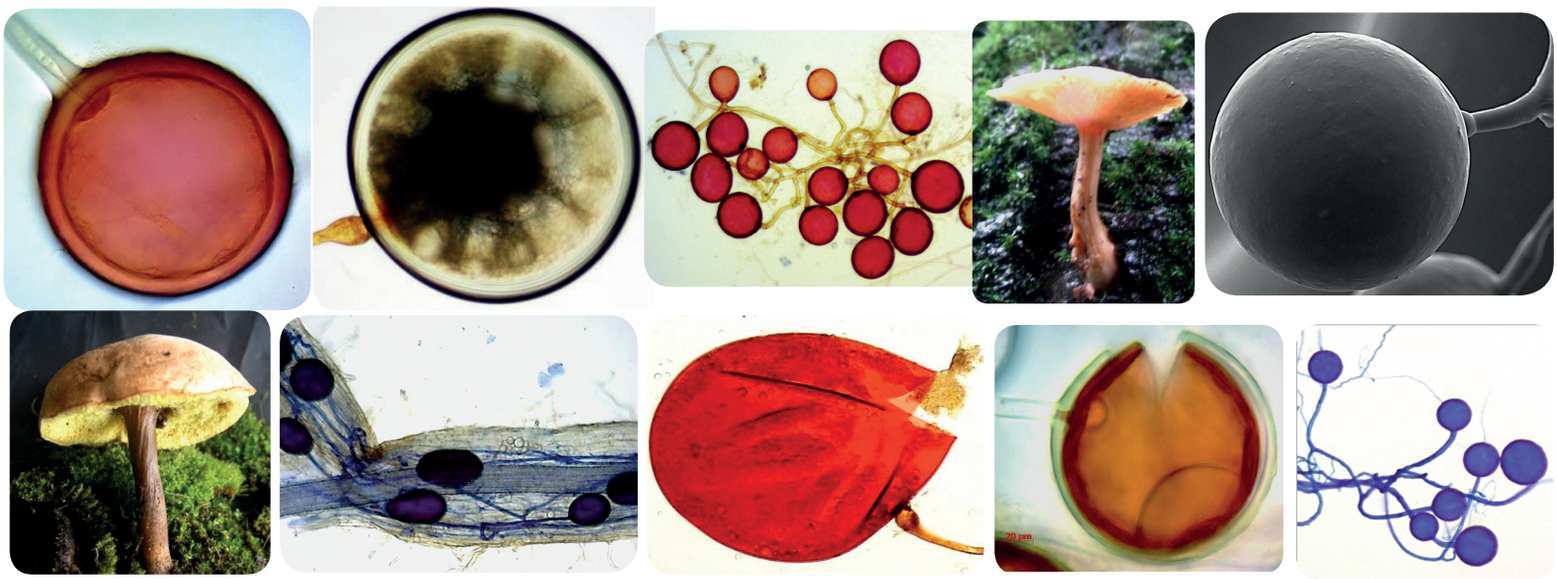
teri

MYCORRHIZA NEWS

The Quarterly Newsletter of Mycorrhiza Network

Volume 29 • Issue 4 • January 2018



About **TERI**

The Energy and Resources Institute (TERI) is a dynamic and flexible organization with a global vision and a local focus. TERI's focus is on research in the fields of energy, environment, and sustainable development, and on documentation and information dissemination. The genesis of these activities lies in TERI's firm belief that the efficient utilization of energy, sustainable use of natural resources, large-scale adoption of renewable energy technologies, and reduction of all forms of waste would move the process of development towards the goal of sustainability.

TERI's **Mycorrhiza Network**

TERI's Mycorrhiza Network is primarily responsible for establishing the Mycorrhiza Information Centre (MIC), the Centre for Mycorrhiza Culture Collection (CMCC), 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 the 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.

CONTENTS

RESEARCH FINDING PAPERS

Screening of Efficient Arbuscular Mycorrhizal Species for Growth Improvement of *Leucaena leucocephal*a (Lam.) de Wit at Coastal Saline Soil of West Bengal 2

CMCC ARTICLE
Morpho-taxonomy of *Glomus proliferum* (Accession CMCC/AM-1903) 7

RECENT REFERENCES 11

FORTHCOMING EVENTS 15

Screening of Efficient Arbuscular Mycorrhizal Species for Growth Improvement of *Leucaena leucocephala* (Lam.) de Wit at Coastal Saline Soil of West Bengal

Anjan Sengupta[*], Ananya Roy Chowdhury[a], and Biren Panja[b]

Introduction

Leucaena leucocephala, popularly known as 'subabul' in India, is a fast growing, higher biomass-producing mimosoid tree native to Southern Mexico and northern and southern America. During the 1970s and 1980s, it was promoted as 'Miracle Tree' for its multiple uses. It is used as a source of high protein content, palatable legume fodder (due to which it was also known as 'alfalfa of the tropics') for the cattle and also an important source of firewood/ charcoal/ green manure, higher biomass production, paper pulp, gums, resins, tannin, and dyestuff. It is considered as the prime candidate for restoration of soil cover, watersheds, grassland, soil nitrogen, physicochemical-, and microbiological properties. It is also a potential intercrop under agro-forestry system and could be used as live support as well as shade tree for many plantation crops. The introduction and cultivation of this crop at the marginal and fallow upland of coastal saline zone may provide these benefits to the growers. Besides, *Leucaena leucocephala* can withstand salinity and can grow well in soil having pH above 7.0. It is known to colonize by arbuscular mycorrhizae (AM) fungi (Rani and Bhaduria 2001) and is considered highly a mycorrhiza dependent crop (Manjunath and Habte1991). AM fungi can provide multiple benefits in terms of macro and micro nutrients nutrition and growth of host plant (Ojeda *et al.*1995; Oyetunji *et al.* 2008) establishment and restoration of vegetation at the disturbed sites, maintenance of inter-specific competition, plant succession, plant diversity (Van der Heijden *et al.* 1998), protection of host from certain plant pathogens (Azcon-Aguilar and Barea 1996), improvement of water relation and stress tolerance in plants (Davis *et al.* 2002), enhancement of fitness of plant to polluted environments (Gaur and Adholeya 2004) and contribute to soil aggregates and stability (Miller and Jastrow 1992) to the host plant.

Considering the significance of *Leucaena* and AM fungi, it can be assumed that the benefits to the *Leucaena* growers could be zoomed out by sustaining growth and improving biomass production of *Leucaena* through the integration of AM technology either by augmenting indigenous AM fungal population or through introducing exotic single species inoculums for their consortium. Though the AM fungi are believed to lack specificity, they continue to exercise preference towards certain plant or groups of plants (Mosse 1977). Such plants not only pick up preferred AM fungus or fungi and promote their growth, multiplication, and survival selectively, but also retrieve maximum benefit from this type of mycorrhizal association. Neither has any attempt been made to improve the growth of such a potential plant such as *Leucaena* with the help of mycorrhizal technology by augmenting indigenous mycorrhizal population nor has any effort been made in this regard by introducing exotic mycorrhizal species in sole or combined form. Keeping the above mentioned research gap in mind, an experiment was conducted with *Leucaena* seedlings inoculated separately with sole or combined form of single mycorrhizal species with a view to find out the best performing one with respect to improvements in its growth parameters.

Materials and Methods

An experiment was conducted with *Leucaena leucocephala* (Lam.) de Wit seedlings in the glass house of Bidhan Chandra Krishi Viswavidyalaya (BCKV)

* Department of Botany, Chakdaha College, Chakdaha, Nadia, West Bengal, India. Email:anjansengupta112@gmail.com
a Department of Botany, Chakdaha College, Chakdaha, Nadia, West Bengal, India. Email:ananya.chakdaha1@gmail.com
b Department of Plant Pathology, B C K V, Kalyani, West Bengal, Nadia, India. Email:birenpanja@rediffmail.com

Research Farm, at Kalyani (22^0 59′ 0″ N/ 88^0 29′0″E), India with coastal saline soil. It was laid out with five treatments in five replications following complete randomized block design. Four out of five treatments consisted of three arbuscular mycorrhizal (AM) fungal species, viz., *Funneliformis mosseae* (Gerdemann and Nicolson 1963) Walker & Schiiβler, *Glomus fasciculatum* (Thax. Sensu Gerd.) Gerdemann and Trappe, *Gigaspora margarita* Becker and Hall and a mixed consortium of the above mentioned three species. Control (heat killed inoculum) constituted the other treatment.

