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ARBUSCULAR MYCORRHIZAL FUNGI FROM SOME COASTAL PLANTS OF KARACHI (PAKISTAN)

Abdul Rauf, D. Khan and M. Javed Zaki

Department of Botany, University of Karachi, Karachi – 75270, Pakistan.

ABSTRACT

Fourteen species of angiosperms belonging to 11 genera and 8 families were tested for their association with AM fungi in their roots and rhizospheres in Hawkes Bay coastal environment of Karachi, Pakistan. Thirteen species of AM fungi belonging to four genera were found to associate with the angiosperms. Among these fungi, Genus *Glomus* was the most dominant genus – represented by nine species. The maximum number of AM fungi (8) associated with a legume, *Lotus garcinii*, followed by a composite *Launaea resedifolia* (7 AM fungi) and a grass *Aeluropus lagopoides* (7 AM fungi). The lowest number of AM fungi (2) associated with *Atriplex griffithii* and *Avicennia marina*. Each of the 14 species tested for AMF occurrence had at least association with one *Glomus* species. The number of *Glomus* species associated with some angiospermic species was quite substantial. The frequency of occurrence of AM fungi with the angiospermic species, *Glomus macrocarpum* was the most frequent fungi (57.14%), *Glomus epigaenum* and *Gigaspora geosporum* associate with 7 angiospermic species each. (Freq: 50%). *Glomus leptotichum* and *Gigaspora marga*rita associated with 6 species each (Freq: 42.86%) and *Glomus mossaee*, *Acaulospora laevis* and *A. birecticulata* had frequency of 35.71% (association of each AM fungi with five angiospermic species. The number of AMF spores per 100 g rhizospheric soil of angiospermic species varied substantially (CV: 48.7%) amongst the species tested and averaged to a grand mean of 400.31 ± 52.09 spore. The number of AMF spores were lesser than the grand mean in case of *Cyperus longus, Indigofera argentea, Ipomoea pes-caprae, Heliotropium subulatum, Heliotropium* sp. and *Suaeda* sp. whereas the number of AMF spores were near equal to grand mean value in case of species viz. *Aeluropus lagopoides, Atriplex griffithii* and *Suaeda fruticosa*. The number spores were considerably larger than the grand mean value in *A. marina*, *C. cretica*, *L. resedifolia*, *L. garcinii,* and *Cyperus* sp.

Root colonization (%) also varied substantially amongst the angiospermic species (CV: 49.59%) and averaged to a grand mean of 22.40 ± 2.97. Root colonization happened to be lesser than the grand mean value in *Atriplex griffithii, Cyperus longus, Indigofera argentea, Ipomoea pes-caprae, Heliotropium* sp., *Launaea resedifolia* and *Suaeda* sp. and substantially larger than the grand mean value in *Aeluropus lagopoides, Avicennia marina, Cressa cretica, Heliotropium subulatum, Lotus garcinii, Suaeda fruticosa*, and *Cyperus* sp. The mean number of AMF spores per 100 g rhizospheric soil was quite larger in magnitude in Families Leguminosae and Asteraceae and somewhat equally moderate in Families such as Convolvulaceae, Chenopodiaceae, Cyperaceae and Poaceae.

AMF clusters were recognized by Ward method of Hierarchical clustering – each cluster was a collection of highly similar species.

Cluster A: *Glomus clariodeum + Glomus geosporium;* Cluster B*: Gigaspora margarita;* Cluster C*: Glomus epigaenum + Acaulospora birecticulata + Scutellospora dipapillosa;* Cluster D*: Glomus scaledonium + Glomus leptotichum;* Cluster E: *Glomus mosseae + Glomus intraradices;* Cluster F: *Glomus clariodeum + Glomus macrocarpum + Acaulospora laevis*

The following seven clusters of angiospermic species were recognized on the basis of presence or absence of AMF species. Each cluster was a collection of closely similar species.

Cluster A: *A. marina + S. fruticosa;* Cluster B: *Ipomoea pes-caprae + Cyperus longus;* Cluster C: *Cressa cretica + Heliotropium sp.;* Cluster D: *Lotus garcinii;* Cluster E: *Indigofera argentea + Suaeda sp.,* Cluster F: *Launaea resedifolia + Cyperus sp.;* Cluster G: *Atriplex griffithii + Heliotropium subulatum + Aeluropus lagopoides.*

Key-words: Arbuscular mycorrhizal (AM) fungi, coastal plants, Hawkes Bay, Karachi, Pakistan.

