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Diversity of filamentous and yeast fungi in soil of citrus and grapevine plantations in the Assiut region, Egypt

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An extensive survey of soil mycobiota on citrus and grapevine plantations in Sahel-Saleem City, Assiut Governorate, Egypt was carried out using the dilution-plate method and 2 isolation media at 25 °C. Sixty-four genera and 195 species of filamentous fungi and 10 genera and 13 species of yeasts were recovered. A higher diversity (number of genera and species) and gross total counts were recovered from citrus than from grapevine soil.

The peak of filamentous fungi recovered from both soils was found to be in February. *Aspergillus* (45 species) was the most dominant genus; *A. ochraceus* predominated in citrus plantations, while *A. niger* and *A. aculeatus* in grapevine. The *Penicillium* count came second after *Aspergillus* in citrus (23 species) and after *Aspergillus* and *Fusarium* in grapevine (11 species). *Penicillium citrinum*, *P. ochrochloron* and *P. olsonii* were more common in citrus plantations, but they were replaced by *P. oxalicum* in grapevine soil. *Fusarium* (19 species) was represented in 88.9–100% of both soils on both media; *F. solani* predominated in both soils, while *F. incarnatum* came next in citrus, and *F. babinda* and *F. oxysporum* in grapevine. *Humicola* (3 species) with the dominant *H. fuscoatra* was recorded in 61.1–83.3% of soil of both plantations, while *Talaromyces* (with *T. purpureogenus* followed by *T. pinophilus* being the most common) was recorded in 83.3–100% on DRBC and 38.9–50% on DYM from the soil of plantations of both crops. *Volutella* (5 species) was common in citrus but missing from grapevine soil. The present study reveals that hyaline fungi predominated over dark-coloured ones.

Yeasts comprised only minor proportions in both soils (maximum 0.5%). They showed their peak in the soil of citrus plantations in April and in grapevine in February. All species were recovered in one or two samples only. *Diutina catenulata*, *Debaryomyces hansenii*, *Galactomyces* (3 species), *Hanseniaspora occidentalis*, *Kluyveromyces marxianus*, *Meyerozyma caribbica*, and *Schwanniomyces pseudopolymorphus* were encountered in citrus only, while *Cryptococcus laurentii*, *Pichia kudriavzevii*, *Meyerozyma guilliermondii* and *Rhodotorula* sp. in grapevine only. Physiological and growth characteristics were obtained for most of the recovered yeasts.

Key words: Mycobiota, biodiversity, phenotypic and biochemical characterisation, ITS sequence, *Coniochaeta canina*, *Aspergillus stella-maris*.

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Abdel-Sater M.A., Moubasher A.H., Soliman Z.S.M. (2016): Diverzita vláknitých hub a kvasinek v půdě citrusových a révových plantáží v Asijútské oblasti v Egyptě. – Czech Mycol. 68(2): 183–214.

Extenzivní průzkum půdní mykobioty na plantážích citrusů a vinné révy v okolí města Sahel-Saleem (Asijútský guvernorát, Egypt) byl proveden s využitím zřeďovací metody a izolace na dvou vybraných médiích při 25 °C. Touto cestou byly zjištěny celkem 64 rody se 195 druhy vláknitých hub a 10 rodů s 13 druhy kvasinek. Vyšší diverzita (počet rodů i druhů), jakož i vyšší četnost byla zjištěna v půdě z citrusových plantáží.

Vrcholný výskyt vláknitých hub byl zjištěn v únoru na obou typech plantáží. *Aspergillus* (45 druhů) je nejvíce zastoupeným rodem; *A. ochraceus* dominoval na citrusových plantážích, zatímco na révových převládaly *A. niger* a *A. aculeatus*. *Penicillium* je druhým nejpočetnějším rodem v půdě pod citrusy (23 druhy) a třetím pod révou (po *Aspergillus* a *Fusarium*, 11 druhů). *Penicillium citrinum*, *P. ochrochloron* a *P. olsonii* jsou běžné na plantážích citrusů; na révových je střídá *P. oxalicum*. *Fusarium* (19 druhů) bylo zastoupeno v 88.9–100 % vzorků z obou typů půd na obou médiích; v obou půdách dominovalo *Fusarium solani*, následované *F. incarnatum* pod citrusy a *F. babinda* s *F. oxysporum* pod révou. *Humicola* (3 druhy) s dominantním druhem *H. fuscoatra* byla zaznamenána v 61.1–83.3 % vzorků půd z obou plantáží. *Talaromyces* (nejběžnější *T. purpureogenus* následovaný *T. pinophilus*) byl zaznamenán v 83.3–100 % vzorků na DRBC, ale jen ve 38.9–50 % na DYM v půdách z plantáží obou plodin. *Volutella* (5 druhů) je běžná pod citrusy, ale chybí v půdě pod révou. Výsledky studie ukazují, že houby s hyalinními hyfami zde převládají nad tmavě zbarvenými.

Kvasinky mají jen malý podíl na mykobiotě obou půd (nejvýše 0,5 %). Pod citrusy se nejvíce vyskytují v dubnu, zatímco pod révou mají vrchol výskytu v únoru. Všechny druhy byly zjištěny jen v jednom nebo dvou vzorcích. *Diutina catenulata*, *Debaryomyces hansenii*, *Galactomyces* (3 druhy), *Hanseniaspora occidentalis*, *Kluyveromyces marxianus*, *Meyerozyma caribbica* a *Schwanniomyces pseudopolymorphus* byly zaznamenány jen v půdě citrusových plantáží, zatímco *Cryptococcus laurentii*, *Pichia kudriavzevii*, *Meyerozyma guilliermondii* a *Rhodotorula* sp. jen na révových plantážích. Pro většinu druhů kvasinek byly zjištěny jejich fyziologické a růstové charakteristiky.

INTRODUCTION

Soil fungi have been extensively studied in Egypt by Moubasher and his collaborators (1965–2016) and several other investigators (Sabet 1935, Ragab 1956, Besada & Yusuf 1968a, 1968b, Moubasher & Moustafa 1970, Moubasher & El-Dohlob 1970, 1972, Salama et al. 1971, Moubasher & Mazen 1972, Ali et al. 1975, Moubasher & Abdel-Hafez 1978a, 1978b, Moubasher 1993, 2010, Moubasher et al. 1971, 1985, 2013). During this period, extensive surveys were performed in the Assiut University laboratory and in different environments in Egypt. The achievements were very fruitful with regard to the unprecedented broad knowledge of fungi in Egypt, which culminated by the establishment of a large culture collection of fungi included into the Mycological Centre at this university.

According to the results, soil fungi show seasonal periodicities. The months with moderate temperatures are regularly the richest (in counts and species spectra), while the summer months are the poorest (Moubasher & El-Dohlob 1970, Moubasher & Abdel-Hafez 1978b). Naim (1967) isolated 17 genera and

44 species of fungi from soil under citrus trees, where the dominant genera were *Aspergillus*, *Penicillium*, *Alternaria* and *Cladosporium*. He identified five *Penicillium* species including *P. digitatum* and *P. italicum* as the dominants. Moubasher et al. (1971) found that the mycobiota of soil under five varieties of citrus was not specific, but almost similar to that in other Egyptian cultivated soils. The basic components here were *Aspergillus*, *Fusarium* and *Penicillium*. Sharma et al. (2011) studied microfungi in soil and decaying leaf litter of *Quercus serrata* in a climatically similar region in subtropical natural oak forest and managed plantation in Northeastern India.

Yeasts are widely distributed in nature. They have been found in soils of widely different texture, chemical composition, humidity, and pH value at various geographic locations and in diverse climatic conditions, in bare soils as well as in soils supporting natural vegetation or cultivated by man. In most cases, especially on agricultural land, the soil should be regarded more as a reservoir for yeasts from sources above it than as a specific habitat (Carmo-Sousa 1969). However in some instances there are many yeast species which are typical soil inhabitants and for which no obvious surface sources are known (Phaff et al. 1978). Haridy (2002) found that many yeast species to be dominants in rhizosphere and non-rhizosphere areas of many plants in Egypt.

The present work was designed to investigate the diversity and seasonal fluctuations of filamentous and yeast (for the first time in this laboratory) fungi in soil of two economically important plants, citrus (orange) and grapevine, in a 12-month experiment, employing two media of isolation [yeast extract and malt extract agar supplemented with dichloran (DYM) and dichloran rose Bengal chloramphenicol agar (DRBC)]. This paper follows the article concerning fungal diversity in the air of citrus and grapevine plantations in the studied area (Moubasher et al. 2016).

MATERIAL AND METHODS

Sampling location and collection of samples. This study was carried out in the town of Sahel-Saleem (also spelled as Sahel-Selim) approximately 25 km south-east of the city of Assiut. Sampling was conducted bimonthly over a twelve-month period from April 2008 to February 2009. Three different plantations of citrus in the suburbs of Sahel-Saleem and three of grapevine in the village of El-Khawaled (about 6 km east of the bank of the river Nile), northeast of Sahel-Saleem were selected.

A total of 36 soil samples were collected from non-rhizosphere areas of citrus and grapevine plantations (18 each). Soil samples were collected away from rhizosphere areas (soil particles attached to young roots). From each place at

least five samples were taken at random, which were then put into one composite sample which was mixed thoroughly several times. Each soil sample was put directly into a clean plastic bag. Samples were brought to the laboratory and kept at 5 °C until fungal analysis.

Determination of soil moisture content and pH. Soil samples for the moisture content and pH measurements were collected at the above-mentioned farms (three plantations of citrus and three of grapevine). Three replicates were performed at each sampling site and their means were calculated.

The soil moisture content was determined by drying the freshly collected samples in an oven at 105 °C until constant weight. The loss of weight was determined and then the percentage of moisture content was calculated.

To determine the pH in the soil samples, a sample extract was prepared by shaking a certain weight of the sample in a known volume of distilled water at a ratio of 1:5 (w/v) for about 30 min. and leaving the mixture overnight to settle. The extract was then filtered, centrifuged at 4000 rpm for 15 min. A pH meter (Orion Research Model GOHL Digital Ionalyzer, Cambridge, Massachusetts, USA) was used to determine the pH (Jackson 1958).

