EDAPHIC FACTORS AFFECTING DISTRIBUTION OF SOIL FUNGI IN THREE CHOTTS LOCATED IN ALGERIAN DESERT

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ABSTRACT

A total of 327 colonies of fungi were isolated from three chotts located in the Northeast of Algerian Sahara (Chott Merouane, Melghir and Tighdidine). Twenty eight species representing thirteen genera were recorded in Chott Merouane, twenty two species representing eleven genera were isolated from Chott Melghir and twenty five species corresponding to eleven genera were recorded in Chott Tighdidine. The most common genera were *Aspergillus*, *Penicillium* and *Cladosporium*. Statistical analysis revealed a significant positive correlation between fungal population and number of edaphic factors, especially organic carbon and nitrogen contents. Fungal population showed negative correlation with chloride and sodium. The most species isolated in this study were melanized fungi.

KEYWORDS: Fungi, distribution, hypersaline soil, edaphic factors.

RESUME

Trois cent vint sept colonies de champignons filamenteux sont isolées à partir de trois chotts localisés dans le Nord-est du Sahara Algerien (Chott Merouane, Melghir and Tighdidine). Vingt-huit espèces de 13 genres ont été isolées de Chott Merouane. Vingt-deux espèces de 11 genres ont été isolées de Chott Melghir et vingt-cinq espèces correspondant à 11 genres ont été obtenues de Chott Tighdidine. Les genres les plus abondants sont *Aspergillus*, *Penicillium* et Cladosporium. L'analyse statistique a révélé une corrélation positive significative entre la densité de la population fongique et un nombre des facteurs édaphiques, en particulier la teneur en carbone organique et l'azote. La densité de la population fongique a montré une corrélation négative avec la teneur de chlorure et de sodium.

MOTS CLES: Champignons filamenteux, distribution, sol hypersalin, facteurs édaphiques.

1 INTRODUCTION

Fungi are the largest group of organisms. They are remarkable for their antiquity, diversity, ubiquitous distribution and longevity and are known to occur in almost all environments [1].

A variety of fungi inhabit same the extreme environments. These extremophilic organisms have evolved several structural and chemical adaptations, which allow them to survive and grow in these habitats. The products obtained from extremophiles such as proteins, enzymes (extremozymes) and compatibles solutes are of great interest to biotechnology [2].

Algeria contains a great number of wetlands, including freshwater and brackish marshes, lakes, and salt pans. The largest wetland surface area is made up of salt pans, spread out from the coastal area to the northern Saharan fringes and across the High Plateaus [3].The largest Algerian Chotts, which is an Arabic term for dry, salt depression are located in the Great Oriental Erg, in the north-east of the

Sahara [3,4]. Most of the studies of fungi in extreme salt conditions have been performed in the northern latitudes, in the region of Russia and Dead Sea. Butinar *et al*. (2005) described fungi isolated from several natural and man-made hypersaline environments including those found in France, Namibia, Portugal, Slovenia, Spain, and Dominican Republic [5]. However, few studies exist on the microbial diversity in the Algerian Sahara and even on saline soils in this area, with the exception of this of Boutaiba *et al*. (2011); they studied the physicochemical and microbial properties of the hypersaline Sidi Ameur and Himalatt salt lakes in the south of Algeria. Their results of eukaryal community composition are not surprising, where no fungus has been detected [6].

Up to now, no previous reports on fungi have been documented from saline habitats in the Algerian Sahara. In this study, an attempt has been made to review the diversity and distribution of fungi that occurs in Chott Merouane, Chott Melghir and Chott Tighdidine, which are wetlands in arid regions; administratively they are attached to the Wilaya of El Oued. These chotts represent the most suitable areas for the search of organisms adapted to high temperatures and salinities.

2 MATERIALS AND METHODS

2.1 Site description

The study was conducted in Oued Righ (33°19’59’’N, 6°52’59’’E) also called Bas-Sahara (80m altitude). The region of Oued Righ is located in the Great Erg Oriental at the south-east of the country, more precisely about 700 Km south-east of Algiers (Fig.1). The climate in this region is extremely arid, with only sporadic rainfall varies between 80 to 100 mm per year.

