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Arbuscular mycorrhizal fungi in salinized and surrounded areas at the São Francisco Submedium Valley, Brazil

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ABSTRACT - (Arbuscular mycorrhizal fungi in salinized and surrounded areas at the São Francisco Submedium Valley, Brazil). In order to increase the knowledge about AMF in saline areas, 23 samples were collected from the rhizosphere of 15 host plants in four areas, with increasing levels of salinity: areas I (0.08-0.45 dS m^{-1}), II (1.03-6.38 dS m^{-1}), and IV (4.97-19.86 dS m^{-1}), with a Yellow Latosol soil, are in the Irrigation Project "Bebedouro" (Petrolina, Pernambuco State), while area III (3.18-10.91 dS m^{-1}), with a Vertisol soil, is in the Irrigation Project "Mandacaru" (Juazeiro, Bahia State). AMF spores density in the field ranged from 0.31 to 8.06 spores g^{-1} soil. Sporulation was improved on the first multiplication cycle, decreasing after that. Species of *Gigaspora* and *Scutellospora* were recovered only after the second cycle. The index of similarity of AMF species between the areas varied from 43 to 66%. Twenty one taxa of AMF were identified. *Glomus mosseae* and *G. intraradices* were the most commonly found in soils varying from 3.18 to 10.91 dS m^{-1}.
Key words: electrical conductivity, Glomales, diversity, semiarid

RESUMO - (Fungos micorrízicos arbusculares em solos salinizados e adjacentes no vale do submédio São Francisco, Brasil). Visando ampliar os conhecimentos sobre FMA em áreas salinizadas, foram coletadas 23 amostras de solo na rizosfera de 15 hospedeiros, em quatro áreas, caracterizadas por níveis crescentes de salinidade: áreas I (0,08-0,45 dS m^{-1}), II (1,03-6,38 dS m^{-1}) e IV (4,97-19,86 dS m^{-1}), com Latossolo Amarelo, estão incluídas no Projeto de Irrigação Bebedouro (Petrolina, Pernambuco), enquanto área III (3,18-10,91 dS m^{-1}), com Vertissolo, está no Projeto de Irrigação Mandacaru (Juazeiro, Bahia). A densidade de esporos de FMA no campo variou de 0,31 a 8,06 esporos g^{-1} de solo; o primeiro ciclo de multiplicação favoreceu a esporulação, que decresceu a partir do segundo ciclo. Espécies de *Gigaspora* e *Scutellospora* foram recuperadas apenas após o segundo ciclo. As áreas apresentaram índice de similaridade entre as espécies de FMA de 43 a 66%. Foram identificados 21 taxóns de FMA; *Glomus mosseae* e *G. intraradices* foram os mais comumente encontrados em solos variando de 3,18 a 10,91 dS m^{-1}.
Palavras-chave: condutividade elétrica, Glomales, diversidade, semi-árido

Introduction

The arbuscular mycorrhizal fungi (AMF) are widely distributed in nature, forming symbiotic associations with approximately 85% of vascular plant families (Heijden et al. 1998). Wilkinson (2001) emphasizes the relevance of the association of vascular plants with AMF for the success in the conquest of the terrestrial environment, since these fungi provide the plant with larger surface for absorption of nutrients and water through the external mycelium, while the fungus is favoured, receiving carbohydrates from the host plant. Considered for a long period among the Endogonales and later transferred to Glomales (Morton & Benny 1990), the AMF were recently moved to a new phylum, Glomeromycota, with four orders and seven families that include less than 10 genera (Schübler et al. 2001).

The mycorrhizal symbiosis occurs in diverse ecosystems, from arctic to desert areas, but most concentrated in the tropics, and the importance of these organisms in arid and semiarid regions has been shown (Stutz et al. 2000). In Brazil there are only a few reports of AMF in these environments (Maia & Trufem 1990, Farias 1994, Silva 2000) and in salinized soils (Yano-Melo et al. 1997).

