

## The suppressiveness of Finnish light coloured *Sphagnum* peat

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**Abstract:** Half of the *Sphagnum* peat lots used as the substrate significantly reduced or inhibited damping-off caused by *Alternaria brassicicola* Wiltshire, *Plenodomus lingam* (Tode ex Fr.) Höhnelt and *Rhizoctonia solani* Kühn on cauliflowers. New peat slowed down the spread of *Fusarium oxysporum* Schl. f. sp. *lycopersici* (Sacc.) Snyder & Hansen from infected tomato plants to healthy ones and development of the disease on infected seedlings in comparison to disinfected peat. When new peat was added to disinfected peat the suppressing effect was regained. The most common microbes in the peat were bacteria, *Streptomyces* spp., followed by fungi, *Penicillium* spp., *Mortierella* spp. and *Trichoderma viride* Pers. ex Fr. *Streptomyces* spp. and *T. viride* effectively inhibited the growth of a number of soil and seed-borne fungi on a nutrient medium. Treating the peat or seeds with *T. viride* and *Streptomyces* spp. isolates inhibited or reduced damping-off caused by *A. brassicicola*, *P. lingam* and *R. solani* on cauliflower growing on the peat substrate.

### Introduction

Light-coloured *Sphagnum fuscum* peat is the most common substrate used in greenhouse cultivation in Finland. The structural, physical and chemical properties of this type of peat make it an ideal growing medium for plants. The peat research carried out by Prof. PUUSTJÄRVI (1973) has resulted in peat cultivation becoming well established and the programmed growing of a number of crop plants has already become quite developed (PUUSTJÄRVI 1977).

New peat is known to be free from plant pathogens and pests, which in many cases has been the deciding factor for the success of such a type of cultivation. It has even been shown that peat inhibits the spreading of plant pathogens from infected to healthy plants (PUUSTJÄRVI 1974). The fact that peat is an organic substrate enables it to support a high level of microbial activity and its microflora is characterised by large numbers of bacteria, *Actinomycetes* and fungi but a relatively small number of individual microbial species (ALEXANDER 1961, CHRISTENSEN and WHITTINGHAM 1965, HOLDING et al. 1965). The high level of microbial activity in fertilized and limed

peat, as well as the presence of certain chemical compounds such as phenols, are presumably the main reason for the ability of peat to suppress fungal pathogens. It has been known for a long time that mineral soil is capable of suppressing fungal pathogens (BAKER and COOK 1974, BAKER 1981), but the information about peat in this respect is sparse and partly contradictory (WATSON and FORD 1972, CHINN 1967).

It was found in some experiments carried out at the Department of Plant Pathology, the University of Helsinki, that the presence of seed-borne pathogens on cruciferous plants, even in large numbers, was of little practical significance when the plants were growing on new peat (TAHVONEN 1979). Following these observations, a number of studies were started to investigate the capacity of light-coloured *Sphagnum* peat to suppress fungal pathogens. The aim was to determine the extent and significance of this phenomenon in peat cultivation and the possible causes of the phenomenon.

## Material and methods

Unless otherwise stated, the peat used in these experiments was ST-400 A0 peat supplied by Satoturve Oy. The sample lots obtained from different peat producers which were included in the experiments are listed in Figures 1 and 2. The peat was limed with dolomite limestone ( $10 \text{ kg/m}^3$ ) and fertilized with basic fertilizer (N-P-K: 17-9-14, and micronutrients)  $1.5 \text{ kg/m}^3$  in the seedling growing experiments and  $2 \text{ kg/m}^3$  in the tomato experiments.

Cauliflower seed was used in the seedling growing experiments in which the pathogen suppressiveness of different peat lots was tested. The seeds were artificially infected with *Alternaria brassicicola* Wiltshire, *Plenodomus lingam* (Tode ex Fr.) Höhnelt or *Rhizoctonia solani* Kühn. The test fungi were grown on PDA medium for about 10 days and then scraped off into distilled water at a level of 1 petri dish/100 ml. The seeds were soaked in the suspension for 5 minutes and then dried overnight between sheets of filter paper.