Starter culture inocula of three isolates obtained from the Mycorrhiza Research Laboratory, BCKV, Kalyani, Nadia, West Bengal, India, were multiplied as sole and mixed (equivalent quantity of sole culture) by inoculating maize seeds, sown in pots (30 cm height, 20 cm diameter) containing 4 kg steam sterilized soil, maintaining the inoculated plants for 60 days. Roots of inoculated maize plants with more than 85% mycorrhizal colonization were harvested separately, air dried, powdered, and mixed with their respective air dried soil and stored at room temperature for future experimental use. Mycorrhizal infectivity status of AM fungal sole and mixed inoculum and experimental soil was determined following ten-fold dilution series methods (Powel 1980) using sterile soil as diluents and taking *Cajanus cajan*as test plant for assessing their AM infective potential. The number of positive vials of last three dilutions was compared with the values of the most probable number (MPN) table (Alexander 1965). The number of infective propagules assessed per g was 56 for *Funneliformis mosseae*, 67 for *Glomus fasciculatum*, 65 for *Gigaspora margarita*, 72 for mixed inoculum, and 5.3 for experimental soil.

Leucaena leucocephala seedlings were raised from seeds sown in sterile coastal saline soil and maintained for a month. The one-month-old saplings were transplanted singly per 2.5 L PVC pot containing 2 kg experimental soil in five replicates. Plants under mycorrhizal treatment inoculated separately with three different mycorrhizal isolates and their mixed consortium with the amount of soil root mixed inoculum equivalent to 2,000 number of infective propagules. The seedlings under control were given equal amount of heat killed inoculum soil. Hence, for AMF inocula having MPN value of 56 and 67 per g, the dose of artificial inoculation would be 35.7 and 29.9 g, respectively, for per kg experimental soil to be inoculated.

Experimental plants were maintained for 120 days. No other treatment, except normal watering, was given to the seedlings during the entire period of experimentation. Data on plant growth parameters were recorded at the time of harvest. However, the dry weight of plant samples was recorded after reaching constant weight. Physicochemical analyses of soil samples were done according to Dewis and Freitas (1984). Mycorrhizal analysis of soil samples from study location for AMF spore density was carried out following the technique of wet sieving and decanting (Gerdemann and Nicolson 1963), and identified based on spore morphology as per the type description given by Schenck and Perez (1990). Plant roots were cleared and stained following the methods as described by Philips and Hayman (1970). AMF colonization in roots after clearing and staining was assessed as per the methods proposed by Kormanik and McGraw (1984).

Spore viability was estimated by MTT 3-(4,5 dimethylthiazol-YI-2,5-diphenyl-2H-tetrazolium bromide) vital stain procedure (An and Hendrix 1988).

Results and Discussion

Results of the physicochemical analysis of the experimental soil revealed that the soil had high electrical conductivity, slightly higher pH than the neutral, moderate organic matter percentage, very low available P but had high total N and available potassium (Table 1). So, the soil used under the experiment exhibited salinity stress with poor P status. Under such P nutritional and salinity stress in the rhizosphere, AM fungi can provide nutritional and other benefits to the host plant because of their ability to perform better in growth, multiplication, and function than other fungi. Mycorrhizal fungi have unique capacity to support plant growth under low P soil (Panja and Chaudhuri 2006) by increasing the zone of P acquisition and its efficient transportation to the plant cell through extra-radical hyphal network system (Hattingh *et al.* 1973). Mycorrhizal analysis of location soil exhibited poor mycorrhizal status in terms of quantity of total or viable/infective spore propagules and quality, that is,species richness and diversity (Table 2). Out of seven mycorrhizal species belonging to four genera recorded, *Funneliformis mossea*e was found dominant followed by *Gigaspora margarita, Glomus fasciculatum, Glomus multicaulis*, and others. A particular AMF species becomes dominant if it is preferentially favoured, picked up, and multiplied by specific host (Panja and Chaudhuri 1998). Besides, such AMF species exhibit better fitness, efficiency, and adaptability to an environment than others. For exploitation of plant growth promotion and nutrition uptake benefit, maintenance of population density of such AMF species is very critical. Augmentation of population density *in situ* could be done by selecting suitable mycotrophic crops (Panja and Chaudhuri 2004) or could be enhanced by exogenous application of single species inoculums or their consortium. As

the AMF population density of experimental soil was low and in that soil *Funneliformis mosseae*, *Gigaspora margarita*, *Glomus fasciculatum* are the dominant AM fungal species, hence the application of these species either in sole or their consortium from exogenous sources may be advantageous.

Three single AMF species were collected and their consortium was prepared. Thereafter, these sole and consortium of the three single AMF species were tested on *Leucaena* seedlings grown in coastal saline soil. Results of the experiment indicated that seedlings inoculated with either single species or their consortium improved all the growth parameters, such as twig and leaf number, stem, root- and internodal-length, stem diameter, fresh and dry weight of leaf, stem and root significantly over control (Tables 3 and 4). Among the three AMF isolates and their mixed consortium tested, *Gigaspora margarita*, mixed inoculum, *Glomus fasciculatum*, *Funneliformis mosseae* showed the highest and or at par increment of ten, seven, five, and four out of twelve parameters tested respectively. So, it is evident from the result that *G. margarita* appears to be better in promoting growth parameters of *Leucaena* seedlings than the other two single AM fungal cultures, *G. fasciculatum* and *Funneliformis mosseae* and even the mixed culture.

During screening of AM fungal species, Nalini *et al.* (1986) indicated earlier that *Gigaspora margarita*, *Glomus fasciculatum*, *Glomus monosporum* were most effective than others for obtaining healthy and vigorous *Leucaena* seedling. It is interesting to know from the present investigation that mixed or consortium culture exhibits better performance than that of the single species cultures of *G. fasciculatum* and *Funneliformis mosseae*. Combined inoculation of AMF species sometime gives more benefit than their sole inoculation as evident from the findings of Mallesha and Bagyaraj (1990) wherein they indicated that shoot and root growth of *L. leucocephala* were increased more by inoculation with *Gigaspora margarita* than with *Funneliformis mosseae*, while combined inoculation further increased the growth. Isolate(s) species showing best performance in growth and nutrition improvement of target crop under glass house condition have the potential for large-scale field use (Mallesha and Bagyaraj 1990).

