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Halophilic and halotolerant fungi in cultivated dessert and salt marsh soils from Egypt

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One hundred halophilic and halotolerant species in addition to 3 varieties belonging to 27 genera were collected from 25 samples of cultivated desert and saline soils from different habitats in Egypt on 5-25 %. NaCl-Czapek's agar at 28° C (± 2°C). The results reveal that there were no characteristic halophilic and halotolerant fungi of these various types of soils. The growth of all recovered fungi was tested in medi containing 5-25 % sodium chloride. Almost all halophilic fungi (growing better on 5-25 % than on 0 % sodium chloride) were *Aspergillus* species. Most of the highly and fairly halotolerant fungi were *Aspergillus* and *Penicillium* species. All test fungi were halophilic or halotolerant.

INTRODUCTION

The term "halophilic and halotolerant" fungi is used in a general sense defining fungi growing only or better on media containing high salt (sodium chloride) concentrations. Numerous investigations have been made on fungi in saline soils, which contain high values of total soluble salts, from different places all over the world (B a y l i s E l l i o t, 1930; D a i t o, 1952; P u g h, 1961, 1962; S a l a m a et al. 1971; A b d e l - F a t t a h et al., 1977; A b d e l - H a f e z et al., 1977; A l - A b a d et al., 1979; M a l i k et al., 1979; and others). In Egypt, several investigations were made on glucophilic, cellulose-decomposing, osmophilic (or osmotolerant) and keratinophilic fungi from various substrates, but only two studies dealt with halophilic and halotolerant soil fungi, from the Red Sea shore (A b o l - N a s h r, 1981) and Wadi Bir-El-Ain (M o u b a s h e r et al., 1985). The present investigation was designed to study intensively the composition, numbers and frequency of occurrence of halophilic and halotolerant fungi from cultivated, desert and salt marsh soils collected from different habitats in Egypt.

MATERIALS AND METHODS

Twenty five samples of each of cultivated, desert and saline soils were collected under some of the common or cultivated plants from different parts of Egypt including the Nile valley, Delta area, Eastern desert, Suez Canal shore and Mediterranean Sea coast (Figs. 1,2), according to the method described by J o h n s o n et al. (1959).

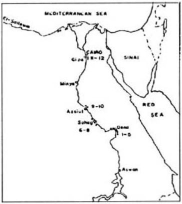
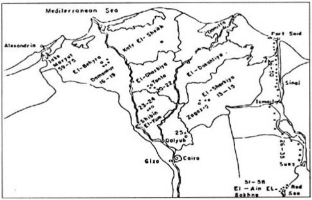


Fig. 1. Different places in Egipt (except Delta area) from which the soil samples were collected



Ryc. 2. Different places of Delta area from which the soil samples were collected

The soil samples were analysed chemically for the estimation of organic matter, total soluble salts, carbonate, bicarbonate and chlorides (J a c k s o n, 1958). Elements (Ca, Mg, Na, K) were also estimated (S c h w a r z e n b a c k, R i e d e r m a n, 1948; W i l l i a m s, T w i n e, 1960). A pH-meter (WGPYE model 220) was used for the determination of soil pH. The soil type was determined by the hydrometer method as described by P i p e r (1955).

The dilution-plate method was used for the estimation of soil fungi as described by J o h n s o n et al. (1959). Glucose-Czapek's agar ($NaNO_3$, 3 g; K_2HPO_4, 1 g; $MgSO_4 \cdot 7 H_2O$, 0,5 g; $FeSO_4 \cdot 7 H_2O$, 0,01 g; yeast extract, 0,5g; glucose, 10g; Agar agar 15 g; per liter H_2O) supplemented with 5 %, 10 %, 15 %, 20 % and 25% sodium chloride, were used. To these media rose-bengal (1/15000) was added as a bacteriostatic agent (S m i t h, D a w s o n, 1944). Twenty five plates were used for each sample, plates for each concentration of sodium chloride in agar medium. The plates were inclubated at 28°C (± 2°C) for 4-6 weeks and the developing fungi were counted, identified and calculated per 1g dry soil. The colonies of slow growing fungi which were about to be overgrown, as well as mycelial fragments of some colonies, were transferred to agar slants to ensure precise counting and identification.

Halophilic ability was assessed by growing the fungi recovered in the present investigation (100 species and 3 varieties belonging to 27 genera) on glucose-Czapek's liquid medium supplemented with 0 % (control), 5 %, 10 %, 15 %, 20 % and 25 % NaCl. 20 ml from each medium were placed in a 100 ml flask and inoculated with 1 ml spore suspension obtained from a 15-day-old culture of the test organism. The flasks were incubated at 28°C for 20 days after which the fungal mat was removed, rinsed with distilled water and dried at 105°C and weighed. Three replicates were used for each concentration.

