THE MYCOFLORA OF A LIGHT SOIL IN A CITRUS FERTILIZER TRIAL IN ISRAEL[1])

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INTRODUCTION

The studies described here form part of a series of investigations of the mycoflora of crop soil in Israel carried out on fields and groves of the long-term trials in progress for several decades at the Soil Research Institute at Mikve Israel in the central coastal plain of Israel. Another part of these investigations, dealing with unirrigated field crops on heavy soil has been published elsewhere (JOFFE, 1963).

MATERIALS AND METHODS

The soil

The soil of the grove of Shamouti oranges on which the manure and fertilizer trial is being carried out is of a light type. The soil has been formed as a result of weathering of calcareous sand-stone, which consisted of quartz sand and grains cemented by lime. The prevailing texture of this soil is that of sand and sandy loam, the prevalent colour red and reddish brown, as is typical for the Israel citrus belt.

Mechanical composition

Soil analysis made in 1958 according to the Atterberg system, yielded the following results:

	0—15 cm depth	15—30 cm depth
Clay	5.75 %	9.50 %
silt	2.80 %	2.90 %
fine sand	38.0 %	46.4 %
coarse sand	53.45 %	41.2 %
hygroscopic moisture	0.8 %	1.2—1.4 %

The soil reaction in 1963 approximated 6.2—6.5 in plots receiving NPK as chemicals only, 5.3—6.7 in those receiving only N and P as chemicals, 6.9—7.3 in plots supplied partly with manure and partly with fertilizers, and 7.2—7.5 in the control plots.

[1]) Dedicated to the late Meir Winnik, Pioneer of Soil Research in Israel.

Chemical composition

The soil contains only traces of calcium carbonate and has an exchange capacity of 8—10 milligram equivalents/100. The nitrogen content is 0.04—0.055 %, that of P_2O_5 and K_2O (as determined by extraction with 20 % HCl) is 0.016—0.027 and 0.09—0.16 % respectively. The carbon content is 0.4—0.5 %, which corresponds to 0.68—0.80 % organic matter.

Description of the fertilizer trial

The trial is being carried out in a grove of Shamouti oranges grafted on sweet lime stock and inarched 5 years later with sour orange. This grove was planted in 1929. Up to 1945 all plots in the grove were treated uniformly, received no organic manure, and were given only small quantities of NPK fertilizers. During this period the yield of each individual tree was carefully recorded so that plots with equal initial yield could be laid down when differential treatments of fertilizers and manure commenced in 1945. In that year the yield for the entire experimental grove averaged 4.5 tons per dunam (=1000 sq.m.) Of the numerous combined treatments tested as from 1945, plots receiving the following annual applications were chosen for mycoflora studies:

Treatment 2 – NPK, applied as fertilizers only, at the rates per hectare of 180 kg N (2/3 of which were applied in form of ammonium sulphate, 1/3 as nitrochalk), 60 kg P_2O_5, in form of superphosphate, and 75 kg K_2O, as sulphate of potash.

Treatment 5 – N and P, but no K, applied as in treatment 2.

Treatment 8 – Manure – NPK, receiving the following nutrients per hectare:

900 kg sheep manure, containing approx. 1.1 % N;
90 kg N, of which 1/3 as ammonium sulphate, 2/3 as nitrochalk;
45 kg P_2O_5 in form of superphosphate;
30 kg K_2O in form of sulphate of potash.

Treatment 11 – NPK with an increased dose of manure: fertilizers were applied as in treatment 8, but the dose of sheep manure (containing approx. 1.5 % N) was increased to 1800 kg per hectare.

Treatment 12 – Control, receiving neither fertilizer nor manure after 1945.

Each treatment was applied to 3 replicate plots (Blocks A, B, C), each consisting of 12 trees.

Sampling

Samples were taken on 29th November 1959 and 19th November 1960 from one replicate (Block A) of each treatment, and on 13th September 1962 and 9th September 1963 from 3 replicates (Blocks A, B, C) of treatments 2, 5, 8 and 11, but only from Block A of the control. On every occasion 3 samples were taken at each

spot, at depths of 5, 20, and 50 cm. The total number of samples amounted to 114. The technique of sampling was the same as in our earlier work (JOFFE, 1963).

Determination of Mycoflora

Our methods of culturing in general, and those for culturing Fusaria in particular, have been described elsewhere (JOFFE, 1963). The composition of the substrates used is indicated below:

1. Czapek's medium, pH 4.6
2. Potato dextrose agar, pH 4.8
3. Malt extract agar, pH 4.6 (malt extract 20.0, dextrose 20.0, peptone 1.0, agar 20.0, distilled water 1000 ml).
4. Waksman's medium, pH 4.0 (JOFFE, 1963).
5. Waksman's medium modified, pH 4.5 (JOFFE, 1963).
6. Soil extract 20 ml, dextrose 10 g, K_2HPO_4 0.5, $MgSO_4$ 0.25, agar 20, distilled water 800 ml, pH 4.2.
7. Soil extract 100 ml, dextrose 5 g, K_2HPO_4 0.5, $MgSO_4$ 0.2, agar 20, distilled water 900 ml. pH 4.8.
8. Soil extract 200 ml, dextrose 2 g, agar 20, distilled water 800 ml. pH 4.2.
9. Starch agar, pH 7.5—8.0. K_2HPO_4 0.5 g, $MgSO_4$ 0.5, NKO_3 1.0, NaCl 0.5, $FeSO_4$ 0.01, soluble starch 10.0, agar 20.0, distilled water 1000 ml. This substrate served for isolation of actinomycetes, yeasts and bacteria.

Diagnosis for some of the species found were in addition to GILMAN (1957) based on the following authorities:
Phycomycetes – CUTTER (1964), NAUMOV (1939), FITZPATRICK (1930).
Ascomycetes – DINGLEY (1951), RAPER & THOM (1949), THOM & RAPER (1939, 1945), SKOLKO & GROVES (1948, 1953).
Deuteromycetes – ATKINSON (1953), BILAI (1955), GORDON (1952), GROVES & SKOLKO (1944, 1945), HUGHES (1951), LINDER (1934), MOREAU (1951), OMVIK (1955), ORR *et al.* (1963), PIDOPLICHKA (1953), GORDON (1952), SAKSENA (1955), SCHOL-SCHWARZ (1959), SNYDER & HANSEN (1940, 1941).