It may be concluded from the results of the above mentioned experiment that *Gigaspora margarita* seems to be promising mycorrhizal candidate out of the other two single mycorrhizal species, *Funneliformis mosseae and Glomus fasciculatum* as well as of one mixed culture prepared from three single

Table 1: Physicochemical properties of coastal saline soil

Mechanical analysis			pH	EC(m.mhos/cm)	Organic carbon(%) Phosphorus (ppm)	Total nitrogen (%) Potassium (ppm)	Available	
Sand(%)	Silt (%)	Clay(%)	7.7	3.5	0.70	0.15	7.6	228
36.3	33.5	30.2						

Table 2: Mycorrhizal properties of coastal saline soil

Arbuscular mycorrhizal (AM) spore density per 100 g dry soil	Most probable number of AM spore density per g dry soil	Dominant AM fungal species
190.3	5.3	*Funneliformis mosseae>Gigaspora margarita> Glomus fasciculatum>Glomus multicaulis> Glomus spp.>Gigaspora spp.>Acaulospora spp.*

Table 3: Growth of different plant parts of *Leucaena leucocephala* inoculated with sole and consortium of three arbuscular mycorrhizal fungal species

AM fungal species and their consortium	Twig number	Leaf number	Stem length (mm)	Root length(mm)	Internodal length (mm)	Stem diameter (mm)
G.fasciculatum	11.6a+1.5	68.8b+3.3	70.3b+3.0	34.7+1.7	5.88a+0.51	1.32b+0.15
Funneliformis mosseae	12.2a+1.3	69.6b+7.5	72.7ab+5.8	30.5bc+2.3	5.40a+0.63	1030b+0.07
G. margarita	13.4a+2.1	76.6a+6.1	78.2a+5.9	31.8b+0.8	5.80a+0.29	1.54a+0.05
Mixed culture	12.0a+0.7	68.6b+4.2	71.1b+4.8	28.1c+2.6	5.68a+0.44	1.54a+0.23
Control	8.4b+1.1	42.6c+3.5	45.9c+3.0	32.7ab+2.9	3.70b+0.42	1.10c+0.07
SEm +	0.6	2.3	2.1	1.0	0.21	0.06
CD 0.05	1.9	6.9	6.1	2.9	0.62	0.18

Table 4: Fresh and dry biomass of *Leucaena leucocephala* inoculated with sole and consortium of three arbuscular mycorrhizal fungal species

AM fungal species and their consortium	Leaf fresh wt. (g)	Stem fresh wt. (g)	Root fresh wt.(g)	Leaf dry wt.(g)	Stem dry wt.(g)	Root dry wt.(g)
G.fasciculatum	4.650c+0.262	4.130b+0.540	2.050bc+0.075	1.158c+0.090	1.176ab+0.123	0.582b+0.045
F.mosseae	5.502b+0.585	4.190b+0.219	2.180b+0.103	1.392ab+0.079	1.086b+0.117	0.618b+0.033
G. margarita	6.1920a+0.394	5.108a+0.832	2.566a+0.131	1.262bd+0.160	1.324a+0.086	0.702a+0.057
Mixed culture	5.890ab+0.228	4.508ab+0.312	1.944c+0.330	1.426a+0.113	1.228ab+0.074	0.594b+0.055
Control	3.740d+0.338	2.738c+0.343	1.686d+0.104	0.958d+0.104	0.872c+0.240	0.464c+0.103
SEm +	0.171	0.224	0.078	0.048	0.063	0.020
CD 0.05	0.505	0.660	0.231	0.143	0.186	0.058

species for growth improvement of *Leucaena* at early seedling stage.

References

Alexander M.1965. Most probable number method for microbial populations. In: Black CA, Evans DD, White JL, Ensminger LE, Clark FE (Eds.) *Methods of Soil Analysis*, Part-II. Amer Soc Agron, Wisconsin, USA, pp. 1467–1472.

An ZQ and Hendrix JW.1988. Determining viability of endogonaceous spores with a vital stain. *Mycologia* **80**: 259–261.

Azcon-Aguilar C and Barea JM.1996. Arbuscular mycorrhizas and biological control of soil borne plant pathogens, an overview of the biological mechanisms involved. *Mycorrhiza* **6**: 57–464.

Davis FT, Olalde-Portugal V, Anguilera-Gomez L, Alvardo MJ, Ferrera- Cerrato RC, and Boutton TW. 2002. Alleviation of drought stress of Chile ancho pepper (Capsicm annum L. cv. San Luis) with arbuscular mycorrhiza indigenous to Mexico. *Sci Hortic* **92**: 347–359.

Dewis J and Freitas F.1984. Physical and chemical methods of soil and water analysis. FAO of United Nations, Rome, pp. 275.

Gaur A and Adholeya A.2004. Prospects of arbuscular mycorrhizal fungi in phytoremediation of heavy metal contaminated soils. *Current Science* **86**: 528–534.

Gerdemann JW and Nicolson TH.1963. Spores of mycorrhizal endospore species extracted from soil by wet sieving and decanting. *Trans Br Mycol Soc* **46**: 235–244.

Gianinazzi S and Schuepp H.1994. Impact of arbuscular mycorrhiza on sustainable agriculture and natural ecosystem. Birkhauser Velag, Basel, p. 226.

Hattingh MJ, Gray LE, and Gerdemann JW. 1973. Uptake and translocation of ^{32}P labelled phosphate to onion roots by endomycorrhizal fungi. *Soil sci* **116**: 383–387.

Kormanik PP and McGraw AC.1984. Quantification of vesicular arbuscular mycorrhizae in plant roots. In: Schenck NC (ed.) *Methods and Principle of Mycorrhizal Research*. The American Phytopathological Society, St. Paul, MN,USA, pp. 37–45.

Mallesha BC and Bagyaraj DJ.1990. Reaction of *Leucaena* to single inoculation versus dual inoculation with Glomus mosseae and/ or *Gigaspora margarita, Leucaena.Res Rep* **11**:56–57.

Manjunath A and Habte M.1991. Relationship between mycorrhizal dependency and rate variables associated with P uptake, utilization and growth. *Communications in Soil Sc. and Plant Analysis* **22**(13–14): 1423–1437.

Miller RM and Jastrow JD.1992. The application of VA mycorrhizae to ecosystem restoration and reclamation. In: Allen MJ(Ed.) *Mycorrhiza Functioning*. Chapman and Hall, New York, pp. 438–467.

Mosse B.1977. The role of mycorrhiza in legume nutrition on marginal soils. In: Vincent JM, Whitney AS and Bose J(eds) In: Exploiting the legume- *Rhizobium* symbiosis in tropical agriculture. Univ Hawaii, miscellaneous publication, pp. 175–292.

Nalini PA, Byra Reddy MS, and Bagyaraj DJ.1986. Selection of an efficient VA mycorrhizal fungus for *Leucaena*- A preliminary report. *Leucaena.Res Rep* **7**: 61–62.

Ojeda L, Hernandez C, Munoz P, Ferrazola E, and Herrera R.1995. Effectiveness of strains of mycorrhizae in the development of *Leucaena leucocephala* cv. *Peru. Pasturas Tropicalis* **17**(2): 36–39.

Oyetuniji OJ, Fagbola O, and Ososubi O.2008. Evaluation of contributions of *Glomus* species to uptake of micronutrient and its partitioning by cassava in sub-humid tropics. *Crop Research*, Hisar **35**(3): 237–244.

Panja BN and Chaudhuri S.1998. Effect of monoculture of spme plants on inoculums build up and quantitative distribution of different VA- mycorrhizal species. *Mycorrhiza News* **10**:13–15.

Panja BN and Chaudhuri S.2006. Screening of efficient arbuscular mycorrhizal species for growth and nutrition of lemon (*Citrus lemon* Burn F.) in red laterite soil of West Bengal. *J Interaca* **10**(3): 319–326.

Philips JM and Hayman DS.1970. Improved procedure for cleaning roots and staining parasites and VA-mycorrhizal fungi for rapid assessment of infection. *Trans Br Mycol Soc.* **55**: 158–161.

Powell CL.1980. Mycorrhizal infectivity of eroded soil. *Soil Biol Biochem* **12**: 247– 250.

Schenck NC and Perez Y.1990. Manual for the identification of VA mycorrhizal fungi. 3rd Edition, Synergistic Publications, Gainesville, FL, USA, p. 286.

Rani V and Bhaduria S.2001. Vesicular-arbuscular mycorrhizal association with some medicinal plants growing on alkaline soils of Manipuri district, Uttar Pradesh. *Mycorrhiza News* **13**(2): 12–14.

Vander Heijden MGA, Klironomos JN, Usic M, Peter M, Streitwolf-Engel R, Boller T, Wiemken A, and Sanders S. 1998. Mycorrhizal fungal diversity determines plant biodiversity, ecosystem variability and productivity. *Nature* **396**: 60–72.