INTRODUCTION

Arbuscular mycorrhizal (AM) fungi are very important and almost essential components of soil rhizosphere and play important role in sustainable plant soil environment by forming symbiotic association with roots of plants (Sharma *et al.*, 2009;Vogelsand and Bever, 2010). AM fungi form association with roots of plant belonging to ecologically different habitats. AM fungi are widely distributed and have been found to show mutual relationship with almost 80-85% of all vascular plants (Brundrett, 2002; Wang and Qiu, 2006) from all continents including Asia (Ganesan *et al*., 1991), Europe (Jansa *et al*., 2002; Land and Schonbeck, 1991), South America (Caproni *et al*., 2003; Vestberg, 1999), North America (Dalpe and Aiken, 1998), Antarctica (Cabello *et al*., 1994), Africa (Redhead, 1977) and from Oceania (Australia) (Hall, 1977) as well. AM fungal colonization have been found to almost all woody plant groups including flowering families like angiosperm and gymnosperm as well as some other nonflowering group including some members of pteridophytes (Mishra *et al*., 1980; Muthukumar and Udaiyan, 2000), gametophytes of bryophytes (Schüβler 2000) and some aquatic plants (Nielsen *et al*., 2004) are also known to show AM colonization within roots. In some families like Chenopodiaceae, Cruciferae and Cyperaceae AM association is rare (Hudson, 1986) while no association has so far been reported in Pinaceae, Betulaceae, and Urticaceae (Bagyaraj, 1986). Their density has been reported to vary in wide range of environmental conditions in soil like salinity (Gerdemann, 1968), soil phosphorus level (Jeffries *et al*., 1988) and soil pH (Read *et al*., 1976).

AM fungi are universal in occurrence – throughout the World in most terrestrial ecosystems (Vogelsang and Bever (2010). Khan (1974) investigated 52 xerophytes, 21 halophytes and 16 hydrophytes from Pakistan for incidence of mycorrhiza. Since then, a number of researchers in Pakistan have described status of AM fungal spore in different areas and around different crops (Saif and Khan, 1975; Jalal-ud-din and Anwar, 1991). Khan (1972) in Lahore, Anwar and Jalaluddin (2011) in different localities of Sindh, Burni *et al*. (2007, 2011), Burni and Ilahi (2004), Zainab and Burni (2005), Nasrullah *et al*. (2010) in KPK, Sharief *et al*. (2005) in D.I Khan described the distribution of AM fungal spores.

In this paper, 14 plant species of Hawkes Bay (Karachi coast) have been investigated for their association with AM fungi. Isolation of AMF spores from the rhizospheric soil of the studied species and the root colonization of these species by AMF have also been studied.

MATERIALS AND METHODS

Isolation and extraction of arbuscular mycorrhizal fungi

Soil and root sample collection

To study the population and composition of AM fungal spore in soil, samples of soil along with plant root were collected from five different locations on sand ridge running along the shore line of Hawkes Bay (Karachi Coastal area), Karachi. Roots of plants also collected along with soil sample but they were separated from soil sample in the laboratory. Soil and root samples were kept separately in plastic bags. EC of the saturated extract of the soil was determined as described by Estefan *et al* **(**2013).

Isolation of arbuscular mycorrhizal fungi

Spores of Arbuscular mycorrhizal fungi were isolated from soil by wet sieving and decanting technique (Gerdemann and Nicolson, 1963) followed by sucrose centrifugation technique (Jenkins, 1964).

Study of AM fungal Spores

Fungal spore were quantified in 100ml suspension after sucrose centrifugation technique. Spores of AM fungi were identified morphologically as described by Schenek and Perez (1990).

Root colonization of AM fungi

To determine AM fungal infection and colonization within root, a combined method of Philip and Haymen (1970) and Koske and Gemma (1989) were used. While percent root colonization were determined as described by Giovannetti and Mosse (1980), McGonigle *et al.* (1990).

Tissue clearing

Roots of plants were rinsed with tap water, cut into pieces of 1cm and placed in petri plates containing 10% (w/v) KOH. Petri plates containing 10% KOH were heated in autoclaved for 10 min at 15 psi. After heating root segments were taken out from 10% KOH solution and rinse with sterilized water.

Bleaching

Root segments rinse with sterilized water then in alkaline H_2O_2solution for 10 to 20 minutes until root became bleached. Alkaline H_2O_2 solution was prepared by adding 3mL of NH_4OH to 30 mL of 10% H_2O_2 and adds 567mL distilled water in it. After treating with H_2O_2 solution, root segments were washed with sterilized water.

Acidification

Roots segments were soaked in 1% HCl solution for about 10 minutes for acidification purpose to bind the stain to study AM structure within root, after10 minutes separate out roots from solution and poured off the solution.

Staining

Roots after acidification with 1% HCl were placed in beaker containing lacto phenol along with 0.05% trypan blue. Roots in lacto phenol solution were heated in autoclaved for 10 min at 15 PSI. Poured off the staining solution and roots were dipped in destaining solution.

AM fungal root colonization

Ten root segments from each sample were examined under stereoscopic microscope and percent AM root colonization calculated.

$$\% \text{ Colonization} = \frac{\text{Number of root segments colonized}}{\text{Total number of root segments}} \times 100$$

Statistical analysis

The data were statistically analyzed for descriptive statistical parameters using computer package SPSS v. 12. The dendrograms for AMF and angiospermic species were prepared by cluster analysis on the basis of the presence or absence of species and Ward (1963) method was used for joining species in form of a dendrogram.

