MYCORRHIZA NEWS
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About TERI

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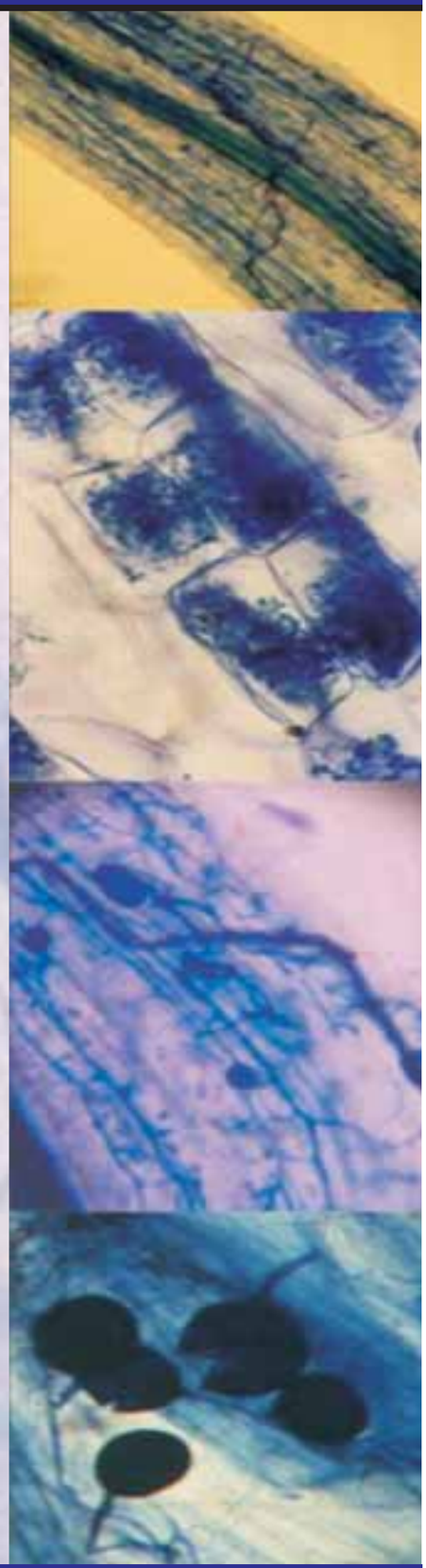
TERI's Mycorrhiza Network is primarily responsible for establishing the MIC (Micorrhiza Information Centre), the CMCC (Centre for Mycorrhiza Culture Collection), and publishing Mycorrhiza News. The Network helps scientists carry out research in mycorrhiza and promotes communication among mycorrhiza scientists.

Mycorrhiza News

The Mycorrhiza News provides a forum for dissemination of scientific information on mycorrhiza research and activities; publishes state-of-the-art papers from eminent scientists; notes on important breakthroughs; brief accounts of new approaches and techniques; publishes papers complied from its RIZA database; provides information on forthcoming events on mycorrhiza and related subjects; lists important research references published during the quarter; and highlights the activities of the CMCC.



Courtesy: Cover design by Dr Sharda W Khade

Contents

Research finding papers

Taxonomic series: *Glomus* from Goa

*Sharda W Khade**

1. *Glomus albidum* Walkers and Rhodes, Mycotaxon 12: 509–514, 1981 (Plate 1)

Chlamydospores occur singly in soil. It appears hyaline to white when young and yellowish to brownish yellow in transmitted light through compound microscope. It is a spore with one subtending hypha (Plate 1A). Mature spores have a cross-sectional area of 90–150 × 80–175µm, hyaline globose to subglobose. The spore wall consists of hyaline outer wall, which is 0.5–2µm thick and the inner sub-equal wall is a finely laminated wall, which is light yellow in colour and is 0.5–2µm thick. The outer wall becomes roughened at maturity (Plate 1B). Subtending hypha is two walled and the outer wall is thickened at the spore base with a diameter of 5-10 µm. It is constricted at the spore base (Plate 1A) and it is expanded by thickening of the outer wall to become slightly funnel shaped (Plate 1C) away from the spore base. The outer hyphal wall (0.7 µm thick), sloughing at maturity, leaves the inner wall (0.5 µm thick) unsupported. The hypha, then, appears to be shriveling and collapsing.

Distinguishing feature – Subtending hypha is two walled and is constricted at the spore base. It is expanded by thickening of the outer wall to become slightly funnel shaped away from the spore base.

Distribution – Recorded from Valpoi in March with 12.5% frequency of occurrence.

Association – Found in association with *Carica papaya* L. plants from the Western Ghats, Goa, India.

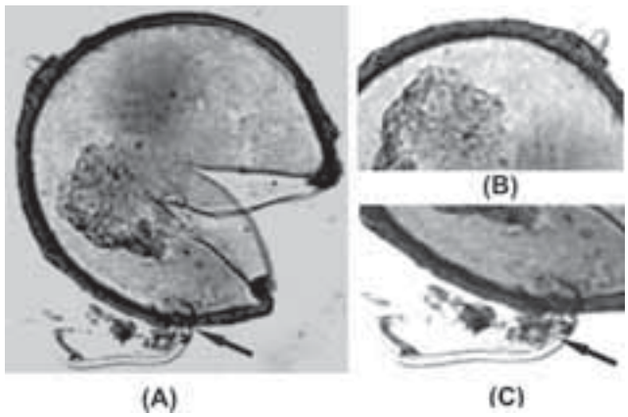


PLATE 1. A) Crushed spore of *Glomus albidum* with subtending hypha constricted at the spore base (arrow) (× 400).
B) Laminated wall in *Glomus albidum* (× 400).
C) A portion of spore of *Glomus albidum* with hyaline funnel shaped hypha (arrow) formed away from the spore base (× 400).

2. *Glomus boreale* (Thaxter) Trappe and Gerdemann, Proceedings of the American Academy of Arts and Sciences 57: 291–350 (Plate 2)

The spore mass is irregular, coherent, spongy, brown to almost chocolate brown. Its diameter is about seven to eight mm (Plate 2A). It is a gleba of loosely interwoven hyphae, 10–25 µm in diameter, among which foreign matter is incorporated along with many abortive spores (Plate 2B). The spores are yellow

* Dr Khade S W, Department of Botany, Goa University, Taleigao plateau, Goa 403206, India.
E-mail: sharda_khade@yahoo.com

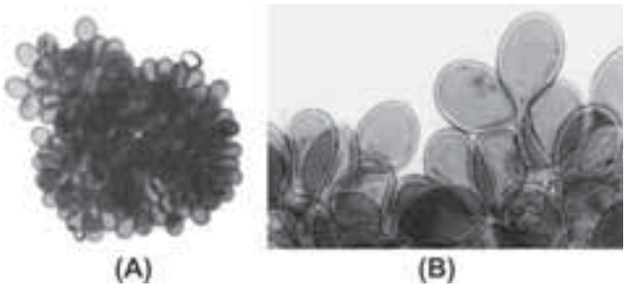


PLATE 2. A) A sporocarp of *Glomus boreale* (× 100).
B) Broadly symmetrical and ellipsoidal spores of *Glomus boreale* (× 400).

to reddish brown in colour. They are symmetrically ellipsoidal, about 125 × 100 µm in diameter, the larger ones are 145 × 110 µm in diameter (Plate 2B). The thick, reddish brown walls are about 8 µm in diameter.

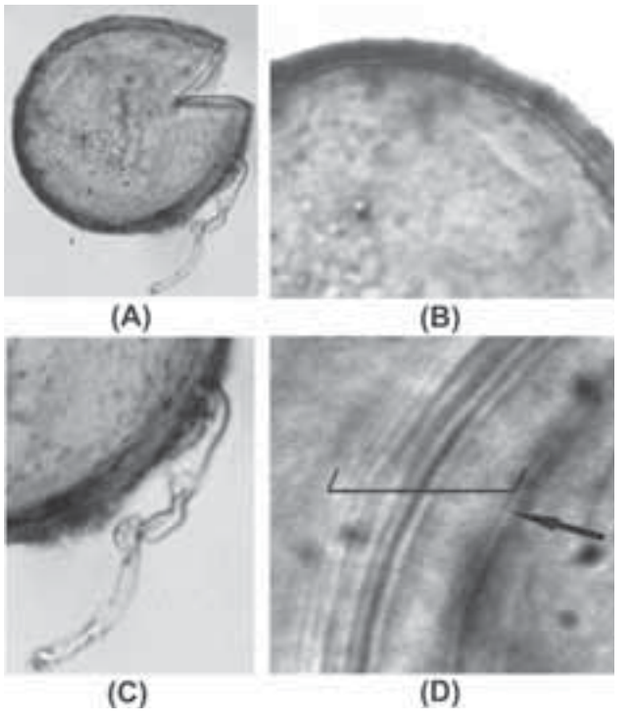


PLATE 3. A) Crushed old spore of *Glomus claroideum* with subtending hypha (× 400).
B) Laminated roughened wall in old spore due to debris (× 400).
C) A portion of old spore with subtending hyphae thicker at the point of attachment to the spore (× 400).
D) A mature spore of *Glomus claroideum* with outer laminated thicker wall with adjoining thinner membranous wall (arrow) (×1500).

They are borne on slender hyphae and are frequently subtended by septum.

Distinguishing feature – The spore mass is irregular, coherent, spongy, brown to almost chocolate brown with thick walled spores.

Distribution – Recorded from Valpoi in March with 12.5% frequency of occurrence.

Association – Found in association with *Carica papaya* L. plants from Western Ghats, Goa, India.

3. *Glomus claroideum* Schenck and Smith, Mycologia 74: 77–92 (Plate 3).

