Ecological and Physiological Studies on Soil Fungi at Western Region, Libya

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Abstract:

Sixty-three species and 5 varieties belonging to 30 fungal genera were collected from 75 soil samples. Cultivated (29 genera and 58 species+ 5 var.) and saline soil (21 and 41+1 var.) fungi were recovered on glucose-, cellulose- and 50% sucrose-Czapek's agar at 28 C. The most common genera were :*Alternaria, Aspergillus* , *Emericella Fusarium, Mycosphaerella, Nectria* and *Penicillium.* The most prevalent species from the three types of soils on the three types of media were *Alternaria alternata, Aspergillus flavus, A. fumigatus, A. niger, A. terreus, Emericell anidulans, Fusarium oxysporum, Mycosphaerell atassiana, Nectriahae*

matococca and *Penicillium chrysogenum*. *Chaetomium globosum* was in the top of fungi in producing endo-β-1,4-glucanases among the 42 tested isolates obtained from soils on cellulose-Czapek's agar. Maximum production of this enzyme by *C. globosum* obtained after 6 days of incubation at 30 C with culture medium containing maltose as a carbon source and ammonium nitrate as a nitrogen source and pH initially adjusted to 6.

Key words : Soil fungi ,Cellulolytic ability

Introduction:

Cellulose, a major polysaccharide constituent of plant cell walls, is a -1,4 linked linear polymer of 8000~12000 glucose units. Three major enzymes are involved in degradation of cellulose to glucose are endoglucanase (endo-1,4-d-glucanase, EG), cellobiohydrolase (exo-1,4-d-glucanase,CBH), and β-glucosidase (1,4- glucosidase, BG). EG acts in random fashion, cleaving linked bonds within the cellulose molecule; CBH removes cellobiose units from the nonreducing ends of the cellulose chain and BG degrades cellobiose and cellooligosaccharides to glucose (Saha, 2004). Several fungi such as members of *Aspergillus, Penicillium, Trichoderma, Chaetomium* and some other moulds of Mucors and dematiaceoushypomycetes produced celluloytic enzymes as reported by several researchers (Nelly, 1991; Abdel-Hafez *et al*., 1995, 2003; Moharram *et al*., 2004; El-Said *et al*., 2005, 2006; Vasil'chenko*et al*., 2005). This investigation aimed to study the occurrence and distribution of various groups of fungi in cultivated, desert and saline soils as well as the ability of fungal isolates to produce cellulase enzyme under different environmental and nutritional conditions.

Materials and Methods

Cultures. Twenty-five soil samples of each of cultivated (Nos. 1-25), desert (Nos. 26-50) and saline (Nos. 51-75) were collected from different localities in Western region in Libya according to the method described by Johnson and Curl (1972). The geographical feature of El-Gaffara plain is refer that it is a big region in Libya, as it is covers more than 17,000 km^2. It takes a triangle shape with apex at the east near Al-Khums town. The north is parallel with mediteranean sea coast and about 275 km long. The western side forming the western borders of the republic and about 150 km long (Fig. 1).

Chemical analysis of soil samples. Organic matter content (OM) was determined by Walkely and black method (Jackson, 1958). The amount of total soluble salts per one g oven-dry soil (TSS) was calculated according to (Jackson, 1958). A pH meter (Orior Research model 601 T /digitalionalyzer) was used for the determination of soil pH according to (Jackson, 1958). Carbonate (CO_3^{--}) and bicarbonate (HCO_3^{-}) were determined directly in soil by back-titration (Hydrochloric acid digestion) according to the method described by (Jackson, 1958). Soluble chloride (Cl^{-}) was estimated by applying the silver nitrate titration method using potassium chromate as an indicator (Jackson, 1958). Calcium (Ca^{++}) and magnesium (Mg^{++}) were determined by titration method (Schwarzenbach and Biederman, 1948). The cations such as sodium (Na^{+}) and potassium (K^{+}) were determined by using Carl Zeiss flame photometer method (Williams and Twine 1960).

Estimation of soil fungi. The dilution-plate method as described by Johnson and Curl (1972) was used for estimation of soil fungi. Modified

Czapek'sDox agar medium was employed (g/L: glucose 10.0 or cellulose powder 20.0 or sucrose 50.0, sodium nitrate 3.0, magnesium sulphate 0.5, potassium dihydrogen phosphate 0.5, ferrous sulphate 0.01, agar 15), in which glucose or powdered cellulose or sucrose were used for the isolation of glucophilic, cellulose-decomposing and osmophilic (or osmotolerant) fungi, respectively. These media were supplemented with rose Bengal (0.1 mg / ml) and chloramphenicol (0.05 mg / ml) in order to suppress bacterial growth. The plates were incubated at 28°C for 5~10 days during which the developing fungi were counted, identified (purely morphologically, based on macro-and microscopic characters) and calculated per g dry soil.

Screening of fungal isolates for cellulose production .Forty-one species and 1 species variety representing 26 genera were screened for their ability to produce endoglucanase (C_x enzyme). Isolates were cultured on Eggins and Pugh medium (1962) of the following composition (g/liter): $(NH_4)_2SO_4$, 0.5; L-asparagin, 0.5; KH_2PO_4, 1.0; KCl, 0.5; $MgSO_4.7H_2O$, 0.2; $CaCl_2$, 0.2; yeast extract, 0.5; microcrystalline cellulose (Merck), 10; Agar-agar, 20. pH was adjusted to 5.4 using acetate buffer. Cultures were incubated at 28°C for 7 days. Using sterile cork borer, 10 mm diameter, discs were cut to inoculate 50 ml sterile liquid medium (in 250 ml Erlenmeyer conical flasks) or Prasad and Verma medium (1979) for endoglucanase which contained the following ingredients (g/liter: NH_4NO_3, 2.1; KH_2PO_4, 1.0; $MgSO_4.7H_2O$, 0.5; carboxymethylcellulose (CMC), 10.0. After 7 days incubation period at 28°C the cultures were filtered and the filterates were used to detect the activity of C_x enzyme

Detection of endoglucanase (C_x enzyme): Using a sterile cork borer three cavities (10 mm diameter) were made in plates containing solid

medium of Dingle et al., (1953) for detection of endo-B-1,4- glucanase .0.1 ml of culturel filtrate was dropped in each of these cavities followed by incubation at 28 C for 24 hours, then the plates were flooded with cloriodide of zinc solution and the clear zones gave a measure for cellulolytic power of isolate.

