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CONTENT

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Page http://res.agr.ca/brd/fusarium/home1.html

INTRODUCTION

Fusarium is a genus of hyphomycetes, formerly classified in the Deuteromycetes, and now widely considered an anamorphic genus affiliated with the Hypocreales (Ascomycetes). The sexual stages (teleomorphs) of many of the most important species are in *Gibberella*; a number of species also have teleomorphs in *Nectria*.

Fusarium is characterized by the production of slimy, hyaline, septate, canoe-shaped conidia (known as macroconidia) that in most species are produced in fruiting-structures called sporodochia. In addition to this, some species also produce distinctly different conidia in the aerial mycelium (often referred to as microconidia). According to the species and/or the ecological situation, either macroconidia or microconidia may dominate on the natural substrate. Chlamydospores are also produced by some species. Because one must see all of these anamorphic forms in order to identify a *Fusarium* species with certainty, most modern *Fusarium* taxonomy is based on cultural characters.

Identifying cultures of *Fusarium* species requires careful observation and attention to detail. The presently available identification manuals provide a series of synoptic keys (Nelson *et al.* 1983), dichotomous keys (Booth 1971), tabular keys (Burgess *et al.* 1988) or no key at all (Gerlach and Nirenberg 1982). Synoptic keys are ideally suited to computers, because entered data can be sorted very quickly.

This key includes the thirty common species of *Fusarium* included in Nelson *et al.* (1983), several species described by the authors of that book and their colleagues since that time, and several less common species that, although not included in Nelson *et al*., appear to be generally accepted by most *Fusarium* workers. Taxonomic data was extracted from all of the manuals cited above. The identification process involves placing available data onto the datasheet. The entered data is then compared with a database of known species, and a list of possible species for the unknown appears. Differences between the unknown and the listed species are enumerated and can be listed.

This program is not intended to replace the works listed above, but has been designed to be used as a tool with those books. The identifications suggested by this program should be confirmed by comparison with the descriptions and illustrations in those identification manuals. In general, we have found that identifications with similarity indeces above 90% are worth considering carefully, provided enough characters have been entered.

The program presented here is actually a fourth generation product. We developed the original database to be used by a PC-based synoptic key program called SYNOPKEY written by David Malloch of the University of Toronto. After that, using the dBase programming language, we wrote a menu-driven program similar in concept to PENNAME (Pitt 1990. pp. 279-281 In: Modern Concepts in *Penicillium* and *Aspergillus* Classification. R. A. Samson and J. I. Pitt, Eds. Plenum Press, New York and London). Later, this was redone as a Visual Basic Application that would run under Windows. Now, the search engine for the key has been written to operate on UNIX, as part of a html document for use on the World Wide Web. At each step in the process, the database has been refined, additional species have been added, and the characters have been reconsidered.

We hope that you will find this key useful. If you have comments please send them to: Keith Seifert at: seifertk@em.agr.ca

HOW TO USE THE KEY

The data entry sheet consists of a series of check boxes and radio buttons that represent particular characters of taxonomic importance. The user checks off as many characters as have been observed. It is not necessary to enter data for all characters. Only characters that are chosen as positive or negative will be considered in the identification process.

The characters are divided into several categories:

- Colony characters on PDA
- Macroconidia from sporodochia
- Microconidia from aerial mycelium
- Chlamydospores
- Miscellaneous characters

Assistance with the interpretation of many of these characters is available by clicking on the underlined words in the character descriptions. Accurate identification of *Fusarium* species requires training of the eye because subtle distinctions in qualitative characters such as macroconidial shape and proliferation of conidiogenous cells are critical. There is a temptation to use easily interpreted characters such a colony colour, growth rates and conidial dimensions to make identifications, but these characters may be of secondary taxonomic importance. After the data is entered, the user clicks on a button to begin the identification process.

Unlike many synoptic key programs, FUSKEY does not eliminate taxa from consideration, but presents a list of species ordered by most similar to the unknown to least similar. The user can then click on any of these names on the list to a) see an illustration of the species b) get more information on the species or c) see what characters of that species differ with the entered characters of the unknown.

LIST OF CHARACTERS

Colony Characters on PDA

Growth rates

Use: Potato Dextrose Agar (PDA) at 25^{O}C for 10 days.
Interpretation: Growth rates are used primarily to distinguish between the slowly growing species (less than 3 cm diam.) in sections *Eupionnotes* and *Arachnites*, from the more rapidly growing species (7-10 cm diam.) in other sections. There are a few species in sections *Discolor* and *Lateritium* that are characterized, in part, by intermediate growth rates.

Aerial mycelium

Use: Potato Dextrose Agar (PDA) at 25^{O}C for 7-10 days.

Interpretation: Aerial mycelium is the growth of hyphae above the agar surface, often forming a convex shape, with a cottony or somewhat ropey texture. This character is used to distinguish species in sections *Eupionnotes* and *Arachnites*, which tend to have smooth colonies with little aerial mycelium, from those in other sections. Note that the lack of aerial mycelium tends to correlate with

slower growth rates. Rapidly growing isolates lacking aerial mycelium are often what is known as 'pionnotal mutants.' The colour of the aerial mycelium is dramatic in some cultures, but because this is a highly variable character amongst cultures of some species, it is not included as a character in this key.

Colony reverse

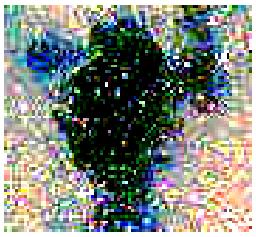
Use: Potato Dextrose Agar (PDA) at 25^{O}C for 7-10 days.

Interpretation: The colour of the back side of the colony tends to be highly variable within a species, but can be critical for a few species. Generally, a purple reverse is indicative of species in section *Liseola*. Red pigments are produced by species of several sections. The absence of red pigments is critical for recognizing some species. Pigments are often more intense in colonies incubated in complete darkness. Pigments produced on 'home made' PDA are much more intense than those produced on commerically available formulations.

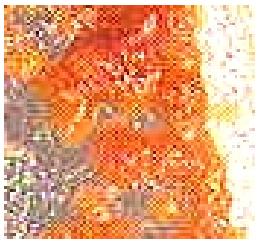
Macroconidia from sporodochia

Conidial mass

orange



bluish



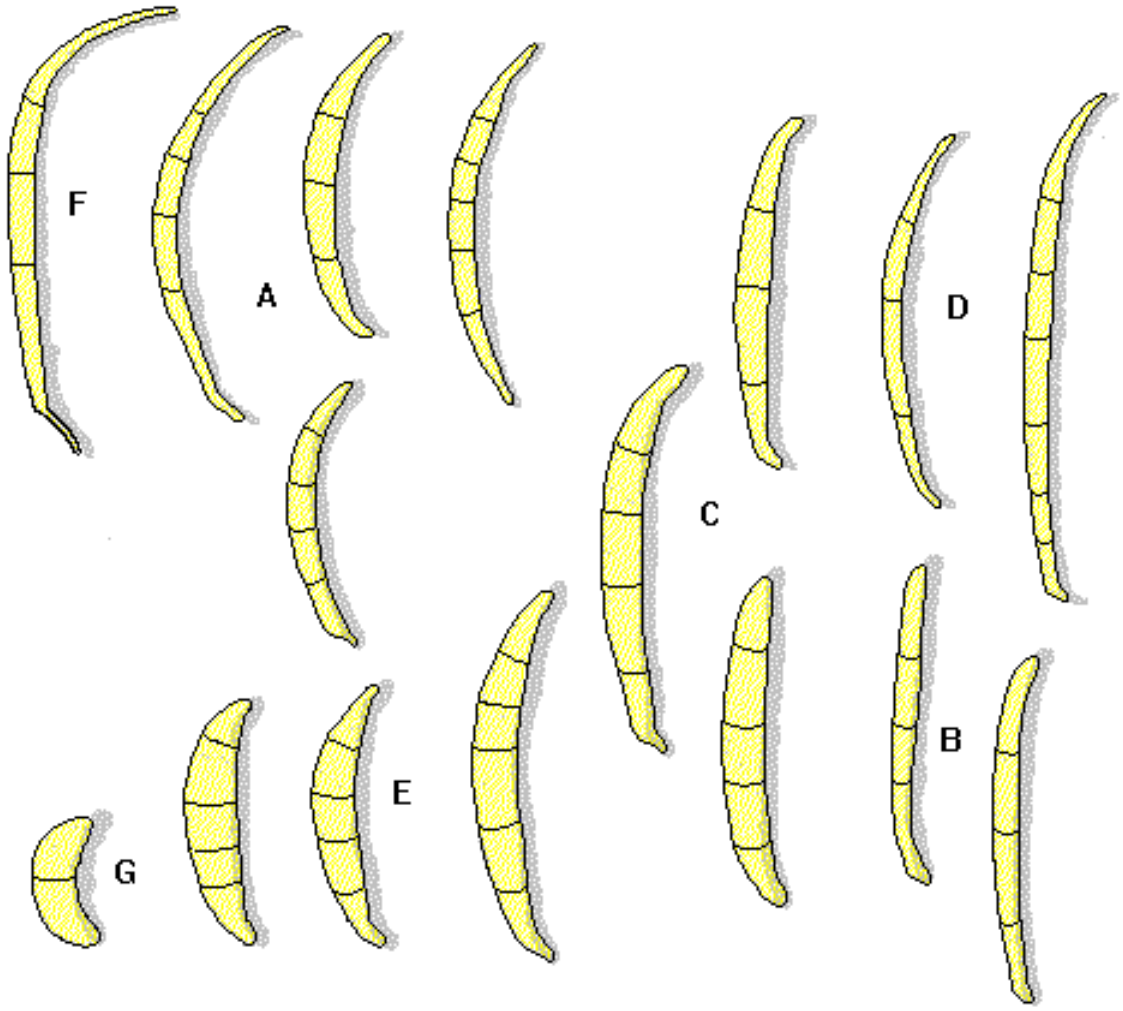
reddish brown

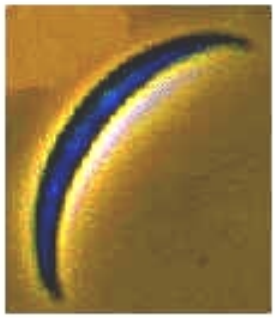
sporodochial colours

Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), Potato Dextrose Agar (PDA), or Banana Leaf Agar (BLA), 7-10 days under UV light.

Interpretation: This character can be interpreted from any medium on which discrete sporodochia form. Most species will produce sporodochial conidial masses that can be interpreted as cream-coloured, yellow or orange. *Fusarium crookwellense* produces characteristic reddish brown or brick red conidial masses that make the species easily recognizable. Blueish conidial masses are produced by some isolates of *Fusarium solani*. Yeast-like conidial masses give the slow growing colonies of species in sections *Eupionnotes* and *Arachnites* their smooth appearance.

Macroconidial shape





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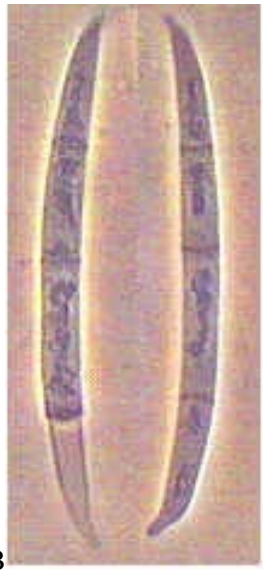

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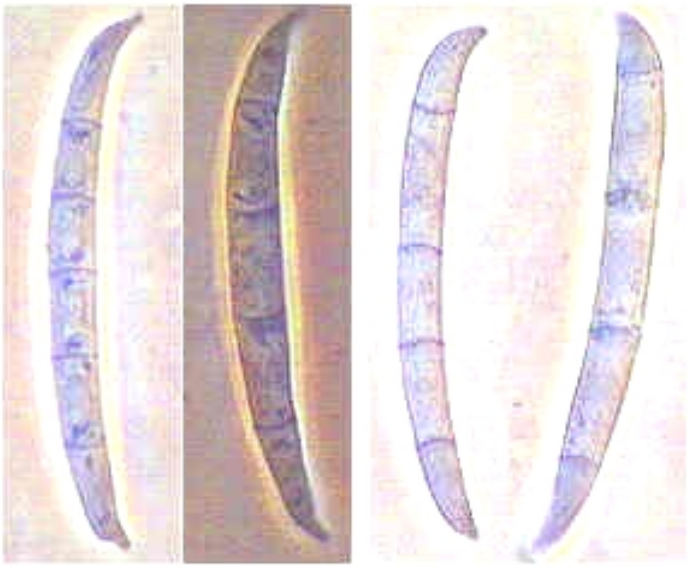
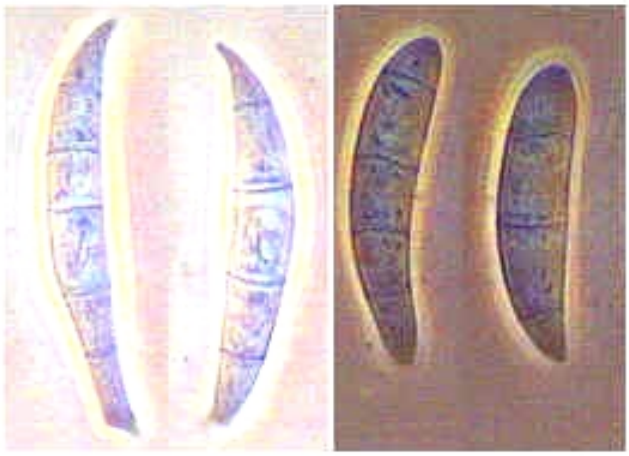


C

D



E

F

Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), or Banana Leaf Agar (BLA), 7-10 days under UV light.

Interpretation: This is *the* critical character for correct identification, and it takes some experience to interpret. It is important that true macroconidia from sporodochia be examined. For many species, cultures must be incubated under fluorescent and or black (near UV) light in order for good sporodochia to be produced. Macroconidium-like spores produced in the aerial mycelium can be deceptive. Macroconidia *must* be examined from colonies on SNA, CLA or BLA. It is *sometimes* useful to look at Potato Dextrose Agar (PDA), but as a general rule, macroconidia produced on PDA should be examined only as a last resort.

The figure used above is for the classification of macroconidial shapes and is an integral part of this program. The different categories are distinguished by the relative degree of curvature (straight on the right to conspicuously curved on the left) and their relative length/width rations (slender at the top to robust on the bottom). Examine the range of macroconidia produced by your unknown isolates, decide what is 'typical' or 'average' and then try to match this with the figure. There is a certain amount of forgiveness in interpreting this character in the database, but an error here will make correct identification unlikely.

Widest part of macroconidium

Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), or Banana Leaf Agar (BLA), 7-10 days under UV light.

Interpretation: This is a critical character for several species. The macroconidia of *F. culmorum* and *F. sambucinum*, for example, are sometimes described as 'wedge-shaped'-- this simply means that they

are broadest above the centre of the spore. According to Nelson *et al.* (1983), the macroconidia of *F. acuminatum* are distinctive because they are broadest below the centre of the spore. In some taxonomic systems, the user is asked to interpret whether the walls of the macroconidia are parallel. In our experience, this is a very difficult concept to convincingly demonstrate, hence our approach here.

Macroconidial dimensions

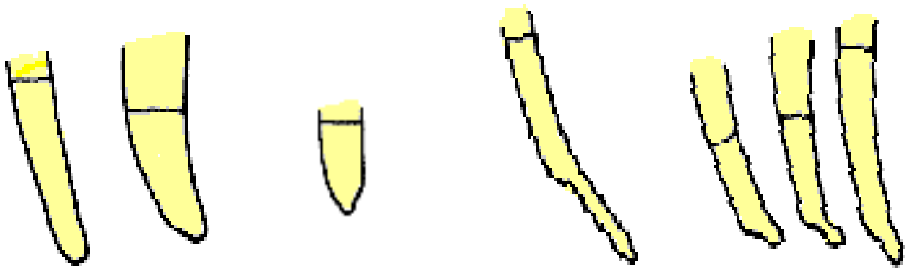
Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), or Banana Leaf Agar (BLA), 7-10 days under UV light.

Interpretation: The dimensions of macroconidia produced in sporodochia are considered trivial in several taxonomic systems, but in our opinion actual dimensions are more informative than qualitative descriptors. Conidial dimensions are not diagnostic for species with medium-size macroconidia, but are helpful for distinguishing species with unusually short, long or broad macroconidia. It is important to enter the average dimensions, not the extreme dimensions. Macroconidial width is a very useful character for separating *F. culmorum* and *F. sambucinum*.

Macroconidial septation

Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), or Banana Leaf Agar (BLA), 7-10 days under UV light. **Interpretation:** Most species have 3-7 septate macroconidia produced in sporodochia. If an unknown consistently has 1 (-3) septate macroconidia, or macroconidia with more than seven septa, this can be important information.

Basal cel'



not notched or blunt | *papillate* | *extended foot* | *notched or foot-shaped*

Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), or Banana Leaf Agar (BLA), 7-10 days under UV light.

Interpretation: The cell at the base of many *Fusarium* macroconidia is often described as 'foot shaped'. This means that the basal cell has an asymmetrical papilum on it, delimited from the rest of the cell by a distinct notch. In some isolates of *F. equiseti* and *F. longipes*, this extension of the basal cell is longer than 2 um. In strains of a few species, such as *F. culmorum*, the basal cell can be quite blunt, with little noticeable papilum. If the papillum on the basal cell is symmetrical, as occurs in *F. semitectum* and *F. camptoceras* then it is called papillate.

Length of apical cell

Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), or Banana Leaf Agar (BLA), 7-10 days under UV light.

Interpretation: The relative length of the apical cell compared with the cell next to it (the penultimate cell) is a useful character for recognizing some species. In most species, these cells are of more or less equal length, or the apical cell is slightly longer than the penultimate cell. Macroconidia with apical cells shorter than the penultimate cell are characteristic of *F. culmorum* and *F. sambucinum*. Macroconidia with extended (or whip-like) apical cells are characteristic of some species of section *Gibbosum*, and of some isolates of *F. avenaceum*.

Shape of apical cell

hooked *nipple-like* *blunt* *conical*

Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), or Banana Leaf Agar (BLA), 7-10 days under UV light.

Interpretation: The shape of the apical cell is often very difficult to interpret, and this is the part of the key that we most often leave blank. In most species, the apical cell can be interpreted as being conical (although often somewhat asymmetrical). In order to be considered hooked, the macroconidium should have a distinct bend in the apical cell, not just a constant curve. Blunt apical cells are more broadly rounded and have less of a point-like terminus than conical apical cells, and are typically found in species with short apical cells, such as *F. culmorum* or some strains of *F. solani*. Nipple-like apical cells (described as 'snout-like' by Nelson *et al.* 1983) have a distinct constriction resulting in a narrower terminus delimited from the main part of the cell by a notch on either side. This is an important character for distinguishing *F. sambucinum*, for example, from *F. crookwellense*.

Microconidia from aerial mycelium

Relative abundance of microconidia in aerial mycelium

Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), or Banana Leaf Agar (BLA), 7-10 days under UV light.
Interpretation: Some *Fusarium* species produce morphologically distinct conidia in the aerial mycelium, which are usually smaller and have fewer septa than the macroconidia produced in sporodochia. Therefore, they are often called microconidia. These spores are easier to observe and interpret if a slide is made that includes *only* aerial mycelium. In most cases it will be obvious whether there are many conidia in the aerial mycelium. Macroconidium-like spores are also found in the aerial mycelium, but in general, these can be ignored for identification purposes (but see discussion of mesoconidia below in the section of microconidial shapes). Species that lack microconidia in the aerial mycelium generally also do not produce macroconidium-like conidia there. When in doubt, search for conidiogenous cells. If abundant conidiogenous cells occur in the aerial mycelium, and these do not arise from highly branched conidiophores that might represent reduced sporodochia, then it is safe to assume that microconidia can be considered present.

Microconidia in chains or heads

Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), or Banana Leaf Agar (BLA), 7-10 days under UV light.

Interpretation: Most microconidia of *Fusarium* species are produced in slimy heads at the tips of the conidiogenous cells, which appear as glistening balls under the dissecting microscope. A few species produce microconidia end to end, in dry chains. Most books recommend examining the CLA or SNA

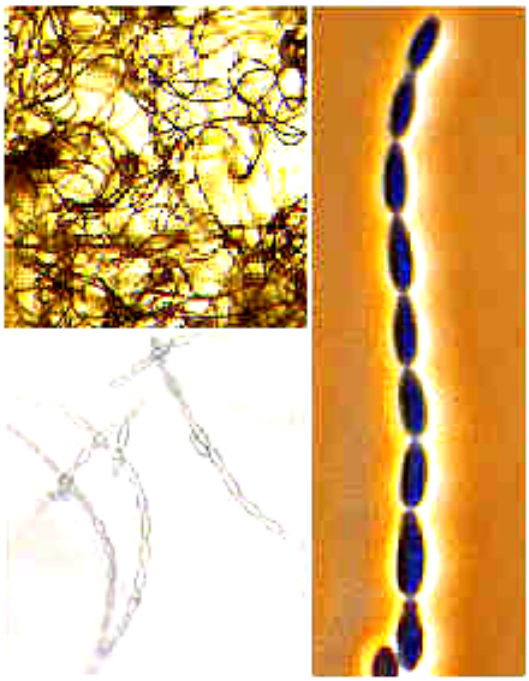


plate directly under the low power or high dry of the compound microscope. Microconidial chains are usually obvious using this method, but this practise exposes the user to the risk of inhaled spores. Microconidial chains are usually evident in wet mounts of the species that produce them. They can also be demonstrated with a dissecting microscope with substage illumination, at magnifications of 64X and above.

left: microconidial chains in aerial mycelium

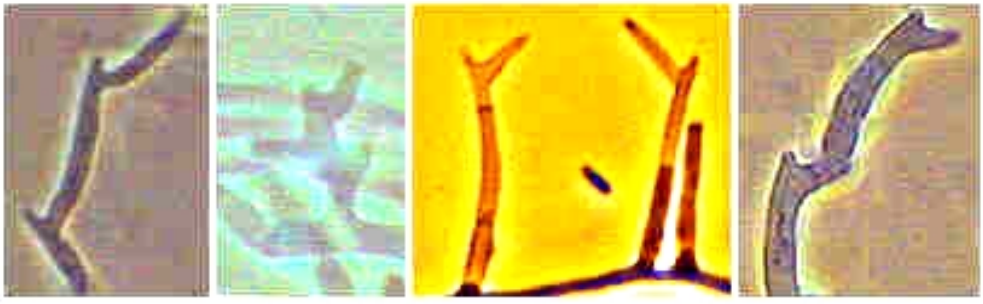
Microconidial shape

Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), or Banana Leaf Agar (BLA), 7-10 days under UV light.

Interpretation: The interpretation of microconidial shapes is much more straight forward than macroconidial shapes. Note that many species produce microconidia with more than one of these shapes, and that all observed shapes can be entered. The presence of globose microconidia is particularly significant for distinguishing *F. sporotrichioides* and *F. chlamydosporum*, and for recognizing *F. poae*. Lemon-shaped microconidia are produced in quantity only by *F. tricinctum*, although they may be found in small numbers in other species. Sometimes it is necessary to examine slides made from colonies on Potato Dextrose Agar (PDA), to view the complete range of microconidial shapes.
The interpretation of fusiform conidia is more complicated, because they intergrade with macroconidia that may also occur in the aerial mycelium. Pascoe (1990) introduced the concept of mesoconidia to describe fusiform, septate conidia that are produced in the aerial mycelium of some species. Mesoconidia are generally produced from polyphialides (see below) and are dry. They do not form false heads, and can be seen to be produced singly when a culture is examined directly under the compound microscope, or under high magnification of a dissecting microscope with substage illumination. Some species, such as *F. solani*, produce fusiform, septate conidia in the aerial mycelium from monophialides, which do form false heads, and are not considered mesoconidia. The concept of mesoconidia is not used explicitly in this key, but the combination of fusiform conidia in the aerial mycelium and polyphialides is equivalent.