RESULTS

Table I presents a list of the species found and indicates the number of their colonies. The figures have been grouped in two ways: (a) For those 4 series of plots that received fertilizers and/or manure totals have been calculated for one plot each in 1959 and 1960 (Block A), and for three plots each in 1962 and 1963 (Blocks A, B, C), i.e. for grand totals of 8 plots; (b) for all fertilized and/or manured series as well as the control series, totals have been calculated separately for the plots in Block A, because control samples were examined only from this block, so that comparisons between plots receiving nutrients and those receiving none could be

TABLE I

rs of colonies of fungal species isolated from Citrus soil under various fertilizer and manure treatments and from control soil receiving no nutrients.

s species	Total from blocks A.B.C.				Block A only				
	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	Control No. 12
'COMYCETES									
i butleri LENDN.	5				5				
ica HAG.			11				11		
theimii (LUCET & STATIN) LENDN.*		7	13	7		2	10		
idis (VUILL.) HAG.		1							
iosa LENDN.	13	42	32	77		25	2	25	
mucor corymbosus RZ) NAUMOV*		12							
lla spinosa v. TIEG. E MONNIER**		13	3						
ighamella bainieri MOV*-**	4								
holletiae STADEL**	3			22	3			22	
esleana LENDN.*		2		1				1	
nulata THAXT.	3	8	4		3	8	3		
ins LINK	9		3	12	3			9	
	8	4	3		4			3	3
ophora sp.		1							
vella bainieri CONIN	5		4		2		4		
nicola OUD.				8				8	
bellina OUD.		5							
illa OUD**		2							
*	10	5	10		8	3	4	13	
circinelloides v.	8	3			8	3			
seo-cyanus HAG.**		3				3			
sseni LENDN.	11								
cedo (L.) BREF.**	4	5	14	14	4		7	10	14
mbeus BONORDEN		37	6	9		26	6		
emosus FRES.**	6	8	31	25	4		21	4	31
*	11	2	4			2			4
m sp.				10					3
us nigricans ENB.**.	63	64	160	103	49	51	101	64	74
ae WENT & GERS	117	106	64	175	65	58	53	127	22
halastrum racemo- (COHN) SCHROET.	1	27	11			15	6		
idium elegans LINK**	5	15	25			4	20		
l Phycomycetes	286	371	398	455	154	204	248	286	151
MYCETES									
illus alliaceus THOM HURCH			4						

Table I (cont.)

Fungus species	Total from blocks A.B.C.				Block A only				
	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	Control No. 12
A. amstelodami (MANG.) THOM & CHURCH*	14	16	8	30			8	30	
A. candidus LINK**	4		11					14	
A. chevalieri (MANG.) THOM & CHURCH**	18	6		11	6	6			
A. echinulatus (DELACR.) THOM & CHURCH*				9				5	
A. effusus TIRAB.	3	5		8					8
A. flavipes (BAIN. & SART.) THOM & CHURCH.**	6	8	5	28	6	8			13
A. flavus LINK**	15	3	35	6	3		12		13
A. fumigatus FRES.**	26	6	16	34	20		21	30	
A. glaucus LINK	6	4	4			4			
A. granulosus RAPER & THOM		4		4					
A. humicola CHAUDHURI & SACHAR	2								
A. melleus YUKAWA*-**	4	9	2	2		9			
A. nidulans (EIDAM) WINT.**	38	41	133	76	15	28	61		
A. niger v. TIEGH.**	195	132	263	255	132	51	116	128	229
A. niveus BLOCH.*-**	3	3		17				24	
A. ochraceus WILHELM	25	6	59	5		6	46		3
A. quercinus (BAIN.) THOM & CHURCH*	4								4
A. repens (CDA.) DE BARY**	3	4	3	4	3		3		3
A. rugulosus THOM & RAPER	5		3		2				4
A. sclerotiorum HUBER*	4	21	6	7	4	21	6		4
A. sulphureus (FRES.) THOM & CHURCH**	84	21	14	34	60	8		27	
A. sydowi (BAIN. & SART.) THOM & CHURCH				5					
A. tamarii KITA			7	35			7	26	9
A. terreus THOM**	59	83	46	58	24	44	23	4	11
A. ustus (BAIN.) THOM & CHURCH**	184	157	189	99	102	100	121	69	139
A. variecolor (BERK. & BR.) THOM & RAPER	9	13	28	4		19	28		6
A. versicolor (VUILL.) TIRAB.**	82	68	46	52	82	47	38	30	7
A. wentii WEHMER**	22	23	6	23	5	18	6		19
A. sp.	4	4	4		4				
Auxarthron conjugatum (KUEHN) ORR & KUEHN*				1					
Chaetomium elatum KUNZE*			4						
C. globosum KUNZE**	4	5	5	19			5	19	
C. murorum CORDA**			7	5					
C. spirale ZOPF**	4	6			4	6			
C. sp.	4	3				3			

Table I (cont.)

Fungus species	Total from blocks A.B.C.				Block A only				
	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	Control No. 12
Gymnoascus corniculatus Orr & Plunkett*	3				3				
G. reessii Baranetzky					8				
Melanospora lagenaria (Pers.) Fuckel	7		4					4	4
M. sp.*					4	4		6	
Microascus trigonosporus Emmons & Dodge*		3							
M. sp.*		4				4			
Myxotrichum sp.*			4				4		
Nectria hematococca Berk. & Br.*	9				6				4
N. sp.*	30	12	17	58	12	6	4	5	11
Neocosmospora vasinfecta E. F. Smith		13	11	3		8	4	3	7
Penicillium atramentosum Thom		6	5			6			4
P. baarnense van Beyma**		4		7		4		7	3
P. brefeldianum Dodge	2				2				
P. brevi-compactum Dierckx**		5	5	19		5	5	14	
P. chrysogenum Thom**	12			19	7			18	
P. citreo-viride Biourge				2			1	1	
P. citrinum Thom**		17		15		12		15	6
P. claviforme Bainier	7				4				6
P. corylophilum Dierckx	8	10				7			
P. decumbens Thom	3	4							4
P. expansum (Link) Thom				6				6	3
P. egyptiacum v. Beyma	13	39		8		35			
P. fellutanum Biourge	4	3							
P. frequentans Westl.**	23	11		4	14		11		6
P. frequentans series				2				2	
P. funiculosum Thom	36		30	19	11		12		39
P. fuscum (Sopp) Raper & Thom	2	6				6			
P. granulatum Bainier**	6				6				3
P. humuli v. Beyma	1	1	1	2	1			1	
P. islandicum Sopp		12				12			3
P. italicum Wehmer		3	3						
P. janthinellum Biourge**	21	14	7		10	5	7		
P. jenseni Zal.**		17	9	12		17		12	4
P. lanosum Westl.**	18		10	1	18		4		1
P. lilacinum Thom**	292	381	458	212	130	159	180	111	121
P. lividum Westl.		5				5			
P. luteum Zukal**	6				6				
P. martensii Biourge**	1	2	1						3
P. miczynskii Zal.	5	3			3				4
P. multicolor Grig. Man. & Porad.*			3	8			3	6	

Table I (cont.)