Factors affecting endoglucanase.The effect of different ecological and nutritional factors on production of Cx enzyme by *Chaetomium globosum* were studied , since this species was found to be highly active in endoglucanase production

a) Effect of temperature and time course*:* Inoculated flasks were incubated at 20°, 30° and 40° for 14 days and harvested at 48 h intervals.Culture fluids were filtered and centrifuged at 5000 r.p.m. for 10 min. The clear supernatents were assayed for C_x enzyme activity.

b) Effect of pH values: *Chaetomium globosum*was grown on the basal medium of Deacon (1985) .. The initial medium was adjusted with 0.1 N NaOH or 0.1 N HCl to different values of pH ranging from 2 to 12. After inoculation, cultures were incubated at 30°C (the best temperature for endoglucanase activity) for 6 days (the best incubation period), then filtered, centrifuged at 5000 r.p.m. for 10 min and the clear supernatents were assayed for C_x enzyme activity.

c) Effect of various nitrogen sources: To determined the effect of the nitrogen source on Cx enzyme activity, the sodium nitrate (3 g/l) in cellulose-Czapek's medium was replaced with the same amount of various nitrogen compounds such as; $NaNO_2$, KNO_3, NH_4NO_3, $(NH_4)_2SO_4$ and $CaNO_3$. Cultures in flasks were incubated at 30°C for 6 days, filtered,

centrifuged and was the filtrate used for the detection of endoglucanase activity using the method described by Naguib (1964).

d) Effect of different carbon sources: For estimation the effect of cellulolytic materials on endoglucanase activity, the carboxymethylcellulose (CMC) in cellulose-Czapek's medium was replaced with the same weight of different carbon sources such as: clover straw, filter paper, maltose, powdered cellulose, wheat bran, wheat straw and yeast extract. The inoculated flasks were incubated at 30°C for 6 days and the cultures were filtered. After centrifugation the filtrate was used for detection the C_x enzyme activity.

Results and Discussion:

The moisture contents of the soil samples tested varied from a low value (0.1-3.6%), a moderate value (0.3-6.4%) and a high value (1.29-15.5%). The highest value (15.5%) occurred in cultivated soil sample No. 22 collected from Sabratah under *Solonumlycopersicum*. Abdel-Sater (1987) found that the water content of 25 soil samples collected from different habitats of each of cultivated, desert and saline soils in Egypt fluctuated between a low value (2.4-9.9%), a moderate value (10-15.2%) and a high value (15.3-21.9%). El-Said (1994) recorded that the moisture contents of soil samples collected from Bahreen ranged between 0.1-1.1%.

The soil samples were generally poor in their content of organic matter, but the cultivated soil was the richest (0.08-1.71% of dry soil) followed by desert (0.1-0.57%) and saline soils (0.01-0.54%).The present observations almost agree with the results previously obtained from different types of Egyptian soils (Moubasher and Moustafa, 1970; Moubasher and Mazen, 1972; Abdel-Fattah, 1973; Moubasher*et al.*, 1975,

1985; Abdel-Fattah *et al.*, 1977; Batanouny and Abo-Sitta, 1977; Moubasher and Abdel-Hafez, 1978 a, b ; Abdel-Sater, 1987 and Abdel-Hafez *et al.*, 1989 a,b, 1990 a , b ,1991, 1995), as well as from soils of some Arab countries (Moustafa and Al-Musallam, 1975; Abdel-Hafez, 1982c; Abdel-Hafez *et al.*, 1983 a,b,c and El-Said, 1994).

The highest of total soluble salts was detected in saline soils (1.02-8.89%). These high amounts of salts were not found in the cultivated (0.06~0.85%) and desert (0.01~0.48%) soils. Similar results were recorded by Abdel-Sater (1987) who found that the total soluble salts in the samples of cultivated, desert and saline soils collected from Egypt ranged between 0.13-1.69%, 0.03-1.6% and 6.62-18.63%, respectively. Also, Abdel-Hafez *et al.* (1991, 1995) recorded that the total soluble salts in soils collected from Egypt fluctuated between 2.2-4.7% and 0.18-0.30%. Moubasher*et al.* (1977); Abdel-Hafez (1982 b); Abdel-Hafez *et al.* (1983 b) and El-Said (1994) reported that the amount of total soluble salts fluctuated between 2.3~4.7% in cultivated soils of Bahreen.

Amounts of carbonates, bicarbonates and chlorides in the samples tested fluctuated markedly from 2.01-7.60%, 0.23-2.04% and 0.02-0.24%; 3.21-7.75%, 0.32-2.02% and 0.001-0.32%; and 6.09-7.49 %, 0.18-1.72% and 0.02-1.31% in cultivated, desert and saline soils, respectively. Abdel-Sater (1987) recorded that the amount of carbonate, bicarbonate and chlorides in the samples of cultivated, desert and saline soils collected from Egypt ranged between 2.26-5.4%, 0.36-1.5% and 0.07-0.68%; 1.65-5.88%, 0.23-1.02% and 0.14-3.9%; and 4.2-5.94%, 0.18-1.93% and 0.36-4.14%, respectively.