RESULTS

Occurrence of AM fungi

Fourteen species of angiosperms belonging to 11 genera and 8 families were tested for their association with AM fungi in their roots and rhizospheres (Table 1) in Hawkes Bay coastal environment of Karachi, Pakistan. Many of these species (9 in number) were the well known halophytic species and associated with soils of differential salinity status (Table 1). Thirteen species of AM fungi belonging to four genera were found to associate with the angiosperms. Among these fungi, Genus *Glomus* was the most dominant genus – represented by nine species. The occurrence of AM fungi in respect of the angiosperms tested is presented in Fig.1. The maximum number of AM fungi (8) associated with a legume, *Lotus garcinii*, followed by a composite *Launaea resedifolia* (7 AM fungi) and a grass *Aeluropus lagopoides* (7 AM fungi). *Cressa cretica*, *Heliotropium subulatum*, *Indigofera argentea*, *Cyperus* sp. and *Suaed*a sp. associated with 5 AM fungi each. Four AM fungi were found to be in the rhizosphere of *Cyperus longus* and *Ipomoea pes-caprae* each. *Suaeda fruticosa* had three AM fungi. The lowest number of AM fungi (2) associated with *Atriplex griffithii* and *Avicennia marina*. Each of the 14 species tested for AMF occurrence had at least association with one *Glomus* species. The number of Glomus species associated with some angiospermic species was quite substantial e.g. six *Glomus* spp. occurred with *A. lagopoides*, five *Glomus* spp. with *I. argentea* and *L. garcinii* each, four *Glomus* spp. occurred with *L. resedifolia, Heliotropium subulatum, C. cretica* and *Ipomoea pes-caprae each*. *Cyperus longus*, *Cyperus* sp. *Heliotropium subulatum* and *Suaeda* sp. had three *Glomus* spp. each. *A. griffithii* and *S. fruticosa* associated with *Glomus* each.

Table 1. Occurrence of angiospermic species in sites sampled and salinity associated with them.

S. No.	Species	Family	site Number	EC: $dS.m^{-1}$
1.	*Aeluropus lagopoides* (L.) Trin. Ex Thw.*	Poaceae	1,3	10.10 ± 1.20 (8.9-11.30)
2.	*Atriplex griffithii* Moq. *	Chenopodiaceae	3,4	13.42 ± 5.59 (7.83-19.0)
3.	*Avicennia marina* *	Acanthaceae	3	32.70
4.	*Cyperus longus*	Cyperaceae	3,5	6.69 ±0.31 (6.38-7.0)
5.	*Cyperus* sp.	Cyperaceae	1,4	6.66 ± 1.22 (5.44-7.88)
6.	*Cressa cretica* L. *	Convolvulaceae	2,4	14.76 ± 4.24 (10.52-19.0)
7.	*Indigofera argentea* Burm. F.	Leguminosae	3,5	19.12 ± 10.0 (9.12-29.12)
8.	*Ipomoea pes-caprae* (L.) R.Br. *	Convolvulaceae	1,5	9.82 ± 1.24 (8.58-11.06)
9.	*Heliotropium subulatum* (Hochst) Vatke	Boraginaceae	2	15.05
10.	*Heliotropium* sp.	Boraginaceae	1,5	17.50 ± 5.50 (12.0-23.0)
11.	*Launaea resedifolia* (L.) O.K. *	Asteraceae	1,3	13.38 ± 2.40 (8.58-15.79)
12.	*Lotus garcinii* DC. *	Leguminosae	2,3,4	7.24 ± 5.24 (1.60-12.89)
13.	*Suaeda fruticosa* (L.) Forsk. *	Chenopodiaceae	2,5	11.35 ± 1.48 (9.87-12.83)
14.	*Suaeda* sp. *	Chenopodiaceae	1	15.7

*, well known coastal halophytic species.

