# Microbiological Analysis of three Profiles of a Xerorthent Soil in Greece with Particular Emphasis on Microfungi

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Zusammenfassung. — Drei Waldbodenprofile (xerorthent) unter *Quercus coccifera — Dorycnium herbaceum* Vegetation in 460—480 m Seehöhe im Gebiet der Chalkidike, N-Griechenland, wurden mikrobiologisch untersucht. Nach einmaliger Probennahme wurden in den $A_1$-, $A_3$- und B/C-Horizonten Bakterien, Pilze und zellulolytische Mikroorganismen ausgezählt, Dehydrogenase-Aktivität und gesamte Biomasse bestimmt nebst zahlreichen physikalischen und chemischen Bodendaten. Die drei Profile enthielten eine quantitativ reiche Mikroflora, die mit zunehmender Bodentiefe rasch abnahm. Das Pilzspektrum wurde mittels Plattenguss, Warcup's Bodenplatten und Bodenwaschung auch qualitativ untersucht. *Penicillium*-, *Aspergillus*- und *Cladosporium*-Arten dominierten nebst etlichen anderen Hyphomyceten und zwei *Mucor*-Arten (insgesamt 52 Arten, 37 neu für Griechenland). Geringe Unterschiede zwischen den Horizonten der drei Profile und den entsprechenden Horizonten zwischen den Profilen liessen noch kein deutliches Muster erkennen.

## Introduction

Soil fungi have been extensively studied in many areas of the world. Up to the present time relatively little research on soil fungi in Greece has been undertaken. Pugh (1964) investigated the occurrence of cellulolytic soil fungi near Athens, while Satanimi (1970) surveyed the soil ascomycetes of Mt. Pelion in Central Greece. Pantidou (1973) gave a comprehensive review of the fungal species so far known in Greece. Thanasoulopoulos & Kitsos (1977) published a short paper on soil fungi in a Patras soil in Southern Greece.

The aim of the present investigation was to obtain information on the populations of bacteria and fungi in the horizons of a forest soil in Greece and to determine their relationship with a variety of soil factors.

## Soil and Vegetation

The mountain-side chosen for this analysis was an area of undisturbed dry forest vegetation unsuitable for agriculture about 470 m above sea level, at roughly 40° 25′ N and 23° 26′ E. The sites studied were situated along the road between Paleokastron village and the town of Polygyros in Northern Greece (Fig. 1).

According to American Classification System of soils (7th approximation), the investigated soil is classified as Typic Xerorthent (Entisol). (Soil Survey Staff, 1975).

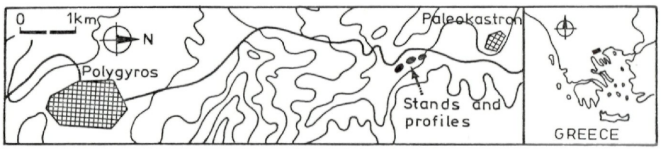


Fig. 1. Situation of the sampling locality

## Soil sampling

The three stands studied (Fig. 2) lie at 300 meters distance from each other on a mountain slope. All soil samples were collected in October 1979. After discarding the organic horizons, a soil pit was dug to expose the mineral horizons. A flamed spatula was used to scrape a vertical wall of the pit and to remove any contaminating soil present from other horizons. Composite samples (six subsamples) weighing approximately 1 kg were taken with a flamed spatula from each distinguishable layer in sterilized polyethylene bags. The sampling tools were wetted with 70% ethanol and flamed each time before use. The samples were stored overnight at 2—3° C and analysed the next day. They were passed through a 2 mm sieve; a small portion of each composite sample was used for making bacterial und fungal isolations; the remaining larger portions were air dried and used for conducting physical and chemical analyses.

## Isolation and identification of microorganisms

For the isolation of microorganisms dilution plates, soil plates (Warcup, 1950), and soil washing (modification by Gams & Domsch, 1967) were used.