The amount of elements in cultivated,desert and saline soils were calculated in mg / g dry soil,respectively as follows: Ca: 0.03-0.73, 0.05-0.2 and 0.09-2.85 ; Mg: 0.03-0.19 , 0.02-0.35 and 0.03-1.02; K: 0.07-0.27, 0.11-0.53 and 0.10-0.89 and Na: 0.03-0.09, 0.02-0.46 and 0.1-0.79. Abdel-Sater (1987) found that the amount of elements in cultivated, desert and saline soils collected from Egypt were: Ca: 0.3-0.75, 0.03-2.67 and 0.07-3.75; Mg: 0.13-0.54, 0.02-0.54 and 0.013-1.23; K: 0.02-0.27, 0.02-0.51 and 0.05-0.88; and Na: 0.16-4.8, 0.12-8.05 and 2.35-39 mg/g dry soil, respectively.

pH values of cultivated, desert and saline soils ranged between 4.5-7, 6.4-7.2 and 6.4-7.3, respectively. Abdel-Sater (1987) found that the pH values of cultivated, desert and saline soils gathered from Egypt fluctuated between 7.2-8.9, 6.9-7.4 and 7.2-8.8, respectively. Similar observations were obtained by Abdel-Hafez *et al*. (1989b, 1991, and 1995) and El-Said (1994).

Sixty three species and 5 species varieties belonging to 30 genera were collected from 75 soils samples of each of cultivated (29 genera and 58 species + 5 var.), desert (22 and 35 + 2 var.) and saline (21 and 41 + 1 var.) on glucose-, cellulose- and 50% sucrose-Czapek's agar at 28°C (Tables 1,2 and 3).The most common genera encountered were: *Alternaria*(2 species), *Aspergillus* (11 + 4 var.), *Emericella* (1+2), *Fusarium* (4), *Mycosphaerella* (1), *Nectria* (1) and *Penicillium* (7). The most prevalent species from the three types of soils on the three types of media were: *Alternaria alternata, Aspergillus flavus, A. fumigatus, A. niger, A. terreus, Emericell anidulans ,Fusarium oxysporum, Mycosphaerell atassiana, Nectriahaem atococca*and *Penicilliumc*

hrysogenum. Several of the above species were isolated, but with different numbers and frequencies from various soils in many parts of the world by several workers (Abdel-Hafez *et al.* 1990a,b; Moubasher and Mazen,1991; Abdel-Hafez, 1994; Karl and Iain, 2004; Lalley and Viles, 2005 and several others). Abdel-Hafez *et al.* (1991) found that the most common species in the Egyptian soils on glucose-, cellulose- and 50% sucrose-Czapek's agar were: *Aspergillus flavus, A. fumigatus, A. niger, A. sydowii, A. terreus, E. nidualns*var.*lata*, *Penicillium chrysogenum, P. puberulum* and *Rhizopusstolonifer*. On the other hand, the most frequently encountered species in Bahreen soils recovered on glucose-, cellulose- and 50% sucrose- Czapek's agar were *Alternariaal ternata, Aspergillusflavus, A. fumigatus, A. niger, A. sydowii, A. terreus, Emericell anidulans, E. nidualns*var. *dentata*, *Fusarium oxysporum, Nectriahaem atococca, Penicillium chrysogenum*and *P. corylophilum*. (El-Said, 1994).

Eurotium incorporation was recovered from the three types of soils on plates of 50% sucrose-Czapek's agar and these were: *Eurotium amestelodami, E. chevalieri*and *E. rubrum*. Members of *Eurotium* are well known osmophilies as reported by numerous workers (Abdel-Hafez *et al.*, 1989a, b, 1990 a, 1991, 1995; El-Said, 1994; El-Said *et al.*, 2005).

Cellulolytic Activities Of Fungal Isolates*:*

All fungal isolates (42 isolates) were screened for their abilities to produce endo 1,4-B-glucanase (CMase or Cx enzyme) all of them exhibited cellulolytic ability but with variable degrees. Ten isolates (23.80% of total isolates) showed high cellulolytic activity in endo-B-1,4-glucanase and these were: *Alternaria alternata, Aspergillus flavus, A. fumigatus, Chaetomiumg lobosum, Cladosporium cladosporioides,*

Fusarium oxysporum, Mucorrace mosus, Papulaspor aimmersa, Rhizopus stolonifer and Sterile mycelia. The moderately cellulolytic isolates included 16 isolates (38.09% of total isolates) and the most important isolates being: *Aspergillus niger, A. sydowii, Emericella nidulans, fusarium poae, Penicillium chrysogenum, P. puberulum*and *Phoma glomerata.* Sixteen isolates (38.09% of total isolates) were found to be of weak cellulolytic activities which comprised for example: *Aspergillus ochraceus, Cochlioboluss picifer, Myrotheci umverrucaria, Nectriahaem atococca, Setosphaeria rostrata*and *Ulocladium botrytis* and others(Table 4) . Most of the above fungal isolates were reported as cellulase producers, but with variable capabilities by several workers (Abarha and Gashe, 1992; Abdel-Hafez *et al*., 1995; Moharram*et al*., 1995, 2004; El-Said, 2001; Berlin *et al*., 2005).