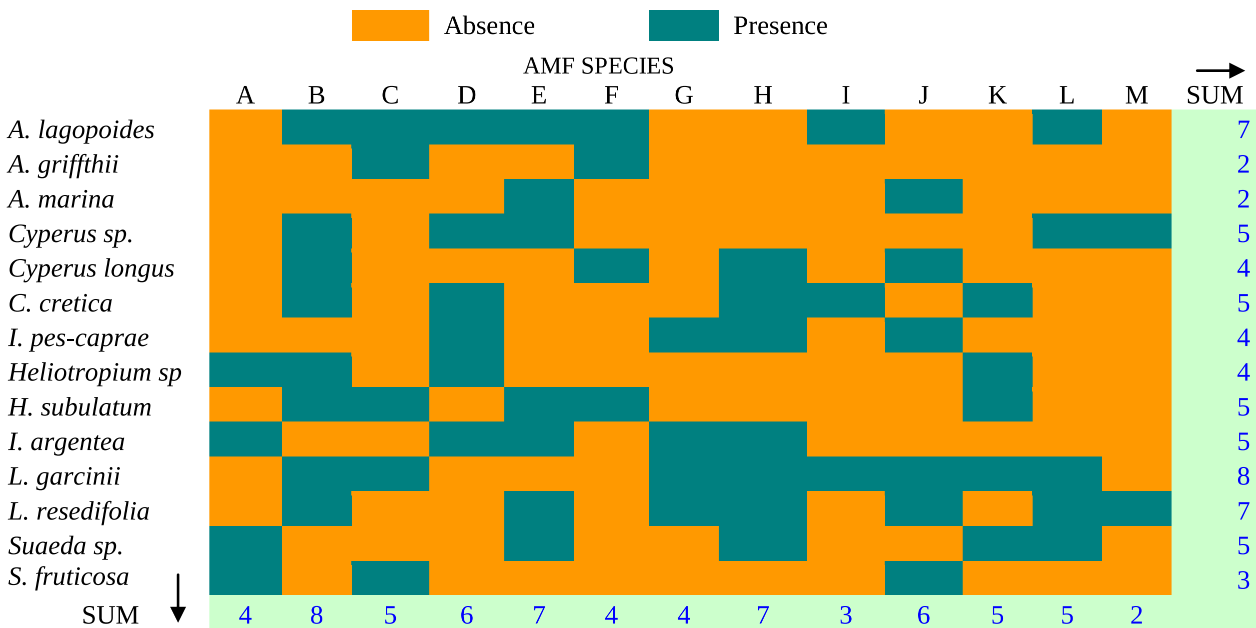

Fig. 1. Representation of association of AMF with various coastal angiospermic species. Acronyms for AMF species: A, *Glomus scaledonium*; B, *G. macrocarpum*; C, G. mossaee; D, *G. leptotichum*; E, *G. epigaenum*; F, *G .intraradices*; G, G. clarum*;* H, G. geosporum; I, *G. claroideum*; J, *Gigaspora margarita*; K, *Acaulospora laevis*; L, *A. birecticulata*; M, *Scutellospora dipapillosa*.

As regard to the frequency of occurrence of AM fungi with the angiospermic species, *Glomus macrocarpum* was the most frequent fungi (57.14%), *Glomus epigaenum* and *Gigaspora geosporum* associate with 7 angiospermic species each. (Freq: 50%). *Glomus leptotichum* and *Gigaspora margar*ita associated with 6 species each (Freq: 42.86%) and *Glomus mossaee*, *Acaulospora laevis* and *A. birecticulata* had frequency of 35.71% (association of each AM fungi with five angiospermic species. Three AM fungi viz. *Glomus scaledonium*, *Glomus intraradices* and *Glomus clarum* associated with four angiospermic species. *Glomus claroideum* and *Scutellospora dipapillosa* associated with 3 and 2 species respectively. It follows from the results that *G. macrocarpum* was the most frequent AM fungus in salinity-affected Hawkes Bay ecosystem and *S. dipapillosa*, the least frequent species.

Isolation of AM fungal spores from the rhizospheric soil

Spores of AM fungi, in these studies, were identified morphologically as described by Schenek and Perez (1990). The spores of some important AM fungi are shown in Fig. 2 and 3 and their numerical abundance along with root colonization data are presented in Table 2. The number of AMF spores per 100 g rhizospheric soil of angiospermic species varied substantially (CV: 48.7%) amongst the species tested and averaged to a grand mean of 400.31 ± 52.09 spore. The number of AMF spores were lesser than the grand mean in case of *Cyperus longus*, *Indigofera argentea*, *Ipomoea pes-caprae*, *Heliotropium subulatum*, *Heliotropium* sp. and *Suaeda* sp. whereas the number of AMF spores were near equal to grand mean value in case of species viz. *Aeluropus lagopoides*, *Atriplex griffithii* and *Suaeda fruticosa*. The number spores were considerably larger than the grand mean value in *A. marina*, *C. cretica*, *L. resedifolia*, *L. garcinii*, and *Cyperus* sp.

Root Colonization (%)

Root colonization (%) also varied substantially amongst the angiospermic species (CV: 49.59%) and averaged to a grand mean of 22.40 ± 2.97. Root colonization happened to be lesser than the grand mean value in *Atriplex griffithii*, *Cyperus longus*, *Indigofera argentea*, *Ipomoea pes-caprae*, *Heliotropium* sp., *Launaea resedifolia* and *Suaeda* sp. and substantially larger than the grand mean value in *Aeluropus lagopoides*, *Avicennia marina*, *Cressa cretica*, *Heliotropium subulatum*, *Lotus garcinii*, *Suaeda fruticosa*, and *Cyperus* sp. (Table 2).

It is obvious from the Table 3 that mean number of AMF spores per 100 g rhizospheric soil was quite larger in magnitude in Families Leguminosae and Asteraceae and somewhat equally moderate in Families such as Convolvulaceae, Chenopodiaceae, Cyperaceae and Poaceae. The spores were lesser in Family Boraginaceae.