Isolation of soil fungi. The dilution-plate method was used for enumeration of different fungal species as described by Johnson & Curl (1972) and employed in the laboratory by Moubasher and his collaborators. The plates (5 plates for each type of medium) were incubated at 28 °C for 1–2 weeks, during which the developing fungi were counted and isolated, and the number of colony forming units (CFUs) was calculated per gramme of dry sample. Isolates were maintained on Yeast extract malt extract agar (for yeasts), and Czapek's agar and malt extract agar slants (for filamentous fungi) and stored at 5 °C until the identification was confirmed.

The total number of colony forming units (CFU) was calculated for all fungal taxa per gramme of dry soil in all 18 samples for each plantation type. The CFU percentage was calculated for each taxon per total number of CFUs in all samples. The frequency of occurrence was calculated from 18 samples in the case of both plantations; occurrence was rated as high, moderate, low and rare (see legend to Tab. 4).

Media used for isolation of fungi. Two media were used for isolation. Yeast extract malt extract agar (YM; Wickerham 1951) of the following composition was employed (g/l): yeast extract 3.0, malt extract 3.0, peptone 5.0, glucose 10.0, agar 20.0; chloramphenicol (250 mg/l) was used as a bacteriostatic agent. This medium was modified by the addition of 1 ml/l of 2 mg of dichloran dissolved in 10 ml ethanol (Moubasher et al. 2016) and designated as Dichloran yeast extract malt extract agar (DYM).

The other medium was Dichloran rose Bengal chloramphenicol agar (DRBC; King et al. 1979) of the following composition (g/l): peptone 5.0, potassium dihydrogen phosphate 1.0, magnesium sulphate 0.5, glucose 10.0, dichloran (20 µg/ml) and agar 15.0, in addition to which rose Bengal (25 µg/ml) and chloramphenicol (100 mg/l) were used as bacteriostatic agents (Smith & Dawson 1944, Al-Doory 1980).

These two media were found superior over four other media (YM of Wickerham 1951, glucose-Czapek's agar and cellulose-Czapek's agar both supplemented with rose Bengal and chloramphenicol, and Standard potato glucose agar supplemented with rose Bengal and 1% oxgall) used in the preliminary screening. However, zygomycetes prevailed on most of them, therefore just these two media were finally chosen since both contained dichloran, which restricts mucoraceous growth without affecting other species (King et al. 1979, Moubasher et al. 2016).

Identification of filamentous fungi. Identification of the genera and species was performed using morphological characteristics. The following references were used for identification of fungal genera and species (based on macro- and micromorphology using a Carl Zeiss, Axiostar Plus microscope, Microimaging GmbH, Göttingen, Germany, magnification up to 1000×): Raper & Fennell (1965), Rifai (1969), Ellis (1971, 1976), Pitt (1979), Sutton (1980), Moubasher (1993), Gams & Bissett (1998), Schroers (2001), Garcia et al. (2004), Leslie & Summerell (2006), Domsch et al. (2007), Samson & Varga (2007), Seifert et al. (2011), Samson et al. (2011, 2014), Salgado-Salazar et al. (2016).

Identification of yeasts. Morphological characters. Formation of pseudomycelium and true mycelium (Wickerham 1951) and the ability to form ascospores on three sporulation media (corn meal agar, potato glucose agar and yeast extract malt extract agar, YM, at 25 °C) were determined (Barnett et al. 2000).

Physiological characters. In addition to morphology, biochemical characteristics were obtained in the case of yeasts (Tab. 3). A fermentation test of sugars was performed and oxidative utilisation of carbon compounds was tested according to Barnett et al. (2000). The growth of yeast strains on nine nitrogen compounds (potassium nitrate, sodium nitrite, ethylamine-HCl, L-lysine-HCl, creatine, creatinine, D-glucosamine, imidazole, D-tryptophan) was also determined (Suh et al. 2008). Hydrolysis of urea, growth at high osmotic pressure, growth at different temperatures, growth in the presence of cycloheximide, diazonium blue B (DBB) and production of extracellular starch-like compounds were also performed.

Identification keys by Barnett et al. (2000) were employed to assign each isolate to species level. Confirmations of these identifications were carried out using molecular techniques.

Molecular methods. In suspected isolates, molecular techniques [internal transcribed spacer (ITS) sequences of nuclear ribosomal DNA amplified using primers ITS1, ITS4] were employed. The fungus was grown on CYA plates and incubated at 25 °C for 7 days (for filamentous isolates) and on YMA plates and incubated at 25 °C for 2 days (for yeast isolates). A small amount of fungal biomass was scraped off and suspended in 100 µl of distilled water and boiled at 100 °C for 15 minutes following the manufacturer's protocol (SolGent Company, Daejeon, South Korea). The samples were either directly sent for extraction and sequencing, or they were collected in a batch and stored at –70 °C before sending to Korea.

Fungal DNA was extracted and isolated using SolGent purification beads at this company. Internal transcribed spacer (ITS) sequences of nuclear ribosomal DNA were amplified using the universal primer ITS1 (5'- TCC GTA GGT GAA CCT GCG G -3'), and ITS4 (5'- TCC TCC GCT TAT TGA TAT GC -3'). Then amplification was performed using the polymerase chain reaction (PCR) (GeneAmp® PCR System 9700 thermal cycler, Applied Biosystems, Foster City, California, USA). The PCR reaction mixtures were prepared using SolGent EF-Taq as follows: 10X EF-Taq buffer 2.5 µl, 10 mM dNTP (T) 0.5 µl, primer (F-10p) 1.0 µl, primer (R-10p) 1.0 µl, EF-Taq (2.5 U) 0.25 µl, template 1.0 µl, DW up to 25 µl. Then the amplification was carried out using the following PCR reaction conditions: one round of amplification consisting of denaturation at 95 °C for 15 min. followed by 30 cycles of denaturation at 95 °C for 20 s, annealing at 50 °C for 40 s and extension at 72 °C for 1 min., with a final extension step of 72 °C for 5 min.

The PCR products were then purified with the SolGent PCR Purification Kit-Ultra (SolGent, Daejeon, South Korea) prior to sequencing. After that, the purified PCR products were reconfirmed (using size marker) by electrophoreses of the PCR products on 1% agarose gel. These bands were then eluted and sequenced. Each sample was sequenced in sense and antisense direction.

Contigs were created from the sequence data using the CLCBio Main Workbench program. The sequence obtained from each isolate was further analysed using BLAST from the National Center for Biotechnology Information (NCBI) website. Sequences obtained together with those retrieved from the GenBank database were subjected to the Clustal W analysis using MegAlign software version 5.05 (DNASTAR Inc., Madison, Wisconsin, USA) for the phylogenetic analysis (Thompson et al. 1994).

Representative strains of the species recovered are deposited at Assiut University Mycological Centre Culture Collection (AUMC). ITS gene sequences of the yeasts and some filamentous strains were deposited at the National Center for Biotechnology Information (NCBI) and accession numbers assigned to them (Tab. 2).

The nomenclature of particular species is mainly unified according to MycoBank (www.mycobank.org); in some cases the Index Fungorum (www.indexfungorum.org) has been used or the species names are based on current monographs (see above).

RESULTS AND DISCUSSION

OVERALL ASSESSMENT

Moisture content and pH of soil

The pH values of the soil samples investigated were on the alkaline side, ranging between 7.22–7.95 in citrus soil and 7.46–8.14 in grapevine soil. The moisture content ranged between 14.44–22.94% and 20.18–30.12% at the time of sampling (Tab. 1). The lowest pH value in the soil of both plantations was recorded in the month of February. The slight drop of the soil pH in February can be attributed to the diminution of urea fertiliser (pH ~ 8.73) applied for both plants four times from March till October.

Tab. 1. Mean moisture content (MC) and pH values of soil samples collected from citrus and grapevine plantations.

Month	Citrus plantations		Grapevine plantations	
	Mean MC	Mean pH	Mean MC	Mean pH
April 2008	15.97	7.91	24.34	7.98
June 2008	22.94	7.95	30.12	8.14
August 2008	17.96	7.81	20.18	8.04
October 2008	21.57	7.82	26.61	7.98
December 2008	14.44	7.82	24.44	8.09
February 2009	15.53	7.22	22.55	7.46

Fungi recovered from soil in citrus and grapevine plantations

A total of 208 species belonging to 74 genera of filamentous and yeast fungi were recovered from soil in both citrus and grapevine plantations (Tab. 2, 4). Filamentous fungi were represented by 64 genera and 195 species, while yeast fungi were represented by 10 genera and 13 species. A higher number of genera and species (56 genera and 152 species) were recovered from the soil of citrus plantations compared with those recovered from grapevine plantation soil (46 genera and 135 species).

Tab. 2. Assiut University Mycological Centre accession number (AUMC) of filamentous strains, ascomyceteous and basidiomyceteous yeast strains, and their isolation sources together with the closest matches from the GenBank database.

