Turk J Bot
27 (2003) 83-92

Research Article

Isolation and Identification of Soilborne Fungi in Fields Irrigated by GAP in Harran Plain Using Two Isolation Methods

Ayşe Dilek AZAZ
Balıkesir University, Faculty of Science and Arts, Department of Biology, Balıkesir - TURKEY

Received: 21.02.2001
Accepted: 23.09.2002

Abstract: The microfungal flora of field soils irrigated by the South-eastern Anatolia Project (GAP: Güneydoğu Anadolu Projesi) in Harran Plain were investigated in terms of quality and quantity, using the soil dilution plate and soil washing methods. A total of 1690 microfungi were isolated from 105 soil samples. With the identification of these isolates, 109 species plus 16 different sterile fungi were identified. Sixty-two of these taxa were isolated through the soil dilution plate method, seven through the soil washing method, and 40 through both methods. The results indicate that ten of these species belong to *Mucorales*, four to *Sphaeriales*, one to *Coelomycetes* and 94 to *Hyphomycetes*. The most widespread genera were *Penicillium* Link ex Gray (24 species), *Aspergillus* Mich. ex Fr. (20 species), and *Acremonium* Link ex Fr. with the soil dilution plate method. The most common species were *Aspergillus niger* Tiegh. (284 colonies), *Penicillium lanosum* Westling (238 colonies), *Penicillium canescens* Sopp. (170 colonies), *Penicillium brevicompactum* Dierckx (174 colonies) and *Penicillium clavigerum* Demelius (146 colonies). The results obtained from the soil dilution plate method show that fresh soil bulk equivalent to 1 g of oven-dried soil contains on average 72 487 propagules.

Key Words: *Hyphomycetes*, Microfungi, Soil

Harran Ovası GAP Sulama Alanı İçerisinde Kalan ve Sulamaya Alınan Tarla Toprak Funguslarının İki Metod Kullanılarak İzolasyon ve İdentifikasyonu

Özet: Harran Ovası GAP sulama alanı içerisinde kalan ve sulamaya alınan tarla topraklarından alınan 105 toprak örneğinin Toprağı Sulandırma ve Toprağı Yıkama metodlarıyla kalitatif ve kantitatif olarak incelenmesi sonucu toplam 1690 mikrofungus izolatı elde edilmiştir. Bu izolatların teşhislerinin yapılması sonucu 109 tür ayrıca 16 farklı steril mikrofungus elde edilmiştir. Bu taksonların 62 tanesi Toprağı Sulandırma, 7 tanesi Toprağı Yıkama, 40 tanesi ise her iki metodla da elde edilmiştir. Bunlardan 10 tanesi *Mucorales*, 4 tanesi *Sphaeriales*, 1 tanesi *Coelomycetes* ve 94 tanesi *Hyphomycetes* takımlarına aittir. Elde edilen cinsler arasında Toprağı Sulandırma metoduna göre en yaygın cinsler sırasıyla *Penicillium* Link ex Gray (24 tür), *Aspergillus* Mich. ex Fr (20 tür) ve *Acremonium* Link ex Fr. (9 tür)'dur. En yaygın türler ise *Aspergillus niger* Tiegh. (284 koloni), *Penicillium lanosum* Westling (238 koloni), *Penicillium canescens* Sopp. (170 koloni), *Penicillium brevicompactum* Dierckx (174 koloni) ve *Penicillium clavigerum* Demelius (146 koloni)'dur. Toprağı Sulandırma metoduna göre 1 g fırın kuru toprağa karşılık gelen taze toprakta ortalama 72487 birim mikrofungus bulunmuştur.

Anahtar Sözcükler: *Hyphomycetes*, Mikrofungus, Toprak

Introduction

GAP (Güneydoğu Anadolu Projesi) investigations are carried out to enhance the productivity of field soils in South-east Anatolia within the scope of the project involving irrigation and energy production. As dry farming used to be carried out in south-east Anatolia, it is expected to observe changes in the activity of soil micro-organism as a result of the newly initiated farming using irrigation.

The insufficient amount of total rainfall per year before irrigation used to reduce and limit the ecological activity of micro-organisms in the field soils. This investigation was undertaken to determine the ecological changes resulting from irrigation.

Studies on soil mycology in Turkey have primarily been concentrated on North-eastern Anatolia (Hasenekoğlu, 1982; Hasenekoğlu & Azaz, 1991; Hasenekoğlu & Sülün, 1991; Sülün & Hasenekoğlu, 1993), the vicinity of İzmir (Ekmekçi, 1974 a and b; 1975; Asan & Ekmekçi, 1994; Öner, 1974) and Thrace (European Turkey) (Asan, 1997 a and b).