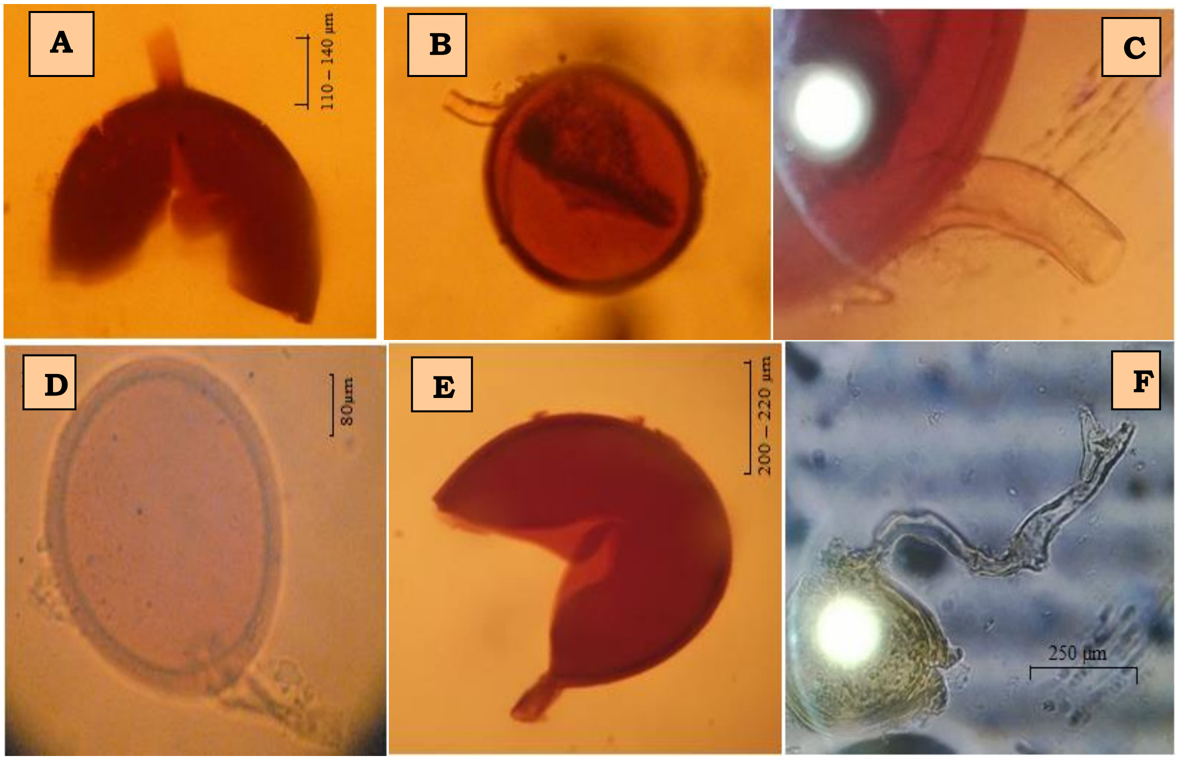

Fig. 2.Spores of *Glomus* species isolated from rhizospheric soil of different plant species. **A-C)** *Glomus intraradices* D**)** *Glomus claroideum* **E)** *Glomus geosporum*, ***F***, *G. clarum*

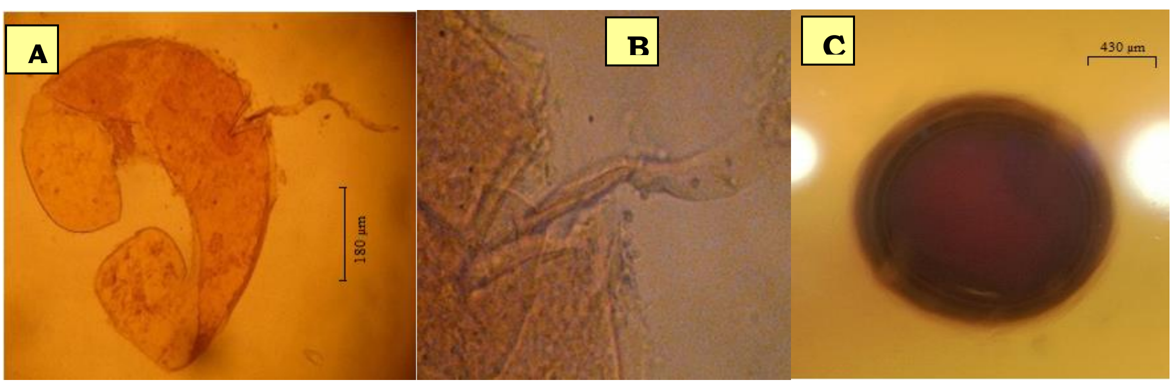

Fig. 3. Spores of *Gigaspora* and *Scetullospora* and *Glomus* isolated from rhizospheric soil from different plant species. A and B) *Scetullospora dipapillosa;* C) *Gigaspora margarita.*

Root colonization was more or leas comparable in Families Poaceae, Leguminosae, Convolvulaceae (25-27%), relatively lesser in Boraginaceae, Chenopodiaceae, and Cyperaceae (17-19%) and substantially high (40%) in Acanthaceae. Root colonization was the minimum in Asteraceae (8%).

Agglomerative Clustering

Dendrograms based on agglomerative clustering of AM fungi (when angiospermic species have been the attributes for the presence or absence of AMF) and the angiospermic species (when AM fungi have been the attributes for the presence or absence with the angiospermic species) are presented in Fig. in 4 and 5.

From Fig. 4, following AMF clusters were recognized – each cluster was a collection of highly similar species in the given context of their occurrence amongst the angiospermic species. Each cluster is a composite of two or more AMF species in connection with the angiospermic flora in sandy salinity-affected environment of Hawkes Bay.

Cluster A: *Glomus clariodeum* + *Glomus geosporium,*
Cluster B*:* *Gigaspora margarita,*

Cluster C: *Glomus epigaenum + Acaulospora birecticulata + Scutellospora dipapillosa,*
Cluster D: *Glomus scaledonium + Glomus leptotichum,*
Cluster E: *Glomus mosseae + Glomus intraradices,*
Cluster F: *Glomus clariodeum + Glomus macrocarpum + Acaulospora laevis*

Table 2. Number of AMF spores per 100g of the rhizospheric soil and the root colonization (%) of various angiospermic species of Karachi coast, Pakistan.