Conidiophores in the aerial mycelium

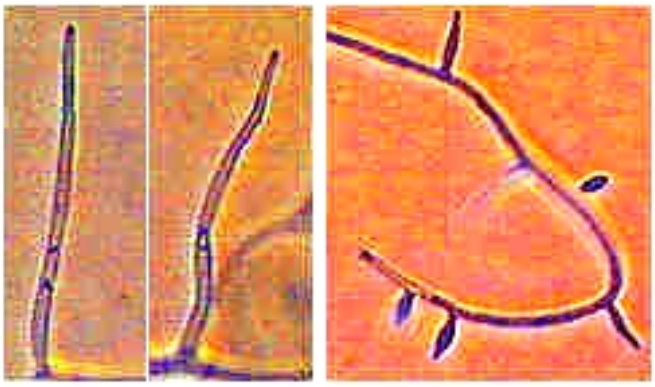
polyphialides in the aerial mycelium of 4 different Fusarium species



Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), or Banana Leaf Agar (BLA), 7-10 days under UV light.

Interpretation: The conidiophores and conidiogenous cells in the aerial mycelium can be diagnostic for some species. This character is easiest to determine in slides that contain only a very small piece of aerial mycelium, and no agar. Most species produce monophialides, that is, phialides that produce conidia from one opening only. Other species, particularly those in sections *Sporotrichiella* and *Liseola*, produce polyphialides in addition to monophialides. Polyphialides produce conidia from more

than one opening in the same cell. This seemingly simple concept causes all kinds of practical problems, especially for novices who sometimes get the concept confused with the branching of conidiophores. The trick is to learn to recognize a conidiogenous aperture, then to recognize when more than one is present on one cell. This is clearly illustrated in all of the contemporary taxonomic works on *Fusarium* and it is probably a matter of checking out some previously identified cultures of species known to produce these structures in order to learn to recognize them (*F. sporotrichioides* and *F. subglutinans* would be suitable). Unfortunately, polyphialides are ephemeral in some strains of *F. avenaceum* and can be difficult to find in cultures more than 7 days old. They can be very sparse in some cultures of *F. proliferatum*, particularly if the incubation temperature is above 25 C. Cross-shaped polyphialides are a useful character for recognizing the tropical species, *F. scirpi*.



F. solani *F. oxysporum*

long, slender monophialides *short and plump monophialides*

Distinguishing *F. solani* (left) and *F. oxysporum* (right) is problematic for some people, but the species are readily distinguished by the production of long, slender monophialides in the aerial mycelium of *F. solani*. In *F. oxysporum*, the monophialides in the aerial mycelium are short and plump.

Chlamydospores

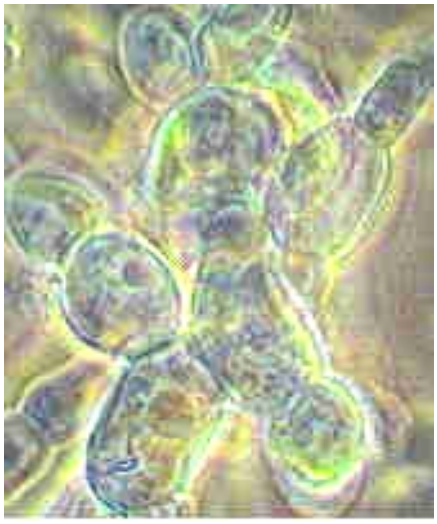
Miscellaneous characters

Chlamydospores

Use: Synthetic Nutrient Agar (SNA), Carnation Leaf Agar (CLA), Potato Dextrose Agar (PDA), or Banana Leaf Agar (BLA), 7-10 days under UV light.

Arrangements of Chlamydospores

in chains



in clumps

in pairs

simples

Interpretation:
Chlamydospores are 'storage' cells, usually thick-walled, swollen cells, sometimes with roughened and/or pigmented walls. They may be produced in the agar, in the aerial mycelium, or in sporodochial macroconidia, and may be single, in pairs, chains, or clumps. This is a character that tends to preoccupy the novice because it can be easy to interpret. Unfortunately, many strains of *Fusarium* species are very slow to make chlamydospores (20-30 days), and sometimes do not make them, at all without special media (such as soil extract agar). If chlamydospores are unequivocally present, this can be a useful character, but declaring them absent is a risky decision that can affect the reliability of an identification. It pays to make separate slides from the agar and the aerial mycelium of both CLA (or SNA) and PDA plates if finding chlamydospores is critical. *Fusarium solani* and *F. oxysporum* tend to produce their chlamydospores most often singly or in pairs, sometimes in triplets, and only rarely in clumps. According to the published wisdom, species in section *Liseola* are not supposed to produce chlamydospores. Some strains, particularly in *F. proliferatum*, produce chains of 'swollen cells' in the aerial mycelium that look very similar to chlamydospores. The production of chlamydospores in macroconidia in older cultures has not been demonstrated to be a taxonomically useful character, but it is included here because it is an easy character to interpret when present.

Geographic distribution

Most of the *Fusarium* species in this key are considered cosmopolitan and can be isolated virtually anywhere in the world. A few of the species are considered to be more tropical, or have been found (so

far) in relatively restricted areas of the globe. Biogeography of *Fusarium* is a rather poorly researched topic at the moment, and this character, therefore, should be employed with caution.

Substrates

The substrate portion of the key allows the user to select species known to occur on specific hosts. This is a useful filter in some cases, but generally should be treated with caution. Some species (for example those that occur on scale insects) exhibit a high degree of host specificity. A number of species are best known for causing diseases of cultivated plants in temperate regions of the world, and the list of known species from corn and wheat, for example, is probably fairly complete.

SEARCHING THE INTERACTIVE KEY

Colony

Conidial Mass on PDA, SNA or CLA:

- blank
- cream coloured
- orange
- yellow
- tan or brown
- reddish brown
- with bluish tones
- yeast-like

Colony diameter after 10 days PDA:

- blank
- < 3 cm
- 3-7 cm
- > 7 cm

Aerial mycelium on PDA:

- blank
- present or abundant
- absent or sparse

Reverse on PDA:

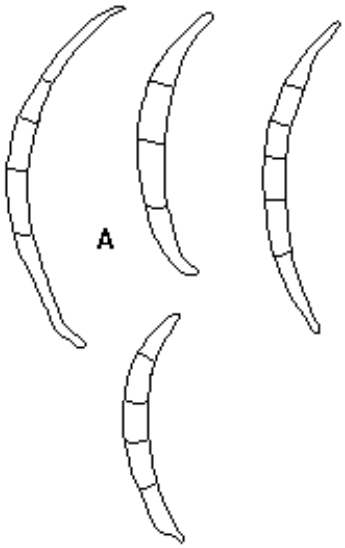
- blank
- colourless to cream
- tan to brown
- orange
- red
- purple

Odour

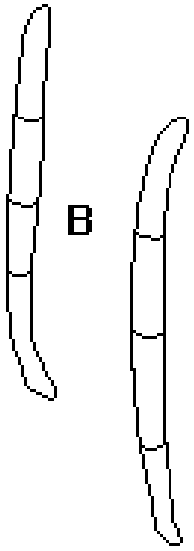
- blank
- fruity
- like lilac
- musky

Macronidia

Macroconidia shape



A



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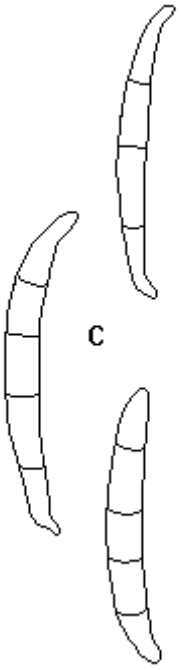

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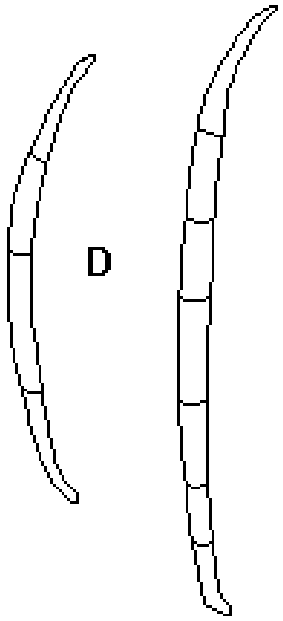

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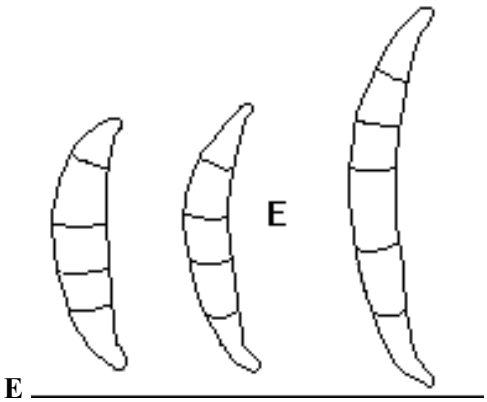
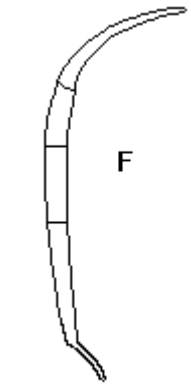


E



F

G

- **Average length of macroconidia (µm):**
- **Average width of macroconidia (µm) :**
- **Average number of septa:**

Widest part of macroconidia:

- at or near centre
- above centre
- below centre

Apical / Basal cell

Apical cell length

- < penultimate cell
- = penultimate cell
- **1.5 - 2x** longer than penultimate cell
- **>2x** longer than penultimate cell

Apical cell shape

- conical
- hooked
- blunt
- nipple-like

Basal cell shape

- Notched or foot shaped
- No foot
- Basal cell with extension > 2 µm
- with papilla

Microconidia

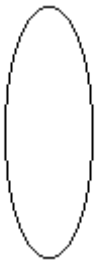
Microconidia in aerial mycelium

- absent or sparse
- present or abundant

Conidiophores

- microconidiophores monophialidic
- microconidiophores long and narrow mycelium
- microconidiophores mono- and polyphialidic
- phialides with wavy apex
- macroconidia produced with polyphialides

Shape



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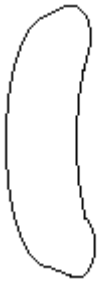
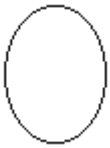


B

C



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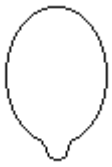

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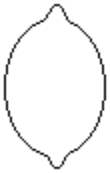
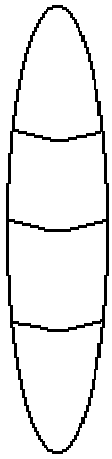


F



G

Chlamydospores

- absent
- present

- formed in chains
- **not** formed in chains
- single/paired
- chained
- in macroconidia

Known from

- corn
- wheat
- soil
- roots
- scale insects
- trees or bark
- other grains

Origin

- Temperate
- Tropical

♠ *Identify*

♠ *Identify new isolate*

GROWING *FUSARIUM* SPECIES FOR IDENTIFICATION

Content

Growing *Fusarium* species for identification

Fusarium taxonomy has long been controversial and confusing for the uniniated, and even for taxonomic specialists lacking familiarity with the genus. Many species require specific conditions to develop optimum morphology and other species tend to mutate rapidly. Furthermore, many of the differences between species are subtle and qualitative, and challenge the observational talents of some workers.

In the past 10-15 years, a more broadly accepted *Fusarium* taxonomy has been evolving based on the following principals:

1. Cultivation for examination of microscopic characters must be done on nutrient poor media such as carnation leaf agar (CLA) or *synthetischer närstoffärmer Agar* (SNA). We have also found, in common with some colleagues in South East Asia, that Banana Leaf Agar (BLA) is also a useful medium.

2. Optimal development of sporodochia and sporodochial conidia (macroconidia) requires at least exposure to fluorescent light, and preferably also near UV (or black) light.

3. Potato Dextrose Agar (PDA) or Potato Sucrose Agar (PSA), widely used for studies of micromorphology in the past, are useful only for studying cultural characters and should not be used for studying micromorphology or for maintaining cultures. The high sugar levels in both media tend to promote mutation in many species of *Fusarium*.

In addition, the concept of working with only single-spore isolates, and even of transferring cultures only as single conidia, has won favour with some American and Australian workers (Nelson *et al.* 1983, Burgess *et al.* 1988). We share the opinion of the Europeans that this treatment is unnecessary in most cases, we generally use it only for purifying cultures containing more than one species or for preparing fungal 'clones' for genetic studies.

Isolation of *Fusarium* species

Fusarium species are widespread and can be isolated from most soils, from insects, running water and from roots, seeds and other tissues of a wide variety of herbaceous and woody plants, both wild and domesticated. The media below are suitable for spread plating of suspensions or direct plating of debris or surface sterilized plant material for the isolation of *Fusarium* species. Their efficacy for isolation is roughly similar. DCPA allows more sporulation of the *Fusarium* species, employs a less

toxic fungicide, and includes an autoclavable antibacterial antibiotic rather than a heat labile one. If you can obtain dichloran, DCPA may be the preferred medium. Other selective media for *Fusarium* species are reviewed by Burgess *et al.* (1988).

Recognizing degenerated strains

In general, trying to identify degenerated strains of *Fusarium* species is an exercise in futility. Degenerated strains might have slower growth rates, an abundance of aerial mycelium, greatly reduced pigmentation, or a paucity of macroconidia. Degeneration can be a consequence of growth on too rich a medium (hence the constant admonition in the literature not to use PDA as a maintainance medium for *Fusarium* cultures), accumulation of carbon dioxide in sealed petri dishes, spontaneous mutation, bacterial contamination or genetic changes introduced during culture preservation (lyophilization or liquid nitrogen). Cultures contaminated by bacteria often have hyphae and macroconidia with collapsed cytoplasm that are evident even if you can't find the bacterial cells. Unfortunately, antibiotics may also cause culture degeneration, and the very process of getting rid of the bacteria may cause further degeneration of the culture.

Some species degenerate in predictable ways and can still be recognized despite the poor development of important diagnostic characters. Degenerated cultures of *Fusarium oxysporum*, for example, can often be recognized by the wet fascicles of aerial mycelium that collapse onto the agar surface, the production of single or paired chlamydospores, relatively abundant production of comma-shaped microconidia, and a general absence of pigmentation on PDA. Degenerated cultures of *F. poae* are virtually sterile, but it is usually possible to find a small number of globose microconidia on a slide. Recognizing degenerated cultures of particular species is a matter of experience, however, and not a trival matter.

Media for identification of *Fusarium* species

Carnation Leaf Agar (CLA)

Young leaves should be harvested from greenhouse grown carnations that have not been exposed to fungicides. Cut into about 1 cm square pieces, air dry, and sterilize by gamma irradiation or propylene oxide fumigation. Place a few sterile pieces on 1.5-2% water agar as it is solidifying in petri dishes.

Recipe from Nelson *et al.* (1983).

Potato Dextrose Agar (PDA)

Wash 250 g unpeeled, baking grade white-skinned potatoes. Autoclave on steam bypass (8 lbs overpressure) for 45 minutes in 500 ml in one flask, alongside 20 g of agar in 500 ml water in a second flask. Strain the potato broth through cheese cloth into the molten agar. Add 125 ml of the remaining pulp to the molten agar along with 20 g glucose (=dextrose). Fill up to 1 litre with water, mix, and autoclave.

Recipe from Nelson *et al.* (1983). Note that this medium is vastly superior to the available dried, commercial preparations, which should not be used for *Fusarium*.

Synthetischer nährstoffärmer agar (SNA)

- KH_2PO_4 1.0 g
- KNO_3 1.0 g
- $MgSO_4.7H_2O$ 0.5
- KCl 0.5 g
- Glucose 0.2 g
- Saccharose 0.2 g

- Agar 20.0 g
- dH_2O 1000 mL

Place pieces of sterile filter paper (about 1 cm square) on the surface of the agar after it has solidified.

Recipe from Gerlach and Nirenberg (1982).

Banana Leaf Agar (BLA)

Cut banana leaves into 1-2 cm squares and autoclave. Place autoclaved banana leaves on the surface of cornmeal agar (commercial preparations of cornmeal agar are fine).

Frozen banana leaves are available in oriental grocery stores in many parts of the world and are comparatively inexpensive.

This medium was first suggested to us by some colleagues from Thailand for *Fusarium*, then independently by some American colleagues as a general fungal medium. We have not grown all *Fusarium* species on it, but have been impressed with the results for the species we have tried.

Recipe from Matsushima, 1971, *Microfungi of the Solomon Islands and Papua-New Guinea* (Published by the author, Kobe, Japan, 78 pp).

Media for the isolation of *Fusarium* species

Dichloran Chloramphenical Peptone Agar (DCPA)

- Peptone 15.0 g
- KH_2PO_4 1.0 g
- $MgSO_4.7H_2O$ 0.5 g
- Chloramphenicol 0.2 g
- Agar 20.0 g
- dH_2O 1000 mL

After autoclaving, add 0.002 g Dichloran in 10 ml ethanol.

Recipe from Burgess *et al.* (1988). Dichloran is a growth retardent, and a common name for 2-6-dichloro-4-nitroaniline. It is known as 'Botran' in North America and may have other names in different countries.

Peptone PCNB Agar (= PPA/ Nash-Snyder Medium)

- Peptone 15.0 g
- KH_2PO_4 1.0 g
- $MgSO_4.7H_2O$ 0.5 g
- Terrachlor 1.0 g
- Agar 20.0 g
- dH_2O 1000 mL

Autoclave, cool to 55^{O}C then add the following dissolved in 10 ml sterile dH_2O:

- Streptomycin sulfate 1.0 g
- Neomycin sulfate 0.12 g

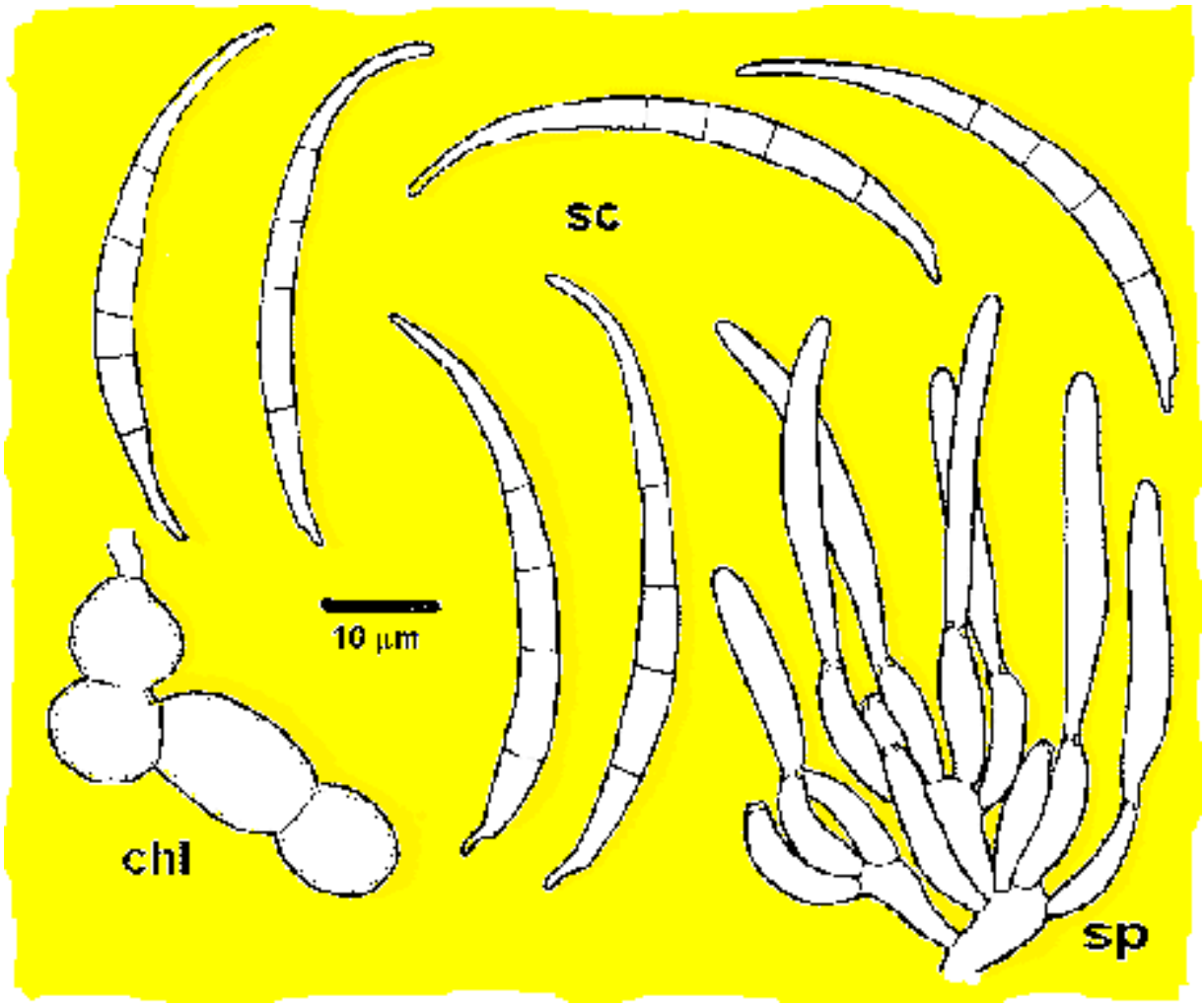
Allow the surface water to soak into the solidified agar before use.

Recipe from Burgess *et al.* (1994). PCNB (= pentachloronitrobenzene, the active ingredient in Terrachlor at 75%) is a fungicide that inhibits most fungi and is available under different brand names in different countries. It is carcinogenic and must be handled with care, this may limit the usefulness of this medium in some situations, although the medium is still widely used. Whitish *Fusarium*colonies appear on the medium 5-7 days after plating, which must then be transferred to other media .