Khan (1974) reported low number of spores and mycorrhizal colonization in halophytes from salinized areas of Pakistan, although in the winter and autumn spore density had increased. The author pointed out

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the importance of mycorrhizal colonization of halophytes by AMF for increasing plant tolerance to adverse conditions. Sengupta & Chaudhuri (1990) found four *Glomus* and one *Gigaspora* species associated to salt marsh plants, and considered that these AMF contribute for ecological adaptation of such plants.

Species of *Glomus*, mainly *G. fasciculatum* and *G. mosseae,* were the most commonly found in salinized soils of cultivated areas in Egypt (Mankarios & Abdel-Fattah 1994). Among 47 plant species, 32 were colonized by AMF; however, an inhibitory effect on spores number and mycorrhizal colonization was observed with increasing salinity. *Sclerocystis* and *Glomus* were the dominant species of AMF in saline soils from Tamilnadu, with densities of 1.4 to 4.6 spores g^{-1} of soil (Bhaskaran & Selvaraj 1997). Considering that plants in this area are mycorrhizal, the authors emphasize that AMF determine the success of environmental programs in saline soils.

In Brazil, Yano-Melo et al. (1997) reported the presence of three *Acaulospora,* one *Entrophospora* and five *Glomus* species in salinized areas of banana plantations in which there was approximately 55% root colonization. Although these research data had been from diverse geographical areas, there is a certain similarity in occurrence of some species. Goodfriend (1998) found high similarity between patterns of microbial communities in areas subject to salinity.

Most of the taxonomic surveys related to AMF are based on identification of spores found in the field (Douds & Millner 1999). Morton & Bentivenga (1994) pointed out the importance of other sources of propagules which are not detected by direct extraction of material from the field. Thus, it has been suggested that trap cultures allow better evaluation of indigenous species, mainly in soils from arid and semiarid zones (Stutz & Morton 1996).

The total salinized area in the semiarid zone of northeast Brazil is around 15,000 ha in irrigated systems (Christofidis 2001), and the main reason for salinization of these areas has been inadequate management in soils with low drain. The aim of this survey was to determine AMF diversity in salinized and surrounded areas, by direct examination and trap cultures; to determine the similarities in these areas regarding AMF populations; and to reveal ecological aspects of AMF that will allow the use of these fungi in future management programs for recovering salinized areas.

Material and methods

Studied areas - salinized and not salinized areas were chosen at the São Francisco Valley (Juazeiro, Bahia State, and Petrolina, Pernambuco State). These areas are included: a) in the Project of Irrigation "Mandacaru" (area III) located at 40°26'W and 9°24'S, characterized by a soil Vertisol, in Juazeiro, Bahia State; b) in the Project of Irrigation "Bebedouro" (areas I, II, and IV) located at 40°22'W and 9°9'S, characterized by a soil Yellow Latosol, in Petrolina, Pernambuco State. During the collecting period, the average temperature and total precipitation were 27.5°C and 0.6 mm in the Bebedouro area and 27.4°C, without rain, in the Mandacaru area, respectively.

Collections - soil samples (up to 20 cm deep), formed by 3 subsamples (≅ 1.5 kg), were collected at random from the rhizosphere of different plant species. Part (1 kg) was used for studies with AMF and part sent to the Laboratory of Soils of "Embrapa Semi-Árido" (Petrolina, Pernambuco State) for chemical and physical analysis (table 1). The number of samples per area ranged from 4 to 8 replicates.

Spores density and root colonization - AMF spores were extracted from soil by wet sieving (Gerdemann & Nicolson 1963) and water and 40% sucrose centrifugation, respectively for 3' and 1' at 2.500 g min^{-1}. The spores were placed in plastic dishes and counted in a stereomicroscope. Evaluations of spore density were performed before and after each multiplication cycle of AMF in trap cultures. Roots present in the rhizosphere samples were fixed in 50% ethanol, and later washed, cleared with 5% potassium hydroxide for 24 h, at room temperature (28°C), washed in distilled water and treated with 1% chloridric acid for 3', stained with Trypan blue in lactoglycerol for 24 h, at room temperature (modified from Koske & Gemma 1989) and maintained in lactoglycerol. These roots were observed with the stereomicroscope for recording presence/absence of mycorrhizal colonization in each plant.