Morpho-taxonomy of *Glomus proliferum* (Accession CMCC/AM-1903)

*Aditi Pandit, Varsha, and Alok Adholeya**

Arbuscular mycorrhiza fungi (AMF) are the obligate symbiotic associations formed with majority of the terrestrial plants, covering almost 80% of the land plant species (Smith and Read 2008). To identify the microorganism of this unique group, various morphological characterization analyses were done to identify the AMF at the level of species and genera. This study approach has helped many mycorrhizologists to perform AMF morphological feature identification and classification. For the identification of the AMF various features, such as spore size, number of wall layer, spore, hyphae size, hyphal wall orientation, hyphal attachments and spore reaction with different mounting reagents are of great importance (Souza 2015). There are also different research approaches for identification of the AMF species but one of the initial and crucial step is the morpho-taxonomic analysis.

In continuation to the previous articles, this current issue will focus on the morpho-taxonomical study of the AMF culture which was maintained under the greenhouse condition in the Centre for Mycorrhizal Culture Collection (CMCC), TERI, with the accession number of CMCC/AM-1903. The study has observed critically and insights in the detailed description of the morphology of CMCC/AM-1903.

Monosporal Establishment

The culture of this accession CMCC/AM-1903 was raised and isolated from the soil of Asia. For increasing the sporulation, the trap cultures were raised under greenhouse in pot conditions with *Sorghum bicolor* as the host plant. The traps were allowed to grow for three months and after the adequate life cycle of the *Sorghum* plant, soil samples were screened for diversity of spores using wet sieving and decanting method (Gerdemann and Nicolson 1963). Initially, the weighed soil was suspended in the distilled water and was passed through sieve of 60,100, and 300 British Standard Size (BSS). The sieving was critically analysed using light microscope for AMF density and diversity. Healthy and morphologically similar spores were selected to raise pure culture of the accession CMCC/AM-1903.

For studying the morpho-taxonomic features of the culture, voucher specimens were prepared. The voucher slides were prepared with two mounting reagents, polyvinyl lacto glycerol (PVLG) and Polyvinyl lacto glycerol: Melzer's reagent (1:1).

The raised cultures were allowed to grow under greenhouse conditions for three to six months, the roots of the host were stained and checked for colonization. Culture with morphologically similar spores are considered to be pure when compared with that of mother cultures which was used during the raising of the monosporals (Figure 1).

Spore Morphology and Shape

From the monosporals, spores were isolated and found to be present in loose aggregates and also sometimes occur in clusters, at times containing many hundreds of spores which have origin blastically at the tip of or intercalary inside hyphae branched from parent

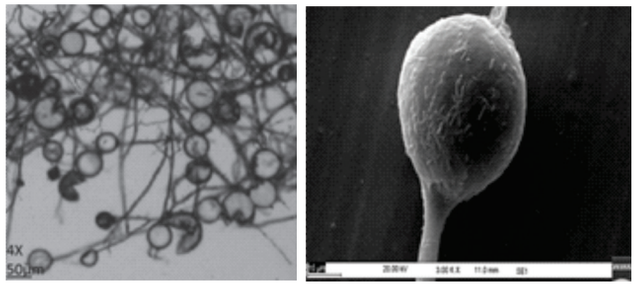


Figure 1 Compound microscopic image (4x) showing spores in clusters and scanning electron micrographs (SEM) of CMCC/AM-1903 showing spore with subtending hyphae

Centre for Mycorrhizal Research, Biotechnology and Management of Bioresources, The Energy and Resources Institute, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi 110 003, India
* Corresponding author, Email: aloka@teri.res.in

hyphae. Mostly the spore colour varied from hyaline to pale yellow to brown. The shape of the spores varied from globose to sub-globose. Scanning electron micrograph (SEM) of the spores showed smooth spore surface with subtending hyphae (Figure 2). The average diameter of the spores was found to be in the range of 42- (65) – 87 µm (Figure 3).

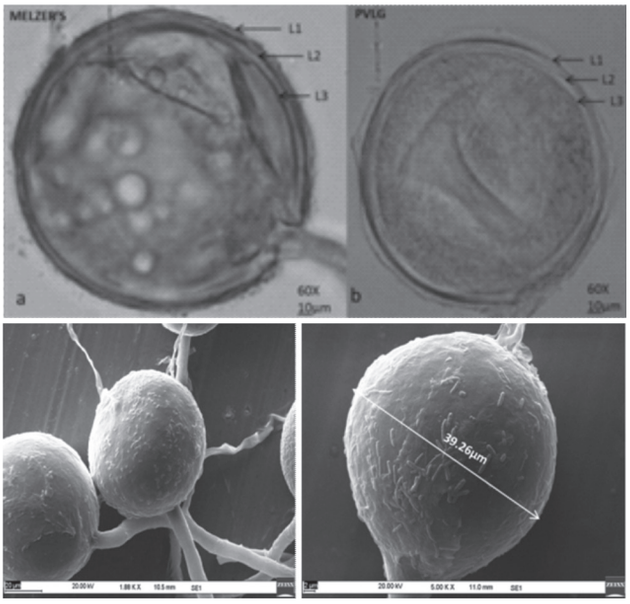


Figure 2 Compound microscopic image of spores mounted in Melzer's (a) and PVLG (b) and SEM of mature spores of accession CMCC/AM-1903 showing spore smooth surface.

Subcellular Structure of the Spore

Spore of this accession showed no or very less reaction with polyvinyl lacto glycerol: Melzer's reagent but no reaction was seen with polyvinyl lacto glycerol (PVLG).

The following subcellular structure and wall layer (Figure 4).

Spore Wall Layer 1 (L1)

Layer 1 is the outermost layer of the spore which is hyaline in colour and forms the spore surface. This layer is mucilaginous and smooth in nature when observed under the light microscope. The average thickness of this outermost layer is 1.0–1.5 µm. This layer is present in the complete life cycle of the spore, that is, from juvenile to mature spores.

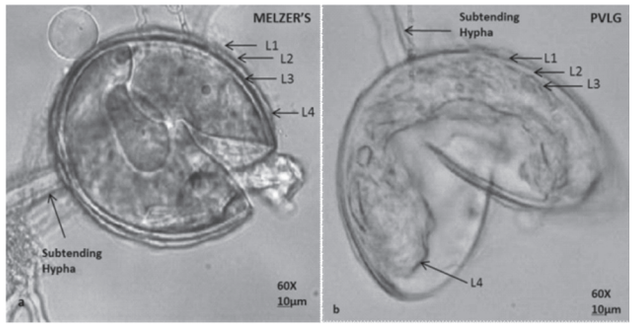


Figure 4 Compound microscopic images of spore wall layers of CMCC/AM- 1903 after mounting them in Melzer's (a) and PVLG reagents (b)