Description of research area

The study area is located at 37°10'N, 36°41'N and 38°41'E, 39°10'E. The investigation covers 89 farmland sites in the south and south-east parts of Şanlıurfa, the first to be irrigated. The stations were selected on maps of 1/200,000 scale created by the 19th. District Directorate of Rural Affairs, and 1/50,000 scale created by the General Directorate of State Hydraulic Works (D.S.İ.). The sample sites were chosen randomly and marked on maps (Figure 1). Prior to irrigation, wheat (*Triticum sativum* L.), barley (*Hordeum vulgare* L.), lentil (*Lens culinaris* Medik.) and other such plants were grown in the area. Since the start of irrigation, crops such as cotton (*Gossypium* L. spp.), sesame (*Sesamum indicum* L.) pepper (*Capsicum annuum* L.) and tomato (*Lycopersicum esculentum* Miller) have been grown in the area.

Materials and Methods

In the collected samples, first a soil profile was extracted and then the surface of the profile was cleaned. Vertical samples were taken from 10 cm depths with a disinfected spatula. The spatula was applied perpendicular to the vertical surface of the profile. The samples were stored in a large sterilized cooled thermos bottle until they reached the laboratory. The samples were processed in an isolation process using the soil dilution plate (Waksman, 1922) and soil washing methods (Gams et al., 1987) in the laboratory. The moisture content of a certain amount of soil was determined and fresh soil quantities corresponding to 25 g of oven-dried soil were calculated (Öner, 1973). Then 1/10,000 dilutions of the samples were prepared (Warcup, 1955). Before the settling of organic matter and soil particles (Phara & Kommedahl, 1954), 1 mL of the dilutions was applied to prepared Peptone Dextrose Agar. Plates were then inoculated with each sample (Gams et al., 1987) and incubated at 25 °C for 10 d. In order to suppress bacterial growth, 30 mg/L of streptomycin was added and to restrict the colonial growth 30 mg/L of rose bengal was added to the isolation medium (Martin, 1950).

Twenty grams of fresh soil was placed in a glass funnel lined with muslin (pore size 0.5 mm) for isolation using the soil washing technique. The soil samples were first washed with 2 L of tap water and the outflow was collected in a funnel. The procedure was then repeated using 2 L of sterile water. After this treatment, the muslin and its contents were transferred into a sterile petri dish with the same water containing streptomycin. Organic particles floating on the surface of the water and the washed soil particles were picked up with a loop and forceps and transferred onto plates of Peptone Dextrose Agar with rose bengal. The plates were incubated at 25 °C for 10 d (Gams et al., 1987).

The colonies were counted and identified using the soil dilution plate method. The counting and identification procedure was carried out under a stereomicroscope. Then the identified colonies were transferred to petri dishes containing agar. In the petri dishes, different types of colonies developed around the soil, and organic particles were isolated using the soil washing technique. For identification purposes, the genera *Aspergillus* Mich. ex Fr. and *Penicillium* Link ex Gray were plated on Czapex Dox Agar and Malt-Extract and the others on Malt-Extract Agar. For the identification of the isolates, Smith (1971) was followed. Identification of the taxa were carried out according to Hasenekoğlu (1991), Subramanian (1983), Ellis (1971), Gerlach & Nirenberg (1982), Raper & Thom (1949), Raper & Fennell (1965), Zycha et al. (1969), Samson & Pitt (1985), and Samson & Pitt (2000). Citation of the names of authors presented is standardized according to the Authors of Fungal Names (Kirk & Ansell, 1992).

The reason for using the soil dilution plate method was to isolate the propagules of microfungi occurring inactively in the soil, whereas the reason for using the soil washing technique was to isolate active microfungus hypha.

Results

A total of 1690 isolates were obtained from the analyses of 105 soil samples taken from the area in August 1997 through soil dilution plate and soil washing methods to determine the microfungi flora of field soils irrigated in Harran Plain in Şanlıurfa within the GAP irrigated area. The identification of these isolates resulted in 109 species and varieties plus 16 sterile microfungi. Among the identified species, ten of these belonged to *Mucorales*, four to *Sphaeriales*, one to *Coelomycetes*, and 94 to *Hyphomycetes* (Tables 1 and 2). Sixty-one of the taxa were isolated with the soil dilution plate technique,