RESULTS AND DISCUSSION

The water contents of cultivated, desert and saline soils widely varied from 10,5-20,8 %, 2,4-9,8 % and 11,1-21 %, respectively. The soil samples tested were generally poor in organic matter content, but cultivated soils were the richest (0,13--1,98 % of dry soil) followed by saline (0,12-0,89 %) and desert soils (0,02-0,4 %). This is in agreement with the results previously obtained from various types of Egyptian soils (A b d e l - F a t t a h et al., 1977); B a t a n o u n y, A b o - S i t t a, 1977; M o u b a s h e r, A b d e l - H a f e z, 1978). The cultivated (0,13-1,69 %) and desert (0,03-1,6 %) soils were poor in total soluble salts content, but in saline soils it varied widely from moderate values (6,62-9,67 %, 7 samples) to high values (11,42-14,65 %, 10 samples) and very high values (15,26-18,62 %, 8 samples). Similar observations were recorded by Abdel-Fattah et al. (1977), Batanouny, Abo-Sitta (1977), Moubasher, Abdel-Hafez (1978), Abol-Nasr (1981) and Moubasher et al. (1985). The contents of carbonate, bicarbonate and chloride were almost regularly higher in saline soils than in cultivated and desert soils, and their respective ranges were as follows: carbonate 4,2-5,94 %, 2,26-5,4% and 1,65-5,94 %; bicarbonate 0,18-1,93 %, 2,36-1,5 % and 0,23-1,02 %; chloride 0,36-4,4 %, 0,13-0,68 % and 0,14-3,98 %. Batanouny, Abo-Sitta (1977) recorded that the amount of the previous fractions fluctuated widely in the mound body of *Limoniastrum monopetalum* (carbonate: 1,7-7,3 %, and 6,3-8,3 %; bicarbonate 61-153 mg and 305-458 mg/100 g dry soil; and chlorides: 241-468 mg and 417-789 mg/100 g dry soil in the less-saline and highly-saline habitats, respectively). The amounts of elements in cultivated, desert and salt marsh soils were Ca: 0,3-0,75, 0,03-2,67 and 0,07-3,75 mg; Mg: 0,13-0,54, 0,02-0,54 and 0,013-1,23 mg; K: 0,02-0,27, 0,02-0,51 and 0,05-0,88 mg; and Na: 0,16-4,8, 0,12-9,05 and 2,35-39 mg/g dry soil, respectively. Botanouny, Abo-Sitta (1977) and Abdel-Hafez et al. (1977) recorded that the amount of elements fluctuated widely in salt marsh soils (Ca: 0,01-0,75 mg, Mg: 0,002-0,54mg, K: 0,01-5 mg, and Na: 1-175 mg/g dry soil). Moubasher et al. (1985) found that the elements contents of Wadi Bir-El-Ain soils varied between Ca, 0.01-4,5mg; Mg, 0,01-0,48 mg; K, 0,04-2 mg; and Na, 0,04-3,5 mg/g dry soil. The pH values of cultivated and saline soils were all on the alkaline side (7,2-8,9), but in the desert soils they were around neutrality (6,9-7,4). This is in agreement with the results obtained preciously from Egyptian cultivated (Moubasher, Abdel-Ha-fez, 1987), desert (Moubasher et al., 1985) and saline soils (Botanouny, Abo-Sitta, 1977; Abdel-Hafez et al., 1978). The textures of soil samples tested were as follows; cultivated soils: 18 clay, 5 clay-loam and 2 sandy clay; desert soils: 9 sandy, 7 sandy-clay, 4 sandy-loam and 5 sandy-clay-loam; 6 sandy, 12 sandy-clay and 7 samples sandy-clay-loam (Table 1).

Total counts and range of genera and species. The results reveal that the total counts of halophilic and halotolerant fungi in cultivated, desert and saline soils on 5-25 % NaCl-Czapek's agar at 28°C (± 2°C) widely fluctuated between 15-2700 and 25-4200; 6,7-2420 and 15-3300; and 3,3-2340 and 10 -3200 colonies/g dry soil, respectively. The widest spectrum of genera and species in the soil samples of the three types of soils were estimated on 5 % NaCl agar plates 8 -9 genera and 16-21 species) followed by 10 % (3-4 genera and 10-11 species), 15 % (2-3 genera and 6-7 species), 20 % (2 genera and 4-8 species) and 25 % NaCl (2 genera and 2 species). The results show clearly that there was no regular correlation between the total counts and number of genera and species in the samples tested. But, some soil samples with a high value of the total count also contributed a larger number of genera and species and vice versa. This is almost in agreement with the results previously obtained in soils from Egypt (M o u b a s h e r et al., 1985) and Saudi Arabia (A b d e l - H a f e z, 1981) on 5 % NaCl agar plates.

H a l o p h i l i c a n d h a l o t o l e r a n t s o i l f u n g i. A hundred species which belong to 27 genera were collected from 25 samples of each of cultivated (19 genera and 69 species + 2 varieties), desert (22 genera and 79 species + 3 varieties) and saline soils (19 genera and 78 species + 2 varieties) on 5-25 % NaCl-Czapek's agar at 28°C (Tables 2, 3).

Most of the preceding species have been encountered, but with variable numbers and frequencies, in salt marsh soils in different places of the world (B a y - l i s E l l i o t, 1930; S a i t o, 1952; P u g h, 1961, 1962; S a l a m a et al., 1971; M a l i k et al., 1979; and others).

Aspergillus was the most common genus in the three soil types on 5 % and 10 % NaCl agar medium, and was found in all samples comprising 55,1-74,1 % and 67,7-90,9 % of total fungi at the two sodium chloride concentrations, respectively. It was represented by 33 species and 2 varieties (24+2, 25+2 and 29 species + 2 varieties in the three soil types, respectively) of which *A. flavus*, *A. niger*, *A. terreus*, *A. flavipes*, *A. ochraceus*, *A. versicolor*, *A tamarii*, and *A. sydowi* were the most common on 5 % and 10 % NaCl agar medium; these occurred in 24-80%, 8-92 % and 12-92 % of the samples constituting approximately 2,1-25,9 %, 0,4-39,5 % and 1,2-33,2 % of total *Aspergillus* and 1,5-18,1 %, 0,2-28,2 % and 0,6-22,8 % of total fungi in the three habitats, respectively. These species were also common in Wadi Bir-El-Ain (M o u b a s h e r et al., 1985) and Red Sea shore soils (A b o l - N a s r, 1981) on 5 % and 10 % NaCl Czapek's agar. The remaining *Aspergillus* species were less frequent. A b d e l - H a f e z (1981) isolated 20 species and 3 varieties of *Aspergillus* from Saudi Arabian desert soils on 5 % NaCl agar plates and the most prevalent species were *A. amstelodami*, *A. chevalieri*, *A. ruber* and *A. ochraceus*.

Penicillium occurred very frequently in cultivated and saline soils at the two concentrations of sodium chloride; from emerged in 64-72 % of the samples contributing 15,6-25,5 % and 24,8-26,1 % of total fungi, respectively. This genus was also isolated in high frequency from desert soils on 5 % NaCl agar medium, but was less frequent on 10 % NaCl.