Trap cultures - the soil samples were diluted in sand (3:1) and used as trap cultures for AMF in plastic cups (500 mL), with *Panicum miliaceum* L. and *Sorghum vulgare* L. as hosts. Three multiplication cycles (4 months each) of these trap cultures were maintained in the greenhouse and irrigated every day. AMF identification - intact and broken spores were

Table 1. Chemical and physical characteristics of soils collected in salinized and surrounded areas at the São Francisco Submedium Valley, in Petrolina (I, II and IV), Pernambuco State, and Juazeiro (III), Bahia State.

Area	Granulometry			pH*	E.C.$_s$**	P***	OM
	Sand	Silt	Clay		dS m^{-1}	mg dm^{-3}	g kg^{-1}
I	84-89	4-12	3-7	5.5-6.7	0.08-0.45	7-23	4.3-6.0
II	82-87	7-12	6-10	6.0-7.0	1.03-6.38	22-52	6.1-9.9
III	23-26	25-28	46-52	7.2-7.4	3.18-10.91	32-91	11.3-14.5
IV	68-73	17-21	8-13	6.2-6.4	4.97-19.86	7-9	12.1-16.4

* H_2O (1:2.5); **25 °C; *** extractor Mehlich I. OM =organic matter.

mounted with PVLG and PVLG + Melzer's reagent (1:1 v/v) and observed with the light microscope. Schenck & Pérez (1990) and the data base of the International Culture Collection of Arbuscular and Vesicular-Arbuscular Mycorrhizal Fungi (INVAM) at the site http://invam.caf.wvu.edu, as well as new species descriptions, were used for identification of the AMF.

Statistical analysis - differences on AMF sporulation among the areas (I, II, III and IV) and multiplication cycles (in the field, 1°, 2°, and 3°), as well as the interactions between these factors were shown by analysis of variance (ANOVA). Sporulation data were transformed ($\sqrt{x} + 2.5$). Averages of significant factors were compared by the Tukey test using the Statistica Program (StatSoft 1997). Differences between spores density in samples from each host in relation to the multiplication cycles were also analyzed. The Sorensen index was used to compare similarities between the populations of AMF in the studied areas: $S = 2c/a+b \times 100$ (c = number of species common to both areas (1 and 2); a = number of species in area I; b = number of species in area II.

Results

Except for the samples II.2 and III.3, respectively from *Herissantia crispa* and *Sida cordifolia*, all roots were colonized by AMF (table 2). Twenty one taxa of AMF were identified in the areas, with the highest numbers corresponding to *Glomus* (8) and *Acaulospora* (5) species (table 3). Soils from non-salinized areas (I) or with low salinity (II) presented higher number of species, 14 and 16, respectively. Lower numbers of species (7 and 8) were found in areas III and IV, characterized by higher electrical conductivity (EC$_s$). Some species (*Acaulospora scrobiculata, Archeospora leptoticha, Glomus etunicatum, G. macrocarpum* and *G. mosseae*) were common to all areas. These two latter fungi were the most frequent, being observed in 10 of the 15 hosts (table 4). Species of *Gigaspora* were not found in areas III and IV, while species of *Scutellospora* did not occur in area III.

Similarity (> 60%) of AMF species was a little over the average between areas I and II, I and III, and III and IV (table 5). The areas with the lowest species similarity (II and III) present soils that differ in granulometry and EC$_s$, but have similar pH and < 20 mg of P dm^{-3}.

The number of spores found in the rhizosphere soon after the collections varied from 0.31 to 8.06 in *Musa* sp. (area I) and *Passiflora foetida* (area III), respectively. The soil from area III contained the highest number of AMF spores in the field and until the second multiplication cycle, with approximately 3.5 spores g^{-1} of soil, differing statistically from soils of the other areas (figure 1). The pot cultures with the collected soils favoured AMF sporulation (table 2); these trap cultures allowed higher production of spores than that obtained directly from the field, mainly in the first cycle. However, after the second multiplication cycle the density of spores dropped; on the other hand, only after this cycle, species such as *Scutellospora gregaria, S. heterogama, Glomus sinuosum, Gigaspora albida*, and *G. margarita* were detected.