AUMC number	Isolation source	GenBank Accession number	Length (bp)	Closest GenBank match # ITS	Culture collection code	Sequencing similarity (%)	Species	References
Filamentous fungi								
5762	Soil of citrus	JQ425385	584	KM231781	CBS 100252	99	*Sarcopodium circinosetiferum*	Lombard et al. 2015
6717	Soil of citrus	JQ425406	554	FN907924 FN907949 FN907946	VI03589 VI04832 VI03611	98	*Aspergillus calidoustus*	Varga et al. 2008
6784	Soil of grapevine	JQ425383	590	AY681177	CBS 102191	99	*Gelasinospora bonaerensis*	Cai et al. 2006
7757	Soil of citrus	JQ425384	575	JX481775	CBS 133243^{T}	97	*Coniochaeta canina* (asexual stage: *Lecythophora canina*)	Troy et al. 2013
Ascomyceteous yeast strains								
7259	Soil of citrus	JQ425346	725	EF568057 GU256755	CBS 712 ATCC 60480	100	*Kluyveromyces marxianus*	Kang et al. 2010
7260	Soil of citrus	JQ425347	628	AJ586524 EF198011	CBS 2008^{T} WC43-3	100	*Schwanniomyces pseudopolymorphus* (≡ *Debaryomyces pseudopolymorphus*)	Martorell et al. 2005
7261	Soil of citrus	JQ425348	407	GU246267 AJ853765	CBS 565^{T} WM 6	99 100	*Diutina catenulata* (≡ *Candida catenulata*)	Groenewald & Smith 2010
7262	Soil of grapevine	JQ425359	864	HQ909093 HQ693782	KDLYC36-9 W63245-01	99 100	*Meyerozyma caribbica* (≡ *Pichia caribbica*)	Kurtzman & Suzuki 2010, Jensen & Arendrup 2011
7753	Soil of citrus	JQ083436	598	HQ909093 HQ693782	KDLYC36-9 W63245-01	99 100	*Meyerozyma caribbica*	Kurtzman & Suzuki 2010, Jensen & Arendrup 2011

AUMC number	Isolation source	GenBank Accession number	Length (bp)	Closest GenBank match # ITS	Culture collection code	Sequencing similarity (%)	Species	References
7759	Soil of citrus	JQ083435	715	HQ396523 GU256755	CHY 1612 ATCC 60480	100	*Kluyveromyces marxianus*	Kang et al. 2010
7751	Soil of citrus	JQ425358	632	EF643593 JQ425353	LN-3 AUMC 7263	100 100	*Debaryomyces hansenii*	Moubasher et al. 2016
7752	Soil of citrus	JQ425390	625	EF198011 AJ586524	WC43-3 CBS 2008^T	100	*Schwanniomyces pseudopolymorphus*	Martorell et al. 2005
7756	Soil of citrus	JQ425361	770	GU246267 AJ853765	CBS565^T WM 6	99 100	*Diutina catenulata*	Groenewald & Smith 2010
7758	Soil of citrus	JQ425357	750	EU541358 AJ973092 AJ512429	isolate 21* CBS 6783^T CBS 2592^T	100 99 97	*Hanseniaspora occidentalis* *Hanseniaspora occidentalis* var. *citrica* *Hanseniaspora occidentalis*	Cadez et al. 2003, 2006
7770	Soil of grapevine	JQ425391	501	FM199972 GU931323	H7S6K11 5B12	100	*Pichia kudriavzevii* (= *Issatchenkia orientalis*)	Daniel et al. 2009
Basidiomyceteous yeast strains								
7798	Soil of grapevine	JQ425403	547	FN561807 AF410468	SEG-8-9 CBS 139^T	99 98	*Cryptococcus laurentii*	Scorzetti et al. 2002
7799	Soil of grapevine	JQ425407	665	FN561807 AF410468	SEG-8-9 CBS 139^T	90 89	*Cryptococcus laurentii***	Scorzetti et al. 2002

* No special code was designated by the authors.
** The strain probably represents a species of the genus *Cryptococcus*, but the exact identification is somewhat doubtful due to rather low sequencing similarity.

DRBC supported regularly a higher total number of taxa (49 genera and 128 species in the soil of citrus plantations and 41 genera and 117 species in grapevine soil) than DYM (41 genera and 109 species in citrus plantations and 35 genera and 97 species in grapevine). The gross total counts of all fungi were also much higher in citrus plantations (25,542 and 29,530 CFU/g) than in grapevine plantations (16,572 and 17,549 CFU/g on DYM and DRBC, respectively) (Tab. 4).

The peaks of total number of propagules of filamentous fungi recovered from soil of both citrus and grapevine plantations were found to be in February on both isolation media, while their troughs were found in December and October on DYM and DRBC, respectively, in citrus plantations and in June in grapevine plantations on both media.

The widest spectrum of species recovered from the soil of citrus plantations was registered in February (48 species on DYM) and October (50 on DRBC), and from the soil of grapevine plantations in February (49 on DYM and 55 on DRBC), while the narrowest was recorded in June (35 on each medium) in citrus soil as well as in grapevine (23 and 24 on DYM and DRBC, respectively).

FILAMENTOUS FUNGI

Filamentous fungi dominate in the soil samples from both plantations. The soil of citrus and grapevine were similar in some highly encountered fungi on both isolation media (*Aspergillus*, *Penicillium*, *Fusarium* and *Humicola*), or on one medium (*Cladosporium*, *Mucor* and *Talaromyces*). *Aspergillus*, *Penicillium* and *Fusarium* were the most frequent genera.

Frequent genera

Aspergillus was represented by 45 species in the soil of both citrus and grapevine plantations (39 species in citrus soil and 28 in grapevine soil). *Aspergillus* had 37.01–41.59% of the total amount of CFU recovered from soil of the two plants. Its peak was recorded in February and its trough in April on both media in both plantations. In the soil of citrus plantations, *A. ochraceus* was the most common *Aspergillus* species, contributing with large numbers of propagules, but it was recovered in small numbers in grapevine soil despite its recovery in high and moderate frequencies on DYM and DRBC, respectively. On the other hand, *A. niger* and *A. aculeatus* were the most common species in the soil of grapevine plantations, causing high total counts of the genus. *Aspergillus niger* was also recorded in 72.2% and 83.3% of the samples on DYM and DRBC, respectively, in citrus soil but in small numbers, while *A. aculeatus* was rare on DRBC and absent on DYM. *Aspergillus calidoustus* was recorded in 66.7% and 77.8% of citrus soil samples on DYM and DRBC, respectively, but in 11.1% on DYM and 33.3% on

DRBC in grapevine soil. *Aspergillus heterothallicus*, *A. puniceus*, *A. ustus* and *A. versicolor* were recorded in 27.8%–61.1% of the samples from citrus soil while they were infrequent or absent in grapevine soil. *Aspergillus flavus* was isolated in 27.8% and 33.3% from the soil of citrus and grapevine plantations, respectively, on DYM and 11.1% in citrus soil and 16.7% in grapevine soil on DRBC. Seventeen species of *Aspergillus* were recorded from citrus soil only, while six species were isolated from grapevine only (Tab. 4).

Aspergillus was already earlier reported as the dominant genus from soil under citrus trees (Naim 1967, Moubasher et al. 1971). Species of section *Nigri* (the black aspergilli) are ubiquitous saprotrophs in soils around the world, particularly in tropical and subtropical regions (Raper & Fennell 1965, Moubasher 1993, Domsch et al. 2007, Sharma et al. 2011). *Aspergillus ochraceus* has a wide distribution in soil in Egypt (Moubasher & Moustafa 1970, Moubasher & Abdel-Hafez 1978a, Moubasher et al. 1985), Jordan (Moubasher et al. 1977, 1981), Kuwait (Moustafa & Al-Musallam 1975, Moustafa & Sharkas 1982, Halwagy et al. 1982), Qatar (Moubasher & Al-Subai 1987), Saudi Arabia (Abdel-Hafez 1981, 1982), Sudan (El-Amin & Abdalla 1980), and Syria (Abdel-Kader et al. 1983).

Some *Aspergillus* species commonly reported in the current study are well known to be toxigenic, such as the ochratoxin A-producing ones which have been isolated from grapes frequently, e.g. *A. carbonarius* (Battilani et al. 2003, Serra et al. 2003), or less frequently, e.g. *A. niger* and *A. ochraceus* (Serra et al. 2005), and have often been found associated with black rot of grapes (Logrieco et al. 2003). Aflatoxin-producing strains of *A. flavus* are also well documented (e.g. Logrieco et al. 2003, Ismail et al. 2016).

Aspergillus fumigatus was recovered from only one soil sample of a citrus and a grapevine plantation on DYM and from two samples of grapevine soil on DRBC. In Egypt, it had a moderate occurrence in soils sampled in the 1960s (Moubasher & Moustafa 1970), but was the second most frequent fungal species in the 1970s (Moubasher & Abdel-Hafez 1978b) and was recorded in high frequency in the 1980s (Moubasher et al. 1985), while it was recorded in low frequency in the present and other investigations accomplished in the 1990s and the 2010s (Moubasher 2010). The 1970s and 1980s saw the highest intensity of pesticide application in Egypt, which might have induced certain basic environmental conditions, hypothetically responsible for the remarkable abundance of this species during that period (Moubasher 2010).

Aspergillus stellatus was common in citrus but infrequent in grapevine plantations. This species was previously isolated from soil in Egypt (Moubasher & Abdel-Hafez 1978b) and Jordan (Moubasher et al. 1977). *Aspergillus stella-maris* (synonym: *Emericella stella-maris*) was previously recorded in Tunisia and Slovenia (Zalar et al. 2008), therefore our record in citrus plantations near Assiut is the third locality. In these plantations the species was previously recorded

from air (Moubasher et al. 2013), therefore the current record is the second one in this region.

Penicillium constituted about one-fourth of the total number of propagules in citrus soil (24.52–29.09%) but was low in counts (1.66–6.36%) of those recovered from grapevine soil. Its count peak was recorded in February and April on DYM and DRBC, respectively, in citrus soil and in February on both media in grapevine, while its trough was registered in October on both media in citrus soil and in April and June on DYM and DRBC, respectively, in grapevine.

Twenty-four species of *Penicillium* (23 species from citrus and 11 species from grapevine) were recorded from soil of both plantations. *Penicillium citrinum* was isolated in high or moderate frequency from citrus soil, while it was recorded in low frequency in grapevine soil. *Penicillium oxalicum* was isolated in high or moderate frequency from grapevine soil, while it was recorded in moderate frequency in citrus soil. *Penicillium ochrochloron* was isolated in moderate frequency on both media in citrus soil, contributing 9.02–13.76% to the total amount of CFU, but was recovered in small numbers and low frequency on DRBC from grapevine only. *Penicillium olsonii* was recorded in considerably large numbers and in moderate frequency on both media from citrus soil while it was missed in grapevine soil. Some species were recorded from soil of citrus plantations (13 species) only, while one species was recorded from grapevine only (Tab. 4).