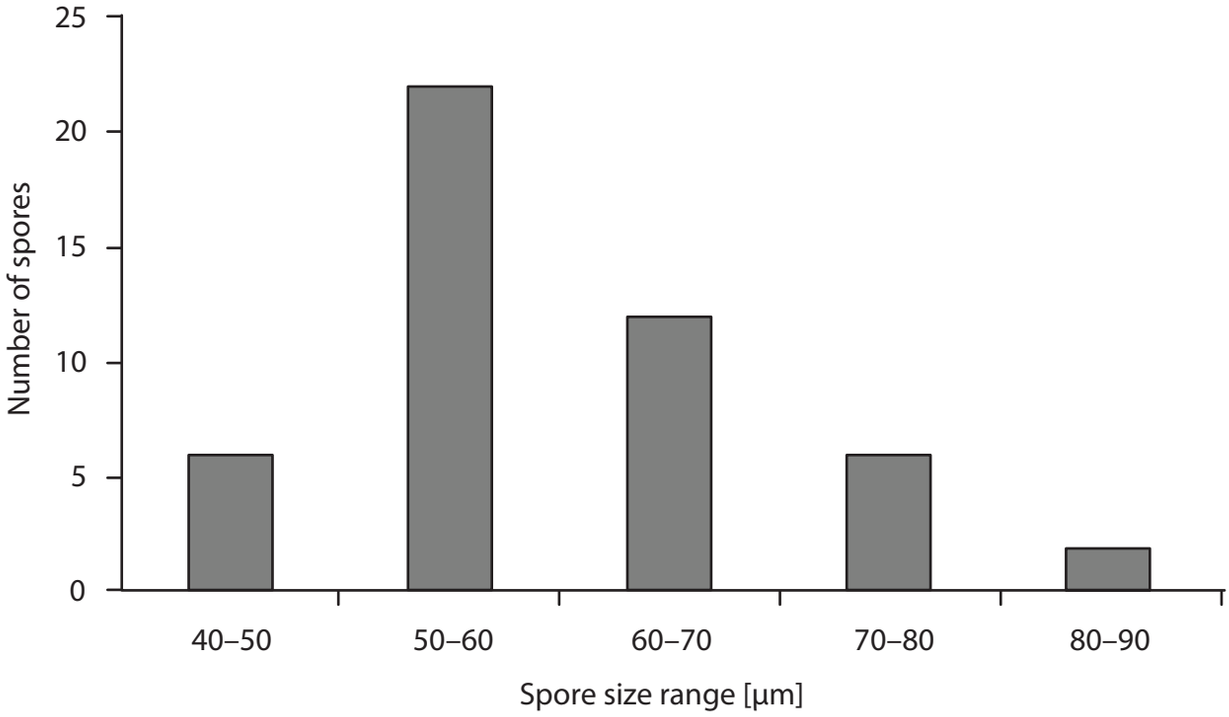


Figure 3 Analysis of spore diameter of 50 cleaned and mature spores obtained from one-year-old raised monosporal culture of accession CMCC/AM-1903.

Spore Wall Layer 2 (L2)

This layer is smooth and hyaline and is tightly adherent with the spore wall layer 1. This wall layer is semi-permanent and semi-flexible in nature. The thickness of this layer is 1.5-2.0 µm. This layer is also present throughout the life cycle of the spore.

Spore Wall Layer 3 (L3)

Layer 3 is hyaline, finely laminated, and its thickness varies. This laminated layer forms loose texture arrangement which can be seen within the spore in the form of like undulation structures. The average thickness of the layer is 1.5–2.0 µm. All three layers L1–L3 are present in the mature spores. But, there is presence of L4 (spore wall layer 4) which is again hyaline and smooth. But in old spores L4 is easily separated from layer 3 (Figure 5).

Subtending Hyphae

All the spores showed unique, cylindrical to slightly flared; recurved or straight subtending hyphae which is sometimes slightly constricted at the spore base. The width of the subtending hyphae at the point of attachment with the base of the spore varies from 5.0–8.0µm. The hyphal wall of the subtending hyphae has three layers continuous with spore wall layers 1–3 (Figure 6).

Mycorrhiza

The roots of the host plant *Sorghum,* in which the monosporal culture of this accession were raised were harvested. The roots were stained in ink-vinegar (Vierheilig *et al.* 1998) to screen the colonization. Different mycorrhiza structures, such as vesicles, hyphae, and spores were observed. Both intra-radical and extra-radical hyphae were seen. Abundant amount of intra-radical vesicles were observed in the root cortex (Figure 7).

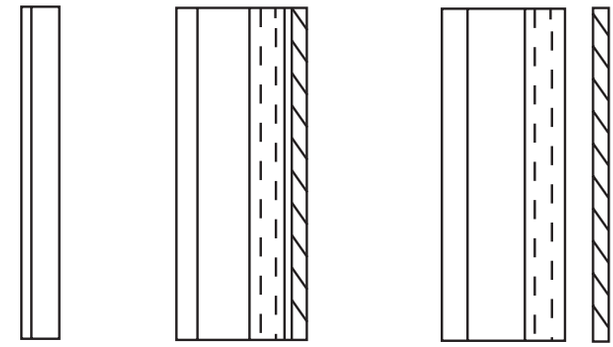


Figure 5 Murograph (Walker 1983) of the mature spore showing different wall layer found in different life stages of the spore

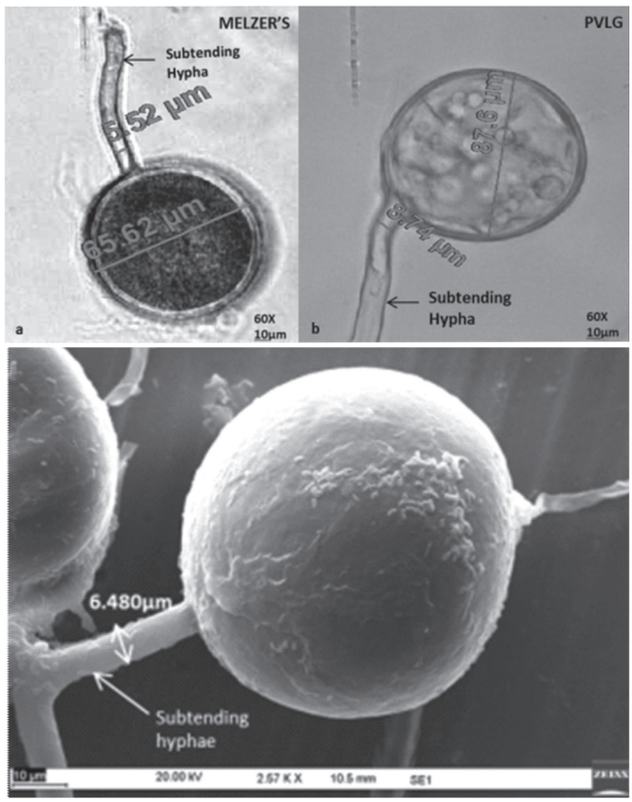


Figure 6 Compound microscopic images of the spores of CMCC/AM-1903 showing cylindrical hyphae (a and b).Scanning electron microscopy (SEM) image showing hyphae attached with the spore

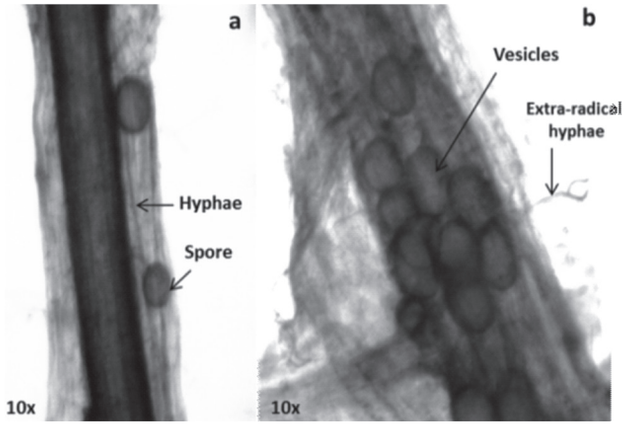


Figure 7 Compound microscopic images of roots of *Sorghum bicolor* stained with ink-vinegar solution and were observed for mycorrhiza structures and colonization. CMCC/AM-1903 showing presence of intra-radical hyphae and spores (a); and abundant vesicles and extra-radical hyphae (b)

Conclusion and Classification Level

On the basis of the above morpho-taxonomic analysis of the accession CMCC/AM-1903, many distinguishing features regarding the family, genera, and the species could be derived. The

following features were taken into consideration for characterization and identification:

- Globose to sub-globose, a sexual spores produced singly or in clusters with three-to four-layered spore walls.
- Spore wall layer is composed of outer hyaline layer followed by one inner fine sub-layer which is semi-flexible followed by a third layer.
- Spores are of varying shapes and sizes ranging from globose to sub-sub-globose.
- Formation of both intra-radical and extra-radical hyphae and abundant vesicles.

All these features suggest that the culture CMCC/AM-1903 belongs to the family of *Glomus proliferum* (Declerck *et al.* 2000).

Following are some of the unique morpho-taxonomic features of the accession:

- From pale yellow to pale orange-brown to orange in colour, globose to sub-globose, asexual spores produced singly with layered spore walls; spores are of varying shapes and sizes ranging from globose to sub-globose. Size ranges 42- (65)–80 µm.
- Spore wall layer is composed of outer hyaline layer, inner fine layer tightly adhered to the outmost layer, a third flexible innermost layer.
- Formation of both intra-radical and extra-radical hyphae and abundant vesicles and intracellular arbuscules.