Chlamydospores are formed singly in soil, globose, having a cross sectional area of 70–100 µm diameter (Plate 3A). The spore wall is 4–8 µm thick and consists of one or two walls with a laminated outer wall. It is usually thicker than the inner wall (Plate 3D). The spore wall hyaline is yellow and becomes yellow- brown with age (Plate 3D). The outer wall is smooth but soil particles or debris often sticks to the wall (Plate 1B). Subtending hyphae is 7–10 µm diameter at the point of attachment (Plate 3C). Hyphal walls in the young spore are 3.0–5.5 µm thick and in the older spore it is 1.5–3.0µm thick (Plate 3C).

Distinguishing feature – The outer spore wall is laminated and is usually thicker than the inner wall.

Distribution – Recorded in December from Valpoi, Colva, Kodar and Collem with 50% frequency of occurrence. Recorded four times a year (January, April, July and October) in Valpoi and Kodar with 100% frequency of occurrence. Recorded in Old Goa in January, April and October with 50% frequency of occurrence. Recorded in Old Goa in June, July, August and September with 62%, 50%, 37% and 25% frequency of occurrence respectively.

Association – Found in association with *Carica papaya* L. plants from Western Ghats, plateaus and coastal areas of Goa, India.

4. *Glomus clavisporum* (Trappe) Almeida and Schenck, Mycologia 82 (6): 703–714, 1990 (Plate 4)

Sporocarp is globose to subglobose, 500–700 µm in diameter. It is yellowish-brown, brownish-black to black. It is minutely verrucose from the exposed tips of spores which are formed radially in a single, tightly packed layer around a central plexus of hyphae. It has an indented base and lacks in peridium. Chlamydospores are brown and have a cross sectional

area of 100–176 × 25–40 µm diameter. They are clavate to subcylindric, tapering to a hyphal attachment of 7–10 µm diameter (Plate 4A). The spore walls are 1–5–5 µm thick on the sides and at the spore apex they are thicknend to 17–25 µm, while the thickness at the base is 5–8 µm (Plate 4A, Plate 4B). Sometimes in old spores cross walls are formed equidistance from the apex and the base of the spore (Plate 4B). The functions of these cross walls are unknown. Microbial in-growths also visible in old spores (Plate 4B).

Distinguishing feature – Large sporocarps without the peridium and spores with thickened apex are tightly packed around the central plexus.

Distribution – Recorded from Valpoi in December with 12.5% frequency of occurrence.

Association – Found in association with *Carica papaya* L. plants from Western Ghats, Goa, India.

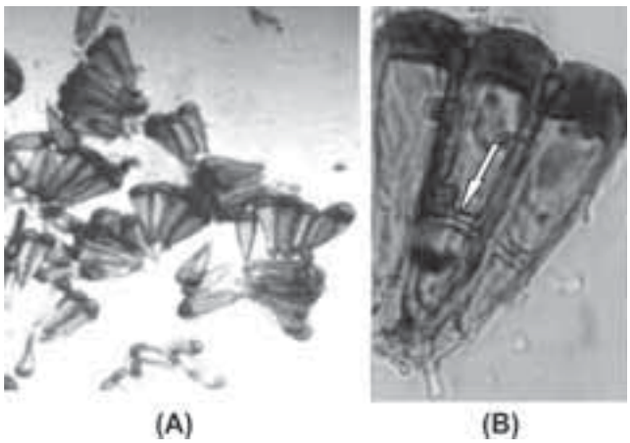


PLATE 4. A) Crushed sporocarp of *Glomus clavisporum* showing spores with thickened apices (× 400).
B) Spores of *Glomus clavisporum* developing unusual cross wall (arrow) equidistance from the apex and base of the spore (× 1000).
[Note the microbial in growth in the spores]

5. *Glomus constrictum* Trappe, Mycotaxon 6: 359–366, 1977 (Plate 5)

The spores formed singly in soil are dark brown to black in colour. They are shiny-smooth, subglobose to globose, with a diameter of 150–225 µm (Plate 5A). The spore walls are 12–15 µm thick, dark brown in colour, and are one layered. They have a straight base or occasionally have a short funnel-shaped projection. The attachment is occluded by wall thickenings and contains oil globule of widely varying sizes. The attached hypha is straight to recurved (Plate 5A) with the following features appearing in sequence away from the spore – (a) point of attachment with dark brown walls is 3–6 µm thick, (b) just beyond the point of attachment the hypha is constricted to 12–20 µm diameter, (c) just beyond the constriction the hypha is inflated to 15–30 µm with (d) yellow to yellow-brown walls that are 2–3 µm thick from which several hyaline often grow to yellow, fragile, thin-walled hyphae with a diameter of 5–7 µm, (e) just beyond the inflated segment is a thick-walled septum, and (f) beyond the inflated segment the hypha is dichotomously forked (Plate 5B, C).

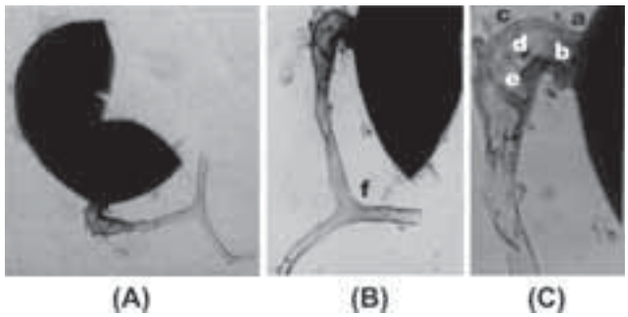


PLATE 5. A) Crushed spore of *Glomus constrictum* with recurved hyha (× 400).
B) A portion of spore with constricted hypha near the spore base and forked (f) away from the spore (× 400).
C) Characteristics of hypha of *Glomus constrictum* (a-e) as mentioned in the description (× 1000).

Distinguishing feature – Brownish-black, shiny spore with series of characteristics in its hypha.

Distribution – Recorded from Collem in December with 16.66% frequency of occurrence.

Association – Found in association with *Carica papaya* L. plants from Western Ghats, Goa, India.

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Effect of additional phosphate on growth performance of *Gmelina arborea* Roxb. inoculated with arbuscular mycorrhizal fungi

Dudhane M, Borde M, and Jite P K *

Introduction

Arbuscular mycorrhizal fungi (AMF) are important in mobilizing phosphorus (P) nutrition in many soils through hyphal transport to the plant (Jakobsen and Larsen 1994). Nutrient exchange between the two symbionts is at the core of the arbuscular mycorrhizal (AM) association and reciprocal transfer is a requirement for a functioning symbiosis (Fitter 2006). The first model to quantify the contribution of the external fungal mycelium to plant P uptake was developed by Schnepf and Roose (2006). Karthikeyan *et al*. (2008) analysed the effect of AMF and *Glomus mosseae* along with P levels on the growth and alkaloid content of *Catharanthus roseus*.

Microorganisms have been found to solubilize the low soluble calcium phosphate via the production of exo-metabolites (phosphatases) and make them available to plants (Rao 2000). Alkaline phosphatase (ALP) has long been suspected of being involved in phosphate efflux from arbuscules because of strong ALP activities at arbuscules (Ezawa, Saito, and Yoshida 1995; Saito 1995). The phosphatase activity of extramatricle mycelium and roots is of vital importance for the supply of P to plants (Joner and Johansen 1999). ALP activity appears to be indicative of the efficiency of AMF on plant nutrition (Guillemin *et al*. 1995).

The past decade has witnessed a rapid increase of interest in agroforestry and plantation as a land use practice across India. Of the tree species, currently being tested for agroforestry or plantation, *Gmelina arborea* Roxb. is one moderately fast growing indigenous tree used for the purpose of timber, fuel, and pulp production (Dhar and Mridha 2003).

The ultimate aim of this study was to see the effect of AMF on *Gmelina arborea* in respect of morphological, biochemical, and acid phosphatase and alkaline phosphatase activities under two different phosphate levels over non-inoculated plants.

Materials and methods

Plant material and AM inoculum – Seeds of *Gmelina arbo*rea Roxb. were brought from Synergy farm, Pasure, Tal-Bhor district of Pune, Maharashtra, India, for culture of *Glomus fasciculatum* (Thaxter) Gerd. and Trappe emend. Walker and Koske were maintained on Guiana grass for two months and used as inoculum (containing rhizosphere soil, AM colonized roots, and spore 10–15/gm of soil) for seedling of *Gmelina arborea* (in autoclaved soil for one hour at 121 ^{0}C).

Experimental design – The experimental design consisted of six treatments having non-AM inoculated and AM inoculated *Gmelina* plants with three phosphate levels (KH_2PO_4: 0, 50 mg in 100 ml D.W. , and 200 mg in 100 ml distilled water) per 3 kg of sterilized soil. Pots were arranged in completely randomized block design. Six replicates of each treatment were grown; total 36 pots (three plants/pot) were arranged. Two months old seedlings of *Gmelina* were used for phosphate experiment. KH_2PO_4 dibasic was used as phosphate source. After 30 days of AM inoculation, P treatment was given at eight days interval, and it was continued till the last observation was taken. Observations were recorded after 45, 75, and 100 days after AM inoculation.

Statistical analysis was done with the help of statistical package for social sciences (SPSS) software, Duncan Multiple Range Test (DMRT) and it was found that the values were significant at $P \leq 0.05$.

Morphological parameters – Shoot length, root length, fresh weight, dry weight, leaf area, and per cent root colonization were studied.

Physiological parameters – Total chlorophyll was determined by Arnon's method, 1949. The amount of total chlorophyll was expressed in mg/gm fresh weight. P was measured as described by Fiske and Subba Raw's (1925) method. Amount of phosphorus was expressed in mg/gm dry weight.

Acid phosphatase and alkaline phosphatase – Phosphatase activities were determined by Lowry *et al*. (1954) method. Absorbance was read at 405 nm. The amount of phosphatase activity was expressed in moles of para-nitro phenol (PNP) released/minutes/gm of fresh weight of roots.

