nummularius (L.) L.	46	LABS
Ipomoea aquatica Forssk.	55	ECLB
I. asarifolia (Desr.) Roem. Schult.[c]	32	GGGT
I. caritica (L.) Sweet.	—	—
I. carnea Jacq.	45	LCLR, LCRD
I. coptica (L.) Roth ex Roem. & Schult.[c]	32	CHTG
I. kentrocaulos Clarke	—	—
I. pes-caprae (L.) R. Br.	80	GABD, LAGR, LFSC, CPLC
I. pes-tigridis L.	50	GABD, LFSC
I. pulchella sensu Wight	—	—
I. sepiaria Koen ex Roxb.	—	—
Merremia dissecta (Jacq.) Hall. f.	—	—
M. emarginata (Burm. f.) Hall. f.	28	GABA
M. hederacea (Burm. f.) Hall. f.	30	LMNS
M. tridentata (L.) Hall. f.	80	LABS, SPCC
Operculina turpethum (L.) Silva Manso	—	—
Rivea hypocrateriformis (Desr.) Choisy	—	—
Solanaceae		
Capsicum annuum L.	95	LAGR, LFSC
Datura innoxia Mill.	—	—
Lycopersicon esculentum Mill.	41	LINR
Nicotiana tobacum L.	—	—
Physalis minima L.	—	—
Solanum anguivi Lam.	—	—
S. elageanifolium Cav.	—	—
S. melongena L.	74	LHTS, LFSC
S. nigrum L.	—	—

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
S. trilobatum L.	38	LMRC
Withania somnifera (L.) Dunal	80	GABD, CHTG
Scrophulariaceae		
Bacopa monnieri (L.) Pennell	—	—
Centranthera tranquebarica (Spreng.) Merr.	—	—
Dopatrium junceum (Roxb.) Buch.-Ham. ex Benth.	—	—
D. lobelioides (Retz.) Benth.	—	—
Glossostigma diandrum (L.) Kuntze	—	—
Limnophila indica (L.) Druce	—	—
L. polystachya Benth.	—	—
Lindernia antipoda (L.) Alston	—	GABD
L. caespitosa (Blume) Panigrahi	—	—
L. crustacea (L.) F. v. Muell	56	LABS, LFSC
L. hyssopioides (L.) Haines	—	—
L. parviflora (Roxb.) Haines	—	—
Peplidium maritimum (L. f.) Asch.	—	—
Scoparia dulcis L.	42	LINR
Sopubia delphiniifolia (L.) G. Don	—	—
Stemodia viscosa Roxb.[c]	80	GGGT, LAGR, LETC
Striga angustifolia (D. Don) Saldanha	33	LABD, LFSC
S. asiatica (L.) Kuntze	—	LAGR, LABS, LINR
S. densiflora Benth.	—	LMSS
Torenia lindernioides Saldanha	—	—
Verbascum chinense (L.) Sant[c]	56	LHTS
Bigoniaceae		
Kigelia africana (Lam.) Benth.	—	LETC, LPBS
Millingtonia hortensis L. f.	20	LMNS
Tabebuia rosea (Bertol.) DC.	85	LFSC, LMSS, LPST
T. serratifolia (Vahl) Nicholson	56	LAGR, LAGT
Tecoma stans (L.) Kunth	—	—
Pedaliaceae		
Pedalium murex L.	80	LINR
Sesamum laciniatum Klein ex Willd	83	LABS, LFSC
S. indicum L.	76	LFSC
Martyniaceae		
Martynia annua L.	80	LAGR, LHTS, LMNS
Acanthaceae		
Acanthus ilicifolius L.	—	—
Andrographis paniculata (Burm. f.) Wall ex Nees	—	—
Asystasia gangetica (L.) T. And.	—	GGGT, LABD
Barleria noctiflora L. f.[c]	70	LAGR, LCTC
B. prionitis L.[c]	58	LFSC
Blepharis maderaspatensis (L.) Heyne ex Roth[c]	50	LMSS
Dipteracanthus patulus (Jacq.) Nees	40	LETC
Dyschoriste madurensis (Burm. f.) Kuntze[c]	56	LMSS
Ecbolium viride (Forssk.) Alston	—	—
Elytraria acaulis (L. f.) Lindau	—	LINR
Gendarussa vulgaris Nees	—	—
Hygrophila auriculata (Schum.) Heine	—	—
H. balsamica (L. f.) Rafin.	—	—

