Database

i AMF – CENTRALIZED DATABASE OF ARBUSCULAR MYCORRHIZAL DISTRIBUTION, PHYLOGENY AND TAXONOMY

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ABSTRACT

Arbuscular mycorrhizal fungal database, named *i*AMF (www.amfungi.aurobindo.du.ac.in) is first digital database on biodiversity and phylogeny of these beneficial fungi in India. It provides access to data on 161 species of arbuscular mycorrhizal fungi (AMF) along with comprehensive information on their GPS location of reported occurrence, taxonomy, molecular sequence, phylogeny and bibliography. The database is based on primary data collected by authors through ongoing surveys (year 2009-2017) and secondary data from earlier studies (2008–2016). Data is carefully curated to verify that it corresponds to the reference publication and a valid species name is used. Apart from being ecological meta-analysis data source, it would have significant application in selection of non-indigenous AMF inoculum in agriculture, reforestation, horticultural and land reclamation practices.

KEY WORDS: AM fungi, database, arbuscular, phpMiniAdmin

INTRODUCTION

In recent years there has been an exponential increase in number of studies describing distribution, biodiversity and ecology of arbuscular mycorrhizae (AM) all across the globe[1,2]. This is the result of developments in molecular techniques and third generation sequencing that allowed collection of data at a greater speed. Arbuscular mycorrhizas are symbiotic associations between fungi belonging to Subphylum Glomeromycotina of Phylum Zygomycota [3] and the plant roots. They are increasingly being recognized as important drivers of plant growth and productivity, soil stability and plant community dynamics in almost all terrestrial ecosystems [4,5]. The arbuscular mycorrhizal fungal (AMF) partner of this association extracts up to 20% of the photosynthetically fixed carbon from the plant [5] and provides phosphorus, nitrogen and other micronutrients to the host plant in return. AMF also benefit the plant by improving pathogen resistance; mitigating different kinds of plant stresses such as drought or heavy metal toxicity which leads to better growth and productivity of plants [5]. Modelling the interaction of AM fungal species with host plant species and environmental factors in any geographical region could be of great importance in designing and shaping the community structure [2, 6]. The first step in this direction is to create a database, where the descriptions of AMF are available in machine readable formats which could further be used to decipher the information contained in the data. Such database apart from being ecological meta-analysis data source may have significant application in selection of non-indigenous AMF as inoculum in agriculture, reforestation, horticultural and land reclamation practices.

Biodiversity databases and digital flora for AMF are already developed for many countries like Germany [6,7], USA [8] not only for enlisting the biodiversity but also to uncover underlying ecological process. For example

Menzel et al. [6] analyzed the spatial distribution pattern of plant species and AMF across Germany region and related environmental drivers based on MYCOFLOR [7] database and suggested the integration of plant mycorrhizal status as a functional trait in future macro-ecological study. It requires immense efforts to carry out such a project at country or at a global level [1] at one go. The alternative is to have a common platform and public integrated resources where authors can deposit data in controlled formats so that it could be used for making generalizations. The present database was built with the following objectives: (i) to provide a common platform to mycorrhizal community in India where they can submit their findings on distribution and occurrence of AM fungi in India, (ii) the distribution, taxonomy, phylogeny and other related information on these fungi is made available in machine readable formats. (iii) to develop an easy to use AMF dedicated database with stored information on AMF along with molecular sequences of high quality.

Here we present, *i*AMF - the centralized database available online both at amfungi.aurobindo.du.ac.in and amfungi.in (figure 1). The data is carefully curated for 161 species of AMF to verify their correspondence in source articles existing in literature or by laboratory isolation and culture of spores [9, 10, 11]. It provides comprehensive information on exact GPS location of each AMF species along with classification and availability of culture collections and the accepted scientific name [12]. It also takes user to NCBI link for the availability of the curated sequences for the searched species. Researchers in the field of mycorrhiza and soil microbial ecology can search and retrieve information by entering the names of species or location or sequence of their interest (figure 1).

DEVELOPMENT AND CURATION OF DATA

Data source

Following data sources were searched for curation and creation of present database:

(i) Primary data generated by the authors from studies (2009 to 2017) on rhizosphere soil collected across 8 Indian states, namely, Himachal Pradesh, Uttar Pradesh, Delhi, Punjab, Haryana, Maharashtra, Jammu & Kashmir and UK from 2013 onwards under Delhi University Innovation Project [9]and UGC Minor [10] and Major Research Projects [11].

(ii) Secondary data from 99 studies reporting occurrence of AM fungi from 2008 to 2016.The literature, which mentioned exact location of isolated AM fungal species, and specifically identified them up to species level, were considered as source of secondary data. GPS server was used for collection of geographical location data, if it was not provided by the authors.

(iii) Accepted species names, synonyms and basionyms were taken from updated species-list by Schüßler and Walker [12].

(iv) Phylogenetic information about the searched species was derived from established literature, 335 curated sequences from public databases, which spanned partial or full, small subunit (SSU) rRNA, internal transcribed spacer (ITS) and large subunit (LSU) rRNA region and from few primary sequences of our study. Only those sequences were curated which referred to morphologically identified AM fungal spores which were identified up to species level and occupied the correct phylogenetic position, much in congruence with latest phylogenetic classification [13].