LIST OF SPECIES

- *Fusarium acuminatum*
- *Fusarium anthophilum*
- *Fusarium aquaeductuum*
- *Fusarium avenaceum*
- *Fusarium beomiforme*
- *Fusarium camptoceras*
- *Fusarium chlamydosporum*
- *Fusarium coccophilum*
- *Fusarium compactum*
- *Fusarium crookwellense*
- *Fusarium culmorum*
- *Fusarium decemcellulare*
- *Fusarium dimerum*
- *Fusarium dlamini*
- *Fusarium equiseti*
- *Fusarium graminearum*
- *Fusarium graminum*
- *Fusarium heterosporum*
- *Fusarium larvarum*
- *Fusarium lateritium*
- *Fusarium merismoides*
- *Fusarium moniliforme*
- *Fusarium napiforme*
- *Microdochium nivale (Fusarium nivale)*
- *Fusarium nygamai*
- *Fusarium oxysporum*
- *Fusarium pallidoroseum*
- *Fusarium poae*
- *Fusarium polyphialidicum*
- *Fusarium proliferatum*
- *Fusarium reticulatum*
- *Fusarium sambucinum*
- *Fusarium scirpii*
- *Fusarium solani*
- *Fusarium sporotrichioides*
- *Fusarium subglutinans*
- *Plectosporium tabacinum (Fusarium tabacinum)*
- *Fusarium tricinctum*
- *Fusarium tumidum*
- *Fusarium xylarioides*

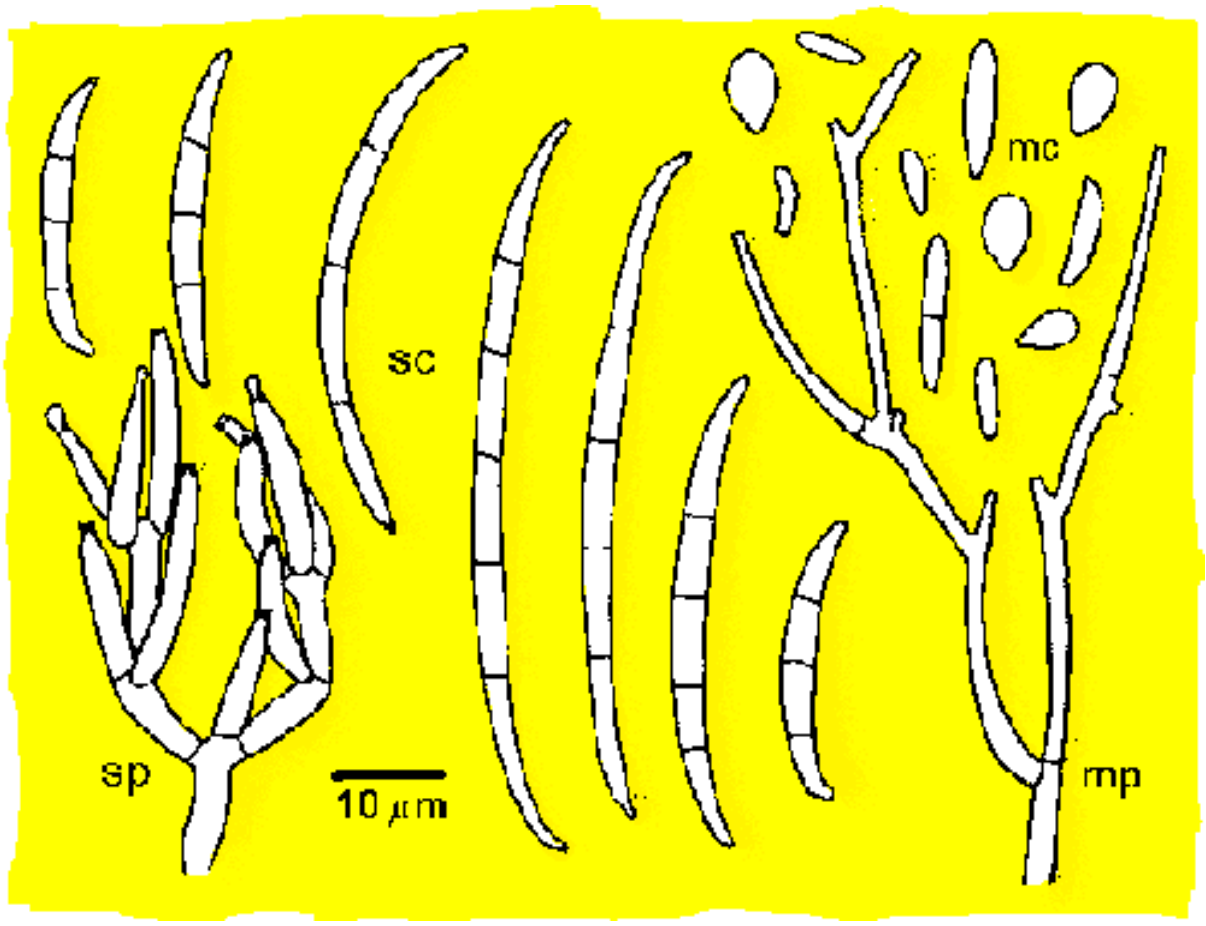
NOTES ON THE SPECIES



Fusarium acuminatum Ellis & Everhart

Section: *Gibbosum*
Teleomorph: *Gibberella acuminata* Booth (heterothallic)
Notes
Main difference from *F. equiseti* - red pigment on PDA. Main difference from *F. avenaceum* - chlamydospores and no mesoconidia or polyphialides.
References
Nelson, Toussoun and Marasas. 1983. p. 100.
Booth. 1971. p. 159.
Gerlach and Nirenberg. 1982. p. 187.
Burgess, Liddell and Summerell. 1988. p. 129.

NOTES ON THE SPECIES



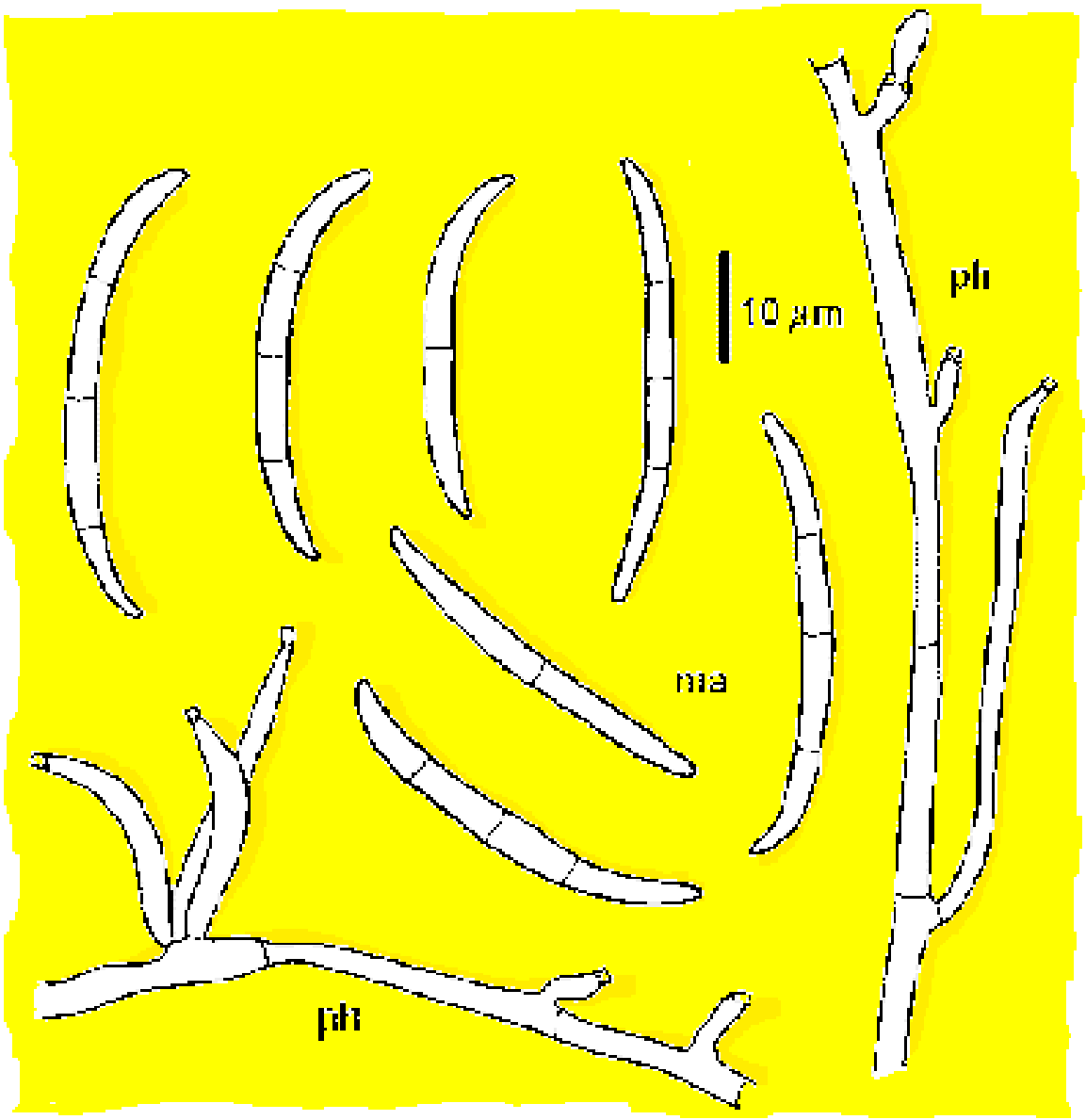
Fusarium anthophilum (A. Braun) Wollenw.

Section: *Liseola*

References

Nelson, Toussoun and Marasas. 1983. p. 139.
Gerlach and Nirenberg. 1982. p. 337.
Burgess, Liddell and Summerell. p. 90.

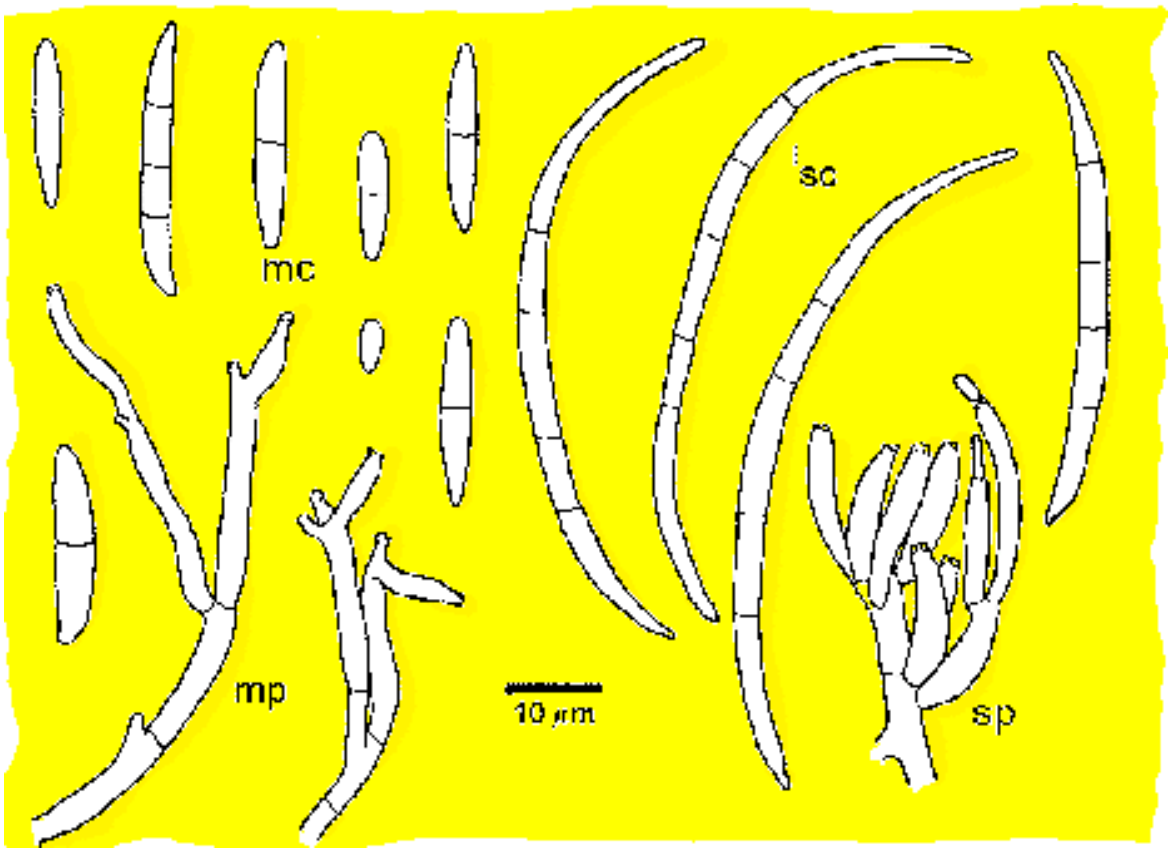
NOTES ON THE SPECIES



Fusarium aquaeductuum (Radlk. & Rabenh.) Lagerh.

Section: *Eupionnotes*
Teleomorph: *Nectria purtonii* (Grev.) Berk.
References
Nelson, Toussoun and Marasas. 1983. p. 52.
Booth. 1971. p. 62.
Gerlach and Nirenberg. 1982. p. 11.

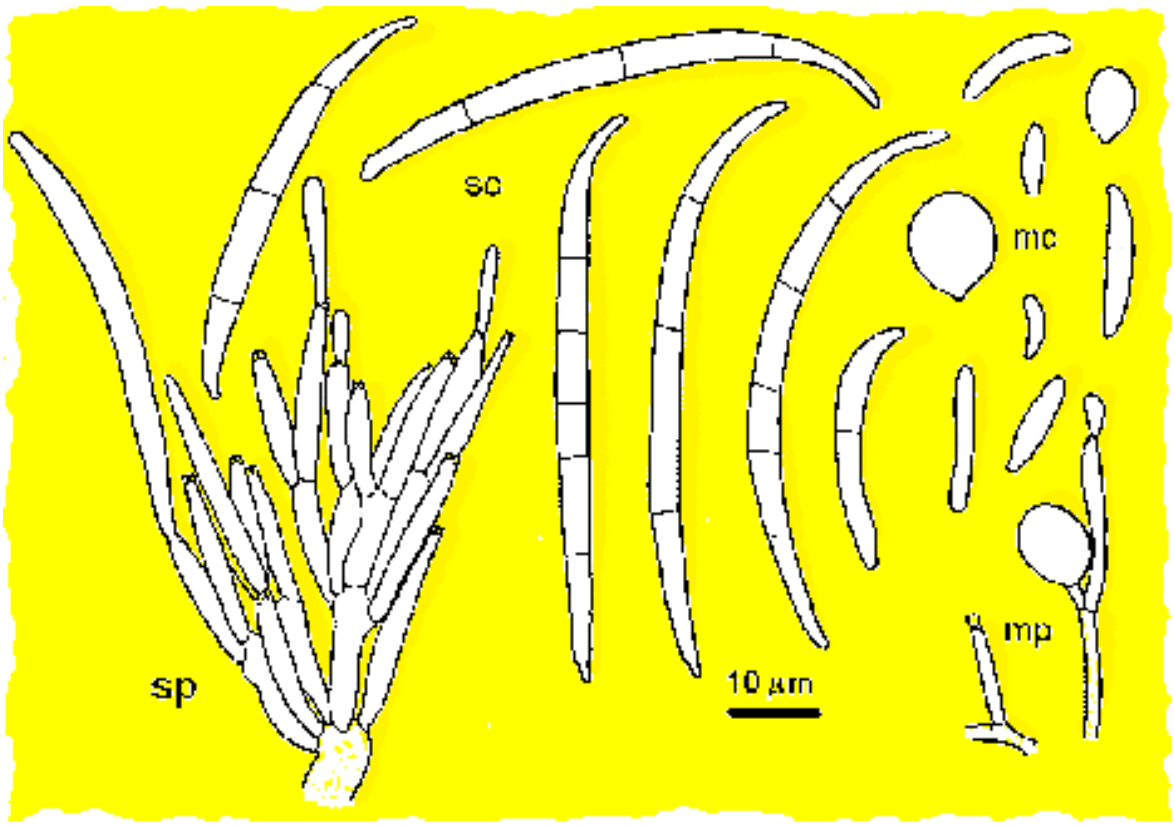
NOTES ON THE SPECIES



Fusarium avenaceum (Fr.) Sacc.

Section: *Roseum*
Teleomorph: *Gibberella avenacea* R. J. Cook
Diagnostic characters
Long, slender macroconidia of type A, produced in orange sporodochia. Septate, fusiform mesoconidia produced from polyphialides in the aerial mycelium (see above). No chlamydospores produced.
Notes
The production of mesoconidia from polyphialides in the aerial mycelium and the absence of chlamydospores distinguish this species from *F. acuminatum*. Nelson *et al.* state that *F. avenaceum* does not produce polyphialides, but this has been convincingly refuted by Pascoe (1990). In some strains, it is necessary to examine cultures on SNA at 3-5 days to find the polyphialides. In other strains, they are easily detected in older cultures. Molecular and isozyme results derived from a variety of techniques and in independent laboratories presented at recent conferences indicate that *F. avenaceum* is heterogeneous.
References
Nelson, Toussoun and Marasas. 1983. p. 80.
Booth. 1971. p. 91.
Gerlach and Nirenberg. 1982. p. 139.
Burgess, Liddell and Summerell. 1988. p. 127.
Pascoe. 1990. Mycotaxon 37: 128.

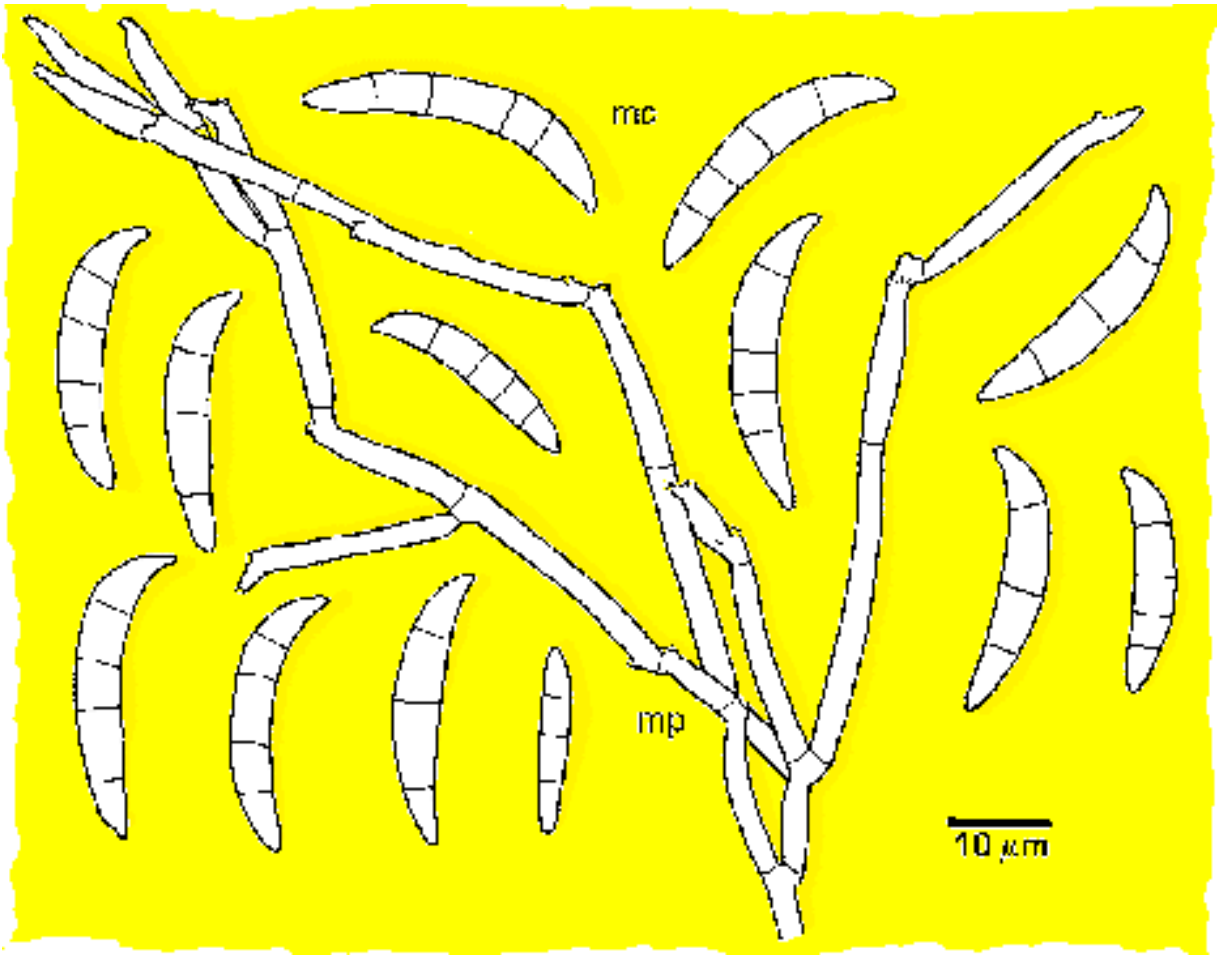
NOTES ON THE SPECIES



Fusarium beomiforme Nelson & Toussoun

Section: unassigned
Reference
Nelson, P.E. and T.A. Toussoun. 1987. Mycologia 79: 884-889.

NOTES ON THE SPECIES



Fusarium camptoceras Wollenw. & Reinking

Section: *Arthrosporiella*

Notes

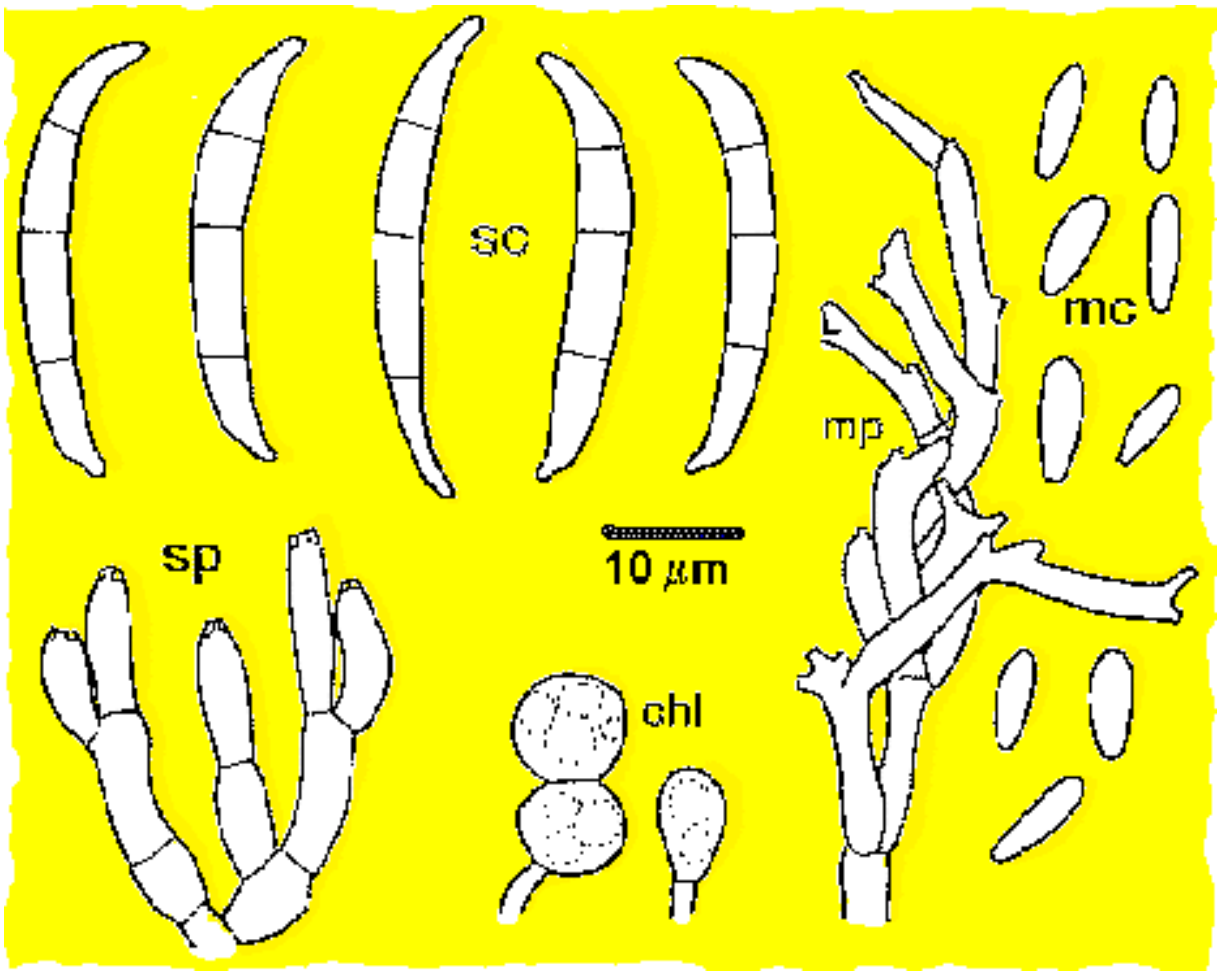
The concept of this species presented by Booth (1971) was rejected by the authors below.

References

Nelson, Toussoun and Marasas. 1983. p. 87.

Gerlach and Nirenberg. 1982. p. 162.

