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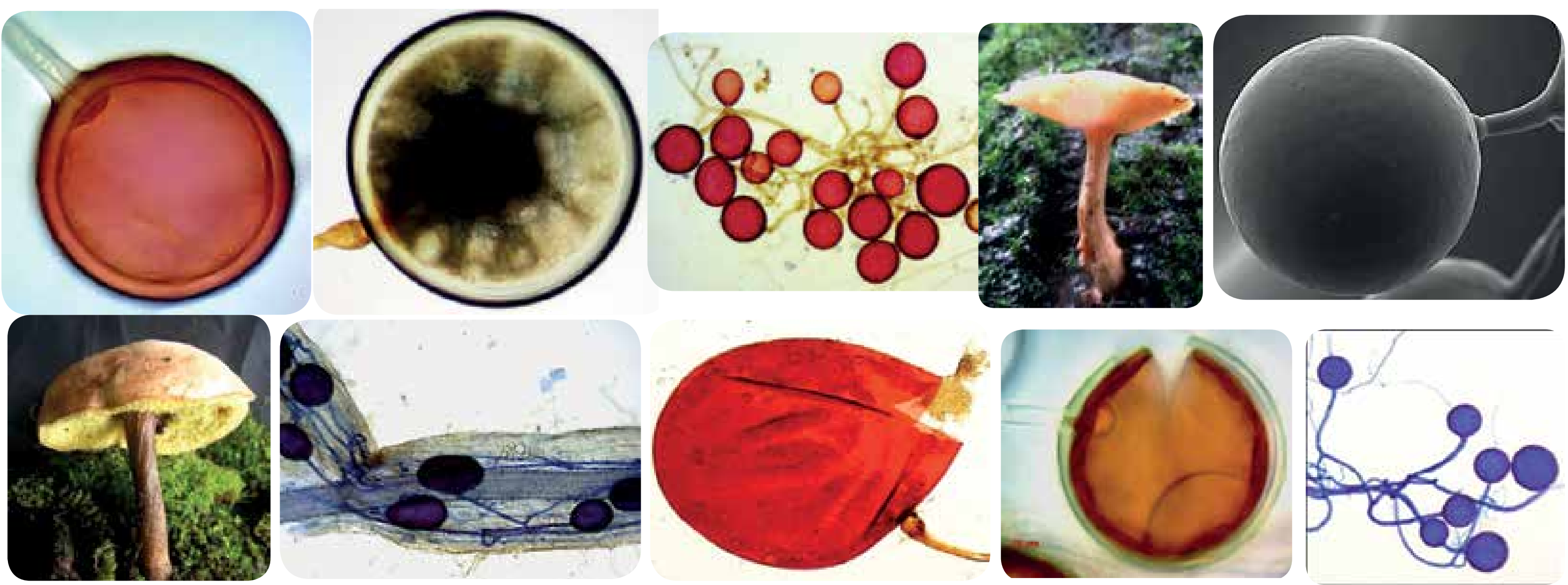
MYCORRHIZA NEWS

The Quarterly Newsletter of Mycorrhiza Network

Volume 30 • Issue 4 • January 2019



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.

For further information, visit www.mycorrhizae.org.in

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RESEARCH FINDING PAPER

Distribution of Arbuscular Mycorrhizal Fungi in Coal Mine and Forest Soils of North Telangana

*Dayakar Govindu, Althaf Hussain, Sharath Bellamkonda, Anusha Duvva and Srinivas Podeti**

Introduction

Coal mining activities are adversely affected the soil and subsoil, thus causing the loss of land reclamation of the coal mine region. There is an enormous problem of coal mine dumped soils which needs to be domestic and used for vegetation (Sheoran et al. 2010; Akhilesh et al. 2010). Mycorrhizal fungi constitute a linkage between the biotic and abiotic factors of the soil ecosystem which are important colonizers of coal mine spoils to improve the soil quality in order to ensure reclamation of degraded soils (Rodrigues 2000). AM fungi modify the root system and play an important role in the nutrient uptake. This can be taken as a crucial parameter to access reclamation success in degraded soils (Aggarwal et al. 2011). Thus, the success of restoration depends on the augmentation of biological activity of the soil surface horizons (Srinivas et al. 2005; Cicatelli et al. 2010; Logaprabha and Tamilselvi 2014).

The importance of AM fungi in revegetation of mining sites has been investigated by many workers (Daft et al. 1975; Hazarika et al. 2010; Chen et al. 2014). It has been reported that soil disturbances associated with mining activity reduce the colonization of AM fungi in vegetation to different extents, depending upon the mining operation and environment (Selvam and Mahadevan 2002; Agus et al. 2018).

The greenhouse experiments conducted by Jasper et al. (1987) indicated that after 4–5 years of revegetation, the number of infective propagules appear to be restored to a level equivalent to that of undisturbed soil. AM fungi are not host-specific fungal genotype which can express symbiotic nature. Even though AM fungi may be important in natural and managed systems (Bever et al. 2009; Wilson et al. 2009; Swarnalatha et al. 2017). Further, they suggested the urgent need to investigate the possibility of improving revegetation by using the AMF inoculum in disturbed sites.

AM fungi in forest soils

AM fungi, associated with higher plants, play an important role in their 'P' nutrition (Schatman et al. 1998). The beneficial effect of mycorrhizae is of special importance for those plants having a coarse and poorly branched root system (Janaki Rani and Manoharachary 1994; Hindumathi and Reddy 2011). This is important for the absorption of nutrients of low mobility in soil solutions, such as P, Zn, and Cu. Many plant species form association with AM fungi (Mosse 1981). Research on mycorrhizal dependency of crops has clearly indicated that some important tropical crops and pastures are highly mycotrophic and will not grow or produce well in low P soils without an effective mycorrhizal atmosphere. Mycorrhizal dependency can be termed as the maximum growth yield that can be achieved by a plant species at a given level of soil fertility (Thompson 1991).

