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Assessment of some coastal psammophytes for AM fungal association

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ABSTRACT

Present paper deals with assessment of Arbuscular Mycorrhizal (AM) Fungal association in some psammophytes from a sandy beach at Murud Dapoli in Maharashtra which is under great pressure of anthropogenic activities like tourism and is accelerating sand erosion effect vigorously. Results obtained suggest that Fabaceae members (Crotalaria retusa L, Crotalaria vericosa L. and Derris trifoliata Lour.) were found as dominated AM Fungi associating psamophytes. While Pandanus fascicularis Lam. along the beach areas was encountered with highest percentage colonization.

Keywords: Arbuscular Mycorrhizal Fungi, Coastal sand dunes, Psammophytes.

INTRODUCTION

Coastal sand dunes (CSD) are natural structures protecting the coast from high waves and salt-water intrusions [5] and protecting the coast from erosion [8]. The plants living in sand dunes are called Psammophytes which are naturally adapted to stress conditions and survive in experiencing salt spray, sand burial, low moisture content, high light intensity, wind exposure, soil salinity and nutrient deficiency. Psammophytes comprise vital components of CSD habitats owing to their bioengineering role in sediment accumulation, sand binding and land building processes [28]. The typical sand dune vegetation can be studied under three zones *viz.*, pioneer zone, midshore zone and the backshore zone [1], [9]. The pioneer zone is closest to the sea covered by herbaceous crawling plant species and the backshore zone is farthest mostly covered with trees while the middle zone has shrubs. These three zones together form a vegetation slope, which acts as a block to the movement of wind and sand [9]. The importance of Arbuscular Mycorrhizal (AM) fungi in sand vegetation i.e. psammophytes is now well understood. The Temperate coastal dunes are well studied and documented with reference to AM fungal association [22] as compared to studies on tropical coastal dunes [13], [32]. Although Maharashtra has a coastline of 720 Km which is composed with either sandy or rocky area, the AM fungal research is fairly ignored with very few recent reports [36] as an exception. Hence, in present paper an attempt was made to study AM fungal association in some psammophytes from Murud beach which is exposed to great pressure of anthropogenic activities like, recreation, tourism and is accelerating sand erosion effect rapidly.

MATERIALS AND METHODS

AM fungal colonization and species identification: Roots and rhizosphere soil samples of some of the psammophytes were collected from three vegetation zones (Pioneer zone, Midshore zone and Backshore zone) of Murud beach Dapoli, which is situated in the Ratnagiri District, State of Maharashtra, India, (17°45′32", North 73°11′8" East). In the laboratory, roots of each plant sample from every location were made free from soil debris by washing after following clearing and staining method of Phillips and Hayman [6] they were observed under a binocular microscope (Magnus, ICON FREEDOM- 528428) to evaluate mycorrhizal colonization following the technique of Giovannetti and Mosse [16]. Percentage colonization of AM fungi was calculated using Nicolson formula [33]. After root removal, the soil samples from each location were combined to obtain a single sample per location. Samples were extracted directly using the wet sieving and decanting method of Gerdemann and Nicolson [7]. AM fungal species were identified using the original descriptions [19].