S. No.	Species	Spores per 100g soil	Root colonization (%)
1.	*Aeluropus lagopoides* (L.) Trin. Ex Thw.*	398.00 ± 99.96	27.0 ± 4.0
2.	*Atriplex griffithii* Moq. *	392.50 ± 94.51	14.25 ± 10.3
3.	*Avicennia marina* *	858.00	40.0
4.	*Cyperus longus*	288.00 ± 52.01	12.80 ± 1.80
5.	*Cyperus* sp.	443.0 ± 57.01	26.50 ± 1.50
6.	*Cressa cretica* L. *	466.050 ± 233.5	38.0 ± 15.0
7.	*Indigofera argentea* Burm. F.	288.50 ± 78.50	14.0 ± 1.0
8.	*Ipomoea pes-caprae* (L.) R.Br. *	288.50 ± 78.50	15.0 ± 2.0
9.	*Heliotropium subulatum* (Hochst) Vatke	302.00	34.1
10.	*Heliotropium* sp.	163.00 ± 51.01	9.0 ± 0
11.	*Launaea resedifolia* (L.) O.K. *	495.0 ± 120.02	13.95 ± 9.05
12.	*Lotus garcinii* DC. *	703.33 ± 71.23	31.62 ± 3.93
13.	*Suaeda fruticosa* (L.) Forsk. *	390.33 ± 123.02	29.40 ± 7.4
14.	*Suaeda* sp. *	128.0	8.0
	Grand mean	400.31 ± 52.09	22.40 ± 2.97
	CV (%)	48.7	49.59

Table 3. Average number of spores, number of AMF species and mean root colonization (%) for various plant families of the site studied in Karachi coast.

S. No.	Plant Families	Mean Number of spores per 100g Soil	Mean Root Colonization (%)	Mean Number of AMF Species
1	Acanthaceae	858.0	40.0 ± 0	2
2	Asteraceae	495.0 ± 120.02	8.0	7
3	Boraginaceae	209.33 ± 54.90	17.37 ± 8.37	4.5 ± 0.5
4	Convolvulaceae	377.50 ± 112.94	27.75 ± 8.99	4.5 ± 0.5
5	Chenopodiaceae	338.60 ± 71.96	19.06 ± 6.01	3.33 ± 0.88
6	Cyperaceae	365.50 ± 54.72	19.65 ± 4.07	4.5 ± 0.5
7	Leguminosae	540.20 ± 106.21	24.60 ± 4.84	6.5 ± 1.5
8	Poaceae	398.0 ± 99.96	27.0 ± 4.0	7

From Fig. 5, following seven clusters of angiospermic species were recognized on the basis of presence or absence of AMF species. Each cluster was a collection of closely similar species in the context of the intensity of the association of AM fungi.

Cluster A: *A. marina + S. fruticosa,*
Cluster B: *Ipomoea pes-caprae + Cyperus longus,*
Cluster C: *Cressa cretica + Heliotropium sp.*
Cluster D: *Lotus garcinii,*
Cluster E: *Indigofera argentea + Suaeda sp.*
Cluster F: *Launaea resedifolia + Cyperus sp,*
Cluster G: *Atriplex griffithii + Heliotropium subulatum + Aeluropus lagopoides*