Mean annual temperature is 23°C; the means of the coldest month (Jan.) and warmest month (Jul.) are 08°C and 40°C, respectively. The present investigation was carried out in three different Chotts of Oued Righ *viz*. Chott Merouane, Chott Melghir and Chott Tighdidine (Fig.1). The first two Chotts were designated as a RAMSAR site and are classified as an Important Bird Areas (IBA). However, Chott Tighdidine is not yet included in the list of this convention.

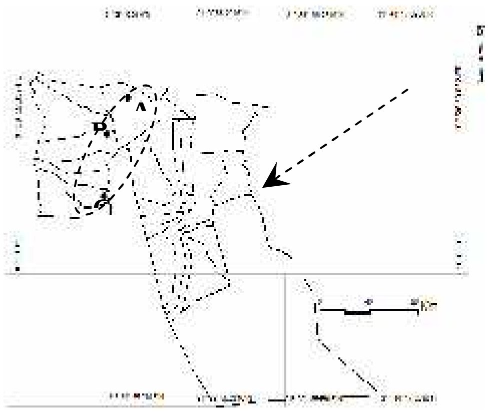

Figure 1: Study location and map of El Oued area showing three sampling sites (A: Chott Merouane, B: Chott Melghir and C: Chott Teguedidine)

2.2 Soil sample collection

Soil samples were collected aseptically from five sampling points around each site at a depth of 10 to 30cm. The collections were made in October (2011 and 2012). The soil samples collected from each chott was transported in sterile polythyene bags to the laboratory where they were stored at 4°C for no longer than 24 to 48 h. for isolation of fungi and physic-chemical analysis.

2.3 Edaphic parameters

The pH and electrical conductivity of the soil samples were determined in 1:5 (w/v) soil-water suspensions. Soil moisture content was determined by drying 10 g of fresh soil overnight in a hot air at 105°C. For chemical analysis, samples were air dried, ground, and sieved through a 0.2 mm sieve. Total nitrogen was determined by the Kjeldahl method. Total organic carbon was determined by oxidation with dichromate. The chloride was determined by Mohr method [7]. Available nutrients such as calcium, magnesium, potassium and sodium were determined according to Rodier (2005). The first two elements were assayed in the presence of EDTA. However the latter two were determined with flame photometer [8].

2.4 Fungal isolation and identification

The dilution plate method was adopted for the isolation of fungi [9]. The soil sample (10 g) was suspended in 90 ml of a sterile solution of NaCl (1%). One ml of each dilution was inoculated on potato dextrose Agar (PDA) supplemented with NaCl (1%) and chloramphenicol (50 mg/L) to suppress bacterial growth [10].Triplicate plates were used for each sample. The plates were incubated at 30°C, and examined daily for developing colonies. All fungal colonies appearing on the plates were counted and subcultured for purification and further taxonomic identification. Taxonomic identification of fungal isolates

was based on their morphological and cultural characteristics. All names of species are cited by consulting taxonomic monographs [10, 11].

2.5 Data analyses

Density of fungal isolates was expressed as colony forming units (CFU) per g wet weight soil. Edaphic parameters were analyzed statistically to identify any differences among the means by analysis of variance (ANOVA). Tukey test was performed to compare means. Correlation coefficients (r) between fungal population and various edaphic characteristics were analyzed by using Pearson's correlation coefficient. P values <0.01 and 0.05 were considered as significant. Statistical analysis was performed by SPSS, version 21.

3 RESULTS

Results of edaphic parameters are listed in table 1. Soil parameters varied significantly by sites. The soil in the studied area is slightly alkaline to alkaline, with maximal and minimal pH in Chott Merouane and Tighdidine, respectively. The soil of the first two Chotts were extreme in salinity, whereas the last site has the lowest value (14.41ms/cm), Chott Tighdidine was classified as the less salty [7]. Organic carbon (C %) and total nitrogen (N %) contents were highest in Chott Merouane, however the three sites are very poor in these two elements.

The soil in the studied areas is characterized by a dominance of sodium and chloride ions. In Chott Merouane and Melghir, they are followed by magnesium and potassium ions. However, in Chott Tighdidine, the content of calcium is higher than potassium and magnesium.