Penicillium was the basic component of the soil mycobiota under five varieties of citrus (Moubasher et al. 1971). It is worth mentioning that *P. chrysogenum*, which was the most frequent species in Egyptian soils in previous records from soil in this laboratory, was rare in the present investigation. *Penicillium citrinum*, the most frequent species in citrus soil in the current study, was also present in tea soil in Barak Valley, Assam, India (Dutta et al. 2010).

Phytopathologically, *Penicillium* species are the incitants of serious plant diseases. For example *P. expansum* causes blue mould rot of apple and pear. *Penicillium italicum* and *P. digitatum* are the incitants of blue and green citrus rot, respectively. Several species also cause decay of grains and legumes during harvest, storage or transit, especially at temperatures slightly below normal and at moisture contents slightly above normal (Logrieco et al. 2003).

Talaromyces (represented by 9 species and one unidentified) was isolated in frequencies of 83.3–100% on DRBC and in 38.9–50% on DYM from soil samples under both plants. *Talaromyces purpurogenus* was isolated in high or moderate frequency contributing to relatively larger numbers of propagules in grapevine soil (3.11–4.03% of total amount of CFU) than those in citrus soil (0.19–0.45%). *Talaromyces pinophilus* was recorded in moderate frequency on DRBC from the soil of both plants. *Talaromyces brevicompactus* was isolated from citrus soil only, while several species were isolated from grapevine soil only (Tab. 4).

For comparison with this study, *T. stipitatus* was isolated from water, soil, and the bank of the Lake of Aswan High Dam (El-Hissy et al. 1990) and *T. islandicus* was isolated from tea soil in the Barak Valley, Assam, India (Dutta et al. 2010). Phytopathologically, *T. brevicompactus* was the most frequent pathogenic species in Madeira grapes (Logrieco et al. 2003).

Fusarium (19 species) showed relatively higher percentage counts in citrus soil (13.04–19.79%) than in grapevine (13.39–16.69%). Its peak was recorded in February and December in citrus soil on DYM and DRBC, respectively, and in April and August in grapevine soil, while its trough was registered in August on both media in citrus soil and in October and April in grapevine on DYM and DRBC, respectively. In the soil of both plants, *F. solani* was the most common *Fusarium* species, with higher percentage counts in citrus soil (8.47–9.85%) than in grapevine soil (3.84–5.54%). In citrus soil, *F. incarnatum* came second in frequency after *F. solani*, while it was isolated in high and moderate frequencies from grapevine soil. In grapevine soil, *F. babinda* and *F. oxysporum* occupied the second position after *F. solani*, as they were recorded in moderate frequencies on both media in citrus soil. Several species were isolated exclusively from grapevine soil (Tab. 4).

Fusarium was shown to be dominant in the soil under citrus plantations of Egypt (Moubasher et al. 1971), soil of a tea plantation area in Cachar District, Assam, India (Dutta et al. 2010) and in Brazilian semiarid soil (Maia & Gibertoni 2002). Sharma et al. (2011) also found that *F. solani* was ubiquitous in managed oak plantation soil, but was a summer-rainy species in forest soil in Northeastern India, while *F. incarnatum* was isolated during the winter season only, and *F. oxysporum* was one of the dominant soil colonisers. *Fusarium solani*, *F. oxysporum* and *F. moniliforme* (= *F. verticillioides*) were recorded in moderate occurrence in soil in Egypt (Moubasher & Abdel-Hafez 1978a); *F. solani* was also isolated from soil in Egypt (Moubasher & Moustafa 1970), Qatar (Moubasher & Al-Subai 1987), Kuwait (Moustafa & Al-Musallam 1975), Saudi Arabia (Abdel-Hafez 1981), Sudan (El-Amin & Abdalla 1980), and Syria (Abdel-Hafez et al. 1983, Abdel-Kader et al. 1983).

Phytopathologically, *Fusarium* species are the incitants of serious plant diseases, e.g. *Fusarium solani* is well documented as a pathogen of a number of legumes and other tropical plants; it is often associated with cankers and dieback problems of trees in the tropical regions (Nelson et al. 1983). In Egypt, *F. solani* f. sp. *fabae* causes damping-off, bulb root and wilt of *Vicia faba* (El-Helaly et al. 1966). *Fusarium incarnatum* has been reported to cause canker of walnut, pod and seed rot of beans, reduced seed germination and seedling growth of sorghum, corky dry rot of melons, and storage rot problems of bananas and other fruits (Leslie & Summerell 2006). *Fusarium* species are also well known to be toxigenic (Logrieco et al. 2003).

Humicola (3 species: *H. fuscoatra*, *H. grisea* and *Humicola* sp.) was recorded in 61.1–83.3% of soil samples of both citrus and grapevine plantations on DYM and DRBC. Its peak was recorded in February on both media in the soil of citrus plantations but in June and August on DYM and DRBC, respectively, in grapevine plantations. *Humicola fuscoatra* was more common than *H. grisea* in both plantations, while *Humicola* sp. was recorded in low frequency in citrus soil only. Both *H. fuscoatra* and *H. grisea* were previously reported from Egyptian soil (Moubasher 1993).

Cladosporium was isolated in frequencies of 50–61.1% from citrus soil samples on both media, but in grapevine soil it was recorded in frequencies of 27.8% and 61.1% on DYM and DRBC, respectively, although it showed smaller percentage counts in citrus soil (1.46–1.97%) than in grapevine (2.57–5.57 %). Its peak was recorded in February in the soil of both plants on both media, while its trough was registered in June on both media in citrus soil and in October and April in grapevine on DYM and on DRBC, respectively. In the soil of grapevine plantations, *C. cladosporioides* was isolated in moderate and high frequencies, having small percentages of the total amount of CFU in grapevine, while it was recorded in low and moderate frequencies in citrus, yielding lower percentage counts. *Cladosporium sphaerospermum* was recorded in moderate and high frequencies in the soil of citrus plantation on DYM and DRBC, respectively, but in grapevine soil it was isolated in low and moderate frequencies on DYM and DRBC, respectively. *Cladosporium herbarum* was isolated only from the soil of grapevine plantations.

In Egyptian soil, *Cladosporium* occupied the sixth position in frequency (Moubasher and Moustafa 1970) and was represented by two species (Moubasher & Mazen 1972). Naim (1967) found that *Cladosporium* was one of the dominant genera isolated from soil under citrus trees. The common species *C. cladosporioides* was isolated from soil of *Vigna sinensis*, Egypt (Abdel-Kader et al. 1983), soil at Wadi Bir-El-Ain, Eastern Desert, Egypt (Moubasher et al. 1985), and soil in Jordan (Moubasher et al. 1977, Mazen et al. 1980), Kuwait (Moustafa & Al-Musallam 1975, Moustafa & Sharkas 1982, Halwagy et al. 1982), Qatar (Moubasher & Al-Subai 1987), Saudi Arabia (Abdel-Hafez 1981, 1982, Abou-Heilah 1985), and Syria (Abdel-Hafez et al. 1983). This species was one of the dominant soil colonisers in Northeastern India (Sharma et al. 2011) and is the incitant of serious plant diseases, e.g. pod rot and blight of pea and southern pea (Agrios 2005).

Less frequent genera

Trichoderma (8 identified and 1 unidentified species) was recorded in frequencies of 61.1% on DRBC and 44.4% on DYM in the soil of citrus plantations but

in frequencies of 38.9% and 27.8% on DRBC and DYM, respectively, in grapevine plantations. The most common species, *T. harzianum* and *T. atroviride*, were isolated three times on DRBC and twice on DYM from both citrus and grapevine plantations, while other species were reported once or twice only from one or both soils. Of the species reported here, *T. koningii* and *T. viride* were previously isolated from Egyptian soil (Moubasher 1993) as well as from forest soil in Northeastern India (Sharma et al. 2011).

Volutella (5 species) was recovered in 55.6% and 33.3% on DRBC and DYM, respectively, from soil samples of citrus plantations but was absent in grapevine plantations. *Volutella ciliata* and *V. minima* were the most common species. It is worth mentioning that all species of *Volutella* recorded in the present study (Tab. 4) had not previously been recorded in Egypt.

Also, *Coniochaeta canina* (97% ITS similarity with the type strain), recovered in the current study once from citrus soil, is reported here as the second record after its original description by Troy et al. (2013).

Alternaria (2 species) was isolated in 33.3–38.9% of samples from grapevine soil, but in citrus soil it was recorded in 5.6% and 11.1% on DRBC and DYM, respectively. It showed relatively lower percentage counts in citrus soil than in grapevine soil. Its peak was recorded in February in the soil of grapevine on both media while it was recorded only in June on DYM and in December on DRBC in citrus soil. In the soil of both plantations, *A. alternata* was recorded on both media, in low frequency in citrus soil but in moderate frequency in grapevine soil, while *A. chlamydospora* was isolated on DYM from grapevine soil only.

Alternaria was isolated from the soil of a tea plantation in Assam, India (Dutta et al. 2010). *Alternaria alternata* was isolated from Egyptian soil (Moubasher & Moustafa 1970, Moubasher & Mazen 1972, Moubasher & El-Dohlob 1972, Moubasher & Abdel-Hafez 1978a, 1978b), soil at Wadi Bir-El-Ain, Eastern Desert, Egypt (Moubasher et al. 1985), and soil in Jordan (Moubasher et al. 1977, Mazen et al. 1980), Kuwait (Moustafa & Al-Musallam 1975, Moustafa & Sharkas 1982, Halwagy et al. 1982), Libya (Naim 1967), Qatar (Moubasher & Al-Subai 1987), Saudi Arabia (Abdel-Hafez 1981, 1982, Abou-Heilah 1985), and Syria (Abdel-Hafez et al. 1983), as well as forest soil in Northeastern India in the summer-rainy seasons (Sharma et al. 2011).

Phytopathologically, *A. alternata* is the incitant of serious plant diseases, e.g. black rot of citrus (Logrieco et al. 2003) and *Alternaria* brown spot of mandarin (Dewdney 2016).