For the dilution plates aliquots of 10 g soil were suspended in 95 ml sterile water, shaken mechanically for 30 min. A dilution series (1/500, 1/1000, 1/10.000 and 1/100.000) were prepared. 1-ml aliquots from the appropriate dilution were pipetted on the top of each of the prepared plates. By gentle rotation the soil suspension was spread evenly over the plate. The final dilutions selected would yield about 30—300 bacterial colonies and 30—60 fungal colonies. Three replicates were prepared each for fungi, bacteria and cellulolytic microorganisms. The plates were incubated at 25° C, 4 days for bacteria, 7—10 days for fungi and 16 days for cellulolytic microorganisms. For the isolation of aerobic bacteria

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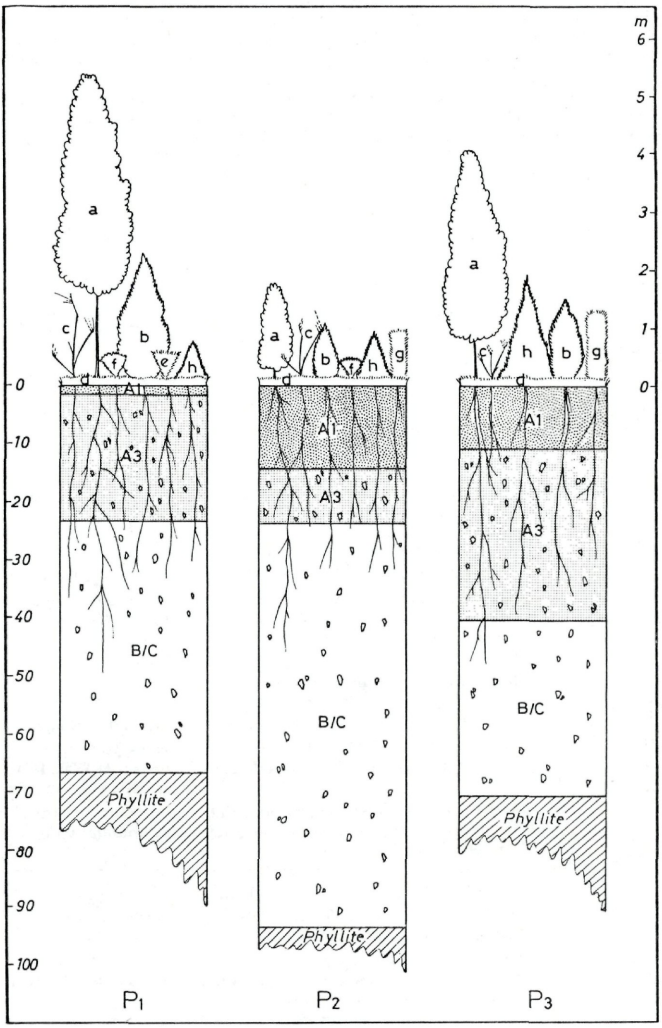
Fig. 2. Profiles of the forest soil studied. *Quercus pubescens* Willd. (a) *), *Q. coccifera* L. (b), *Erica arborea* L. (c). The most important herbs (d) of the ground layer are *Trifolium arvense* L.; *Dorycnium hirsutum* (L.) Ser.; *Filipendula vulgaris* Moench; *Thymus sinthorpi* Bentham; *Vicia tenuifolia* Roth.; *Anthoxanthum odoratum* L. and *Geranium sanguineum*. L. *Arbutus unedo* L. (e). *Cistus incanus* L. *ssp. creticus* (Loisel.) Heywood (f). *Juniperus communis* L. (g). *Phillyrea media* L. (h)

*) The small letters in parentheses of this section represent trees, shrubs or grasses.



(heterotrophs) BUNT & ROVIRA's (1955) soil extract agar pH 7.0 was used. For the isolation of fungi Czapek's — Dox agar with 5 g of yeast extract $l^{-1}$ pH 6.0 with aureomycin 30 $\mu g\ ml^{-1}$ and penicillin 10 $\mu g\ ml^{-1}$ was used. For the isolation of cellulolytic microorganisms Cellulose — agar pH 7.0—7.5 (EGGINS & PUGH, 1962) was used. For the reduction of fungal development on the isolation media actidione (50 $\mu gml^{-1}$) was used.

Fungi were identified to species. For the identification of *Aspergillus*, *Gliocladium* and *Paecilomyces* Czapek-Dox agar and 2% malt extract were used. *Mucor* was cultured on soil extract agar. *Penicillium* was cultured on Czapek yeast autolysate agar (CYA) 2% malt extract agar and 25% glycerol nitrate agar (PITT, 1980). *Penicillium* isolates were subcultured on these media and