Table 1

Dominant plant, pH values and soil type, moisture content (MC), organic matter content (OMC), total soluble salts (TSS), carbonate, bicarbonate and chloride calculated as percentage of dry soils; elements (Ca, Mg, K, Na) calculated as mg per g dry soil of the soil samples tested

No.	Dominant plant	MC	pH	OMC	TSS	CO_3^{--}	HCO_3^-	Cl^-	Elements Ca^{++}	Mg^{++}	K^+	Na^+	% Sand	Clay	Silt	Soil type
1		2							3				4			5
A.	CULTIVATED SOILS															
01	*Lupinus termis*	14.9	7.4	0.63	0.48	4.50	1.48	0.31	0.05	0.05	0.27	0.28	10	81	09	Clay
02	*Sorghum dura*	11.5	7.5	1.53	0.43	4.80	1.05	0.16	0.10	0.09	0.14	0.20	11	80	08	
03	*S. dura*	14.6	7.6	0.60	1.69	4.66	0.72	0.57	0.10	0.05	0.23	2.80	19	68	13	
04	*Gossypium barbadense*	18.9	7.2	0.63	0.97	3.87	1.06	0.07	0.75	0.08	0.12	0.20	8	79	13	
05	*Lupinus termis*	13.3	7.6	0.63	0.51	4.95	1.50	0.14	0.75	0.04	0.19	0.52	21	49	40	Clay-loam
06	*L. termis*	15.3	7.5	1.60	0.35	5.40	1.43	0.22	0.45	0.14	0.09	0.16	10	67	23	Clay
07	*Allium cepa*	11.8	7.3	0.62	0.40	2,26	1.05	0.23	0.13	0.06	0.09	0.32	12	70	18	
08	*Saccharum officinarum*	15.9	7.8	0.62	0.83	4.20	1.06	0.28	0.18	0.18	0.03	4.80	49	42	09	Sandy-clay
09	*Triticum durum*	16.9	7.8	0.62	0.27	4.50	1.36	0.13	0.08	0.09	0.11	1.17	19	61	20	Clay
10	*Trifolium alexandrinum*	14.9	7.4	1.63	0.63	2.36	0.73	0.18	0.10	0.12	0.18	0,64	18	62	20	
11	*Lupinus termis*	11.1	7.9	0.33	0.27	2.55	0.55	0.17	0.09	0.02	0.03	0.63	15	65	20	
12	*Trifolium alexandrinum*	10.5	7.8	0.13	0.38	4.20	0.54	0.68	0.12	0.11	0.03	0.61	39	42	19	Sandy-clay
13	*Beta vulgaris* var. *cylica*	16.9	8.9	0.32	1.39	4.62	0.73	0.36	0.12	0.13	0.08	0.67	10		23	Clay
14	*Trifolium alexandrinum*	17.7	7.8	0.29	0.13	5.22	0.75	0.46	0.08	0.09	0.10	0.67	19	41	40	Clay-loam
15	*Triticum vulgare*	18.7	7.4	0.64	0.38	2.32	0.74	0.46	0.05	0.03	0.05	0.39	20	40	40	
16	*T. vulgare*	18.5	8.4	0.34	0.04	4.92	0.92	0.39	0.08	0.02	0.05	0.36	25	50	25	
17	*T. vulgare*	15.2	7.6	0.35	1.23	4.30	0.83	0.37	0.07	0.05	0.06	0.19	30	50	20	Clay
18	*T. vulgare*	20.2	7.9	0.20	0.42	4.74	0.73	0.36	0.11	0.06	0.10	0.41	21	51	28	
19	*Trifolium alexandrinum*	20.5	7.8	1.98	0.85	4.94	0.85	0.31	0.08	0.02	0.05	0.43	20	40	40	Clay-loam
20	*Triticum durum*	21.2	7.3	0.98	0.79	4.53	0.55	0.34	0.21	0.15	0.21	0.52	10	70	20	Clay
21	*Raphanus sativus*	16.9	8.0	0.85	0.86	4.65	0.73	0.36	0.08	0.54	0.09	0.64	11	61	28	
22	*R. sativus*	17.6	7.6	0.38	0.24	4.47	0.37	0.37	0.03	0.03	0,04	0.56	15	65	20	
23	*Vicia faba*	19.9	7.7	0.32	0.48	3,27	0.55	0.39	0.06	0.03	0.05	1.18	14	65	21	
24	*Eruca sativa*	20.8	7.8	0.25	0.61	3,27	0.36	0.24	0.03	0.04	0.06	0.83	19	62	19	
25	*E. sativa*	20.2	8.6	0.68	0.99	4,50	0.54	0.64	0,18	0,09	0,10	2,13	18	65	17	

B. DESERT SOIL															
26 *Tamarix*	2.4	6.7	0.07	0.83	4.20	1.02	3,98	0.95	0.55	0.51	0.78	60	21	19	Sandy-clay-loam
27 *Tamarix*	6.0	6.9	0.09	0.36	5.85	0.62	0,36	1.75	0.24	0.09	0.22	61	20	19	
28 *Alhagi maurorum*	5,3	7.3	0.05	0.52	5.76	0,92	2,54	2,10	0.52	0.13	8,05	48	42	10	Sandy-clay
29 *Zygophyllum coccinum*	4.2	7.2	0.17	0.66	5.88	0.55	0,48	0.33	0.03	0.11	1.35	47	45	08	
30 *Casuarina equisetifolia*	6.4	7.4	0.14	0.03	3.18	0.37	0.57	0.03	0.05	0.02	1.01	66	19	15	
31 Non	3.7	7.4	0.14	1.08	1.65	0.54	0.36	0.27	0.02	0.08	0.36	60	31	09	Sandy-clay-loam
32 Non	3.6	7.1	0.22	0.86	3.00	0.54	0.43	0,08	0.05	0.11	0.56	49	40	11	Sandy-clay
33 Non	9.9	7.5	0.14	0.85	2.01	0.36	0.29	0.11	0.11	0.02	0.03	70	15	15	Sandy
34 Non	6.9	6.9	0.02	0.25	2.40	0.57	0.33	0.03	0.02	0.05	0.16	80	10	10	
35 Non	2.4	7.3	0.16	0.69	2.46	0.53	0.34	0.06	0.05	0.06	0.37	79	11	10	
36 *Phragmites communis*	3.6	7.2	0.40	0.57	3,15	0.57	0.99	0.99	0.52	0.22	2.70	78	11	11	
37 *P. communis*	5.6	7.2	0.03	0.77	2.43	0.55	0.37	1.11	0.36	0.18	1.82	68	10	22	Sandy-loam
38 *P. communis*	9.1	7.3	0.15	0.40	3.43	0.73	0.85	0.81	0.24	0.02	3.88	69	10	21	
39 Non	3.6	7.2	0.26	0.41	4.47	0.73	0.14	0.81	0.02	0.15	0.81	50	41	09	Sandy-clay
40 Non	6.3	7.3	0.04	0.70	4.20	0.32	0.57	0.13	0.05	0.05	0.11	66	19	15	Sandy-loam
41 Non	4.9	7.4	0,35	1.60	4.26	0.74	0.28	0.33	0.16	0.11	0.80	80	09	11	Sandy
42 Non	7.5	7.2	0.08	1.06	4.05	0.37	0.36	0.18	0.11	0.24	9.30	78	09	13	
43 Non	3.6	7.3	0.26	0.18	3.78	0.63	0.36	0.30	0.09	0.08	0.47	48	40	12	Sandy-clay
44 Non	7.1	7.1	0.21	0.21	3.90	0.93	0.37	0.04	0.05	0.06	0.16	49	40	11	
45 Non	9.8	7.2	0.03	0.05	4.14	0,54	0.28	0.17	0.03	0.08	0.16	47	42	11	
46 Non	3.6	6.9	0.27	0.48	5.16	0.73	0.31	0.05	0.04	0.05	0.24	56	30	14	Sandy-clay-loam
47 Non	6.3	6,1	0.25	0.41	3.26	0.37	0.92	2,67	0.20	0.81	2.03	79	10	11	Sandy
48 Non	7.5	7.0	0.02	0.42	3.03	0.65	0.95	0.44	0.10	0,03	0.18	64	25	11	Sandy-clay-loam
49 Non	3.6	7.3	0.08	0.14	4.68	0.55	0.36	0.05	0.04	0.05	0.18	77	09	14	Sandy
50 Non	5.7	7.2	0.30	0.71	3.78	0.23	0.64	0.13	0.08	0.23	1.40	82	08	10	
C. SALT MARSH SOIL															
51 Non	12.4	7.3	0.19	13.32	5.70	1.05	1.42	2.23	0.93	0.16	4.36	59	19	22	Sandy-clay-loam
52 Non	11.9	7.5	0.18	14.65	5.80	1.40	0.39	1.75	0.33	0.12	2.35	59	31	10	
53 Non	20,2	7,1	0,15	13,98	5,94	0,70	1,21	0,15	1,23	0,29	8,23	59	27	14	
54 Non	17,5	7,6	0,66	18,62	5,58	1.62	4,14	3,75	0,54	0,48	6,04	48	40	12	Sandy-clay
55 Non	12,9	7,4	0,53	17,98	5,82	1,92	2,63	0,55	0,04	0,06	35,51	50	40	10	
56 Non	15,3	7,5	0,35	09,33	5,85	1,92	0,52	0,06	0,18	0,19	11,01	52	38	10	
57 Non	19,1	7,0	0,29	08,66	5,85	1,93	1,78	0,75	0,11	0,24	5,76	55	35	10	
58 Non	13,6	8,3	0,16	18,33	5,88	1,82	2,63	0,68	0,09	0,33	39,00	59	30	11	Sandy-clay-loam