Results and discussion

In this study it was observed that plants inoculated with AMF have grown taller than the non-inoculated plants. Shoot and root length consequently increased

* Department of Botany, University of Pune, Pune–411007, India (*E–mail* paramjit.jite@gmail.com)

in Gf+1P level as compared to C+1P after 45 and 75 days of AM inoculation (Table 1). Increased shoot length was observed in AM inoculated plants as compared to control *Gmelina* plants. Similar observations were made by Chiramel *et al*. (2006). They showed that plants inoculated with *Glomus leptotichum*, *G. etunicatum*, and *G. mosseae* showed higher plant height as compared to non-inoculated plants. In *Gmelina*, at Gf+2P as well as C+2P, shoot and root length decreased as compared to Gf+1P as well as C+1P respectively (Table 1). Similar results were obtained by Karthikeyan *et al*. (2008) in *Catharanthus roseus* inoculated with *Glomus mosseae*.

Plant fresh and dry weight of AM inoculated plants increased in all phosphate levels studied. After 100 days of AM inoculation, fresh and dry weight decreased in Gf+2P as well C+2P level, but was still higher in AM inoculated *Gmelina* as compared to non-AM inoculated plants (Table 1).

Per cent mycorrhizal colonization increased with an increase in phosphate level in early stages of colonization (Table 2). In our study there was significant increase in per cent root colonization during 45 and 75 days of *G fasciculatum* inoculation. It was decreased after 100 days of AM inoculation in Gf+2P level because of high P condition. It is reported that colonization, sporulation, and plant responses are inhibited by high soil P (Liu *et al*. 2000).

Total chlorophyll content consequently increased in AM inoculated plants than in non-AM inoculated control plants at low phosphate level (50 mg) after 45, 75, and 100 in days of inoculation. But at high phosphate level (200 mg), total chlorophyll content decreased in non-AM inoculated control plants (C +2P) as well as AM inoculated plants (Gf +2P) after 45, 75, and 100 days of AM inoculation (Table 2). Similar result was observed by Allen *et al*. (1981) in *Bouteloua gracilis* with phosphate addition.

Phosphatase was induced in the presence of *Glomus* spores and AMF are sensitive to the higher level of phosphate in the environment (Pacovsky *et al*. 1991). Selvaraj (1998) found that due to inoculation of AMF, *G. fasciculatum*, there was acid and ALP activity in leaves and roots of *Prosopis juliflora*. Similar results were obtained in *Gmelina* where ALP activity was found to be less affected as compared to acid phosphatase enzyme. Acid phosphatase activity increased in roots of *Gmelina* with increasing levels of phosphate, but it was found to decline in 100 days of AM activity in Gf+2P as well as C+2P treatment (Table 2). Thus, increase in acid phosphatase activity was similar to the earlier findings of AM inoculated *Moringa concanensis* plants (Panwar and Vyas 2002). ALP was found to increase significantly in C+1P and Gf+1P *Gmelina* plants, but decreased slowly in Gf+2P as well as C+2P level (Figure D and E).

Table 1 Morphological parameters of *Gmelina arborea* Roxb. inoculated with *Glomus fasciculatum* under two different phosphate levels

Treatments		*Leaf area* (cm^2)	*shoot Length* (cm)	*Root length* (cm)	*Fresh weight* (gm)	*Dry weight* (gm)
C	45	13.00 ± 1.447 d	15.90 ± 0.489 b	13.80 ± 0.282 c	2.540 ± 0.333 c	0.670 ± 0.110 d
	75	14.66 ± 0.542 d	20.66 ± 1.699 a	14.00 ± 1.414 e	2.930 ± 0.206 e	0.975 ± 0.076 c
	100	15.55 ± 2.216 c	25.33 ± 1.699 bc	23.00 ± 1.632 b	3.722 ± 0.482 b	1.167 ± 0.041 c
C+1P	45	14.37 ± 2.640 cd	16.96 ± 1.049 b	14.63 ± 0.449 bc	2.826 ± 0.253 c	0.891 ± 0.053 c
	75	17.33 ± 1.632 cd	22.00 ± 2.828 a	16.00 ± 0.816 d	3.266 ± 0.918 de	1.074 ± 0.044 c
	100	19.33 ± 2.160 bc	27.00 ± 1.632 b	23.66 ± 1.699 b	4.340 ± 0.175 b	1.498 ± 0.315 bc
C+2 P	45	18.33 ± 1.515 bc	18.03 ± 0.124 b	16.33 ± 0.471 bc	3.232 ± 0.033 bc	0.972 ± 0.019 bc
	75	21.00 ± 1.414 bc	23.00 ± 0.816 a	18.00 ± 1.632 c	3.790 ± 0.098 cd	1.099 ± 0.088 bc
	100	22 .66 ± 2.318 b	23.00 ± 1.632 c	22.33 ± 0.471 b	4.065 ± 0.396 b	1.445 ± 0.392 b
Gf	45	17.00 ±1.521 bcd	21.00 ± 0.816 a	16.00 ± 2.160 ab	2.638 ± 0.283 bc	1.077 ± 0.196 b
	75	19.22 ± 1.908 ab	22.50 ± 1.471 a	18.00 ± 0.816 c	3.556 ± 1.458 bc	1.162 ± 0.083 bc
	100	21.22 ± 1.908 ab	31.66 ± 1.247 a	29.33 ± 1.247 a	6.272 ± 0.198 a	1.885 ± 0.801 a
Gf+1P	45	19.33 ± 2.526 ab	22.33 ± 1.699 a	18.00 ± 0.816 ab	3.484 ± 0.643 b	1.042 ± 0.205 b
	75	22.77 ± 1.343 ab	23.33 ± 0.471 a	25.66 ± 0.471 b	4.250 ± 1.217 ab	1.298 ± 0.135 b
	100	24.44 ± 1.769 ab	33.66 ± 1.247 a	29.66 ± 0.942 a	6.763 ± 0.116 a	1.976 ± 0.223 a
Gf+2P	45	23.00 ± 0.820 a	23.00 ± 0.816 a	19.66 ± 0.471 a	4.564 ± 0.222 a	1.533 ± 0.165 a
	75	24.44 ± 1.812 a	24.66 ± 1.699 a	28.30 ± 0.942 a	4.490 ± 0.445 a	1.623 ± 0.290 a
	100	27.00 ± 2.943 a	27.33 ± 1.699 b	24.00 ± 0.816 a	6.344 ± 0.206 a	1.903 ± 0.259 a

Table 2 Biochemical parameters of *Gmelina arborea* Roxb inoculated with *Glomus fasciculatum* under two different phosphate levels.

Treatments		*Percent root colonization*	*Total Chlorophyll* (mg /gm of tissue)	*P content* (mg /gm X 10^{-3})	*Acid phosphatase* (moles pnp released / min/gm fresh weight)	*Alkaline phosphatase* (moles PNP released / min/gm fresh weight)
C	45	0.00	1.162 ±0.0183 e	13.98 ± 0.77 d	0.146 ± 0.012 e	19.53 ± 0.025 f
	75	0.00	1.671 ± 0.0143 c	17.48 ± 3.74 d	0.316 ± 0.022 e	27.60 ± 0.028 f
	100	0.00	1.816 ± 0.0626 d	22.04 ± 1.13 d	0.686 ± 0.018 d	28.30 ± 0.018 d
C+1P	45	0.00	1.302 ±0.0106 d	18.39 ± 1.55 c	0.254 ± 0.018 cd	21.84 ± 0.025 d
	75	0.00	1.625 ± 0.0099 d	27.52 ± 2.47 bc	0.478 ± 0.018 bc	28.77 ± 0.022 b
	100	0.00	2.224 ± 0.0115 b	29.80 ± 0.93 c	0.863 ± 0.018 b	30.23 ± 0.028 b
C+2P	45	0.00	1.377 ±0.0038 c	21.13 ± 1.87 c	0.282 ± 0.015 bc	22.47 ± 0.025 c
	75	0.00	1.493 ± 0.0082 e	23.87 ± 0.93 c	0.439 ± 0.018 cd	27.84 ± 0.020 e
	100	0.00	1.360 ± 0.0147 f	27.82 ± 0.98 c	0.714 ± 0.022 d	29.30 ± 0.701 c
Gf	45	70.00 ± 8.164 a	1.307 ±0.0063 d	14.59 ± 0.98 d	0.221 ± 0.015 d	21.78 ± 0.028 e
	75	86.66 ± 4.714 a	1.778 ± 0.0033 b	26.45 ± 1.70 bc	0.408 ± 0.025 d	28.20 ± 0.028 c
	100	83.33 ± 12.47 a	2.122 ± 0.0380 c	32.99 ± 1.13 b	0.699 ± 0.015 d	29.74 ± 0.031 bc
Gf+1P	45	73.33 ± 9.428 a	1.617 ±0.0056 b	25.84 ± 0.93 b	0.303 ± 0.015 ab	23.40 ± 0.025 b
	75	93.33 ± 4.714 a	1.988 ± 0.0033 a	29.49 ± 1.13 b	0.578 ± 0.018 a	29.46 ± 0.034 a
	100	90.00 ± 8.164 a	2.409 ± 0.0185 a	44.55 ± 0.21 a	1.010 ± 0.025 a	30.94 ± 0.025 a
Gf+2P	45	76.66 ± 9.428 a	1.798±0.0135 a	38.46 ± 1.76 a	0.323 ± 0.018 a	25.53 ± 0.022 a
	75	86.66 ± 9.428 a	1.618 ± 0.0070 a	35.58 ± 0.37 a	0.508 ± 0.018 b	28.05 ± 0.022 d
	100	83.33 ± 4.714 a	1.451 ± 0.0099 e	43.79 ± 0.74 a	0.809 ± 0.025 c	29.39 ± 0.022 c

Note Data were analysed by Duncan's multiple new range test and different small alphabetical letters indicate significant differences at p=0.05 level. C-Control, C+1P- Control with first Phosphate level, C+2P- Control with second Phosphate level, Gf-*G. fasciculatum*, Gf +1P-*G. fasciculatum* with first Phosphate level, Gf +2P- *G. fasciculatum* with second Phosphate level

Mycorrhizal roots have been known to absorb P faster as compared to non-mycorrhizal plants (Jakobsen *et al*. 1992). The study revealed that P content increased significantly in AM *Gmelina* plants as compared to non-AM plants. P content increased in 45 and 75 days of AM inoculated plants in all phosphate levels (Table 2). The increased P uptake may be a result of increased phosphorylase activity on the surface of mycorrhizal roots. The increment was observed to be greater in AM inoculated plants than non-AM inoculated control plants. After 100 days of AM inoculation it was found to be more in Gf +2P as compared to C +2P treatment (Table 2).