The taxonomic feature of the accession CMCC/AM-1903 matches the characters of *Glomus proliferum* (Declerck *et al.* 2000).

Systematic Classification

Glomeromycota
Glomeromycetes
Glomerales
Glomeraceae
Glomus

Most of the work on AMF focusses on phylogeny, ecology, genetics, taxonomy, and functional properties. Identification of morphological features of an organism has been used as a conventional method for identifying an organism and comparing it with existing reference or type species. Morphological features about AMF spore morphology, wall layers, hyphal attachment, reaction with reagents, and so on help to reveal information about genera and species to which the AMF belongs. Sometimes, this approach can create a problem in identification of the organism at species level. Therefore, using alternative methods have more significant advantages over traditional taxonomic approaches. Characterization techniques, such as biochemical characterization through fatty acid methyl ester profiles and sequencing of ITS region of 18s rDNA (molecular characterization), have become more popular. Analyses of rDNA regions have often confirmed the morphologically defined species.

Acknowledgements

We acknowledge the contribution of Mr Awadesh for maintenance of AMF cultures. Technical assistance provided by Mr Chandrakant Tripathi during scanning electron microscopy of AMF spores is also thankfully acknowledged.

References

Declerck S, Cranenbrouck S, Dalpé Y, Séguin S, Grandmougin-Ferjani A, Fontaine J, and Sancholle M. 2000. *Glomus proliferum sp. nov.*: A Description Based on Morphological, Biochemical, Molecular and Monoxenic Cultivation Data. **92**:1178–1187.

Gerdemann JW and Nicolson TH. 1963. Spores of mycorrhizal Endogone extracted from soil by wet sieving and decanting. *Transactions of the British Mycological Society* **46**: 235–244

Smith S and Read D. 2008. Mycorrhizal Symbiosis. Third Edition. London: Academic Press

Souza T. 2015. *Handbook of Arcuscular Mycorrhizal Fungi*. Switzerland: Springer.

Vierheilig H, Coughlan AP, Wyss U, and Piché1 Y. 1998. Ink and Vinegar, a Simple Staining Technique for Arbuscular-Mycorrhizal Fungi. *Appl Environ Microbiol* **64**: 5004–5007.

Walker C. 1983. Taxonomic concepts in the Endogonaceae: III. The separation of Scutellospora gen. nov. from Gigaspora Gerd. & Trappe. *Mycotaxon* **27**: 169–182.

Recent references

The latest additions to the network's database on mycorrhiza are published here for the members' information. The list consists of papers from the following journals:

- *Agriculture, Ecosystems & Environment*
- *Applied Soil Ecology*
- *Biochimica et BiophysicaActa (BBA) - Proteins and Proteomics*
- *Biotechnology Reports*
- *Ecological Engineering*
- *Ecotoxicology and Environmental Safety*
- *Environmental and Experimental Botany*
- *Environmental Pollution*
- *European Journal of Soil Biology*
- *Fungal Ecology*
- *Geoderma*
- *Journal of Applied Research on Medicinal and Aromatic Plants*
- *Journal of Arid Environments*
- *Journal of Plant Physiology*
- *Mycoscience*
- *Physiological and Molecular Plant Pathology*
- *Plant Physiology and Biochemistry*
- *Rhizosphere*
- *Science of The Total Environment*
- *Soil Biology and Biochemistry*
- *Trends in Plant Science*

Name of the author(s) and year of publication	Title of the article, name of the journal, volume number, issue number, page numbers (address of the first author or of the corresponding author, marked with an asterisk)
Aguilera P*, Larsen J, Borie F, Berríos D, Tapia C, Cornejo P. 2018	**New evidences on the contribution of arbuscular mycorrhizal fungi inducing Al tolerance in wheat** *Rhizosphere* **5**: 43–50 [*Departamento de CienciasQuímicas y RecursosNaturales, Center of Amelioration and Sustainability of Volcanic Soils, Scientific and Technological Bioresource Nucleus, BIOREN-UFRO, Universidad de La Frontera, Av. Francisco Salazar 01145, Temuco, Chile]
Awoyemi OM*, Dzantor EK. 2017	**Toxicity of coal fly ash (CFA) and toxicological response of switchgrass in mycorrhiza-mediated CFA-soil admixtures** *Ecotoxicology and Environmental Safety* **144**: 438–444 [*Department of Agricultural and Environmental Sciences, College of Agriculture, Human and Natural Sciences, Tennessee State University, Nashville, TN 37209, USA, Email:doctoroma@yahoo.com]
Basu S*, Rabara RC, Negi S. 2018	**AMF: The future prospect for sustainable agriculture** *Physiological and Molecular Plant Pathology* **102**: 36–45 [*NMC Biolab, New Mexico Consortium, Los Alamos, NM, USA, Email sbasu@newmexicoconsortium.org]
Birhane E*, Aregawi K, Giday K. 2017	**Changes in arbuscular mycorrhiza fungi spore density and root colonization of woody plants in response to exclosure age and slope position in the highlands of Tigray, Northern Ethiopia** *Journal of Arid Environments* **142**: 1–10 [*Department of Land Resources Management and Environmental protection, Mekelle University, Mekelle, PO Box 231, Ethiopia, Email:emiru.birhane@mu.edu.et]
Demenois J*, Carriconde F, Bonaventure P, Maeght J-L, Stokes A, Rey F. 2018	**Impact of plant root functional traits and associated mycorrhizas on the aggregate stability of a tropical Ferralsol** *Geoderma* **312**: 6–16 [*AgroParisTech, 75 005 Paris, France, Email:demenois@iac.nc]
Dhawi F*, Datta R, Ramakrishna W. 2017	**Proteomics provides insights into biological pathways altered by plant growth promoting bacteria and arbuscular mycorrhiza in sorghum grown in marginal soil** *Biochimica et BiophysicaActa (BBA) - Proteins and Proteomics* **1865**(2): 243–251 [*Department of Biological Sciences, Michigan Technological University, Houghton, MI, USA]