Table 1. General characterisation of the three stands and profiles

| | | | | |
|---|---|---|---|---|
| Stand characteristics | Stand | $S_1$ | $S_2$ | $S_3$ |
| | Altitude | 480 m | 470 m | 460 m |
| | Exposition | NW | NW | SW |
| | Inclination | 20° | 40° | 30° |
| Soil profiles | | $P_1$ | $P_2$ | $P_3$ |
| Soil horizon | Aoo | 1—2 cm | 2—3 cm | 1—3 cm |
| | | Fresh or slightly altered dead organic material (litter), consisting mainly of leaves of *Quercus coccifera* and *Q. pubescens*, mosses and lichens. | | |
| | $A_1$ | 1.5—2 cm | 10—15 cm | 8—10 cm |
| | | Very dark greyish-brown (10YR 3/2)*) sandy loam very fine. | Very dark greyish-brown (10YR 3/2) loam. | Very dark greyish-brown (10YR 3/2) sandy loam very fine. |
| | | fine crumb structure; with roots. | | |
| | $A_3$ | 20—22 cm | 8—12 cm | 30—32 cm |
| | | Dark brown (7.5YR 4/4) loam | Dark brown (7.5YR 4/4) loam | Dark yellowish brown (10YR 4/4) sandy loam very fine |
| | | With roots; frequent coarse and fine roots; coarsely granular structure; enough medium and fine pores; abundant angular gravels 5—10 cm. | | |
| | B/C | 40—45 cm | 60—70 cm | 30—34 cm |
| | | Yellowish red (5YR 4/6) clay loam. | Yellowish red (5YR 4/6) loam. | Dark reddish brown (2.5 YR 3/4) clay loam |
| | | Coarsely granular structure; abundant angular gravels. Amount of roots less than in $A_3$. | | |

*) Colour symbols according to MUNSELL (1975).

incubated at 25° C, 37° C and 5° C. Microscopic description of its conidiophores was made only from colonies grown on (CYA) at 25° C after 7 days incubation. The remaining isolates were subcultured on oat meal agar.

## Physical, chemical and microbiological analyses (table 2)

Moisture content was determined after drying at 105° C to constant weight. pH by the paste method. $CaCo_3$ content by ALLISON & MOODIE (1965) method. Organic matter by WALKLEY & BLACK's (1934) method. Total nitrogen by KJELDAHL's method. Exchangeable $Ca^{2+}$ and $Mg^{2+}$ by the EDTA method, exchangeable $Na^+$ and $K^+$ by flamephotometer and total cation exchange capacity (cec), by ALEXIADES-PAXINO's (1967) method. Grain size distribution analysis by the pipette method. Soil color according to MUNSELL (1975). Microbial activity determinating the dehydrogenase activity with 2, 3, 5-triphenyl tetrazolium chloride (LENHARD, 1956). Microbial biomass by partial

Table 2. Physical and chemical analysis of soil

| Soil profiles | Horizons | K | pH | $CaCO_3$ % | C % | Organic matter % | N g% | C/N | Exchangeable cations (me/100 g of soil) $Ca^{++}$ | $Mg^{++}$ | $Na^+$ | $K^+$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | 48.8 | 7.4 | 0.3 | 2.9 | 5.0 | 0.2 | 15.3 | 14.0 | 4.1 | 0.07 | 0.07 |
| $P_1$ | $A_3$ | 30.4 | 7.3 | 0.4 | 1.1 | 1.9 | 0.1 | 13.0 | 16.3 | 4.0 | 0.09 | 0.10 |
| | B/C | 20.7 | 7.0 | 0.1 | 1.0 | 1.7 | 0.1 | 12.4 | 14.0 | 3.3 | 0.10 | 0.38 |
| | $A_1$ | 48.3 | 7.4 | 0.3 | 5.1 | 8.8 | 0.4 | 14.0 | 14.2 | 6.0 | 0.09 | 0.25 |
| $P_2$ | $A_3$ | 38.9 | 7.2 | 0.4 | 1.2 | 2.2 | 0.1 | 13.4 | 14.1 | 8.0 | 0.09 | 0.10 |
| | B/C | 22.9 | 6.5 | 0.0 | 0.4 | 0.8 | 0.1 | 10.0 | 14.1 | 3.3 | 0.04 | 0.25 |
| | $A_1$ | 21.7 | 7.8 | 4.4 | 6.3 | 11.0 | 0.4 | 15.0 | 12.4 | 6.0 | 0.07 | 0.07 |
| $P_3$ | $A_3$ | 18.2 | 7.7 | 0.5 | 1.3 | 2.3 | 0.1 | 13.5 | 10.7 | 10.0 | 0.09 | 0.10 |
| | B/C | 18.2 | 7.0 | 0.0 | 0.7 | 1.2 | 0.1 | 13.0 | 12.0 | 4.2 | 0.09 | 0.13 |