Fungus species	Total from blocks A.B.C.				Block A only				
	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	Control No. 12
P. nigricans (BAIN.) THOM**	17	8	15	11	17		15		6
P. notatum WESTL.				22				22	9
P. ochro-chloron BIOURGE*		7				4			
P. oxalicum CURRIE & THOM**	3		3				3		
P. palitans WESTL.									3
P. purpurogenum STOLL**	23				15				8
P. raciborskii ZAL.			4				4		2
P. restrictum GIL. & ABB.**	37		27	11	31		14	11	
P. rubrum STOLL**	27	61	9	32	10	29	5	9	5
P. rugulosum THOM	2			11	2				
P. steckii ZAL.**	26	18	4	10	11	3	4	15	
P. stoloniferum THOM**	4	4			4		4		3
P. tardum THOM	3				3				
P. thomii MAIRE		4		7				7	3
P. urticae BAIN.*	6	6			6				8
P. variabile SOPP		3							
P. vinaceum GILM. & ABBOTT		3				3			
P. viridicatum WESTL.	6	11				4			
P. spp.	18	14	14	17	8	11	5	9	
Rosellinia sp.*	1				1				
Sordaria fimicola (ROB.) CES & DE NOT.	1	1							
Total Ascomycetes	1526	1373	1558	1347	825	727	793	669	780
DEUTEROMYCETES									
Acrostalagmus albus PREUSS			1	6		3		6	
A. sp.*		3		5				1	
Alternaria fasciculata COOK & ELLIS		14		11		9		5	
A. geophila DASZEWSKA**	4	5				5			
A. grisea SZILVINYI**	1			3					
A. humicola OUD.**	40	26	17	15	21	8		10	
A. tenuis NEES**	25	12	20	51	10	4	23	25	3
A. sp.			7	9			3		
Botrydiplodia theobromae PAT.		27	11	28		5		5	
Botryotrichum piluliferum SACC. & MARCHAL**	3	6	3	2		3		2	4
Botrytis cinerea PERS.**			5				5		4
B. terrestris JENSEN	3				3				
B. sp.		20	8			15	8		2
Cephalosporium acremonium CDA.**	32	15	56	20	20		33	12	10
C. asperum MARCHAL									9
C. curtipes SACC.**	26	22	48	45	14	5	11	17	
C. humicola OUD.**	18	24		13	18	24		6	

Table I (cont.)

Fungus species	Total from blocks A.B.C.				Block A only				
	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	Control No. 12
C. roseo-griseum SAKSENA			4				4		4
C. sp.*	32		16	10	21		9	6	3
Chaetomella sp.*		1							
Cladosporium epiphyllum PERS.**									2
C. herbarum (PERS.) LINK**	35	22	20	8	28	6	16	8	
C. sp.*			6	2				2	
Clonostachys sp.		2							
Coccospora agricola GODDARD	3			6	3				
Coniothyrium fuckeli SACC.				3					6
C. sp.*									3
Coremium sp.			7	3			3		
Curvularia lunata (WAKK.) BOED.				11		5		6	
C. pallescens BOED.	4			14	4				
Cylindrocarpon cochinchinense BUGN.	1								
C. curtum BUGN.*				1	1				
C. curvatum HOCH.*-**	2	1				1			
C. didymum (HARTUNG) WR.	8	3	2		6	2			
C. radiciola WR.	52	32	18	18	12	13	6		2
C. sp.*	15	4	9		6				
Dicoccum asperum CDA.		1		1					
Epicoccum nigrum LINK		18	30				14		13
E. purpurascens EHRENB.				1					
E. sp.*			2						
Fusarium avenaceum (FR.) SACC.**			7						
F. culmorum (W. G. SMITH) SACC.**	3		2						
F. dimerun PENZIG**	3	2	6	7	1		4	4	2
F. equiseti (CDA). SACC.**	70	72	55	86	42	23	25	12	6
F. javanicum KOORDERS**	14			4	14			4	2
F. lateritium NEES**			5		5				2
F. merismoides CDA**	4		3					3	
F. moniliforme SHELDON emend. SNYD. & HANS.**	6	4	11	15	6	4	11	4	4
F. oxysporum SCHL. emend. SNYD. & HANS.**	36	135	55	83	15	22	30	48	22
F. sambucinum FUCKEL**	23			2	20				1
F. semitectum BERK.& RAV.**	3	5	24	14		4	6	12	8
F. solani (MART.) APPEL & WR. emend. SNYD. & HANS.**	394	484	354	578	155	184	203	368	46
Geotrichum candidum LINK			1				1		6
G. sp.*	10				3				

Table I (cont.)

Fungus species	Total from blocks A.B.C.				Block A only				
	NPH No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	Control No. 12
Gliocladium atrum GIL. & ABB.				2					
G. catenulatum GIL & ABB.	4				2				
G. fimbriatum GILL. & ABB.		3		5		3			
G. penicilloides CDA**.		6	56	8	9			8	4
G. roseum (LINK) BAIN.	28	8	5	16	28			7	
G. vermoeseni (BIOURGE) THOM**		12	42	6			20	6	8
G. sp.*	23	20	8	13	4	3			2
Gliomastix convoluta (MARCHAL) MASON	4				4				
Gonytrichum macrocladium (SACC.) HUGHES	8	10	3	3	4			3	
Graphium bulbicola HENNINGS	3								
G. sp.*	6	10	12	4	3	4	3	4	1
Helminthosporium nodulosum (BERKELEY & CURTIS) SACC.		4	5						
H. tetramerum MCKINNEY		2							
H. spp.*	15	13	7		10	11			
Heterosporium allii ELL. & MART.**		10				4			
H. terrestre R. G. ATKINSON	4			3				3	
Hormiscium stilbosporum (CORDA) SACC.	2	1							
Hormodendrum cladosporioides (FR.) SACC.**	14	15	19	7	7	5			
H. hordei BRUHNE**	13	43	22	12	13	28	5	12	9
H. nigrescens PAINE**	16	8	17	24	9		11	9	2
H. olivaceum (CDA). BONORDEN	3	3		1	3	3			
H. pallidum OUD.		5	10	18			5	13	
H. resinae LINDAU			1						
H. viride (FRES.) SACC.**	12	7	4	20	7		4	20	
H. sp.*	2				2				
Humicola brevis (GILL. & ABB.) GILMAN**	6	3	11	4	4		11		5
H. grisea TRAAEN	11		8	6					
H. nigrescens OMVIK		7		2		4		2	
H. sp.*	9					7			
Monilia acremonium DELACROIX				4				4	
M. grisea DASZEWSKA	3				3				
M. pruinosa COOKE & MASSEE		7							
M. sp.*	13	4	17	25	7			4	
Myrothecium roridum TODE			10				10		5

Table I (cont.)