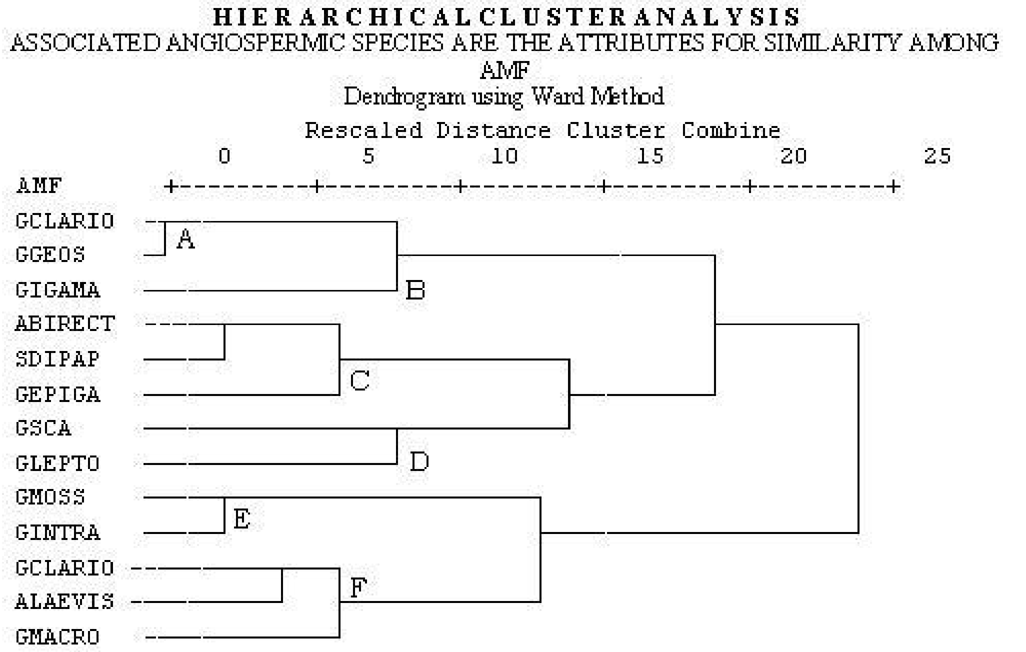

Fig.4. Cluster dendrograms for AMFs. Acronyms: GMOSS, *Glomus mossaee*; GCLARIO, *G. claroideum*; GMACRO, *G. macrocarpum*; GINTRA, *G. intraradices*; G. LEPTO, *G. leptotichum*, GEPIGA, *G. epigaenum*; ABIRECT, *Acaulospora birecticulata*; SDIPAP, *Scutellospora dipapillosa*; GSCA, *Glomus scaledonium*; ALAEVIS, *A. laevis*; GCLARIUM, *Glomus clarum*; GGEOS, *Glomus geosporum*; CIGAMA, *Gigaspora margarita*.

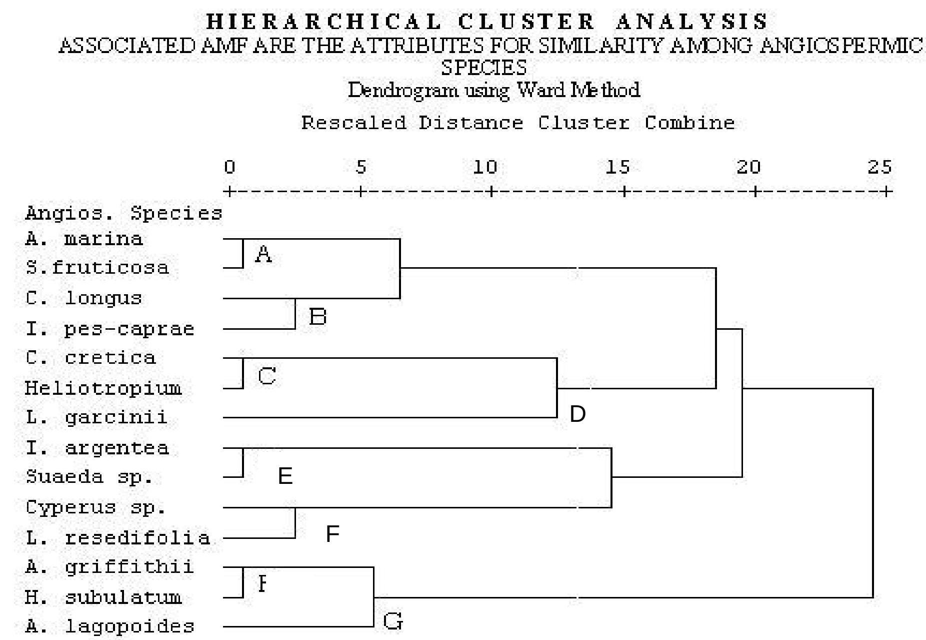

Fig. 5. Cluster dendrogram for angiospermic species. Acronyms: A. marina, *Avicennia marina*; L. resedi., *Launaea resedifolia*; I. pescap., *Ipomoea pes-caprae*; A. griffi., *Atriplex griffithii*; S. fruti., *Suaeda fruticosa*, C. longus, *Cyperus longus*; C. cretica, *Cressa cretica*; L. garcinii, *Lotus garcinii*; Helio. Sp., *Heliotropium* sp.; I. argent. *Indigofera argentea*; A. lagopo., *Aeluropus lagopoides*; H. Sabula. *Heliotropium sabulatum*.

DISCUSSION

Mycorrhizal fungi are one of the important components of microflora around rhizosphere of plants (Mukerji *et al.*, 2012). . Because of their symbiotic efficiency, they play an important role in association between plant and soil.

These fungi produces spores and sporocarps in soil and these spores are the key structures helpful in identification of fungal species. Study was carried out to obtain AM fungal spore dispersion, their distribution and composition in a salinity-affected coastal sand ridge of Hawkes Bay, Karachi. AM fungi were identified by the identification manual of Schenck and Perez (1990). During study variation in composition of AM species were found in which species belonging to four genera (*Glomus, Gigaspora, Acaulospora* and *Scutellospora*) isolated showed different dispersion pattern amongst the angiospermic species. All tested species associated with ≥ 2 AM fungi. Beena *et al.* (2001) tested 28 species of West coast of India for mycorrhizal fungi and found 23 plants (71.43%) colonized by AM fungi.

Each of the 14 species tested for AMF occurrence had at least association with one *Glomus* species. The number of *Glomus* species associated with some angiospermic species was quite high e.g. six *Glomus* spp. occurred with *A. lagopoides*, five *Glomus* spp. with *I. argentea* and *L. garcinii* each, four *Glomus* spp. occurred with *L. resedifolia, Heliotropium subulatum*, *C. cretica* and *Ipomoea pes-caprae each*. With other species three or less than three AM fungi associated. *In Ipomoea pes-caprae* association of moderately and severely disturbed dunes, three *Glomus* species (*G. mosseae, G. dimorphicum*, and *G. fasciculatum* associated with *Ipomoea* roots besides other genera like *Gigaspora* and *Acaulospora*. In both sites, spore density strongly correlated with nitrogen content of the rhizospheric soil in the West coast of India (Beena *et al.*, 2000).