| Soil profiles | Horizons | Water holding capacity g% | T-cec me/100 g of soil | Base saturation | Grain size distribution analysis Sand g% | Silt g% | Clay g% |
|---|---|---|---|---|---|---|---|
| | $A_1$ | 44.6 | 18.3 | 99.9 | 56.2 | 30.4 | 15.0 |
| $P_1$ | $A_3$ | 31.1 | 20.6 | 100.0 | 47.2 | 38.0 | 13.2 |
| | B/C | 43.4 | 17.6 | 99.9 | 34.2 | 34.0 | 30.0 |
| | $A_1$ | 77.7 | 20.4 | 99.9 | 44.3 | 41.0 | 17.0 |
| $P_2$ | $A_3$ | 24.9 | 22.0 | 100.0 | 48.2 | 41.0 | 12.0 |
| | B/C | 44.2 | 18.0 | 99.0 | 36.6 | 37.0 | 25.0 |
| | $A_1$ | 90.0 | 18.0 | 99.0 | 52.0 | 35.0 | 16.0 |
| $P_3$ | $A_3$ | 41.0 | 21.0 | 99.0 | 51.4 | 35.2 | 15.0 |
| | B/C | 47.5 | 16.0 | 99.9 | 39.1 | 34.0 | 27.0 |

$$K = \frac{\text{water holding capacity}}{\text{moisture content}} \times 100$$

sterilization — reinoculation (JENKINSON, 1966). For comparison of fungal populations the following calculations were used:

$$\text{abundance } (\%) = \frac{\text{number of isolates of a particular species}}{\text{Total number of isolates}} \times 100$$

SÖRENSEN's similarity coefficient: $c = \frac{2\,w}{\alpha+\beta}$

$\alpha$ = total number of species in one population
$\beta$ = total number of species in the other of population
w = the number of species common to both populations.

SPEARMAN's coefficient: $r = 1 - \frac{6.\Sigma d^2}{N\,(N^2-1)}$ (WOLF, 1968).

## Results and Discussion

a. Overall determinations.

Total counts of microorganisms are given in table 3. Microfungal populations were generally high (e. g. 559,000 propagules per g of dry soil in $A_1$ horizon of $P_3$).

The highest numbers of all microorganisms occurred in the $A_1$ horizon, falling off gradually, with depth in all profiles. This effect was correlated with the organic matter and Ca contents.

The Ca/Mg ratios in all horizons ranged between 1.11 and 4.25, influencing to soil penetrability, soil air capacity, and movement of soil water (ALEXIADES, 1967).

The cation exchange capacities were satisfied mostly by calcium and magnesium and the soils are considered to be base-saturated,

Table 3. Microbiological analysis of the three soils

| Soil profiles | Horizons | Number of microorganisms in 1000 per g dry soil | | Number of cellulolytic micro-organisms in 1000 per g dry soil | | mg. Triphenyl formazan per g. dry soil for 24h | mg C of biomass per 100 g dry soil |
|---|---|---|---|---|---|---|---|
| | | Heterotrophic bacteria | Fungi | Bacteria | Fungi | | |
| $P_1$ | $A_1$ | 3,003 | 447 | 511 | 110 | 0.0428 | 56.83 |
| | $A_3$ | 497 | 243 | 126 | 80 | 0.0096 | 20.56 |
| | B/C | 297 | 176 | 90 | 40 | 0.0014 | 14.33 |
| $P_2$ | $A_1$ | 3,494 | 511 | 606 | 121 | 0.0456 | 66.41 |
| | $A_3$ | 797 | 266 | 199 | 91 | 0.0143 | 24.56 |
| | B/C | 200 | 78 | 60 | 25 | 0.0023 | 6.82 |
| $P_3$ | $A_1$ | 3,504 | 559 | 621 | 139 | 0.0237 | 69.50 |
| | $A_3$ | 702 | 292 | 211 | 99 | 0.0013 | 23.05 |
| | B/C | 208 | 120 | 70 | 30 | 0.0011 | 9.63 |

yielding a good structure (PETERSON, 1947). The amount of exchangeable sodium in all horizons had low values ranging between 0.07—0.10%. These values are less than 15 and the soils are considered to be regular (ALEXIADES, 1967).

The C/N ratios in all profiles ranged from 10.0 to 15.3. Ratios below 15 : 1 are known to indicate high mineralization activities of decomposing microorganisms (SCARSBROOK, 1965).