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
H. heinei Sreemadh.	35	LAGR, LCLR
Indoneesiella echioides (L.) Sreemadh.	—	LHTS, CGLM
Justicia adhatoda L.	—	—
J. glauca Rottl.	32	LMRC
J. tranquebariensis L. f.	—	LFSC
Peristrophe paniculata (Forssk.) Brummit	—	—
Rostellularia prostrata (Roxb. ex Clarke) Majumdar	43	LDST
Ruellia tuberosa L.	—	—
Rungia repens (L.) Nees	68	GABD, LHTS
Verbenaceae		
Clerodendrum calamitosum L.	—	—
C. inerme (L.) Gaertn.	23	LABD, LMRC
Gmelina asiatica L.	52	GABD, LFSC
Lantana camara L. var. *aculeata* (L.) Mold	82	LHTS, SMRC
Lippia alba (Mill.) N. E. Br.	—	LDST
L. geminata H. K. B.	—	—
Phyla nodiflora (l.) Greene	86	LAGR, LGSP, CHTG
Premna serratifolia L.	—	GABD, LMNS
Stachytarpheta jamaicensis (L.) Vahl.	80	LAGR
Tectona grandis L.	83	LAGR, LFSC, LMSS
Vitex negundo L.	60	LFSC
Avicenniaceae		
Avicennia marina (Forssk.) Vierh.	—	—
A. officinalis L.	—	—
Lamiaceae		
Anisomeles indica (L.) Kuntze	45	LABS
A. malabarica (L.) R. Br.	90	LAGR, LFSC, LHTS
Basilicum polystachyon (L.) Merr.	60	LAGR, SPCC
Geniosporum tenuiflorum (L.) Merr.	58	LAGR, SPCC
Hyptis suaveolens (L.) Poit	80	SPCC
Leonotis nepetiifolia (L.) R. Br.[c]	46	LMAG
Leucas aspera (Willd.) Link	50	LSGT
L. diffusa Benth.[c]	35	LAGR, LCLR
Ocimum americanum L.	—	—
O. basilicum L.	38	GABD, LCLR
O. tenuiflorum L.	—	—
Orthosiphon pallidus Benth.	—	LABS
O. thymiflorus (Roth) Sleensen	—	—
Nyctaginaceae		
Boerhavia diffusa L.	47	LINR
Pisonia aculeata L.[c]	30	LETC, LFSC
Amaranthaceae		
Achyranthes aspera L.	—	LCRD, LINR, SPCC
Aerva lanata (L.) Juss ex Schult.	—	LINR
A. persica (Burm. f.) Merr.	—	LABS, LHTS
Allmania nodiflora (L.) R. Br.	—	LABS, CFLG
Alternanthera paronychioides A. St. Hil.	42	LAGR, LOCT
A. sessilis (L.) R. Br.	68	GGGT, LABS
Amaranthus spinosa L.	—	SPCC
A. tricolor L.	—	LMCL
A. viridis L.	36	GABD, LTNB
Celosia argentea L.	30	SRBF
C. polygonoides Retz.	—	—