The peat used in the experiments on tomato wilt disease caused by *Fusarium oxysporum* Schl. f. sp. *lycopersici* (Sacc.) Snyder & Hansen was disinfected by steaming at  $100^\circ\text{C}$  for 1 hour and then adding 0, 10, 25 or 50 % new, non-disinfected peat to the steamed peat after it had cooled down. Fertilization and liming were carried out after the peat had been disinfected. Each sample block consisted of a basin,  $1.4 \times 1.6 \text{ m}$  in size, containing 400 l of peat and separated from the other blocks and sub-soil by plastic sheeting. Each block was planted with two rows of four seedlings. 20 ml of a suspension of *F. oxysporum* f. sp. *lycopersici* (at a concentration of one PDA petri dishfull/100 ml) was pipetted into the bottom of the planting holes in one of the rows during planting out. A 2 cm-thick layer of non-infected peat from the same block was placed in the planting holes on top of the suspension. The seedlings were then planted in the normal way. Dead plants were removed during the course of the growing season and, at the end of the experiment, samples of plant tissue were removed from the stems of plants lacking leaf symptoms, at a height of 10 cm above the ground. The tissue

samples were incubated on PDA medium in order to test for the presence of *Fusarium* infection. In 1977-78 the tomato seedlings were planted out immediately after the peat substrate had been treated, but in 1979 greenhouse cucumbers were grown on the peat for 4 months before planting out the tomato plants. The peat substrate was not subjected to any treatment at all when the plant coverage was changed. The tomato variety "Rimset" was used in the experiments. The seedlings were grown, irrigated, fertilized and otherwise tended using the cultivation techniques approved in Finland for peat culture. The experiments were carried out with three replications.

The microflora of the peat was determined in 1975 by homogenising the peat in sterile water at levels of 1 of 5 g/100 ml. Dilutions ( $10^{-1}$  to  $10^{-6}$ ) were then made and 1 ml and 10 ml pipetted into cooled ( $40^{\circ}\text{C}$ ) PDA medium. After mixing the agar was poured into three petri dishes. Determinations were made on 7 peat lots. In 1979, 25 % of the water in the PDA medium was substituted by an extract made by compressing peat of normal cultivation moisture content at a pressure of about 200 atmos. Two selective media were prepared from this nutrient medium. One of them contained 10 ppm of prothiocarp fungicide (Previcur N) and 400 ppm of streptomycene, and the other 10 ppm prothiocarp fungicide and 5 ppm benomyl (Benlate). One gramme of peat was homogenised in 99 ml of water and aliquots of the  $10^{-2}$ - $10^{-7}$  dilutions pipetted into the cooled-down media and then poured into three petri dishes. As this method was found to be very time-consuming, determinations were made on one peat lot only which had been stored in different ways: dry peat, fertilized peat at normal moisture content and peat used as the substrate for the tomato plants. The same peat lots were also used in the seedling growing experiments. Samples were taken from the different peat lots at monthly intervals over a period of three months (14.4.-13.7.). The microflora determinations carried out in 1975 were mainly concerned with determining the fungi present in the peat. Of the bacteria, only *Streptomyces* spp. were investigated. The experiments carried out in 1979 were designed to determine the variations in different micro-organisms during storage and cultivation. The results obtained in this study concerning the numbers of micro-organisms are only relative values and can only be used as supportive evidence because only two of the samples had duplicates and the results are to a great extent dependent on the type of method used in the determinations.

A number of the bacteria and fungi (Table 1) isolated from the peat were tested against the most common fungal pathogens on PDA medium (Tables 1 and 2). This was done by transferring the microbe isolated from the peat to four points around the edge of the petri dishes and the test pathogen to the centre of the dish. These tests were carried out in triplicate.

The microbes found to be most effective on the nutrient medium were tested for suppression of damping-off in seedling growing experiments. In 1975, a suspension of *Trichoderma viride* Pers. ex Fr. (1 petri dish/100 ml) was added to the peat at a concentration of 1.5 l of suspension/15 l autoclaved peat five days before sowing. Cauliflower seeds inoculated with *A. brassicicola*, *P. lingam* or *R. solani* (see p. 00) were sown in new and disinfected peat and peat inoculated with *T. viride* with four replications. In the

experiment carried out in 1979, seeds infected with *A. brassicicola* and *R. solani* were treated by immersing them in suspensions (1 petri dish/100 ml H<sub>2</sub>O) prepared using 4 *Streptomyces* spp. isolates and 3 *T. viride* isolates. The seeds were sown in steam-disinfected peat after being dried. The results are expressed as the percentage of healthy seedlings out of the number of seedlings sown.

## Results

### Capacity of light-coloured peat to suppress fungal pathogens

The peat lots from different sources exhibited variation in their capacity to suppress damping-off fungi. In the tests carried out in 1975, the peat lots obtained from Leivonmäki and Metsämaa effectively suppressed damping-off caused by *Rhizoctonia solani* Kühn and *Plenodomus lingam* (Tode ex Fr.) Höhnelt on cauliflower in comparison to the other peat lots (Fig. 1). Similarly, in the tests carried out in 1979 (Fig. 2) unconstituted peat from Satoturve, samples from Eurajoki and the peat lot from Hartola were effective against damping-off caused by *Alternaria brassicicola* Wiltshire in comparison to the other peat lots tested.