Dehydrogenase activities were correlated with soil moisture contents. The moisture level optimal for biological activity in soil usually is 50—70% of the water holding capacity (PRAMER & SCHMIDT, 1964). In our investigation the maximal microbial activity (0.045 mg triphenylformazan) coincided with 48.3% moisture-holding capacity, in the $A_1$ horizon of $P_2$. Dehydrogenase activities also decreased in all profiles with depth and were mostly correlated with microbial numbers.

The biomass measurements also decreased with depth.

b. Qualitative fungal analyses.

52 species of fungi isolated: 2 Zygomycetes and 50 fungi imperfecti. Several fungi were found that had not been previously reported from Greece (table 4).

Most fungal species were also found growing on cellulose agar medium as the only source of carbon (table 4).

Most fungal species were isolated from dilution or soil plates.

There were qualitative and quantitative differences in species composition among the profiles and horizons (table 4, 5).

The numbers of fungal species isolated depended on the number of total isolates per horizon (fig. 3). Most fungal species were found in $A_1$ horizons and least of them in B/C horizons.

*Penicillium griseofulvum*, *Cladosporium herbarum* and sterile white mycelia were the most common and dominant fungi isolated during the survey in all profiles.

The species of *Penicillium* in the soil horizons ranged from 38—69.6 per cent of abundance dilution plates, while the equivalent value for *Aspergillus* was 0—11.6% and for sterile mycelia 8.3—48.0%.

Species of *Penicillium*, *Aspergillus*, and *Cladosporium* were found in all profiles and their horizons, but they were most abundant in the $A_1$ horizons. The *Aspergilli* were poorly represented in all horizons. Sterile mycelia also appeared throughout the profiles and slightly increased at the greatest depths ranging in abundance from 8.3 to 48.0% (dilution plates), and from 25 to 100% (soil washing). Among the sterile mycelia the white ones were the most frequent.

*Fusarium solani* and *Verticillium* sp. were present in all horizons but more common in the $A_3$ and B/C layers than in $A_1$.

*Trichoderma koningii* did not play a significant role in the mycoflore and usually occurred in the $A_1$ horizons.

Table 4. Abundance and frequency of fungal species isolated by dilution plate and soil plate methods