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
Digera muricata (L.) Mart.	54	CGLM
Gomphrena serrata L.	—	—
Nothosaerva brachiata (L.) Wight.	—	LABS
Psilotrichum nudum (Heyne ex Wall.) Moq.	—	LETC
Pupalia lappaceae (L.) Juss.	—	LMNH
Trichurus monsoniae (L. f.) Thowns[c]	41	LFSC, SMRC
Chenopodiaceae		
Arthrocnemum indicum (Willd.) Moq.	—	—
Basella alba L. var. *rubra* (L.) J. L. Stewart	—	—
Salicornia brachiata Roxb.	—	—
Suaeda maritima (L.) Dumort.	—	—
S. monoica Forssk. ex Gmel.	—	—
Polygonaceae		
Antigonon leptopus Hook. & Arn.	—	—
Polygonum glabrum Willd.	—	—
P. plebeium R. Br.	—	LABS
P. pulchrum Blume	—	LCLR
Aristolochiaceae		
Aristolochia bracteolata Lam.	—	GABD
A. indica L.	—	LHTS
Piperaceae		
Peperomia pellcuida (L.) H. B. K.[c]	68	LMRC, LPST
Hernandiaceae		
Gyrocarpus asiaticus Willd.	32	LFSC, LHTS
Santalaceae		
Santalum album L.	76	LAGR, SPCC, SRBF
Euphorbiaceae		
Acalypha fruticosa Forssk.	12	GGGT
A. indica L.	25	LOCT
A. lanceolata Willd.	—	LMRC
Breynia vitis-idaea (Burm. f.) Fischer	—	LABS, LMNH
Chrozophora rottleri (Geiserler) Juss.	—	GABD, LCLR
Croton bonplandianum Baill.	60–72	LCLR, SRBF
Drypetes sepiaria (W. & A.) Pax & Hoffm.	37	LMRC
Euphorbia antiquorum L.	63	LPST
E. corrigioloides Boiss.	49	GABD, LAGR
E. cyathophora Murr.	—	LFSC
E. heyneana Spreng.	—	GGGT, LCRD
E. hirta L.	13	ECLB, LCLR
E. rosea Retz.[c]	60	LHTS, LMCC
E. thymifolia L.	—	—
E. tirucalli L.	—	—
Excoecaria agallocha L.	—	—
Jatropha curcas L.	60	LCRD
J. glandulifera Roxb.	—	LCTC
J. gossypifolia L.	—	LETC
J. tanjorensis Ellis & Saroja	60–80	LFSC, LMRC, SPCC
Manihot esculenta Crantz.	70	LMSS, LPST
Mallotus repandus (Willd.) Muell.-Arg.	—	—
Micrococca mercurialis (L.) Benth.	—	LAGR, CGLM
Phyllanthus amarus Schum. & Thonn.	57	LAGR
P. emblica L.	—	—
P. maderaspatensis L.	—	GGGT

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
P. reticulatus Poir.	29	LFSC, LINR
P. rotundifolius Klein ex Willd.	52	LMAG, LRTC
P. virgatus Forst. f.	60	GABD, CPLC
Ricinus communis L.	—	ALGL, LABS
Sauropus bacciformis (L.) Airy Shaw.	—	LMNS
Sebastiania chamaelea (L.) Muell.-Arg.	43	LMSS, SMRC
Securinega leucopyrus (Willd.) Muell.-Arg.	—	LABS, CHTG
Tragia involucrata L.	85	LABD, LDST, CFLG
T. plukenetii R. Smith[c]	72	LABS, LINR, LMAG
Urticaceae		
Pouzolzia zeylanica (L.) Benn.	—	LPBS
Ulmaceae		
Trema orientalis (L.) Blume	—	GABD, LINR
Moraceae		
Artocarpus heterophyllus Lam.	53	LFSC, LRTC
Ficus benghalensis L.	—	—
F. hispida L. f.	—	—
F. microcarpa L. f.	—	—
F. religiosa L.	—	—
Morus alba L.	30	LMCC, CNGR
Plecospermum spinosum Trec.	—	—
Streblus asper Lour.	—	—
Casuarinaceae		
Casuarina litorea L.	—	GABD, LAGR, LFSC, SPCC, CHTG
Salicaceae		
Salix tetrasperma Roxb.	—	—
Ceratophyllaceae		
Ceratophyllum demersum L.	—	—
Hydrocharitaceae		
Blyxa octandra (Roxb.) Planch ex. Thw.	15	ECLB
Enhalus acroides (L. f.) Royle	—	—
Halophila ovalis (R. Br.) Hook. f.	—	—
H. ovata Gaudich.	—	—
Hydrilla verticillata (L. f.) Royle	60–85	ECLB, LCLR
Nechamandra alternifolia (Roxb.) Thw.	40	—
Ottelia alismoides (L.) Pers.	45	—
Vallisneria natans (Lour.) Hara	24	LCLR, LOCT
Bromeliaceae		
Ananas comosus (L.) Merr.	37	LFSC, SPCC
Agavaceae		
Furcraea foetida (L.) Haw.	61	LABS, LCTC
Sansevieria roxburghiana Schult & Schult.	—	LETC, LINR, LMSS
Dioscoreaceae		
Dioscorea oppositifolia L.	50	LABS, LMSS
D. pentaphylla L.	—	LAGR, LHTS
Liliaceae		
Asparagus racemosus Willd.	70	LDST, SMRC