The forest soil was varied in their amount and mobility of phosphorous, the mycorrhizal dependency (MD) of a single plant species likely to vary from soil to soil. (Srinivas *et al.* 1999). The knowledge of AM dependency of the host species is crucial for better understanding of plant nutrition and is considered necessary to predict the host response to AM inoculation (Smith *et al.* 1999; Eom *et al.* 2000). Though some information is available on the

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mycorrhizal dependency of some tropical crops (Diem *et al.* 1981) and forage species (Howler *et al.* 1987), only little is known about the AM dependency of forest tree species (Cruz *et al.* 1992; Habte and Musko 1994). Tropical trees were inoculated with AM fungi have shown increased nutrient uptake, growth, withstanding the transport shock, hostile conditions like drought resistance and survival (Sieverding and Toro 1987; Michelsen and Rosendahl 1990).

The effect may be prominent in degraded areas with sparse vegetation coverage, where the density of AM fungal propagules generally is low (Michelsen and Rosendahl 1989) resulting in a slow rate of AM colonization of newly planted seedlings (Miller and Michael 1987). The out planting performance of mycorrhizal inoculated seedlings has been reviewed by Castellano and Michael (1989). In the present investigation, an attempt has been made to determine the mycorrhizal status of two agroforestry tree species (*Albizia lebbeck* and *Acacia nilotica*) in coal mine and forest soils.

Materials and Methods

The rhizosphere soil samples were collected from two agroforestry tree species from different locations of North Telangana. The roots were collected from study plants (*Albizia lebbeck L.Benth* and *Acacia nilotica L. Willd. ex Del*) for determination of AM colonization by using the method of Phillips and Hayman (1970). The percentage of root colonization was calculated by gridline and intersect method (Giovannetti and Mosse 1980). The AM fungal spores were extracted by using wet sieving and decanting methods (Gerdemann and Nicolson 1963; Pacioni 1992). The AM fungal spores were observed under the streobinocular microscope Nikon SMZ18 and identified based on morphological characteristics of spores by using nomenclature method (Sturmer 2012). The physicochemical characteristics of soils were analysed by using the method of Jackson (1973).

Results

The results on physic-chemical characteristics of different coal mine and forest soils are shown in Table 1. The highest pH was observed in Yellendu soil while it was lowest in the soil of Godavarikhani. Electric conductivity was found more in Yellendu coal mine soil whereas it was lowest in Bhopallpally coal mine soils. Similar trend was also observed in forest soils. Soil organic matter has been observed maximum in between 0.5%–0.7%. The available phosphorus and potassium were recorded highest in Kothagudem and Godavarikhani soils. The chemical analysis of 'P' and 'K' was also varied with the type of soil which might be due to microbial mineralization. The pH was found to be varied with the type of soil. Soil edaphic factors were used for succession of plants. Similar observations were also recorded in Jharia coalfield top soil by Maiti et al. (2002). The available phosphorus and potassium was varied with the type of coal mine soil. However, our study area consists of some forest tree species along with study plants, such as Acacia mangium, Enterolobium saman, Dalbergia sisso, Albizia procera, Harwikia binata, Pongamia pinnata, Azadirachta indica, and Tamarindus indica.

Coal Mine soils

Determination of AM colonization in roots of *Albizia lebeck* and *Acacia nilotica* rhizosphere soils were analysed. The AM fungal spore population was observed in two plant species and the results are presented in Table 2. The AM fungal root colonization results are shown in Figure 1. The highest root

Table 1: Physico-chemical characteristics of different coal mine and forest soils

Soil Sample	Soil texture	pH	EC mho/cm	Organic matter	Available phosphorous P_2O_5(mg/g)	Available potassium kg/hect
Coalmine soils						
Kothagudem	SL	8.3	0.38	< 0.5	7	190
Bhopalpally	SL	8.9	0.32	0.5-0.7	4	130
Godavarikhani	SL	7.4	0.45	<0.5	8	170
Ellandhu	SL	9.3	0.72	<0.5	5	104
Forest soils						
Kothagudem	SL	7.3	0.38	0.5-0.7	8	152
Bhopalpally	SL	6.9	0.32	<0.5	7	123
Godavarikhani	SL	7.4	0.45	0.5-0.7	4	230
Yellendu	SL	7.3	0.72	□0.5	9	131

colonization was recorded in Kothagudem soil sample supporting by *Albizia lebbeck* while it was lowest in Godavarikhani and Bhopallpally rhizosphere samples of *Albizia lebbeck.* On the other hand, the lowest root colonization was found in *Acacia nilotica* of Godavarikhani soil, but the AM fungal spore population was observed moderate. However, the AM fungal spore population incidence varied with the type of soil.

The highest AM fungal spore incidence was recorded in Kothagudem and Bhopallpally soils. Similar trend was also observed in Godavarikhani and Yellendu soils. The AM fungal spore incidence was varied with the type of soil. *Glomus* species was dominant in the rhizosphere soil samples of two test plants. *Gigaspora* species was found highest in the rhizosphere of *Albizia lebbeck* of Kothagudem soil whereas it was found lowest in Yellandhu soil. On the other hand, *Sclericystis* and *Acaulopsora* were found highest in Kothagudem soil, while it was lowest in Bhupalapally soil. Interestignly, no *Scutellospora* species could be recorded in the rhizosphere of *Albizia lebeck* (Godavarikhani soil). Similar trend was also observed in *Acacia nilotica*.