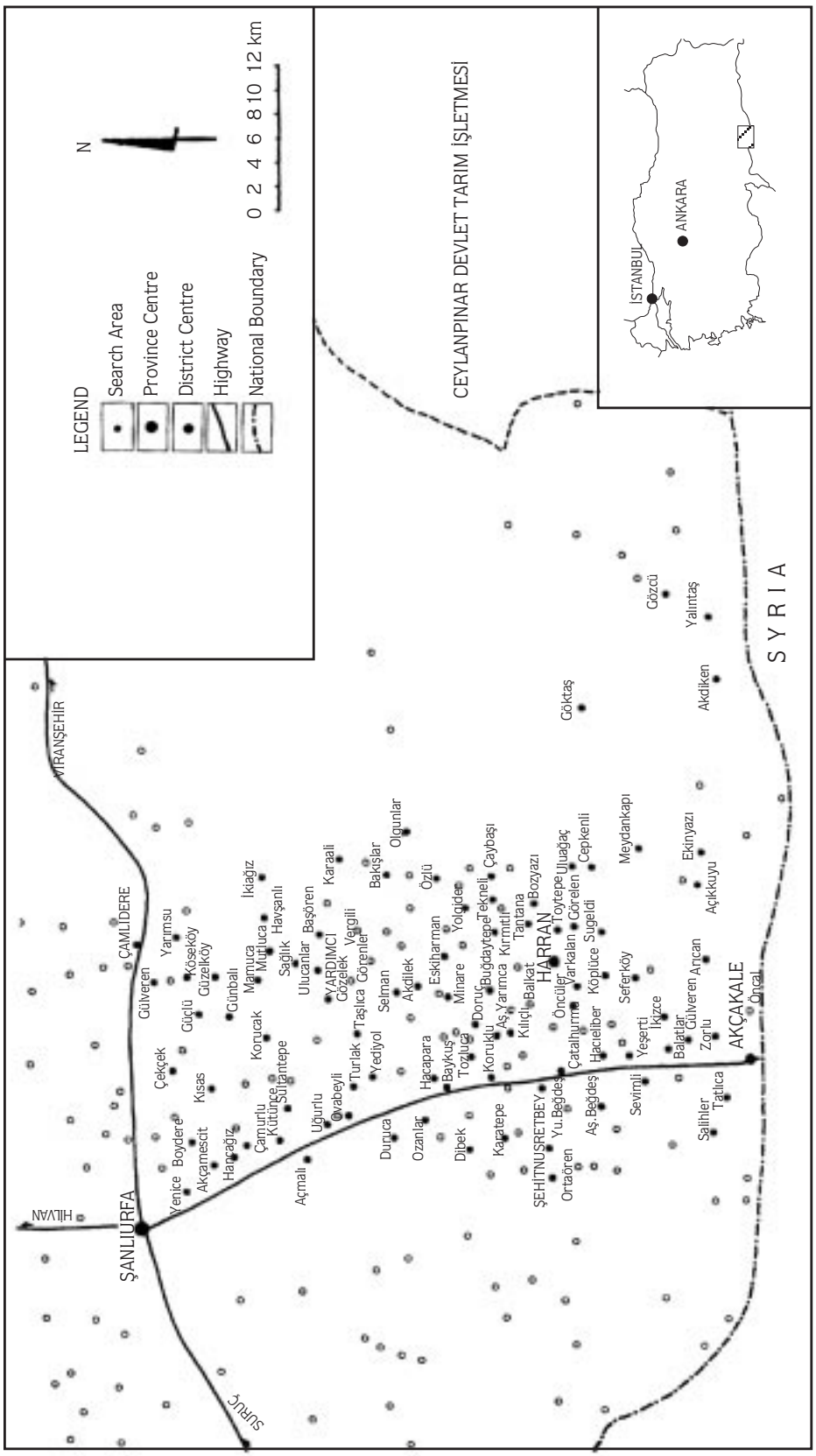

Figure 1. The Soil Collection Stations in the Study Area.

Table 1. The colony and isolate numbers of genera, their ratio to total number and comparison of the two methods.