Development of Database

Primary structure of database consisted of 7 tables originally created in MS access after manual curation and then were transferred to phpMiniAdmin (http://phpminiadmin.sourceforge.net/)for SQL. Details of table names along with their contents are summarized in Table 1. Database was designed and developed with high-performance, object-oriented, component-based MVC, PHP web application framework Yii (http://www.yiiframework.com/). The interface parameters are depicted in Figure 2.

SEARCH AND RETRIEVAL

The search engine in the database provides comprehensive information about 161 species of AM fungi known to occur in different states of India. The data can be searched three ways under the menu 'checklist' (Figure 1)

(i) Browse the checklist - If the user query is to search through species name

(ii) Phylogenetic map - If the user is interested in molecular sequences

(iii) Distribution map - If the search involves a location in a particular state of India

The output provides detailed information about: (i) state wise distribution, with exact GPS location; (ii) present accepted name along with synonyms and basionyms; (iii) whether the decision is based on field soil or cultures based study; and (iv) taxonomic identification is based on molecular or morphological parameters, if molecular then which barcode sequence is used for identification. It also gives information about availability of live cultures for that species; link to original description and full bibliographic information. In Figure 3 an example output for *Glomus macrocarpum* is depicted. Phylogenetic information about the searched species includes its phylogenetic positions, the GenBank accession numbers of the sequences which could be of interest as far as identification of species is concerned and a link to these sequences.

Table 1: Details of tables along with their contents uploaded at phpMiniAdmin

S No	Table name	Information
1	Accession number	GenBank accession numbers curated
2	Classification	Genus , family, order and class
3	GPS Co ordinates	Longitudes and latitudes
4	Literature	All literature curated is given an unique ID
5	Species reported	List of species reported along with unique ID
6	State wise distribution	States where reported
7	Synonyms	Accepted names and synonyms

Figure 1: Home page of database with different search options being highlighted

Figure 2: Interface of database parameters

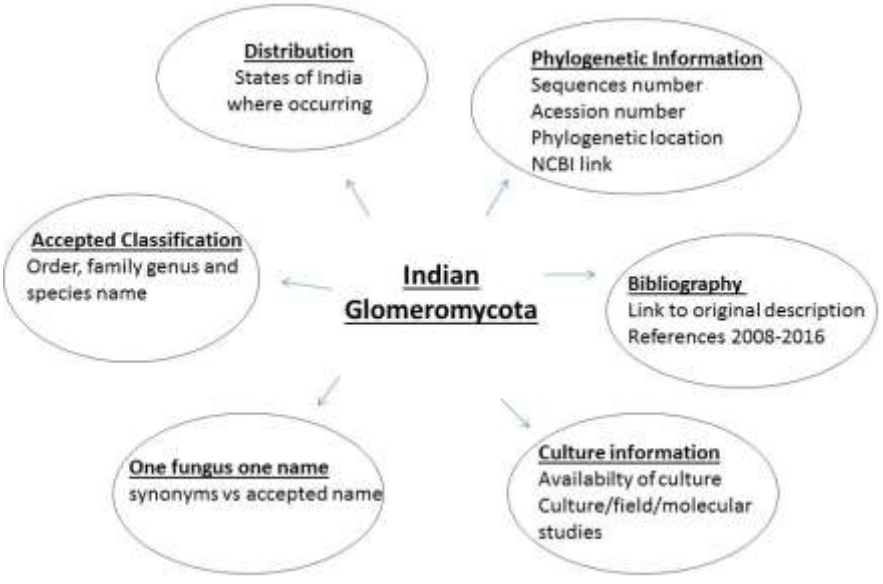

Figure 3: Snap shot of output of search performed for *Glomus macrocarpum i*AMF database

PERSPECTIVE

iAMF is first database in India developed on AM fungi and is gaining popularity among scientists and researchers working in field of AMF. As on date it has 15616 hits. It's expanding steadily and after updating soil ecology data, it could of further interest for drawing ecological conclusions as well.

In the first attempt of estimating total species number of AM fungi in India [12], revealed a figure of 148 species belonging to 21 genera present across 18 states of India. *Funneliformis mosseae* was reported to be the most commonly occurring species followed by *Rhizophagus fasciculatus. Glomus* was the most diverse genus represented by 48 species, followed by 27 and 10 for *Acaulospora* and *Scutellospora* respectively [12]. The upgradation of data in 2016 however revealed 161 species to be occurring in 23 states of India. New species added to the list were *Acaulospora colombiana, Diversispora eburnean, Diversispora spurca, Glomus albidum, Glomus pallidum, Glomus pustolatum, Glomus tortuosum, Glomus versiforme, Rhizophagus diaphanous, Sclerocystis liquidambaris, Scutellospora armeniaca , Scutellospora pellucida* and *Scutellospora reticulata.*

In addition to providing useful information to scientists and researchers in the field of mycorrhiza, the database would also be useful to officials in Central and State governments, besides Botanical Survey of India, to develop a list of AM fungi, to help in formulation of strategies for conserving biodiversity of that region .It serves as a platform for regular upgradation of data for biodiversity listing and expediting the process of many ecosystem conservation priority approaches.

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