Forest soils

The highest root colonization was observed in the roots of *Albizia lebbeck* ofYellendu sample, while it was observed lowest in Bhupalpally. Percentage of root colonization had significantly varied with the type of plant. AM colonization was recorded moderately in the samples of Bhupalpally and Godavarikhani. On the other hand, AM fungal spore population was found highest in Kothagudem soil of *Albizia lebbeck*, while it was lowest in Yellendu soil. Similarly it was also observed in *Acacia nilotica*. Likewise, the highest root colonization was found in *Acacia nilotica* of Bhopalpally, while it was lowest in Godavarikhani. The AM fungal spore incidence was varied with the rhizosphere soil of Kothagudem followed by Yellendu, Bhupalpally and Godavarikhani. On the other hand, rhizosphere soil was showed a great variation in the incidence of different AM fungi both qualitatively and quantitatively. *Glomus* species was recorded

Table 2: Incidence of AMF in two agroforestry tree species of four coal mine sites of North Telangana

				Individual spore incidence				
S.No.	Location	Plant species	Cumulative spore Glomus	Gigaspora	Sclerocystis	Aculospora	Scutellospora	
Coalmine soils								
1	Kothagudem	A.lebbeck	79.7±0.45	31	26	11	8	3
		A.nilotica	61.3±0.76	26	15	9	6	4
2	Bhopalpally	A.lebbeck	55.7±0.33	33	11	4	5	2
		A.nilotica	63.3±0.88	29	12	10	9	3
3	Godavarikhani	A.lebbeck	73.0±0.73	44	14	10	5	-
		A.nilotica	48.7±0.20	17	15	6	6	4
4	Yellendu	A.lebbeck	53.7±0.45	29	10	7	5	2
		A.nilotica	44.3±0.88	15	13	10	4	2
Forest soils								
1	Kothagudem	A.lebbeck	155.0±0.53	98	21	32	4	-
		A.nilotica	92.7±0.45	63	12	11	6	-
2	Bhopalpally	A.lebbeck	106.7±0.20	76	12	9	6	3
		A.nilotica	137.0±0.73	72	35	16	9	5
3	Godavarikhani	A.lebbeck	82.3±0.88	48	16	12	-	6
		A.nilotica	63.7±0.45	39	13	8	3	-
4	Yellandu	A.lebbeck	98.2±0.33	57	23	18	-	-
		A.nilotica	118.7±0.45	80	15	10	7	6

A.lebbeck-Albizia lebbeck, A.nilotica- Acacia nilotica dominant in the rhizosphere soils. *Gigaspora* species was found highest in the rhizosphere of *Acacia nilotica* (Bhupalpally soil), while it was observed lowest in Godavarikhani soil. Similarly, *Sclerocystis* species was found highest in Kothagudem soil of *Acacia nilotica*, while it was lowest in Godavarikhani soil. *Acaulospora* species could be recorded highest in Bhupalpally soil while, it was found lowest in Godavarikhani soil. Interestingly, no *Acaulospora* species could be observed in Godavarikhani and Yellandhu soils of *Albizia lebbeck*. *Scutellospora* species was found lowest in Godavarikhani and Bhopalpally soils. No correlation was observed between AM colonization and the spore population.

Discussion

The present study involved in coal mine and forest soils for assessment of mycorrhizal colonization and spore incidence. The AM root colonization had reduced in plants grown in coal mine overburden soils supporting to attribution of poor emergence of roots, as a result of low soil fertility, erosion, the soil edaphic factors affecting the survival of plants, and low colonization of AM fungi. The highest root colonization was recorded in Kothagudem while it was lowest in Yellendu. Planting of different species not only control erosion and also increases species diversity and enhance the succession rate that execute the revegetation process (Katoria *et al.* 2013; Cahyanti and Agus 2017). According to reports, the seedling growth and survival of tree species were affected by seedling of grasses and legumes (Cunningham and Wittwer 1984; Wulandari *et al.* 2014). The grasses are useful in verifying the soil erosion, while legumes improve soil nutrient level. AM fungi can support plant establishment and survival in different ways in coal mine degraded lands (Brundetti 1991; Verma 1994; Gaur and Adholeya 2004).

Agroforestry is the collective word for land use system in association with AM fungi. The highest spore incidence was found in the Kothagudem soils while it was observed lowest in spore incidence. AM fungal spore incidence varied with the soil physico-chemical characteristics (Hayman 1982). Most leguminous plants are responsive and extensively colonized by AM association especially in soils, where non-availability of available 'P' nutrients for plant growth (Venkatesh *et al.* 2009; Kumar 2010). Mycorrhizal association can facilitate the probability or extent of mycorrhizal infection of seedlings and thus mycorrhizal interaction among distantly-related plants might be a particular ecological interest, as this may permit succession of plants (Holl 2002; Hindumathi and Reddy 2016).

Conclusion

The present study has demonstrated the differential association of AM fungi with two leguminous agro forestry tree species, that is, *Albizia lebbeck* and *Acacia nilotica* in two different soil types. The plant root colonization and spore population was found highest in Kothagudem forest soil whereas the lowest spore population was recorded in coal mine overburden spoils.

The AM fungi exhibit different distribution patterns between these two soil types. The *Glomus* species was found dominant among the species, whereas the species of *Scutellospora* and *Acaulospora* were recorded lowest in the spore incidence. Further, our investigation is focussed on the screening of AM fungi for revegetation of coal mine overburden spoils.