cont.

1	2							3				4			5
59 *Halocnemon strobilaceum*	14.9	7.8	0.89	13.65	5.64	0.18	0.71	0.17	0.79	0.43	04.23	68	12	20	Sandy
60 *Atriplex halimus*	12.9	7.9	0.46	09.67	5.79	0.37	0.85	0.16	0.04	0.23	10.16	61	29	10	Sandy-clay-loam
61 *Salicornia fruticosa*	11.1	8.2	0.24	07.25	5.76	0.55	0,36	0.18	0.27	0.21	09.79	70	10	20	Sandy
62 *Suaeda fruticosa*	13.6	8.2	0.12	13.87	5.70	0.55	1.78	0.17	0.01	0.81	13.89	70	20	10	
63 *Cressa cretica*	16.4	8.3	0.22	11.42	5.73	0.18	0.43	0.07	0.49	0.35	10.23	69	19	12	
64 *Zygophyllum album*	13.6	8.4	0.31	09.21	5.70	0.37	1.28	1.44	0.43	0.58	05.35	62	18	20	
65 *Limoniastrum monopetalum*	12.4	7.6	0.26	18.05	5.90	0.73	1.78	0.84	0.02	0.24	06.26	80	10	10	
66 *Suaeda pruinosa*	12.3	8.5	0.31	11.97	4.20	0.73	0.90	0.13	0.28	0.34	02.45	50	25	25	Sandy-clay-loam
67 *Zygophyllum album*	19.1	8.2	0.19	18.63	5.70	0.55	1.92	1.13	0.03	0.61	05.39	49	40	11	Sandy-clay
68 *Anthrocemon glaucum*	19.1	8.5	0.39	18,47	5.80	0.57	2.77	0.58	0.06	0.48	07.55	49	42	09	
69 *Salicornia fruticosa*	11,1	7.2	0.35	11.83	5.88	0.57	2.21	0.14	0.05	0.51	05.14	48	42	10	
70 *Anthrocnemon glaucum*	20,5	8.6	0.39	08.43	4.57	0.67	3.55	0.47	0.04	0.59	07.39	50	40	10	
71 *Limoniastrum monopetalum*	21.0	8.8	0.35	6.62	5.94	0.29	2.06	0.48	0.05	0.16	05.87	48	27	25	Sandy-clay-loam
72 *Frankenia revoluta*	20.4	8.3	0.13	13.64	4.47	0.37	1.63	0.18	0.18	0.33	03.42	50	42	08	Sandy-clay
73 *Zygophyllum album*	16.3	7.5	0.25	15.26	5.76	0.72	1.56	0.48	0.03	0.89	04.05	52	40	08	
74 *Cressa cretica*	16.9	8.6	0.29	17.63	5.91	0.82	3.41	0.41	0.04	0.13	06.13	53	41	06	
75 *Zygophyllum album*	14.2	7.4	0.33	12.83	5.70	0.57	1.69	1.12	0.39	0.28	06,13	47	43	10	

Table 2

Average total count and maximum value (calculated per g dry soil in every sample) and number of cases of isolation of fungal genera and species isolated from 25 samples of each of cultivated, desert and saline soils on 5 % and 10 % sodium chloride-Czapek's agar at 28°C (± 2°C)