It is concluded that mycorrhizal fungi were able to enhance the absorption of nutrients from the soil, which could have moved to the roots principally by mass flow, in addition to those which could have diffused through the soil slowly. This has resulted in higher root biomass production in AMF inoculated *Gmelina* plants. Thus, the study suggests that mycorrhizal fungi may help *Gmelina* to perform better under moderate P conditions.

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Arbuscular mycorrhizal fungal diversity and distribution around natural salt lake of Lonar, Maharashtra, India

*Deotare P W and Wankhede T B**

Introduction

Lonar salt water lake is the oldest crater and third largest in size after the Bosmatvi lake in Ghana and another lake in New Quebec in Canada. This lake was created by hypervelocity meteoric impact some 520 00 years ago (Hawkes 1967). Past record showed that the crater water was extremely saline with its pH reaching 12.5. The lake at the bottom has a unique microecosystem that has led to evolution of new life forms, which endure salinity that is even higher than sea water. The forest in the crater is remarkably different from scrubby vegetation common to the countryside. The United States Geological Survey and the Geological Survey of India has confirmed that Lonar rocks are similar to moon rocks and are meteoric in origin (1973). The lake is geologically interesting and is the only inland natural lake situated in the Basaltic terrain. The mineral of the lake were formed from elements of Basaltic rock under tremendous heat.

Keeping this unique geological characteristic of the lake in mind, researchers from all over the world are attracted to know about microbial micro-ecosystems, which evolved and sustained in and around the lake thousands of years ago. The present investigation was carried out for the first time to report arbuscular mycorrizal (AM) fungal diversity and distribution in the shore soil of the lake.

Materials and methods

The diameter of the lake is about 1600 metres with a depth of 150 metres and absolutely confined from all sides by walls of the crater (Plate 1). The collection

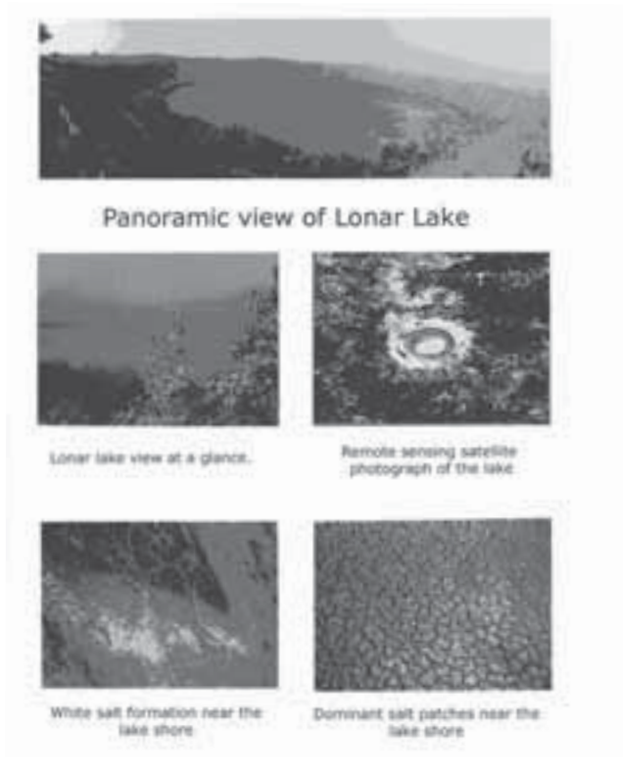

Plate 1 Panoramic view of Lonar Lake

sites were selected from four different directions of the lake. In all nineteen rhizospheric soil samples, along with the roots of four different plant species growing very close to the lake water, were collected.

The samples were collected from a depth of 10–15 centimetres in December 2005. Physiochemical analysis of all the soil samples were carried out on

Table 1 Phyicochemical characteristics of rhizophere soil

Soil	*North Zone*					*South Zone*				*West Zone*					*East Zone*				
characteristic	N1	N2	N3	N4	N5	S1	S2	S3	S4	W1	W2	W3	W4	W5	E1	E2	E3	E4	E5
Temp ˚C	30.7	30.9	31.4	31.2	30.7	31.0	32.3	31.4	31.2	31.0	31.2	32.4	32.0	30.8	32.o	31.3	31.0	31.2	30.8
pH	8.83	8.84	8.65	8,86	8.82	9.87	9.58	8.60	8.41	8.30	8.96	8.60	8.36	8.70	8.43	8.56	8.59	8.80	8.15
EC dsm^{-1}	3.2	3.0	3.5	3.2	3.6	1.8	1.6	3.2	4.1	3.1	2.5	3.6	2.8	1.3	5.7	3.5	4.9	5.2	4.7
TDS mg/L	2170	2070	2470	2168	2480	1160	1070	1780	2890	2250	1680	2750	2150	850	4070	2450	3850	3980	32.0
Salinity ppm	5.8	5.5	6.4	5.9	6.5	3.1	2.8	5.4	7.7	5.3	4.5	6.3	3.3	2.3	11.o	6.5	9.8	10.0	9.78

*Mycorrhizal Biotechnology Laboratory, P G Department of Botany, Shri Shivaji Science College, Amravati–444 603 (M S), India

the spot with the help of soil and water analysis kit. Phillips and Hayman (1970) procedure was employed to clear and stain the root samples for the detection of mycorrhizal infection. AM resting spores were extracted from the soil samples following wet-sieving and decanting technique of Gerdemann and Nicolson (1963). Estimation of spore density as per the spores colour was carried out according to the procedure given by Gaur and Adholeya (1994). Intact resting spores were picked up using fine capillary tubes and mounted in PVGL (Polyvinyl alcohol lactoglycerol) for taxonomic identification. The species of AM fungi (AMF) were identified according to the spore's characters, that is, spore colour, size, walls, contents, hyphal attachment, and other morphological characters given in the manual of Schenck and Perez (1990).

Result and discussion

Only four different plant species were found growing near the shore and were identified as *Acacia nilotica* (*seedlings*), *Bacopa moniera, Schoexopletus* sp., and *Typha angustata*. Physicochemical analysis of rhizospheric soil samples of these plant species was carried out and the data is presented in Table 1. It is evident from the table that the pH of the shore soil of the lake ranged between 8.31–9.87, electrical conductivity (EC) of the soil ranged between 0.8–5.7 dsm^{-1}, the total dissolved salts (TDS) ranged between 490–4070 mg/L, and the soil salinity was 1.4–11 ppm, thus, clearly indicating moderate to high alkaline nature of the shore soil. The terminal feeder roots of all the plant species were found to be colonized by AM fungal hyphae but arbuscules were not recorded in root cortical cells. Only thick-walled intracellular hyphal coils and intercellular vesicles were observed.

The spore count according to their broad colours were recorded to find out AM spore density (Table 2). The average spore count was found in between 361 to 889/100 grams of soil. The dark coloured spore especially black, brownish-black, and dark brown were maximum in number in comparison to light colored spores. Hyaline to light colored spores were found in very less number and were totally absent in the north zone.

Every individually isolated spore was identified taxonomically as per their morphological characters. Altogether 38 different AMF species, belonging to five different genera, were identified. *Glomus* was found to be the most dominant genus with 26 different species, followed by *Acaulospora* with 7, *Scutellospora* with 3, and *Sclerocystis* and *Gigaspora* with only one species

Table 2 AMF Spore density

S.No	*Zone*	*Site*	*Spore colour*	*Spore count*	*Average count/100g*
1	West	W1 + W2 + W3 + W4 + W5	Black to blackish-brown	910	361
			Dark brown to brown	878	
			Light colour	19	
2	South	S1 + S2 + S3 + S4 + S5	Black	491	290
			Brown	645	
			Light colour	25	
3	East	E1 + E2 + E3 + E4	Black	1948	889
			Brown	1544	
			Light color	64	
4	North	N1 + N2 + N3 + N4 + N5	Black	1300	432
			Brown	862	
			Light colour	00	

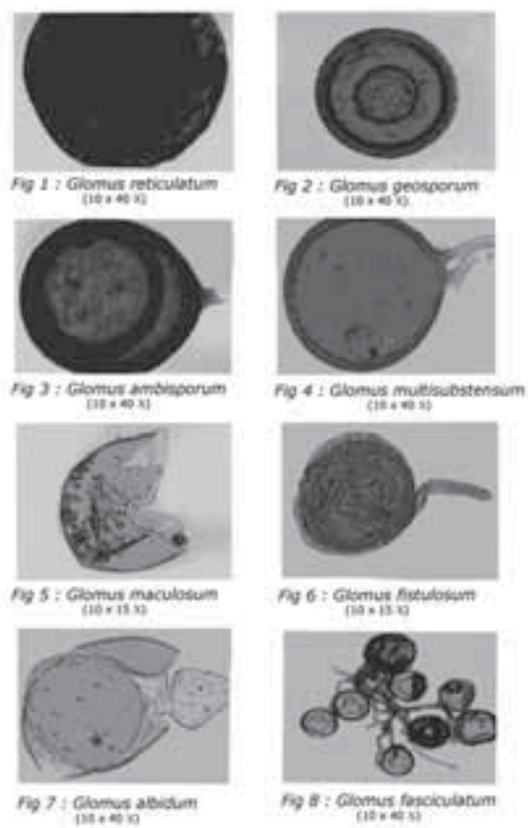

Plate 2 AM fungal diversity in and around Natural Salt Lake of Lonar, District Buldana, Maharashtra, India