Acknowledgements

We gratefully acknowledge the Head, Department of Biotechnology, Kakatiya University, Warangal, for providing necessary facilities and the financial assistance received from DBT-MRP No: (BT/PR7539/BCE/8/950/2012).

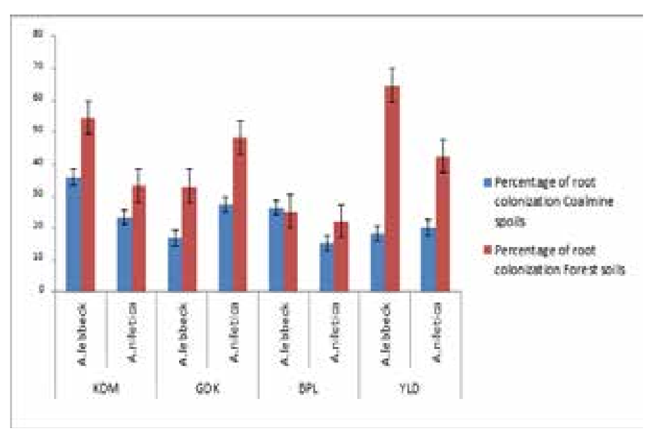

Figure 1: Percentage of root colonization in two different soil types

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Mycorrhiza Information and Resources Centre at TERI: Some Aspects and Prospects

Research in the field of mycorrhiza is making remarkable progress as more and more scientists the world over are turning to it, and are engaged in exploring new and potential species of mycorrhiza that can be used as biofertilizers; their role in the transport of phosphorous, nitrogen, and other micronutrients; and their mass production, formulations, and subsequent field trials. Furthermore, research is also being carried out to study resistance of plants to biotic and abiotic stresses, such as drought resistance, disease resistance, and other benefits imparted by mycorrhiza to the plant species. In view of climate change and global warming, there is a necessity to evolve suitable mycorrhizal strains which can adapt to changing environments, soil conditions, agro-climatic zones, geographical locations, and host complementarity in order to boost crop production. Suitable mycorrhiza can be identified for reclamation of waste lands, mine soils, and non-productive soils.

Data generated by all these endeavours needs to be made accessible to those interested in mycorrhizal research. Moreover, mycorrhiza information is often disseminated through a wide range of publications which sometimes makes the process of retrieving information difficult and/or time consuming. So, there is a need to put in place an information and resource centre that will be a storehouse of the information on mycorrhiza. This will help improve networking, aid in disseminating knowledge, and facilitate exchange of information amongst organizations/individuals, and would be of immense support in continuously disseminating the latest research findings to mycorrhiza scientists.

Against this background, TERI, with support from the Department of Biotechnology, Government of India, initiated a project, titled 'Mycorrhiza Information and Resources Centre' which collects, compiles, and disseminates information on mycorrhizal research and as a resource material for crop production, forest seedling establishment, bioremediation, and other biological/biotechnological applications.

A web accessible framework using one of the most dynamic portal engines and with a recognized content management system has been designed and developed with a query-based retrieval methodology. The website (Figure 1) has been hosted at http://www.mycorrhizae.org.in

