FIRST OBSERVATIONS ON THE OCCURRENCE OF VESICULAR-ARBUSCULAR MYCORRHIZAE (VAM) IN HYDROPHYTES, HYGROPHYTES, HALOPHYTES AND XEROPHYTES IN THE REGION OF LAKE RETBA (CAP-VERT, SENEGAL) DURING THE DRY SEASON

BY

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RÉSUMÉ. — *Premières observations sur la présence de mycorhizes à vésicules et arbuscules (VAM) chez des phanérogames de la région du lac Retba (Cap-Vert, Sénégal) pendant la saison sèche.* — Les racines de 69 espèces de phanérogames, appartenant à 28 familles, ont été examinées en vue de rechercher les endomycorhizes à vésicules et arbuscules (VAM). Les VAM étaient présentes dans 49 espèces (71% des espèces examinées). Les VAM étaient absentes chez les hydrophytes (Ruppiaceae, Lemnaceae), absentes ou rares chez la plupart des hygrophytes (Cyperaceae, Lythraceae, Typhaceae) et les halophytes (Amaranthaceae, Aizoaceae, Chenopodiaceae, Tamaricaceae). D'une manière générale, les xérophytes étaient bien pourvus en VAM. Les champignons présumés responsables des VAM appartiennent aux genres *Glomus* et *Gigaspora* (Endogonaceae). Des hyphes septées foncées (DS) ont été souvent observées dans les racines endomycorhizées. Elles semblent cependant manquer chez les halophytes. La conclusion principale à tirer de cette étude est que les sols très salés ou gorgés d'eau en permanence ne sont pas favorables aux endomycorhizes VAM.

SUMMARY. — The incidence of vesicular-arbuscular mycorrhizae (VAM) in the roots of 69 species of phanerogams, belonging to 28 families, was investigated. VAM were present in 49 species (71% of the investigated species). They were absent in hydrophytes (Ruppiaceae, Lemnaceae) and in most of the hygrophytes (Cyperaceae, Lythraceae, Typhaceae) and halophytes (Amaranthaceae, Aizoaceae, Chenopodiaceae, Tamaricaceae). As a rule, all xerophytes were infected. The fungi responsible of the VAM infections belong to the genus *Glomus* and *Gigaspora* (both Endogonaceae). Dark septate hyphae (DS) were frequently observed in roots infected by VAM. However, they seemed to lack completely in the halophytes. The main conclusion of this study is that salt or permanent waterlogged soils are not suitable for VAM infections.

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INTRODUCTION

Present information suggests that conditions of habitat, such as humidity and salinity of soils, influence the distribution of VAM infections. This agrees with the previous results of other researches (KHAN 1974, DIEM *et al.* 1981, READ & HASELWANDTER 1981).

DIEM *et al.* (1981) forwarded the important role of VAM in crop plants and trees in the semi-arid zone of Senegal. However, the knowledge of the distribution of VAM infections of natural or semi-natural habitats remains scanty.

MATERIAL AND METHODS

Sampling sites were selected to include a wide range of habitats (table 1). They were located in typical plants communities on the shore and in the vicinity of the lake Retba, an oversalted lake (about 380 g/l salt at the end of the dry season, in June). The samples were collected during the dry season, in March and April 1985.

According to the unpublished data of Gac (ORSTOM, Dakar), the main climatic features of the region are :

- mean annual insolation : 3000 h
- mean annual rain : 401 mm (1975-1982)
- extreme values of annual rain : 184-702 mm
- length of dry season : 7 to 8 months
- annual potential evapotranspiration : 1335 mm
- mean annual temperature : 24.8°C
- maximum mean temperature in November : 33.1°C
- minimum mean temperature in January : 14.0°C

Mycorrhizal infection was detected by examining at least 10 root segments of 1 cm under the compound microscope following PHILLIPS & HAYMAN (1970).