NOTES ON THE SPECIES



Fusarium chlamydosporum Wollenw. & Reinking

Section: *Sporotrichiella*

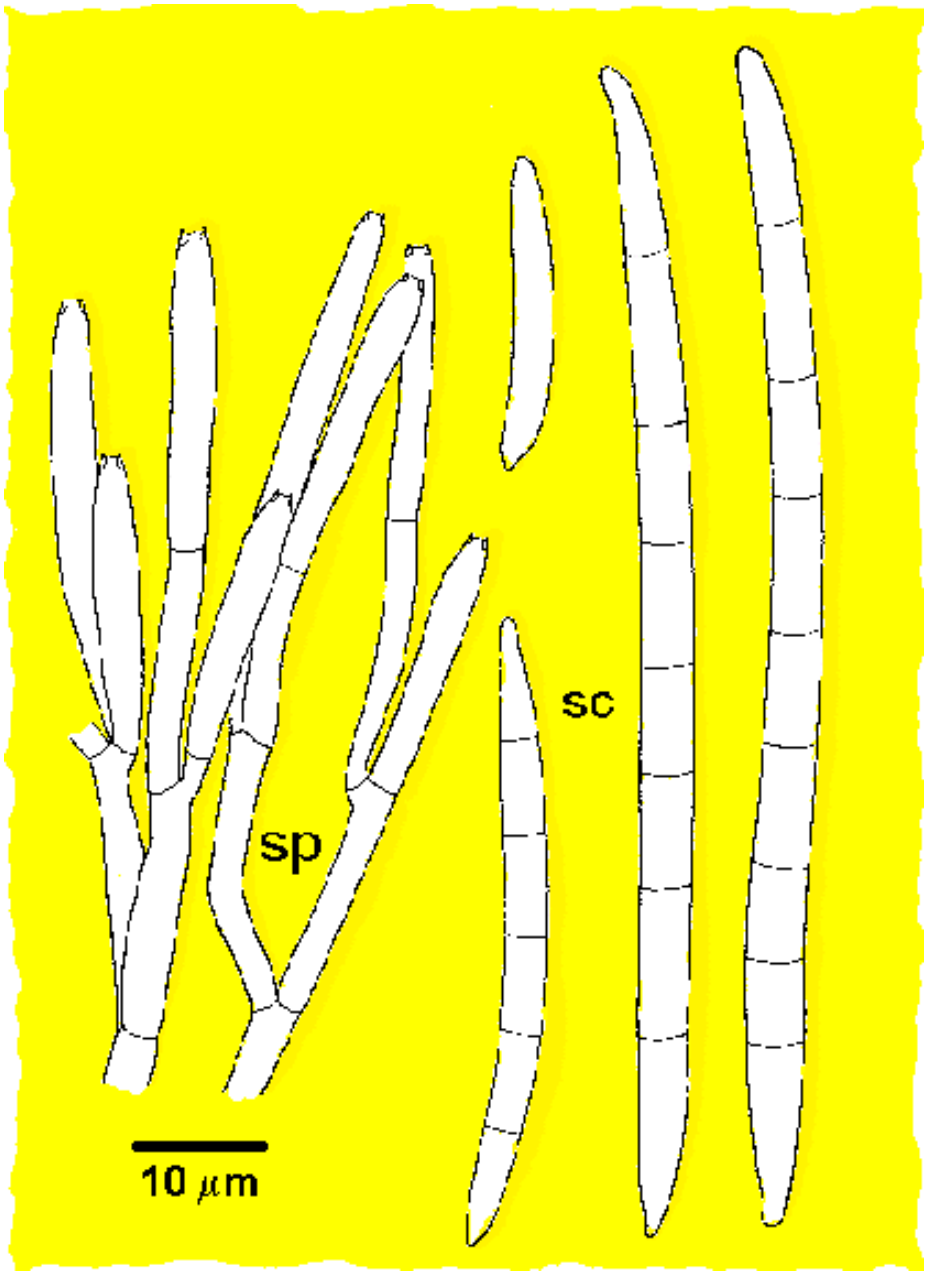
Notes

Requires UV to produce macroconidia. Distinguished from *F. sporotrichioides* by the absence of globose microconidia in the aerial mycelium. This should be confirmed on PDA.

References

Nelson, Toussoun and Marasas. 1983. p. 74.
Gerlach and Nirenberg. 1982. p. 119.
Burgess, Liddell and Summerell. 1988. p. 116.
Pascoe. 1990. Mycotaxon 37: 147.

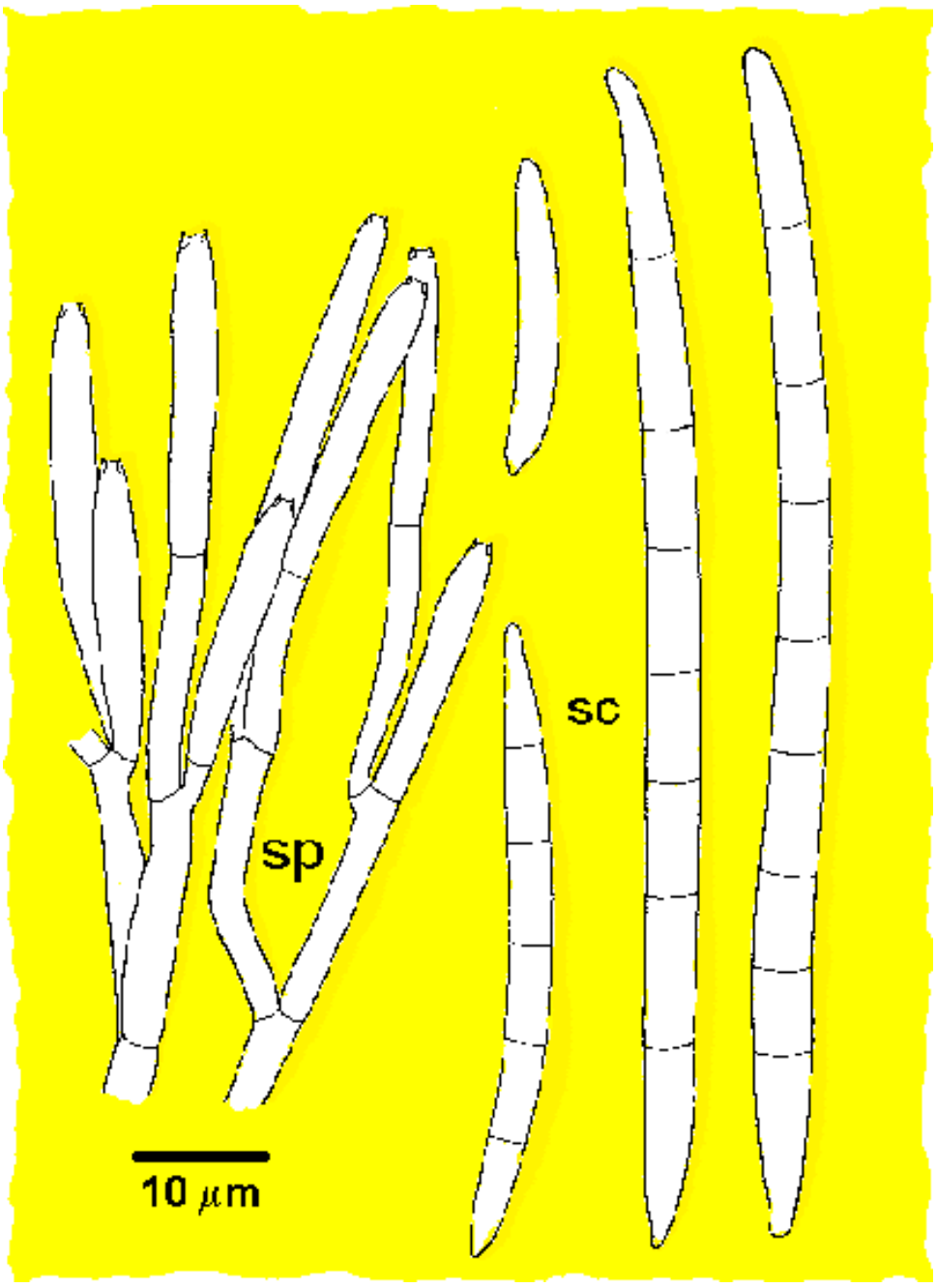
NOTES ON THE SPECIES



Fusarium coccophilum (Desm.) Wollenw. & Reinking

Section: ***Macroconia***
Teleomorph: *Nectria flammea* (Tulasne) Dingley
Diagnostic characters
Produces synnemata, restricted to scale insects. Growth slow in culture. Macroconidia are type C, straight and rather long.
Notes
Compare with *F. larvarum*, also known from scale insects.
References
Nelson, Toussoun and Marasas. 1983. p. 153.
Booth. 1971. p. 100.
Gerlach and Nirenberg. 1982. p. 79.

NOTES ON THE SPECIES



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Teleomorph: *Nectria flammea* (Tulasne) Dingley
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Nelson, Toussoun and Marasas. 1983. p. 153.
Booth. 1971. p. 100.
Gerlach and Nirenberg. 1982. p. 79.

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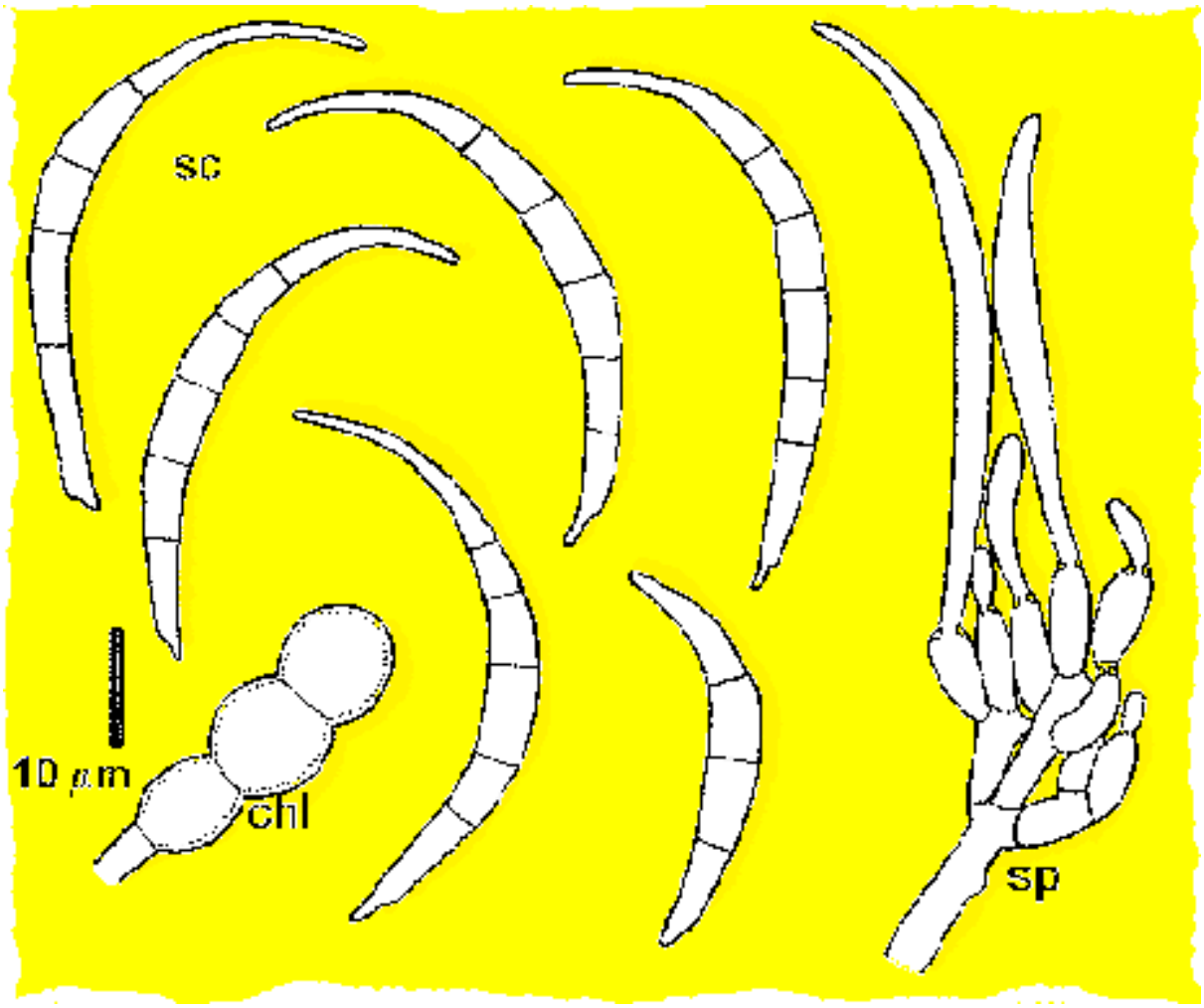
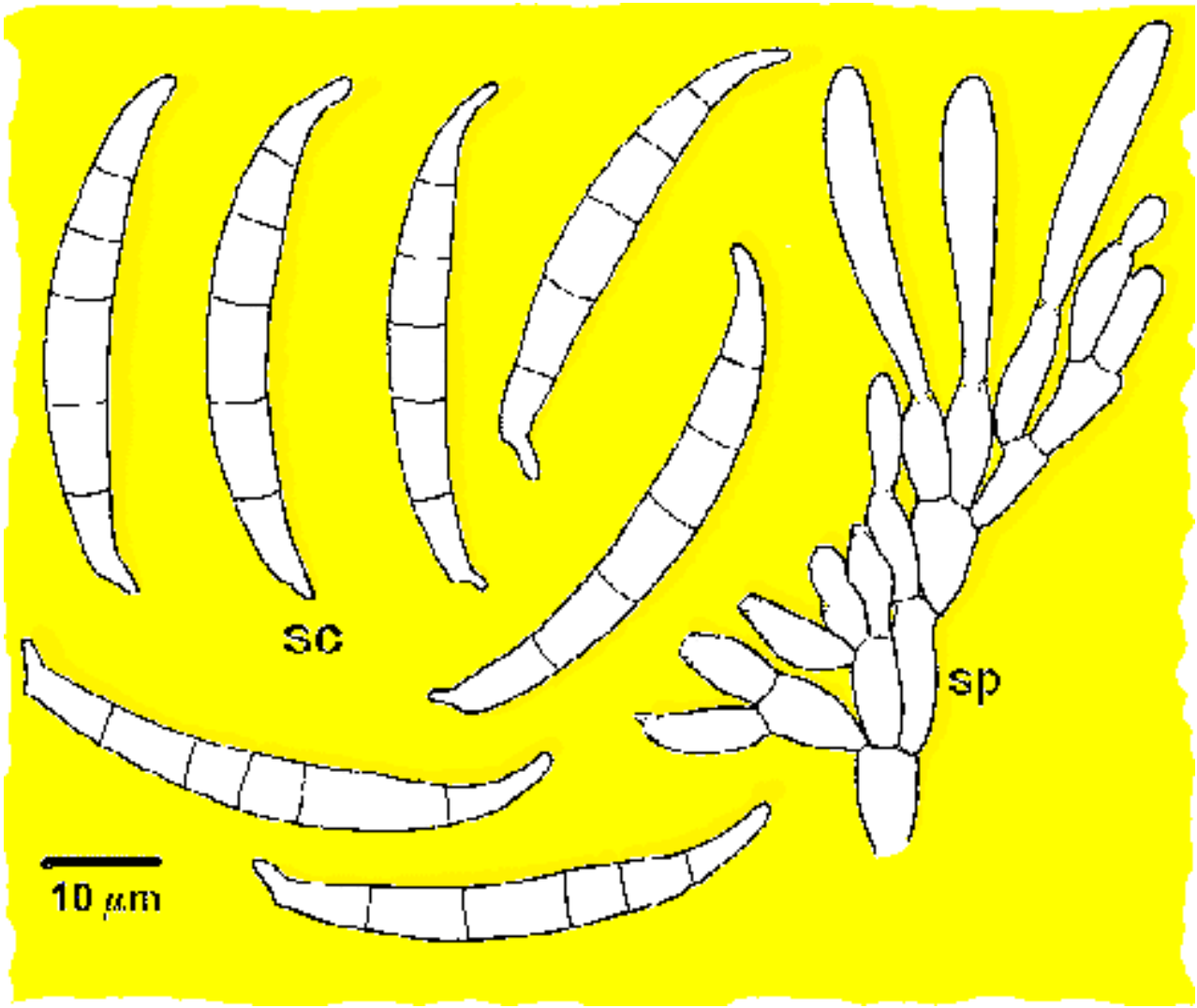


Fusarium compactum (Wollenw.) Gordon

Section: *Gibbosum*
Notes
Very similar to *F. equiseti*, but produces more robust conidia.
References
Gerlach and Nirenberg. 1982. p. 183.
Burgess, Liddell and Summerell. 1988. p. 138.

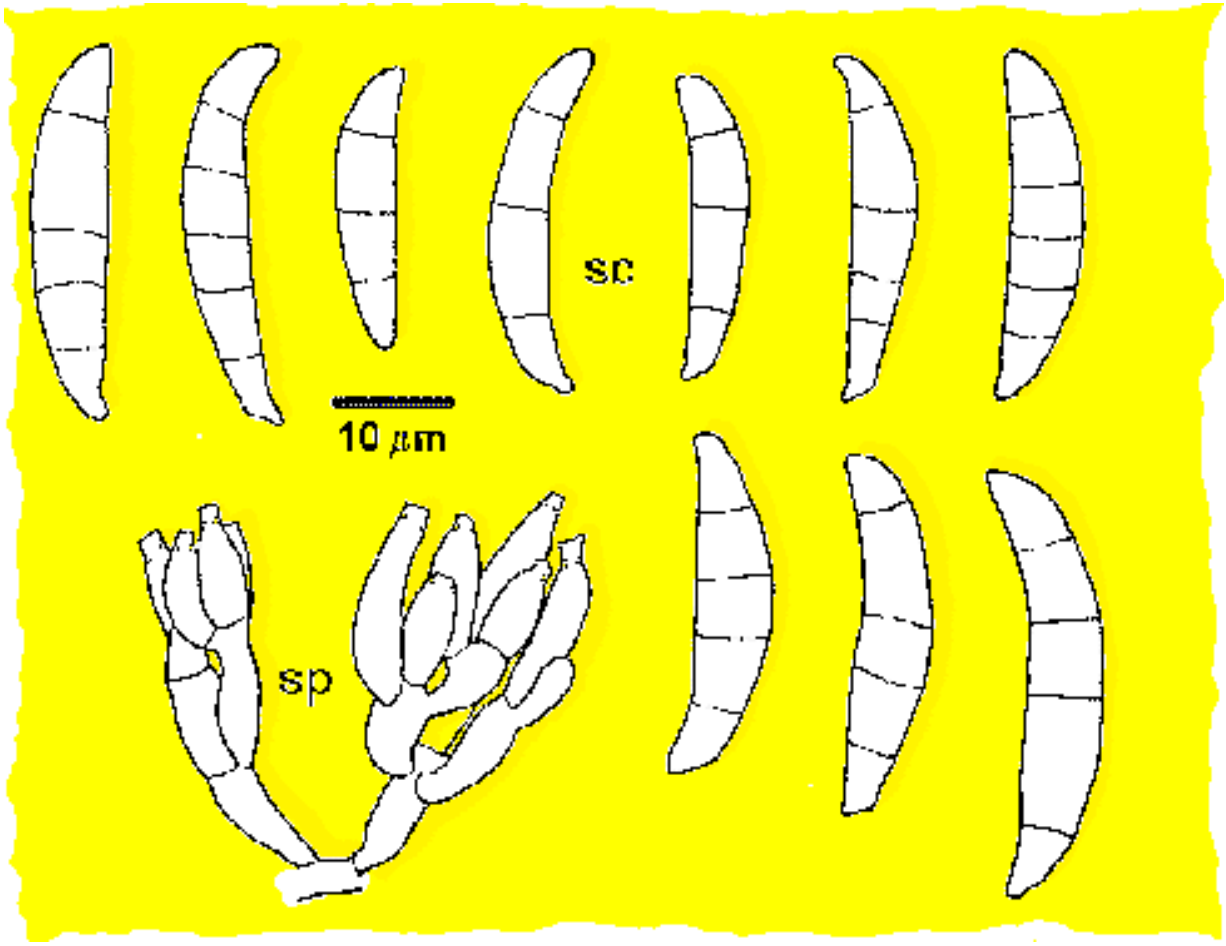
NOTES ON THE SPECIES



Fusarium crookwellense Burgess, Nelson & Toussoun

Alternate Name: *Fusarium cerealis* (Cooke) Sacc.
Section: *Discolor*
Diagnostic characters
Relatively straight, robust macroconidia of type E (could be interpretted as C), usually conspicuously widest and appearing swollen in the middle. The sporodochia are usually reddish-brown.
Notes
The macroconidia are generally not broadest above the centre, as they are in *F. culmorum* and *F. sambucinum*. The macroconidia of *F. graminearum* are usually not swollen in the centre, as they are in *F. crookwellense*.
References
Nelson, Toussoun and Marasas. 1983. p. 121.
Burgess, Liddell and Summerell. 1988. p. 116.

NOTES ON THE SPECIES



Fusarium culmorum (W.G. Smith) Sacc.

Section: *Discolor*

Diagnostic characters

Broad, robust macroconidia of type E, usually conspicuously wider above the centre of the spore, often with a fairly rounded basal cell.

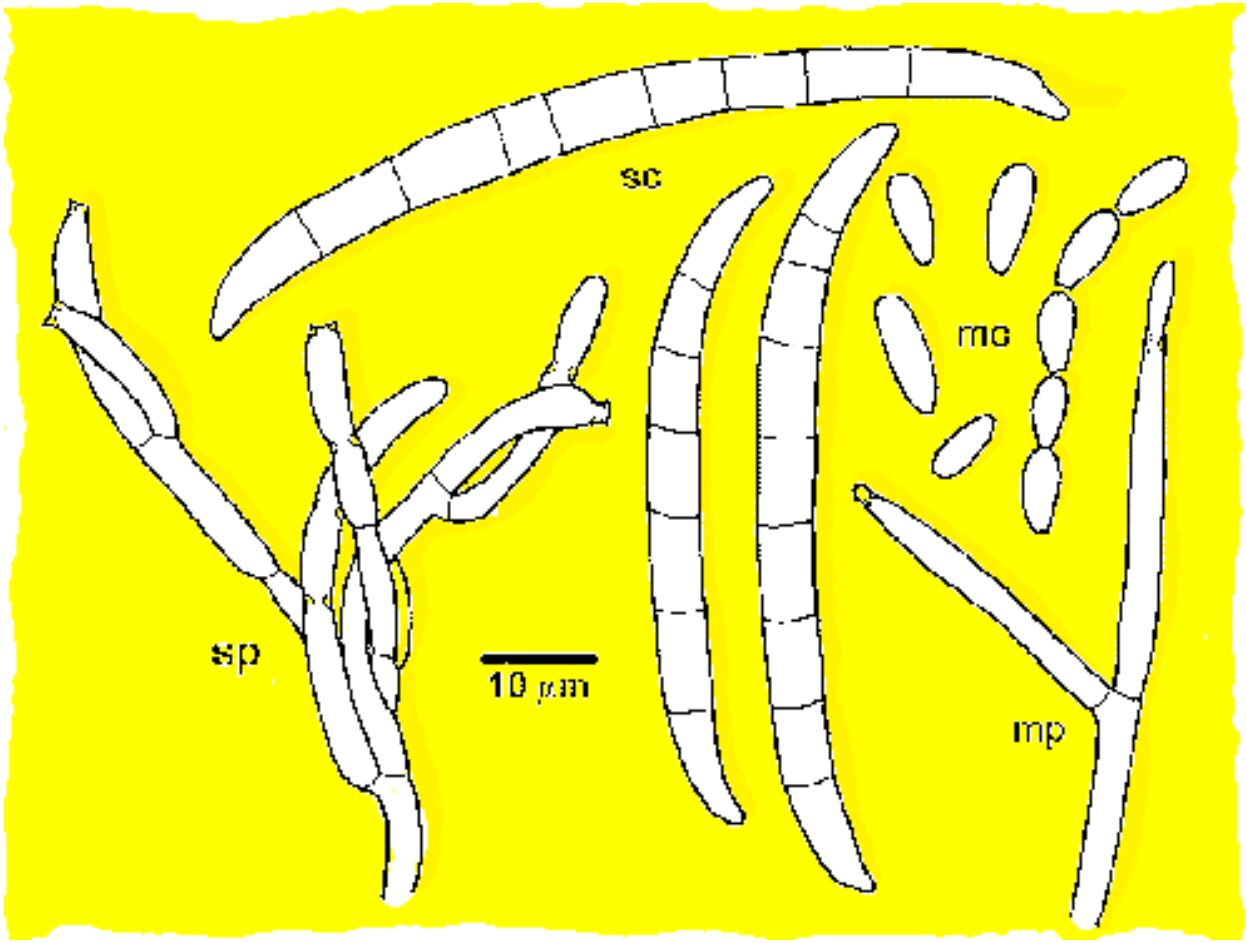
Notes

The main distinguishing character from *F. sambucinum* is the broader macroconidia.