	Soil Dilution Plate Method		Soil Washing Method	
	Colony Number	Ratio to total Number (%)	İsolate Number	Ratio to Total Number
MUCORALES				
Absidia Tiegh.	16	0.431	4	1.081
Circinella Tiegh. & F.Monnier	-	-	1	0.270
Cuninghamella Matr.	15	0.404	11	2.972
Mucor Michx. ex Fr.	-	-	38	10.270
Rhizopus Ehrenb.	136	3.671	-	-
SPHAERIALES				
Chaetomium Kunze ex Fr.	38	1.025	2	0.540
COELOMYCETES				
Phoma (Fries.) Desm.	3	0.080	-	-
HYPHOMYCETES				
Acremonium Link ex Fr.	275	7.424	63	17.027
Alternaria Nees ex Fr.	7	0.188	-	-
Aspergillus Mich. ex Fr.	770	20.788	45	12.162
Beauveria Vuill.	76	2.051	1	0.270
Botryotrichum Sacc. & Marchal	-	-	2	0.540
Botrytis Mich. ex Fr.	21	0.566	-	-
Cladosporium Link ex Fr.; Link	35	0.944	-	-
Dicyma Boulanger	3	0.080	-	-
Drechslera Ito	2	0.053	-	-
Embellisia E.G.Simmons	6	0.161	-	-
Fusarium Link ex Fr.	8	0.215	-	-
Geomyces Traaen	7	0.188	6	1.621
Gliocladium Corda	92	2.483	-	-
Gliomastix Gueguen	36	0.971	2	0.540
Harzia Costantin	1	0.026	-	-
Humicola Traaen	19	0.512	3	0.810
Melanopsamma Niessl.	29	0.782	-	-
Myrothecium Tode ex Fr.	74	1.997	-	-
Paecilomyces Bainier	72	1.943	17	4.594
Penicillium Link ex Gray	1464	39.524	80	21.621
Scolecobasidium E.V.Abbott	-	-	1	0.270
Scopulariopsis Bainier	7	0.188	-	-
Stachybotrys Corda	102	2.753	1	0.270
Trichoderma Pers. ex Fr.	6	0.161	1	0.270
Trichothecium Link ex Gray	1	0.026	-	-
Ulocladium Preuss.	55	1.484	2	0.540
Verticillium Nees ex Link	88	2.375	4	1.081
Sterile 1	47	1.268	2	0.540
Sterile 2	10	0.269	3	0.810
Sterile 3	45	1.214	2	0.540
Sterile 4	32	0.863	9	2.432
Sterile 5	13	0.350	12	3.243
Sterile 6	-	-	2	0.540
Sterile 7	3	0.080	1	0.270
Sterile 8	2	0.053	1	0.270
Sterile 9	6	0.161	-	-
Sterile 10	4	0.107	-	-
Sterile 11	4	0.107	-	-
Sterile 12	7	0.188	28	7.567
Sterile 13	3	0.080	3	0.810
Sterile 14	30	0.809	1	0.270
Sterile 15	8	0.215	-	-
Sterile 16	26	0.701	22	5.945

Table 2. The colony and isolate numbers of the taxa and their ratios to their own genera, to the total colony number and to the isolate number, and comparison of the two methods.

	Soil Dilution Plate Method			Soil Washing Method		
	Colony Number	Ratio to Own genus (%)	Ratio to Total Number (%)	Isolate Number	Ratio to Own genus (%)	Ratio to Total Number (%)
MUCORALES						
Absidia cylindrospora Hagem	16	100	0.431	1	25	0.270
A. cylindrospora var. *rhizomorpha* Hesselt. & J.J.Ellis	-	-	-	3	75	0.810
Circinella rigida A.H.Sm.	-	-	-	1	100	0.270
Cunninghamella echinulata Thaxt	15	100	0.404	6	54.545	1.621
C. elegans Lendner	-	-	-	5	45.454	1.351
Mucor circinelloides van Tiegh. f. *griseo-cyanus* (Hagem) Schipper	-	-	-	10	26.315	2.702
M. hiemalis Wehmer f. hiemalis	-	-	-	16	42.105	4.324
M. hiemalis f. *luteus* Schipper	-	-	-	12	31.578	3.243
Rhizopus oryzae Went & Prins. Geerl.	103	75.735	2.780	-	-	-
R. stolonifer (Ehrenb. Fr.) Vuill. var. *stolonifer*	33	24.264	0.890	-	-	-
SPHAERIALES						
Chaetomium muelleri Arx	8	21.052	0.215	-	-	-
C. raii G. Malhotra & Mukerji	12	31.578	0.323	2	100	0.540
Chaetomium sp.1	12	31.578	0.323	-	-	-
Chaetomium sp.2	6	15.789	0.161	-	-	-
COELOMYCETES						
Phoma (Fries) Desm.sp.1	3	100	0,080	-	-	-
HYPHOMYCETES						
Acremonium butyri Beyma W. Gams	10	3.636	0.269	3	4.761	0.810
A. furcatum F. & V. Moreau ex W.Gams	3	1.090	0.080	-	-	-
A. strictum W.Gams	144	52.363	3.887	26	41.269	7.027
Acremonium sp.1	20	7.272	0.539	-	-	-
Acremonium sp.2	21	7.636	0.566	12	19.047	3.243
Acremonium sp.3	5	1.818	0.134	10	15.873	2.702
Acremonium sp.4	34	12.363	0.917	3	4.761	0.810
Acremonium sp.5	16	5.818	0.431	5	7.936	1.351
Acremonium sp.6	22	8.00	0.593	4	6.349	1.081
Alternaria alternata Keissl.	7	100	0.188	-	-	-
Aspergillus alliaceus Thom & Church	34	4.415	0.917	1	2.222	0.270
A. allahabadii B.S. Mehrotra & Agnihotri	10	1.298	0.269	-	-	-
A. candidus Link	10	1.298	0.269	-	-	-
A. carneus Blochwitz	46	5.974	1.241	2	4.444	0.540
A equitis Samson &W. Gams	15	1.948	0.404	-	-	-
A. ficuum (Reichardt) Henn.	22	2.857	0.593	8	17.777	2.162