The extend of VAM infection was estimated semi-quantitatively : 0, no VAM detected ; +, less than 5% infected roots ; ++, 5 to 10% ; +++, 11 to 50% ; ++++, more than 50%.

Spores of Endogonaceae in adjacent soil were not traced systematically but incidently observed. The genera *Glomus* and *Gigaspora* were found after wet sieving.

TABLE 1

Characteristics of the main habitats studied in the Lake Retba region

Habitats	pH (water) (1)	Conductivity (mS) (2)
BP : brackish ponds	7,4-8,2	14,80-19,60
SM : salt marshes	7,6-8,6	2,15-14,20
BM : brackish marshes	8,2-8,7	0,19- 2,30
SS : shell rich sandy strands	7,9-8,8	0,09- 0,25
SH : sandy shell hills	8,1-8,6	0,07- 0,22
FD : free sand dunes	7,3	0,06
SD : semi-fixed dunes	6,0	0,04
CU : cultures on sandy soils	ND	ND

(1) pH of top soil, determined with a digital pH meter Consort D114.
(2) determined with a digital conductimeter Schott-Geräte CG857 (0-20 mS).

VAM were mainly detected by the presence of hyphae and vesicules. Arbuscules were generally not visible ; however, they were present in *Paspalum vaginatum* (when growing in well drained soil), *Borreria verticillata, Glinus oppositifolius, Fimbristylis ferruginea* and *Corchorus tridens.* In a few species, neither vesicules nor arbuscules were seen but only inner hyphae. This was the case in *Sonchus oleraceus* and *Lobelia senegalensis.*

Dark septate hyphae (DS), as described by READ & HASELWANDTER (1981), were not systematically investigated. However, for 21 species, 14 beared DS ; among the remainders, 4 were halophytes and 1 a parasite.

RESULTS AND DISCUSSION

Results of the 69 species investigated are given in table 2 ; 20 lacked VAM infection at the moment of sampling.

1. THE DICOTYLEDONS

The 2 Aizoaceae, 2 Amaranthaceae and 2 Chenopodiaceae analysed lacked VAM infection. These families belong to the Caryophyllales (Centrospermatae) which usually lack VAM (KHAN 1974). However, certifying that a family is devoid of VAM infection must be done with caution. GIOVANNETTI & NICOLSON (1983) found a weak VAM infection in two *Silene* sp. (Caryophyllaceae) and ALLEN (1983) detected VAM in *Atriplex gardneri* (Chenopodiaceae). Infection levels may depend on sampling season, on humidity of top soil, on physiological state of the host plant e.o. (KHAN 1974, SØNDERGAARD & LAEGAARD 1977, ALLEN 1983).

Whereas KHAN (1974) observed no infection in 2 Euphorbiaceae, I detected VAM in the 5 Euphorbiaceae examined. However *Euphorbia glaucophylla,* a pionneer on sand dunes, considered as a halophile, was once observed without any infection and once with few VAM.

In *Nesaea radicans* (Lythraceae), growing in very wet soils often covered by water, no VAM were noted.

Striga gesnerioides (Scrophulariaceae), a parasite on *Alternanthera maritima,* lacked VAM, whereas *Scoparia dulcis,* another Scrophulariaceae, was VAM infected. LESICA & ANTIBUS (1986) showed that hemiparasitic Scrophulariaceae were essentially non mycorrhizal.

Tamarix senegalensis, a small halophile (or halotolerant) tree, lacked VAM, just as 3 other *Tamarix* species observed by KHAN (1974). VAM were present in *Lobelia senegalensis,* as in *L. dortmanna* in Europe (SØNDERGAARD & LAEGAARD 1977).

2. THE MONOCOTYLEDONS

Lemna perpusilla and *Ruppia maritima* always lacked VAM just as hydrophytes generally do (ASAI 1934, STAHL 1949, MAEDA 1954, KHAN 1974) ; however some of them possess true VAM (SØNDERGAARD & LAEGAARD 1977, BAGYARAJ *et al.* 1979).