Discussion

Higher diversity of AMF species (13) was found in the rhizosphere of species of *Musa,* while in those of the other hosts a lower number of taxa (from 1 to 8) was recorded. This might be probably a result of number of collections that were performed around the

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Table 2. List of host plants in the field, occurrence of root colonization, and density of spores of arbuscular mycorrhizal fungi, after collection and successive cycles in trap cultures, at the greenhouse, in association with *Panicum miliaceum* and *Sorghum vulgare*.

Areas	Hosts	Colonization[1]	Density of AMF (spores g^{-1} soil)[2]			
			In the field	1° cycle[a]	2° cycle	3° cycle
I	1. *Musa* sp. **	+	1.48 b	1.32 b	1.65 b	4.01 a
	2. *Musa* sp.	+	1.48 a	0.56 a	0.50 a	0.29 b
	3. *Musa* sp.	+	1.93 a	2.00 a	0.74 c	1.05 b
	4. *Musa* sp.	+	0.93 a	0.14 a	0.51 a	0.06 a
	5. *Musa* sp.	+	0.31 c	0.96 b	2.16 a	1.35 ab
	6. *Manihot pseudoglaziovii* Pax et K. Hoffmann	+	1.57 b	9.04 a	0.85 c	0.06 c
	7. *Tagetes minuta* L.	+	1.46 a	1.72 a	1.38 a	1.11 a
	8. *Musa* sp.	+	0.72 b	2.04 a	1.15 a	1.39 a
II	1. *Sida cordifolia* L.	+	1.70 b	4.32 a	1.43 b	1.88 b
	2. *Herissantia crispa* (L.) Brizicky	-	1.38 a	1.16 a	1.06 a	0.20 b
	3. *Panicum maximum* L.	+	3.30 a	2.72 a	2.67 a	0.16 b
	4. *Senna* sp.	+	2.04 a	1.12 b	1.76 a	0.28 b
	5. *Crotalaria* sp.	+*	0.75 b	6.32 a	0.15 b	0.25 b
	6. *Scoparia dulcis* L.	+	0.49 b	7.42 a	0.72 b	1.72 b
III	1. *Parkinsonia aculeata* L.	+	5.26 b	11.40 a	1.67 c	0.40 c
	2. Leguminosae ***	+	2.64 ab	3.88 a	2.10 b	0.34 c
	3. *Sida cordifolia* L.	-	1.64 b	1.48 b	6.90 a	0.25 b
	4. *Passiflora foetida* L.	+	8.06 a	2.28 b	2.22 b	0.20 b
	5. *Cenchrus ciliaris* L.	+	1.12 a	0.36 a	1.41 a	0.07 a
IV	1. *Cenchrus ciliaris* L.	+	0.56 b	1.60 a	0.51 b	0.60 b
	2. *Cenchrus ciliaris* L.	+	2.02 a	1.32 a	0.97 a	0.62 a
	3. *Mimosa tenuiflora* (Willd.) Poir.	+	0.92 a	0.60 a	0.57 a	0.85 a
	4. Malvaceae***	+	0.84 a	0.64 a	1.45 a	0.50 a

[1]+ = presence or - = absence. [2] Mean (n= 3) * presence of *Rhizobium* nodules,** cv. Grande Naine, *** unidentified. Mean followed by the same letter in the line do not differ by the Tukey test at 5%. [a]Cycles of four months.

roots of *Musa* sp. considering the frequency of this plant species in some of the areas. This occurred, for example, in area I, where five of the hosts in the collecting points (chosen at random) were banana plants. Conversely, in the same area there was only one collection of soil from the rhizosphere of *Manihot pseudoglaziovii*, and only one species of AMF was identified, even with similar number of spores as that found in the rhizospheres of *Musa* sp. Distribution of fungal propagules in the soil is in patches and most of the time not all taxa are recovered and identified. Only two hosts (*Herissantia crispa* and *Sida cordifolia*) were not associated with AMF, and consequently did not show mycorrhizal colonization, although in their rhizospheres many spores of AMF had been found. This is not an exception because presence of AMF propagules in the rhizosphere of a certain plant does not imply necessarily in symbiosis. The formation or not of a mycorrhizal association, or even the percentage of colonization seems to be genetically determined (Abbott & Robson 1991, Heijden et al. 1998). Thus, the establishment of a mycorrhiza and the occurence of AMF depend on many factors, including physical and chemical environmental aspects, soil management, age, species and variety of plants, as well as the plant-fungus interaction – because of that, presence of AMF and plant in a same environment does not assure establishment of a symbiosis.