Fungus species	Total from blocks A.B.C.				Block A only				
	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	Control No. 12
M. verrucaria (ALB. & SCHW.) DITM.**	28	22	19		25	12	8		10
M. sp*	4	3			4	3		4	4
Neurospora crassa SHEAR & DODGE			5				5		
Nigrospora sphaerica (SACC.) MASON**	12	15			12				
Oospora variabilis (LINDNER) LINDAU	4			6	4				8
O. sp.*				4					
Paecilomyces fimetarius (MOESZ) BROWN & SMITH*	3								
P. flavescens BROWN & SMITH*		4						4	2
P. heliothis (CHARLES) BROWN & SMITH*	3								
P. javanicus (FRIEDERIKS & BALLY) BROWN & SMITH*			3			3			
P. sp.*	26	22	8	8	7	12	6	3	12
Pestalotia sp.*	9	5	7	4	3	3	4	4	
Phoma glomerata (CDA.) WR. & HOCHAPFEL	13	27	41	4	9	16	26		14
P. hibernica GRIM. O'CON. & CUM.			5						2
P. humicola GILL. & ABB.			6				6		4
P. sp.*	17	13	23	24	6	6	12	6	2
Pyrenochaeta decipiens MARCHAL	57	15	51	8	26	12	18	5	14
P. sp.*	2	5	14				7		3
Scopulariopsis brevicaulis (SACC.) BAIN.	30	12	9	9	13	5		9	6
S. constantini BAIN.	4			5		5			
S. sp.*		2		7				4	
Sepedonium chrysospermum (BULL.) FR.	6	6	3	10	3	4			5
S. sp.*	2			2			4		1
Spicaria decumbens OUD.			3	3					
S. divaricata (THOM) GIL. & ABB.**	25	16	10	9	19	6			10
S. simplicissima OUD.	2								
S. violacea ABBOTT**	21	25	17	6		6	13	6	
S. sp.*	4	6	6	17	2	6		9	
Spondylocladella botrytioides LINDN.*		1							
Spondylocladium sp.*		1		1		1			
Sporotrichum sp.*	11	11	12	6	5	7			7
Stachybotrys alternans BONORDEN		4				3			

Table I (cont.)

Fungus species	Total from blocks A.B.C.				Block A only				
	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	NPK No. 2	NP No. 5	NPK+ manure No. 8	NPK+ incr. manure No. 11	Control No. 12
S. atra CDA.**	3	31	21	3		31	24		6
S. lobulata BERKELEY		4				4			
S. subsimplex COOKE*					2				2
S. sp.*			3						
Stachylidium bicolor LINK ex FR.*								1	
Stemphylium consortiale (THUEMEN) GROVES & SKOLKO	48	14	23		26	4	12		20
S. macrosporoideum (BERK. & BROOME) SACC.			4					3	2
S. piriforme BONORDEN	13				13				
S. sp.*	9	6		6	3	6		6	6
Stilbella sp.*		1				1			
Stysanus medius SACC.	4		7	4			7		
S. stemonites (PERS.) CDA.	56	20	24	15	30	11	13		2
S. sp.*			2						
Thielaviopsis basicola ZOPF	2	2					2		
Tilachlidium humicola OUD.**		3		10					15
T. sp.*	6		2		6		2		
Torula lucifuga OUD.		11		4				4	
T. sp.*	19	22	31	37	8	3	15		8
Trichoderma glaucum ABBOTT	84	53	25	8	30	37	6		10
T. koningi OUD.**	24	41	28	21	5	10	5	10	22
T. lignorum (TODE) HARZ**	72	86	131	94	45	62	54	34	27
Trichurus spiralis HASSELBRING*	14	12		44	4			38	4
T. sp.*	2								2
Trichothecium roseum LINK**			9	9			9	4	5
Verticillium sp.	23		10	3	14		5	3	
Volutella sp.*	18	6	32	7			14	5	
Volutina sp.	4	2	4	16				3	
Zygodesmus fuscum CDA.*		2							
Z. sp.*			2	6					
Unidentified			3	2				2	
Total Deuteromycetes	1751	1692	1667	1717	871	696	761	833	435
MYCELIA STERILIA									
Rhizoctonia sp.	4	10	4		4	10	4		
Sclerotium rolfsii SACC.	3		5						
S. sp.	22	4	14		12		7		
Unidentified		5	12	18			4	3	
Total Mycelia sterilia	29	19	35	18	16	10	15	3	0

*) Not listed by GILMAN (1957).
**) Listed by JOFFE (1963)

TABLE II

Numbers of colonies and of species isolated from the various fertilizer and manure treatments

Fungi	Total from blocks A.B.C.					Block A only				
	NPK	NP	NPK+ manure	NPK+ incr. manure	Total	NPK	NP	NPK+ manure	NPK+ incr. manure	Control
I. NUMBERS OF COLONIES										
Phycomycetes	286	371	398	455		154	204	248	286	151
Ascomycetes	1526	1373	1558	1347		825	727	793	669	780
Deuteromycetes	1751	1692	1667	1687		871	696	761	832	435
Mycelia Sterilia	29	19	35	18		16	10	15	3	0
All fungi	3592	3455	3658	3507		1866	1637	1817	1790	1366
Numbers Percent*	100	96.2	101.8	96.8		100	87.7	97.4	95.9	73.2
II. NUMBERS OF SPECIES										
Phycomycetes	18	22	17	12	32	11	13	13	11	7
Ascomycetes	66	61	48	51	97	43	38	34	29	44
Deuteromyctetes	88	86	83	89	150	66	56	50	56	59
Mycelia Sterilia	3	3	3	1	4	2	1	3	1	0
All fungi	175	172	152	153	283	122	108	100	97	110
Numbers Percent*	100	98.0	86.8	87.0		100	88.5	82.0	79.5	90.0

*) Percentage calculated in relation to NPK plots.

made for this block alone. Table II shows summaries of the figures contained in table I. The figures for NPK plots have throughout been taken as 100 %.

The species determined have been arbitrarily divided into two groups: 1) dominant species of which 50—80 or more colonies were counted, and in relation to which the effect of nutritional treatments might be assessed; and 2) rare species, which are specifically discussed only where their occurrence is of special interest.