*Chaetomium globosum*was in the top of fungi in producing of endo 1,4-B-glucanase (Cx enzymes) in this investigation .Maximum production of the enzyme by *C. globosum* was achieved 6 days after incubation at 30°C with the of maltose as carbon sucrce and NH_4NO_3 as nitrogen sources in the culture medium which was initially adjusted to pH 6 (Fig.2 and 3). These findings were almost in agreement with those reported by Sandhu and Kalra (1985) who noticed that the maximum production of C_1 and Cx enzymes with *T. long ibrachiatum* was achieved after 5 or 6 days of incubation at 27°C but with the incorporation of 1% lactose in culture medium which initially adjusted to pH 5. They, also found that CMC and malt extract were favourable for the enzymes production.The maximum production of exo- and endo-B-1,4-glucanase by *Chaetomiumg lobosum*and*Trichodermaviride* were after 6 and 8 days of incubation at 25°C with culture medium containing wheat bran as a carbon source and

pepton as nitrogen source and initially adjusted to pH 6. (Abdel-Hafez *et al*.1995 .El-Said 2001)., El-Said *et al*., (2006) Recently found that the maximum production of exo- and endo-B-1,4-glucanase by F. oxysporum could be achieved after 8 days 0f incubation at 30 °C with the incorporation of carboxymethycellulose as a carbon source and peptone as nitrogen source in the culture medium which initially adjusted to pH 6.

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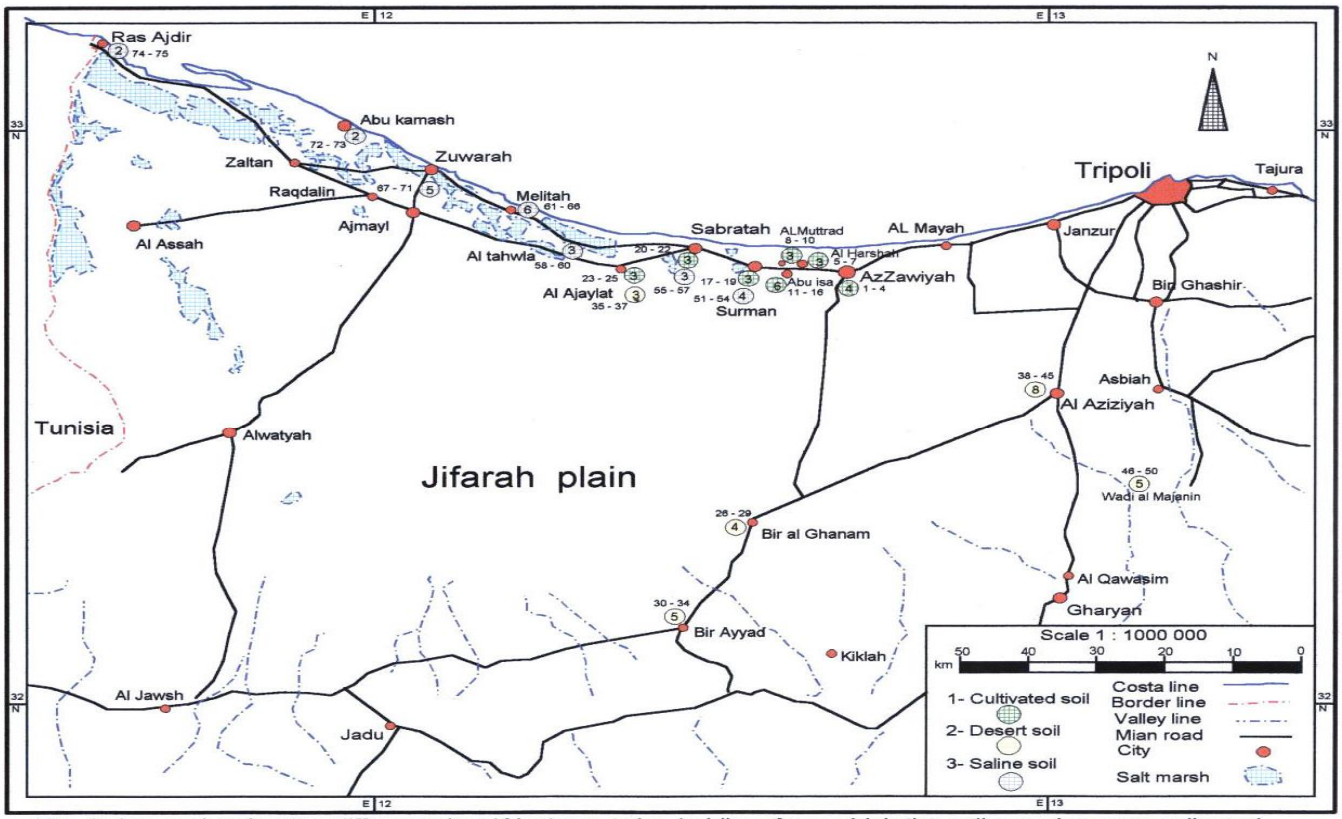

Fig. 1: Amap showing the different sites Western region in Libya from which the soil samples were collected.

* Dr.Ali Ayad Ben-Hamed. Geographic department. National Atlas of Jamahiriya. 1977. p.p.33-34.