Peat fertilized with basic fertilizer and stored for 2 months at normal moisture content also suppressed damping-off caused by *A. brassicicola*. The

### HEALTHY SEEDLINGS

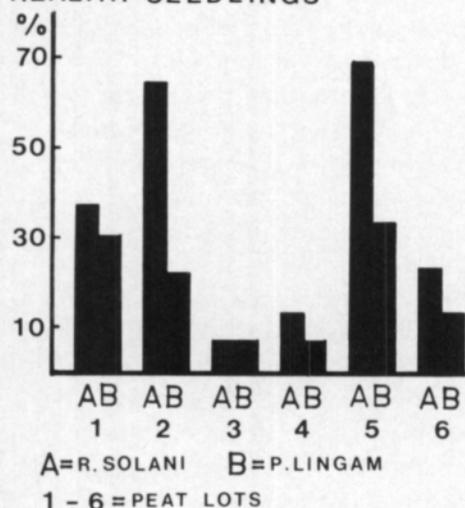


Fig. 1. Effect of peat lots from different sources on damping-off caused by *Rhizoctonia solani* and *Plenodomus lingam* on cauliflower after the seedlings had been growing for 3 weeks. Peat source: 1 = Kontiolahti, 2 = Metsämaa, 3 = Luumäki, 4 = Eurajoki, 5 = Leivonmäki, 6 = Pylkönmäki.

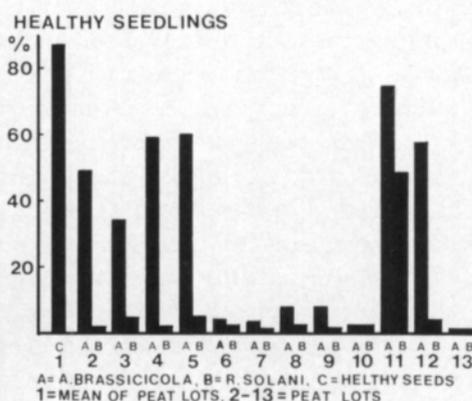


Fig. 2. Effect of peat source and pretreatment on damping-off caused by *Rhizoctonia solani* and *Plenodomus lingam* on cauliflower after the seedlings had been growing for 3 weeks. Source of peat and pretreatment: 2 = Satoturve Oy St-400 A0, 3 = Eurajoki, 4 = Eurajoki, 5 = Hartola, 6 = Haapavesi, 7 = Lappeenranta, 8 = Karttula, 9 = Sompaneva, 10 = Peräseinäjoki, 11 = peat used for growing tomatoes, 12 = fertilized peat kept moist, 13 = steam-sterilised peat.

capacity of the peat used as the substrate for the tomato plants to suppress fungal pathogens increased so strongly that the incidence of damping-off caused by *A. brassicicola* was only 13 % and that of damping-off caused by *R. solani* 30 %. Almost all the seeds growing in steam-sterilised peat and in peat lots with a weaker suppressiveness died (Fig. 2).

Wilt disease caused by *Fusarium oxysporum* Schl f. sp. *lycopersici* (Sacc.) Snyder & Hansen on tomato plants spread in 1977 to a considerably smaller extent from infected tomato plants to adjacent rows when growing in new peat than in steam-sterilised peat (Fig. 3). Although cucumber plants had been grown on the steam-sterilised peat for four months, the capacity of the peat to suppress fungal pathogens had not recovered to anywhere near the level exhibited by new peat (Fig. 4). The infected seedlings also died off at a slower rate in new peat than in steam-sterilised peat (Figs. 3 and 4).

The suppressiveness of the substrate returned to the level for new peat when either 25 % or 50 % new peat was added to the steam-sterilised peat (Figs. 3 and 4). The peat used in the tomato experiment in 1978 was not able to suppress *Fusarium* wilting disease to any significant extent (Fig. 3).

#### The microflora present in the peat

The following micro-organisms were identified in the peat lots:

##### Bacteria

- Eubakteriales
  - unidentified bacteria
- Actinomycetales
  - Streptomyces* spp.