Table 2 (Continued)

A. flavus Link	39	5.064	1.052	3	6.666	0.810
A. fumigatus Fresen.	19	2.467	0.512	-	-	-
A. heteromorphus Bat. & H.Maia	14	1.818	0.377	-	-	-
A. niger Tiegh.	284	36.883	7.667	21	46.666	5.675
A. ornatulus Samson & W.Gams	7	0.909	0.188	5	11.111	1.351
A. oryzae (Ahlb.) Chon	2	0.259	0.053	-	-	-
A. phoenicis (Corda) Thom	6	0.779	0.161	3	6.666	0.810
A. sclerotiorum G.A.Huber	93	12.077	2.510	-	-	-
A. terreus Thom	35	4.545	0.944	-	-	-
A. terricola var. *americanus* Marchal in Thom & Church	12	1.558	0.323	2	4.444	0.540
A. tubingensis (Schöber) Mosseray	9	1.168	0.242	-	-	-
A. ustus (Bainier) Thom & Church	34	4.415	0.917	-	-	-
A. versicolor (Vuill.) Tirab.	64	8.311	1.727	-	-	-
A. wentii Wehmer	15	1.948	0.404	-	-	-
Beauveria alba (Limber) Saccas	12	15.789	0.323	-	-	-
B. bassiana Vuill.	48	63.157	1.295	1	100	0.270
B. brongniartii (Sacc.) Petch	16	21.052	0.431	-	-	-
Botrytis cinerea Pers. & Nocca & Balb.	21	100	0.566	-	-	-
Botryotrichum sp.1	-	-	-	2	100	0.540
Cladosporium cladosporioides (Fresen.) G.A.Vries	20	57.142	0.539	-	-	-
C. herbarum (Pers) Link ex Gray	13	37.142	0.350	-	-	-
C. sphaerospermum Penz.	2	5.714	0.053	-	-	-
Dicyma sp.1	3	100	0.080	-	-	-
Drechslera australiensis (Bugnic.) Subram & Jain ex M.B.Ellis	2	100	0.053	-	-	-
Embellisia chlamydospora (Hoes, Bruehl & Show) Simmons	6	100	0.161	-	-	-
Fusarium solani (Matr.) Appel & Wollenw. Emend.Snyd. Hans.	3	37.5	0.080	-	-	-
Fusarium sp.1	3	37.5	0.080	-	-	-
Fusarium sp.2	2	25.00	0.053	-	-	-
Geomyces pannorum Sigler & J.W.Carmich. var. *pannorum* Oorschot	7	100	0.188	6	100	1.621
Gliomastix murorum Corda var. *felina* (Marchal) G.C.Hughes	24	66.666	0.647	2	100	0.540
G. musicola C.H. Dickinson	12	33.333	0.323	-	-	-
Gliocladium catenulatum J.C.Gilman & Abbott	62	67.391	1.673	-	-	-
G. roseum Bain.	6	6.521	0.161	-	-	-
G. solani (Harting) Petch	24	26.086	0.647	-	-	-
Harzia sp.1	1	100	0.026	-	-	-
Humicola fuscoatra Traaen var. *fuscuatra*	1	5.263	0.026	-	-	-
H. grisea Traaen var. *grisea*	18	94.736	0.485	3	100	0.810
Melanopsamma pomiformis Niessl	29	100	0.782	-	-	-

Table 2 (Continued)