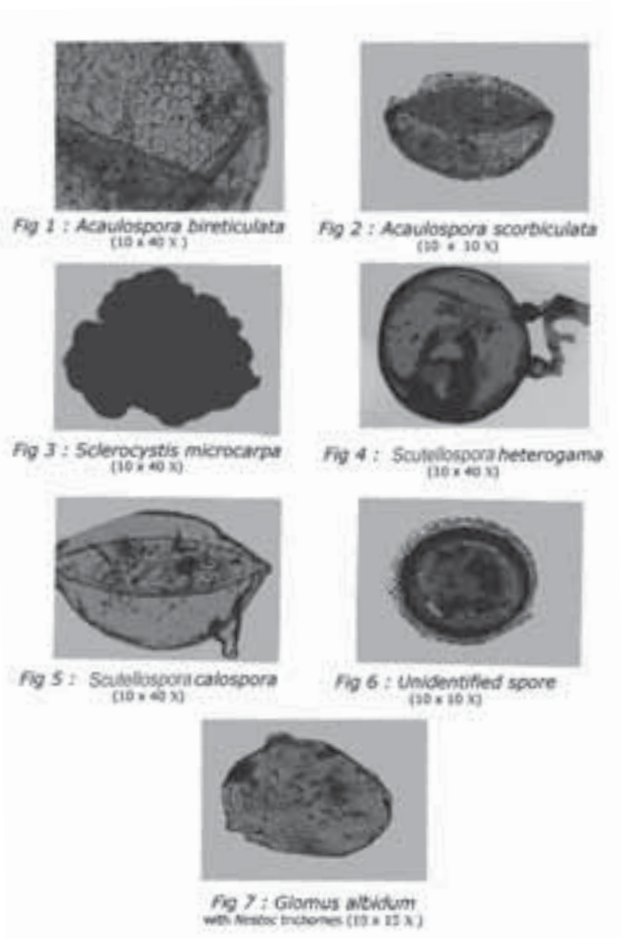

Plate 3 AM fungal diversity in and around Natural Salt Lake of Lonar, District Buldana, Maharashtra, India

of each. Black to brownish-black *Glomus* species, *G. reticulatum*, was recorded as the most dominant one followed by *Acaulospora bireticulata*, *G. geosporum*, and *G.ambisporum* (Table 3)(Plate 2 and 3).

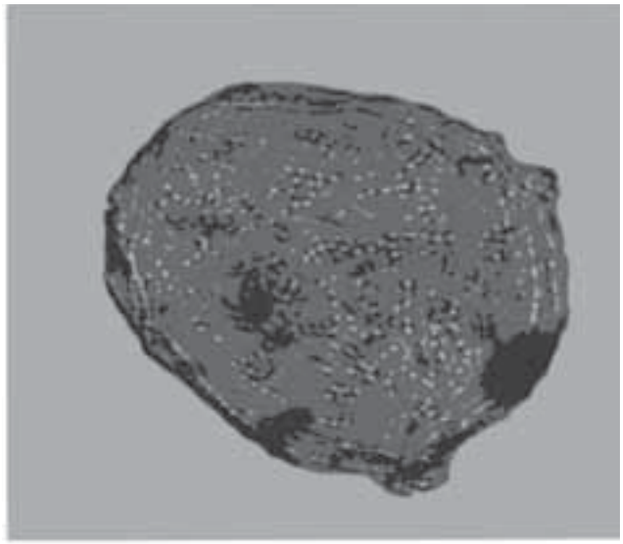

Plate 4 An enlarged view of *Glomus albidum* with *Nostoc* trichomes (10×15 X)

One very interesting and unique spore has been recovered from this soil (Plate 3 Figure7), which showed its similarity with the newly discovered species of *Geosiphon pyriforme*, a coenocytic fungus associated with *Nostoc punctiformae* (Schufsler 2002*)*. *G. pyriforme*, a fungus lives together with cyanobacteria on the surface and in the upper layer of wet soils, which are poor in inorganic nutrients especially phosphate (Kluge *et al.* 2002; Schufsler and Kluge 2001). This unidentified spore (named temporarily as *Glomus albidum*) is isolated from the same habitat as mentioned earlier by Kluge *et al* (2002). The isolated, unidentified spore, under present investigation, could be a glomelean fungus, which was colonized by *Nostoc* trichomes (Plate 4). This newly isolated species may represent a symbiotic association between glomalean fungus and a photoautotrophic prokaryotic alga. This

Table 3 Occurrence of AMF species around Lonar Lake

S.No.	*AMF Genus*	*AMF Species as per dominance*
1	*Glomus*	*G. reticulatum, G. geosporum, G. ambisporum, G. heterosporum, G. fecundisporum, G. multisubstensum, G. maculosporum, G. australe, G. fragllistratum, G. fistulosum, G. leptoticum, G. formosanum, G. callosum, G. mossae, G. pansihalos, G. pustulatum, G. etunicatum, G. melanosprum, G. botryoides, G. manihot, G. dimorphicum, G. clarum, G. albidum, G. fasciculatum, G. aggregatum, G. lacetum*
2	*Acaulospora*	*A. bireticuiata, A. lavies, A. scorbiculata, A. spinosa, A. denticulate, A. calospora, A. rehmi.*
3	*Gigaspora*	*G. albida*
4	*Sclerocystis*	*S. microcarpa*
5	*Scutellospora*	*S. minuta, S. heterogama, S. calospora.*

association could reflect an ancestral partnership like *Geosiphon pyriforme* and would provide an important model system for another symbiosis. It may bear a great potential for the study of many fundamental mechanisms and evolutionary questions concerning AM (Kluge *et al.* 2002). Thus, it can be assumed that during the evolution of plant life, the other symbiotic association in between AMF and photoautotrophic organisms might have existed.

One more different type of unidentified spore was recovered from the same soil (Figure 6). The spore looks exactly the same as AMF spore, but it showed few different unique morphological characters. Detail investigations are in progress for these two interesting organisms.

Conclusion

It is evident from the present investigation that AM fungal occurs naturally even under highly stressed and alkaline conditions of soil, which suggest their potential of adaptability and high biodiversity. AM species, *Glomus reticulatum*, is well adapted to these soil conditions and would be implemented to develop salt-tolerant AMF culture to reclaim salt-affected soils.

Acknowledgement

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Arbuscular mycorrhizal fungi in medicinal plants in Thrissur district, Kerala

*Sudha K and Ammani K**

Introduction

Arbuscular mycorrhizal fungi (AMF) are obligate biotrophic organisms that live symbiotically with the roots of plants. The nutrient deficient soils usually harbor more AMF (Sanders and Tinker 1973). Hence, their ecological significance is enormous. AMF acts as agents of plant nutrition and soil nutrition (Van Hiejden and Sanders 1998, 2003). The AMF are the obligate symbionts and they need a living plant root in order to grow and multiply. About 80%–90% of land plant species harbor AMF. AMF associations were also found in aquatic habitats (Khan 1974). AMF help in plant nutrition and disease resistance and also provide an alternative to chemical fertilizers particularly in land reclamation, habitat restoration and sustainable agriculture.

The state of Kerala with its wide array of topographical features such as coastlines along the Arabian sea, hills of Western Ghats, valleys, abundant water bodies including 49 rivers and 34 lakes, and bountiful backwaters. There is variety of different soils including red, ferruginous, sandy, black, peat lateric, and loamy soils in many parts of the state. Alluvium soil is usually found along the banks of the main rivers and broadly in the lower basins of the Pampa and Periyar rivers. These varied kinds of soils and the varying climatic conditions – ranging from tropical equable, hot, humid, and dry – enables the growth of an assortment of flora and other plantation crops. Among the almost 4000 flowering plant species, 900 species are highly sought medicinal plants.

There is more work on the incidence of AMF in relation to crop plants (Bagyaraj *et al.* 1979; Bagyaraj and Varma 1995), cereal crops (Ammani *et al.* 1985), vegetable plants (Creighton Miller *et al.* 1986) and cash crops and many others but there is a little work on medicinal plants in relation to AM colonization. Mohan *et al.* (2005) reported distribution of AMF in association with some important medicinal plants of Tamil Nadu. Medicinal plants form an integral part of life of people and the demand for medicinal plants has been increasing rapidly with the consumption of crude drugs. The pharmaceutical industries have embarked on large scale cultivation of medicinal plants to meet the increasing demand. In view of AMF being biofertilizer, biofarming with these fungi enhances the plant growth. Hence, in view of interest, survey was carried out on AMF distribution and their per cent of root colonization in medicinal plants in different places in Kerala.

Materials and methods

Rhizosphere soils and root samples of 57 medicinal plants were collected in different places in Thrissur district, Kerala. The roots were uprooted carefully and washed gently in tap water and made into small segments of 1 cm length. The roots bits were stained by the method of Phillips and Hayman (1970). The root bits were cleared in 10% KOH for about 30 minutes and then rinsed in tap water and acidified with dilute HCL. The root segments were stained with 0.1% Trypan blue in lacto phenol. The statined root bits were placed on a clean slide and covered with cover slip and gently pressed. The slides were observed under microscope for mycorrhizal colonization. The colonized and uncolonized root segments were counted and calculated.