Table 1: Edaphic parameters over three sites

Site	pH	EC (25°C) (ms/cm)	OC (%)	N (%)	Na (mg/g)	K (mg/g)	Mg (mg/g)	Ca (mg/g)	Cl (mg/g)	DF (UFC/g)
A	7.63^{a}±0.1	25.32^{b}±0.2	0.45^{b}±0.1	0.05^{c}±0.0	8.74^{b}±0.3	1.27^{b}±0.2	1.37^{a}±0.1	0.22^{a}±0.0	13.36^{b}±0.4	134
B	7.80^{a}±0.1	27.43^{c}±0.7	0.15^{a}±0.0	0.02^{a}±0.0	12.32^{c}±0.5	4.92^{c}±0.6	4.79^{b}±0.6	1.59^{b}±0.1	16.25^{c}±1.1	81
C	9.00^{b}±0.2	14.41^{a}±0.1	0.17^{a}±0.0	0.04^{b}±0.0	2.29^{a}±0.1	1.25^{a}±0.1	0.93^{a}±0.0	5.21^{c}±0.3	9.71^{a}±0.3	112

Note: Mean ± Standard Deviation (SD). Site A: Chott

Merouane, Site B: Chott Melghir and Site C: Chott Tighdidine. Non significant differences between sites are shown by identical letters, (P>0.05). EC: electric conductivity, OC: organic carbon, N: total nitrogen, Na: sodium, K: potassium, Mg: magnesium, Ca: calcium, Cl: chloride, DF: density of fungal.

A total of 327 colonies of fungi, were recovered during the present study in all soils of the different chotts. Most of isolates were melanized fungi such as *Auriobasidium*, *Cladosporium*, *Stachybotrys*, *Phoma* and species belonging to *Aspergillus*, *Rhizopus* and *Penicillium*. Twenty eight species of 13 genera were recorded in Chott Merouane (Fig. 2); twenty two species of 11 genera were isolated from Chott Melghir and 25 species of 11 genera were recorded in Chott Tighdidine.

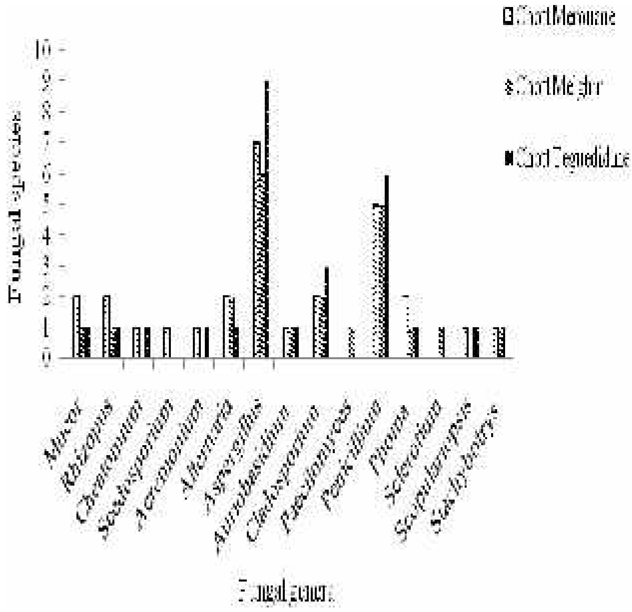

Figure 2: Graphical representation shows the occurrence of fungal species over different chotts

The results of the correlation between different edaphic factors and the density of fungal population are presented in table 2. The population density in different chotts was not correlated with both soil electric conductivity and calcium. The population density was significantly positively correlated with organic carbon and nitrogen in the three chotts, significantly negatively correlated with chloride. The fungal population in Chott Tighdidine was significantly correlated with potassium, but no correlation was observed in Chott Merouane and Chott Melghir. The population density was not correlated with sodium in Chott Melghir and Chott Tighdidine, while they were significantly negatively correlated in Chott Merouane. In this latter no correlation was observed between the pH and magnesium with the fungal population. However, they were significantly positively correlated in Chott Melghir and Chott Tighdidine.