References

Nelson, Toussoun and Marasas. 1983. p. 115.
Booth. 1971. p. 173.
Gerlach and Nirenberg. 1982. p. 225.
Burgess, Liddell and Summerell. 1988. p. 111.

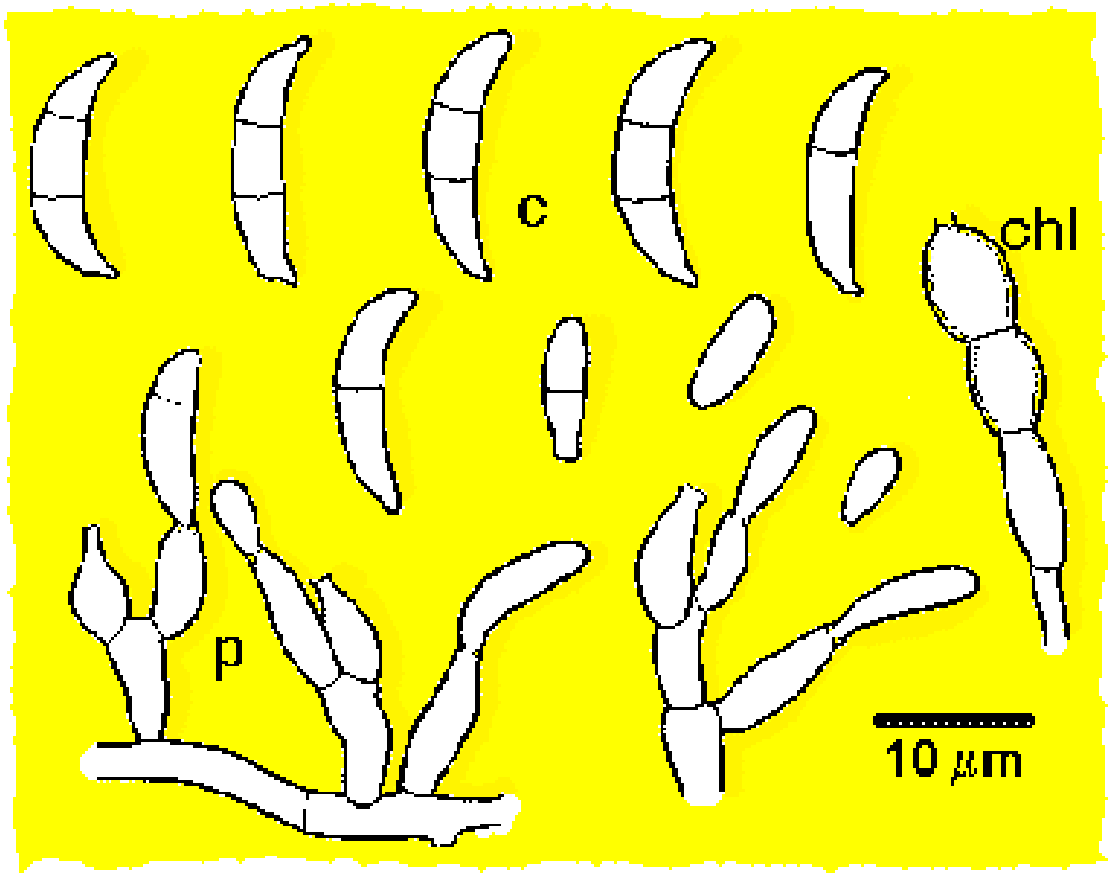
NOTES ON THE SPECIES



Fusarium decemcellulare Brick

Section: *Spicarioides*
Teleomorph: *Calonectria rigidiuscula* (Berk. & Br.) Sacc.
Diagnostic characters
Microconidia are produced in chains from monophialides in the aerial mycelium. The macroconidia are comparatively large, straight, and of type C.
Notes
The macroconidia of this species are much larger than the other species of *Fusarium* (all in section *Liseola*) that produce microconidia in chains.
References
Nelson, Toussoun and Marasas. 1983. p. 60.
Booth. 1971. p. 75.
Gerlach and Nirenberg. 1982. p. 83.
Burgess, Liddell and Summerell. 1988. p. 73.

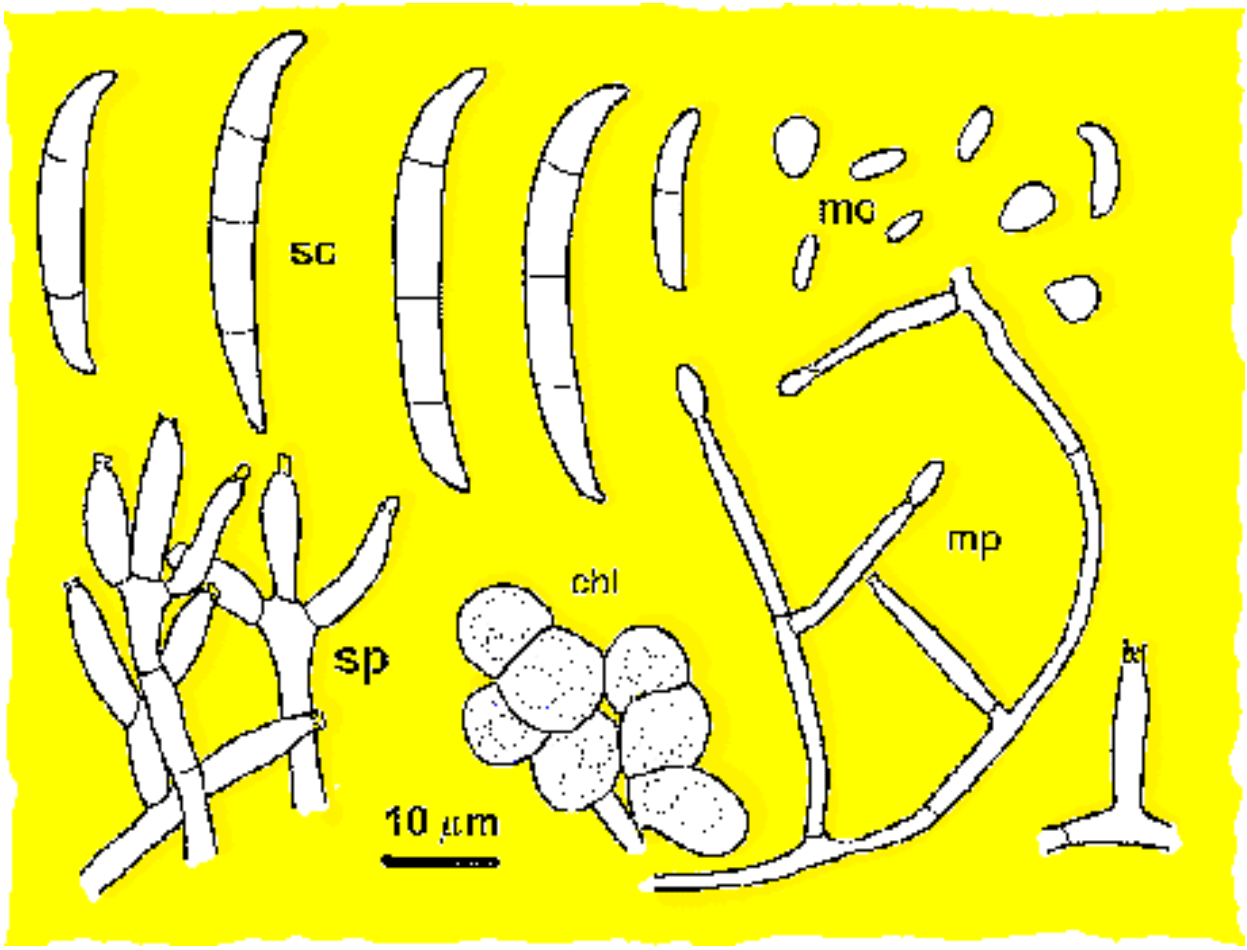
NOTES ON THE SPECIES



Fusarium dimerum Penzig

Section: *Eupionnotes*
References
Nelson, Toussoun and Marasas. 1983. p. 58.
Booth. 1971. p. 40
Gerlach and Nirenberg. 1982. p. 47.

NOTES ON THE SPECIES



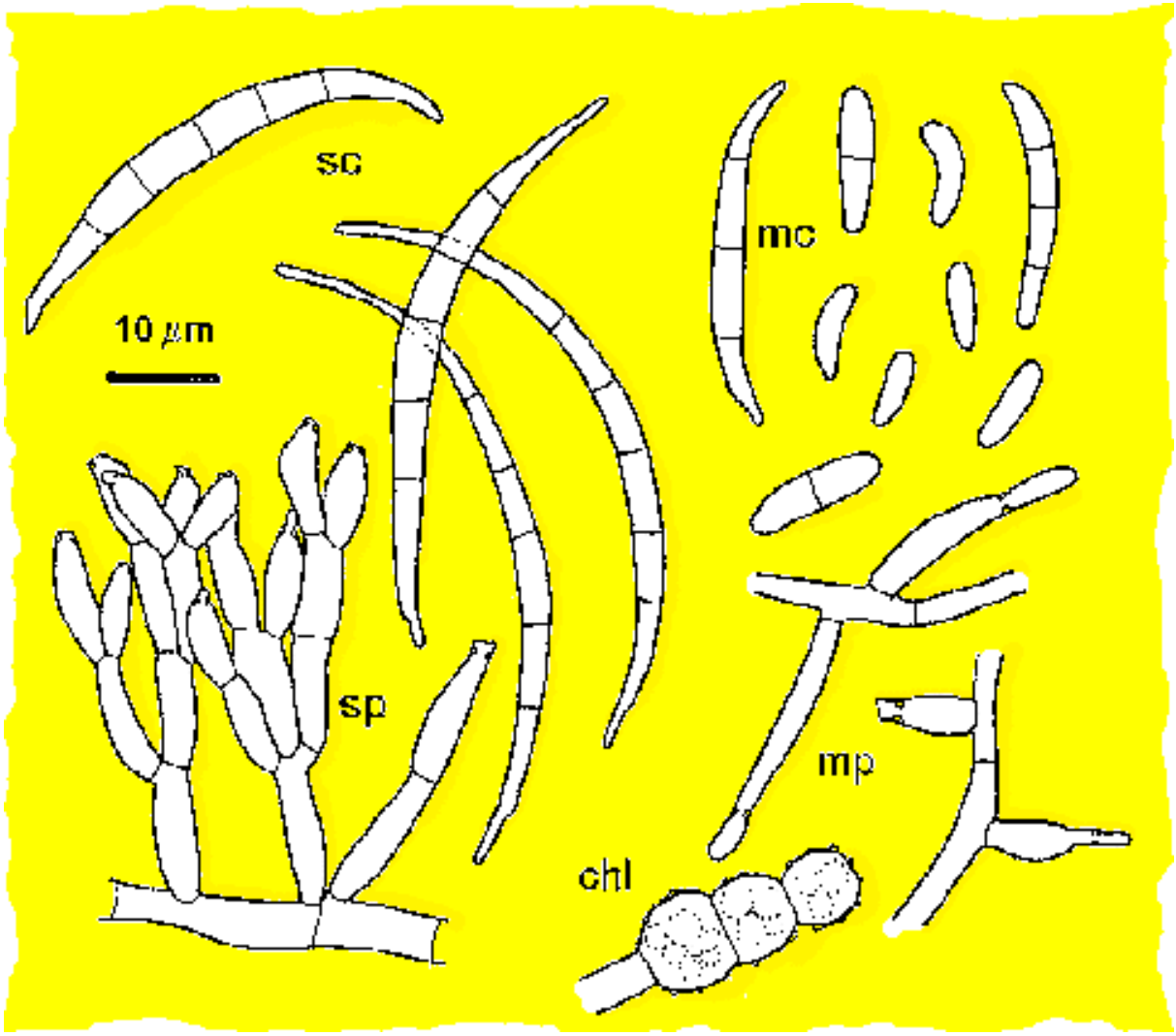
Fusarium dlamini Marasas, Nelson & Toussoun

Section: unassigned

References

Marasas, Nelson and Toussoun. 1985. Mycologia 77: 971-975.

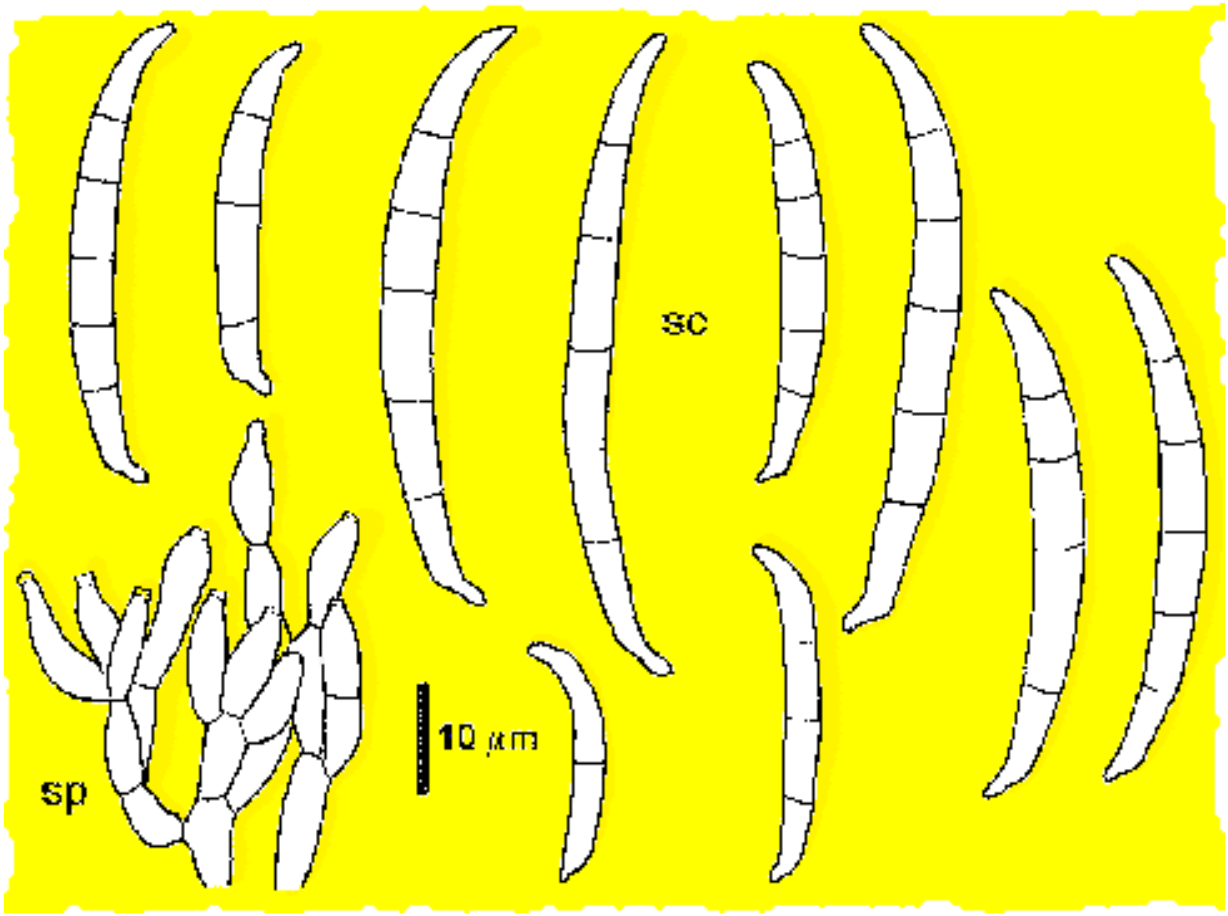
NOTES ON THE SPECIES



Fusarium equiseti (Corda) Sacc.

Section: *Gibbosum*
Teleomorph: *Gibberella intricans* Wollenw.
Notes
Chlamydospores form better without UV light. Main difference from *F. acuminatum* - colonies red on PDA. Macroconidia in aerial mycelium extremely variable.
References
Nelson, Toussoun and Marasas. 1983. p. 89.
Booth. 1971. p. 157.
Gerlach and Nirenberg. 1982. p. 177.
Burgess, Liddell and Summerell. 1988. p. 140.

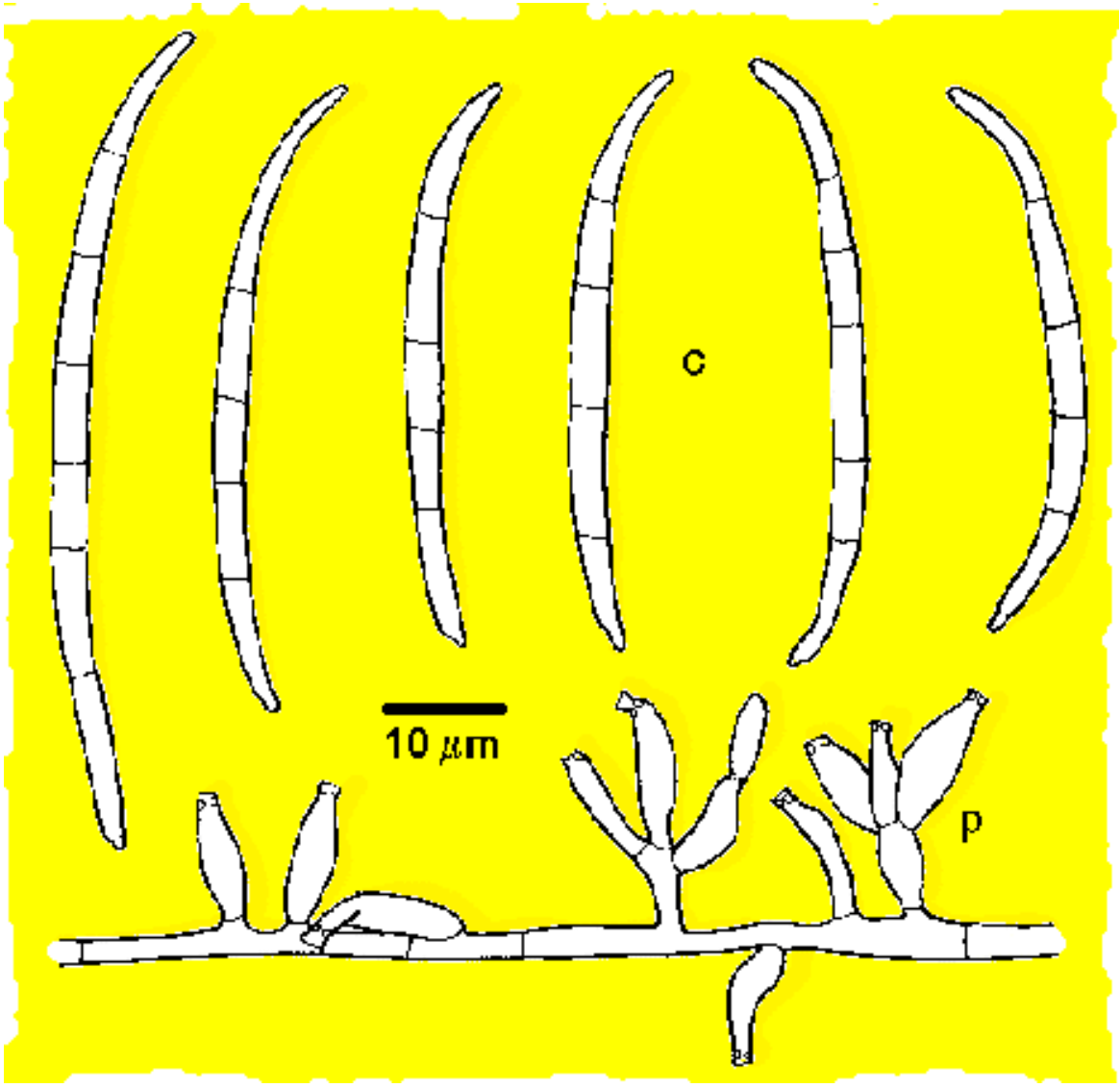
NOTES ON THE SPECIES



Fusarium graminearum Schwabe

Section: *Discolor*
Teleomorph: *Gibberella zeae* (Schw.) Petch (homo- and heterothallic)
References
Nelson, Toussoun and Marasas. 1983. p. 118.
Booth. 1971. p. 179.
Gerlach and Nirenberg. 1982. p. 241.
Burgess, Liddell and Summerell. 1988. p. 118.

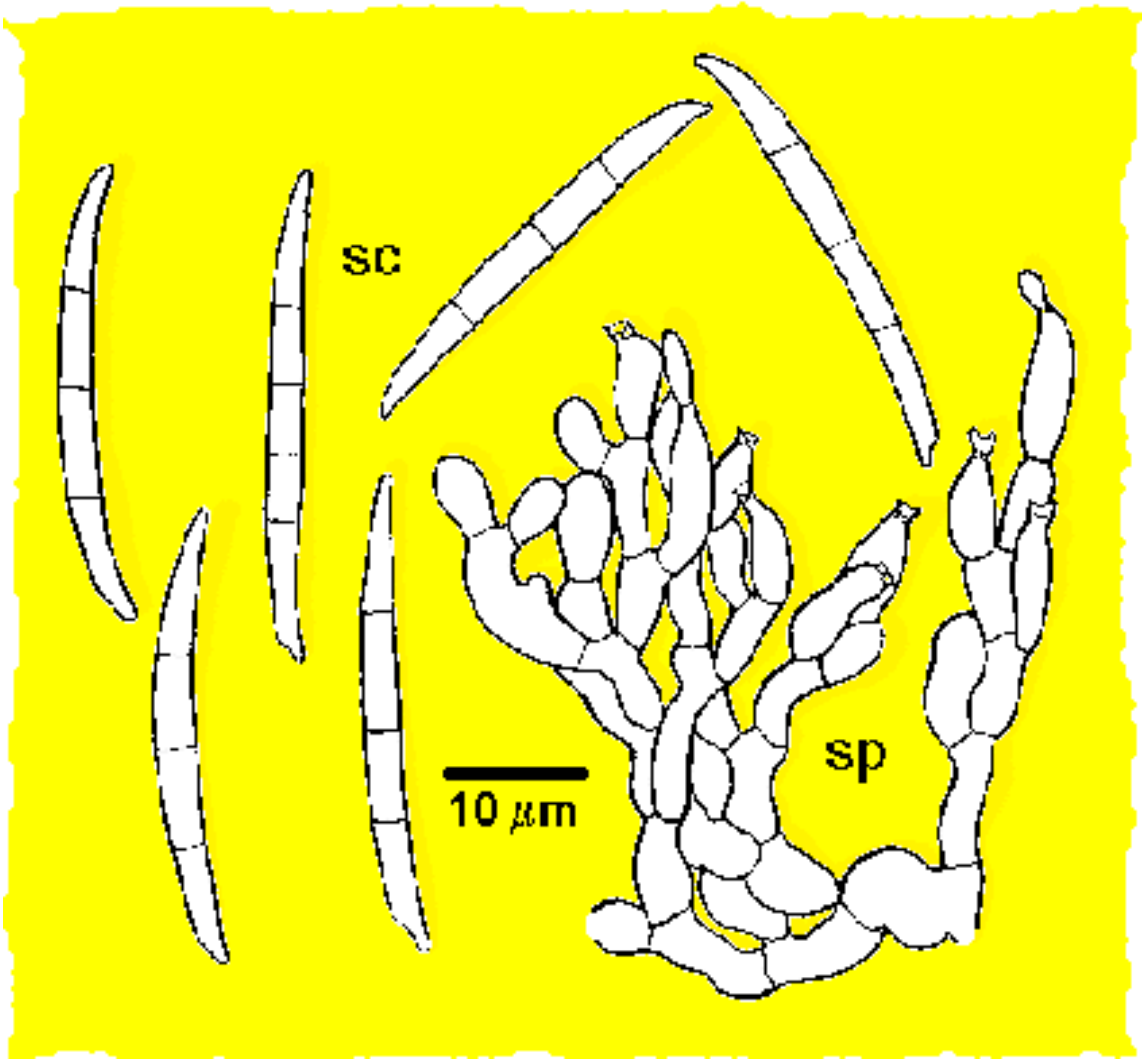
NOTES ON THE SPECIES



Fusarium graminum Corda

Section: *Roseum*
References
Nelson, Toussoun and Marasas. 1983. p. 77.
Gerlach and Nirenberg. 1982. p. 135.
Burgess, Liddell and Summerell. 1988. p. 124.