Fungi	Cultivated soil						Desert soil						Saline soil					
	5 % NaCl			10 % NaCl			5 % NaCl			10% NaCl			5 % NaCl			10% NaCl		
	ATC	MV	NCI	ATC	MV	NCI	ATC	MV	NCI	ATC	MV	NCI	ATC	MV	NCI	ATC	MV	NCI
1	2			3			4			5			6			7		
Aspergillus	23860	29100	25	19170	20500	25	21390	22175	25	14406	17520	25	19380	21100	25	13241	12520	25
A. flavus Link	1890	2650	19	799	885	19	1470	1950	18	2423	2655	19	2400	2625	20	1892	2030	18
A. niger van Tieghem	3670	4900	19	2186	2445	17	1760	2150	22	1071	1280	15	4250	5200	23	4393	5000	20
A. terreus Thom	6190	8850	19	4727	5050	18	8440	9275	23	3621	4100	17	1700	2450	18	1217	1375	14
A. flavipes (Bain. et Sart.) Thom et Church	2270	2750	14	948	1135	09	60	125	02	217	310	05	235	375	11	242	350	03
A. ochraceus Wilchelm	2660	3550	14	2296	2820	20	690	1100	13	2684	3080	15	1325	1325	11	786	1120	13
A. versicolor (Vuill.) Tiraboschi	1690	2200	13	400	550	06	1520	1775	13	484	745	07	240	625	05	166	225	02

A. tamarii Kita	840	1350	11	460	760	13	195	400	09	340	250	07	1325	2050	15	1339	2000	10
A. sydovii (Bain. et Sart.) Thom et Church	1020	1700	10	1854	2210	16	1700	2125	11	190	168	06	225	300	05	450	575	08
A. flavus var. *columnaris* Raper et Fennell	210	850	07	126	175	04	90	100	01	337	460	04	135	150	03	113	300	03
A. carneus (v. Tiegh.) Blochwitz	570	1050	05	497	745	03	105	150	01				60	100	01			
A. fumigatus Fres.	390	500	04	50	.100	02	190	400	05	87	130	03	3020	4125	14	226	375	04
A. nidulas (Eidam) Wint.	110	250	04	133	200	01	3350	4825	17	1232	1800	07	480	875	06	226	375	04
A. ustus (Bain.) Thom et Church	360	1100	04	225	320	05	570	875	13	707	875	08	955	1175	07	83	175	
A. wentii Wehmer	300	550	04	1147	1950	08				7	20	01	110	250	01	75	150	02
A. amstelodami (Mangin) Thom et Church	340	600	03	551	100	07	10	25	01	93	130	02	65	175	02	467	650	06
A. ruber (Koning, Spieck. et Bremer) Thom et Church	180	450	03	683	840	06				10	20	01	160	200	02	118	150	04
A. candidus Link	60	150	02				40	75	02	37	50	01	225	475	04	17	50	01
A. melleus Yukama	50	150	02	111	185	03	5	25	01	100	150	01				133	200	02
A. quadrilineatus Thom et Raper	290	850	02				550	825	02	67	100	01						
A. repens de Bary	100	500	02	751	775	04							30	100	01	91	125	02
A. chevalieri (Mangin) Thom et Church	10	50	01	1017	1380	08										300	325	01
A. japonicus Saito	30	150	01	94	100	02	105	125	02				755	975	09	358	500	02
A. nidulans var. *latus* Thom et Raper	90	350	01	9	25	01	360	550	05	504	585	04	150	200	03			
A. niveus Blochwitz	60	300	01				20	50	02				60	100	01			
A. parasiticus Speare	170	850	01							48	65	02	895	1500	04	250	375	02
A. terricola Marchal	40	200	01				20	50	01	9	25	01	10	50	01			
A. tonophilius Ohtsuki				54	70	02										108	325	01
A. sclerotiorum Huber				25	50	01	70	100	01							209	250	01
A. rugulosus Thom et Raper							80	100	01	167	200	01	350	500	01			
A. sulphureus (Fres.) Thom et Church							30	50	01	37	50	01				108	325	01
A. oryzae (Ahlb.) Cohn													20	50	02	100	300	01
A. aculeatus Lizuka													200	450	01			
Penicillium	5700	7500	18	6701	7060	16	3330	3650	24	862	1380	08	8735	1175	25	5095	5225	18
P. chrysogenum Thom	4240	6050	16	5594	5930	15	920	1700	10	416	590	03	2845	3475	19	3326	3475	14
P. citrinum Thom	270	350	04	323	460	02	430	750	10	218	275	02	2195	3250	08	417	725	06
P. aurantiogriseum Dierckx	420	1150	03	747	880	02	260	550	05	27	40	02	1665	2250	08	1025	1200	05
P. janczewskii Zaleski	90	200	02				460	625	07				490	600	06			
P. oxalicum Currie	230	350	02				100	150	01				230	350	04			
P. funiculosum Thom	60	150	01				35	50	02				85	125	02			
P. janthinellum Biourge	100	400	01				255	325	03	37	50	01				267	525	01
P. puberulum Bainier	30	150	01				35	50	01				135	250	04			
P. purpurogenum Stoll	160	500	01				80	100	01				65	125	02			
P. verruculosum Peyronel	100	500	01				60	100	01				145	250	03			
P. jensenii Zaleski				37	50	01	245	350	04	108	125	01	235	400	03			
P. paxilli Bainier							250	350	04									
P. rugulosum Thom							110	150	02									
P. waksmanii Zaleski							90	200	02				75	125	01			
P. brevi-compactum Dierckx										4	10	01						

cont.