##### Fungi

- Zygomycetes
  - Absidia* sp.
  - Mortierella* spp.
  - Mucor* sp.
  - Piptocephalis* sp.
- Ascomycetes
  - Sordaria* spp.
- Deuteromycetes
  - Ascochyta* sp.
  - Aspergillus* spp.
  - Aureobasidium pullulans* Arnaud
  - Chrysosporium* sp.
  - Goidaniehella scopula* Arnaud
  - Hughesiella* sp.
  - Oidiodendron rhodogenum* Robak
  - Penicillium* spp.
  - Rhodotorula* sp.
  - Thermomyces* sp.
  - Trichoderma viride* Pers. ex Fr.
- Unidentified fungi producing mycelia

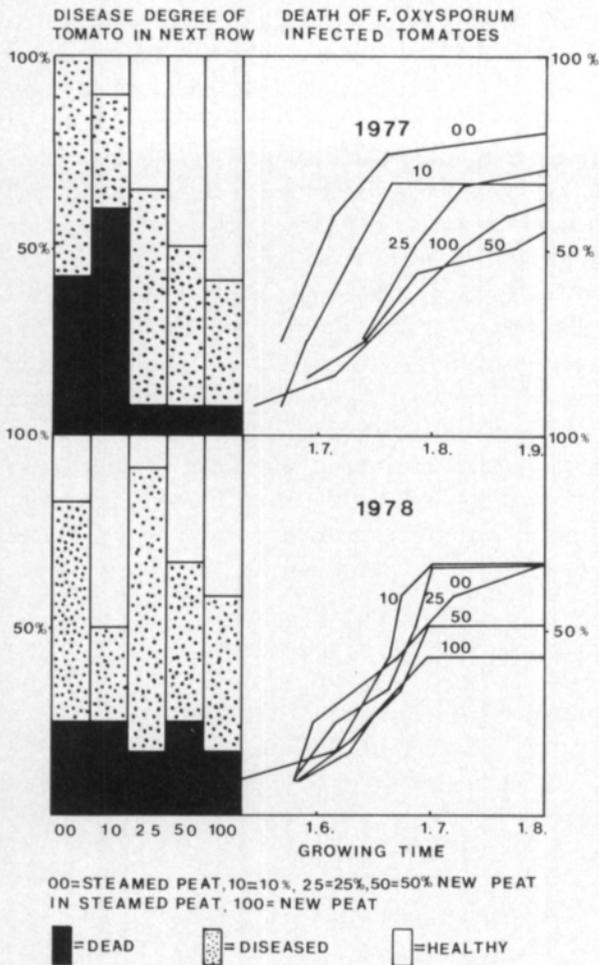


Fig. 3. The spread of *Fusarium oxysporum* f. sp. *lycopersici* from inoculated tomato plants to plants in the adjacent row by the end of the growing season and the mortality rate of inoculated plants on peat substrates to which different amounts of new peat were added after steam-sterilisation.

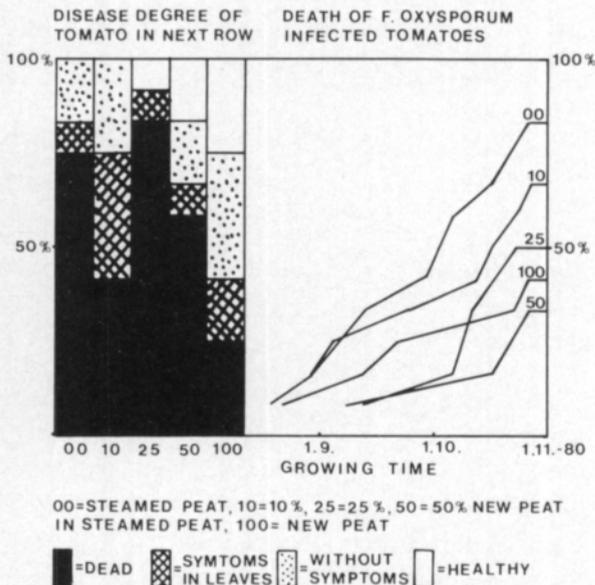


Fig. 4. The spread of *Fusarium oxysporum* f. sp. *lycopersici* from inoculated tomato plants to plants in the adjacent row by the end of the growing season and the mortality rate of inoculated plants on peat substrates to which different amounts of new peat were added after steam-sterilisation. Cucumbers were grown on the substrate for four months before planting the tomatoes.