The zygomycetous fungi *Mucor* (*M. circinelloides*, *M. hiemalis*), *Rhizopus* (*R. oryzae*), *Mortierella* (*M. alpina*) and *Absidia* (*A. cylindrospora*, *A. glauca*, and *Absidia* sp.) were all recovered from soil of both plantations. *Mucor circinelloides*, *M. hiemalis* and *Absidia corymbifera* were previously recorded in soil in Egypt (Moubasher 1993).

On the other hand, *Myrothecium* (2 species) and *Clonostachys* (4 species) were recorded in frequencies of 55.6–77.8% in soil of grapevine plantations but in frequencies of 5.6–44.4% in soil of citrus plantations. *Myrothecium verrucaria* was the most common species in both plantations, followed by *M. roridum*. *Clonostachys rosea* was the most prevalent species of this genus. Of the species recorded here, *M. verrucaria*, *M. roridum* and *C. rosea* (≡ *Gliocladium roseum*) were previously isolated from Egyptian soil (Moubasher 1993). *Clonostachys rosea* f. *catenulata* was also reported from a managed oak plantation and natural oak forest soils in Northeastern India, a region climatically similar to Egypt (Sharma et al. 2011).

Setosphaeria (*S. rostrata*) was isolated from 5.6–27.8% of the samples from soil of grapevine plantations only. *Pleospora* (*P. allii* and *P. tarda*, sexual states of *Stemphylium vesicarium* and *S. botryosum*, respectively) was isolated in low frequency from grapevine soil and rarely from citrus soil. *Pleospora tarda* was more frequent in grapevine than *P. allii*. *Setosphaeria rostrata* and *P. tarda* were isolated from soil in Egypt (Moubasher & Mazen 1972, Moubasher & Abdel-Hafez 1978a, 1978b), and soil in citrus plantations in Upper Egypt (Moubasher et al. 1971).

Sarocladium (*S. strictum* and *S. kiliense*) and *Botryotrichum* sp. were infrequently recorded from both soils. On the other hand, *Scopulariopsis* (*S. japonicum* and *S. brumptii*), *Colletotrichum* (*C. dematium* and *Colletotrichum* sp.), *Purpureocillium lilacinum* (≡ *Paecillium lilacinum*), *Sarcopodium* (*S. circinosetiferum*) and *Tritirachium* (*T. oryzae*) were recovered from citrus soil only. *Purpureocillium lilacinum* had a low frequency in soil in Egypt (Moubasher & Moustafa 1970, Moubasher & Abdel-Hafez 1978b). *Tritirachium oryzae* was isolated from air dust at the Kharga oasis, Western Desert, Egypt (Ismail 1990).

Phoma (4 identified and 1 unidentified species) was isolated from 11.1% of samples from the soil of both plantations, with *P. epicoccina* and *P. leveillei* being found in both plantations, *P. eupyrena* found in grapevine plantations, and *P. putaminum* and *Phoma* sp. from citrus plantations only. Species of *Phoma*, namely *P. glomerata* and *P. herbarum*, were previously recorded from Egyptian soil (Moubasher 1993).

Beltrania (*B. querna*) was more common in citrus plantations than in grapevine plantations. It was recovered in low frequency from citrus soil, and rarely from soil of grapevine plantations.

Gliocladium (*G. penicillioides*, *G. solani*) was more frequent in the soil of grapevine than citrus plantations. *Gliocladium solani* was isolated from both plantations, while *G. penicillioides* was isolated from grapevine plantations only.

Rich occurrence of *Beauveria bassiana* was observed in grapevine soil (15.39% of total number of propagules on DYM and 11.42% on DRBC) contrary to its poor count (0.59%) in citrus soil on DRBC only. *Beauveria bassiana* is a widely

distributed parasite of insects, and dead insects (colonised by this fungus) may serve as a source of spores. It is possible that some insect source (with massive sporulation) occurred at the two sites, and subsequently a large amount of propagules appeared in the samples.

Scolecobasidium (*S. constrictum* and *S. tshawytschae*) was recovered from soil of both plantations. It has a worldwide distribution since it was also isolated from soil in the USA (Miller et al. 1957), Canada (Barron & Busch 1962), India (Subramanian 1971), Japan and South Africa (Domsch et al. 2007).

Comparison of the communities

Generally, of filamentous fungi, the genera *Aspergillus* and *Fusarium* were the most dominant in both soils. *Humicola* and above all *Penicillium* had distinctly higher frequencies in citrus soil; *Volutella* was also recorded as a dominant but only from citrus soil, while *Alternaria*, *Cladosporium*, *Clonostachys*, *Myrothecium*, *Rhizopus*, *Scolecobasidium* (absent in citrus), *Talaromyces* and *Beauveria bassiana* were more dominant in grapevine soil.

Despite the preferences of the latter genera, the total number of species as well as the total occurrence was higher in citrus soil (see above). This diversity pattern in fungi and their dominance may be attributed to citrus plants having the advantage of being taller with dense evergreen foliage, which may have a more positive effect on the environments around it than in grapevine plantations.

Concerning a comparison of air and soil mycobiota, Moubasher (1995, 2010) adopted the hypothesis that fungal spores are dislodged from soil by air currents. A part of them remains suspended in the air, while others alight or are sedimented on the vegetation surface, where a new substrate or niche is initiated. The conditions in this niche are substantially different from those in soil. Competition for the colonisation of this substrate is less strong. Atmospheric conditions are more drastic, and a high light intensity and strong diurnal fluctuations of temperature and humidity occur here. Consequently, the mycobiota developing in this niche have a basically different pattern from those of soils. The dark-coloured fungi, i.e. the melanin-containing ones, predominate over the hyaline ones, in contrast to the pattern in the soil. This hypothesis may explain the predominance of hyaline fungi (e.g. *Penicillium*, *Aspergillus* and *Fusarium*) in soil of both plantations over dark-coloured ones (e.g. *Cladosporium*, *Alternaria*, *Humicola* and *Setosphaeria*).

Eleven species and 2 unidentified taxa belonging to 10 yeast genera were recovered from the soil of both plantations (9 species belonging to 7 genera from citrus and 4 species related to 4 genera from grapevine, see Tab. 4). Physiological and growth characteristics of most yeast species are presented in Tab. 3.

Both soils were poor in yeasts. They had low percentage counts in grapevine soil (0.15% and 0.21% of total amount of CFU on DYM and DRBC, respectively) and citrus soil (0.47% and 0.49%, respectively). Yeast fungi showed their peak of total number of propagules in soil of citrus plantations in April and in grapevine plantations in February on both media. Their trough occurred in June and October on DYM and in August on DRBC in soil of citrus plantations, and in April and December on DYM and in October and December on DRBC in grapevine plantations.

Diutina catenulata (≡ *Candida catenulata*) was recorded in 5.6% of the samples of citrus soil on both media, possessing minute percentage counts (0.02–0.04% of total amount of CFU). It was not recorded from grapevine soil. Concerning these yeasts, five *Candida* species were recovered from soil at different sites in the Zagazig area, Egypt (El-Sherbeny 1987). *Candida* sp. was present in soil of tea plantation areas in the Barak Valley, Assam, India (Dutta et al. 2010), and *C. parapsilosis* and *Candida* spp. were isolated from soil in the Brazilian Amazon Basin (Mok et al. 1984).

Meyerozyma was encountered in frequencies of 5.6–11.1% in grapevine soil on both media, represented by *M. guilliermondii* (≡ *Pichia guilliermondii*), and in 11.1% on DRBC in citrus soil only, represented by *M. caribbica* (≡ *P. caribbica*). *Meyerozyma guilliermondii* was isolated from soil in the Brazilian Amazon Basin (Mok et al. 1984).

Pichia kudriavzevii was isolated from grapevine in a frequency of 5.6% on DRBC only, but was not recorded from citrus soil. On the other hand, *Kluyveromyces* (represented by *K. marxianus*, sexual stage of *Candida kefyr)* was recorded in citrus soil in low frequency on DYM, but was absent from grapevine soil. *Kluyveromyces marxianus* was the dominant species in soil under potato, maize, and cabbage plants in the town of El-Minia, Egypt (Haridy 2002).

Cryptococcus was recorded in grapevine soil only in 5.6% and 11.1% of the samples on DRBC and DYM, respectively, represented by *C. laurentii*, showing minute percentage counts (0.03–0.07% of total amount of CFU). In previous studies, *C. laurentii* and *C. albidus* were prevalent in soil in Egypt (Monib et al. 1982, Haridy 2002), and four species of this genus were recovered from soil at different sites in the Zagazig area, Egypt (El-Sherbeny 1987). In the world, *Cryptococcus* species were the most common yeast species identified in the soil of the Dry Valley and in soils surrounding the historic huts of the Ross Sea region in Antarctica

(Arenz et al. 2006), in soil of polar deserts in South Victoria Land, Antarctica (Connell et al. 2008), and *C. albidus* was isolated from the soil of a garden at the Karachi University campus, Pakistan (Mushtaq et al. 2004). The isolation of *Cryptococcus* species from different habitats and environments reveals its widespread distribution (see also Barnett et al. 2000).

Schwanniomyces pseudopolymorphus and *Debaryomyces hansenii* were recorded in 5.5–16.7% on DRBC and DYM, respectively, from citrus soil only, with small percentage counts (0.07% and 0.31% of total amount of CFU on DYM, and 0.12% and 0.08% on DRBC, respectively). *Debaryomyces hansenii* has a widespread distribution, since it was isolated from soil of a cultivated wheat field and a garden at the Karachi University campus, Pakistan (Mushtaq et al. 2004), soil in the Zagazig area, Egypt (El-Sherbeny 1987) and soil in South Victoria Land, Antarctica (Connell et al. 2008).

Galactomyces was encountered only in citrus soil in 11.1–16.7% of total samples, constituting 0.05–0.16% of the total amount of CFU. *Galactomyces candidum* was recorded on DYM and *G. citri-aurantii* was recovered on DRBC, while *Galactomyces* sp. was recorded on both media.