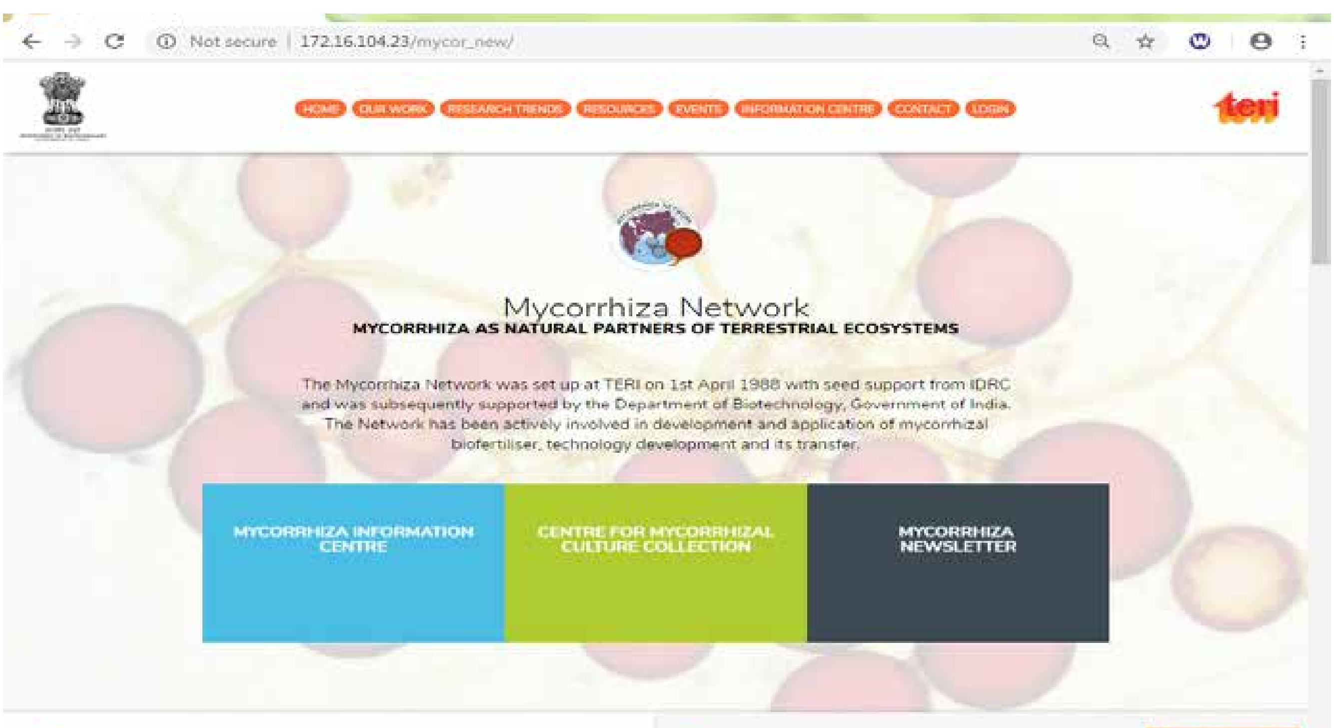

Figure 1. Mycorrhiza Network website

This issue presents 'Literature Abstracts' developed as part of information services provided by the Mycorrhiza Information Centre at TERI.

Database of Mycorrhiza Literature Abstracts

Mycologists, young scientists, growers, teachers, foresters, agriculturists, consultants, students, and other microbiologists need to keep themselves updated with latest developments on the wealth of information available on mycorrhiza research. However, due to sheer volume of the published literature available today, it is difficult for an individual to search through it for the required information.

Consequently, the researcher could easily miss a crucial piece of research that could have a significant impact on his work. Comprehensive databases with abstracts would be of immense help to fill up the gap in current knowledge availability. Against this background, the Centre has developed a web-based database of mycorrhiza literature with an objective to facilitate access to current research findings and development in the field of Mycorrhiza and promote research among scientists, agriculturists, mycorrhizologists, and others. The database contains bibliographic information and abstracts on mycorrhiza-related literature and has over 5,000 classified references published since 2008 from national and international journals.

Figure 2 Mycorrhiza Literature Database

The database contains over 5,000 published references that have been classified as per Table 1:

Additionally, each record has been included with the name of the country, organisms, and hosts relevant to mycorrhiza (with which the work has been done), and the year.

Online data retrieval methodology using open-source database software has been developed to ensure better processing and faster performance. Two to five different combinations of search are made possible for specific information retrieval for the

Table 1: Classification Structure of Literature References

Each reference in the database has been assigned with one of the six categories of mycorrhiza, namely:	Under each category, the references in the database have been assigned with one or more of the 17 broad SUBJECTS as listed below	Majority of these broad subjects are further divided into relevant sub-subjects to make the data retrieval as specific as possible. For example, sub-subjects under Broad subject Soil Plant Relations are listed
EctoMycorrhiza	Anatomy	Nursery management
Arbuscular mycorrhiza	Biochemistry	Soil moisture
Orchid mycorrhiza	Biocides	Soil toxicity
Ericoid mycorrhiza	Biological interaction	Soil temperature
Ectendo mycorrhiza	Culture	Burning
	Ecology	Disturbed land
	Genetics	Difficult sites
	Mass production	Dependency
	Methodology	Cropping effect
	Morphology	Tissue culture
	Physiology	Cuttings
	pollution	
	Soil plant relations	
	Systematics	
	Ultrastructure	
	Reviews	
	General	

following two categories of groups:

Utility to Mycorrhiza Scientists

Scientists who are actively engaged in mycorrhiza research will be able to retrieve information on a specific aspect of mycorrhiza research. This will keep them not only abreast with latest research being done in that particular field but will also help them to avoid duplication and formulate projects for conducting original and relevant research.

For example, if a scientist intends to retrieve information on any sub-subject of the broad subject, that is, under the broad subject 'soil plant relations', effect of soil moisture (sub subject) on the development of VA mycorrhiza, the following entries will be combined to retrieve the above information:

CATEGORY 2 (Vesicular Arbuscular Mycorrhiza) [AND] SUBJECT (Soil Plant Relations) [AND] SUB-SUBJECT (Soil Moisture) Thus the combination would be Arbuscular mycorrhiza AND Soil plant relations AND Soil moisture

Utility to Information Analysts

Information analysts will be able to acquire information on the status of research being done on any particular host with any particular fungus of any one category. If he intends to know the VA mycorrhizal work conducted on wheat in India with Glomus, his combination would be CATEGORY 2 (VA mycorrhiza) [AND] COUNTRY (India) [AND] HOST (Wheat) [AND] ORGANISM (Glomus). Thus, his combination would be VA mycorrhiza AND India AND Wheat AND Glomus AND Country AND Year = search result

The aim of the database therefore is that information can be retrieved at macro level on broad subjects and at micro level, that is, on a very limited subject, such as effect of temperature, pH, soil moisture, soil quality on development of mycorrhiza, different aspects of biochemistry of mycorrhizal fungi, such as production of phosphatases and other enzymes by mycorrhizal fungi, production of flavonoids, iso flavonoids, turpenoids by mycorrhizal fungi, etc. For the retrieval of information at micro levels, sub-subjects would be judiciously selected by subject experts.

Continent-/country-wise publication statistics

Based on further analysis of over 2,300 sample references (published between 2012 and 2016) taken from the database, the following continent-/country-wise statistics of mycorrhiza publications have been retrieved using the search format specially devised for the purpose.