The most common organisms isolated from the peat were bacteria, *Streptomyces* spp., *Penicillium* spp., *Mortierella* spp. and *T. viride*. Changes occurred in the composition of the microflora and in the numbers of individual organisms during storage and cultivation. The number of bacteria in new, unfertilized peat varied from  $5 \cdot 10^8$  to  $1.5 \cdot 10^9$  bacteria/g. Peat fertilized with basic fertilizer and stored at normal moisture content contained  $6 \cdot 10^{10}$ – $1.3 \cdot 10^{11}$  bacteria/g and peat used for growing tomato plants  $2 \cdot 10^{11}$ – $4 \cdot 10^{11}$  bacteria/g. The numbers of *Penicillium* spp. in new peat were  $5$ – $12 \cdot 10^8$ /g, in peat stored moist  $4 \cdot 10^7$ – $8 \cdot 10^{10}$ /g and in peat where tomatoes had been grown  $1$ – $6 \cdot 10^6$ /g. The numbers of *T. viride* in the different peat lots varied between  $5 \cdot 10^6$  and  $4 \cdot 10^9$ /g. There was considerable variation in the numbers of *Streptomyces* spp. They were not found at all in the peat stored at normal moisture content, the number of spores in the peat used for growing tomatoes varied from  $5 \cdot 10^7$  to  $4 \cdot 10^8$ /g in the first and last plate count and in the dry peat the number of spores was  $3 \cdot 10^7$ /g in one plate count. The numbers of *Mortierella* spp. varied from  $3 \cdot 10^6$ – $5 \cdot 10^8$ /g.

#### The effect of peat micro-organisms on fungal pathogens

Of the different microbes isolated from the peat samples, the *T. viride* and *Streptomyces* spp. isolates suppressed, extremely effectively, the growth of *Fusarium oxysporum*, *Rhizoctonia solani* and *Pythium debaryanum* auct. non Hesse on the nutrient medium (Table 1). In additional tests, the *Streptomyces* spp. isolates were also effective against *A. brassicicola*, *F. culmorum* (W.G. Smith) Sacc., *F. sulphureum* Schlechtendahl, *Helminthosporium sativum* Pammel, King & Bakke, *Phoma exigue* Desm. var. *foveata* (Foister) Boerema, *P. exigue* Desm. var. *exigui* Maas. and *Whetzelinia sclerotiorum* (Lib.) Korf & Dumont (Table 2, Figs. 5 and 6). In the preliminary tests carried out in 1975, three of the bacterial isolates from the peat suppressed the growth of *Fusarium* to a moderate extent, but in the tests

Table 1. The suppressive effect of microbes isolated from peat against different fungi growing on nutrient medium.

Microbe and number of isolates	<i>Fusarium oxysporum</i>			<i>Rhizoctonia solani</i>			<i>Pythium debaryanum</i>		
	–	(+)	+	–	(+)	+	–	(+)	+
Bacteria, 10	10	0	0	10	0	0	10	0	0
<i>Streptomyces</i> spp., 10	3	0	7	3	2	5	3	3	4
<i>Penicillium</i> spp., 1	0	1	0	0	1	0	0	1	0
<i>Sordaria</i> sp., 1	0	1	0	1	0	0	1	0	0
<i>Trichoderma viride</i> , 6	0	1	5	0	0	6	0	1	5
Unidentified, mycelium-forming fungi, 6	6	0	0	6	0	0	6	0	0

Table 2. The suppressive effect of certain *Streptomyces* isolates against different fungi growing on nutrient medium.

Test fungus	<i>Streptomyces</i> isolate				
	1	2	3	7	21
- = ineffective, (+) = medium strong, and + = strong suppressive effect					
<i>Alternaria brassicicola</i>	+	+	+	+	+
<i>Fusarium avenaceum</i>	(+)	(+)	+	-	-
<i>F. culmorum</i>	(+)	(+)	+	(+)	(+)
<i>F. oxysporum</i>	-	+	-	-	-
<i>F. sulphureum</i>	+	+	+	+	+
<i>Helminthosporium sativum</i>	+	+	+	+	+
<i>Phoma exigue</i> v. <i>foveata</i>	+	+	+	+	+
<i>P. exigue</i> v. <i>exiguae</i>	+	+	+		
<i>Rhizoctonia solani</i>	(+)	(+)	(+)	-	-
<i>Whetzelinia sclerotiorum</i>	+	+	+	+	+