Hanseniaspora occidentalis was identified only in one sample of citrus soil on DRBC, while an unidentified species of *Rhodotorula* was isolated from 2 samples of grapevine soil on DRBC only. *Rhodotorula glutinis* and *R. mucilaginosa* were previously recorded predominantly in soil in Egypt (Monib et al. 1982, El-Sherbeny 1987, Haridy 2002), the latter species also in South Victoria Land, Antarctica (Connell et al. 2008). The isolation of *Rhodotorula* species from different habitats and environments reveals its cosmopolitan occurrence.

Tab. 3. Physiological comparison of strains of the recorded yeast (and one filamentous) species tested.
Filamentous species: 1 – *Coniochaeta canina* AUMC 7757.
Ascomycete yeast species: 2 – *Diutina catenulata* AUMC 7756, 3 – *Galactomyces* sp. AUMC 7749, 4 – *Debaryomyces hansenii* AUMC 7751, 5 – *Schwanniomyces pseudopolymorphus* AUMC 7752, 6 – *Hanseniaspora occidentalis* AUMC 7758, 7 – *Pichia kudriavzevii* (= *Issatchenkia orientalis*) AUMC 7770, 8 – *Kluyveromyces marxianus* AUMC 7759, 9 – *Meyerozyma caribbica* (≡ *Pichia caribbica*, asexual stage: *Candida fermentati*) AUMC 7753.
Basidiomycete yeast species: 10 – *Cryptococcus laurentii* AUMC 7798, 11 – *C. laurentii* AUMC 7799 (see the note below Tab. 2).
Symbols: + – growth, w – weak growth, d – delayed growth, - – no growth; gap – not tested.

Species no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Fermentation of sugars											
D-glucose	-	+	-	-	+	+	+	+	+	-	-
D-galactose	-	+	-	-	-	-	-	+	d	-	-
Maltose	-	+	-	-	-	-	-	-	-	-	-

Species no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Sucrose	-	+	-	-	+	-	-	+	+	-	-
Melibiose	-	d	-	-	-	-	-	-	-	-	-
Lactose	-	+	-	-	-	-	-	-	-	-	-
Cellobiose	-	d	-	-	-	-	-	-	-	-	-
Raffinose	-	+	-	-	d	-	-	+	+	-	-
Inulin	-	-	-	-	-	-	-	+	d	-	-
Assimilation of carbon compounds											
D-glucose	+	+	+	+	+	+	+	+	+	+	+
D-galactose	+	+	+	+	+	-	-	+	+	+	+
L-sorbose	d	-/w	+	+	+	-	-	w	d	-	-
D-ribose	d	+	d	+	+	d	-	+	+	+	+
D-xylose	+	+	+	+	+	+	d	+	+	+	+
L-arabinose	+	+	d	+	+	+	-	+	+	+	+
L-rhamnose	+	+	d	+	+	+	-	-	d	d	+
Sucrose	+	+	+	+	+	-	+	+	+	+	+
Maltose	+	+	+	+	+	-	+	+	+	+	+
α,α-trehalose	+	+	d	+	+	-	-	d	+	+	+
Methyl-α-D-glucoside	+	-	+	+	+	-	-	-	+	+	+
Cellobiose	+	-	+	+	+	+	-	d	+	+	+
Salicin					+	+	-	+	+		
Arbutin					+	+	-	+	+		
Lactose	d	+	-	+	+	-	-	+	-	+	+
Raffinose	d	+	+	+	+	d	-	+	+	+	+
Melezitose	+	-	+	+	+	-	-	-	+	+	+
Inulin	-	-	d	d	d	-	-	+	+	+	+
Soluble starch	+	+	+	+	+	d	d	+	d	+	+
Glycerol					+	d	+	+	+		
Meso-erythritol	+	-	+	+	+	-	-	-	-	+	+
Xylitol					+	-		+	+		
D-glucitol	+	+	+	+	+	-	-	+	+	-	d
D-mannitol	+	+	+	+	+	-	-	d	+	+	+
Galactitol	-	-	d	d	+	-/w	-	-	d	+	+
Myo-inositol	+	-	-	-	-	-	+	-	-	+	+
Glucono-d-lactone	+	+	+	+	+	d	d	w	d	+	+
D-glucuronate	+	+	d	+	-	-	-	-	-	+	+
D-galacturonate	d	-	+	w	-	-	-	d	-	d	+
Succinate					+	-	+	d	+		
Citrate	+		+	+	+	-	d	+	+	+	+
Methanol	-	-	-	-	w	-	-	w	w	-	-
Ethanol	d	+	+	+	+	-	+	+	+	+	+

Species no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Propane-1,2-diol	d		-	-	-	+	-	-	-	-	-
Butane-2,3-diol	d		+	-	-	-	-	+	d	-	-
Quinic acid	+	-	+	+	+	-	-	-	-	-	-
Utilisation of nitrogen compounds											
Potassium nitrate	+	-	-	-	-	-	-	-	-	-	-
Sodium nitrite	+	-	-	-	+	-	-	-	-	-	-
Ethylamine-HCl	w	-	+	+	+	w	+	+	+	+	+
L-lysine-HCl	-	+	+	+	+	+	+	+	+	+	+
Creatine	-	-	+	+	-	-	-	-	-	-	-
Creatinine	-	-	+	+	-	-	-	-	-	-	-
D-glucosamine	-	-	-	-	+	-	-	w	+	+	+
Imidazole	-	-	-	-	-	-	-	-	-	-	-
D-tryptophan	w	-	+	-	-	-	-	-	-	-	+
Miscellaneous											
0.01% cycloheximide	d	-	+	+	+	+	-	+	+	d	d
0.1% cycloheximide	d	-	+	+	+	+	-	+	+	d	d
50% D-glucose	-	+	+	+	+	-	-	+	+	-	+
60% D-glucose	-	-	+	+	+	-	-	-	+	-	+
10% NaCl	-	+	+	+	+	-	-	-	+		
16% NaCl	-	-	-	+	-	-	-	-	-	-	-
Starch formation	+	-	-	-	-	-	-	-	-	+	+
Urea hydrolysis	+	-	-	-	-	-	-	-	-	+	+
Diazonium blue B	-	-	-	-	-	-	-	-	-	+	+
Growth characteristics											
Growth at 30 °C	+	+	+	+	+	+	+	+	+	+	+
Growth at 37 °C	+	+	+	+	-	-	+	+	+	+	+
Growth at 42 °C	+	-	-	-	-	-	+	+	+	-	-
Growth at 45 °C	-	-	-	-	-	-	+	+	-	-	-
Pink colony	-	-	-	-	-	-	-	-	-	-	-
Budding	+	+	-	+	+	+	+	+	+	+	+
Lemon-shaped cells	-	-	-	-	-	+	-	-	-	-	-
Budding on stalk	-	-	-	-	-	-	-	-	-	-	-
Splitting cells	-	-	+	-	-	-	-	-	-	-	-
Filamentous hyphae	+	-	+	-	-	-	+	-	-	-	-
Pseudohyphae	-	+	-	+	-	-	-	-	+	-	-
Septate hyphae	-	+	+	-	-	-	-	-	-	-	-
Arthroconidia	-	-	+	-	-	-	-	-	-	-	-
Ballistoconidia	-	-	-	-	-	-	-	-	-	-	-
Ascosporogenesis	-	-	-	-	+	-	-	-	-	-	-
Ascospores round	-	-	-	-	+	-	-	-	-	-	-

Fermentation of Me-α-D glucoside, α,α-trehalose, melezitose, starch and D-xylose gave negative results with all species tested and were omitted from the table.

Tab. 4. Collective data of counts, percentage counts of total amount of colony forming units (CFU) and frequency of occurrence of fungi from soil of citrus and grapevine plantations on DYM and DRBC agar media, recovered bimonthly during the period of April 2008 to February 2009 (counts of CFU calculated per gramme of soil in each sample, collectively in 18 samples in each plantation).
F = Frequency of occurrence out of 18 samples in the case of citrus and grapevine.
O = Occurrence remarks: H – high, 9–18; M – moderate, 5–8; L – low, 3–4; R – rare, 1–2 samples.