All fungi

Taking the total of 283 species isolated and of 15,578 colonies grown as 100 %, the relative preponderance of the various fungal groups was as follows: Phycomycetes 11.1 % of species and 10.7 % of colonies; Ascomycetes 34.8 and 42.2 %; Deuteromycetes 53.1 and 46.5 %, and Mycelia Sterilia only 1.0 % and 0.6 %.

The number of species isolated was lowest on the plots supplied with organic manure and fertilizers, about equal on NP and control plots, and highest on the NPK plots. But the number of colonies was markedly lower in the controls than in any of the plots receiving nutrients. Differences between the latter were slight, with the number of colonies tending to be somewhat lower on the NP plots than on those with NPK treatment with or without manure (Table II).

Phycomycetes

The number of species and of colonies of this group was lowest in the control plots. As regards the number of colonies, the difference between controls and NP as well as fertilizer-manure plots was very considerable, but in the NPK plots colonies of Phycomycetes were hardly more numerous than in the control.

Dominant species

Colonies of the two species of *Rhizopus* were the most numerous. *Rhizopus oryzae* was by far the most frequent on plots receiving NPK and increased doses of manure, and by far the least frequent on the control plots. *R. nigricans*, on the other hand, was definitely most frequent on plots receiving NPK and the lower dose of manure, moderately frequent in those with NPK and increased doses of manure and in the control, and least frequent in NPK and NP plots. This contrasts with our findings on unirrigated, heavy soil under field crops, where *R. nigricans* was much rarer on unfertilized than on fertilized plots (JOFFE, 1963) and *R. oryzae* was absent altogether. Nor is the latter species mentioned among the soil fungi listed by GILMAN (1957), except in one case from India.

Absidia spinosa was fairly common, especially on plots with increased doses of manure, but this as well as the other 4 species of

Absidia were entirely absent from the controls. It may be worth noting that our isolates of *A. spinosa* abundantly produced zygospores.

Mucor racemosus was more frequent on control than on treated plots, again in contrast to our earlier work (JOFFE, 1963).

Rare species

Absidia butleri has been found in many of the southern states of the U.S. (GILMAN, 1957), and especially on forest soils (HODGES, 1962; MILLER *et al.*, 1957). *A. orchidis* has so far been recorded chiefly from temperate climates (GILMAN, 1957).

Actinomucor corymbosus has not been recorded previously as a soil fungus except in Israel (RAYSS & BORUT, 1958).

Cunninghamella bainieri has previously been noted as a soil fungus only from Israel (RAYSS & BORUT, 1958; JOFFE, 1963), and *C. blakesleeana* from Somali (SAPPA & MOSCA, 1954a).

Dicranophora sp. is here for the first time recorded from Israel. It has not been mentioned in literature as a soil fungus.

Mortierella isobellina is known chiefly from the forest soils in the southern U.S. (HODGES, 1962; MILLER *et al.*, 1957). *M. pusilla* has been described only from Europe and Canada (GILMAN, 1957) and in our earlier paper (JOFFE, 1963).

Ascomycetes

The number of Ascomycetes species in the NPK and control plots (43—44) slightly exceeded that in the NP plots (38), but was markedly higher than that in plots receiving manure and fertilizers (29—34). The number of colonies of this group was appreciably smaller in the plots receiving increased doses of manure than in all other plots.

Dominant species

Aspergillus niger developed far more colonies in the controls than in the NPK and manure-fertilizer plots and this species was particularly infrequent in the NP plots. The preponderance of *A. niger* in the control plots is in complete contrast with our earlier finding (loc. cit.), as on unirrigated crop land we found only a fourth as many isolates of this fungus in control, as compared with manured plots.

As regards *A. ustus*, the differences between control and treatment plots were considerable, especially with regard to the plots with NPK and increased manure, where this species was less frequent. *A. nidulans* was prominent in the plots receiving NPK with the lower dose of manure, but was entirely absent from the controls and this agrees with our earlier work. *A. sulphureus*, on the other hand, was by far the most frequent in the NPK plots, and this was also true for *A. versicolor*. Both these species were rare in,

or absent from, the control plots. The only species of *Aspergillus* markedly more frequent on NP plots than on any of the others was *A. terreus*.

Among the 48 species of *Penicillium*, *P. lilacinum* was by far the most numerous; there was little difference in its frequency in the controls and most of the treated plots, but the highest number of colonies was obtained from the plots receiving NPK with the lower dose of manure. *P. restrictum* was entirely absent from control and NP plots while fairly frequent on others whereas *P. rubrum* was most prominent on the NP plots.

Rare species

Of the 30 species of *Aspergillus*, *A. echinulatus* and *A. effusus* do not appear in literature as soil fungi; and the following have been recorded only in rare instances:
A. alliaceus from India and Texas (GILMAN, 1957) and from Israel (RAYSS & BORUT, 1958); *A. humicola* from India (GILMAN, 1957; DUTTA & GHOSH, 1965); *A. melleus* from Israel (RAYSS & BORUT, 1958; JOFFE 1963); *A. niveus* and *A. sclerotiorum* from Israel (loc. cit.) and India (DUTTA & GHOSH, 1965); *A. quercinus* from Somali (SAPPA & MOSCA, 1954a) and Israel (RAYSS & BORUT, 1958).

Auxarthron conjugatum has been mentioned by ORR *et al.* (1963a) from soil in southern U.S.A. The same authors (1963b) record *Gymnoascus corniculatus* from soil in California. *Chaetomium elatum* has not previously been referred to as soil fungus.

Microascus trigonosporus has been recorded in Israel (RAYSS & BORUT, 1958); and *Nectria hematococca* in Honduras (GOOS, 1963).

Of the 49 species of *Penicillium*, the following have been recorded rarely: *P. brefeldianum* from Egypt and *P. humuli* from Panama (GILMAN, 1957); *P. citreo-viride* from Georgia (MILLER *et al.*, 1957) and Austria (GILMAN, 1957); *P. lividum* from North America, England and the U.S.S.R. (GILMAN, 1957) and from Australia (MCLENNAN & DUCKER, 1952); *P. martensi* from Poland, Wisconsin (GILMAN, 1957), Georgia (MILLER *et al.*, 1957) and Israel (JOFFE, 1963); *P. multicolor* from the southern U.S. (HODGES, 1962), Somali (SAPPA & MOSCA, 1954b) and Israel (RAYSS & BORUT, 1958); *P. ochro-chloron* from Israel (RAYSS & BORUT, 1958); *P. tardum* from Canada (GILMAN, 1957) and India (DUTTA & GHOSH, 1965); and *P. urticae* from Somali (SAPPA & MOSCA, 1954b) and Australia (MCLENNAN & DUCKER, 1952).