Myrothecium roridum Tode ex Fr.	74	100	1.997	-	-	-
Paecilomyces carneus						
(Duché & R.Heim) Brown & Smith	2	2.777	0.053	-	-	-
P. farinosus Holm ex S.F.Gray	9	12.5	0.242	-	-	-
P. lilacinus (Thom) Samson	55	76.388	1.484	17	100	4.594
P. variotii						
Bainier	6	8.333	0.161	-	-	-
P. brevicompactum Dierckx	174	11.684	4.696	13	15	3.242
P. canescens Sopp.	170	11.611	4.588	13	16.25	3.594
Penicillium charlesii G.Sm.	12	0.819	0.323	-	-	-
P. chermesinum Biourge	6	0.409	0.161	2	2.5	0.540
P. chrysogenum Thom	83	5.669	2.240	2	2.5	0.540
P. citrinum Thom	15	1.024	0.404	2	2.5	0.540
P. claviforme Bain.	6	0.409	0.161	-	-	-
P. clavigerum Demelius	146	9.972	3.941	-	-	-
P. decumbens						
Thom	4	0.273	0.107	-	-	-
P. diversum Raper & Fennell	107	7.308	2.888	-	-	-
P. expansum Link	46	3.142	1.241	8	10.00	2.162
P. herquei Bainier & Sartory	17	1.161	0.498	-	-	-
P. italicum Wehmer var. *italicum* Samson,						
Stolk & Hadlok	113	7.718	3.050	9	11.25	2.432
P. janthinellum Biourge	78	5.327	2.105	5	6.25	1.351
P. jenseni W.Zalessky	45	3.073	1.214	12	15.00	3.243
P. lanosum Westling	238	16.256	6.425	3	3.75	0.810
P. madriti G.Sm	9	0.614	0.242	-	-	-
P. multicolor Grig. Man. & Porad.	68	4.644	1.835	3	3.75	0.810
P. olsonii Bain. & Sartory	20	1.366	0.539	-	-	-
P. roqueforti Thom	12	0.819	0.323	-	-	-
P. simplicissimum (Oudem.)Thom	4	0.273	0.107	4	5.00	1.081
P. steckii W.Zalessky	14	0.956	0.377	-	-	-
P. variabile Sopp.	13	0.887	0.350	-	-	-
P. verrucosum var. *cyclopium* (Westling) Samson,						
Stolk & Hadlok	64	4.371	1.727	5	6.25	1.351
Scolecobasidium constrictum Abbott	-	-	-	1	100	0.270
Scopulariopsis brumptii Salv.-Duval	7	100	0.188	-	-	-
Stachybotrys microspora (Mathur et Sankhla)						
Jong et Davis	95	93.137	2.564	1	100	0.270
S. parvispora S.Hughes	7	6.862	0.188	-	-	-
Trichoderma harzianum Rifai	2	33.333	0.053	1	100	0.270
T. pseudokoningii Rifai	4	66.666	0.161	-	-	-
Trichothecium roseum (Pers.)Link ex Gray	1	16.666	0.0269	-	-	-
Ulocladium atrum Preuss	52	94.545	1.403	2	100	0.540
U. tuberculatum E.G.Simmons	3	5.454	0.080	-	-	-
Verticillium dahliae Kleb.	5	5.681	0.134	-	-	-
V. lecanii (Zimm.) Viégas	83	94.318	2.240	4	100	1.081

eight with the soil washing technique and 40 with both methods. The number of colonies obtained by the soil dilution plate method was 3704, and 370 were isolated using the soil washing technique.

The genera with the greatest number of species were *Penicillium* (24 species), *Aspergillus* (20 species), *Acremonium* Link ex Gray (nine species) in the soil plate method. The most widely distributed and abundant colony forming taxa in the soil plate method were *Penicillium* (1464 colonies), *Aspergillus* (770 colonies), *Acremonium* (275 colonies), *Rhizopus* Ehrenb. (136 colonies) and *Stachybotrys* Corda (102 colonies).

With the soil dilution plate technique, the richest genera in terms of the number of species were *Penicillium* and *Aspergillus*, and the most common ones in these two were *Aspergillus niger* Tiegh. (284 colonies), *Penicillium lanosum* Westling (238 colonies), *P. canescens* Sopp. (161 colonies), *P. brevicompactum* Dierckx (160 colonies) and *P. clavigerum* Demelius (146 colonies) (Tables 1 and 2).

The most common taxa obtained from the soil washing technique were Sterile 12 (28 isolates), *Acremonium strictum* W.Gams (26 isolates), *Aspergillus niger* (21 isolates), *Paecilomyces lilacinus* (Thom) Samson (17 isolates), *Mucor hiemalis* Wehmer f. *hiemalis* (16 isolates), *Penicillium canescens* (13 isolates), *P. jensenii* W. Zalessky (12 isolates) and Sterile 5 (12 isolates) (Tables 1 and 2).

An average of 72,487 propagules of microfungi were calculated in fresh soil equivalent to 1 g of oven-dried soil.

Discussion

One hundred and nine different species and strains and also 16 different sterile microfungi were obtained as a result of the analysis with the soil dilution plate and soil washing methods of 105 soil samples taken from 89 farmland sites within the area of GAP irrigation. Fresh soil equivalent to 1 g of oven-dried soil contained an average of 72,487 propagules of microfungi using the soil dilution plate method. For some isolations, the soil washing method was used. In this method, fungus propagules are removed from the soil by a washing procedure. Sixty-one different taxa assumed to be actively present in the soil were isolated.