Glomus was the most representative genus in the areas. Similar results, showing high number of *Glomus* species, were obtained by Sengupta & Chaudhuri (1990), Mankarios & Abdel-Fattah (1994) and Aliasgharzadeh et al. (2001). However, the diversity of species found represents only 9% of the species of this genus already described. *Acaulospora* was also well represented, with five species (15% of the total described) (table 3). Among them, only *A. scrobiculata, A. tuberculata* and *A. appendicula* (= *Archaeospora leptoticha*) had been recorded in salinized soils of arid and semiarid areas (Bhaskaran

Table 3. Species of arbuscular mycorrhizal fungi occurring in salinized and surrounded areas at the São Francisco Submedium Valley, Northeast Brazil.

Taxa	Areas				Presence/area
	I 0.08-0.4*	II 1.0-6.4	III 3.2-10.9	IV 4.9-19.8	
Acaulospora excavata Ingleby, Walker & Mason		X			1
A. longula Spain & Schenck	X				1
A. rehmii Sieverding & Toro		X			1
A. scrobiculata Trappe	X	X	X	X	4
A. tuberculata Janos & Trappe		X		X	2
Archaeospora leptoticha (Schenck & Smith) Morton & Redecker	X	X	X	X	4
Gigaspora albida Schenck & Smith	X	X			2
G. margarita Becker & Hall	X	X			2
Glomus clarum Nicolson & Schenck		X			1
G. etunicatum Becker & Gerdemann	X	X	X	X	4
G. intraradices Schenck & Smith	X		X		2
G. macrocarpum Tulasne & Tulasne	X	X	X	X	4
G. microaggregatum Koske, Gemma & Olexia				X	1
G. mosseae (Nicolson & Gerdemann) Gerdemann & Trappe	X	X	X	X	4
G. sinuosum Gerdemann & Bakshi	X				1
G. tortuosum Schenck & Smith	X	X			2
Paraglomus occultum (Walker) Morton & Redecker	X		X		2
Scutellospora erythropa (Koske & Walker) Walker & Sanders		X			1
S. gregaria (Schenck & Nicolson) Walker & Sanders	X	X			2
S. heterogama (Nicolson & Gerdemann) Walker & Sanders		X		X	2
S. pellucida (Nicolson & Schenck) Walker & Sanders	X	X			2
Total of taxa	14	16	7	8	

* Electrical conductivity (dS m^{-1})

& Selvaraj 1997, Yano-Melo et al. 1997). Conversely, Diem et al. (1981) did not report this genus in a semiarid area of Senegal. In Brazil, *A. scrobiculata* has been found in many natural and agroecosystems (Fernandes & Siqueira 1989, Trufem & Bononi 1985, Stürmer & Bellei 1994, Carrenho et al. 2001).

Trap cultures and successive cycles allowed the identification of four *Scutellospora* species. Some species of this genus were reported in areas of the Brazilian semiarid (Maia & Trufem 1990, Farias 1994, Yano-Melo et al. 1997). In a semiarid zone of Australia, McGee (1989) recovered spores of *S. calospora* up to 30 cm deep in the soil. Conversely, Stutz et al. (2000) did not find *Scutellospora* in arid and semiarid zones of Namibia and North America.

Glomus tortuosum was observed only after successive culture cycles and in high quantity. This species was recently reported in a semiarid area of the State of Bahia (Silva 2000) and is now recorded for the State of Pernambuco, which has similar climatic conditions.

Pot cultures with multiple host species usually allow sporulation of higher number of AMF species than those with only one host (Ezawa et al. 2000). The utilization of *S. vulgare* and *P. miliaceum* probably allowed sporulation of higher number of species and also of those that germinate late, considering that *S. vulgare*, besides supporting soil salinity, has a longer life cycle than *P. miliaceum*.