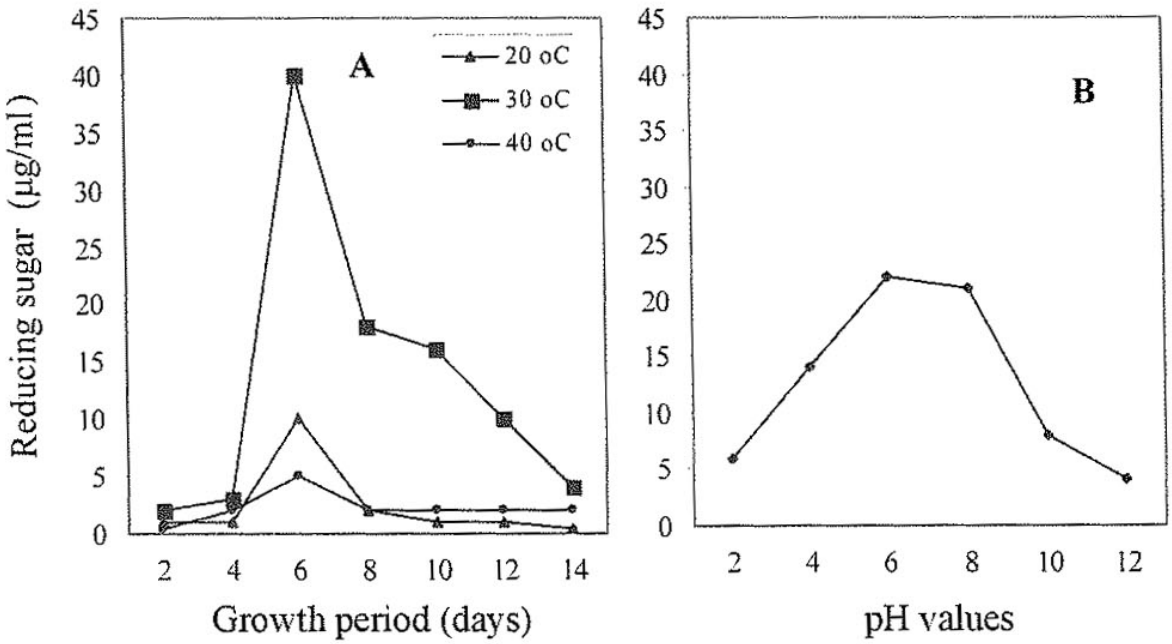

Fig. 2. Cellulase production by *C. globosum* in cultures incubated at different temperatures for different periods (A) and in cultures initially adjusted to different pH values (B).

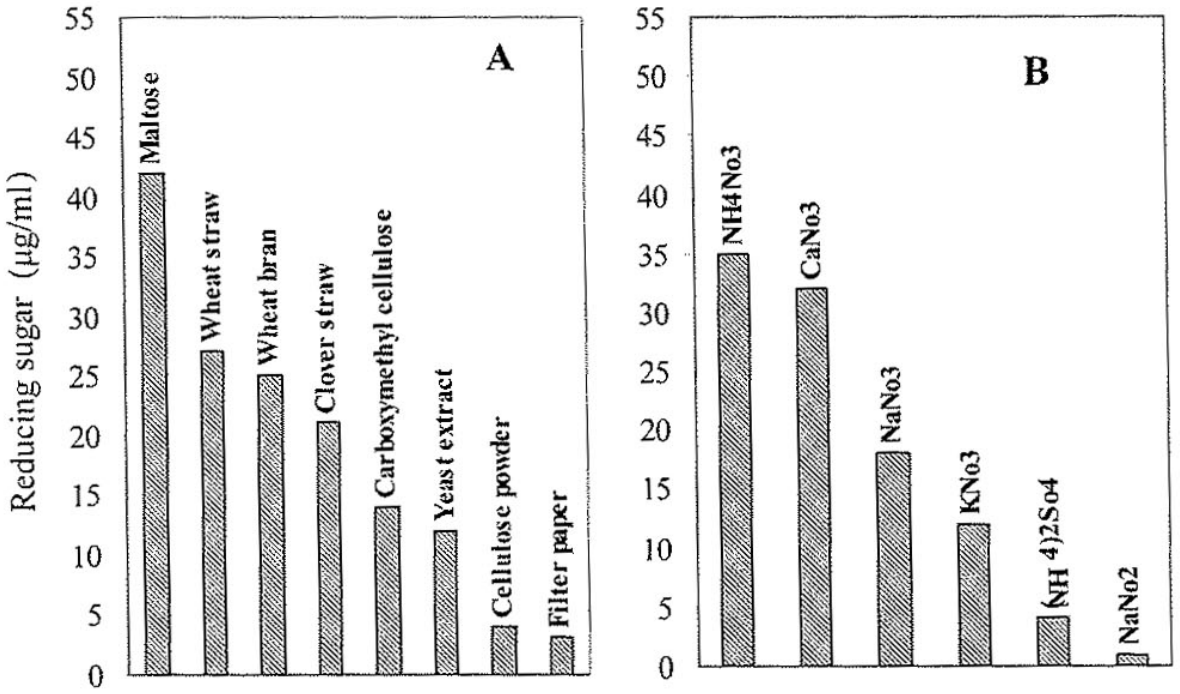

Fig. 3. Cellulase production by *C. globosum* in culture media containing different carbon (A) and nitrogen (B) sources.

Table 1 : Average total count (calculated per g dry soil in very sample), number of cases of isolation (NCI, out of 25 cases) and occurrence remarks (OR) for fungal genera and species recovered from 25 cultivated soil samples on glucose, cellulose and 50% sucrose-Czapek's agar at 28°C (±2°C).