RESULTS AND DISCUSSION

In present study eight Psammophytes *viz.*, *Crotalaria retusa* L., *Crotalaria vericosa* L., *Derris trifoliata* Lour. (Fabaceae); *Ipomoea pes-caprae* (L.) R. Br. (Convolvulaceae); *Launea sarmentosa* (Willd.) Sch. Bip (Asteraceae); *Pandanus fascicularis* Lam. (Pandanaceae); *Sesuvium portulacastrum* (L.) L. (Aizoaceae) and *Triumfetta rhomboidea* N. Jacq (Tilliaceae) were investigated for AM fungal association from three zones of study area *viz.*, pioneer zone, midshore zone, and the backshore zone. Out of eight plants except *I. pes-caprae*, *S. portulacastrum* and *T. rhomboidea* remaining five plants were exhibiting all the three components of AM fungi *viz.*, vesicles, arbuscules and hyphae and hence type of colonization is referred as *VAH*. AMF colonization observed in studied psammophytes was in the range of 19-75 % (Table 1). In present study, *C. retusa* showed variation in vesicular formation, in which aggregation of vesicles (*Av*) was characteristically observed in individual cortical cell (Fig. 1). The external mycelium or extramatrical mycelium (*em*) was well developed in *C. retusa*, *C. vericosa*, *D. trifoliata*, *I. pes- caprae*, *L. sarmentosa* and *P. fascicularis* (Fig. 1-6). Previously it has been demonstrated that the external mycelium of AM fungi plays a significant role in the process of dune stabilization because sand grains are bound together mechanically by their hyphae [4], [14], [24], [29-31]. Thus Mycorrhizal colonization benefits soil rehabilitation and erosion control by stimulating soil aggregation [3], [5]. Since extramatrical mycelium also provides a large surface area on colonized root for orthophosphate absorption from bulk soil, such colonization cannot be ignored because, absorption of orthophosphate is maximized by the action of a high-affinity transporter which is expressed only in extrametrical mycelium of AM fungi during symbiosis with the plant [17].

In present work internal spread of the hyphal coiling (*hc*) and localized mycelium (*lm*) along with arbuscules was found in *D. trifoliate* (Fig. 3). In addition to vesicles encounter, *Branched absorbing structures* (*BAS*), auxiliary cell (*AU*), external hyphae (*em*), hyphal coilings (*hc*), and chlamydospores (*s*) development was confined with *I. pes-caprae* (Fig. 4), where arbuscules were absent. Although, colonization in *L. sarmentosa* was of *VAH* type, vesicles were very minute in size, chlamydospores (*s*) development on root surface and other fungal endophyte (*ofe*) were also recorded (Fig. 5). In root fragments of *P. fascicularis* hyphae of AM fungus were establishing linear mycelium (*Lm*), corresponding to the *Arum-type*, vesicles were regularly-shaped and chlamydospores (*s*) development was also recorded (Fig. 6). *S. portulacastrum* showed presence of *VH* type colonization and *BAS* along with mycorrhizal endophytes (*me*). These roots were also encountered with other fungal endophytes (Fig. 7). In *T. rhomboidea*, colonization was *VH* type, vesicles were regularly-shaped, arbuscules were absent, other fungal endophytes were also found (Fig. 8).

Our study confirmed that, tropical sand dunes plant species belonging to Asteraceae, Convolvulaceae and Fabaceae contribute towards the stabilization of coastal sand dunes [5], [10], [18], [20], [32] and the AM fungi encounters the rhizosphere of psammophytes belonging to these families. Recent AM fungal studies [36], at disturbed CSD ecosystems in Maharashtra (Arnala and Kalamb) have proved diversity of AM fungal species is existing with two species of mat-forming strand creepers *viz.*, *I. pes-caprae* and *S. portulacastrum* which exhibited comparatively high percentage of mycorrhizal colonization than present samples (Pioneer zone).

Although present study site is also representing a disturbed CSD ecosystem, however high variation in AM fungal colonization may be caused because of highest rate of vegetation destruction in present study area due to over increased coastal tourism practices. Thus leading to loss of mycorrhizal species and thereby reducing the colonization rate in psammophytes of Murud beach. While backshore zone or hind dune psamophyte- *P. fascicularis* was encountered with highest percentage colonization. Undisturbed habitat of *P. fascicularis* might be because of its robust nature and thorny leaves structures which helps plants to get rid off human activities and thereby preventing the loss of mycorrhizal population. Hence *P. fascicularis* probably have highest percentage of colonization than psammophytes of pioneer zone and midshore zone.