1	2			3			4			5			6			7		
P. implicatum Biourge										10	30	01						
P. variabile Scopp										42	50	01						
P. viridicatum Westling													320	500	04			
P. godlewskii Zaleski													250	375	03			
Eupenicillium sinaicum Udagawa et Ueda																100	150	01
Fusarium	2990	3800	17	183	250	05	1255	1525	16	40	50	01	1025	1150	14	133	175	01
F. solani (Mart.) Sacc.	1390	1750	13	147	170	05	650	1000	14	40	50	01	395	7745	11	133	175	01
F. oxysporum Schlecht: Fr.	1260	2000	09	36	50	02	565	850	07				90	100	03			
F. equiseti (Corda) Sacc.	40	100	02				30	100	01				425	775	08			
F. graminearum Schwable	120	150	01															
F. lateritium Nees	10	50	01															
F. moniliforme Scheldon	150	200	01										115	150	02			
F. poae (Peck) Wollenw.	20	100	01															
F. roseum Fuckel var. *coeruleum* Wollenw.							10	25	01									
Mucor	990	2650	08	100	175	01	135	225	03				365	500	07			
M. hiemalis Wehmer	700	1750	04				110	225	02				75	150	02			
M. racemosus Fres.	280	650	03															
M. circinelloides van Tieghem	10	50	01				25	50	01				290	400	05			
M. plumbeus Bonord.				100	175	01												
Circinella muscae (Sorok) Bert. et Detoni	620	1050	07															
Ulocladium	310	550	04				190	275	11				1365	6175	14	516	750	04
U. chlamydosporum Mouchacca	120	200	02				65	150	04				420	800	05	175	250	01
U. atrum Preuss	190	400	02				75	100	04				715	875	08	341	375	03
U. alternariae (Cooke) Simmons							40	75	03				180	350	02			
U. chartarum (Preuss) Simmons							10	25	01				50	100	02			
Alternaria	320	650	03				540	1075	09				760	1250	10			
A. chlamydospora Mouchacca	260	350	02				50	100	02				420	600	05			
A. alternata (Fr.) Kiessler	60	100	01				490	900	08				290	350	04			
A. tenuissima (Kunze: Pers.) Wiltshire													50	100	01			
Humicola grisea Traaen	160	250	03										320	450	06			
Rhizomucor pusillus (Link) Schipper	320	500	03															
Botryotrichum	400	650	02	07	20	01	135	200	02				800	1025	11			
B. atrogriseum van Beyma	230	350	01	07	20	01	135	200	02				800	1025	11			
B. piluliferum Sacc. et Marchal	170	300	01															
Exerohilum	190	350	02				50	75	02				490	750	05			
E. halodes (Drechsler) Leonard et Suggs anam. of *Setosphaeria rostrata* Leonard	100	150	01				25	50	01				400	650	03			
E. rostratum (Drechsler) Leonard et Suggs anam. of *Setosphaeria rostrata* Leonard	90	150	01				25	50	01				90	100	02			
Rhizopus nigricans Ehrenb.	180	250	02				40	50	03				70	125	03			
Stachybotrys	180	250	02				85	150	05				80	100	02			
S. chartarum (Ehrenb.) Hughes	180	250	02				70	125	04				80	100	02			

S. chartarum var. *microspora*							15	25	01									
(Muthure et Sankhla) Jong et Davis																		
Syncephalastrum racemosum (Cohn) Schr.	50	100	02										110	150	02			
Chaetomium	150	250	01				80	125	04									
C. globosum Kunze: Fr.	150	250	01															
C. olivaceum Cook et Ellis							80	125	04									
Cladosporium	40	50	01				125	175	03				380	525	04	42	75	02
C. sphaerospermum Penzig	40	50	01				125	175	03				380	525	04			
C. cladosporioides (Fres.) de Vries																17	50	01
C. herbarum (Pers.) Link																25	75	01
Scopulariopsis	20	50	01	40	50	01	870	1100	11	1995	3090	06	140	275	04	208	325	02
S. halophilica Tubaki	20	50	01	40	50	01												
S. candida (Coeguen) Vuill.							190	250	01	1775	2750	03	75	125	02	100	100	01
S. brevicaulis (Sacc.) Bain.							680	1075	10	220	340	03	65	150	02	108	175	01
Acremonium				17	50	01	395	725	04				935	1250	10			
A. strictum W. Gams				17	50	01	395	725	04				785	1100	10			
A. implicatum Gilman et Abbott													150	250	01			
Monodictys castaneae (Wallr.) Hughes				40	50	01												
Curvularia							35	100	02				110	200	02			
C. tuberculata Jain							35	100	02				90	100	02			
anam. of *Cochliobolus tuberculatus* Sivanesan																		
C. lunata (Wakker) Boedijn													20	100	01			
anam. of *Cochliobolus lunatus* Nelson et Haasis																		
Paecilomyces							55	75	02	04	10	01						
P. terricola Miller, Giddens et Foster							35	50	01									
P. variotti Bainier							20	225	01									
P. lilacinus (Thom) Samson										04	10	01						
Trimmatostroma							100	150	02				110	150	02			
T. salices Corda							100	150	02									
T. betulinum (Corda) Hughes													110	150	02			
Dreshslera spicifera (Bain.) von Arx							05	25	02									
anam. of *Cochliobolus spicifera* Nelson																		
Cephalosporium curtipes Sacc.							25	50	01									
Epicoccum purpurascens Ehrenb. ex Schlecht.							10	25	01									
Merimbla ingelheimense (van Beyma) Pitt										19	30	02				09	25	01
Sterile mycelia (dark coloured)	150	350	04	08	25	01												
Gross total count	16640	43250		26253	27835		28850	30325		17326	21720		35175	37625		19283	20100	

ATC: average total count in every sample. MV: the max. value in all cases. NCI: number of cases of isolation (out of 25 samples).

Occurrence remarks: high occurrence: between 13-25 cases (out of 25 samples). Moderate occurrence: between 6-12 cases. Low occurrence: between 3-5 cases. Rare occurrence: 1 or 2 cases.

Table 3

Average total count and maximum value (calculated per g dry soil in every sample) and number of cases of isolation of fungal genera and species isolated from 25 samples from each of cultivated, desert and saline soils on 15 % and 20 % sodium chloride-Czapek's agar at 28°C (± 2°C)