The Poaceae were strongly infected by VAM, agreeing with READ *et al.* (1976). *Paspalum vaginatum,* a halotolerant grass, was found once heavily infected growing on a dry soil and once without infection growing in brackish water.

TABLE 2

Families and species investigated for vesicular-arbuscular mycorrhiza

Dicotyledons	Infection level of VAM	Main habitats (see table I)
Aizoaceae		
Sesuvium portulacastrum (L.) L.	0	SM
Trianthema portulacastrum L.	0	CU
Amaranthaceae		
Amaranthus viridis L.	0	CU
Philoxerus vermicularis (L.) P. Beauv.	0	SM
Asclepiadaceae		
Calotropis procera Ait.	+++	FD
Asteraceae		
Ambrosia maritima L.	++	SS
Centaurea perrottetii DC.	++++	FD
Crassocephalum picridifolium (DC.) S. Moore	0	BM
Grangea maderaspatana (L.) Poir.	++++	BM
Launaea brunneri (Webb) Amin ex Boulos	+++	FD
Sonchus oleraceus L.	+	CU
Tridax procumbens L.	+++	SS
Borraginaceae		
Heliotropium bacciferum Forsk.	+++	SS
Chenopodiaceae		
Salicornia senegalensis A. Chev.	0	SM
Suaeda maritima (L.) Dumort.	0	SM
Caryophyllaceae		
Polycarpaea linearifolia (DC.) DC.	+	SS
Celastraceae		
Maytenus senegalensis (Lam.) Exell	++++	FD
Convolvulaceae		
Ipomoea coptica (L.) Roth. ex Roem. et Schult.	++++	SS, SH
Ipomoea pes-caprae (L.) R. Br. subsp. *brasiliensis* (L.) van Ooststr.	+++	FD
Jacquemontia tamnifolia (L.) Griseb.	++	SD
Euphorbiaceae		
Chrozophora brocchiana Vis.	++++	SD
Euphorbia glaucophylla Poir.	+/0	FD
Euphorbia hirta L.	++++	CU
Phyllanthus maderaspatensis L.	++++	SH
Phyllanthus pentandrus Schum. et Thonn.	+++	SH
Fabaceae		
Indigofera aspera Perr. ex DC.	+++	SS
Indigofera senegalensis Lam.	+++	SS
Sesbania sericea (Willd.) Link	++++	SS
Lobeliaceae		
Lobelia senegalensis A. DC.	+++	BM
Lythraceae		
Nesaea radicans Guill. et Perr.	0	BM
Malvaceae		
Urena lobata L.	+++	SS
Molluginaceae		
Gisekia pharnaceoides L.	+++	SS
Glinus oppositifolius (L.) A. DC.	++	BM
Limeum diffusum (Gay) Schinz	+++	SS