All the angiospermic species tested by us for their AMF relations were found to associate with differential degree of salinity. In salt –affected areas Occurrence of vesicular and arbuscular mycorrhiza provide added protection to the plant against salinity effects (Rozema *et al.*, 1986). In our studies, The number of AMF spores isolated from the rhizospheres of the subject species, however, showed no correlation with the salinity of the soil (r = 0.326, F = 1.427, NS) i.e. the salinity effects within the given range of salinity were not significantly detected There are, however, reports that occurrence and abundance of AM fungi related with physico-chemical properties of the soil. Schalamuk *et al.,* (2006) and Pagano *et al.* (2010) also isolated *Glomus, Gigaspora, Acaulospora* and *Scutellospora* from spore population. Number of abiotic factors influences the composition of AM fungal species. Physio-chemical properties of soil including pH, electrical conductivity (EC), and total dissolve solvent (TDS) play important role in fungal spore composition and distribution. Asghari *et al. (*2008) investigated the effects of soil salinity on AM fungi colonization of halophytes. The colonization of halophytes by AM fungi was inhibited by very high salinity (45 $dS.m^{-1}$) that may be due to inability of AM fungi to survive under very high salinity which may limit the beneficial effects of AM fungi to the halophytes under moderate and lower salinity level (Aggarwal *et al*., 2012; Al-Garni, 2006; Sevraj and Kim, 2004). Other factors besides salinity such as soil moisture and soil chemical and physical properties and plant species themselves control AM colonization (Wang *et al.*, 2004; Asghari *et al.*, 2008) A number of scientists have published similar reports of variation in spore composition due to physical and chemical nature of soil (Abbot and Robson, 1985; Porter *et al.*, 1987). Variation of AM spore in wide range of soil pH (6.19 to 10) was recorded. Abbott and Robson (1985) also described range of soil pH (5.3 to 7.5) in spore variation. Joshi and Singh (1995) and Duponnois *et al.* (2001) also correlated soil properties with AM fungal population. These results concluded that link between physical and chemical properties of soil and abundance of AM fungal spore vary among different species of AM fungi. Out of 05 different localities, greater number of spore were recorded from Thatta (2794.8/100g soil) along with 85 % AM fungal occurrence, while soil collected from coastal area showed least number of spore (409/100g soil) but with 100% occurrence. Ross and Ruttencutter (1977) also correlated particular plant species with AM fungal spore population in good soil condition (physiochemical properties of soil) and the favorable soil condition favors AM fungal population to increase in Thatta region. Anwar and Jalaluddin (2011) described the distribution of AM fungal spore in different localities of Sindh, according to them maximum spore were recorded in Nawabshah region while rhizospheric soil sample from Thatta showed relatively low result. Various studies showed the occurrence and distribution of AM fungal spore in different part of Pakistan. Burni *et al.* (2011) in KPK, Nasrullah *et al.* (2010) in North West frontier province, Sharief *et al.* (2005) in D.I Khan and Anwar and Jalaluddin, (2011) in Sindh. In present study, *Glomus* was found to be most dominant genus which is parallel with the finding of Morton (1988) that *Glomus* species are most distributed genera in soil all over globe followed by *Acaulospora* and *Gigaspora. Glomus* is the most frequently occurring AM fungi. Hamavani and Thippeswamy (2013) investigated 10 species of Asteraceae for AM fungi association and found ten species of *Glomus* associated with these species in addition to *Acaulospora* and *Archeospora*. The results of the present studies are also in agreement with some studies conducted recently (Zang *et al.*, 2003; Tao *et al.*, 2004; Panwar and Tarafdar, 2006; Wang and Zao, 2008; Sharma *et al*., 2009; Burni *et al*., 2011). This dominance of *Glomus* species in different soil conditions is presumably because of their ability to adopt various soil condition and survival in different pH soil (Pande and Tarafdar, 2004). *Glomus* and *Acaulospora*, because of their smaller spore morphology take minimum time to produce spore as compared to *Gigaspora* (Hepper, 1984). Among *Glomus* species, *Glomus mosseae* was found to be most occurring species. Previous work of Anwar and Jalaluddin (2011) is in agreement with previous studies. They showed the highest number of *Glomus mosseae* in soil collected from Sindh. Out of 11 plant families, family Malvaceae and Poaceae was showed to have maximum number of AM fungal species. Silva *et al.* (2001) also described the family Poaceae as second best among other monocot after Cyperaceae showed highest AM fungal occurrence. Harley and Harley (1987) reported 60% of 173 Poaceae species which showed AM fungal association. The variation in root colonization of AM fungi is observed to mainly depend on water content of soil. The availability of and availability of phosphorus (Wang *et al.*, 2010), and physiology and growth of roots (Lugo *et al.*, 2003) are other controlling factors.. In present study maximum root colonization were observed in *Avicennia marina (*40%). D'Souza and Rodrigues (2013) also reported presence of AM fungal structure inside root of *Avicennia marina*.

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