| Fungi isolated | Abundance Dilution plate method | | | | | | | | | Frequency Soil Plate method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Profile 1 | | | Profile 2 | | | Profile 3 | | | Profile 1 | | | Profile 2 | | | Profile 3 | | | |
| | $A_1$ | $A_3$ | B/C | $A_1$ | $A_3$ | B/C | $A_1$ | $A_3$ | B/C | $A_1$ | $A_3$ | B/C | $A_1$ | $A_3$ | B/C | $A_1$ | $A_3$ | B/C | |
| *Acremonium strictum* Gams * | | | | | | | 1.5 | | | 66.7 | 33.3 | | 66.7 | 33.3 | | 33.3 | 33.3 | | |
| *Alternaria alternata* (Fr.) Keissler | 3.8 | | | 7.3 | | | 3.8 | | | 100.0 | 66.7 | | 66.7 | 33.3 | | 33.3 | 33.3 | | Ce |
| *Aspergillus awamorii* Nakazawa * | | | | | 5.7 | | | | | | | | 33.3 | 33.3 | | | | | Ce |
| *A. carneus* (V. Tiegh.) Blochwitz * | | | | 5.2 | | | | | | | | | 66.7 | 33.3 | | | | | |
| *A. japonicus* Saito * | | | | | | | 1.5 | | | | | | | | | 33.3 | 33.3 | | Ce |
| *A. niger* v. Tieghem | | | | 3.1 | | | | | | | | | 66.7 | 33.3 | | | | | Ce |
| *A. ochraceus* Wilhelm | | | | | | | 1.5 | | | | | | | | | 33.3 | 33.3 | | |
| *A. oryzae* (Ahlburg) Cohn * | | | | 5.2 | | | | | | | | | 66.7 | | | | | | Ce |
| *A. raperi* Stolk * | 3.8 | | 8.3 | | | | 3.7 | | | 66.7 | 33.3 | 100 | | | | 66.7 | | | |
| *A. sulfureus* (Fres.) Thom & Church * | 1.0 | | | | | | | | | 33.3 | | | | | | | | | Ce |
| *A. terreus* Thom * | 2.0 | | | 2.1 | | | | | | 66.7 | 33.3 | | 33.3 | 33.3 | | | | | Ce |
| *A. terricola* Marchal * | 2.0 | | | | | | | | | 33.3 | | | 33.3 | | | | | | |
| *A. tubingensis* (Schöber) Mosseray * | | 3.1 | | | | | | | | 66.7 | 33.3 | | | | | | | | |
| *A. ustus* (Bain.) Thom & Church | 0.9 | | | | | | | | | 33.3 | | | | | | | | | Ce |
| *A. versicolor* (Vuill.). Tiraboschi * | | | | 5.2 | | | | | | | | | 66.7 | 33.3 | | | | | Ce |
| *A. wentii* Wehm. | 1.9 | | | | | | | 3.7 | | | | | | | | | | | Ce |
| *Cladosporium herbarum* (Persoon) Link | 6.7 | 12.1 | | 10.4 | 9.7 | 14.2 | 9.6 | | 9.1 | 100 | 66.7 | | 66.7 | 66.7 | | 33.3 | 33.3 | | Ce |
| *Fusarium oxysporum* Schlecht. | 1.9 | | | | | | 2.2 | | | | | | | | | 66.7 | | | Ce |
| *F. solani* (Mart.) Succ. | | | 8.3 | 2.1 | | | 3.0 | | 12.1 | | 66.7 | 33.3 | 33.3 | 33.3 | | 66.7 | 33.3 | 33.3 | Ce |
| *Geotrichum candidum* Link | | 4.6 | | | | | | 2.0 | | 33.3 | 66.7 | | | | | | | | |
| *Gliocladium virens* Miller et al * | | 3.1 | | | | | 0.7 | | 9.1 | | 33.3 | 33.3 | | | | 66.7 | 33.3 | 33.3 | |
| *G. viride* Matr. ** | 3.8 | 3.1 | | | | | 2.2 | | | 66.7 | 33.3 | | | | | 33.3 | 33.3 | | |
| *Gliomastix murorum* var. *felina* (Marchal) Hughes * | 3.8 | | | | | | | | | 66.7 | 33.3 | | | | | | | | Ce |
| *Mucor* sp. | 7.6 | 7.6 | | 4.2 | | | | 7.4 | | 100 | 66.7 | | 33.3 | | | 66.7 | 66.7 | | |
| *M. circinelloides* v. Tiegh. f. circinelloides * | | 3.1 | 4.2 | | | | 3.7 | | | 66.7 | 33.3 | 33.3 | | | | 66.6 | 66.7 | | |
| *Paecilomyces marquandii* (Massee) Hughes * | | | | | | | 2.2 | | | 66.7 | 33.3 | 33.3 | | | | 33.3 | 33.3 | | |
| *Penicillium adametzii* Zaleski * | 4.8 | | | 3.1 | | | | 7.4 | | 100.0 | 66.7 | | 66.7 | 66.7 | | | | | |
| *P. pinophilum* Hedgcock * | | | | | | | 2.2 | | | | | | | | | | | | |
| *P. aurantiogriseum* Dierckx * | 3.8 | | | | | | | | | 33.3 | 66.7 | | | | | | | | |

Table 4. Abundance and frequency of fungal species isolated by dilution plate and soil plate methods