Root colonization is usually estimated by recording the number of relative abundance of internal or attached mycelium, arbuscles, vesicles or spores. The colonized and uncolonized root segments were counted and calculated by the formula, which is as follows.

$$\text{Per cent of AM colonization} = \frac{\text{Total no. of roots segments colonized}}{\text{Total no. of root segments examined}} \times 100$$

The estimation of colonization provides a measure of the distribution of AM mycelium throughout the root system. The average number of vesicles per 1 cm root length is also determined by counting them in 50 root segment for each sample. The per cent of arbuscles were also determined in the same way.

Rhizosphere soil samples of 57 medicinal plants were collected and observed for fungal spores by wet sieving and decanting method (Gerdemann 1963). For this the 100 g soil sample was taken and suspension was made with water and the suspension of soil was passed through a series of graded sieves. Spores and sporocarps were observed under microscope for the identification of spores.

Results and discussion

The present study revealed that all the 57 medicinal plants investigated showed AM colonization in their roots and spore population in the rhizosphere soils. Spherical and elongated vesicles were observed. Both

* Department of Microbiology, Acharya Nagarjuna University, Guntur (A P) India

external and internal mycelium and arbuscles were observed. The spores of *Glomus mosseae*, *Gigaspora*, *Aculospora* and *Sclerocystis*, were observed in different places. *G. mosseae* and *Gigaspora* were dominant. The results are tabulated (Table 1–7).

Table 1 Plants collected from Panjal for AMF colonization

S. No	*Name of the plant*	*Family*	*% of external mycelium*	*% of internal mycelium*	*Arbuscles*	*Vesicles*	*No.of spores/ 100 g of soil*
1	*Adhatoda zeylanica* Medik. *(Addasaramu)*	Acanthaceae	6	43	-	39	16
2	*Ocimum sanctum* L. *(Krishna Tulasi)*	Labiatae	16	76	+	176	34
3	*Ocimum basilicum* L. *(Rama Tulasi)*	Labiatae	14	90	+	232	13
4	*Leucas aspara* (Wild.)Link. *(Tummi, Pronapushipi)*	Lamiaceae	6	88	-	56	6
5	*Coscinium fenestratum (Manu pasupu)*	Menispermaceae	10	41	+	13	-
6	*Argemone maxicana (Swarna kshiri)*	Papaveraceae	6	54	+	44	6
7	*Andrographis paniculata* (Burm. F.) Wall.ex Nees *(Nelavemu)*	Acanthaceae	-	70	+	96	116
8	*Acorus calamus* L. *(Sweet flag,Vasa)*	Araceae	10	68	-	72	4
9	*Mimosa pudica* L *(Touch me not plant)*	Mimosaceae	-	31	-	11	42
10	*Cymbopogon citratus* (DC.)Stapf*(Lemon grass)*	Gramineae	4	26	+	17	12
11	*Datura stromonium* L.	Solaneceae	-	34	-	12	6
12	*Glycirrhiza glabra* L.	Papilionaceae	-	95	-	13	33

All the data is a mean of three replicates.

All the plants collected from Panjal showed AMF root colonization (Table 1). The highest per cent of root colonization was observed in the plant *Glycirrhiza glabra* (95%) and the least per cent of root colonization was observed in *Tragia involucrate* (24%). The highest spore count was observed in *Andrographis paniculata* (116 spores/100g of soil). The least number of spore counts were recorded in *Acorus calamus* (4 spores/100g of soil). Internal hyphae and external hyphae, spherical to slightly elongated vesicles were observed. *Glomus* and *Gigaspora* were dominant among the spores identified.

Table 2 Plants collected from Killimangalam for AMF colonization

S. No	*Name of the plant*	*Family*	*% of external mycelium*	*% of internal mycelium*	*Arbuscles*	*Vesicles*	*No. of spores/ 100 g of soil*
1	*Phyllanthus emblica L. (Amlika)*	*Euphorbiaceae*	*12*	*81*	-	*46*	*18*
2	*Plantago ovata Forssk.*	*Plantaginceae*	*22*	*77*	-	*17*	*7*
3	*Boerhaavia diffusa L. (Punarnava)*	*Nyctaginaceae*	-	*95*	-	*116*	*22*
4	*Vitivera zizanoides (L.) Nash (Vettiver)*	*Gramineae*	*8*	*29*	+	*27*	*19*
5	*Achyranthes aspera L. (Uttareni)*	*Amaranthaceae*	*10*	*54*	+	*56*	*11*
6	*Atropa acuminata Royle ex Lindley(Belladona)*	*Solanaceae*	-	*54*	+	*46*	-
7	*Caesalpinia sappan L.(Bakaruchakka)*	*Caesalpininaceae*	-	*54*	+	*74*	*19*

All the data is a mean of three replicates.

All the plants collected from Killimangalam showed AMF root colonization (Table 2). The highest per cent of root colonization was observed in the plant *Boerhaavia diffusa* (95%) followed by *Hygrophylla auriculata* (92%) and the least per cent of root colonization was observed in *Vitivera zizanoides* (29%). Highest spore count was recorded in *Boerhaavia diffusa* (22 spores/100g of soil). The least spore number was noted in *Plantago ovata* (7 spores/100 g of soil). Internal hyphae and external hyphae, vesicles and arbuscles were observed. The rhizosphere soils were observed for spore population and *Glomus* was dominant.

Table 3 Plants collected from Shornur for AMF colonization

S. No	Name of the plant	Family	% of external mycelium	% of internal mycelium	Arbuscles	Vesicles	No. of spores/ 100 g of soil
1	Ixora coccinea L.	Rubiaceae	10	34	-	22	9
2	Hemidesmus indicus (L.) R. Br.(Sugandipala)	Pedaliaceae	2	75	+	22	18
3	Tinospora cordifolia (Wild.) Miers ex Hook. f.(Tippateega)	Menispermaceae	-	67	-	72	26
4	Mallotus philippensis L (Kamela,senduri)	Euphorbiaceae	14	65	-	56	33
5	Cinnamomum verum Presl.(Zeylanicum blume)	Lauraceae	-	42	-	38	-
6	Saraca asoca (Asoka) (Roxb.)de Wilde	Caesalpiniaceae	4	64	+	93	71
7	Mintha aravensis L.	Lamiaceae	-	32	+	21	8
8	Nauclea orientalis L.(Rajacadhambum)	Rubiaceae	-	34	-	12	4

All the data is a mean of three replicates.

The results for plants collected from Shornur are tabulated in (Table 3). All the plants collected from Shornur showed AMF root colonization. The highest per cent of root colonization was observed in the plant *Hemidesmus indicus* (75%) and the least per cent of root colonization was observed in *Mintha aravensis* (32%). Highest spore count was recorded in *Saraca asoca* (71 spores/100g of soil) and the least spore number was noted in *Nauclea orientalis* (Rajacadhambum) (4 spores/100g of soil). *Glomus mosseae* was found dominant.

Table 4 Plants collected from Talikulam for AMF colonization

S. No	Name of the plant	Family	% of external mycelium	% of internal mycelium	Arbuscles	Vesicles	No. of spores/100 g of soil
1	Rauvolfia serpentina (L.)Benth.ex Kurz(Sarpagandha)	Apocynaceae	-	76	+	56	18
2	Centenella asiatica (L.) Urban(SaraswathiakuM andukaparni)	Apiaceae/ Umbelliferae	-	66	-	14	23
3	Catharanthus roseus (L.)G.Don	Apocyanaceae	-	31	-	11	7
4	Coleus aromaticus (Doddapatre) Benth	Laminaceae	8	33	+	36	34
5	Eclipta prostrate (L.) L. (Bhringaraj)	Asteraceae	8	62	+	43	11
6	Gymnema sylvestre (Retz.)R.Br.ex.schult. (Sugar killer,Podapatri)	Asclepiadaceae	8	52	-	18	2
7	Ricinus communis L.	Euphorbiaceae	4	78	+	43	22
8	Pterocarpus marsupium Roxb. (Mahakutaj)	Fabaceae	-	72	+	63	9
9	Cymbopogon flexuosus (Nees ex Steud.)Watson	Gramineae	-	32	+	28	3
10	Mentha spicata L. (Spear mint, Pudina)	Laminaceae	4	68	+	43	32

All the data is a mean of three replicates.

All the plants collected from Talikulam showed AMF root colonization (Table 4). The highest per cent of root colonization was observed in the plant *Ricinus communis* (78%) and the least per cent of root colonization was observed in *Catharanthus roseus* (31%). Highest spore count was recorded in *Coleus aromaticus* (34 spores/100g of soil) and the least spore number was noted in *Gymnema sylvestre* (2 spores/100g of soil). *Glomus, Sclerocystis*, and *Acaulospora* were dominant from this place.

Table 5 Plants collected from Mulamkunnathukavu for AMF colonization

S.No	*Name of the plant*	*Family*	*% of external mycelium*	*% of internal mycelium*	*Arbuscles*	*Vesicles*	*No. of spores/ 100 g of soil*
1	*Euphorbia hirta L.(Reddivarinanubalu)*	*Euphorbiaceae*	*-*	*57*	*+*	*66*	*11*
2	*Solanium khasianum Clarke. (Khasia)*	*Solanaceae*	*-*	*37*	*-*	*26*	*18*
3	*Mucuna pruriens (L.) DC. (Dulagondi)*	*Fabaceae*	*-*	*43*	*-*	*26*	*12*
4	*Cassia fistula L. (Indian Laburnum,Suvarnaka)*	*Caesalpiniceae*	*12*	*79*	*+*	*44*	*2*

All the data is a mean of three replicates.

All the plants collected from Mulamkunnathkavu showed AMF root colonization (Table 5). The highest per cent of root colonization was observed in the plant *Cassia fistula* (79%) and the least per cent of root colonization was observed in *Solanium khasianum* (37%). Highest spore count was recorded in *Solanium khasianum* with 18 spores/100g of soil and the least spore count was noted in *Cassia fistula* (2 spores/100g of soil). Internal hyphae and external hyphae, vesicles, and arbuscles were observed. *Glomus mosseae* was dominant among the spores observed.