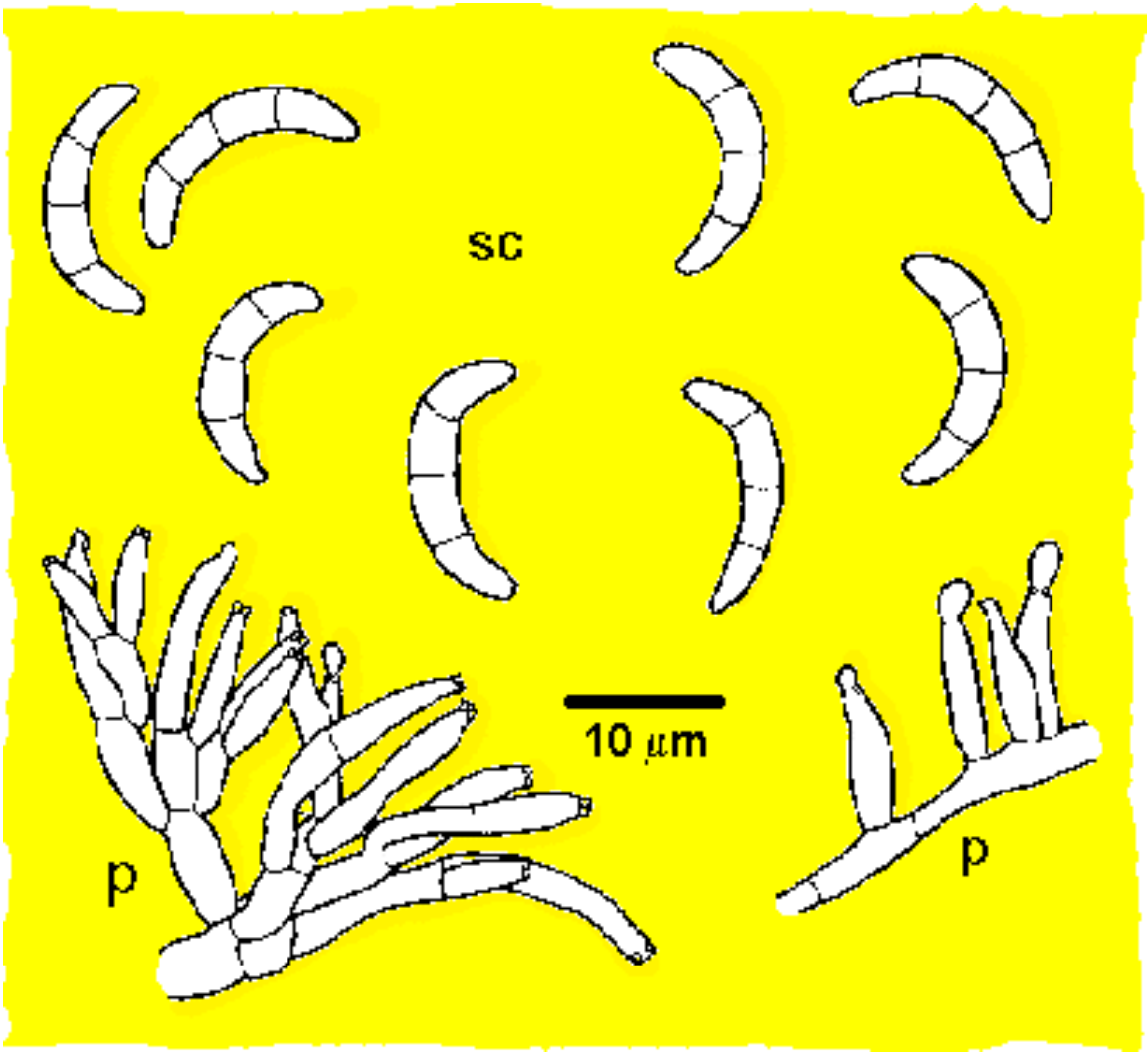
NOTES ON THE SPECIES



Fusarium heterosporum Nees

Section: *Discolor*
Teleomorph: *Gibberella gordonii* Booth
References
Nelson, Toussoun and Marasas. 1983. p. 107.
Gerlach and Nirenberg. 1982. p. 197.

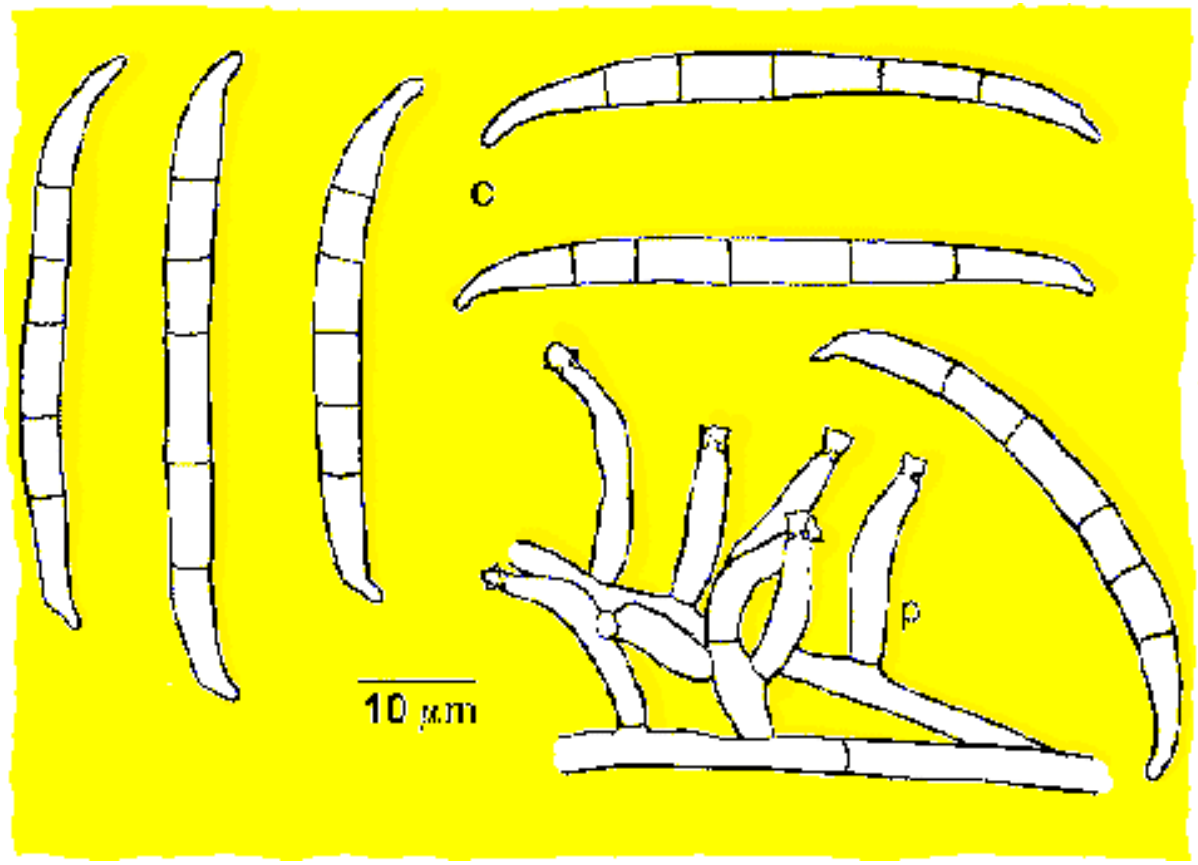
NOTES ON THE SPECIES



Fusarium larvarum Fuckel

Section: *Arachnites*
Teleomorph: *Nectria aurantiicola* Berk. & Br.
Diagnostic characters
Short, generally three-septate conidia produced in bright orange sporodochia. Colonies slow growing. On scale insects.
Notes
Compare with *F. coccophilum*, which also occurs on scale insects.
References
Nelson, Toussoun and Marasas. 1983. p. 157.
Booth. 1971. p. 98.
Gerlach and Nirenberg. 1982. p. 99.

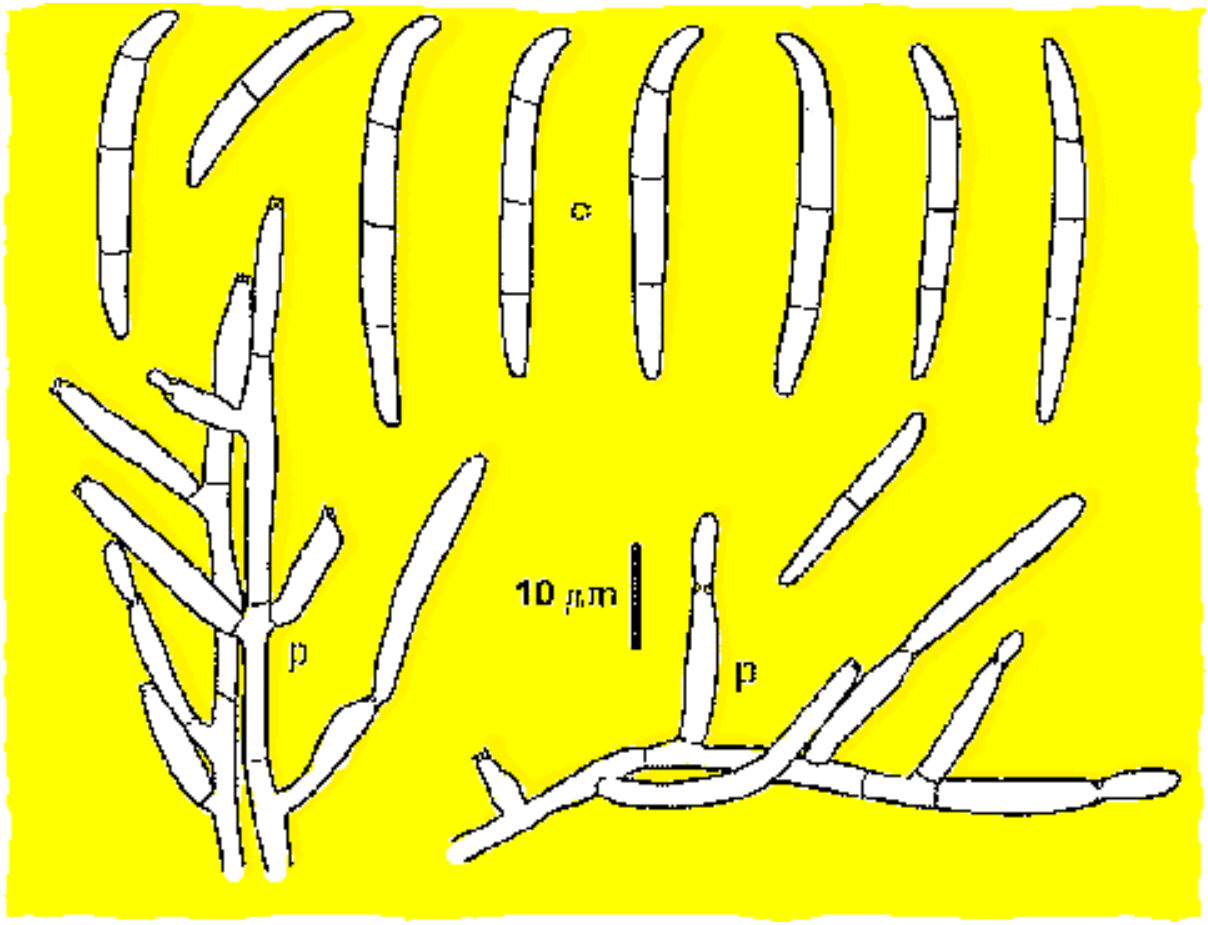
NOTES ON THE SPECIES



Fusarium lateritium Nees

Section: *Lateritium*
Teleomorph: *Gibberella baccata* (Wallr.) Sacc.
References
Nelson, Toussoun and Marasas. 1983. p. 124.
Booth. 1971. p. 108.
Gerlach and Nirenberg. 1982. p. 271.
Burgess, Liddell and Summerell. 1988. p. 71.

NOTES ON THE SPECIES



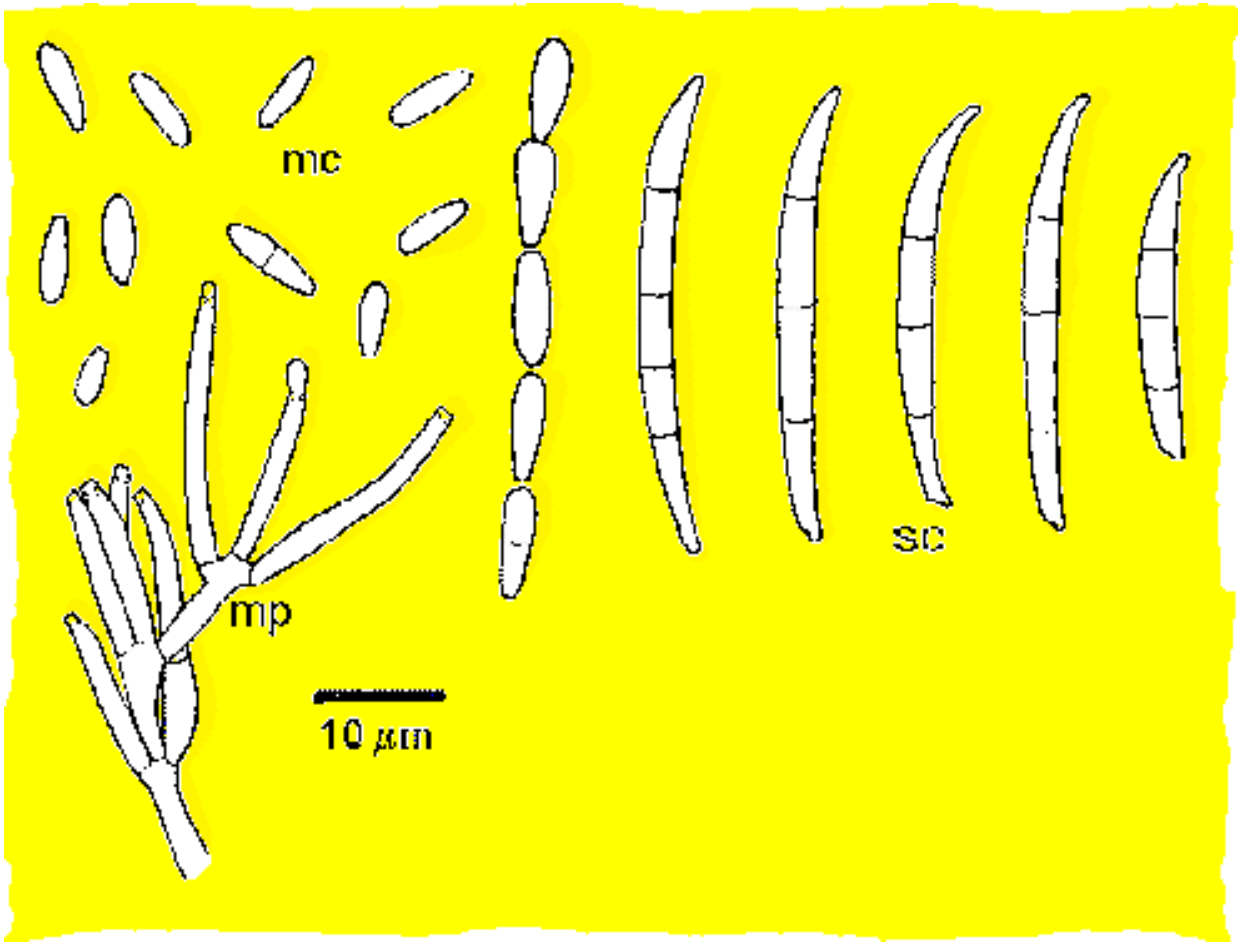
Fusarium merismoides Corda

Section: *Eupionnotes*

References

Nelson, Toussoun and Marasas. 1983. p. 55.
Booth. 1971. p. 70.
Gerlach and Nirenberg. 1982. p. 27.
Burgess, Liddell and Summerell. 1988. p. 70.

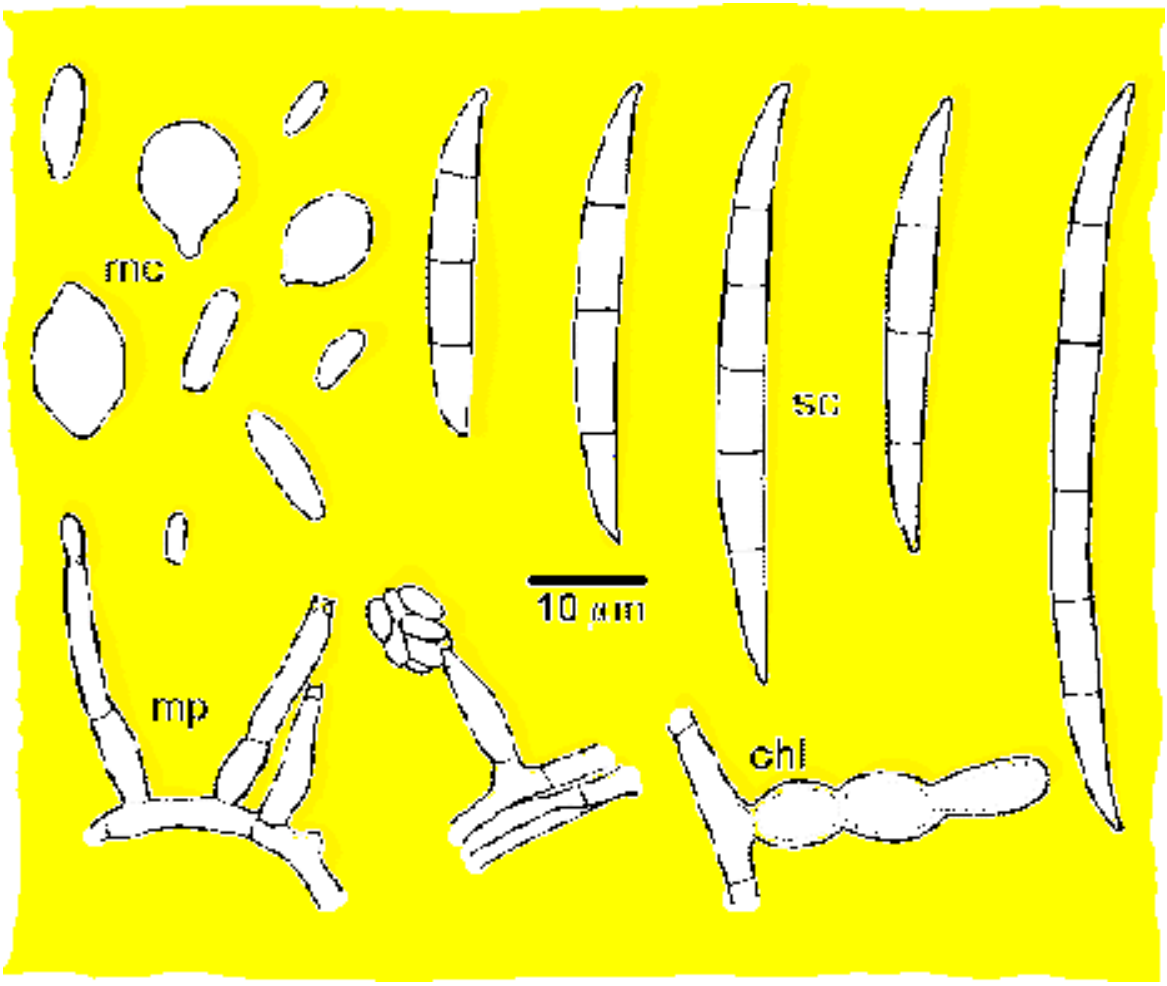
NOTES ON THE SPECIES



Fusarium moniliforme Sheldon

Alternate name: *F. verticillioides* (Sacc.) Nirenberg
Section: *Liseola*
Teleomorph: *Gibberella fujikuroi* (Sawada) Wollenw. or *G. moniliformis* Wineland.
Diagnostic characters
Microconidia produced in chains from monophialides in the aerial mycelium. Macroconidia are usually sparsely produced and are of type B, narrow and straight.
Notes
Macroconidia production may require UV. Distinguished from *F. proliferatum* by the absence of polyphialides in the aerial mycelium. Two apparently reproductively isolated mating populations are known with anamorphs assignable to *F. moniliforme*.
References
Nelson, Toussoun and Marasas. 1983. p. 128.
Booth. 1971. p. 123.
Gerlach and Nirenberg. 1982. p. 301.
Burgess, Liddell and Summerell. 1988. p. 86.

NOTES ON THE SPECIES



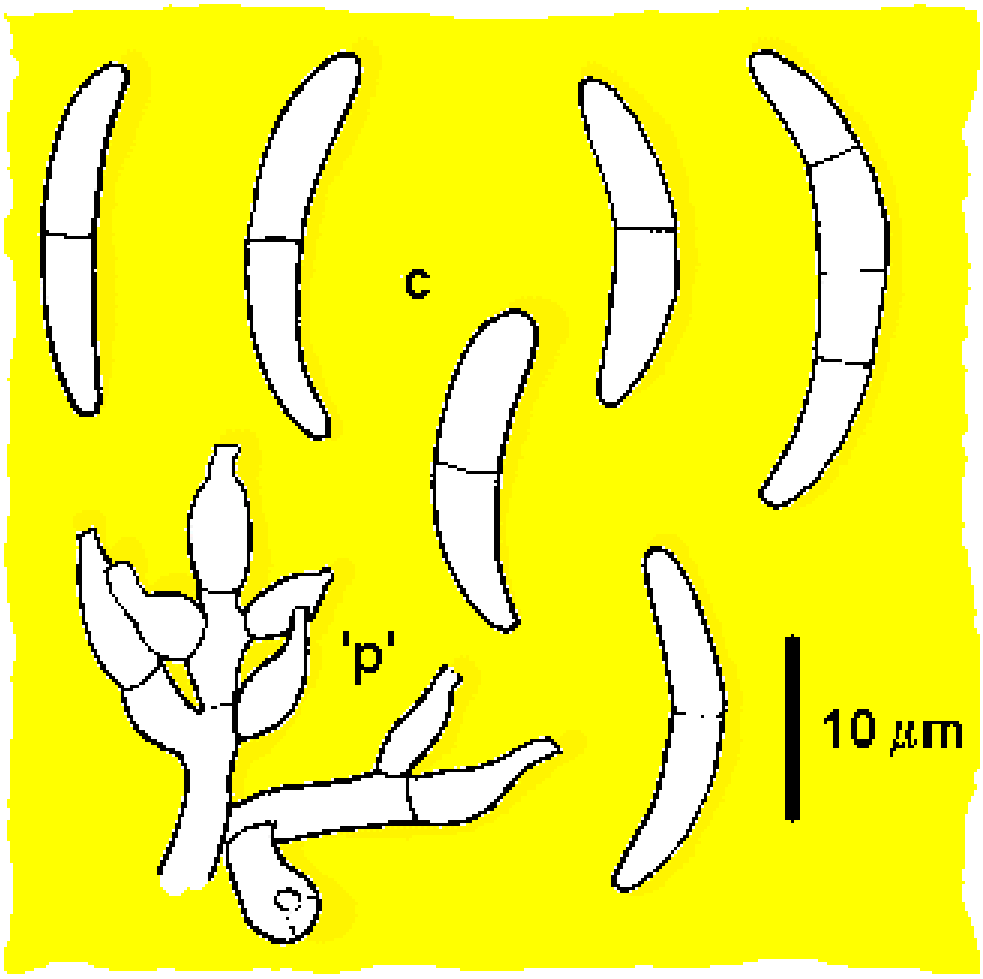
Fusarium napiforme Marasas, Nelson and Rabie

Section: unassigned

References

Marasas, Rabie, Lubben, Nelson, Toussoun and Van Wyk. 1987. Mycologia 79: 910-914.