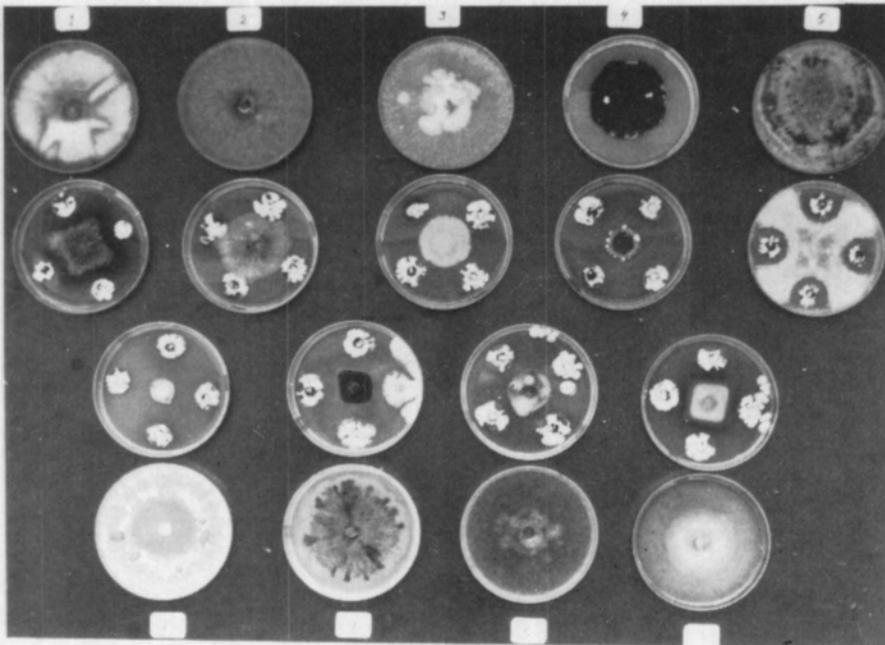


Fig. 5. Effect of *Streptomyces* sp. on different fungal pathogens growing on PDA medium. Top and bottom row = control petri dishes, middle rows = as the other rows except *Streptomyces* isolates transferred to four points at the edge of the dishes. 1 = *Fusarium oxysporum*, 2 = *F. culmorum*, 3 = *F. avenaceum*, 4 = *Helminthosporium sativum*, 5 = *Rhizoctonia solani*, 6 = *Whetzelinia sclerotiorum*, 7 = *Alternaria brassicicola*, 8 = *Phoma exigue* v. *exiguae*, 9 = *P. exigue* v. *foveata*.

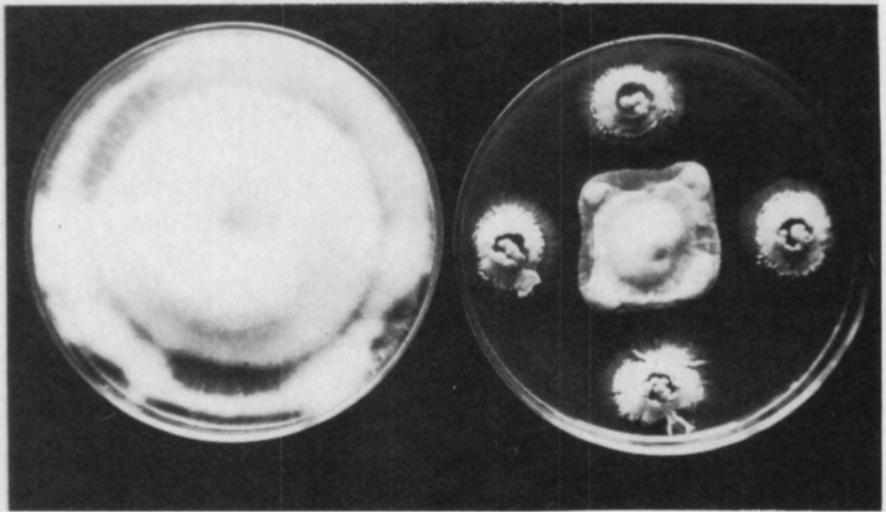


Fig. 6. Effect of *Streptomyces* sp. on the growth of *Pythium debaryanum* on PDA medium. Control dish on the left and a dish with *Streptomyces* isolates transferred to four points at the edge of the dish on the right.

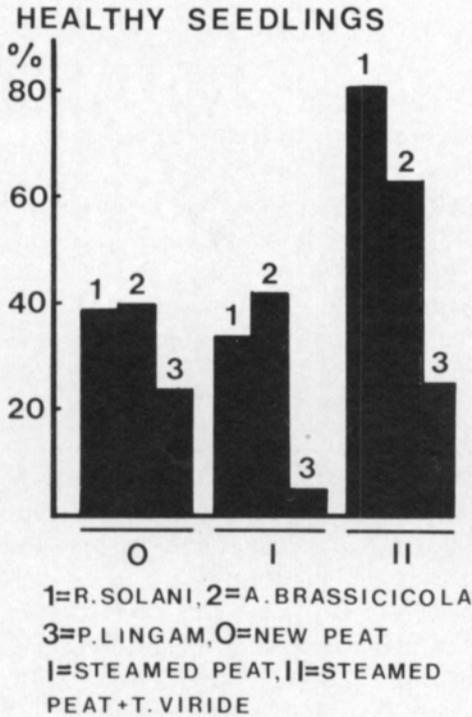


Fig. 7. Effect of inoculating the growing substrate with *Trichoderma viride* five days before sowing on damping-off caused by *Rhizoctonia solani*, *Alternaria brassicicola* and *Plenodomus lingam* on cauliflower.