Taxa	Citrus soil				Grapevine soil			
	DYM		DRBC		DYM		DRBC	
	%CFU	F&O	%CFU	F&O	%CFU	F&O	%CFU	F&O
Filamentous fungi	99.53	18 H	99.51	18 H	99.85	18 H	99.79	18 H
Absidia Tiegh.	0.66	6 M	0.65	6 M	0.04	1 R	0.07	2 R
A. cylindrospora Hagem	0.66	6 M	0.65	6 M	0.04	1 R	0.03	1 R
Alternaria Nees: Fr.	0.23	2 R	0.02	1 R	0.79	7 M	0.85	6 M
A. alternata (Fr.) Keissl.	0.23	2 R	0.02	1 R	0.69	6 M	0.85	6 M
A. chlamydospora Mouch.					0.11	3 L		
Arthrinium sacchari (Speg.) M.B. Ellis	0.16	1 R	0.02	1 R				
Aspergillus P. Micheli ex Haller	37.43	18 H	41.59	18 H	37.01	18 H	39.35	18 H
A. aculeatinus Noonim, Frisvad, Varga & Samson	0.02	1 R	0.04	2 R	3.91	7 M	5.85	7 M
A. aculeatus Iizuka			0.02	1 R	11.77	17 H	8.44	14 H
A. brasiliensis Varga, Frisvad & Samson	0.45	7 M	0.73	7 M	1.59	6 M	1.88	8 M
A. bridgeri M. Chr.	0.09	1 R	0.16	2 R				
A. calidoustus Varga, Houbraken & Samson	1.99	12 H	3.84	14 H	0.11	2 R	0.38	6 M
A. candidus Link	0.14	1 R	0.18	1 R				
A. carbonarius (Bainier) Thom					0.54	1 R	0.07	1 R
A. costaricensis Samson & Frisvad	0.05	1 R	0.08	2 R	0.11	2 R	0.38	2 R
A. flavipes (Bainier & Sartory) Thom & Church	0.82	3 L	0.47	5 M	0.14	2 R	0.07	2 R
A. flavus Link	0.16	5 M	0.08	2 R	0.22	6 M	0.10	3 L
A. fumigatus Fresen.	0.07	1 R			0.07	1 R	0.07	2 R
A. granulosus Raper & Thom	1.29	1 R	0.26	2 R				
A. heterothallicus Kwon-Chung, Fennell & Raper	2.33	5 M	1.85	10 H				
A. nidulans (Eidam) G. Winter	0.21	2 R	0.06	1 R				
A. niger Tiegh.	2.72	13 H	2.54	15 H	13.29	12 H	14.53	18 H
A. ochraceus K. Wilh.	18.60	16 H	22.18	18 H	1.85	9 H	1.91	8 M
A. panamaensis Raper & Thom	0.12	1 R	0.04	1 R				
A. pseudodeflectus Samson & Mouch.	0.26	3 L	1.22	5 M			0.07	1 R
A. puniceus Kwon-Chung & Fennell	3.03	6 M	2.09	11 H	0.04	1 R	0.07	2 R
A. robustus M. Chr. & Raper	0.33	4 L	1.06	5 M				
A. sclerotiicarbonarius Noonim, Frisvad, Varga & Samson	0.05	1 R			0.36	2 R	0.89	1 R
A. sclerotiorum G.A. Huber	0.07	2 R			0.04	1 R	0.17	2 R
A. spelunceus Raper & Fennell	0.33	1 R	0.08	2 R				
A. stellatus Curzi	0.66	8 M	1.14	7 M	0.18	3 L	0.03	1 R
A. sulphureus (Fresen.) Wehmer			0.24	1 R			0.10	1 R
A. sydowii (Bainier & Sartory) Thom & Church			0.04	2 R	0.29	3 L	0.89	4 L
A. terreus Thom			0.06	3 L	0.18	3 L	0.68	6 M

Taxa	Citrus soil				Grapevine soil			
	DYM		DRBC		DYM		DRBC	
	%CFU	F&O	%CFU	F&O	%CFU	F&O	%CFU	F&O
A. tubingensis Mosseray	0.52	2 R	0.68	2 R	1.01	3 L	1.47	3 L
A. ustus (Bainier) Thom & Church	1.10	9 H	1.02	8 M	0.14	3 L	0.21	2 R
A. versicolor (Vuill.) Tirab.	1.86	7 M	1.12	10 H	0.04	1 R	0.03	1 R
Aspergillus spp.			0.06	1 R	1.05	6 M	0.34	5 M
Beauveria bassiana (Bals.-Criv.) Vuill.			0.59	2 R	15.39	2 R	11.42	2 R
Beltrania querna Harkn.	0.19	4 L	0.04	2 R	0.04	1 R		
Bisifusarium dimerum (Penzig) L. Lombard & Crous			0.18	2 R	0.43	6 M	0.48	7 M
Botryotrichum sp.	0.21	4 L	0.59	2 R			0.58	3 L
Chuppia sarcinifera Deighton	0.02	1 R	0.04	1 R				
Circinella muscae (Sorokin) Berl. & De Toni	0.02	1 R	0.02	1 R				
Cladosporium Link	1.46	9 H	1.97	11 H	2.57	5 M	5.57	11 H
C. cladosporioides (Fresen.) G.A. de Vries	0.21	3 L	0.71	7 M	1.96	5 M	2.49	9 H
C. oxysporum Berk. & M.A. Curtis	0.05	2 R	0.06	3 L	0.11	2 R	0.07	2 R
C. sphaerospermum Penz.	1.19	7 M	1.19	9 H	0.51	3 L	2.94	6 M
Clonostachys Corda	0.14	1 R	0.20	3 L	2.72	14 H	3.45	13 H
C. chlorina Schroers					0.54	5 M	0.62	6 M
C. compactiuscula (Sacc.) D. Hawksw. & W. Gams	0.02	1 R	0.18	2 R			0.07	2 R
C. rosea (Link) Schroers, Samuels, Seifert & W. Gams	0.12	1 R	0.02	1 R	2.17	9 H	2.59	11 H
Coccinonectria pachysandricola (B.O. Dodge) L. Lombard & Crous	0.33	1 R	0.02	1 R				
Cochliobolus Drechsler	0.05	1 R	0.08	1 R			0.17	2 R
C. lunatus R.R. Nelson & F.A. Haasis	0.05	1 R	0.08	1 R			0.14	1 R
Colletotrichum dematium (Pers.) Grove	0.07	2 R	0.08	2 R				
Curvularia clavata B.L. Jain					0.25	5 M	0.03	1 R
Cylindrocladiella parva (P.J. Anderson) Boesew.	0.12	2 R	0.10	3 L				
Fusarium Link	19.79	18 H	13.04	18 H	16.69	18 H	13.39	18 H
F. babinda Summerell, C.A. Rugg & L.W. Burgess	0.79	6 M	0.39	7 M	2.75	13 H	1.95	10 H
F. chlamydosporum Wollenw. & Reinking					0.22	3 L	0.82	6 M
F. circinatum Nirenberg & O'Donnell					0.18	3 L	0.27	2 R
F. concolor Reinking	1.41	8 M	0.51	7 M	0.25	1 R		
F. equiseti (Corda) Sacc.	0.42	5 M	0.39	4 L	0.22	3 L	0.07	2 R
F. incarnatum (Roberge) Sacc.	4.72	15 H	2.24	14 H	2.86	10 H	1.33	8 M
F. konzum Zeller, Summerell & J.F. Leslie	0.02	1 R			1.45	8 M	0.31	2 R
F. lactis Pirotta & Riboni					0.11	2 R	0.07	2 R
F. nygamai L.W. Burgess & Trimboli					0.29	3 L	0.07	1 R
F. oxysporum Schltdl.	0.52	8 M	0.45	8 M	2.93	16 H	2.29	11 H
F. proliferatum (Matsush.) Nirenberg	0.02	1 R	0.04	2 R	0.36	1 R	0.07	1 R
F. scirpi Lambotte & Fautrey					0.43	4 L		
F. solani (Mart.) Sacc.	9.85	18 H	8.47	18 H	3.84	16 H	5.54	18 H
F. subglutinans (Wollenw. & Reinking) P.E. Nelson, Toussoun & Marasas	1.97	7 M	0.57	5 M	0.51	5 M	0.38	5 M

Taxa	Citrus soil				Grapevine soil			
	DYM		DRBC		DYM		DRBC	
	%CFU	F&O	%CFU	F&O	%CFU	F&O	%CFU	F&O
F. verticillioides (Sacc.) Nirenberg	0.07	1 R			0.22	2 R	0.17	1 R
Gliocladium Corda			0.02	1 R	0.62	5 M	0.34	2 R
G. penicillioides Corda					0.18	2 R	0.34	2 R
G. solani (Harting) Petch			0.02	1 R	0.43	4 L		
Humicola Traaen	6.06	14 H	3.69	15 H	3.19	14 H	2.12	11 H
H. fuscoatra Traaen	5.97	14 H	3.45	15 H	3.04	14 H	2.02	11 H
H. grisea Traaen	0.07	2 R	0.22	3 L	0.14	1 R	0.10	1 R
H. insolens Cooney & R. Emers.	0.02	1 R	0.02	1 R				
Lecanicillium W. Gams & Zare					0.39	4 L	0.37	2 R
L. fungicola (Preuss) Zare & W. Gams					0.39	4 L	0.34	2 R
Macrophomina phaseolina (Tassi) Goid.					0.04	1 R	0.03	1 R
Metarhizium anisopliae (Metschn.) Sorokin			0.14	1 R			0.17	1 R
Microascus Zukal			0.08	1 R			0.34	2 R
M. brevicaulis S.P. Abbott			0.08	1 R			0.24	2 R
Mortierella alpina Peyronel	0.68	5 M	0.63	4 L	3.11	6 M	0.44	4 L
Mucor P. Micheli ex L.	0.54	11 H	0.20	2 R	1.16	11 H	0.41	7 M
M. circinelloides Tiegh.	0.42	8 M	0.18	1 R	1.09	10 H	0.27	4 L
M. hiemalis Wehmer	0.12	3 L	0.02	1 R	0.07	1 R	0.13	4 L
Myrothecium Tode	2.30	8 M	1.34	7 M	5.07	11 H	2.26	10 H
M. roridum Tode	1.57	4 L	0.73	3 L	0.29	4 L	0.27	3 L
M. verrucaria (Alb. & Schwein.) Ditmar	0.73	5 M	0.61	5 M	4.78	9 H	1.98	8 M
Penicillium Link	24.52	18 H	29.09	18 H	1.66	16 H	6.36	18 H
P. aurantiogriseum Dierckx	3.22	2 R	3.54	4 L	0.21	2 R		
P. chrysogenum Thom	0.09	3 R	0.02	1 R			0.55	2 R
P. citrinum Thom	1.46	8 M	1.44	10 H	0.11	3 L	0.62	3 L
P. corylophilum Dierckx			0.06	3 L				
P. decumbens Thom			0.18	2 R			0.03	1 R
P. dierckxii Biourge	0.02	1 R	0.18	1 R				
P. expansum Link	0.49	4 L	0.22	3 L	0.29	4 L	0.41	4 L
P. glabrum (Wehmer) Westling	0.70	2 R	0.55	2 R				
P. implicatum Biourge	0.99	2 R	2.17	3 L				
P. jensenii K.M. Zalessky			0.16	3 L			0.03	1 R
P. ochrochloron Biourge	9.02	5 M	13.76	8 M			0.38	4 L
P. olsonii Bainier & Sartory	5.26	6 M	2.24	7 M				
P. oxalicum Currie & Thom	1.10	6 M	1.34	6 M	0.94	8 M	3.35	11 H
P. restrictum J.C. Gilman & E.V. Abbott			0.04	1 R			0.07	1 R
P. simplicissimum (Oudem.) Thom	0.07	1 R					0.03	1 R
P. spinulosum Thom	0.19	1 R	0.02	1 R				
P. vinaceum J.C. Gilman & E.V. Abbott					0.11	1 R	0.89	3 L
P. waksmanii K.M. Zalessky	1.67	4 L	2.95	3 L				
Pestalotiopsis sp.			0.14	3 L				