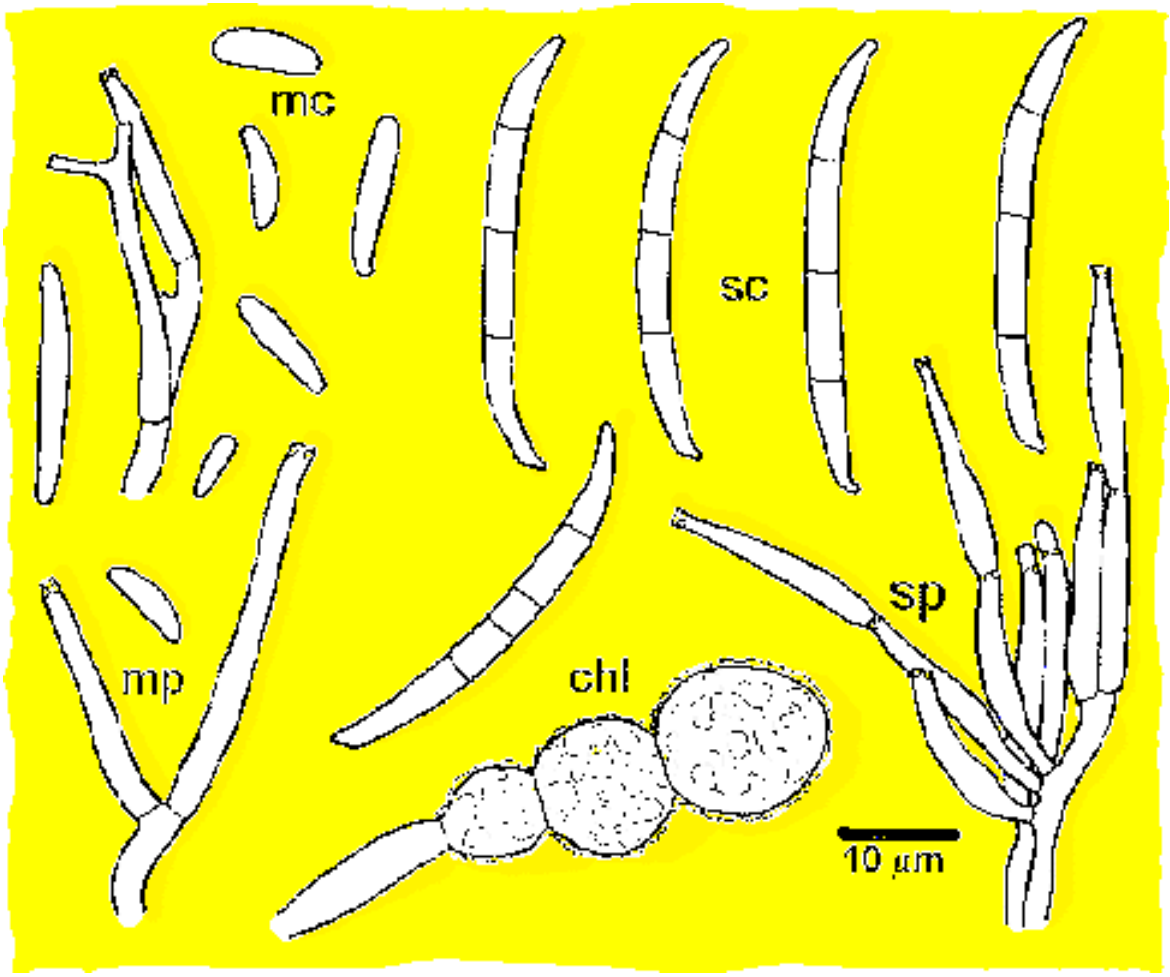
NOTES ON THE SPECIES



Microdochium nivale (Fr.) Samuels & Hallet

Alternate names: *Fusarium nivale* (Fr.) Ces.
Gerlachia nivalis (Fr.) Gams & Muller
Section: *Arachnites*
Teleomorph: *Monographella nivalis* (Schaffnit) Muller
Notes
Because of the different teleomorph, and the presence of annellated conidiogenous cells rather than phialides, this species is properly excluded from *Fusarium*.
References
Nelson, Toussoun and Marasas. 1983. p. 62.
Booth. 1971. p. 42.
Gerlach and Nirenberg. 1982. p. 107.

NOTES ON THE SPECIES



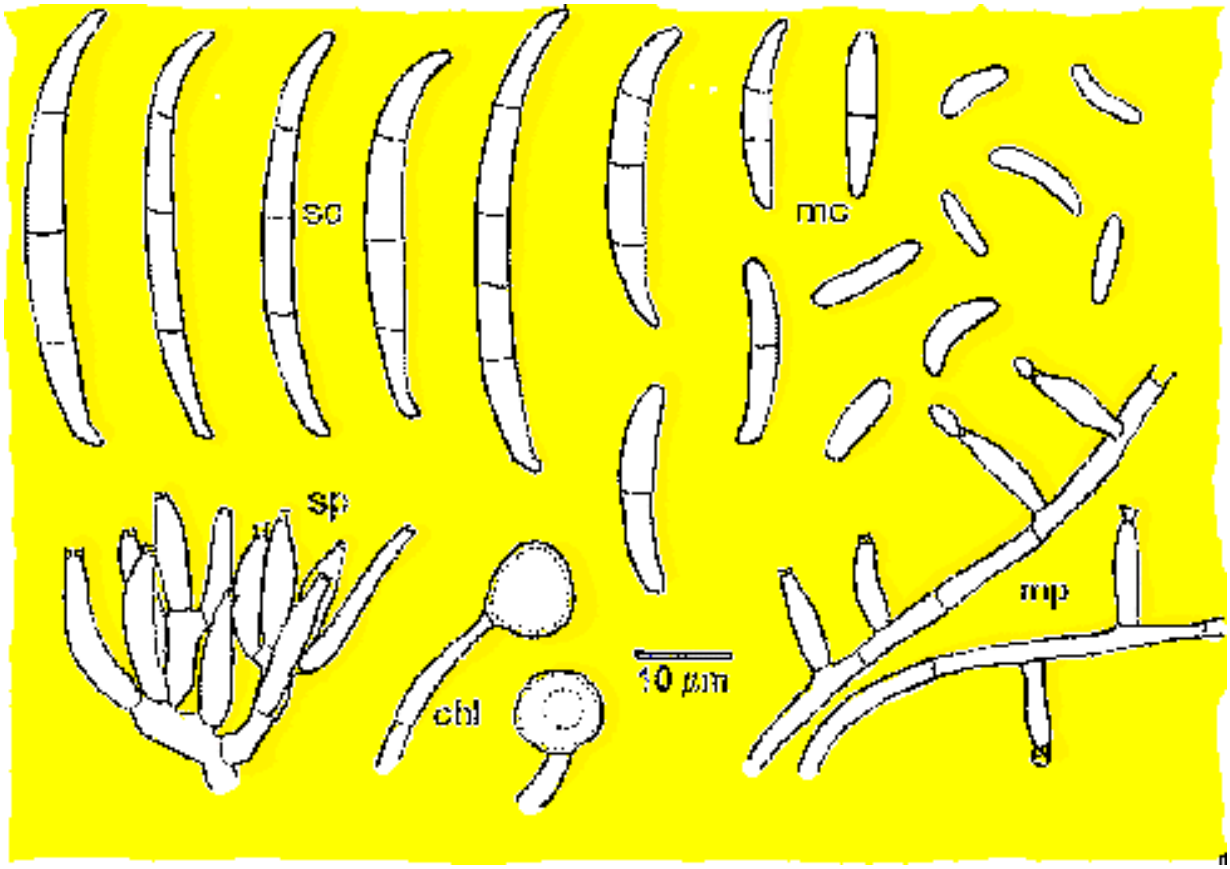
Fusarium nygamai Burgess & Trimboli

Section: unassigned

References

Burgess and Trimboli. 1986. Mycologia 78: 223-229.

NOTES ON THE SPECIES



Fusarium oxysporum Schlecht.

Section: *Elegans*

Diagnostic characters

Macroconidia of type C, straight. Microconidia usually comma shaped or ellipsoidal. Chlamydospores usually produced singly or in pairs.

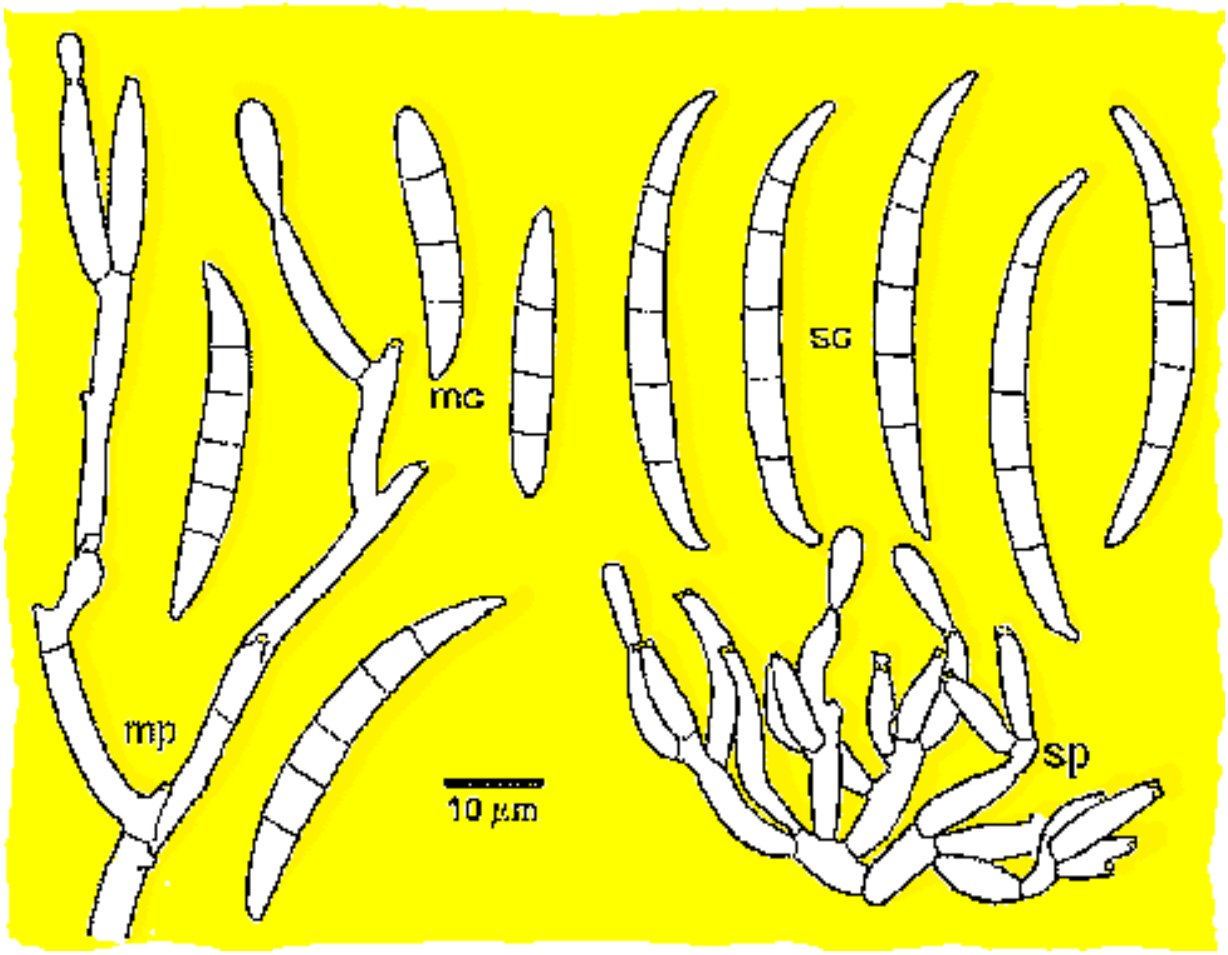
Notes

This species is divided into many *formae speciales* that cannot be distinguished using morphological criteria. It is distinguished easily from *F. solani* by the shorter phialides in the aerial mycelium.

References

Nelson, Toussoun and Marasas. 1983. p. 142.
Booth. 1971. p. 130.
Gerlach and Nirenberg. 1982. p. 345.
Burgess, Liddell and Summerell. 1988. p. 100.

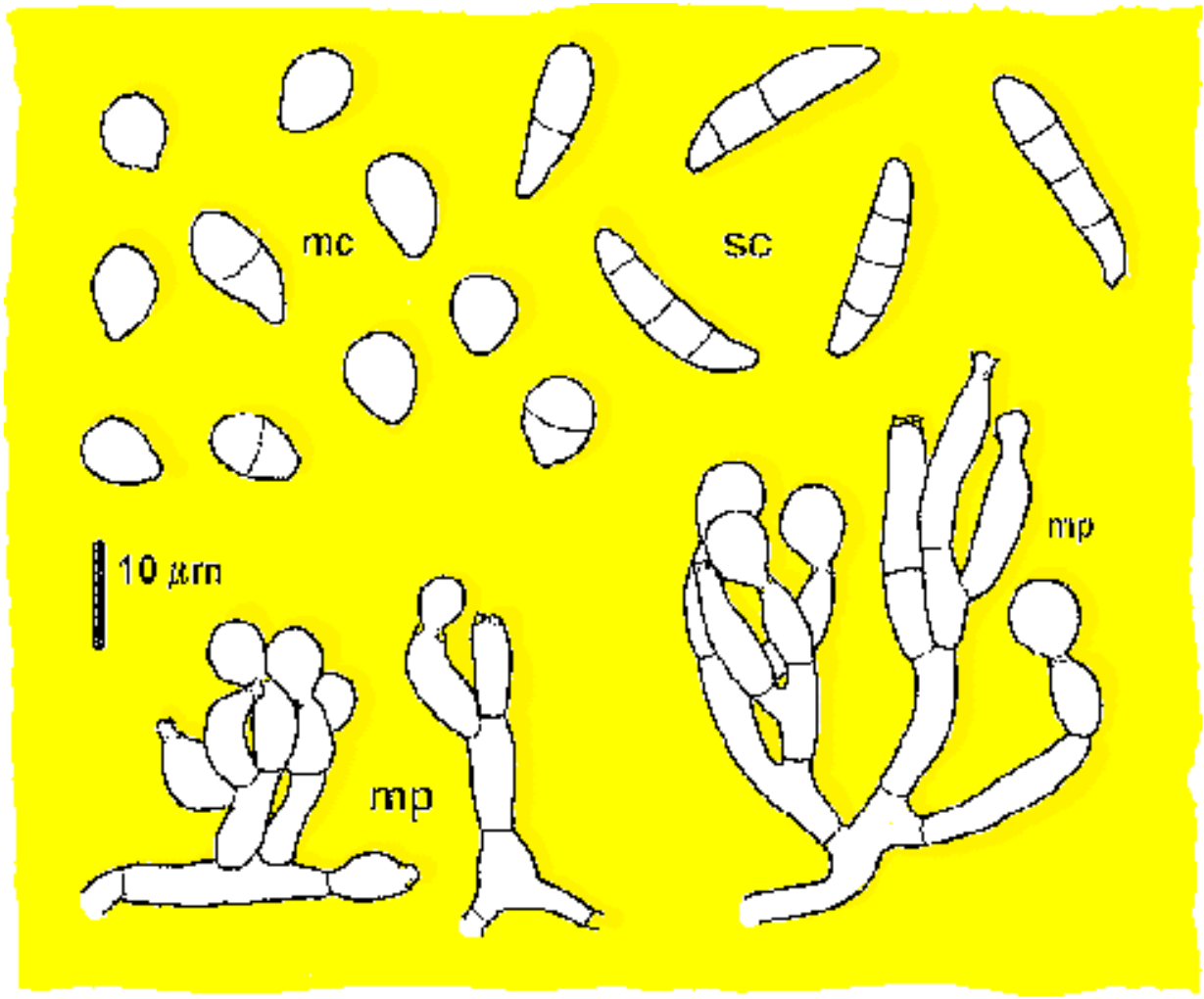
NOTES ON THE SPECIES



Fusarium pallidoroseum (Cooke) Sacc.

Alternate name: *Fusarium semitectum* Berk. & Rav.
Section: *Arthrosporiella*
Notes
The name *F. pallidoroseum* is the correct name for this species because the type specimen of *F. semitectum* represents a different fungus (Booth and Sutton, 1984, Trans. Br. mycol. Soc. 83: 702-704).
References
Nelson, Toussoun and Marasas. 1983. p. 84.
Booth. 1971. p. 94.
Gerlach and Nirenberg. 1982. p. 155.
Burgess, Liddell and Summerell. 1988. p. 146.
Pascoe. 1990. Mycotaxon 37: 136.

NOTES ON THE SPECIES



Fusarium poae (Peck) Wollenw.

Section: *Sporotrichiella*

Diagnostic characters

Round or pip-shaped microconidia produced abundantly from plump monophialides in the aerial mycelium.

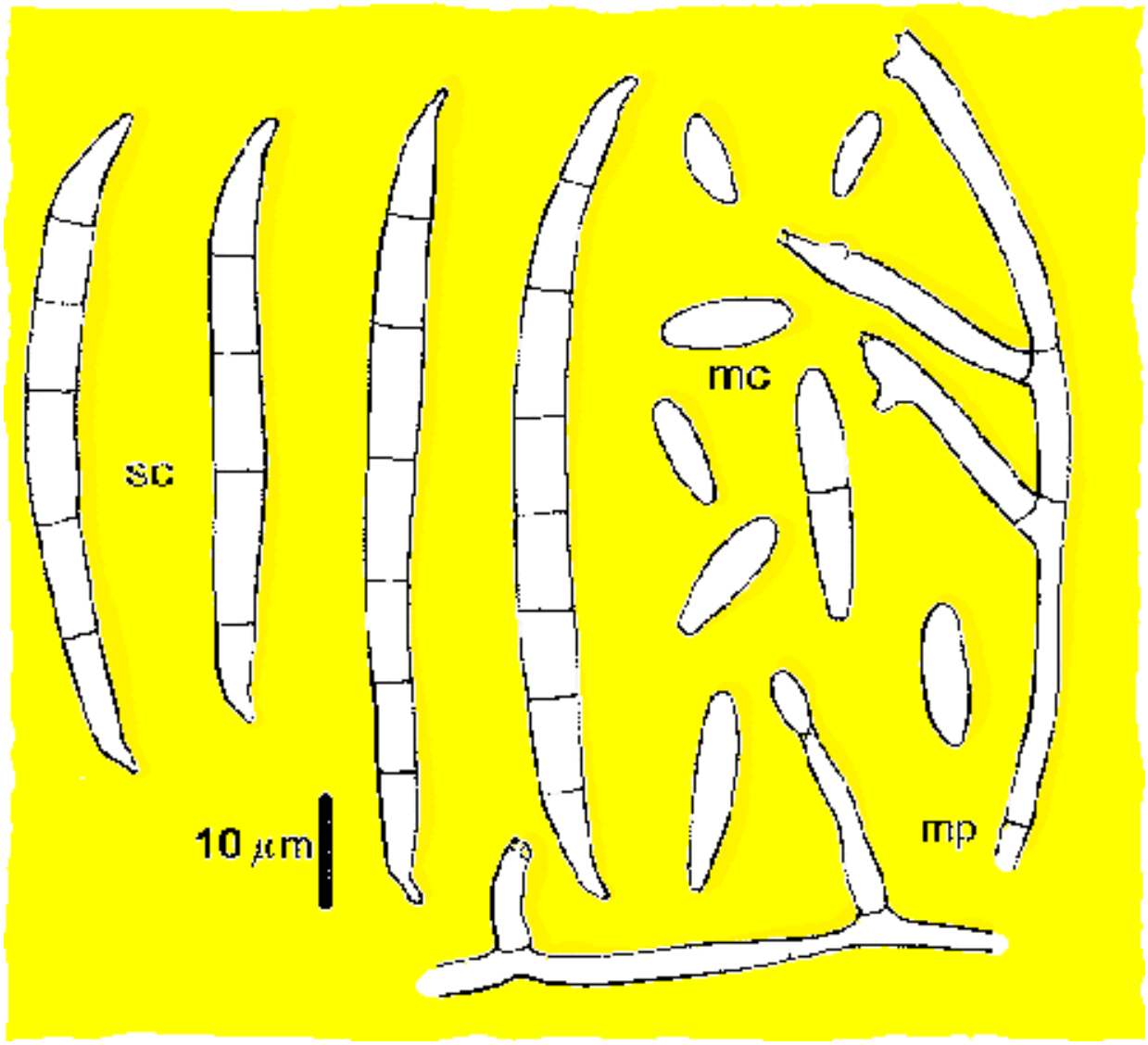
Notes

Macroconidia are difficult to detect, and may only be produced under UV. Because of this, it is sometimes difficult to recognize *F. poae* as a species of *Fusarium* unless one is familiar with the species.

References

Nelson, Toussoun and Marasas. 1983. p. 64.
Booth. 1971. p. 80.
Gerlach and Nirenberg. 1982. p. 115.
Burgess, Liddell and Summerell. 1988. p. 76.