Table 6 Plants collected from Pattikad and Mannuthy for AMF colonization

S.No	*Name of the plant*	*Family*	*% of external mycelium*	*% of internal mycelium*	*Arbuscles*	*Vesicles*	*No.of spores / 100g of soil*
1	*Hyanthus enneaspermus (Ratnapurusha)*	*Violaceae*	*-*	*89*	*-*	*67*	*11*
2	*Trichopus zeylanicus Gaertn (Arogya pacha,Jeevani)*	*Trichopodaceae*	*2*	*44*	*+*	*54*	*-*
3	*Sida cordifolia L. (jayanti)*	*Malvaceae*	*-*	*56*	*+*	*84*	*13*
4	*Rauvolfia tetraphylla L. (Serpent wood Americana)*	*Apocynaceae*	*12*	*30*	*-*	*11*	*2*
5	*Solanum viarum Dunal*	*Solanaceae*	*-*	*87*	*+*	*88*	*22*
6	*Oxalis corniculata L.*	*Oxalidaceae*	*6*	*43*	*+*	*38*	*12*
7	*Acalypha Indica L. (Harittamanjari)*	*Euphorbiaceae*	*-*	*33*	*+*	*14*	*3*
8	*Marsilea quadrifolia L. (Chatuspatri)*	*Marsileaceae*	*-*	*41*	*-*	*8*	*18*
9	*Nardostachys grandiflora DC (Jatamansi)*	*Valerianaceae*	*4*	*32*	*+*	*13*	*23*
10	*Withania somnifera (L.) Dunal (Ashvagandha)*	*Solanaceae*	*28*	*68*	*+*	*56*	*9*
11	*Costus speciosus (Koen.) Smith*	*Zingiberaceae*	*-*	*29*	*+*	*11*	*7*

All the data is a mean of three replicates.

All the plants collected from Pattikad showed AMF root colonization (Table 6). The highest per cent of root colonization was observed in the plant *Hyanthus enneaspermus* (89%) and least per cent of root colonization was observed in *Costus speciosus* (29%). Highest spore count was noted in *Nardostachys grandiflora* (23 spores/100g of soil). Least spore count was observed in *Rauvolfia tetraphylla* (2 spores/100g of soil). *Glomus* and *Aculospora* were found to be abundant.

All the fifty seven plants examined harbored AMF in their root cells. *Glycirrhiza glabra* and *Boerhaavia diffusa* showed highest percentage of AM fungal colonization (95%). *Tagria involucrate* recorded the least AM fungal colonization (24%). The spore count in the rhizosphere soil was highest in *Andrographis paniculata* with 116 numbers per 100 g of soil.

From the per cent of root colonization and spore number, it was observed that there was no correlation between root samples and rhizosphere soils. These findings were in accordance with Ammani (1989, 1986) and Swapna and Ammani (2008).
Swapna and Ammani (2008) have surveyed vesicular arbuscular mycorrhizae (VAM) colonization in

Table 7 Plants collected from Manallur for AMF colonization

S. No	*Name of the plant*	*Family*	*%of external mycelium*	*%of internal mycelium*	*Arbuscles*	*Vesicles*	*No. of spores/ 100 g of soil*
1	*Lantana camara* L.	Verbanaceae	3	30	-	17	2
2	*Ocimum gratissimum* L.	Lamiaceae	-	56	+	46	66
3	*Ocimum americanum* L.	Lamiaceae	-	31	+	30	53
4	*Ocimum canum* Sims.	Lamiaceae	11	18	+	43	71
5	*Ocimum Kilmandscharicum* Guerke *(Camphor basil)*	Lamiaceae	11	78	+	36	51

All the data is a mean of three replicates.

The root colonization of plants collected from Manalur was tabulated (Table7). All the plants collected from Manalur showed AMF root colonization. The highest per cent of root colonization was observed in the plant *Ocimum kilmandscharicum* (78%) and the least per cent of root colonization was observed in *Ocimum canum* (18%). *Glomus, Gigaspora*, *and Aculospora* were highest in number.

medicinal plants in and around Acharya Nagarjuna University campus, Guntur, AP, and the study revealed that all the plant species had AM colonization in the roots and spore population in the rhizosphere soil. There is variation in per cent colonization in the root and spore population in different soils. Gupta *et al*. (2000) reported VAM association in *Ocimum* species. This report supports the present work in *Ocimum* plant. Govind Rao Y *et al*. (1989*)* observed AM association in 25 medicinal plants.

Mohan Kumar and Mahadevan (1984) observed absence of mycorrhiza in medicinal plants that they have studied. Many medicinal plants produce secondary substances like alkaloids, tannins, phenols, and so on. Their findings stated that because of these secondary substances the root system was not colonized by AMF. The present observations and other reports established that medicinal plants also harbour AMF. The absence of AMF in some colonization may be due to the absence of these fungi in the soil or due to the inhibitory effects of some alkaloids.

There was only one preliminary report from Kollenchery, Ernakulum district, Kerala, India, on AMF root colonization in medicinal plants (Gigi George and Malathy 2007). From the present study, it was observed that AMF are distributed widely in medicinal plants in different places in Kerala.

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Condolence

With profound grief, we inform the passing away of Prof. K.G.Mukerji, at his home on 17 January 2010. We pay tribute to his invaluable contribution to the growth of mycorrhiza research and deeply mourn the loss.

CENTRE FOR MYCORRHIZAL CULTURE COLLECTION

Functional analysis of mycorrhizal inoculation and leaf compost on different host plant

*Mohan Kumar S, Bhokta A, Uppal H S, Beri S, Singh R, and Adholeya A**

Abstract

Several experiments were set up to see the effects of the Centre for Mycorrhizal Culture Collection (CMCC) culture and local leaf compost treatments on different crops. The aim of this study was to investigate the effects of leaf compost material and mycorrhiza application on tomato, alfa-alfa, marigold, sorhgum, maize and bar seem growth, and nutrient uptake. The experiment was carried out in a polyhouse at the Centre for Mycorrhizal Research, TERI. The growth media was leaf compost and soil was used for seedling production. Plants were inoculated with 200 spores of CMCC culture from *in-vitro*, trap culture and monosporal culture per pot was placed 3 cm below the seeds. The result showed that compost materials contained different amounts of nutrients. Sorhgum and totamo seedlings showed different responses to each compost material. The results also showed that the mycorrhizal inoculation significantly increased plant root length, shoots, and phosphorus (P). Mycorrhizal inoculation also increased root colonization depending on compost materials.

Introduction

Compost is one of the main organic fertilizers. For optimum growth and balanced nutrition, plants need to be fertilized because soils are very low in plant nutrients, especially in P. P is an essential element for plant development and growth making up about 0.2% of plant dry weight. Plants acquire P from soil solution as phosphate anions. However, phosphate anions are extremely reactive and may be immobilized through precipitation with cations such as Ca2+, Mg2+, Fe3+, and Al3+, depending on the particular properties of soil. In these forms, P is highly insoluble and unavailable to plants. As a result, the amount available to plants is usually a small proportion of this total. With rising environmental concerns about heavy fertilization polluting the soil and water, it is very important to produce mycorrhizal inoculation in order to reduce the amount of chemical fertilizers.

Also very recently there has been a great demand for organic based agriculture. Mycorrhizal fungi (MF) are the most common symbiotic organisms, occurring on nearly 90% of plant species. Most horticultural plants are colonized by arbuscular mycorrhizal fungi (AMF) whose presence can enhance the growth of the host plant (Ortas and Varma 2008). MF can expand effectiveness of root surface area for better nutrient and water uptake. Also it has been reported by Douds *et al*. (1997) that MF seem to be stimulated in cropping systems, which incorporate crop rotations, green manures, reduced tillage, and minimize pesticides and chemical fertilizers while utilizing organic amendments.

Materials and methods

The experiment was carried out in a greenhouse at the Cente for Mycorrhizal Research, TERI. Domestic leaf compost material was produced, and its phosphate content was analysed. Three levels of phosphate were achieved by adding 60 gm, 120 gm, and 180 gm respectively. The corresponding results achieved were low, medium and high level respectively. The six different hosts were inoculated with AMF from CMCC. 200 mycorrhizal spores from three different sources – such as *in-vitro*, trap culture, and monosporal – were placed 3 cm below the seeds. The experiment was carried out in three ways using 60 gm, 120 gm and 180 gm of leaf compost on the basis of low, medium, and high content of P. The inoculated pots were left for three months incubation in a polyhouse at room temperature. Plant roots and

* Centre for Mycorrhizal Research, The Energy and Resources Institute, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi – 110 003, India

shoots were analysed for fresh root weight, dry root weight, fresh shoot weight, dry shoot weight and total P content in shoot.