Name of the author(s) and year of publication	Title of the article, name of the journal, volume number, issue number, page numbers (address of the first author or of the corresponding author, marked with an asterisk)
Feng Y*, Wang J, Yuan K, Zong W, Guo D. 2018	**Vegetation affects pool size and composition of amino acids in Tibetan alpine meadow soils** *Geoderma* **310**: 44–52 [State Key Laboratory of Grassland Agro-ecosystems, College of Pastoral Agriculture Science and Technology, Lanzhou University, 768 West Jiayuguan Road, Lanzhou, Gansu Province 730020, China]
Freitas MAM de*, Silva DV, Guimarães FR, Leal P L, Moreira FM de S, Silva AA da, Souza M de F. 2018.	**Biological attributes of soil cultivated with corn intercropped with *Urochloabrizantha*** in different plant arrangements with and without herbicide application *Agriculture, Ecosystems & Environment* **254**: 35–40 [*Instituto Federal de EducaçãoCiência e TecnologiaGoiano, Campus Posse, Posse, Goiás, Brazil]
Herrera P*, Kottke I, Molina M C, Méndez M, Suárez J P. 2018	**Generalism in the interaction of Tulasnellaceae mycobionts with orchids characterizes a biodiversity hotspot in the tropical Andes of Southern Ecuador** *Mycoscience* **59**(1): 38–48 [*Departamento de CienciasBiológicas, Universidad Técnica Particular de Loja, San Cayetano Alto S/n C.P, 11 01 608, Loja, Ecuador]
Junmin Li*, Liang H, Yan M, Chen L, Zhang H, Liu J, Wang S, Jin Z. 2017	**Arbuscular mycorrhiza fungi facilitate rapid adaptation of Elsholtzia splendens to copper** *Science of The Total Environment* 599–600: 1462–1468 [*Zhejiang Provincial Key Laboratory of Plant Evolutionary Ecology and Conservation, Taizhou University, Taizhou 318000, Zhejiang, China]
Leonardi P*, Iotti M, Zeppa S D, Lancellotti E, Amicucci A, Zambonelli A. 2017	**Morphological and functional changes in mycelium and mycorrhizas of Tuberborchii due to heat stress** *Fungal Ecology* 29: 20–29 [*Department of Agricultural Sciences, University of Bologna, vialeFanin 46, 40127 Bologna, Italy]
Mackay JE*, Cavagnaro TR, Stöver DSM, Macdonald LM, Grønlund M, Jakobsen I. 2017	**A key role for arbuscular mycorrhiza in plant acquisition of P from sewage sludge recycled to soil** *Soil Biology and Biochemistry* **115**: 11–20 [*The Waite Research Institute and School of Agriculture, Food and Wine, University of Adelaide, Waite Campus, Glen Osmond, SA, 5064, Australia, Email:jessica.mackay@adelaide.edu.au]
Mahanta D*, Rai RK, Dhar S, Varghese E, Raja A, Purakayastha TJ. 2018	**Modification of root properties with phosphate solubilizing bacteria and arbuscular mycorrhiza to reduce rock phosphate application in soybean-wheat cropping system** *Ecological Engineering* **111**: 31–43 [*ICAR-Indian Agricultural Research Institute, New Delhi, 110 012, India, Email:dibakar_mahanta@yahoo.com]
Novotná A*, Benítez A, Herrera P, Cruz D, Filipczyková E, Suárez JP. 2018	**High diversity of root-associated fungi isolated from three epiphytic orchids in southern Ecuador** *Mycoscience* **59**(1): 24–32 [*Department of Plant Taxonomy and Nature Conservation, University of Gdansk, WitaStwosza 59, 80-308 Gdansk, Poland, Email:alzbinovotna@gmail.com]

Name of the author(s) and year of publication	Title of the article, name of the journal, volume number, issue number, page numbers (address of the first author or of the corresponding author, marked with an asterisk)
Oyewole BO*, Olawuyi OJ, Odebode AC, Abiala MA. 2017	**Influence of arbuscular mycorrhiza fungi (AMF) on drought tolerance and charcoal rot disease of cowpea** *Biotechnology Reports* **14**: 8–15 [*National Horticultural Research Institute, Ibadan, Nigeria, Email:oyeebarry@yahoo.com]
Rillig MC*, Lehmann A, Lehmann J, Camenzind T, Rauh C. 2018	**Soil Biodiversity Effects from Field to Fork** *Trends in Plant Science* **23**(1): 17–24 [*Berlin-Brandenburg Institute of Advanced Biodiversity Research (BBIB), D-14195 Berlin, Germany, Email:matthias.rillig@fu-berlin.de]
Schmidt CS*, Mrnka L, Frantík T, Motyka V*, Dobrev PI, Vosátka M. 2017	**Combined effects of fungal inoculants and the cytokinin-like growth regulator thidiazuron on growth, phytohormone contents and endophytic root fungi in Miscanthus × giganteus** *Plant Physiology and Biochemistry* **120**: 120–131 [*Institute of Botany, Czech Academy of Sciences, Department of Mycorrhizal Symbioses, Zámek 1, 252 43 Průhonice - Chotobuz, Czech Republic, Email:Christoph.schmidt@ibot.cas.cz]
Sosa-Hernández MA*, Roy J, Stefan Hempel, TimoKautz, Ulrich Köpke, Marie Uksa, Michael Schloter, Tancredi Caruso, Matthias C. Rillig. 2018	**Subsoil arbuscularmycorrhizal fungal communities in arable soil differ from those in topsoil** *Soil Biology and Biochemistry* **117**: 83–86 [*Institute of Biology, Plant Ecology, FreieUniversität Berlin, Berlin, Germany]
Spagnoletti F*, Carmona M, Gómez N ET, Chiocchio V, Lavado RS. 2017	**Arbuscular mycorrhiza reduces the negative effects of *M. phaseolinaon* soybean plants in arsenic-contaminated soils** *Applied Soil Ecology* **121**: 41–47 [*MicrobiologíaAgrícola, Buenos Aires, Argentina, Email:spagnole@agro.uba.ar]
Stürmer L*, Oliveira LZ, Morton JB. 2018	**Gigasporaceae versus Glomeraceae (phylum Glomeromycota): A biogeographic tale of dominance in maritime sand dunes** *Fungal Ecology* **32**: 49–56 [Universidade Regional de Blumenau, Departamento de CiênciasNaturais, Blumenau, SC 89030-903, Brazil Sidney, Email:sturmer@furb.br]
Sujkowska-Rybkowska M*, Czarnocka W, Sańko-Sawczenko I, WitońD. 2018	**Effect of short-term aluminum stress and mycorrhizal inoculation on nitric oxide metabolism in *Medicagotruncatula* roots** *Journal of Plant Physiology* **220**: 145–154 [Department of Botany, Faculty of Agriculture and Biology, Warsaw University of Life Sciences (SGGW), Nowoursynowska Street 159, 02-776 Warsaw, Poland, Email:marzena_sujkowska@sggw.pl]
Sun X*, Shi J, Ding G. 2017	**Combined effects of arbuscular mycorrhiza and drought stress on plant growth and mortality of forage sorghum** *Applied Soil Ecology* **119**: 384–391 [*College of Forestry, Guizhou University, Guiyang, 550025, China, Email:sunxg0518@aliyun.com]
Suriyagoda LDB*, Dittert K, Lambers H. 2018	**Mechanism of arsenic uptake, translocation and plant resistance to accumulate arsenic in rice grains** *Agriculture, Ecosystems & Environment* **253**: 23–37 [*Department of Crop Science, Section of Plant Nutrition and Crop Physiology, University of Göttingen, Carl-Sprengel-Weg 1, 37075 Göttingen, Germany, Email:lalith.suriyagoda@uwa.edu.au]

Name of the author(s) and year of publication	Title of the article, name of the journal, volume number, issue number, page numbers (address of the first author or of the corresponding author, marked with an asterisk)
Tyagi J*, Varma A, Pudake RN. 2017	**Evaluation of comparative effects of arbuscular mycorrhiza (Rhizophagus intraradices) and endophyte (*Piriformospora indica*) association with finger millet (*Eleusine coracana*) under drought stress** *European Journal of Soil Biology* **81**: 1–10 [Amity Institute of Microbial Technology, Amity University Uttar Pradesh, Sector 125, Noida Express Way, Noida, U.P 201313, India]
Wang S*, Augé RM, Toler HD. 2017	**Arbuscular mycorrhiza formation and its function under elevated atmospheric O3: A meta-analysis** *Environmental Pollution* **226**: 104–117 [*Department of Environmental Science and Engineering, Beijing University of Chemical Technology, Beijing, 100029, China, Email:shgwang2013@126.com]
Wu S*, Hu Y, Zhang X, Sun Y, Wu Z, Li T, Lv J, Li J, Zhang J, Zheng L, Huang L, Chen B. 2018	**Chromium detoxification in arbuscular mycorrhizal symbiosis mediated by sulfur uptake and metabolism** *Environmental and Experimental Botany* **147**: 43-52 [*State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, 100085, People's Republic of China]
Yagame T*, Funabiki E, Yukawa T, Nagasawa E. 2018	**Identification of mycobionts in an achlorophyllous orchid, *Cremastraaphylla* (Orchidaceae), based on molecular analysis and basidioma morphology** *Mycoscience* **59**(1): 18–23 [*Tsukuba Botanical Garden, National Museum of Nature and Science, 4-1-1, Amakubo, Tsukuba, Ibaraki 305-0005, Japan, Email:sebacina@gmail.com]
Zardak SG*, Dehnavi MM, Salehi A, Gholamhoseini M. 2017	**Responses of field grown fennel (*Foeniculumvulgare* Mill.) to different mycorrhiza species under varying intensities of drought stress** *Journal of Applied Research on Medicinal and Aromatic Plants* **5**: 16–25 [*Agronomy and Plant Breeding Department, Yasouj University, Yasouj, Iran]
Zitlalpopoca-Hernandez G*, Najera-Rincon MB, del-Val Ek, Alarcon A, Jackson T, Larsen J. 2017	**Multitrophic interactions between maize mycorrhizas, the root feeding insect Phyllophagavetula and the entomopathogenic fungus Beauveriabassiana** *Applied Soil Ecology* **115**: 38–43 [*Instituto de Investigaciones en Ecosistemas y Sustentabilidad, Universidad Nacional Autónoma de México (UNAM), Antigua Carretera a Pátzcuaro 8701 Ex-hacienda San José de la Huerta, 58190 Morelia, Michoacán, Mexico]