Azaz & Hasenekoğlu (1997) isolated a total of 3102 microfungi from 203 soil samples prior to irrigation in the same area; they used the same methods as presented in this paper. The identification of these isolates resulted in 133 discrete species and strains and an additional 23 sterile microfungi. The richest genera in terms of the number species were *Aspergillus* (25 species), *Penicillium* (22 species), *Acremonium* (seven species) and *Fusarium* (six species). Although *Aspergillus* has the largest number of species, *Penicillium* has the most abundant colony formation in taxa. On the other hand, *Penicillium* comes first in terms of the numbers of species and colony formation, but *Aspergillus* is in second place in both cases. Quantitatively it was determined that there was an increase in microfungus propagules in 1 g of oven-dried soils equivalent to fresh soil microfungi after irrigation.

Azaz & Hasenekoğlu (1998) conducted an investigation on the field soils and uncultivated soils in Harran Plain in the GAP irrigation area. They obtained 2676 isolates from 124 soil samples with the same methods described in their paper. After the identification of these isolates they reported 100 discrete species and strains and 15 sterile microfungi. They found approximately 46,326 propagules of microfungi in 1 g of oven-dried soil equivalent to fresh soil using the soil dilution plate method. Also according to this method, genera with the richest species were *Penicillium* (27 species), *Aspergillus* (24 species) and *Acremonium* (six species). These results correspond to the investigation carried out after irrigation.

Hasenekoğlu (1985) performed quantitative analysis of the microfungi flora of forest, grass and field soils in the vicinity of Sarıkamış. He reported that the genus *Penicillium* is the most common in terms of species and intensity in his research.

Asan (1992) studied the flora of *Penicillium* and *Aspergillus* in different habitat soils in Edirne. He found 23 species and two varieties belonging to *Aspergillus* and 16 species belonging to *Penicillium*.

Sülün & Hasenekoğlu (1993) researched the flora of *Penicillium* and *Aspergillus* in North-east Anatolia. In their research they found 20 species of *Aspergillus* and 22 of *Penicillium*.

The results of these studies performed in different regions of Turkey are in accordance with those of our

paper, which proves that the genus *Penicillium* is the most common in soil.

İsmail & Abdullah (1977) conducted research on the soil of Iraq where climatic and edaphic factors are very similar to those of our research field. They obtained an average of 31,425 microfungus propagules in 1 g of oven-dried soil from four different soil samples in their research. They reported that there were 5000 and 4700 microfungus propagules in the samples of soils with a water holding capacity of 38% and 21.7% and 66,000 and 50,000 in samples of soils with a water-holding capacity of 48% and 44%, respectively. Therefore, the numbers of microfungi in each sample are different from each other.

The water-holding capacity of the soils in the fields investigated here varies between 35% and 62%. The average capacity is about 40% (Tüzüner et al., 1990).

The results obtained from the soil dilution plate method show that a bulk of fresh soil equivalent to 1 g of oven-dried soil contains on average 72,487 microfungus propagules.

An acceptable number of microfungi in 1 g of fertile land soil is around 400,000 (Hasenekoğlu, 1979). It can be argued that the field lands of this investigation were poor in quantity. In conclusion, there is a quantitative improvement in the field lands as compared to previous investigations. However, there is no significant improvement in the diversity of species.

References

Asan A & Ekmekçi S (1994). The determination of *Penicillium* and *Aspergillus* species in Edirne soils and their seasonal distribution. *Turk J Biol* 18: 291-303.

Asan A (1997a). Trakya Bölgesi mısır tarlaları mikrofungus florası I. *Tr J of Botany*, 21:89-101.

Asan A (1997 b). Trakya Bölgesi mısır tarlaları mikrofungus florası üzerine araştırmalar II. *Kükem Derg* 20: 9-18.

Azaz AD & Hasenekoğlu İ (1997). An investigation into the microfungal flora of field soils in the GAP (Southeastern Anatolia Project) irrigation area of Harran Plain. *Tr J of Botany*, 21: 165-172.

Azaz AD & Hasenekoğlu İ (1998). Harran Ovasında GAP ikinci kademede sulanması planlanan tarla ve işlenmemiş toprakların mikrofungus florası üzerine bir araştırma. *Kükem Derg* 21: 57-67.

Ekmekçi S (1994 a). Güney yarı Ege Bölgesindeki bazı *Aspergillus* (Micheli) Corda ve *Penicillium* Link türlerinin sporulasyonlarının ortam faktörleri ile ilişkileri. *Bitki Derg* 1:183-188.

Ekmekçi S (1994 b). Güney Ege Bölgesinden izole edilen *Aspergillus* (Micheli) Corda ve *Penicillium* Link türlerinin ekolojisi. *Bitki Derg* 1:457-465.

Ellis MB (1971). *Dematiaceus Hyphomycetes*. Kew Surrey UK: Commonwealth Mycological Institute 608p.