Table 3: Based on research articles published (2012–2016) against each category of mycorrhiza by scientists globally

Category	Papers published
Ecto mycorrhiza	726
Vesicular Arbuscular Mycorrhiza	1293
Orchid mycorrhiza	31
Ericoid mycorrhiz	68
Ectendo mycorrhiza	56
Mycorrhiza (Miscellaneous)	126
Total	2300

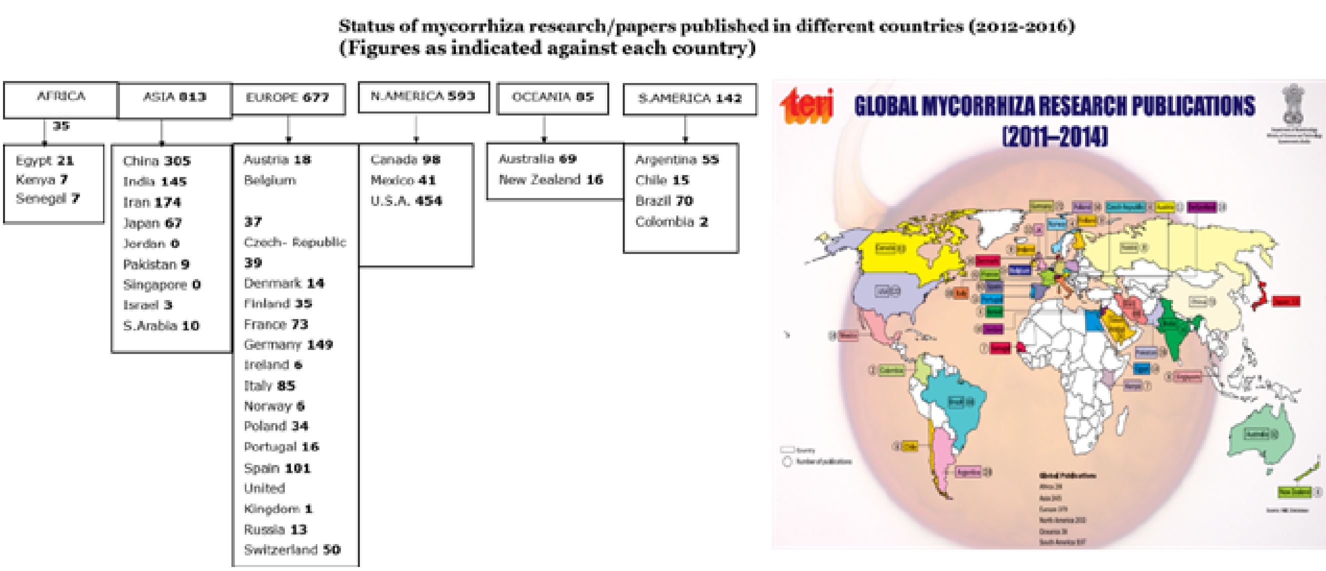

Figure 2: Status of mycorrhizal research articles published in different countries (2012-2016)

Figures against each country indicate number of publications

Table 4 : Research papers published around the world (2012–2016)

Subject	No of papers published
Anatomy	66
Biochemistry	278
Biocides	61
Biological interaction	67
Ecology	262
Genetics	31
Morphology	192
Mass production	34
Methodology	54
Physiology	142
Pollution	97
Soil plant relations	582
Systematics	102
Reviews	64
General	268
Total	2300

Conclusion

The database will provide an exclusive benefit to users including information on the most current advances in the fields of mycorrhizae, particularly in the Indian context. Researchers will find useful references in the database in support of their research, and knowledge about this universal fungal root association known as mycorrhiza.

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Centre for Mycorrhizal Research, TERI, New Delhi—On-line and Print resources – Mycorrhiza Journals, Periodicals, Conference Proceedings, Books

Databases: Science Direct, CAB Abstracts, Agricola, Current Contents

Indian Agricultural Research Institute, New Delhi

School of Life Sciences, Jawaharlal Nehru University, New Delhi

Kerala Agricultural University

University of Delhi

National Institute of Science Communication and Information Resources

(NISCAIR), New Delhi

Centre for Mycorrhizal Research, TERI, New Delhi
On-line and Print resources – Mycorrhiza Journals, Periodicals, Conference Proceedings, Books
Databases: Science Direct, CAB Abstracts, Agricola, Current Contents
Indian Agricultural Research Institute, New Delhi
Kerala Agricultural University
National Institute of Science Communication and Information Resources (NISCAIR), New Delhi

Carbon Sequestration by Mycorrhiza

*C Manoharacharya and Anurag Nathb**

Carbon is an essential component of the environment and plays a crucial role in the terrestrial ecosystems. Carbon content in soil is higher than in atmosphere and in plants. The increasing carbon content can have an adverse impact on the environment while mycorrhiza plays a significant role in maintaining the balance of carbon pool. Mycorrhiza contributes to about 5%–20% of the total carbon uptake by plants (Pearson and Jakobsen, 1993; Hobbie and Hobbie, 2006). Mycorrhiza store nearly 70% of the carbon in leaf litter and soil in Sweden (Clemmensen et al., 2013.). A study established that carbon enters the soil by means of mycorrhizal biomass and it is one of the dominant methods in some ecosystems (Godbold et al., 2006).

The storage of carbon is highly influenced by photosynthesis and respiration in soil. This has been extensively studied in the agricultural and natural environment, however the influence of mycorrhiza in carbon sequestration and respiration has been established in recent years. Arbuscular mycorrhizal fungi (AMF) can be beneficial to the ecosystem as it has the ability to conserve carbon in the soil. The storage of carbon in soil is based on the balance between its sequestration by plants and its release into the atmosphere through respiration. Over time, the stored carbon in the soils eventually lead to the release of the greenhouse gases which can offset the general balance of the atmosphere (Wang et al., 2016). Mycorrhiza has a system of delicate hyphae which can penetrate the complex soil matrix and assist in carbon sequestration.