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
Gloriosa superba L.	70	LDST, SMRC
Iphigenia indica (L.) A. Gray ex Kunth[c]	29	LCLR, CGLM
Scilla hyacinthina (Roth.) Macbr.	33	LAGR, LFSC, LOCT
Pontederiaceae		
Eichhornia crassipes (Mart.) Solms-Laub	—	—
Monochoria hastata (L.) Solms-Laub	25	ECLB, LOCT
M. vaginalis (Burm. f.) Presl	39	LMAG, LFSC
Commelinaceae		
Commelina attenuata Koen. ex Vahl	—	—
C. benghalensis L.	12	LOCT, LMAG
C. diffusa Burm. f.	—	—
Cyanotis papilionaceae (L.) Schult. & Schult.	—	—
Murdannia spirata (L.) Burueckner	13	LHOI, LLPT
M. vaginata (L.) Burueckner	—	LETC
Tonningia axillaris (L.) Kuntze	—	—
Arecaceae		
Borassus flabellifer L.	—	LMRC, LRTC
Caryota urens L.	—	—
Cocos nucifera L.	—	LAGR, LFSC, CPLC
Corypha umbraculifera L.	—	—
Phoenix loureirii Kunth	—	LCLR, LGSP
P. sylvestris (L.) Roxb.	—	—
Pandanaceae		
Pandanus fascicularis Lam.	63	GABD, LFSC, CPLC, SPCC
Typhaceae		
Typha angustata Bory & Chaub.	—	—
Araceae		
Cryptocoryne retrospiralis (Rosb.) Kunth	—	—
Pistia stratiotes L.	—	—
Theriophonum minutum (Willd) Baillon	—	—
Lemnaceae		
Lemna gibba L.	—	—
Spirodela polyrhiza (L.) Schleiden	10	—
Najadaceae		
Najas graminea Del.	—	—
N. minor All.	—	—
Alismataceae		
Limnophyton obtusifolium (L.) Miq.	40	LPST
Aponogetonaceae		
Aponogeton natans (L.) Engl. & K. Krause	30	LINR
Potamogetonaceae		
Cymodocea serrulata (R. Br.) Asch. & Magnus	—	—
Halodule uninervus (Forssk.) Asch.	—	—
Potamogeton nodosus Poir.	—	—
P. pectinatus L.	—	—
Syringodium isoetifolium	—	—
Eriocaulaceae		
Eriocaulon cinereum R. Br.	—	ESHK, LAGR
E. quinquangulare L.	—	LMSS, LPST

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
Cyperaceae		
Bulbostylis barbata (Rottb.) Clarke	—	—
B. puberula (Poir.) Kunth ex Clarke	—	—
Cyperus arenarius Retz.	40	LAGR, LFSC, GGGT, CHTG
C. articulatus L.	—	—
C. bulbosus Vhal	—	LFSC
C. castaneus Willd.[c]	—	—
C. compressus	—	LCLR, LCRD
C. difformis L.	—	ECLB, LLCLR
C. distans L. f.	—	—
C. esculentus L.	—	—
C. exaltatus Retz.	—	—
C. halpan L.[c]	25	ESHK, LCLR
C. laevigatus L.[c]	33	LAGR, LFSC, GABD
C. platyphyllus Roem. & Schult.	—	—
C. pygmaeus Rottb.	—	LAGR, CNGR
C. rotundus L.	35	LOCT, LINR
C. stoloniferus Retz.	58	LAGR, LFSC, SPCC, CHTG
C. tenuispica Steud.	—	LOCT
Eleocharis dulcis (Burm. f.) Henschel	15	LCRD, LOCT
E. geniculata (L.) Roem. & Schult	—	—
Fimbristylis argentea (Rottb.) Vahl	—	—
F. bisumbellata (Forssk.) Bubani	—	LAGR, CGLM
F. complanata (Retz.) Link.	—	LMSS
F. cymosa R. Br.	—	LABD, LFSC
F. dichotoma (L.) Vahl.	—	—
F. dipacea (Rottb.) Clarke	—	ESHK
F. eragrostis (Nees & Meyen ex Nees) Hance[c]	18	LCLR, LCRD
F. falcata (Vahl) Kunth	—	LMSS, LGSP
F. ferruginea (L.) Vahl	—	—
F. miliacea Vahl	—	ECLB
F. ovata (Burm. f.) Kern	—	—
F. polytrichoides (Retz.) R. Br.	—	—
F. schoenoides (Retz.) Vahl	—	—
F. triflora (L.) Schum. ex Engl.	—	LCLR, LDST, GABD, CHTG
Fuirena ciliaris (L.) Roxb.	—	LMSS
F. capitata (Burm. f.) Koyama	—	LAGR, SPCC
Kyllinga brevifolia Rottb.	—	CGLM
K. bulbosa Beauv.	—	LMNS
K. nemoralis (J. R. & Forst.) Dandy ex Hutchj.	—	—
Lipocarpha sphacelata (Vahl) Kunth	—	LMSS, LPST
Mariscus dubius (Rottb.) Kuek. ex Fischer	—	LAGR, LFSC
Mariscus paniceus (Rottb.) Vahl	—	LMRC
M. squarrosus (L.) Clarke	—	—
Pycreus flavidus (Retz.) Koyama[c]	25	LABD
P. polystachyos (Rottb.) Beauv.	—	LPST
P. pumilus (L.) Nees[c]	12	LOCT, LPST
P. puncticulatus (Vahl) Nees	—	ESHK, LOCT
Rikliella squarrosa (L.) Raynal[c]	20	ECLB, LCLR
Schoenoplectus grossus (L. f.) Palla	—	—
S. juncoides (Roxb.) Palla	—	LCLR
S. supinus (L.) Palla[c]	13	ECLB, LPBS
S. senegalensis (Steud.) Palla ex Raynal	—	ECLB, LCLR
Poaceae		
Aeluropus lagopoides (L.) Trin. ex Thw.	—	—