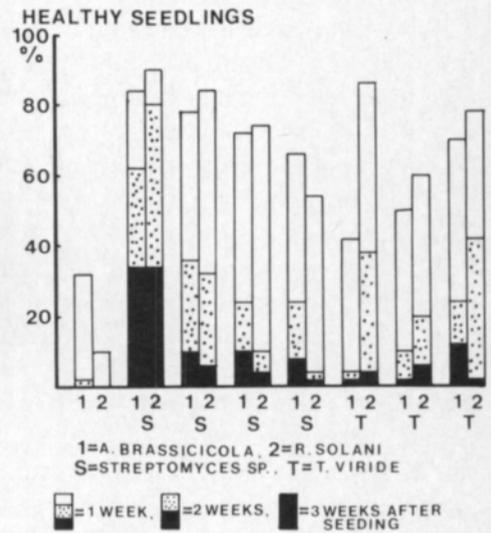


Fig. 8. Effect of treating seeds with *Streptomyces* sp. and *Trichoderma viride* isolates on damping-off caused by *Alternaria brassicicola* and *Rhizoctonia solani* on cauliflower.

carried out in 1979 all the ten isolates tested were ineffective (Table 1). Similarly, all the unidentified, mycelium-forming fungi (6 in all) were ineffective.

*T. viride* reduced or significantly suppressed damping-off caused by *Rhizoctonia*, *Alternaria* and *Plenodomus* on cauliflower growing in steam-sterilised peat (Fig. 7). When the ability of four *Streptomyces* spp. and three *T. viride* isolates to suppress damping-off in peat caused by *Alternaria* and *Rhizoctonia* were compared, the seeds being treated with suspensions of the isolates, all the treatments significantly improved seedling emergence, but only the *Streptomyces* treatment gave any long-term protection against damping-off (Fig. 8).

## Discussion

The capacity of light-coloured *Sphagnum* peat to suppress fungal pathogens is analogous to that which has been observed on numerous occasions in other types of substrate (BAKER and COOK 1974, BAKER 1981). Disease suppression effects have also been found in peat soils (CHINN 1967). As far as is known, however, this phenomenon has not been studied in *Sphagnum fuscum* peat.

The suppressiveness of the different peat lots varied to a very great extent: in some lots there was no suppressive effect while other lots were very effective suppressors of damping-off. This would explain the differences obtained in the tomato wilting disease experiments in different years.

No differences were found in the structure or composition of the peat lots which would have accounted for the variations in the suppressive capacity of the peat lots. Disinfecting the peat by steaming or autoclaving it almost completely eliminated the suppressive effect (cf. LIU and BAKER 1980, SCHER and BAKER 1980). This suggests that suppression is of microbiological origin. Chemical compounds, such as phenols, or microbial remains in the peat may possibly have a slight suppressive effect on fungal pathogens after steam disinfection, as has been observed in an earlier study (TAHVONEN 1979).

The differences in the suppressiveness of the different peat lots can most naturally be explained by variations in the microbial population. The numbers of *Penicillium* spp. and *Trichoderma viride* Pers. ex Fr. varied considerably in all of the peat lots. These are known to be strong competitors and producers of antibiotics (BAKER and COOK 1974). However, the greatest variations occurred in the numbers of *Streptomyces* spp., which surely has a significant effect on the variation in the suppressive effect of the different peat lots. For example, peat lot No. 11 contained very large numbers of *Streptomyces* spp. spores in comparison to lots No. 2 and 12, which did not suppress damping-off caused by *Rhizoctonia solani* Kühn at all (Fig. 2). The *Streptomyces* species found in the soil are known to be prolific producers of antibiotics (ALEXANDER 1961).

The capacity of peat to suppress fungal pathogens can be utilised fairly effectively in reestablishing the suppressive effect in disinfected peat. It has

earlier been very common to add new peat as an ameliorator before steam-sterilisation and this has obviously destroyed the beneficial microbes. If peat is added after disinfection, then the suppressive effect is almost completely regained (cf. SCHER and BAKER 1980). The adoption of this method also seems to be necessary because, according to the results of these experiments, the suppressive effect of disinfected peat is not regained without the addition of new peat, even when cultivated for a long time. However, the beneficial effect of adding peat is not always completely certain because the suppressive effect of certain peat lots are as bad as steam-disinfected peat even.