Results and discussion

Compost made from plant waste had P content (0.15%) level. The results showed that the mycorrhizal inoculation significantly increased sorghum and tomato P content depending on compost materials. The efficiency of mycorrhiza, growth media and compost applications were different. Mycorrhizal colonization was investigated and it was found that

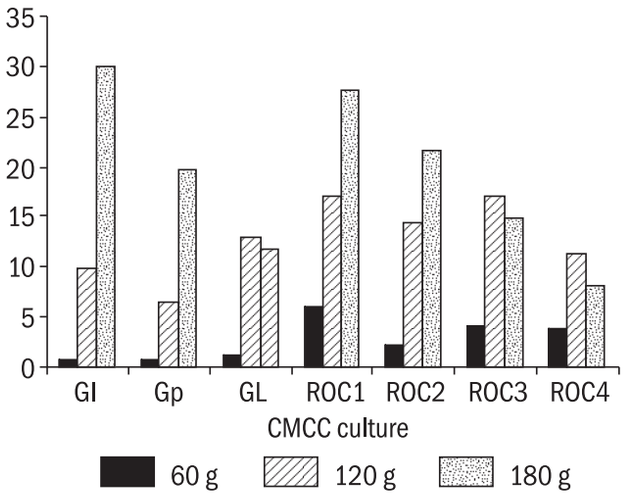

Figure 1 Effect of the compost and CMCC culture (*In-vitro* AMF spore) on sorghum shoots
*60 gm, 120 gm, and 180 gm indicates low, medium and high P level respectively

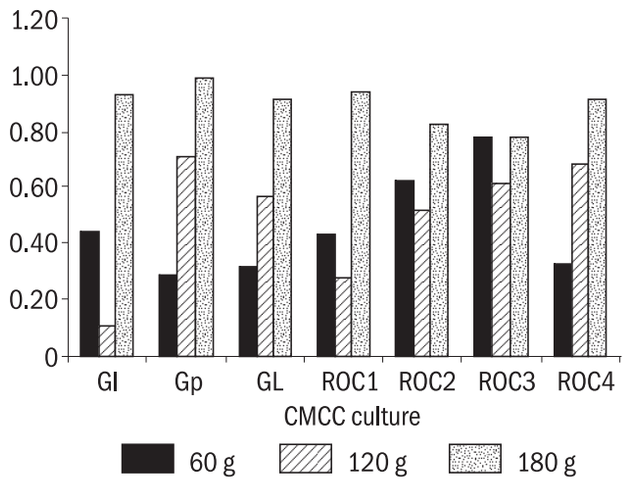

Figure 2 Effect of the compost and CMCC culture (*In-vitro* AMF spore) on phosphorus utilization by sorghum
*60 gm, 120 gm, and 180 gm indicates low, medium and high P level respectively

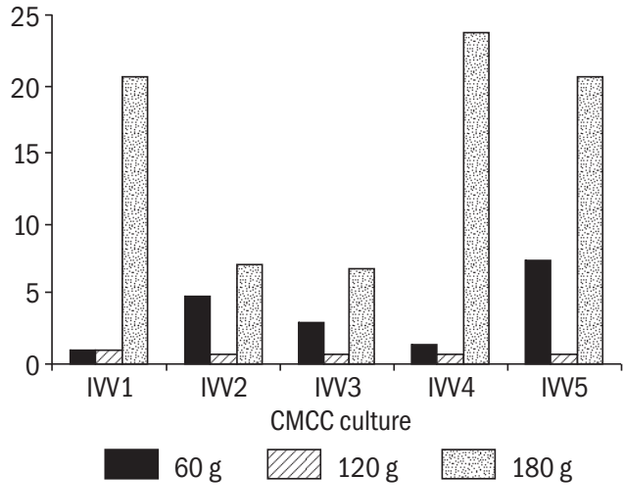

Figure 3 Effect of the compost and CMCC culture (Trap culture) on sorghum shoots
*60 gm, 120 gm, and 180 gm indicates low, medium and high P level respectively

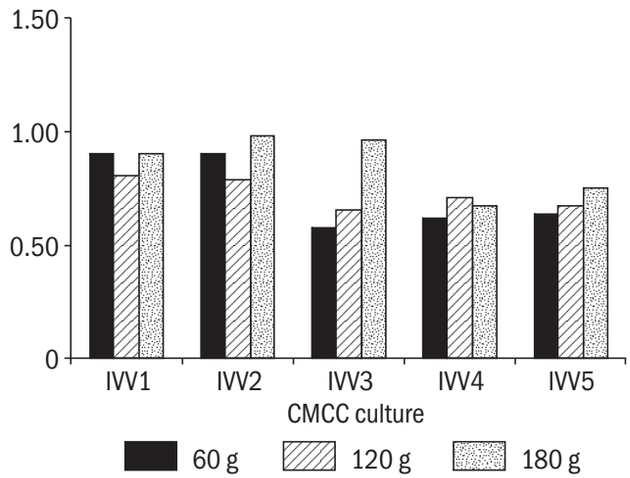

Figure 4 Effect of the compost and CMCC culture (Trap culture) on phosphorus utilization by sorghum
*60 gm, 120 gm, and 180 gm indicates low, medium and high P level respectively

mycorrhizal colonization levels differed in different levels of phosphate applied. MF can improve the performance of seedling quality by stimulating nutrient uptake (Ortas *et al.* 2004). In the present experiment, effects of different level of phosphate were analysed on mycorrhized plants.

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Authors are thankful to the Department of Biotechnology, India, for providing financial support for the establishment of CMCC at TERI, New Delhi

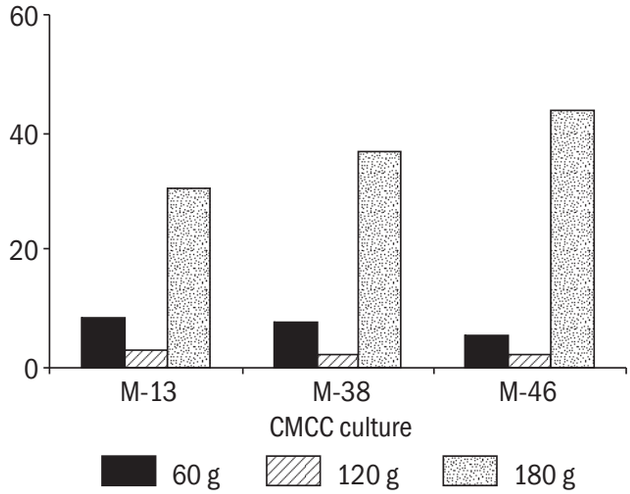

Figure 5 Effect of the compost and CMCC culture (Monosporal culture) on sorghum shoots
*60 gm, 120 gm, and 180 gm indicates low, medium and high P level respectively

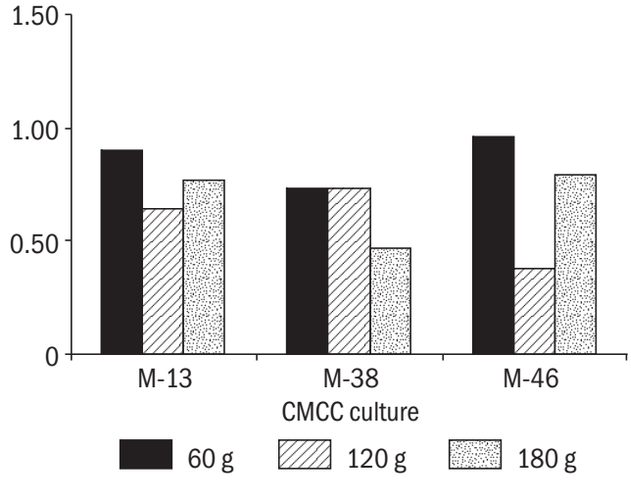

Figure 6 Effect of the compost and CMCC culture (Monosporal culture) on phosphorus utilization by sorghum
*60 gm, 120 gm, and 180 gm indicates low, medium and high P level respectively

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Khade S W*, Rodrigues B F. 2009	**Studies on arbuscular mycorrhization of papaya.** *African Crop Science Journal* **17**(3): 155–165 [Department of Botany, Goa University, Taleigao plateau, Goa – 403 206, India. E-mail: sharda_khade@yahoo.com]
Smith M E*, Douhan G W, Fremier A K, Rizzo D M. 2009	**Are true multihost fungi the exception or the rule? Dominant ectomycorrhizal fungi on *Pinus sabiniana* differ from those on co-occurring *Quercus* species**. *New Phytologist* **182**(2): 295–299 [*Farlow Herbarium and Department of Organismic and Evolutionary Biology, Harvard University, 22 Divinity Avenue, Cambridge, MA 02138, USA]
Lilleskov E A*, Bruns T D, Dawson T E, Camacho F J. 2009	**Water sources and controls on water-loss rates of epigeous ectomycorrhizal fungal sporocarps during summer drought.** *New Phytologist* **182**(2): 483–494 [USDA Forest Service, Northern Research Station, Forestry Sciences Laboratory, 410 MacInnes Drive, Houghton, MI 49931, USA]

FORTHCOMING EVENTS

CONFERENCES, CONGRESSES, SEMINARS, SYMPOSIUMS, AND WORKSHOPS

Pantnagar, **India**
24–27 February 2010

International Workshop on Rhizosphere Biology of Agriculture, Horticulture, and Forestry: Present and Future
Dr A K Sharma, Organizing Secretary, G B Pant University of Agriculture & Technology Pantnagar – 263145, Dist. Udham Singh Nagar, Uttarakhand (India)

Tel. 05944-233309; 233815 (R) • *Mobile*. 09457166676
Fax. 05944-233309; 233473 • *E–mail* anilksharma_99@yahoo.com
Web site www.gbpuat.ac.in

Edinburgh, **UK**
1–6 August 2010

IMC 9 - 9th International Mycological Congress
Mail: Elsevier, The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, UK

Tel. +44 (0) 1865 843297 • *Fax* +44 (0) 1865 843958
E–mail n.cosgrove@elsevier.com • *Web site* www.IMC9.info

Victoria, BC, **Canada**
8–12 August 2010

Fifth International Symposium on Physiological Processes in Roots of Woody Plants
Melanie JONES, University of Victoria, Victoria, BC, Canada

E–mail woodyrts@uvic.ca • *Web site* www.uvic.ca/woodyroot

Seattle WA, **USA**
22–27 August 2010

ISME-13: The International Society of Microbial Ecology
Washington State Convention and Trade Center, 800 Convention Pl Seattle, WA 98101, United States

Tel. +1 206-447-5000 • *Web site* http://www.isme-microbes.org/isme13

Mexico
6–10 September 2010

Sixth National and Third Ibero american Meeting on Mycorrhizae
Dr Alejandro Alarcon, Mexican Society on Mycorrhizal Symbiosis SOMESIMI

E–mail gsmico@hotmail.com or aalarconcp@gmail.com

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