Forthcoming events
conferences, congresses, seminars, symposiums, and workshops

Lisbon, **Portugal**
February 1–3, 2018

8th Advances against Aspergillosis

Hartley Taylor Medical Communications Ltd, Caledonian House, Tatton Street, Knutsford, Cheshire, WA16 6AG, England
Tel.: +44 (0)1565 621967 • *Email:* derry@hartleytaylor.co.uk • *Website:* http://aaa2018.org/

Gurugram, **India**
February 22–24, 2018

Hands-on Training-cum-Workshop on Techniques in Mycorrhizal Research for Sustainable Agriculture and Forestry

Centre for Mycorrhizal Research, Sustainable Agriculture, TERI, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi 110 003, India
Tel.: 9810793533 • *Email*:reenas@teri.res.in, tpsankar@teri.res.in • *Website*: http://mycorrhizae.org.in/

Haifa, **Israel**
February 25–28, 2018

14th European Conference on Fungal Genetics

ECFG14 Conference Secretariat, Diesenhaus-Unitours Incoming Tourism Ltd, Conventions Department, 3 Hamelacha Street, P.O. Box 57176, Tel Aviv 61571, Israel
Tel.: +972(0)3-5651344, +972(0)3-5651313
Email: ecfg14-reg@diesenhaus.com
Website: http://www.ecfg14.org/

London, **United Kingdom**
March 2–3, 2018

13th Annual Fungal Update

Tel.: +44 (0) 1353 780 060 • *Email:* organisers@fungalupdate.org • *Website:* http://fungalupdate.org/

Bengaluru, **India**
March 2–4, 2018

12th National Conference of Society of Indian Human and Animal Mycologists
Conference Secretariat: Dr Jayanthi Savio, Organizing Secretary SIHAM 2018,
Department of Microbiology, St. John's Medical College, Sarjapur Road, Bengaluru 560 034, Karnataka

Tel.: 080-4946-6253, Mobile: 09880250127
Email: contact@siham2018.com / sjmc.micro.conf@stjohns.in
Website: http://www.siham2018.com/

Sydney, **Australia**
March 29–30, 2018

ICAMB 2018: 20th International Conference on Applied Mycology and Biotechnology

Website: https://www.waset.org/conference/2018/03/sydney/ICAMB

Providence, **Rhode Island**
April 15–19, 2018

14th ASM Conference on Candida and Candidiasis
ASM Conference on Candida and Candidiasis, Experient Inc., 5202 Presidents Court Ste 310, Frederick, MD 21703

Email: ASMConferences@experient-inc.com
Website: https://www.asm.org/index.php/14th-asm-conference-on-candida-and-candidiasis

Paris, **France**
April 19–20, 2018

ICFMMR 2018: 20th International Conference on Forest Mycology and Mycorrhiza Research

Website: https://waset.org/conference/2018/04/paris/ICFMMR

Amsterdam, **The Netherlands**
June 28–29, 2018

12th World Congress on Biotechnology and Microbiology Conference

Email: microbialbiotech@microbiologymeetings.com, events@conferenceseries.com, microbialbiotech@microbiologymeetings.com
Website: https://microbiology.annualcongress.com/

Amsterdam, **The Netherlands**
July 2–6, 2018

20th Congress of the International Society for Human and Animal Mycology (ISHAM)

Tel.: +31(0)73 6901415 *Fax:* +31(0)73 6901417
Email: info@congresscare.com *Website:* www.congresscare.com

Paris, **France**
July 4–6, 2018

Plant Sciences for the Future: International Conference SPS 2018
GIS Biotechnologies Vertes, 28 rue du Docteur Finlay, 75015 Paris

Tel.: + 33 (0)1 42 75 95 86 • *Fax:* + 33 (0)1 45 75 63 45 • *Website:* https://symposium.inra.fr/sps-conference-2018

Toronto, Ontario, **Canada**
July 11–12, 2018

7th International Conference on Environmental Microbiology & Soil Microbiology

Email: environmentalmicrobiology@microbiologyconferences.org
Website: https://environmentalmicrobiology.conferenceseries.com/

ISSN 0970-695X Regd No. 49170/89 ₹75/-

Hands-on Training-cum-Workshop on Mycorrhizal Research Techniques

The Centre for Mycorrhizal Research, TERI (The Energy and Resources Institute), New Delhi, with support from the Department of Biotechnology, Government of India, is organizing a Hands-on Training-cum-Workshop on Mycorrhizal Research Techniques.

The course will be held from 21-23 February,2018 at two places, viz., (i) The Energy and Resources Institute (TERI), India Habitat Centre, Lodhi Road, New Delhi and (ii) The RETREAT, TERI Gram, Gual Pahiri, Gurgaon-Faridabad Road, Gurgaon, Haryana. A certificate of successful completion will be provided upon conclusion of the programme.

The specific areas include

- Basic work, involving isolation and identification of mycorrhiza;
- Applied work, involving selection, culture, and inoculation of arbuscular mycorrhizal fungi under nursery and field conditions;
- Advanced techniques, involving molecular and biochemical tools; and
- Promoting an understanding on the relevance of mycorrhizal research in the Indian context.

The participants will be trained on the different aspects of mycorrhizal fungi. Practical laboratory sessions will be supported by lectures and discussions. This will include:

- Recovery and quantitative estimation of AM (arbuscular mycorrhizal) spores from soil
- Image analysis of AM spores
- Assessment of intraradical colonization by AM fungi
- Trap culturing and monosporal culturing for AM
- Biochemical and molecular characterization of AM fungi
- Bio-safety issues
- Impact of IPR (intellectual property right) regimes on agricultural biotechnology issues

Technical manuals containing all experimental protocols will be provided to the participants.

Participants

Researchers and budding scientists who are engaged in the field of mycorrhiza research; technologists and middle-level scientists from the government; agriculturists (who are involved in organic farming); agricultural technology information centre, ICAR; students and faculty from State Agricultural Universities; farmer-entrepreneurs and extension workers; development agencies (non-governmental organizations, community-based organizations); other stakeholders

Registration details

- The registration fee is ₹8,000 per participant (additional registration from the same organization qualifies for 10% discount).
- Registration fee does not include accommodation.
- Accommodation can be arranged on request.
- Registration will be confirmed after receiving the registration fee.
- The registration fee covers admission to training workshop/lab sessions, training material (laboratory manual), interactive coffee breaks, lunches, and GST.

Enrolment is for (shortlisted) 25 participants on a first-come-first-served basis.

COORDINATORS

Dr Reena Singh / Mr T P Sankar
Email: reenas@teri.res.in | tpsankar@teri.res.in
The Energy and Resources Institute (TERI)
Darbari Seth Block India Habitat Centre
Lodhi Road, New Delhi 110 003
Phone +91 11 24682100
Fax +91 11 24682145

Editor Alok Adholeya • **Associate Editor** T P Sankar • **Assistant Editor** Anushree Tiwari Sharma

Printed and published by Dr Ajay Mathur on behalf of The Energy and Resources Institute, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi – 110003, and *printed at* Multiplexus (India), C-440, DSIDC, Narela Industrial Park, Narela, Delhi – 110040.