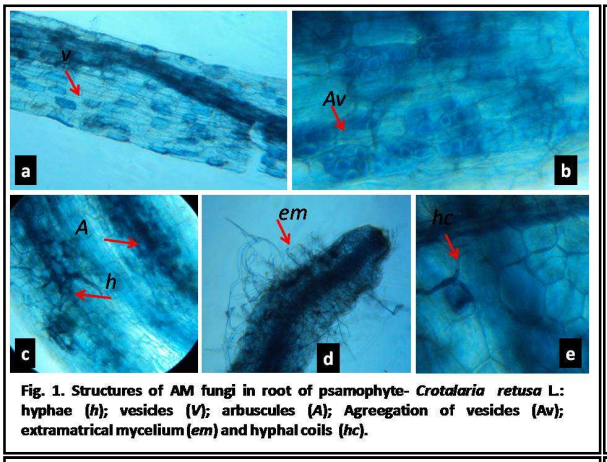

Fig. 1. Structures of AM fungi in root of psamophyte- *Crotalaria retusa* L.: hyphae (*h*); vesicles (*V*); arbuscules (*A*); Agreegation of vesicles (Av); extramatrical mycelium (*em*) and hyphal coils (*hc*).

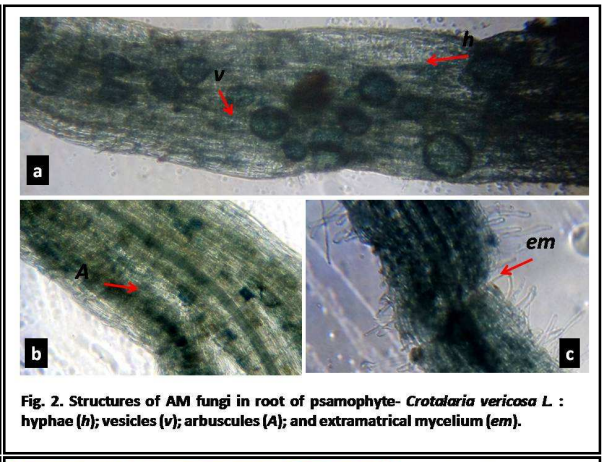

Fig. 2. Structures of AM fungi in root of psamophyte- *Crotalaria vericosa L.* : hyphae (*h*); vesicles (*v*); arbuscules (*A*); and extramatrical mycelium (*em*).

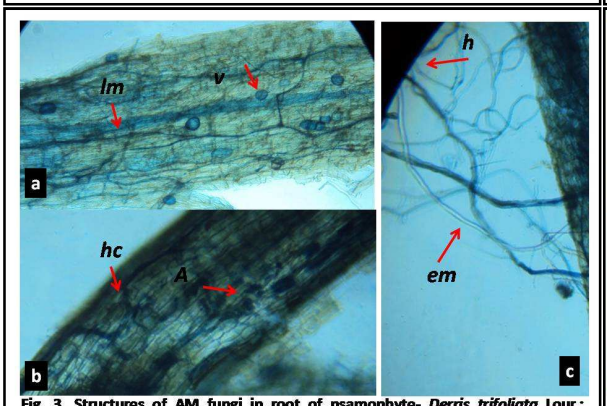

Fig. 3. Structures of AM fungi in root of psamophyte- *Derris trifoliata* Lour.: hyphae (h); vesicles (V); arbuscules (A); hypeal coiling (*hc*); localised mycelium (lm); and extramatrical mycelium (em).

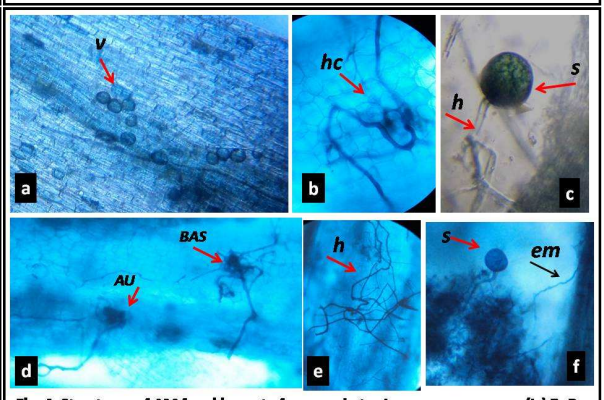

Fig. 4. Structures of AM fungi in root of psamophyte- *Ipomoea pes-caprae* (L.) R. Br: hyphae (*h*); vesicles (v); hyphal coil (*hc*); spore (s); external mycelium (*em*); Branched absorbing structures (*BAS*) and auxiliary cell (*AU*).