The decrease in sporulation of AMF after the first culture cycle indicates that probably the amount of propagules decreased or lost viability, or that the conditions were not suitable for multiplication, which suggests that for the studied soils, one culture cycle is enough for detecting most of the species. These results differ from those of Stutz & Morton (1996) who observed higher production of spores at the third cycle from a trap culture. These authors observed that successive pot cultures reveal high species richness of AMF in arid ecosystems. Although these soils are all from arid or semiarid areas, different responses may be explained by differences in edaphic conditions,

Table 4. Arbuscular mycorrhizal fungi and associated hosts (1= *Cenchrus ciliaris*, 2= *Mimosa tenuiflora*, 3= Malvaceae, 4= *Sida cordifolia*, 5= *Herissantia crispa*, 6= *Panicum maximum*, 7= *Senna* sp., 8= *Crotalaria* sp., 9= *Scoparia dulcis*, 10= *Musa* sp., 11= *Manihot pseudoglaziovii*, 12= *Tagetes minuta*, 13= *Parkinsonia aculeata*, 14= Leguminosae, 15= *Passiflora foetida*), in salinized (II, III and IV) and surrounded areas (I), in the São Francisco Submedium Valley.

AMF	Hosts															Presence/host
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
A. excavata		x														1
A. longula										x						1
A. rehmii									x							1
A. scrobiculata			x		x	x			x	x		x		x		7
A. tuberculata	x								x							2
A. leptoticha	x	x	x	x			x			x		x		x		8
G. albida						x		x		x		x				4
G. margarita					x					x						2
G. clarum				x					x							2
G. etunicatum			x			x					x	x			x	5
G. intraradices	x									x		x			x	4
G. macrocarpum	x	x	x	x	x	x				x		x		x	x	10
G. microaggregatum	x															1
G. mosseae	x			x		x	x	x	x	x			x	x	x	10
G. sinuosum										x						1
G. tortuosum									x	x						2
P. occultum										x		x	x	x		4
S. erythropa							x									1
S. gregaria									x	x		x				3
S. heterogama		x			x											2
S. pellucida					x	x	x			x						4
TOTAL of AMF	6	4	4	4	5	6	4	2	7	13	1	8	2	5	4	

hosts, and also populations of AMF present in the areas. Chemical and physical soil properties affect the distribution and abundance of AMF, and in arid regions, low humidity is the main limiting factor, resulting in low or no sporulation of AMF (Stutz & Morton 1996).

Many of the species (*Glomus etunicatum, G. intraradices, G. mosseae*, and *G. macrocarpum*) frequently recorded for salinized areas (Pond et al. 1984, Sengupta & Chaudhuri 1990, Bhaskaran & Selvaraj 1997, Copeman et al. 1996, Stutz & Morton 1996, Stutz et al. 2000, Aliasgharzadeh et al. 2001) were also found in this survey. Brown & Bledsoe (1996) observed that spores of *G. etunicatum, G. intraradices*, and *G. mosseae* from saline soils were of smaller diameter than that usual for the species, considering that this could be a result of low soil aeration and osmotic stress.

Table 5. Percentage of similarity of species of AMF between salinized (II, III and IV) and surrounded areas (I), in the São Francisco Submedium Valley, Brazil.

Areas	I	II	III	IV
I	-	-	-	-
II	66.6	-	-	-
III	66.6	43.4	-	-
IV	45.4	58.3	66.6	-

The highest number of spores of *Glomus mosseae* and *G. intraradices* were produced in soils with high electrical conductivity, which suggests that this could be an adaptation of these species to this type of stress, as also referred by Levy et al. (1983) and Pond et al. (1984). Besides soil salinity, pH may also have affected the occurrence of *G. mosseae*; although widely distributed (Stahl & Christensen 1991, Dodd et al. 1996), it has been usually found in substrates with neutral or slightly alkaline (6.5 – 8.0) pH (Dodd & Krikun 1984, Schenck & Siqueira 1987, Siqueira 1994, Yano-Melo et al. 1997).