Genera & species	Glucose			Cellulose			50% Sucrose		
	ATC	NCI	OR	ATC	NCI	OR	ATC	NCI	OR
*Acremoniumstrictum*W. Gams				100	2	R			
Alternariaalternata(Fries)	100	1	R	100	2	R	340	4	L
Aspergillus	29600	25	H	11880	23	H	32000	25	H
*A. candidus*Link	180	2	R				260	2	R
A. carneus(V. Tiegh.)Blochwitz	220	3	L						
A. flavus Link	9720	25	H	3480	18	H	6740	24	H
*A. flavus*var. *columnaris*Raper&	60	1	R	100	2	R	100	2	R
*A. fumigatus*Fresenius	100	1	R	2280	9	M	280	4	L
*A. niger*Trieghern	9340	22	H	4220	19	H	12380	25	H
*A. ochraceus*Wilhelm	1180	7	M	600	7	M	760	8	M
A. sydowii(Bainier. Sartory)	240	3	L				260	3	L
A. terreus Thom	3880	14	H	1200	7	M	6940	20	H
*A. terreus*var. *africanus*Fennel	200	3	L				380	3	L
*A. terreus*var. *aureus*Thom,	540	4	L				600	4	L
A. ustus(Bainier) Thom.	2400	10	M				920	6	M
A. versicolor(Vuill.)Tiraboschi	240	3	L						
*A. wentii*Wehmer	1300	10	M				2480	17	H
*Botryotrichumatrogriseum*Van	860	5	L	1540	5	L	100	1	R
*Chaetomiumglobosum*Kunze	140	3	L	740	4	L			
Cladosporium	140	3	L	200	3	L	400	3	L
C. cladosporioides(Fres.) de	140	3	L	200	3	L	240	3	L

Genera & species	Glucose			Cellulose			50% Sucrose		
	ATC	NCI	OR	ATC	NCI	OR	ATC	NCI	OR
*C. sphaerospermum*Penzig							160	2	R
Cochliobolus	200	2	R	620	5	L	200	2	R
*C. hawaiiensis*Alcorn , Trans				300	4	L			
*C. lunatus*Nelson &Haasis	100	2	R				100	2	R
*C. spicifer*Nelson	100	2	R	320	4	L	100	2	R
Cunninghamellaechinulata(Tha	160	2	R						
Emericella	11800	24	H	3560	18	H	5100	16	H
E. nidulans(Eidam) Vuill.	11100	23	H	3560	18	H	5100	16	H
*E. nidulans*var. *dentata*Sandhu	460	5	L						
*E. nidulans*var. *lata*(Thom	240	3	L						
Fusarium	3420	7	M	3620	8	M	920	8	M
F. dimerum(Corda) Sacc.				820	5	L			
*F. moniliforme*Sheldon	300	4	L						
*F. oxysporum*Shelecht.	3120	7	M	2380	7	M	700	8	M
F. poae(Peck)Wollenweber				420	3	L	220	3	L
Gibberella	500	4	L	120	1	R			
*G. acuminata*Wollenweber				120	1	R			
*G. intricans*Wollenw.	500	4	L						
Humicola	600	4	L	5760	13	H			
H. brevis(Gilman et Abbott)	160	3	L	1460	6	M			
*H. grisea*Taaen	440	4	L	4300	13	H			
Eurotium							15060	24	H
*E. amstelodami*Mangin							4540	18	H
*E. chevalieri*Mangin							10100	24	H
*E. rubrum*Konig, Spiekermann.							420	6	M
Mucor	160	2	R	120	2	R	100	2	R

Genera & species	Glucose			Cellulose			50% Sucrose		
	ATC	NCI	OR	ATC	NCI	OR	ATC	NCI	OR
*M. circinelloides*Van Tieghem				60	1	R			
*M. racemosus*Fresenius	160	2	R	60	1	R	100	2	R
Mycosphaerellatassiana(Alberti	1460	10	M	280	4	L	1240	13	H
*Myrotheciumverrucaria*Bainier				180	2	R			
*Nectriahaem atococca*Berkeley,	14080	22	H	10640	21	H			
*Paecilomycesvariotii*Bainier							260	4	L
Penicillium	10660	22	H	2840	16	H	13640	21	H
*P. chrysogenum*Thom	8520	21	H	3980	16	H	12400	21	H
*P. citrinum*Thom	360	4	L				160	3	L
*P. corylophilum*Dierckx	300	4	L	300	4	L	220	2	R
*P. funiculosum*Thom	240	3	L				240	3	L
*P. puberulum*Bainier	1240	8	M	560	6	M	480	8	M
*P. purpurogenum*Stoll							140	2	R
Phomaglomerata(Corda)Wollen	100	1	R						
Pleosporaherbarum(Fr.)Rabenh	140	3	L	540	5	L	100	2	R
Rhizopusstolonifer(Ehrenb.)	80	2	R						
Scopulariopsisbreviculis(Sacc.)	100	2	R						
*Scytalidiumlignicola*Pesante.	100	2	R	180	3	L	100	2	R
*Setosphaeriarostrata*Leonard	100	2	R	300	4	L			
Stachybotryschartarum	180	2	R	400	5	L			
Sterile mycelia(White & dark	100	1	R	220	3	L	220	3	L
Syncephalastrumracemosum(Co	160	2	R				220	2	R
Torulaherbarum(Pers.) Link	60	1	R						
Ulocladium	880	5	L				100	1	R
U. alternariae(Cke) Simmons	260	2	R				100	1	R
U. botrytis Preuss	240	3	L						

Genera & species	Glucose			Cellulose			50% Sucrose		
	ATC	NCI	OR	ATC	NCI	OR	ATC	NCI	OR
U. chartarum(Preuss) Simmons	320	3	L						
*U. tuberculatum*Simmons	60	1	R						
Gross total count	75860			45940			70100		
Number of genera = 29	25			20			16		
Number of spcies = 58 + 5 var.	45+5			31+1			34+3		

ATC = Average total count (per g dry soil) ; NCI = Number of cases of isolation (out of 25); OR = Occurrence remarks: H = High occurrence, from 13-25 (out of 25); M = Moderate occurrence, from 6-12 cases;L = Low occurrence, from 3-5 cases; R = Rare occurrence, from 1 or 2 cases .