| Fungi isolated | Abundance, Dilution plate method | | | | | | | | | Frequency, Soil Plate method | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Profile 1 | | | Profile 2 | | | Profile 3 | | | Profile 1 | | | Profile 2 | | | Profile 3 | | | |
| | $A_1$ | $A_3$ | B/C | $A_1$ | $A_3$ | B/C | $A_1$ | $A_3$ | B/C | $A_1$ | $A_3$ | B/C | $A_1$ | $A_3$ | B/C | $A_1$ | $A_3$ | B/C | |
| *P. brevicompactum* Dierckx * | | | | | 2.8 | | 3.0 | | | | | | 66.7 | 66.7 | | | | | Ce |
| *P. canescens* Sopp * | | | 4.2 | | | | | 2.5 | | | 66.7 | 33.3 | | | | | 33.3 | 33.3 | |
| *P. chrysogenum* Thom | 7.6 | 1.5 | 12.5 | | 5.6 | | 3.0 | 3.7 | | 100.0 | 66.7 | 66.7 | 66.7 | 66.7 | | 33.3 | 66.7 | 33.3 | Ce |
| *P. citrinum* Thom | | 6.1 | 14.6 | | 13.9 | 19.0 | 11.9 | 12.3 | | 66.7 | 33.3 | 66.7 | | 66.7 | 66.7 | 100.0 | 66.7 | 33.3 | Ce |
| *P. decumbens* Thom * | | 10.6 | | 7.3 | | | 5.2 | 8.7 | 18.2 | | 66.7 | 33.3 | 66.7 | 66.7 | | 66.7 | 66.7 | 33.3 | Ce |
| *P. expansum*, Link & Gray | | | | 2,1 | | | | | | | | | 66.7 | 66.7 | | | | | |
| *P. frequentans* Westling * | | 6.1 | 12.5 | | 5.6 | | 5.2 | 2.5 | 9.1 | 66.7 | 33.3 | | 66.7 | 66.7 | | 66.7 | 33.3 | 33.3 | |
| *P. granulatum* Bain * | | | | | | | | | | | | | 33.3 | 33.3 | | | | | |
| *P. griseofulvum* Dierckx * | 9.5 | 10.6 | | 7.3 | 9.8 | 19.0 | 7.4 | 8.7 | | 100.0 | 66.7 | 33.3 | 100.0 | 66.7 | 33.3 | 100.0 | 33.3 | | |
| *P. implicatum* Biourge * | | | | | | | | | | | | | | | | | 33.3 | 33.3 | |
| *P. janthinellum* Biourge | | | | | | | | | | 33.3 | 33.3 | 33.3 | | | | | | | Ce |
| *P. miczynskii* Zaleski * | | | | | | | | | | | | | 33.3 | 33.3 | | | | | |
| *P. oxalicum* Currie & Thom * | | 6.1 | | 10.4 | 18.0 | | 7.4 | 6.2 | | 66.7 | 33.3 | | 66.7 | 33.3 | | 66.7 | 33.3 | | |
| *P. puberulum* Bain. * | 1.9 | | | | | | 1.5 | | | | | | | | | 33.3 | 33.3 | | |
| *P. purpurascens* (Sopp) Biourge * | 3.8 | | | | | | | | 12.1 | 66.7 | 33.3 | | | | | | | 33.3 | |
| *P. roqueforti* Thom * | | | | 3.1 | | | | | | | | | 33.3 | | | | | | |
| *P. roseopurpureum* Dierckx * | 6.7 | | | | | | | | 6.1 | 33.3 | 33.3 | | | | | | | 33.3 | |
| *P. velutinum* v. Beyma * | 2.9 | 3.1 | | 7.3 | 13.9 | | | 8.7 | | 66.7 | 33.3 | | 33.3 | 33.3 | | 33.3 | 33.3 | | |
| *P. verrucosum* Dierckx * | | | | | | | 3.0 | | | | | | 33.3 | | | | | | Ce |
| *P. viridicatum* Westling * | 3.8 | | | 4.2 | | | | | | 33.3 | | | 66.7 | | | | | | |
| *P. waksmanii* Zaleski * | | | | 2.1 | | | | | | | | | | | | 33.3 | | | |
| *Trichoderma koningii* Oudemans * | 3.8 | | | | | | 5.2 | 9.9 | | 66.7 | 33.3 | 33.3 | | | | 33.3 | 33.3 | | Ce |
| *Verticillium* sp. | 1.9 | | 4.2 | | 4.2 | | | | 12.1 | 33.3 | 33.3 | 33.3 | | 33.3 | 33.3 | 33.3 | 33.3 | | |
| Sterile brown mycelia | | | 6.2 | | 1.4 | | | 5.0 | | | | 33.3 | | | 33.3 | 33.3 | | | |
| Sterile orange mycelia | | | | | | | | | | | 33.3 | 66.7 | | | | | 33.3 | 33.3 | |
| Sterile pink mycelia | | | 4.2 | | | | | | | | 33.3 | 33.3 | | | | | | | |
| Sterile white mycelia | 4.8 | 10.6 | 14.6 | 8.3 | 9.7 | 48.0 | 9.6 | 8.6 | 12.1 | 33.3 | 66.7 | 66.7 | 33.3 | 66.7 | 33.3 | 66.7 | 33.3 | 66.7 | Ce |
| Sterile yellow mycelia | 3.8 | 6.1 | 6.3 | | | | | 2.5 | | 33.3 | 33.3 | 66.7 | | | | | | | Ce |
| Total *Aspergilli* | 11.6 | 3.1 | 8.3 | 20.8 | 5.7 | | 6.7 | 3.7 | | | | | | | | | | | |
| Total *Penicillia* | 44.8 | 44.1 | 43.8 | 46.9 | 69.6 | 38.0 | 49.8 | 60.7 | 45.5 | | | | | | | | | | |
| Total Sterile mycelia | 8.6 | 16.7 | 31.3 | 8.3 | 11.1 | 48.0 | 9.6 | 16.1 | 12.1 | | | | | | | | | | |

* = new species for Greece  Ce = appeared on cellulose agar (dilution plates)

The *Mucor* species were present at all sites.