AMF can reportedly incur changes in the carbon sequestration process and in soil respiration. These modifications are such that the host plants get improved nutrition and ability to withstand detrimental effects accompanied by enhanced carbon production. Abiotic stresses in the soil have been found to affect the overall productivity and growth of the plants. In contrast, AMF supports the increased metabolic activity of plants and assists in higher carbon production even in harsh environment of the soil. AMF has the potential capability to increase the photosynthate production in plants consequently causing an increase in the carbon allocation.

AMF impacts the plant respiration by enhancing the sensitivity of respiration to temperature. The increased AMF infection in host plants promotes respiration and photosynthesis. The positive functioning of AMF is towards the improvement of plant growth in terms of increasing the leaf area, improving the chlorophyll content and higher Q10 value. AMF significantly increases the organic matter in the soil and also glomalin which can be associated with enhanced carbon storage in soil.

The increasing the carbon content in the atmosphere is an important factor contributing to global warming. The knowledge about the increasing carbon content and its response to the changing environmental condition is essential to be understood such that AMF can be adopted and employed as a possible solution in this concern.

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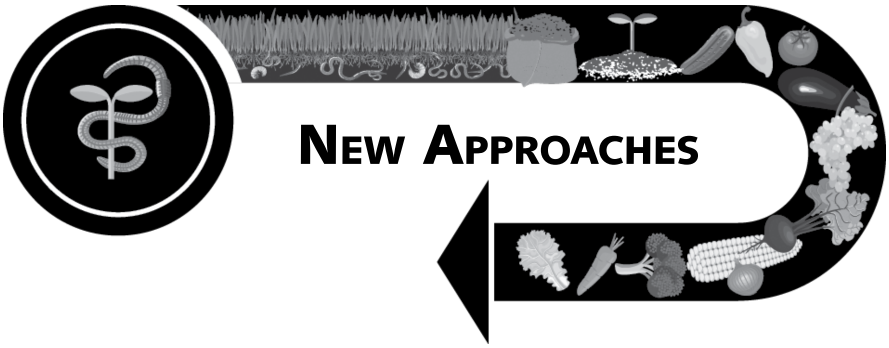
[b]Project Associate, The Energy and Resources Institute (TERI), India Habitat Centre, Lodhi Road, New Delhi 110 003, India
[*]Corresponding author, Email: anurag.nath@teri.res.in



New Approaches and Techniques

1. New DNA sequencing approach for Arbuscular Mycorrhizal Fungi (Chellappan P, et al. Indian J Exp Biol. 2005)

DNA sequencing has been employed for the identification of arbuscular mycorrhiza. However, the nature of mycorrhizal fungi to grow inside the plant tissues poses a challenge in specifically identifying the species adapted to a particular environment. To overcome this concern, barcode tagged primers are used which when employed with high throughput DNA sequencing can assist in identifying rarer species of mycorrhiza. These barcodes are molecules which bind to DNA and enable specific detection of mycorrhiza. The underlying principle is with the operational taxonomic units (OTUs) which represent the separate species or the individual species which are genetically variant. In case of mycorrhiza, about 22 OTUs contribute to nearly 89% of the species density.

2. Enhanced multiplication of AMF by amplifying the ITS region (mycorrhizal fungal communities exposed with new DNA sequencing approach, BOTANICAL SOCIETY OF America)

Enhanced multiplication of AMF can be obtained using IAA and kinetin. Conserved arbitrary oligonucleotides used as specific primers can assist in amplifying the ITS region (Molecular marker for fungal identification) of the fungi. This technique enables an enhanced mycorrhizal association with the root system of plants accompanied by the production of spores without any microbial contamination which makes molecular characterization as well feasible.

ANNOUNCEMENTS

1. In 2016-17, TERI set up the world's biggest facility for mycorrhiza production in Gual Pahari in Gurugram, Haryana.
2. Submission to the Mycorrhiza News in the form of relevant notes, brief write-ups highlighting current research achievements; news/events of common interest to members like seminars/workshops attended, in the field of Mycorrhiza are always welcome! Members are requested to provide the MIC (Mycorrhiza Information Center) with copies of articles, papers, reports, reviews, etc., dealing with Mycorrhiza for the proper dissemination of Mycorrhizal information amongst researchers. Farmers, entrepreneurs, and stakeholders can also send their success stories in Mycorrhizal applications for publication in our newsletter.
3. The Mycorrhiza website www.mycorrhizae.org.in is currently undergoing transformation and will soon be revamped into a better and much more informed website with new added features for better information dissemination.
4. Advertisements relating to conferences, seminars, workshops, published books, etc., on Mycorrhiza can be shared by mailing a request to anurag.nath@teri.res.in

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:

- *Agricultural and Forest Meteorology*
- *Agriculture, Ecosystems & Environment*
- *Applied Geochemistry*
- *Applied Soil Ecology*
- *Aquatic Botany*
- *Biocatalysis and Agricultural Biotechnology*
- *Ecotoxicology and Environmental Safety*
- *Forest Ecology and Management*
- *Fungal Ecology*
- *Industrial Crops and Products*
- *Journal of Environmental Management*
- *Molecular Plant*
- *Mycoscience*
- *Phytochemistry*
- *Plant Physiology and Biochemistry*
- *Saudi Journal of Biological Sciences*
- *Scientia Horticulturae*
- *Soil Biology and Biochemistry*

Copies of papers published by mycorrhizologists during this quarter may please be sent to:
Mr Anurag Nath (anurag.nath@teri.res.in) for inclusion in the next issue.