Table 2 :Average total count (calculated per g dry soil in very sample), number of cases of isolation (NCI, out of 25 cases) and occurrence remarks (OR) for fungal genera and species recovered from 25 desert soil samples on glucose, cellulose and 50% sucrose-Czapek's agar at 28°C (±2°C).

enera& species	Glucose			Cellulose			50% Sucrose		
	ATC	NCI	OR	ATC	NCI	OR	ATC	NCI	OR
*Acremoniumstrictum*W. Gams	40	1	R						
Alternariaalternata(Fries) Keissler	300	3	L	700	4	L	2780	11	M
Aspergillus	16480	22	H	8780	18	H	21860	25	H
A. flavus Link	10180	18	H	4880	16	H	6580	18	H
*A. fumigatus*Fresenius	960	4	L	2800	7	M	4380	8	M
*A. niger*Trieghern	3320	18	H	340	4	L	6660	23	H
*A. ochraceus*Wilhelm	340	3	L	260	3	L	220	4	L
A. sydowii(Bainier. Sartory)	140	2	R						
A. terreus Thom	880	7	M	500	4	L	2180	13	H
*A. terreus*var. *aureus*Thom &Raper	120	2	R				940	7	M
A. ustus(Bainier) Thom Tiraboschi	540	3	L				900	6	M
*Chaetomiumglobosum*Kunze				880	5	L			
*Cochliobolusspicifer*Nelson, Hassis							60	2	R
Emericella	3240	13	H	1120	7	M	4220	16	H
E. nidulans(Eidam) Vuill.	2720	13	H	1120	7	M	4220	16	H

enera& species	Glucose			Cellulose			50% Sucrose		
	ATC	NCI	OR	ATC	NCI	OR	ATC	NCI	OR
*E. nidulans*var. *lata*(Thom &Raper) Subram	520	2	R						
Eurotium							15180	19	H
*E. amstelodami*Mangin							7000	15	H
*E. chevalieri*Mangin							8180	18	H
*Fusariumoxysporum*Shelecht.	160	1	R	160	2	R			
*Humicolagrisea*Traaen				480	4	L			
Mucor	2980	12	M	3320	17	H	740	3	L
*M. circinelloides*Van Tieghem	640	3	L						
*M. hiemalis*Wehmer	1180	6	M						
*M. racemosus*Fresenius	1160	6	M	3320	17	H	740	3	L
Mycosphaerellatassiana(Albertini, Schweinitz) Ditmer ex Steudel	80	1	R				20	1	R
*Nectriahaem atococca*Berkeley, Brown	120	2	R						
*Papulasporaimmersa*Hotson				1020	3	L			
Penicillium	7560	16	H	7480	23	H	11280	16	H
*P. chrysogenum*Thom	7120	16	H	7400	23	H	11000	16	H
*P. citrinum*Thom							140	2	R
*P. puberulum*Bainier	440	3	L	80	2	R	140	3	L
Pomaglomerata(corda) Wollenweber, Hochapfel	100	2	R	260	3	L	60	1	R
Pleosporaherbarum(Fr.) Rabenh.exCes& de Not	240	2	R	720	4	L	420	2	R

enera& species	Glucose			Cellulose			50% Sucrose		
	ATC	NCI	OR	ATC	NCI	OR	ATC	NCI	OR
Rhizopusstolonifer(Ehrenb.) Lindt	120	1	R				200	1	R
*Scytalidiumlignicola*Pesante.	80	1	R	300	3	L	80	2	R
Stachybotryschartarum(Ehrenb. : Lindt) Hughes	360	2	R						
Sterile mycelia(White & dark color)	4620	11	M	2320	8	M	2720	11	M
Syncephalastrumracemosum(Cohn) Schroeter.	680	3	L				1060	2	R
Torulaherbarum(Pers.) Link				620	4	L	520	3	L
Ulocladium	720	2	L	660	4	L	400	1	R
U. alternariae(Cke) Simmons				240	2	R	400	1	R
U. botrytis Preuss	500	2	L	420	3	L			
U. chartarum(Preuss) Simmons	220	2	L						
Gross total count	37880			28820			61600		
Number of genera = 22	16			14			15		
Number of spcies = 35 + 2 var.	26+2 var.			20			23+1 var.		

ATC = Average total count (per day dry soil). ; NCI = Number of cases of isolation (out of 25) ; OR = Occurrence remarks: ;

H = High occurrence, from 13-25 (out of 25) ; M = Moderate occurrence, from 6-12 cases. ; L = Low occurrence, from 3-5 cases; R = Rare occurrence, from 1 or 2 cases

Table 3 :Average total count (calculated per g dry soil in very sample), number of cases of isolation (NCI, out of 25 cases) and occurrence remarks (OR) for fungal genera and species recovered from 25 saline soil samples on glucose, cellulose and 50% sucrose-Czapek's agar at 28°C (±2°C).

Genera & species	Glucose			Cellulose			50% Sucrose		
	ATC	NCI	OR	ATC	NCI	OR	ATC	NCI	OR
*Acremoniumstrictum*W. Gams	1160	7	M	800	4	L	120	2	R
Alternaria	1900	12	M	860	6	M	1260	13	H
A. alternata(Fries) Keissler	1900	12	M	860	6	M	1160	13	H
*A. raphani*Grooves, Skolko							100	2	R
Aspergillus	21620	25	H	10340	22	H	22340	25	H
*A. candidus*Link	80	1	R				140	3	L
A. flavus Link	10300	25	H	4580	19	H	8580	24	H
*A. fumigatus*Fresenius	380	2	R				20	1	R
*A. niger*Trieghern	5700	25	H	3700	16	H	10340	25	H
*A. ochraceus*Wilhelm	860	8	M	280	2	R	420	7	M
A. sydowii(Bainier. Sartory)	200	1	R	120	2	R			
A. terreus Thom	2220	10	M	1120	9	M	1700	10	M
*A. terreus*var. *aureus*Thom &Raper	680	3	L						
A. ustus(Bainier)	1200	9	M	540	3	L	1140	14	H