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
Alloteropsis cimicina (L.) Stapf[c]	33	GGGT, LFSC
Andropogon pumilus Roxb.[c]	40	LMSS, LPST
Apluda mutica L.[c]	32	LFSC, LPBS
Apocopis courtallumensis (Steud.) Henr.	62	LMSS, SPKS
A. mangalorensis (Hochst.) Henr.[c]	39	LFSC, LMSS
Aristida funiculata Trin. & Rupr.[c]	42	LAGR
A. hystrix L. f.[c]	30	LINR, LPST
Arundo donax L.	—	LMCL, LPST
Bambusa arundinacea (Retz.) Roxb.	—	GABD
Brachiaria ramosa (L.) Stapf	—	LINR
B. reptans (L.) Gard. & Hubbard	—	LETC
Chionachne koenigii (Spreng.) Thw.	—	LOCT
Chloris barbata Sw.	31	LHTS, LFSC
C. virgata Sw.[c]	82	GGGT, LCLR, CGLM, CHTG
Chrysopogon aciculatus (Retz.) Trin.[c]	72	LGSP, LTNB
C. fulvus (Spreng.) Chiov.	—	LSGT
Coelachyropsis lagopoides (Burm. f.) Bor	—	LOCT, LCLR
Coix aquatica Roxb.	—	ESHK
C. lacryma jobi L.	—	LOCT
Cynodon dactylon (L.) Pers.	58	GABD, LAGR
Dactyloctenium aegyptium (L.) Willd.	30	LAGR, LOCT, CPLC
Dichanthium annulatum (Forssk.) Stapf.	—	—
Digitaria bicornis (Lam.) Roem. & Schult. ex Loud.	23	LHTS, LOCT
D. longiflora (Retz.) Pers.[c]	26	LFSC, SPCC
D. setigera Roth.[c]	—	LMSS, LSGT
D. retroflexa (Vahl) Panzer	38	LABS, LAGR, SRBF
Diplachne malabarica (L.) Merr.	—	—
Echinochloa colona (L.) Link	—	LOCT
E. crus-galli (L.) P. Beauv.		
var. crus-galli	—	LINR, LOCT
var. *breviseta* (Doell) Neilr	—	LOCT
E. stagnina (Retz.) P. Beauv.	—	ECLB, LCLR
Eleusine coracana (L.) Gaertn.	—	—
Eragrostiella bifaria (Vahl) Bor	—	LABS, LMSS
Eragrostis ciliaris (L.) R. Br.[c]	38	GABD, LAGR
E. gangetica (Roxb.) Steud.	—	—
E. japonica (Thunb.) Trin.	—	LMRC, CPLC
E. maderaspatana Bor	—	—
E. nutans (Retz.) Nees ex Steud.[c]	20	—
E. tenella (L.) P. Beauv.	42	LTNB, CHTG
E. unioloides (Retz.) Nees ex Steud.	—	—
E. viscosa (Retz.) Trin.[c]	50	LMSS, SRBF
Eriochloa procera (Retz.) Hubbard	—	ESHK, LMNS
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult.	12	LABD, LCTC
Holcolemma canaliculatum (Nees ex Steud.) Stapf. Hubbard	—	LFSC, CGLM
Imperata cylindrica (L.) Raensch.	—	LMNS
Isachne globosa (Thunb.) Kuntze	—	LMNS
Ischaemum indicum (Houtt.) Merr.	—	—
I. rugosum Salisb.	—	—
Leptochloa chinensis (L.) Nees[c]	—	LOCT
Leptochloa neesii (Thw.) Benth.[c]	15	LOCT
Lopholepis ornithocephala (Hook.) Steud.	20	LRTC, SPKS
Manisuris myuros L.[c]	—	LHTS, SMRC
Melanocenchris monoica (Rottl.) Fischer[c]	36	LMRC