Genera et species	Cultivated soil						Desert soil						Saline soil					
	15 % NaCl			20 % NaCl			10 % NaCl			20% NaCl			15 % NaCl			20% NaCl		
	ATC	MV	NCI	ATC	MV	NCI	ATC	MV	NCI	ATC	MV	NCI	ATC	MV	NCI	ATC	MV	NCI
Aspergillus	1240,0	1480	16	673,3	750	12	2303,0	2490	23	533,8	600	13	786,7	850	16	66,7	95	7
A. terreus Thom	575,3	600	13	18,3	20	5	1219,3	1330	19	15,1	20	3	96,7	260	5	1,7	5	1
A. halophilicus Christensen, Papavizas et Benjamin	223,3	250	11	131,6	140	7	220,0	260	17	110,0	135	11	53,3	80	7	5,0	10	2
A. amstelodami (Mangin) Thom et Church	60,0	61	9	26,7	60	2	20,0	30	5				23,3	30	3			
A. nioer van Tieghem	43,3	100	5				23,3	30	3				10,0	10	3			
A. niveus Blochwitz	46,7	60	5															
A. sydovi (Bain. et Sart.) Thom et Church	153,3	210	5	8,3	20	2	23,3	40	2	151,7	205	5	53,3	70	7	25,0	40	2
A. wentii Wehmer	43,3	90	4				686,7	960	14	30,1	45	4	443,3	650	4	10,0	25	2
A. chevalieri (Mangin) Thom et Church	20,0	30	4				10,0	20	2									
A. ochraceus Wilhelm	30,0	40	2	386,6	505	6				96,9	150	9				3,3	10	1
A. oryzae (Ahlb.) Cohn	30,0	40	2	6,6	10	2							10,0	20	2			
A. tamarii Kita	3,3	10	1				10,0	20	2									
A. terricola Marchal	10,0	30	1															
A. terricola Marchal	3,3	10	1				10,0	20	2									
A. versicolor (Vuill.) Tiraboschi				55,0	75	5	10,0	30	1	105,0	140	9	66,7	100	5	6,7	15	1
A. tonophilus Ohtsuki				40,0	55	3	50,0	80	3									
A. flavipes (Bain. et Sart.) Thom et Church													16,7	40	2			
A. ustus (Bain. et Sart.) Thom et Church										20,0	30	3						
Aspergillus sp.										5,0	10	1	13,3	30	2	15,0	25	1
Scopulariopsis	33,3	40	4	15,0	20	2	63,3	70	4	26,7	30	6	316,6	450	11	318,3	430	7
S. halophilica Tubaki	33,3	40	4	15,0	20	2	33,4	50	3	26,7	30	6	306,6	420	11	318,3	430	7
S. candida (Gueguen) Vuill							30,0	50	1				10,0	20	1			
Penicillium	53,3	80	2				60,0	110	3				13,3	30	2			
P. chrysogenum Thom	53,3	80	2				56,7	70	3				10,0	30	1			
P. aurantiogriseum Dierckx							3,3	10	1									
P. citrinum Thom													3,4	10	1			
Eupenicillium																		
E. egyptiacum (Van Beyma) Stolk et Scott							33,3	40	4				10,0	20	1			
Gross total count	1326,7	1560		688,0	775		2460,0	2620		560,0	645		1126,0	1340		385,0	550	

ATC: average total count in every sample. MV: the max. value in all cases. NCI: number of cases of isolation (out of 25 samples)

Occurrence remarks: high occurrence: 13-25 cases (out of 25 samples). Moderate occurrence: between 6-12 cases. Low occurrence: between 3-5 cases. Rare occurrence: 1 or 2 cases.

It was encountered in 96 % and 32 % ofthesamples constituting 11,5 % and 4,97 % of total fungi in the two concentrations, respectively. From the genus, 21 species were collected (11, 17 and 14 species in the three soil types, respectively) of which *P. chrysogenum* was the most prevalent in the three substrates at the two concentrations of sodium chloride. *P. citrinum*, *P. janczewskii* and *P. aurantiogriseum* were more common on 5 % NaCl than on 10 % NaCl in the three types of soils. A b d e l - H a f e z (1981) isolated 14 *Penicillium* species from desert soils of Saudi Arabia on 5 % NaCl agar plates and the most common species were *P. chrysogenum* (= *P. notatum*), *P. brevicompactum*, *P. cyano-flavum*, *P. citrinum* and *P. solitum*. A b o l - N a s r (1981) and M o u b a s h e r et al. (1985) found *P. chrysogenum* (= *P. notatum*) and *P. citrinum* were among the common species in soils from the Red Sea shore and Wadi Bir-El-Ain on 5-10 % NaCl agar medium. These two species were also prevalent in salt marsh soils of Egypt (A b d e l - F a t t a h et al., 1977) and Kuwait (M o u s t a f a, A l - -M u s a l l a m, 1975). The remaining species of *Penicillium* were less frequent.

Fusarium was also recovered very frequently from cultivated, desert and saline soils on 5 % NaCl, but it was isolated with low or rare frequency on 10 % NaCl. It was encontered in 68 %, 64 % and 56 % of the samples constituting 7,9 %, 4,3 and 29,1 % of total fungi in the three soil types on 5 % NaCl, respectively. From the genus 8 species were collected and the most common were *F. solani* and *F. oxysporum* in cultivated and desert soils. *F. equiseti* was isolated in moderate frequency from saline soils, but it was of rare frequency in the other two types of soils. The former two species were also the most prevalent species on 5 % NaCl agar from Wadi Bir-El-Ain soils (M o u b a s h e r et al., 1985), but *F. solani* was only common in soil from the Red Sea shore on 5-10 % NaCl agar plates (A b o l - N a s r, 1981). *F. graminearum*, *F. lateritium*, *F. moniliforme*, *F. poae* and *F. roseum* were less frequent.

Ulocladium was recovered with high, moderate and low frequency from saline, desert and cultivated soils on 5 % NaCl-Czapek's agar, respectively. It emerged from 56 %, 44 % and 16 % of the samples contributing nearly 3,9 %, 0,7 % and 0,8 % of total fungi, respectively. It was represented by 4 species of which *U. atrum* was the most common; *U. alternariae*, *U. chartarum* and *U. chlamydosporum* were less frequent. This genus was completely eliminated on 10 % NaCl agar in cultivated and desert soils, but it was isolated with low frequency from saline soils. *U. atrum*, *U. consortiale* and *U. botrytis* were recorvered from the Red Sea shore (A b o l -N a s r, 1981), Wadi Bir-El-Ain (M o u b a s h e r et al., 1985) and Saudi Arabian desert soils (A b d e l - H a f e z, 1981) on 5-10 % NaCl agar plates.

Mucor (4 species) and *Circinella* (1 species), *Scopulariopsis* (2 species) and *Alternaria* (2 species), and *Botryotrichum* (1 species), *Acremonium* (2 species), *Alternaria* (3 species), *Mucor* (2 species) and *Humicola* (1 species) were isolated with moderate frequency on 5 % NaCl agar plates; these emerged from 28 % and 32 %; 36 % and 44 %; and 28-40 % of the samples comprising 1,7 % and 2,7 %; 1,9 % and 3,1 % and 0,9 %-2,7 % of total fungi in cultivated, desert and saline soils, respectively. The preceding genera were also encountered, but with variable densities and frequencies, from soils of Wadi Bir-El-Ain (M o u b a s h e r et al., 1985) and the Red Sea shore (A b o l - N a s r, 1981), as well as from Saudi Arabia desert soil (A b d e l - H a f e z, 1981) on 5 % or 10 % NaCl-Czapek's agar.