By comparing the fungal species found from the three similar soil type profiles (table 1, 4, 5) covered by similar vegetation, we conclude that most of the fungal species were common to the three sites.

Using dilution and WARCUP's soil plates, SPEARMAN's coefficients comparing the same horizons of different sites ranged between 0.97

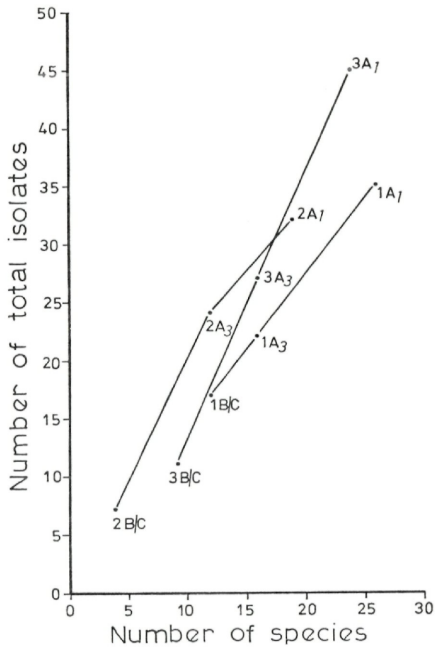



Fig. 3. Correlation between number of species and number of total isolates (Dilution plates)

and 1.0. In vertical comparisons the lowest figure obtained was 0.85 for $2A_3$ vs. 2B/c; for the soil washing technique much lower figures were obtained but the data are too scanty to allow any conclusion. Similar trends, though with greater differences, were found using the Sörensen quotient. The greatest similarities were found between the $A_3$ and B/c horizons, then between the $A_1$ and $A_3$ and finally between the $A_1$ and B/c horizons.

The characteristic genera for soil horizons were the following: *Acremonium, Alternaria, Geotrichum, Gliocladium* and *Gliomastix* for $A_1$, $A_3$; Sterile orange and pink mycelia for $A_3$, B/c; *Aspergillus, Cladosporium, Fusarium, Gliocladium, Mucor, Paecilomyces, Penicillium, Trichoderma, Verticillium.* Sterile brown and yellow mycelia for $A_1$, $A_3$, B/C.

The referred data from one sampling can only give a preliminary impression.

Table 5. Abundance of the most common fungal species isolated by the soil washing technique

| Fungi isolated | Profile 1 | | | Profile 2 | | | Profile 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_3$ | B/C | $A_1$ | $A_3$ | B/C | $A_1$ | $A_3$ | B/C |
| *Aspergillus raperi* STOLK | 8.3 | | | 10.0 | | | | | |
| *A. terreus* THOM | 8.3 | | | 20.0 | | | | | |
| *Fusarium solani* (MART.) SACC. | | | 33.3 | | | | 18.2 | | |
| *Mucor* sp. | 33.3 | 25.0 | | 30.0 | | | | | |
| *M. circinelloides* van TIEGH. *f. circinelloides* | | | | | | | 18.2 | | |
| *Penicillium citrinum* THOM | | | 16.7 | | 14.3 | | | 16.7 | |
| *P. decumbens* THOM | | | | | | | | | 10.0 |
| *P. frequentans* WESTLING | | 12.5 | 16.7 | | 14.3 | | | | |
| *P. griseofulvum* DIERCKX | | 25.0 | | | 28.6 | | 9.1 | | |
| *P. roseopurpureum* DIERCKX | 16.7 | | | | | | | | |
| *P. viridicatum* WESTLING | 8.4 | | | 10.0 | | | | | |
| Sterile orange mycelia | | | | | | 33.3 | | | 40.0 |
| Sterile white mycelia | 25.0 | 37.5 | 33.3 | 30.0 | 42.9 | 66.7 | 54.6 | 83.4 | 40.0 |
| Total *Aspergili* | 16.6 | | | 30.0 | | | | | |
| Total *Penicillia* | 25.1 | 37.5 | 33.4 | 10.0 | 57.2 | | 9.1 | 16.7 | 10.0 |
| Total Sterile mycelia | 25.0 | 37.5 | 33.3 | 30.0 | 42.9 | 100.0 | 54.6 | 83.4 | 80.0 |

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