Table 2 (continued)

Plants[a]	Infection (%)	VAM species[b]
Mnesithea laevis (Retz.) Kunth	—	LHOI, LPBS
Ophiuros exaltatus (L.) Kuntze	—	LABD
Oplismenus burmannii (Retz.) P. Beauv.[c]	35	LGSP, LPBS
Oryza sativa L.	50–75	GABI, LABS, LCRD, LCLR, LFSC, LOCT, LPST
Panicum maximum Jacq.	28	LFSC
P. repens L.	—	LCLR
P. trypheron Schult.[c]	56	LABS, LMSS
Paspalidum flavidum (Retz.) A. Camus	—	LETC, LTNB
P. geminatum (Forssk.) Stapf.	—	ECLB, LCLR
P. punctatum (Burm. f.) A. Camus	—	—
Paspalum distichum L.	—	—
P. scrobiculatum L.	—	LAGR, LHTS, SRBF
Pennisetum purpureum Schum.[c]	43	LABS, LPST
Pennisetum typhoides (Burm. f.) Stapf. C. E. Hubb.	70	LFSC
Perotis indica (L.) Kuntze[c]	47	LOCT, LFSC, CHTG
Pommereulla cornucopiae L. f.[c]	50	LABD, LMNS
Pseudoraphis spinescens (R. Br.) Vickery	—	—
Saccharum officinarum L.	38	LOCT
S. spontaneum L.	—	LCRD, GGGT
Sacciolepis interrupta (Willd.) Stapf.	43	ECLB, LCLR
Setaria pumila (Roir.) Roem. & Schultes	35	LABS, LMSS
S. verticillata (L.) P. Beauv.	—	—
Sorghum saccharum (L.) Moench.	60–80	GABD, LAGR, LFSC, LMSS
Spinifex littoreus (Burm. f.) Merr.	28	LAGR, LHTS, LPST
Sporobolus coromandelianus (Retz.) Kunth[c]	10	LMSS, SRBF
S. maderaspatanus Bor[c]	55	—
S. termulus (Willd.) Kunth	—	—
S. virginicus (L.) Kunth[c]	20	LCLR, LCRD
Trachys muricata (L.) Pers.	46	LABD, CFLG
Tragus roxburghii Panigrahi	—	—
Urochloa panicoides P. Beauv.	—	LCTC
Vetiveria lawsonii (Hook. f.) Blatter & McCann	—	LPVN
Zoysia matrella (L.) Merr.	—	—
Pteridophytes		
Azollaceae		
Azolla pinnata R. Br.	—	—
Isoetaceae		
Isoetes coromandelina L. f.	40	ESHK, LAGR
Marsileaceae		
Marsilea quadrifolia L.	—	—
Salviniaceae		
Salvinia cucullata Roxb.	—	—

[a] Families are arranged according to the Bentham & Hooker system
[b] VAM species represented by code words after Pere'z and Schenck 1990
[c] First report

eas were *Entrophospora schenckii*, *G. aggregatum*, *G. fasciculatum* and *G. multicaule*, and *Sclerocystis pachycaulis*.

Grasslands. Patches of grasslands are scattered throughout the district. *Acaulospora longula*, *Gigaspora albida*, *Glomus ambisporum*, *G. clarum*, and *Scutellospora heterogama* were the dominant species.

Forest soil. The forests of this district are Kodiakkarai dry evergreen forest, plantation forest along the river banks and scrub jungle, and the common VAM species were *Gigaspora albida* and *G. gigantea*, *Glomus pustulatum*, *G. aggregatum*, *G. fasciculatum* and *G. heterosporum*, *Sclerocystis pachycaulis*, and *Scutellospora pellucida*.