Dicotyledons	Infection level of VAM	Main habitats (see table I)
Portulacaceae		
Portulaca oleracea L.	++	CU
Rubiaceae		
Borreria verticillata (L.) G. F. W. Mey.	+++	SS
Sapindaceae		
Dodonaea viscosa Jacq.	++	SS
Scrophulariaceae		
Scoparia dulcis L.	++	SS
Striga gesnerioides (Willd.) Vatke	0	FD
Tamaricaceae		
Tamarix senegalensis DC.	0	SS, SH
Tiliaceae		
Corchorus tridens L.	++++	SH
Verbenaceae		
Phyla nodiflora (L.) Greene	++++	SS, SH
Monocotyledons		
Commelinaceae		
Commelina forskalaei Vahl	++++	SH
Cyperaceae		
Cyperus bulbosus Vahl	0	BM
Cyperus conglomeratus Rottb.	++++	FD
Cyperus crassipes Vahl	0	FD
Eleocharis geniculata (L.) Roem. et Schult.	0	BM
Fimbristylis ferruginea (L.) Vahl	++++	BM
Fimbristylis hispidula (Vahl) Kunth var. *senegalensis* (Cherm.) Napper	0	BM
Fimbristylis cymosa R. BR.	++	BM
Juncellus laevigatus (L.) C. B. Cl.	0	BM
Pycreus polystachyos (Rottb.) P. Beauv. var. *laxiflorus* (Benth.) C. B. Cl.	0	CU
Scirpus pterolepis (Nees) Kunth	0	BP
Lemnaceae		
Lemna perpusilla Torrey (syn.: *L. paucicostata* Hegelm.)	0	BP, BM
Poaceae		
Andropognon gayanus Kunth	++++	SD
Aristida sieberiana Trin.	++++	SD
Brachiaria distichophylla (Trin.) Stapf	+++	SH
Cenchrus biflorus Roxb.	++	SS
Chloris prieurii Kunth	0	SS
Echinochloa colona (L.) Link	+++	SS
Eragrostis ciliaris (L.) R. Br.	+++	SS
Eragrostis cf. *gangetica* (Roxb.) Steud	+++	SS
Imperata cylindrica (L.) P. Beauv.	++++	CU
Paspalum vaginatum Sw.	++++/0	BM, BP
Pennisetum pedicellatum Trin.	++	SS
Sporobolus robustus Kunth	++++	SS
Sporobolus spicatus (Vahl) Kunth	++	SS
Typhaceae		
Typha australis Schum. et Thonn.	+/0	BM
Ruppiaceae		
Ruppia maritima L.	0	BP

Cyperaceae are often growing in marshes, habitats known to be unfavorable to VAM. However, among the 10 investigated Cyperaceae, three species were infected, *Cyperus conglomeratus* and *Fimbristylis ferruginea* strongly and *F. cymosa* weakly. Our observations are in accordance with previous observations among temperate Cyperaceae (READ *et al.* 1976).

Typha australis generally lacked VAM, but only once we found a very weak infection ; KHAN (1974) found no VAM in *Typha augustata* Bory & Chaub.

Table 3 summarizes our observations with regard to the main investigated habitats. No VAM were observed in species of brackish ponds or of salt marshes. The number of VAM infected species was about 50% in brackish marshes and in cultures, which are generally located on drained brackish marshes. The highest number of infected species was observed on the driest soils, with a low salt content.

TABLE 3

Number and percentage of VAM infected species with regard to main habitats

Habitats (see tabl. I)	Number of species	VAM		% VAM	
		absent	present		
BP	3	3	0	0	No VAM infection
SM	3	3	0	0	
BM	13	6	7	54	Medium VAM infection
CU	7	4	3	43	
SS	25	2	23	92	High VAM infection
SH	5	0	5	100	
FD	9	2	7	78	
SD	4	0	4	100	
Total	69	20	49	71	

VAM were present in most species of the sand dunes as observed in temperate regions (NICOLSON 1960, NICOLSON & JOHNSTON 1979, GIOVANETTI & NICOLSON 1983). VAM may play an important role by providing phosphorous, water and other nutrients to host plants capable of fixing sand (NICOLSON & JOHNSTON 1979).

This first account shows clearly that the VAM are distributed in a wide range of habitats and families in the Sahelian region as it has already been stated for other arid regions by TRAPPE (1981).

Our preliminary results confirm the influence of environment on VAM distribution. Some halophytes possess VAM as noted by MASON (1928), FRIES (1944), STAHL (1949), NICOLSON (1960), KHAN (1974).

Lacking of VAM is possibly due to the sampling season. Some plants of very dry places might acquire VAM during the rainy season or VAM might disappear or become scanty during the dry season. Vice versa, some species of wet habitats might acquire VAM in the dry season or in marginal habitats.

In further studies, it will thus be necessary to sample the roots several times a year and to investigate in details the influence of habitat conditions such as water level, salt content, light, temperature, nutrients level, soil microflora, etc.

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