Gams W, van der Aa, HA, van der Plaats-Niterink AJ, Samson RA & Stalpers JA (1987). (C.B.S.) *Centraalbureau voor Schimmelcultures*. Course of Mycology 3rd ed. Baarn: Institute of the Royal Netherlands Academy of Arts and Sciences. 136p.

Gerlach W & Nirenberg H (1982). *The Genus Fusarium – a pictorial atlas*. Berlin: Kommissionsverlag Paul Parey. 406p.

Hasenekoğlu İ (1982). Erzurum et kombinası civarındaki kirlenmiş toprakların mikrofungus populasyonu. *Atatürk Üniversitesi Fen Fak Derg* 1: 409-416.

Hasenekoğlu I (1985). Sarıkamış civarındaki orman, çayır ve tarla topraklarının mikrofungus analizi. *Kükem Derg* 8 : 40-46.

Hasenekoğlu İ (1991). *Toprak Mikrofungusları*. Erzurum: Atatürk Üniversitesi Yayınları No: 689: 7 Cilt.

Hasenekoğlu İ & Azaz AD (1991). Sarıkamış civarı traşlanmış orman topraklarının mikrofungus florası ve bunun normal orman toprakları florası ile karşılaştırılması üzerine bir araştırma. *Doğa-Tr J of Botany*, 15: 214-226.

Hasenekoğlu İ & Sülün Y. (1991). Erzurum Aşkale çimento fabrikasının kirlettiği toprakların mikrofungus florası üzerine bir araştırma. *Doğa-Tr J of Botany* , 15: 20-27.

Ismail ALS & Abdullah SK (1977). Studies on the soil fungi of Iraq. *Proc Indian Acad Sci* 3: 151-154.

Kirk PM & Ansell AE (1992). *Authors of Fungal Names. Index of fungi supplement*. International Mycological Institute. Kew, Surrey UK: An Institute of CAB 95p.

Martin JP (1950). Use of acid rose-bengal and streptomycin in the plate method for estimating soil fungi. *Soil Sci* 69: 215-232.

Nelson PE, Toussoun TA & Marasas WFO (1983). *Fusarium Species- An Illustrated Manual for Identification*. Park and London, USA: The Penssylvania State University Press. 199p

Öner M (1973). *Atatürk Üniversitesi Erzurum Çiftliği, Eğerli Dağı kuzey yamacı ve Trabzon-Hopa sahil şeridi mikrofungus florası ile ilgili bir araştırma*. Ankara: Atatürk Üniv. Yayınları, No.158. 71p.

Öner M (1974). Seasonal distribution of some Fungi Imperfecti in the soils of Western Anatolia. *Mycopat et Mycologia* 19: 248-267.

Papavizas GC & Davey CB (1959). Evaluation of various media and antimicrobial agents for isolation of soil fungi. *Soil Sci* 88: 112-117.

Phara KD & Kommedahl TA (1954). Modified plating technique for the study of soil fungi. *Phytopathol* 44: 502.

Raper KB & Fennell DI (1965). *The Genus Aspergillus*. Baltimore: Williams and Wilkins Company. 685p.

Raper KB & Thom C (1949). *A Manual of the Penicillia*. Baltimore: Williams and Wilkins Company. 875p.

Samson RA & Pitt JI (Eds.) (1985). *Advances in Penicillium and Aspergillus Systematics*. Plenum Press: New York and London. 483p.

Samson RA & Pitt JI (2000). *Integration of Modern Taxonomic Methods for Penicillium and Aspergillus Classification*. Amsterdam: Harwood Academic Publishers. 510p.

Smith G (1971). *An Introduction to Industrial Mycology*. London: Edward Arnold Ltd. 390p.

Subramanian CV (1983). *Hyphomycetes Taxonomy and Biology*. London: Academic Press. 502p.

Sülün Y & Hasenekoğlu İ. (1993). A study on *Aspergillus* Mich ex Fr. and *Penicillium* Link ex Gray flora of the Northeast Anatolia, Türkiye. *Doğa-Turk J Biol* 17: 49-60.

Tüzüner A, Kurucu N, Gedikoğlu İ, Eyüboğlu F, Börekçi M, Sönmez B & Ağar A (1990). *Toprak ve Su Analiz El Kitabı*. Ankara: Köy Hizmetleri Genel Müdürlüğü Matbaası. 375s.

Waksman SA (1922). A method of counting the number of fungi in the soil. *J Bacteriol* 7: 339-341.

Warcup JH (1955). On the origin of colonies of fungi developing on soil dilution plates. *Trans Brit Mycol Soc*, 38: 298-301.

Zycha H, Siepmann R & Linneman G (1969). *Mucorales*. Lehre: Stratuss and Cramer Gmbh. 347p.