In present paper, AM fungal spore study revealed that, most commonly encountered species, from this beach are *viz.*, *Gigaspora margarita* Becker & Hall, *Acaulospora spinosa* Walker & Trappe, *Glomus mosseae* (Nicolson and Gerdemann) Gerdemann & Trappe, *Glomus fasciculatum* (Thaxter) Gerdemann & Trappe emend. Walker & Koske, *Glomus aggregatum* Schenck & Smith emend. Koske. However, there is wide scope to assess the density and abundance of these AM fungal spores from each psammophyte species which is beyond the perspective of present paper. Thus, present paper makes addition of AM fungal data for existing tropical locations because, there are only three such locations *viz.*, Hawaiian Islands [21], [23], [25-27]; India [11-12], [34-35] and Singapore [2] which have surveyed for sand dune AM fungi.

It is now well proved that, vegetation is an effective mean to reduce sand movements on beaches and dunes hence to restore these habitats. Over increased anthropogenic activities near the coastal area and on beaches is a serious concern of vegetation loss from sand dune area [36]. Hence, to strengthen the psammophytic vegetation diversity of disturbed sandy beaches, proper use of native AM fungal consortium is becoming emerging need of time.

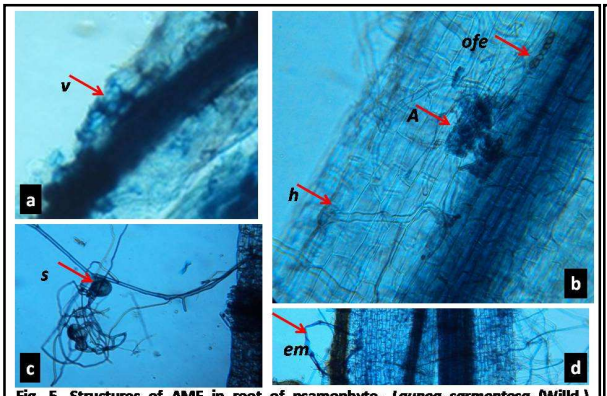

Fig. 5. Structures of AMF in root of psamophyte- *Launea sarmentosa* (Willd.) Sch.Bip: hyphae (*h*); vesicles (*v*); hyphal coil (*hc*); spore (*s*) and extramatrical mycelium (*em*).

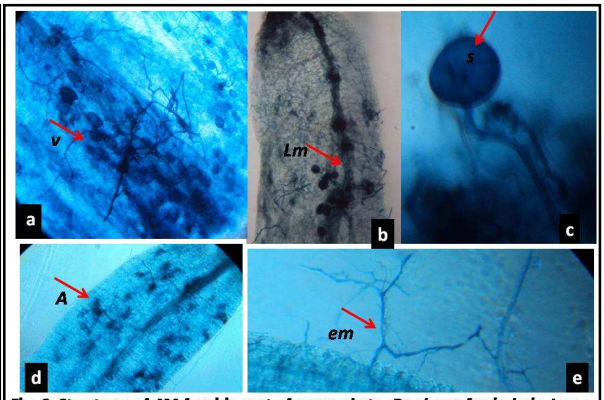

Fig. 6. Structures of AM fungi in root of psamophyte- *Pandanus fascicularis* Lam.: hyphae (*h*); vesicles (*v*); spore (*s*) linear mycelium (*Lm*) and extramatrical mycelium (*em*).