Genera & species	Glucose			Cellulose			50% Sucrose		
	ATC	NCI	OR	ATC	NCI	OR	ATC	NCI	OR
Thom. Tiraboschi									
*Botryotrichumatrogriseum*Van Beyma	360	3	L	220	2	R	80	3	L
Chaetomiumglobosum Kunze	100	1	R	1380	9	M			
Cladosporiumcladosporioides(Fres.) de Vries	240	2	R	280	3	L	380	2	R
*Cochliobolusspicifer*Nelson				280	2	R	180	2	R
Emericellanidulans(Eidam) Vuill.	3500	16	H	1260	8	M	2040	10	M
Eurotium							8300	25	H
*E. amstelodami*Mangin							1680	15	H
*E. chevalieri*Mangin							6340	25	H
*E. rubrum*Konig, Spiekermann. Bremer							280	9	M
Fusarium	1220	6	M	1500	7	M	680	3	L
F. dimerum(Corda) Sacc.				280	4	L			
*F. moniliforme*Sheldon	620	4	L				180	2	R
*F. oxysporum*Shelecht.	600	4	L	1220	6	M	500	2	R
Mucor	760	3	L	620	5	L	540	5	L
*M. hiemalis*Wehmer	340	3	L				320	4	L
*M. racemosus*Fresenius	420	2	R	620	5	L	220	2	R

Genera & species	Glucose			Cellulose			50% Sucrose		
	ATC	NCI	OR	ATC	NCI	OR	ATC	NCI	OR
Mycosphaerellatassiana(Albertini, Schweinitz) Ditmer ex Steudel	2760	15	H	2640	10	M	2140	10	M
*Nectriahaematococca*Berkeley, Brown	7420	22	H	5780	23	H	900	8	M
Penicillium	10200	20	H	7780	17	H	10960	22	H
*P. chrysogenum*Thom	9820	20	H	7100	17	H	10500	22	H
*P. citrinum*Thom	60	1	R						
*P. corylophilum*Dierckx				100	2	R	460	3	L
*P. duclauxi*Delacroix	40	1	R						
*P. puberulum*Bainier	280	2	R	580	3	L			
Phoma	40	1	R	200	1	R			
*P. humicola*Gilman & Abbott									
P. glomerata(corda) Wollenweber, Hochapfel	40	1	R	200	1	R			
Pleosporaherbarum(F) Rabenh.exCes& de Not.	500	4	L	780	4	L	100	2	R
Rhizopusstolonifer(Ehrenb.) Lindt	80	1	R	60	1	R	60	2	R

Genera & species	Glucose			Cellulose			50% Sucrose		
	ATC	NCI	OR	ATC	NCI	OR	ATC	NCI	OR
*Scytalidiumlignicola*Pesante.	2840	8	M	1400	2	R	780	4	L
Stachybotryschartarum (Ehrenb.: Lindt) Hughes	2500	11	M	6460	20	H	160	2	R
Sterile mycelia(White & dark color)	440	3	L	40	1	R	40	1	R
Torulaherbarum(Pers.) Link	600	1	R	100	1	R	1380	7	M
Ulocladium	100	2	R	180	3	L	80	1	R
U. botrytis Preuss	80	1	R	100	2	R			
U. chartarum(Preuss) Simmons	20	1	R	80	2	R	80	1	R
*U. tuberculatum*Simmons	80	1	R						
Gross total count	58340			42960			52520		
Number of genera = 21	19			20			19		
Number of spcies = 41 + 1 var.	32+1 var.			29			31		

ATC = Average total count (per g dry soil). NCI = Number of cases of isolation (out of 25);OR = Occurrence remarks: : H = High occurrence,from 13-25 (out of 25) ;M = Moderate occurrence, from 6-12 cases ;L = Low occurrence, from 3-5 cases ; R = Rare occurrence, from 1 or 2 cases.

Table 4 :Activity of carboxymethylcellulase (C_x) of different fungal speciesisolated on cellulose-Czapek's agar at 28°C.

Organisms	Diameter of clear zonn(mm)
Acremoniumstrictum	17M
Alternaria alternate	22H
Aspergillusflavus	24H
*A. flavus*var. *columnaris*	11W
A. fumigatus	21H
A. niger	18M
A. ochraceus	14W
A. sydowii	18M
A. terreus	13W
A. ustus	17M
Botryotric humatrogriseum	16M
Chaetomium globosum	27H
Cladosporium cladosporioides	20H
Cochliobolus hawaiiensis	13W
C. spicifer	14W
Emericellanidulans	18M
Fusariumdimerum	16M
F. oxysporum	21H
F. poae	18M
Gibberellaacuminata	17M
Humicolabrevis	13W
H. grisea	12W

Organisms	Diameter of clear zonn(mm)
Mucorcircinelloides	16M
M. racemosus	22H
Mycosphaerell atassiana	13W
Myrothecium verrucaria	14W
Nectriahaem atococca	15W
Papulas poraimmersa	20H
Penicillium chrysogenum	19M
P. corylophilum	17M
P. puberulum	18M
Phoma glomerata	18M
Pleospora herbarum	17M
Rhizopusstolonifer	24H
Scytalidiu mlignicola	12W
Setosphaeri arostrata	14W
Stachybotry schartarum	12W
Sterile mycelia (white)	22H
Torulaher barum	17M
Ulocladium alternaria	12W
U. botrytis	14W
U. chartarum	13W

Degree of Cx activity; high activity, H= from 20-28 mm; moderate activity, M= 16-19 mm; and weak activity, W= 11-15 mm