Sordaria fimicola has been recorded in Georgia (MILLER *et al.*, 1957) and Honduras (GOOS, 1963).

Deuteromycetes

The number of Deuteromycetes species did not differ greatly in the various series of plots, but the number of colonies was much lower in the control than in the plots receiving nutrients. This was due largely to the low number of colonies of Fusaria in the controls.

Dominant species

By far the most frequent species of the group was *Fusarium solani*; its colonies were more numerous in the plots receiving increased doses of manure than in other treated plots, but fewer in the controls. This prevalence of *F. solani* in irrigated, light citrus soil is in complete contrast with the low numbers of this species found in unirrigated, heavy soil under field crops in Israel (JOFFE, 1963). Other species of *Fusarium* of common occurrence in our samples were *F. equiseti* and *F. oxysporum*, but the effect of nutrient treatments on their frequency was not clear cut.

Of the species of *Trichoderma*, *T. glaucum* was more frequent on NPK and NP plots than on those receiving manure and on the controls. *T. koningi* was most frequent in the controls, while *T. lignorum* was somewhat more frequent in plots receiving NPK with small doses of manure than in all other series. (These plots exhibited the lowest incidence of *F. solani*.)

Cylindrocarpon radicicola was considerably more frequent in NPK and NP plots than in those receiving manure or in the control. *Pyrenochaeta decipiens*, previously described from citrus soils in Egypt (SABET, 1935) and another as yet unidentified species of this genus, were most common in plots given NPK and NPK with manure. *Stemphylium consortiale* and *Stysanus stemonites* were both at least twice as frequent in the NPK plots than in any of the others.

Rare species

The following species have only rarely been recorded as soil fungi:

Alternaria grisea in Israel (RAYSS & BORUT, 1958) and Sumatra (GILMAN, 1957).

Botrytis terrestris in North America and China (GILMAN, 1957).

Cylindrocarpon cochinchinense nowhere as soil fungus, but in Indochina on a plant host (BUGNICOURT, 1939); and *C. curtum* in Israel in the soil (JOFFE, 1963) and in Indochina on another host (BUGNICOURT, 1939).

Dicoccum asperum in Canada, Colorado, New Jersey and the U.S.S.R. (GILMAN, 1957) and in India (DUTTA & GHOSH, 1965).

Epicoccum purpurescens in Egypt (GILMAN, 1957), Somali (SAPPA & MOSCA, 1954a) and France (MOREAU, 1951).

Gliocladium atrum in Canada, Louisiana (GILMAN, 1957) and India (DUTTA & GHOSH, 1965); and *G. fimbriatum* in China and the southern U.S. (GILMAN, 1957).

Gliomastix convoluta in Canada (GILMAN, 1957), Central America (GOOS, 1960 & 1963), and Georgia (MILLER *et al.*, 1957).

Gonytrichum macrocladium in Central America (GOOS, 1963) and Canada (GILMAN, 1957).

Helminthosporium tetramerum in Canada and India (GILMAN, 1957).

Hormiscium stilbosporum in the northern U.S.S.R. (GILMAN, 1957).

Hormodendrum resinae in Austria (GILMAN, 1957) and Israel (RAYSS & BORUT, 1958).

Monilia grisea in Switserland (GILMAN, 1957).

Neurospora crassa in Central America (GOOS, 1960).

Paecilomyces: three of the four species in our list have nowhere been recorded as soil fungi; *P. flavescens* has been found in forest nursery soil in England (BROWN & SMITH, 1957) and other species of this genus have been isolated from soil by HODGES (1962), MILLER *et al.* (1957), and by KAUFMAN & WILLIAMS (1965).

Phoma hibernica in Canada (GILMAN, 1957) and Israel (RAYSS & BORUT, 1958).

Spicaria simplicissima in Holland and the U.S. (GILMAN, 1957).

Stachyobotrys alternans in Porto Rico (GILMAN, 1957) and the U.S.S.R. (PODOPLICHKA, 1953); *S. lobulata* in Costa Rica, Iowa, Egypt, (GILMAN, 1957) and the U.S.S.R. (PODOPLICHKA, 1953); and *S. subsimplex* in the Ivory Coast (MOREAU, 1951).

Neither *Spondylocladella botrytioides* nor *Stachylidium bicolor* have been recorded as soil fungi.

Actinomycetes, yeasts and bacteria

In the samples taken in winter (1959, 1960), actinomycetes, yeasts and bateria were common at 20 cm depth, less so at 50 cm and least common at 5 cm. However, in the samples taken in autumn, no such distinction between samples taken at various depths was apparent, and the organisms occurred at all depths with much greater frequency.

DISCUSSION

Species rare or new as soil fungi

Of the 283 species listed in Table I, 75 species (marked in the table) are not listed by GILMAN (1957). These include 6 species of Phycomycetes, 21 of Ascomycetes, and 48 of Deuteromycetes. Of the species new or rare as soil fungi, it is of special interest to note that *Rhizopus oryzae* was abundant, and that species of *Paecilomyces* were not only numerous (at least 5) but also fairly common. A fuller description of the new species will be given elsewhere.

Relationship between species of Fusarium and Trichoderma

As pointed out in detail elsewhere (JOFFE, 1966), a neat inverse relation is apparent in our results between the numbers of colonies of *Fusarium solani* and *Trichoderma lignorum* present in any one sample. This relation does not apply to other species of *Fusarium* (*F. oxysporum*, *F. equiseti*) and of *Trichoderma* (*T. koningi*, *T. glaucum*).

In view of the large total number of colonies of *T. lignorum* apparent in our list, it may surprise to find that the number of *F.*

solani colonies is even much larger. This can be explained on the basis of figures presented in Table III which show that in the absence of *F. solani* the number of colonies of *T. lignorum* averaged less than half as much as the number of colonies of *F. solani* obtained in the absence of *T. lignorum* and that moreover *T. lignorum* was absent in far more samples than *F. solani*.

TABLE III

Quantitative relation between the occurrence of colonies of Fusarium solani and Trichoderma lignorum in soil samples from a citrus grove in Israel

No. of samples	Mean No. of colonies of	
	F. solani	*T. lignorum*
54	32.2	0
22	0	14.8

Effects of fertilizers and manure on some soil fungi

In a limited number of cases the effect of the various fertilizer and manure treatments, or of the lack of nutrients, has been clear-cut.