Brackish environment soil. The vegetation here consisted of *Arthrocnemum indicum*, *Salicornia brahitata*, *Aeluropus lagopoides*, *Cressa cretica*. The mycorrhizal infection and spore population were comparatively low. Only a few VAM fungi were isolated, such as *Glomus clarum* and *G. claroideum*.

Mangrove soil. The mangrove soil is highly saline and clayey. No VAM fungi were isolated, despite repeated efforts.

Vegetation and mycorrhizal association

A total of 737 plant species from 121 families of angiosperms and four species of pteridophytes were examined for mycorrhizal colonization. Mycorrhizal root colonization was recorded in 372 species. The data of percent colonization for each species are summarized in Table 2. The quantum of colonization was in the range of 10–90%.

Of the four pteridophytes, only *Isoetes coromandelina* displayed mycorrhizal association. Out of 549 dicotyledonous species surveyed, about 301 displayed mycorrhizal infection, whereas in monocotyledons, 71 species out of 188 were mycorrhizal. Of the 733 angiosperm species examined in this district, roots of 371 species dis-

Table 3. Distribution of mycorrhizae in some major families (root colonization)

Family	Species examined	No. of mycorrhizal species
Leguminosae	94	62
Poaceae	85	39
Cyperaceae	51	12
Euphorbiaceae	35	18
Asteraceae	24	11
Acanthaceae	22	9
Rubiaceae	22	14
Scrophulariaceae	21	5
Convolvulaceae	19	11
Amaranthaceae	17	6

played mycorrhizal infection. The levels of mycorrhizal distribution in 10 major families are summarized in Table 3.

In Fabaceae, the largest family representative of the district, 94 species were examined of which 62 species were mycorrhizal. Of the 85 species of Poaceae, 39 were mycorrhizal. About 51 species of Cyperaceae were screened for VAM colonization but only 12 species exhibited mycorrhizal infection. Members of the Asteraceae, Euphorbiacae, Convolvulaceae and Rubiaceae harbored more than 50% mycorrhizal infection. Other families such as Cyperaceae, Asteraceae, Scrophulariaceae, Amaranthaceae and Poaceae displayed less than 40% mycorrhizal infection.

Only 35 plant species exhibited infection of more than 75%, of which the economically important *Albizia lebbeck*, *Arachis hypogaea*, *Capsicum annuum*, *Coriandrum sativum*, *Dalbergia sissoo*, *Mangifera indica*, *Sesamum orientale*, *Solanum melongena* and *Tectona grandis* are notable. *Hydrilla verticillata*, a member of Hydrocharitaceae, exhibited infection of about 85%. Infection ranged from 50 to 75% in several wild and cultivated crop plants. Mycorrhizal infection was recorded for the first time in India in 102 plant species (Table 2).

Discussion

This study differs in various ways to other investigations on endomycorrhizae. Both plants and rhizosphere soils were collected during a 3-year period (1986–1989), at different stages of plant growth, and during different seasons. Mycorrhizal colonization was recorded in 49% of the total flora. Harley and Harley (1987), who compiled the mycorrhizal association of plants in the British Isles, concluded that most plants in Britain were mycorrhizal.

Mycorrhizal colonization was more frequent in forest areas, where there was a higher diversity of plant species, than in the cultivated fields. It is likely that fertilizer application to cultivated land reduces VAM species (Mosse and Hayman 1980). A similar observation was made by Grime et al. (1987), who worked on the mechanism of floristic diversity with reference to mycorrhizae.

In Thanjavur district, which is located on the Cauvery delta, the soils are wet and marshy during most of the year. This may be the reason for the moderate infection frequency (49%) by VA mycorrhizae of a total of 737 plant species.