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)
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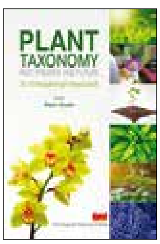
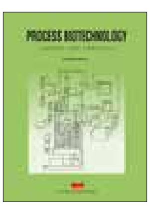


Plant Taxonomy: past, present, and future

Rajni Gupta (ed.)

This book contains various contributions from stalwarts in the field of plant taxonomy, which focus on different aspects of this field. Each contribution has been written based on thorough research, and includes recent developments such as molecular taxonomy and barcoding. Interesting aspects of naming plants, speciation, molecular aspects of plant identification, and e-flora have been dealt with in an elaborate manner. In addition, a chapter is dedicated to the genesis of botanical names and the meaning of the names of plants found in Delhi.

2012 | 376 pages | Hardback | 160mm x 240mm | 9788179933596 | ₹995.00



Process Biotechnology: theory and practice

S N Mukhopadhyay

This book is intended for advanced undergraduate, postgraduate, and PhD students in the field of process biotechnology. It covers biological, ecological, chemical, and biochemical engineering topics related to the subject. It provides much needed theory-based solved numerical problems for practice in quantitative evaluation of various parameters relevant to process biotechnology. It can be used as a self-study text for practising biochemical and chemical engineers, biotechnologists, applied and industrial microbiologists, cell biologists, and scientists involved in bioprocessing research and other related fields.

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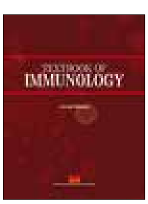

Textbook of Immunology

Arvind Kumar

The book provides in-depth but concise coverage of all the major topics of immunology in simple and lucid manner. The text of the book is illustrated with simplified well-labelled diagrams and pictures to make the subject easily understandable and interesting to read for students. Extensive cross referencing between chapters is used to reinforce and broaden the understanding of the core concepts of immunology. This book might be an ideal source of comprehensive, authoritative, and up-to-date information for those who work in the field of immunology.

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Mycorrhiza News

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; provides brief accounts of new approaches and techniques; publishes papers compiled 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 Centre for Mycorrhizal Culture Collection.

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FORTHCOMING EVENTS
CONFERENCES, CONGRESSES, SEMINARS, SYMPOSIUMS, AND WORKSHOPS

London, **United Kingdom** February 25–26, 2019	**2nd World Conference on Soil Microbiology, Ecology and Biochemistry** **Theme: The Future of Ecosystem, Ecosystem for Future** *Email:* ecology@expertsconferences.org *Website:* https://ecology.environmentalconferences.org/
Osaka, **Japan** February 28–March 01, 2019	**7th Annual Congress on Plant Science and Molecular Biology** **Theme: Advancements & Innovations in Plant Science, Crops & Ecosystem** *Email:* plantscience@asia.com *Website:* https://world.plantscienceconferences.com/
Pacific Grove, **CA** March 12–17, 2019	**30th Fungal Genetics Conference** *Email:* GSAConferences@genetics-gsa.org *Website:* http://conferences.genetics-gsa.org/Fungal/2019/index
Chicago, Illinois, **USA** March 18–19, 2019	**3rd International Conference on Ecology, Ecosystem and Conservation Biology** **Theme: Exploring the Possibilities for a Better Environment** *Email:* ecologyecosystems@annualamericacongress.org *Website:* https://ecologyecosystems.conferenceseries.com/
Sydney, **Australia** March 25–26, 2019	**4th International Conference on Plant Science & Physiology** **Theme: Modern Exploration Technologies in Plant Researches** *Email:* plantphysiology@microbiologyconferences.org *Website:* https://plantphysiology.conferenceseries.com/
Amsterdam, **The Netherlands** April 1–2, 2019	**International Conference on Green Energy** **Theme: Renewable Energy & Emerging Technologies** *Email:* greenenergy@europemeet.com *Website*: https://greenenergy.conferenceseries.com/netherlands/
Prague, **Czech Republic** April 8–9, 2019	**12th World Congress on Plant Biotechnology & Agriculture** **Theme: Exceeding The Vision Towards a Sustainable Agriculture** *Email*: emmadaniel.agriconferences@mail.uk *Website:* https://agriculture-horticulture.conferenceseries.com/europe/
Rome, **Italy** May 2–3, 2019	**ICMFE 2019 : 21st International Conference on Mycology and Fungal Ecology** *Website:* https://waset.org/conference/2019/05/rome/ICMFE
São José dos Campos, SP, **Brazil** May 20–23, 2019	**III International Symposium on Fungal Stress – ISFUS** *Website:* https://isfus2019.wordpress.com/contact/
Berlin, **Germany** May 21–22, 2019	**ICMFFB 2019 : 21st International Conference on Mycology, Fungi and Fungal Biology** *Website:* https://waset.org/conference/2019/05/berlin/ICMFFB
Mérida, **Mexico** June 30–July 5, 2019	**International Conference on Mycorrhizae (ICOM 10)** *Email:* icom10@ciencias.unam.mx *Website:* http://icom10.org/
Singapore August 21–22, 2019	**7th World Congress on Earth and Environmental Science** **Theme: An Insight into the Recent Advancements in Earth and Environmental Science** *Email:* earthscience@conferencesseries.org *Website:* https://geology.earthscienceconferences.com/

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Printed and published by Dr Ajay Mathur on behalf of The Energy and Resources Institute, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi – 110 003, and *printed at* Multiplexus (India), C-440, DSIDC, Narela Industrial Park, Narela, Delhi – 110 040.