No nutrients

In the absence of any fertilization or manuring only two fungi, both species of *Aspergillus*, occurred more commonly in the control plots than in any of the others. This was most evident in the case of *A. niger*, with 229 colonies in the controls as against 51—132 in the treated plots, while with *A. ustus* the differences were smaller. On the other hand, the lack of nutrients had a marked depressing effect on *Rhizopus oryzae* (22 v. 53—127), total *Fusaria* (93 v. 237—455), and *F. solani* (46 v. 155—368), and on *Aspergillus versicolor* (7 v. 30—82).

NPK with higher dose of manure yielded markedly higher numbers of colonies than any other treatment in the cases of *Fusarium solani* (368 v. 46—203) and of *Rhizopus oryzae* (127 v. 22—65).

NP. In the absence of potassium an increase was apparent in the number of colonies of the three species of *Trichoderma* taken together (109 v. 44—80), and of *Aspergillus terreus* (44 v. 4—24). However, growth of *A. niger* was depressed (51 v. 116—229).

Fungi associated with citrus and citrus soils in California and Israel

In his study on the fungus flora of some California soils in relation to slow decline of citrus trees, MARTIN (1947) states that the most important groups of fungi from the point of view of numbers and frequency of occurrence were the species of *Penicillium, Fusa-*

rium and *Aspergillus*, while forms of *Trichoderma*, *Mucor* and *Rhizopus* were less frequently encountered. Our results are very much alike, except for the comparative frequency of colonies of *Trichoderma* and *Rhizopus*, due mainly to the common occurrence of *T. lignorum* and *R. oryzae*, - MARTIN (1947) further mentions as consistently isolated from old citrus soils, a species of *Pyrenochaeta* as well as *Stemphylium piriforme*. The latter was only occasionally found by us, but we found two species of *Pyrenochaeta*, of which *P. decipiens* was fairly common.

In another study, MARTIN (1950) found *Cylindrocarpon radicicola* to be the cause of citrus seed decay and to infect seedling roots. *Fusarium solani* and *Pyrenochaeta* sp., together, inhibited germination and caused seed decay, and *Aspergillus ochraceus*, *Stemphylium piriforme* and *Thielaviopsis basicola* tended to reduce root growth. This adds significance to the frequency with which we found the first three fungi in our citrus soil. *A. ochraceus* was less common, *S. piriforme* and *Th. basicola* infrequent.

Comparison of mycoflora in irrigated grove and unirrigated field

A comparison may be of interest between the mycoflora outlined above in an old established, irrigated citrus grove on light soil and that determined in an unirrigated field under a rotation of field crops on heavy soil (JOFFE, 1963). The grove and the field are only a few hundred metres apart at Miqve Israel, the techniques of study were identical, and the number of samples taken was very similar (114 in the grove, 110 in the field). The comparison may therefore bear quantitative as well as qualitative aspects.

As regards the number of fungal species, the grove was found much richer (283 v. 147), containing at least twice as many species of Phycomycetes and Deuteromycetes than the field, and 60 % more Ascomycetes (97 v. 60). However, a different relationship was obtained with regard to certain important genera, with the species of *Penicillium* only slightly more (48 v. 36) and those of *Fusarium* only half as numerous (12 v. 23) in the grove as in the field. All fungal species found in the field as well as in the grove have been marked by an asterisk in Table I. Ten species of Phycomycetes, 39 of Ascomycetes and 41 of Deuteromycetes were found both in the grove and the field.

From a qualitative aspect, the following species that were common in the grove (at least 70 colonies) were entirely absent from the field: *Rhizopus oryzae*, *Cylindrocarpon radicicola*, *Pyrenochaeta decipiens*, *Stysanus stemonites*, and *Trichoderma glaucum* and 5 species of *Paecilomyces*. Species very rare (1—4 colonies) in the field but common in the grove were *Cephalosporium curtipes*, *C. humicola*, *Hormodendron hordei*, *Myrothecium verrucaria*, *Spicaria violacea*. Of the fungi extremely common (more than 300 colonies) in the grove the following comparative figures with the field may be given:

Aspergillus niger 850 vs. 129, *A. ustus* 630 vs. 20, *Penicillium lilacinum* 1340 vs. 72, *Fusarium solani* 1800 vs. 26, *F. oxysporum* 306 vs. 107, *Trichoderma lignorum* 403 vs. 17.

Summary

A qualitative and quantitative study of the mycoflora has been carried out over 4 years in the central coastal plain of Israel in a grove of Shamouti oranges on plots receiving applications of NPK or NP fertilizers or NPK amended by various amounts of sheep manure. These differential nutrient treatments have been applied to the grove as from 1945.

Of the total of 283 fungal species and 15,578 colonies isolated, Phycomycetes represented 11.1 % of species and 10.7 % of colonies, Ascomycetes 34.8 and 42.2, Deuteromycetes 53.1 and 46.5 and Mycelia sterilia only 1.0 and 0.6.

The dominant species found were *Rhizopus oryzae* (not hitherto known as a prominent soil fungus), *Aspergillus niger, A. ustus, A. nidulans, A. sulphureus, A. versicolor,* and *A. terreus*; *Penicillium lilacinum, Fusarium solani, F. oxysporum* and *F. equiseti*; and *Trichoderma lignorum, T. glaucum* and *T. koningi.* The fairly common occurrence of *Cylindrocarpon radicicola* and *Pyrenochaeta decipiens* may be of significance in view of the pathogenic potentialities of these species.

The fungi less commonly or rarely recorded in this study include 12 species not previously mentioned in literature as soil fungi, 5 species previously recorded only from Israeli soils, and at least 25 further species of rare occurrence in the soil flora.

An inverse relation has been found to exist between the numbers of colonies of *Fusarium solani* and of *Trichoderma lignorum.*

Lack of nutrients in the soil increased prevalence of *Aspergillus niger* and *A. ustus,* but depressed that of *A. versicolor, Rhizopus oryzae* and *Fusarium solani.* The latter two species developed most abundantly on plots supplied with NPK and large doses of sheep manure. Lack of K increased prevalence of three species of *Trichoderma* but depressed that of *A. niger.*

Comparisons are made between the mycoflora of the Israeli grove studied and of citrus groves in California, and between that of the grove and a nearby field of unirrigated field crops.

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Dr. H. H. KUEHN kindly identified the species *Gymnoascus corniculatus,* and Dr. S. BORUT identified *Penicillium humuli* and *P. variabile.*

Literature

ATKINSON, R. G. 1952. A new species of Heterosporium from soil. Mycologia **44**: 813—822.