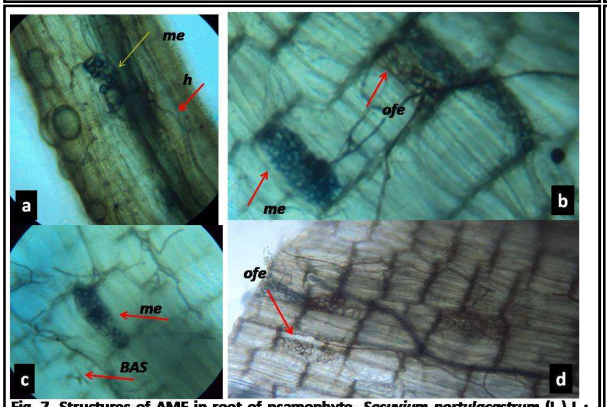

Fig. 7. Structures of AMF in root of psamophyte- *Sesuvium portulacastrum* (L.) L.; vesicles (*v*); hyphae (*h*); Branched absorbing structures (*BAS*); other fungal endophytes (ofe) and mycorrhizal endophyte (*me*).

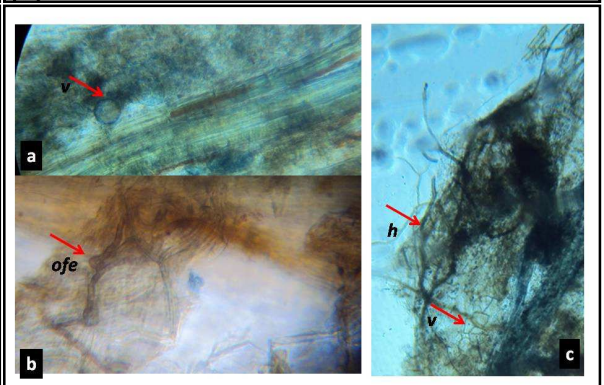

Fig. 8. Structures of AM fungi in root of psamophyte- *Triumfetta rhomboidea* N. Jacq; vesicles (*v*); hyphae (*h*); and other fungal endophytes (*ofe*).

Table 1. AM fungal assessment in psammophytes from Murud beach Dapoli

Sr. No.	Psammophyte species	AM fungal Colonization	
		[@]Type	[*]Percentage (%)
1.	[#]*Crotalaria retusa* L. (Fam. Fabaceae)	*VAH*	62
2.	[#]*Crotalaria vericosa* L. (Fam. Fabaceae)	*VAH*	54
3.	[$]*Derris trifoliata* Lour. (Fam. Fabaceae)	*VAH*	60
4.	[!!]*Ipomoea pes-caprae* (L.) R. Br. (Fam. Convolvulaceae)	*VH*	50
5.	[!!]*Launea sarmentosa* (Willd.) Sch. Bip (Fam. Asteraceae)	*VAH*	40
6.	[$]*Pandanus fascicularis* Lam. (Fam. Pandanaceae)	*VAH*	75
7.	[!!]*Sesuvium portulacastrum* (L.) L. (Fam. Aizoaceae)	*VH*	24
8.	[#]*Triumfetta rhomboidea* N. Jacq (Fam. Tilliaceae)	*VH*	19

*[[@]**Type:** A- Arbuscular, H- Hyphal, V- Vesicular; [$]Backshore zone; [#]Midshore zone; [!!]Pioneer zone; [*]**Percentage:** Mean of three samples]*

CONCLUSION

Although, CSD is a considered as nutrient limited ecosystem, psammophytes have developed specialized mechanisms to cope with the adverse conditions prevailing in this ecosystem. Rhizospheric microbial communities of sand dune habitat in general particularly mycorrhiza may support the growth of these psammophytes directly or indirectly. Present results on psamophytic plants from Murud beach of Dapoli make significant addition in existing AM fungal data for tropical locations in general particularly for Maharashtra. However, to understand species diversity of these mycorrhizal symbionts with studied psammophytes, it is necessary to carry out extension of experimental work.

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