Table 2: Pearson's (r) correlation coefficient between fungal population and edaphic parameters in each site

Site	pH	EC at 25°C (ms/cm)	OC (%)	N (%)	Na (mg/g)	K (mg/g)	Mg (mg/g)	Ca (mg/g)	Cl (mg/g)
A	0.447	-0.311	0.943*	0.904*	-0.891*	-.760	-0.865	-0.025	-0.921*
B	0.995**	0.071	0.995**	0.947*	-0.847	0.572	0.893*	0.406	-0.981**
C	0.935*	0.865	0.987**	0.958*	-0.516	0.883*	0.921*	0.001	-0.948*

**: correlation is significant at the 0.01 level, *: correlation is significant at the 0.05 level. A: Chott Merouane, B: Chott Melghir and C: Chott Tighdidine. EC: electric conductivity, OC: organic carbon, N: total nitrogen, Na: sodium, K: potassium, Mg: magnesium, Ca: calcium, Cl: chloride.

4 DISCUSSION

Species belonging to *Aspergillus* and *Penicillium* genera were common to all chotts. Several studies reported the dominance of these two genera, explained by their greater rate of spore production and dispersal [12, 13]. The present study showed also the dominance of melanized fungi that were reported from similar environment [5, 14, 15]. Melanized fungi can tolerate dehydration, and solar radiation better than the moniliaceous fungi whose cells are devoid of melanin [5].

Soil conditions are one of the most important ecological factors, which govern the distribution of the soil fungi [16, 17]. The soil samples of the three Chotts have been analyzed, firstly to determine the quality of soil and on the other hand to study the influence of edaphic factors on fungi distribution on the grounds of calculated correlation coefficients. We found significant positive correlation between organic carbon, total nitrogen and fungal population in all the Chotts which reflects the major role played by these elements in changing the relative abundance of fungal species. Several studies confirmed that organic matter had a great influence on fungal abundance [13, 18, 19]. Quantity of nitrogen has been reported also to affect the fungal number in a positive direction [20, 21]. High total nitrogen availability increased sporulation, production of antifungal anthroquinone pigments and hyphal growth rate [21]. Numerous studies have revealed the influence of soil pH on the distribution of fungal populations [20, 22]. Significant positive correlation was noted between the fungal population and soil pH in Chott Melghir and Tighdidine, however, no significant correlation was observed in Chott Merouane, which was characterized by the lowest soil pH and the higher number of colonies compared to the other two Chotts. Fungi generally prefer a slightly acidic pH, although they are able to grow in a wide range of pH [10, 23]. Acidic soil facilitates the rate of growth of soil fungi and biodegradation [14].The results of soil pH in the present study were slightly alkaline in Chott Merouane and Melghir but it was alkaline in Chott Tighdidine, which is similar to the studies who reported that soils in arid and semi-arid regions are generally alkaline [15, 24, 25]. Insignificant correlation between electrical conductivity and fungal population was found in all the Chotts. Soil moisture and salts played an important role in the variation of electrical conductivity, it is higher than the critical value (> 4 ds/m) [7], indicating that the soils of this investigation represent an extreme environment for the growth of fungi. Insignificant correlation was noted also between the fungal population and the calcium in the three Chotts, this result is in agreement with other studies [20]. Significant positive correlation was observed between magnesium and fungal population in Chott Melghir and Tighdidine. Calcium and magnesium are trace elements necessary for fungal growth in very low concentration; in this study the concentration of these elements was much higher than the requirements of fungi [26]. Significantly positive correlation was found between potassium and fungal population in Chott Tighdidine, but insignificant correlation in Chott Merouane and Chott Melghir. The stimulatory effects of potassium on soil fungi have been confirmed by many mycologists [13].

The present study reveals a negative correlation between the chloride, sodium contents and fungal population, which was significantly in all the Chotts for chloride, but significantly only in Chott Merouane for sodium. This result can be justified by the high chloride content exceeding the needs of microfungi. Sodium is anelement needed by fungi from the sea and salt lakes, which can conveniently be provided as the chloride [26].

In conclusion, edaphic analysis showed that the study area is an extreme environment in its salinity and its poverty in organic carbon and nitrogen. Generally, edaphic factors influence significantly the distribution of fungi.

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