On 15 % and 20 % NaCl-Czapek's agar, 20 species belonging to 4 genera were collected from cultivated (3 genera and 17 species) desert (4 genera and 18 species) and saline soils (4 genera and 15 species). Total populations of 1326,7 and 688,3; 2460 and 560; and 1126,6 and 385 colonies/g dry soil from 25 samples of each of three soil types were obtained at the two sodium chloride concentrations, respectively. The results obtained on the two media were basically similar and the most common genera were *Aspergillus*, *Penicillium* and *Scopulariopsis*, which emerged from 8-64 %, 12-92 %, and 8-64 % of the samples comprising approximately 2,2-97,8 %, 2,4-93,6 % and 1,2-82,7 % of total fungi in cultivated, desert and saline soils, respectively. *Aspergillus glaucus* (*Eurotium*) group (represented by *A. chevalieri*, *A. amstelodami* and *A. halophilicus*), *A. terreus*, *A. sydowi*, *A. flavus*, *A. versicolor*, *A. niger*, *P. chrysogenum*, and *S. halophilica* were the most prevalent members of these genera in any or all types of soils at any of the two sodium chloride concentrations. A b o l - N a s r (1981)found that *A. sydowii A. amstelodami*, *A. niger*, *A. montevidensis*, *A. versicolor* and *A. repens* were the most prevalent *Aspergillus* species from soils the Red Sea shore on 15 % NaCl-Czapek's agar. Most of the previous species have been encountered, but with variable densities and frequencies, on salt marsh soils from different places of the world (B a y l i s s E l l i o t, 1930; S a i t o, 1952; P u g h, 1962; M o u s t a f a et A l - M u s a l l a m, 1975; A b d e l - F a t t a h et al., 1977; E l - A b y a d et al., 1979; and several others).

On 25 % sodium chloride-Czapek's agar, halophilic and halotolerant fungi, were estimated in the case of cultivated and desert soils, but in saline soils two species were recorvered namely, *A. sydowii* (4 % of the samples and 55,6 % of total fungi) and *S. halophilica* (12 % and 44,4 %). T u b a k i (1973) isolated *S. halophilica* for the firts time from Osaca (Japan) from the salt seaweed, *Undaria pinnatifida*. T r e s n e r and H a y e s (1971) found that *Penicillia* (273 strains of of 124 species) and *Aspergilli* (196 strains of 81 species), as a whole, were outstandingly more resistant to NaCl than any of the other organisms studied. Over three-fourths of penicillia could tolerate 20 % NaCl and more than half survived 25 % or greater concentrations. The aspergilli appeared to be somewhat less tolerant. Nevertheless, about 70 % could withstand 20 % NaCl and nearly half survived 25 % NaCl. No other fungi studied were able to grow at the 25 % level. This is in agreement with the results obtained by B a g y and A b d e l - H a f ez (1984).

In conclusion, the present results reveal that *Aspergillus, Penicillium* and *Fusarium* were consistently the most frequent genera in cultivated, desert and saline soils on 5 % and 10 % sodium chloride-Czapek's agar. But *Ulocladium* which was isolated with high frequency of occurrence from saline soils, retreated to a backward situation in cultivated and desert soils. Also, the *Aspergillus glaucus* group (represented by *A. amstelodami, A. chevalieri, A. halophilicus, A.repens, A.ruber*, and *A. tonophilus*), *S. halophilica* and *S. brevicaulis* were prevalent in the three types of soils on 15 % and 20 % NaCl agar plates.

Comparison between the lists of halophilic and halotolerant fungi recovered from the Red Sea shore (A b d e l - N a s r, 1981) and Wadi Bir-El-Ain (M o u - b a s h e r et al., 1985) soils in Egypt and desert soils in Saudi Arabia (A b d e l - -H a f e z, 1981) reveal that there are no halophilic and halotolerant fungi characteristic of Egyptian cultivated, desert and saline soils, but these lists may differ in the order of frequency of the component fungi.

HALOPHILIC ABILITY

The tested organisms showed different growth rates (based on dry weight of fungal mat) at the different concentrations of sodium chloride (0,5 %, 10 %, 15 %, 20 % and 25 %). Therefore they were classified into the following four categories:

A – Halophilic: which grew on 5-25 % NaCl, but exhibited very restricted growth on Czapek's medium free from NaCl. It was represented by 7 species namely, *Aspergillus amstelodami, A. chavalieri, A. halophilicus, A. repens, A. ruber, A. tonophillus* and *Scopulariopsis halophilica*.

B – Highly halotolerant: which grew on 0 (control)-20 % NaCl. This group included 17 species and 1 variety: *A. nidulans, A. ochraceus, A. sydowi, A. terreus, A. flavus* var. *columnaris, A. versicolor, A. wentii, P. funiculosum, P. godlewskii, P. janthinellum, Penicillium chrysogenum, P. citrinum, C. cladosporioides, Eupenicilium egyptiacum, E. sinaicum, Merimbla ingelheimense, S. candida* and *Ulocladium chlamydosporum*.

C - Fairly (moderately) halotolerant: which grew on 0-15 % and showed best growth at 5 or 10 % NaCl. This group included 29 species and these were *Aspergillus carneus, A. flavipes, A. flavus, A. melleus, A. quadrilineatus, A. rugulosus, A. terricola, A. niger, A. hiveus, A. cryzae, A. sclerotiorum, A. tamarii, Penicillium aurantiogriseum, P. brevicompactum, P. jensenii, P. oxalicum, P. paxilli, P. rugulosum, P. janczewski, P. variabile, P. viridicatum, P. implicatum, P. verruculosum, P. waksmanii, Alternaria chlamydospora, A. tenussima, Cladosporium, Sphaerospermum, Monodictys, Castaneae* and *Fusarium solani*.

D - Weakly halotolerant: with grew on 0-10 % NaCl and showed best growth on control (0 %) NaCl or 5 % sodium chloride. It was represented by the remaining species (Table 2, 3) such as *Alternaria alternata, Circinella muscae, Exerohilum halodes, Fusarium oxysporum, Rhizomucor pusillus, Syncephastrum racemosum, Mucor hiemalis* and *Ulocladium chartarum*.

These results reveal that: 1 — All halophilic species, except one belong to *Aspergillus*. 2 - Most of the highly and fairly tolerant species are *Aspergillus* and *Penicillium* species. 3 - All fungi recorvered were halophilic or halotolerant which means that Egyptian soil fungi in general are adapted to and could survive the xerophytic conditions of most of the land in Egypt. Symilarly Moubascher and Al-Subai (1987) concluded that the fungus flora of the soils of Quatar is of osmophilic nature, enabling it to exist under and tolerate the dry conditions of this country.

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