The microbes isolated from the peat lots, especially *T. viride* and *Streptomyces* spp., were extremely effective antagonists on the nutrient medium against all the fungal pathogens tested. These microbes are known to be effective competitors and/or producers of antibiotics (BAKER and COOK 1974). In preliminary biological control experiments, both *Streptomyces* spp. and *T. viride* suppressed or reduced damage caused by damping-off fungi in peat. This suggests that there are good possibilities of achieving biological control of plant pathogens in disinfected peat substrates at least, or even in new peat which has no natural suppressive effect of any importance.

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## Vaalean rahkaturpeen sienitautien estovaikutus

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Suomessa on kasvihuoneviljelyssä vaalea rahkaturve yleisin kasvualusta, jolla on todettu olevan kasvin kannalta hyvien fyysikaalisten ja kemiallisten ominaisuuksien lisäksi estovaikutusta alustassa leviäviä sienitauteja vastaan. Tämän ilmiön selvittämiseksi järjestettiin vuosina 1975–79 kokeita Helsingin yliopiston kasvipatologian laitoksella.

Eri turvetuottajilta saatiin turve-eriä testettavaksi. Viljelykokeissa käytettiin Satoturve Oy:n ST-400 A0 -turvetta. Sienitautien estovaikutusta mitattiin kylvämällä peruslannoitettuihin ja kalkittuihin turve-eriin *Alternaria brassicicola* Wiltshire -, *Plenodomus lingam* (Tode ex Fr.) Höhnelt - ja *Rhizoctonia solani* Kühn -sienellä saastutettuja kukkakaalin siemeniä. Uusien turve-erien lisäksi kokeissa oli mukana myös höyrytettyä turvetta. Ilmiön merkitystä pitempiaikaisessa viljelyssä kuin taimikasvatuksessa tutkittiin. Kasvualustana käytettiin uutta turvetta ja höyrytettyä turvetta, johon oli lisätty höyrytyksen jälkeen uutta turvetta 0, 10, 25 ja 50 % tilavuudesta. Koeruudussa toinen tomaattirivi saastutettiin istutuksen yhteydessä *Fusarium oxysporum* Schl. f. sp. *lycopersici* (Sacc.) Snyder & Hansen -lakastumistautisienellä. Turve-erien mikrobeja ja niiden runsauksia määritettiin. Yleisimpien mikrobin vaikutus tärkeimpiin sienitauteihin testattiin ravintoalustalla. *Trichoderma viride* Pers. ex Fr. - ja *Streptomyces* spp. -isolaatteja kokeiltiin kukkakaalin taimipolteen torjunnassa.

Noin puolet tutkituista turve-eristä vähensi voimakkaasti tai esti lähes kokonaan kukkakaalin taimipolteen verrattuna huonoimpiin eriin tai höyrytettyyn turpeeseen. Uudessa turpeessa tomaatin *Fusarium*-lakastumistauti tappoi kasveja hitaammin ja vähensi taudin leviämistä terveisiin kasveihin verrattuna höyrytettyyn turpeeseen. Tulos oli samanlainen, vaikka esikasvina oli ollut neljä kuukautta kurkku. Kun höyrytettyyn alustaan lisättiin 25 % tai 50 % uutta turvetta, kasvualustan taudinestovaikutus palautui.

Turpeen yleisimpiä mikrobeja olivat bakteerit, *Streptomyces* spp. sekä sienet *Mortierella* spp., *Penicillium* spp. ja *T. viride*. *Streptomyces* spp. ja *T. viride* estivät ravintoalustalla *F. oxysporum*, *R. solani* ja *Pythium debaryanum* auct. non Hesse -sienten kasvun. Lisätestauksissa *Streptomyces* spp. -isolaatit estivät tehokkaasti edellisten lisäksi *A. brassicicola*, *F. avenaceum* Sacc., *F. culmorum* (W. G. Smith) Sacc., *F. sulphureum* Schlechtendahl, *Helminthosporium sativum* Pammel, King ex Bakke, *Phoma exigue* Desm. v. *foveata* (Foister) Boerema, *P. exigue* Desm. v. *exiguae* Maas. ja *Whetzelinia sclerotiorum* (Lib.) Korf. ex Dumont -sienten kasvun ravintoalustalla.

Alustavissa taimikasvatuskokeissa *T. viride* torjui maahan lisättyinä *Rhizoctonia*- ja vähensi *Alternaria*- ja *Plenodomus*-taimipoltetta kukkakaalilla. Neljää *Streptomyces* spp. ja kolmea *T. viride* -isolaattia verrattiin siemenkäsittelynä kukkakaalin taimipolteen torjumiseksi. Käsitellyt paransivat merkittävästi taimettumista, mutta *Streptomyces*-käsitellyt antoivat pitempiaikaisen suojan taimipoltetta vastaan kuin *T. viride* -käsitely.