Taxa	Citrus soil				Grapevine soil			
	DYM		DRBC		DYM		DRBC	
	%CFU	F&O	%CFU	F&O	%CFU	F&O	%CFU	F&O
Phialophora cyclaminis J.F.H. Beyma	0.09	3 L	0.02	1 R				
Phoma Sacc.	0.09	2 R	0.18	2 R	0.14	2 R	0.14	2 R
P. epicoccina Punith., M.C. Tulloch & C.M. Leach	0.02	1 R			0.04	1 R		
P. eupyrena Sacc.					0.11	1 R	0.03	1 R
P. leveillei Boerema & G.J. Bollen	0.07	1 R					0.10	1 R
Plectosphaerella cucumerina (Lindf.) W. Gams					0.22	1 R	0.03	1 R
Pleospora Rabenh. ex Ces. & De Not.			0.02	1 R	0.04	1 R	0.14	3 L
P. tarda E.G. Simmons			0.02	1 R	0.04	1 R	0.10	2 R
Pochonia sp.	0.07	3 L						
Purpureocillium lilacinum (Thom) Luangsa-ard, Houbraken, Hywel-Jones & Samson	0.21	3 L	0.26	1 R				
Rhizopus oryzae Went & Prins. Geerl.	0.05	2 R	0.06	2 R	0.72	7 M	0.96	7 M
Sarocladium W. Gams & D. Hawksw.	0.12	1 R	0.18	2 R	0.04	1 R	0.38	4 L
S. kiliense (Grütz) Summerbell					0.04	1 R	0.07	2 R
S. strictum (W. Gams) Summerbell	0.12	1 R	0.18	2 R			0.31	3 L
Sarcopodium circinosetiferum (Matsush.) Matsush.	0.09	1 R	0.08	1 R				
Scolecobasidium E.V. Abbott			0.04	1 R	0.62	3 L	1.81	6 M
S. constrictum E.V. Abbott					0.07	1 R	0.51	4 L
S. tshawytschae (Doty & D.W. Slater) McGinnis & Ajello			0.04	1 R	0.54	2 R	1.29	6 M
Scopulariopsis brumptii Salv.-Duval			0.35	3 L				
Setosphaeria rostrata K.J. Leonard					0.39	5 M	0.14	1 R
Talaromyces C.R. Benj.	0.40	7 M	1.83	15 H	5.14	9 M	6.69	18 H
T. brevicompactus H.Z. Kong	0.21	2 R	1.12	3 L				
T. duclauxii (Delacr.) Samson, Yilmaz, Frisvad & Seifert			0.04	1 R			0.27	4 L
T. islandicus (Sopp) Samson, Yilmaz, Frisvad & Seifert					1.16	2 R	0.10	3 L
T. minioluteus (Dierckx) Samson, Yilmaz, Frisvad & Seifert					0.04	1 R	0.17	2 R
T. pinophilus (Hedgc.) Samson,Yilmaz, Frisvad & Seifert			0.22	5 M	0.51	3 L	1.40	6 M
T. purpurogenus (Stoll) Samson, Yilmaz, Frisvad & Seifert	0.19	6 M	0.45	9 H	3.11	6 M	4.03	9 H
T. stipitatus (Thom) C.R. Benj.					0.18	1 R	0.07	1 R
T. variabilis (Sopp) Samson, Yilmaz, Frisvad & Seifert					0.07	1 R	0.65	3 L
Thelonectria P. Chaverri & C. Salgado	0.16	2 R	0.04	1 R	0.14	1 R	0.07	1 R
T. theobromicola (C. Booth) C. Salgado & P. Chaverri	0.16	2 R			0.14	1 R	0.07	1 R
Trichoderma Pers.	0.31	8 M	0.55	11 H	0.25	5 M	0.34	7 M
T. atroviride P. Karst.	0.05	1 R	0.04	2 R	0.07	2 R	0.10	3 L
T. aureoviride Rifai	0.02	1 R	0.04	1 R				
T. harzianum Rifai	0.12	2 R	0.20	3 L				
T. parceramosum Bissett			0.02	1 R	0.04	1 R	0.07	2 R
T. reesei E.G. Simmons	0.07	3 L	0.14	2 R	0.04	1 R	0.10	2 R
Trichoderma sp.	0.05	2 R	0.02	1 R	0.07	1 R	0.07	1 R
Volutella Fr.	2.21	10 H	0.79	6 M				
V. ciliata (Alb. & Schwein.) Fr.	1.36	6 M	0.55	3 L				

Taxa	Citrus soil				Grapevine soil			
	DYM		DRBC		DYM		DRBC	
	%CFU	F&O	%CFU	F&O	%CFU	F&O	%CFU	F&O
V. gilva (Pers.) Sacc.	0.26	4 L	0.12	2 R				
V. minima Höhn.	0.54	6 M	0.08	1 R				
Yeasts	0.47	5 M	0.49	6 M	0.15	3 L	0.21	4 L
Diutina catenulata (Diddens & Lodder) Khunnamwong, Lertwattanasakul, Jindam., Limtong & Lachance	0.02	1 R	0.04	1 R				
Cryptococcus laurentii (Kuff.) C.E. Skinner					0.07	2 R	0.03	1 R
Debaryomyces hansenii (Zopf) Lodder & Kreger	0.07	1 R	0.12	2 R				
Galactomyces Redhead & Malloch	0.05	2 R	0.16	3 L				
G. candidum de Hoog & M.T. Sm.	0.02	1 R						
G. citri-aurantii E.E. Butler			0.08	1 R				
Galactomyces sp.	0.02	1 R	0.08	2 R				
Hanseniaspora occidentalis M.T. Sm.			0.04	1 R				
Kluyveromyces marxianus (E.C. Hansen) van der Walt	0.02	1 R						
Meyerozyma Kurtzman & M. Suzuki			0.04	2 R	0.07	1 R	0.07	2 R
M. caribbica (Vaughan-Mart., Kurtzman, S.A. Mey. & E.B. O'Neill) Kurtzman & M. Suzuki			0.04	2 R				
M. guilliermondii (Wick.) Kurtzman & M. Suzuki					0.07	1 R	0.07	2 R
Pichia kudriavzevii Boidin, Pignal & Besson							0.03	1 R
Rhodotorula sp.							0.07	2 R
Schwanniomyces pseudopolymorphus (C. Ramírez & Boidin) M. Suzuki & Kurtzman	0.31	3 L	0.08	1 R				
Total number of CFU of all species		**25542**		**29530**		**16572**		**17549**
Number of genera (total 74)		**41**		**49**		**35**		**41**
Number of species (total 208)		**109**		**128**		**97**		**117**

Filamentous fungi isolated in rare occurrence on one medium from one plantation type only are listed below:

From citrus soil on DYM: *Actinomucor elegans* 2, *Aspergillus keveii* 1, *A. sepultus* 1, *A. stella-maris* 1, *A. wentii* 1, *Coniochaeta canina* 1, *Dendrodochium cylindricum* 1, *Nigrospora oryzae* 2, *Penicillium griseofulvum* 1, *P. roquefortii* 1, *Quambalaria cyanescens* 1, *Volutella* sp. 1;

— on DRBC: *Aspergillus insulicola* 1, *A. latus* 1, *A. montevidensis* (= *A. amstelodami* sensu Raper & Fennell 1965) 1, *A. silvaticus* 2, *A. tritici* 1, *Geosmithia* sp. 2, *Penicillium crustosum* 2, *P. hirsutum* 1, *P. megasporum* 1, *Penicillium* sp. 1, *Phoma putaminum* 1, *Phoma* sp. 1, *Staphylotrichum coccosporum* 1, *Thelonectria mammoidea* 1, *Trichoderma citrinoviride* 1, *T. viride* 1, *Tritirachium oryzae* 2, *Volutella colletotrichoides* 2, *Wardomyces* sp. 1.

From grapevine soil on DYM: *Acremonium* sp. 1, *Aspergillus flocculosus* 2, *A. japonicus* 2, *Fusarium lateritium* 1, *F. longipes* 1, *Gelasinospora bonaerensis* 1, *Lasiodiplodia theobromae* 2, *Neurospora crassa* 1, *Pseudallescheria boydii* 1, *Talaromyces* sp. 1, *Trichoderma virens* 1;

— on DRBC: *Absidia glauca* 1, *Acremonium curvulum* 1, *A. hyalinulum* 1, *Aspergillus carneus* 2, *A. neoniveus* 1, *A. proliferans* 1, *Bipolaris subpapendorfii* 1, *Cladosporium herbarum* 2, *Clonostachys rhizophaga* 1, *Cochliobolus spicifer* 1, *Eupenicillium* sp. 1, *Fusarium bulbicola* 1, *F. sambucinum* 1, *Lecanicillium aphanocladii* 1, *Microascus manginii* 1, *Pilidium lythri* 1, *Pleospora allii* 1, *Scytalidium lignicola* 1, *Stachybotrys chartarum* 1, *Talaromyces funiculosus* 2.

CONCLUSION

The present study reveals a characteristic pattern of correlation between dominance (counts) of certain groups of fungi in soil where hyaline fungi, e.g. *Penicillium*, *Aspergillus* and *Fusarium*, predominated over dark-coloured ones, e.g. *Cladosporium*, *Alternaria*, *Humicola* and *Setosphaeria*. In this pattern, soil is densely populated by microorganisms, thus competition for existence is very strong. On the other hand, fungi are relatively well protected from the injurious effects of atmospheric conditions, high light intensity, and strong diurnal fluctuations of temperature and humidity. These conditions may selectively favour hyaline over dark-coloured (melanin-containing) fungi.

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