Species of the families Nelumbonaceae, Nymphaeaceae, Brassicaceae, Tamaricaceae, Elatinaceae, Erythroxylaceae, Oxilidaceae, Balsaminaceae, Simaroubaceae, Rhizophoraceae, Barringtoniaceae, Sphenocleaceae, Goddeniaceae, Myrsinaceae, Salvadoraceae, Avicenniaceae, Chenopodiaceae, Polygonaceae, Aristolochiaceae, Urticaceae, Ulmaceae, Salicaceae, Ceratophyllaceae, Arecaceae, Typhaceae, Araceae and Potamogetonaceae were nonmycorrhizal. However, VAM spores were collected from the rhizosphere soils of some of the species. Although VAM colonization was studied in certain pteridophytes (Harley 1967; Cooper 1976; Mishra et al. 1980), the incidence of VAM spores in their rhizospheres has not been investigated. We collected *Entrophospora schenckii* and *Glomus aggregatum* from the rhizosphere of *Isoetes coromandelina* L., which showed a good degree of infection (Ragupathy et al. 1990). *Salvinia cuculata*, which is considered to be an endomycorrhizal plant (Bagyaraj et al. 1979) did not show VAM infection, despite repeated efforts. In contrast to Chaubal et al. (1982), who stated that VAM fungi are rare in aquatic plants, we found that 47% of the aquatic plants examined were mycorrhizal.

Changes in edaphic factors greatly influence mycorrhizal association. The number of VAM spores increased in summer (Mason 1964). Hayman (1970) suggested that the increased number of mycorrhizal spores in wheat fields during summer was related to the season. Schwab and Reeves (1981) also indicated that in addition to temperature and light, mycorrhizal infection in semi-arid region is greatly influenced by the season. Both the population size and the diversity of VAM spores were higher in the rhizospheres of plants growing in sandy soils. In the rhizospheres of clayey, cultivated soils and aquatic sediments, the occurrence of VAM was reduced and the diversity limited. Spores were rare in permanently waterlogged soils and very rare in saline soils. Very few VAM fungi were isolated from brackish environments with high salinity (Ragupathy and Mahadevan 1991).

Several species with VA mycorrhizal infection lacked VAM spores in the rhizosphere soil. This could be due to waterlogging, the clayey nature of the soil or saline condition. During the monsoon rains (September to December), plants such as *Ammannia baccifera*, *Bacopa monnieri*, *Basilicum polystachyon*, *Cyperus halpan* and *C. tenuspica*, *Eclipta prostrata*, *Glossostigma diandrum*, *Heliotropum subulatum*, *Hydrocera triflora*, *Hyderolea zeylanica*, *Ipomoea carnea*, *Ludwigia adscendens*, *Phyla noodiflora*, *Rotala rosea* and *R. verticillaris* became temporarily waterlogged and the mud adhering to their roots usually lacked spores. However, the rhizospheres of the same species growing on adjacent dry soils contained many spores and displayed VAM infection in the roots. Clearly soil moisture profoundly affects spore number. The observations of Khan (1974) are compatible with our findings.

Although 90% of the plant species were associated with VAM spores in the rhizosphere soil, only 49% showed mycorrhizal colonization in their roots. Mosse (1975) proposed that variation in the effectiveness of infection may be due to physiological differences between species. One further possible reason for low infection or lack of infection is the inability of the fungi to compete with other soil microorganisms. Thus unsuitable characteristics of soil and host are responsible for the near absence of VAM infection.

The tree species of Thanjavur showed a high frequency of VAM colonization in the roots compared to herbs, grasses and sedges. Trees such as *Albizia lebbeck*, *Dalbergia sissoo*, *Mangifera indica*, *Mytragyna parvifolia*, *Tabebuia rosea* and *Tectona grandis* had high degrees of

root infection, whereas members of the Poaceae and Cyperaceae that have numerous feeder roots showed only 25 to 40% infection. Exceptions here were *Chloris virgata* and *Cyperus stoloniferous*, which have fewer feeder roots and exhibited heavy infection.

In general, investigations of the distribution of VA mycorrhizal spores in relation to floristics has been undertaken only by a few workers (Grime et al. 1987). Moreover, screening studies of endomycorrhizal taxa in forests and plains which would be economically useful in reforestation practices have been neglected, except for the reports of Mohankumar and Mahadevan (1987) and Thapar and Khan (1973). Endomycorrhizal study of the colonization of mycorrhizae in the flora of different districts will give a clear picture of the distribution of VA mycorrhizae in different classes, families, genera and species.

Investigations linking floristic exploration and endomycorrhizal profiles would greatly help plant taxonomists to understand the influence of VAM on the species diversity and distribution. We certainly hope that plant taxonomists will include endotrophic association as an additional parameter. A complete understanding of the profile of endotrophic fungal association with higher plants will allow speculation about the VAM symbiosis in species diversity (Went and Stark 1968).

Acknowledgement. S. R. thanks the Botanical Survey of India for the award of a research fellowship.

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