BILAI, B. J. 1955. The Fusaria. Publ. Acad. Sci. Ukr. SSR. Kiev. 320 pp. (in Russian).

BROWN, A. H. S. & SMITH, G. 1957. The genus Paecilomyces Bainier and its perfect stage Byssochlamys Westling. Trans. Brit. Mycol. Soc. **40**: 17—89.

BUGNICOURT, F. 1939. Les Fusarium et Cylindrocarpon de l'Indochine. Encycl. Mycol. **XI**, 206 p.

CUTTER, V. M. 1946. The genus Cunninghamella (Mucorales). Farlowia **2**: 321—343.

DINGLEY, J. M. 1951. The Hypocreales of New Zealand. II. The genus Nectria. Trans. Roy. Soc. New Zeal. **79**, 2: 177—202.

DUTTA, B. G. & GHOSH, G. R. 1965. Soil from Orissa (India). IV. Soil fungi of paddy fields. Mycopathol. et Mycol. appl. **25**, 316—322.

FITZPATRICK, H. M. 1930. The lower Fungi Phycomycetes. McGraw Hill Co. 331 p.

GILMAN, J. C. 1957. A manual of the soil fungi. 2nd ed. The Iowa State Coll. Press, Ames, Iowa, 450 p.

GOOS, R. D. 1960. Soil fungi from Costa Rica and Panama. Mycologia **52**: 877—883.

GOOS, R. D. 1963. Further observations on soil fungi in Honduras. Mycologia **55**: 142—150.

GORDON, W. L. 1952. The occurrence of Fusarium species in Canada. II. Prevalence and taxonomy of Fusarium species in cereal seed. Canad. J. Bot. **38**: 209—251.

GROVES, J. W. & SKOLKO, A. J. 1944. Notes on seed-borne fungi. I. Stemphylium. Canad. J. Res., C. **22**: 190—199.

GROVES, J. W. & SKOLKO, A. J. 1945. Notes on seed-borne fungi II. Curvularia. Canad. J. Res. ,C. **23**: 94—104.

HODGES, CH. S. 1962. Fungi isolated from southern forest tree nursery soils. Mycologia **54**: 221—229.

HUGHES, S. J. 1951. Stachylidium, Gonytrichum, Mesobotrys, Chaetopsis and Chaetopsella. Trans. Brit. mycol. Soc. **34**: 551—576.

JOFFE, A. Z. 1963. The mycoflora of a continuously cropped soil in Israel, with special reference to effects of manuring and fertilizing. Mycologia **55**: 271—282.

JOFFE, A. Z. 1966. Quantitative relations between some species of Fusarium and Trichoderma in a citrus grove in Israel. Soil Science **102**: 240—243.

KAUFMAN, D, D. & WILLIAMS, L. E. 1965. Effect of mineral fertilization and soil reaction on soil fungi. Phytopath. **54**: 134—139.

LINDER, D. H. 1934. North American Hyphomycetes. II. New species and a new genus. Mycologia **26**: 436—440.

MARTIN, J. P. 1947. Fungus flora of some California soils in relation to slow decline of citrus trees. Soil Sci. Soc. of America Proc. 1947, **12**: 209—214.

MARTIN, J. P. 1950. Effect of soil fungi on germination of sweet orange seeds and development of the young seedlings. Soil Sci. Soc. of America Proc. 1949, **14**: 184—188.

MCLENNAN, E. I. & DUCKER, C. 1952. The description and distribution of the species of Penicillium Link in some Victorian soils. Proc Roy. Soc. Victoria **64**: 1—71

MILLER, J. H., GIDDENS, J. E. & FOSTER, A. A. 1957. A survey of the fungi of forest and cultivated soils of Georgia. Mycologia **49**: 779—808.

MOREAU, CL. & M. 1951. Sur quelques Hyphomycètes. Bull. Soc. Linn. Normand., 9 sér., **6**: 71—82.

NAUMOV, N. A. 1939. Clés des Mucorinées. Paul Lechevalier, Paris. 137 p.

OMVIK, AASA. 1955. Two new species of Chaetomium and one new Humicola species. Mycologia **47**: 748—757.

ORR, G. F., KUEHN, H. E. & PLUNKETT, O. A. 1963a. A new genus of the Gymnoascaceae with swollen peridial septa. Canad. J. Bot. **41**: 1439—1456.

ORR, G. F. KUEHN, H. H. & PLUNKETT, O. A. 1963b. The genus Gymnoascus Baranetzky. Mycopathol. et Mycol. appl. **21**: 1—18.

PIDOPLICHKA, N. M. 1953. The mycoflora of rough fodder. Publ. Acad. Sci. Ukr. USSR, 486 p. (in Russian).

RAPER, K. B. & C. THOM. 1949. Manual of the Penicillia. The Williams and Wilkins

Company, Baltimore, 875 pp.
RAYSS, T. & BORUT, S. 1958. Contribution to the knowledge of soil fungi in Israel. Mycopathol. et Mycol. appl. **10**: 142—174.
SABET, Y. S. 1935. A preliminary study of the Egyptian soil fungi. Egypt. Univ. Bull. Fac. Sci., **5**: 1—29.
SAKSENA, S. B. 1955. A new species of Cephalosporium. Mycologia **47**: 895—898.
SAPPA, F. & MOSCA, A. M. 1954a. Ricerche sulla micoflora dei terreni forestali Somali. Allonia **2**: 145—153.
SAPPA, F. & MOSCA, A. M. 1954b. Ricerche sulla micoflora dei terreni della savanna spinosa Somala. Allonia **2**: 195—238.
SCHOL-SCHWARZ, M. B. 1959. The genus Epicoccum Link. Trans. Brit. mycol. Soc. **42**: 149—173.
SKOLKO, A. J. & GROVES, J. W. 1948. Notes on Seed-borne Fungi. V. Chaetomium species with dichotomously branched hairs. Canad. J. Res. C. **26**: 269—280.
SKOLKO, A. J. & GROVES, J. W. 1953. Notes on Seed-borne Fungi. VII. Chaetomium. Canad. J. Bot. **31**: 779—809.
SNYDER, W. C. & H. W. HANSEN 1940. The species concept in Fusarium. Amer. J. Bot. **27**: 64—67.
SNYDER, W. C. & HANSEN, H. W. 1941. The species concept in Fusarium with reference to Section Martiella. Amer. J. Bot. **28**: 738—742.
THOM, C. & RAPER, K. B. 1939. The Aspergillus nidulans group. Mycologia **31**: 653—669.
THOM, C. & RAPER, K. B. 1945. A Manual of the Aspergilli. The Williams and Wilkins Co., Baltimore, 373 pp.