Species of *Gigaspora* and *Scutellospora* apparently are more affected by salinity than those of *Glomus* once that, except for *S. heterogama*, there were no Gigasporaceae species in the areas with higher electrical conductivity (III and IV). This may

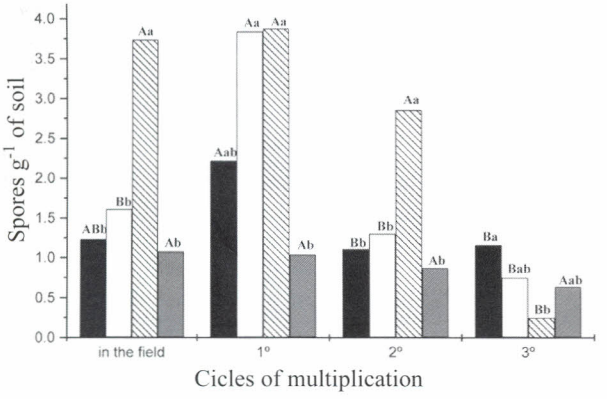

Figure 1. Sporulation of AMF, collected in areas of the São Francisco Sub-medium Valley with increasing levels of electrical conductivity, at the beginning (field) and during three multiplication cycles. Values with the same capital letter in each area and same small letter between areas do not differ ($P < 0.05$, Duncan's test). ■ = area I; □ area II; ▨ area III; ▩ area IV.

indicate differences in life-history strategies as also mentioned by Hart & Reader (2002).

The soils from areas I and II presented similarity of AMF species a little over the average (66%) and the high number of taxa in these areas might be a result of lower levels of soil salinity, when compared with areas III and IV. However, between areas I and III, the latter with lower number of taxa, the level of similarity of AMF species was the same. Invasion of plant species might occur in disturbed areas, favouring high sporulation of AMF (Miller 1987). Allen et al. (1995) considers that some fungi might become abundant after environmental disturbance. However, although sporulation might increase due to the disturbance, colonization might be drastically reduced, dropping to less than 1% (Reeves et al. 1979). Recovering of impacted areas either by revegetation programs or by capacity of the own system (Souza & Silva 1996), presents successional stages characterized by changes on plant composition. Thus, the similarity between saline (area III) and a non saline area (I) may represent different successional stages, that is, the area impacted by salinity (area III) might be in a recovering phase which is observed by the number (7) and similarity (66%) of AMF species, when compared with those values found in area I. It is also possible that soils from stressed areas suffer higher selective pressure than preserved areas, allowing the predominance of one or other species of AMF, as observed by Hildebrandt et al. (2001), who recorded only *Glomus geosporum* in soils with high electrical conductivity. This would indicate higher adaptation of persistent organisms, while the distribution of one or other AMF species, in various environments, may demonstrate higher plasticity of this species, as suggested for *G. mosseae* (Stahl & Christensen 1991).

The amplitude of variation on number of AMF spores isolated from the field soon after the collections (0.49 to 8.06 spores g^{-1}) was slightly higher than the observed in other salinized areas: 0.05 to 0.61 spores g^{-1} in the rhizosphere of halophytes in Pakistan (Khan 1974), and 1.4 to 4.6 spores g^{-1} in soils from India (Bhaskaran & Selvaraj 1997, Sengupta & Chauduri 1990). Recently, 116 AMF spores g^{-1} of soil were registered in Central Europe (Hildebrandt et al. 2001). This wide variation on number of spores might be due to physical characteristics of these soils, once that even with similar EC_{es} levels, soil granulometry may differ, increasing aeration problems (Ayers & Westcot 1991).

The results confirm that AMF are associated to various hosts in the studied areas and that use of trap culture allows the identification of a higher number of species of AMF in saline soils, although most of them might be recognized during the first culture cycle. Some of the species seems to be well adapted to diverse environments, once that they were found in both, salinized and non salinized areas, what indicates a wide distribution of these AMF. Field studies should be performed to allow better understanding of the dynamic and functionality of the AMF, mainly of species such as *G. mosseae* and *G. intraradices*, that are widely reported in saline environments, opening the possibility of being selected for use in management programs in such areas.

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