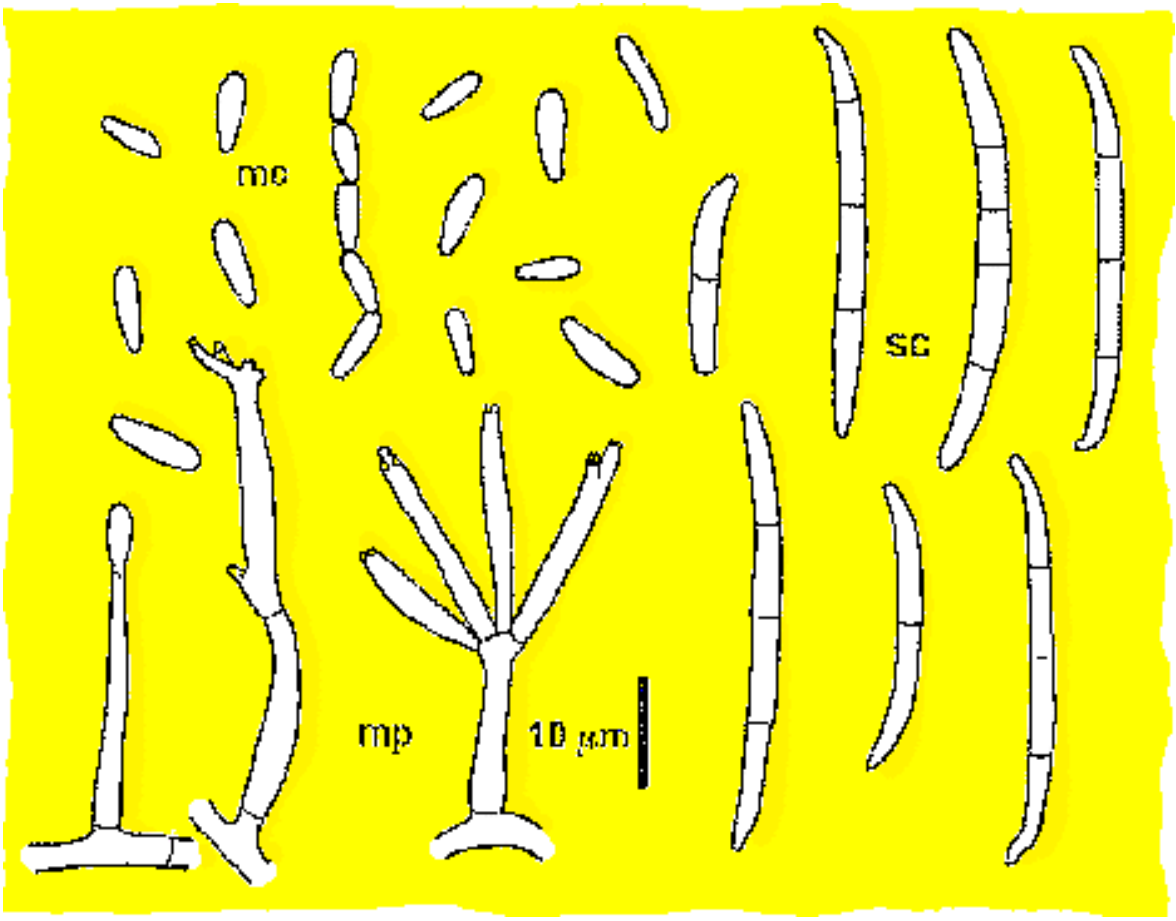
NOTES ON THE SPECIES



Fusarium polyphialidicum Marasas, Nelson, Toussoun & van Wyk

Section: unassigned
References
Marasas *et al.* 1986, Mycologia 78: 678-682.

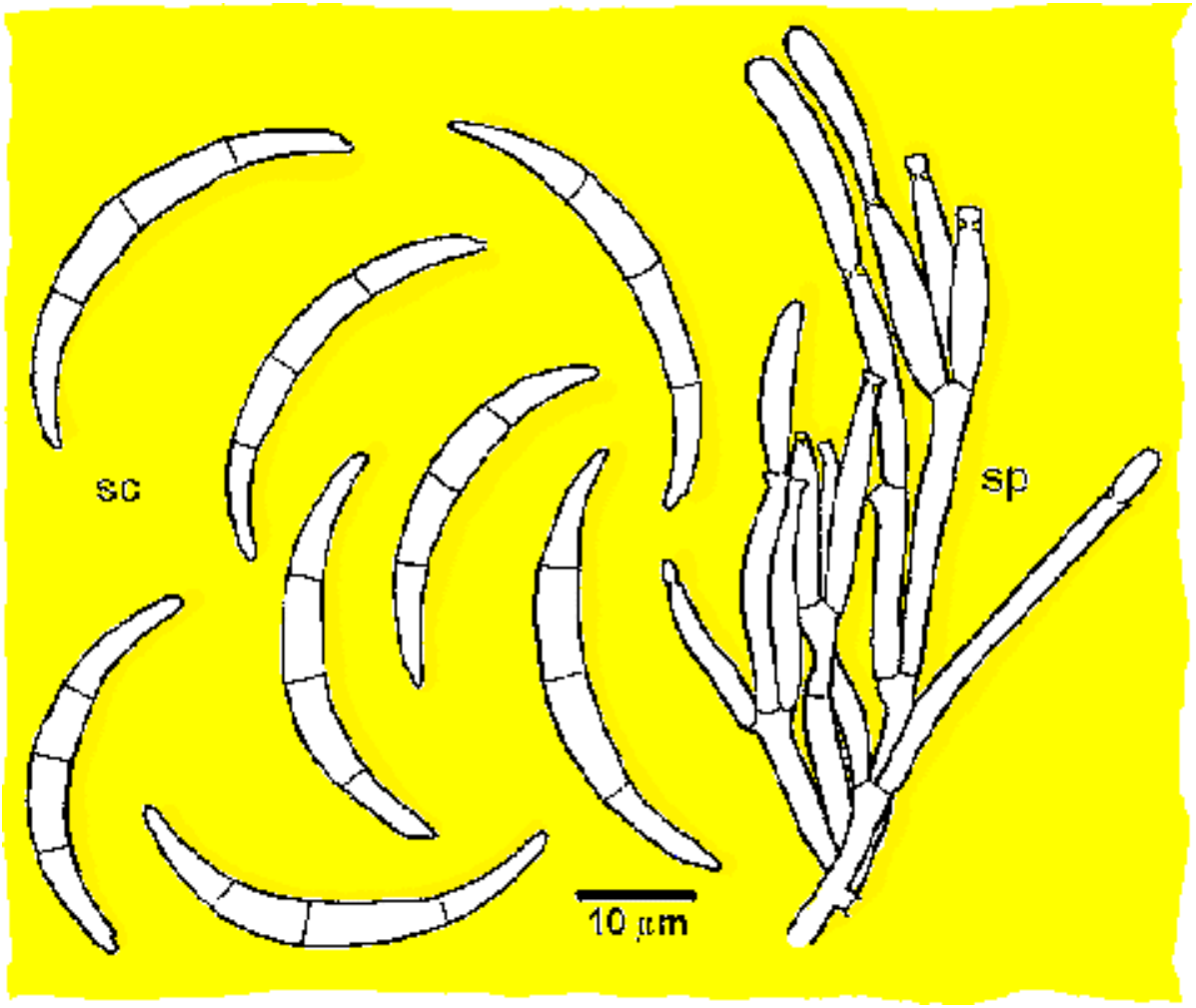
NOTES ON THE SPECIES



Fusarium proliferatum (Mats.) Nirenberg

Alternate name: *F. moniliforme* var. *intermedium* Neish & Leggett
Section: *Liseola*
Diagnostic characters
Chains of microconidia produced from polyphialides in the aerial mycelium. Macroconidia of type B, narrow and straight.
Notes
Distinguished from *F. moniliforme* by the polyphialides in the aerial mycelium. Two apparently reproductively isolated mating populations are known with anamorphs assignable to *F. proliferatum*.
References
Nelson, Toussoun and Marasas. 1983. p. 132.
Gerlach and Nirenberg. 1982. p. 309.
Burgess, Liddell and Summerell. 1988. p. 88.

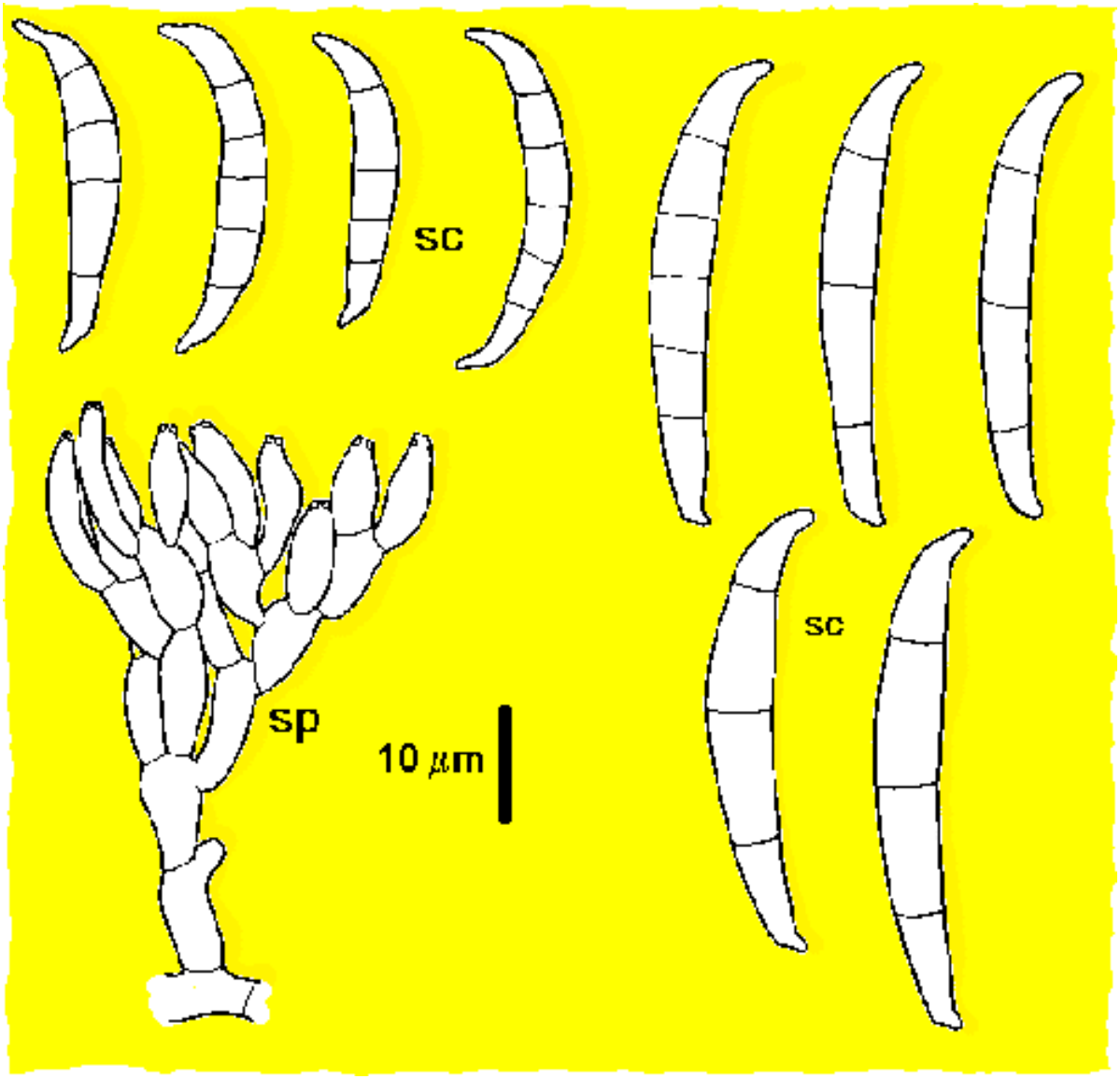
NOTES ON THE SPECIES



Fusarium reticulatum Mont.

Section: *Discolor*
Teleomorph: *Gibberella cyanea* (Sollmann) Wollenw.
References
Nelson, Toussoun and Marasas. 1983. p. 109.
Gerlach and Nirenberg. 1982. p. 203.

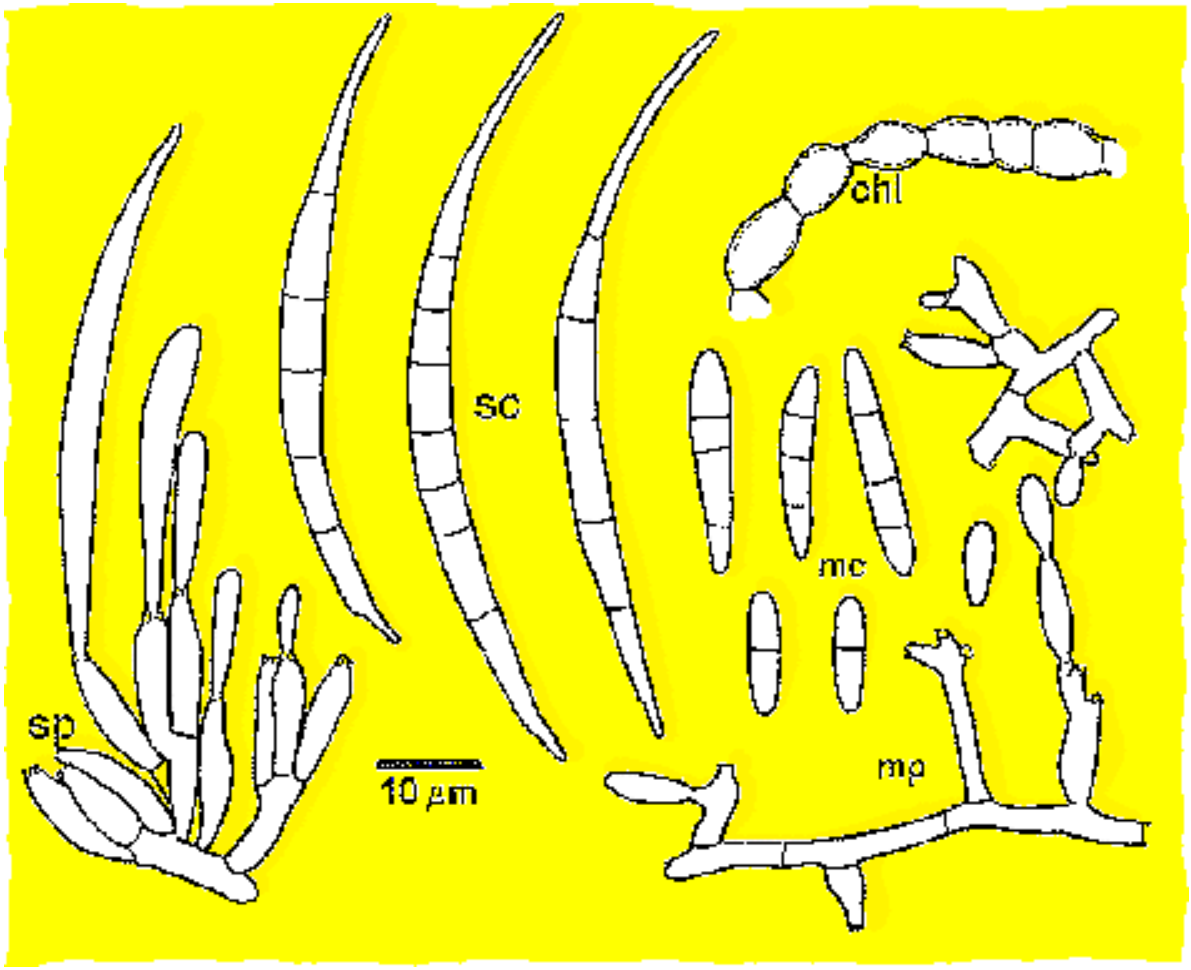
NOTES ON THE SPECIES



Fusarium sambucinum Fuckel

Section: *Discolor*
Teleomorph: *Gibberella pulicaris* (Fr.) Sacc. (heterothallic)
Notes
Distinguished from *F. culmorum* by narrower macroconidia.
References
Nelson, Toussoun and Marasas. 1983. p. 111.
Booth. 1971. p. 168.
Gerlach and Nirenberg. 1982. p. 209.
Burgess, Liddell and Summerell. 1988. p. 114.

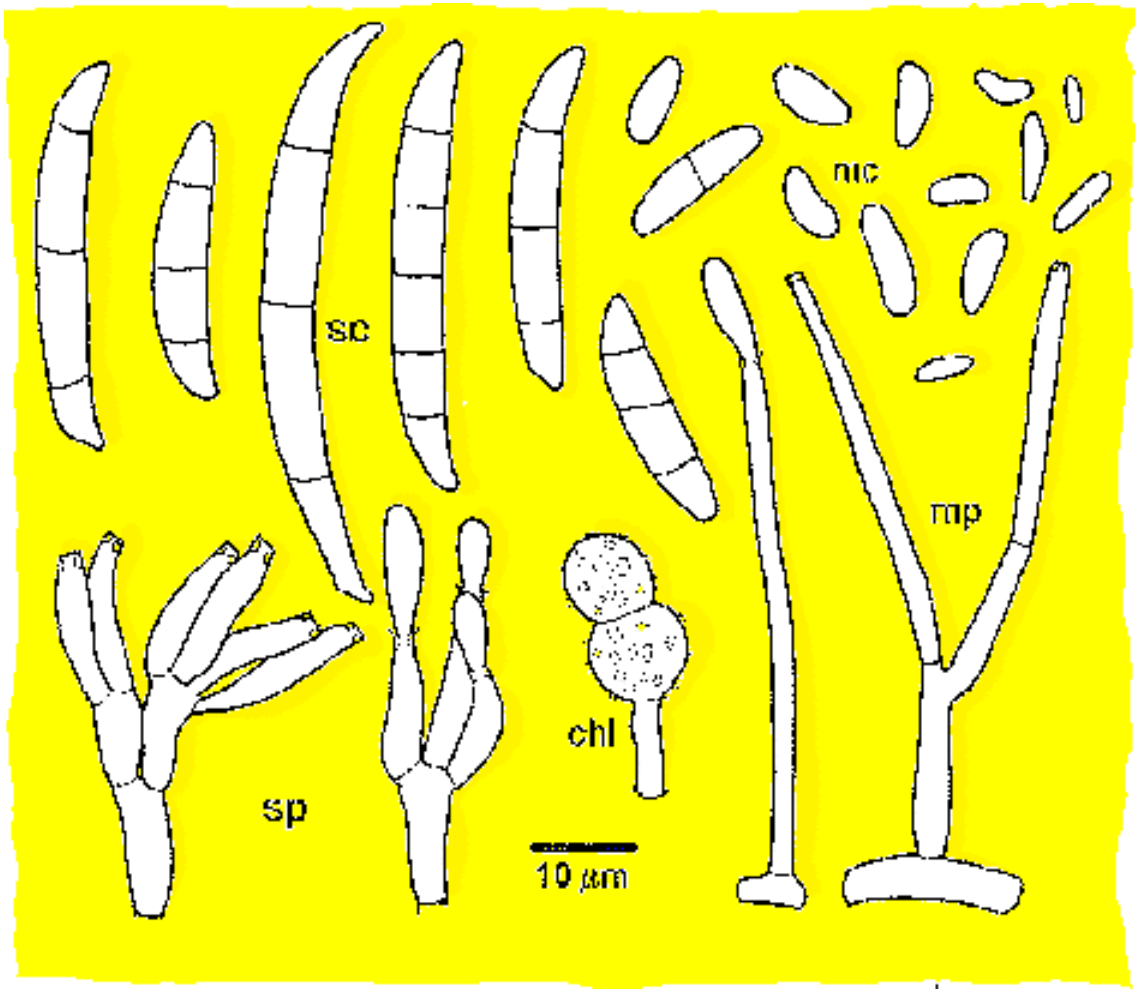
NOTES ON THE SPECIES



Fusarium scirpi Lambotte & Fautr.

Alternate name: *Fusarium chenopodium* (Thumen) Sacc.
Section: *Gibbosum*
References
Nelson, Toussoun and Marasas. 1983. p. 96.
Gerlach and Nirenberg. 1982. p. 181.
Burgess, Liddell and Summerell. 1988. p. 144.
Pascoe. 1990. Mycotaxon: 37: 143.

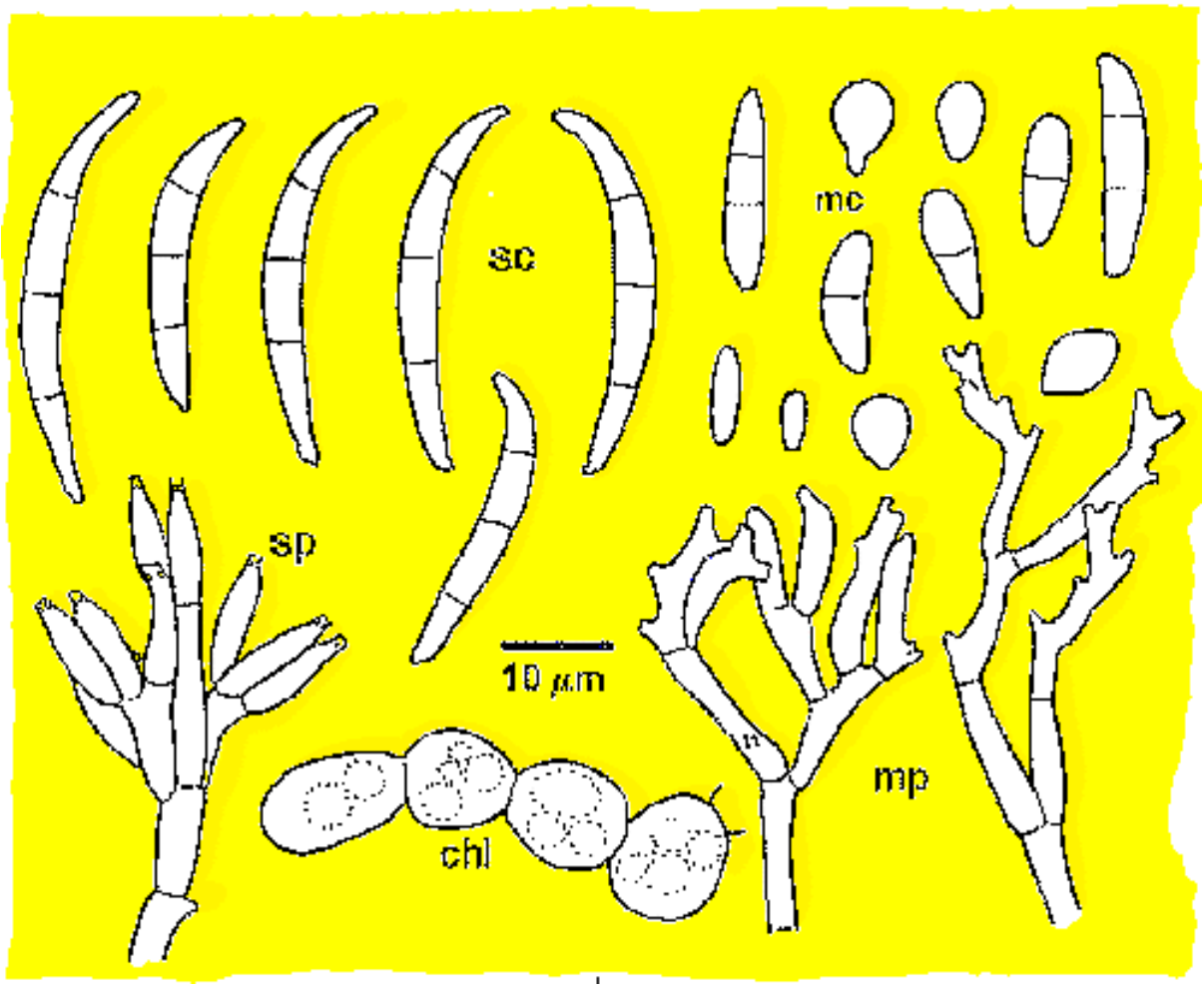
NOTES ON THE SPECIES



Fusarium solani (Mart.) Appel & Wollenw.

Section: *Martiella*
Teleomorph: *Nectria haematococca* Berk. & Br.
Diagnostic characters
Macroconidia of type C, straight, of medium or robust stature, often with rather blunt basal and apical cells. Microconidia ellipsoidal, produced from long monophialides in the aerial mycelium. Chlamydospores usually produced singly or in pairs.
Notes
The interpretation of the limits of this species varies from author to author. It is clear from genetic and molecular results presented at recent conferences that there are many biological species currently included under this one name. *F. solani*, in this broad sense, is easily distinguished from *F. oxysporum* by the long phialides in the aerial mycelium, and the macroconidia usually with blunt apical and basal cells.
References
Nelson, Toussoun and Marasas. 1983. p. 146.
Booth. 1971. p. 46.
Gerlach and Nirenberg. 1982. p. 364.
Burgess, Liddell and Summerell. 1988. p. 98.

NOTES ON THE SPECIES



Fusarium sporotrichioides Sherb.

Section: *Sporotrichiella*

Diagnostic characters

Microconidia ellipsoidal, clavate or round to pip shaped, abundantly produced from polyphialides on tree-like coniodiophores in the aerial mycelium. Macroconidia of type A. Chlamydospores often produced in chains or clumps.

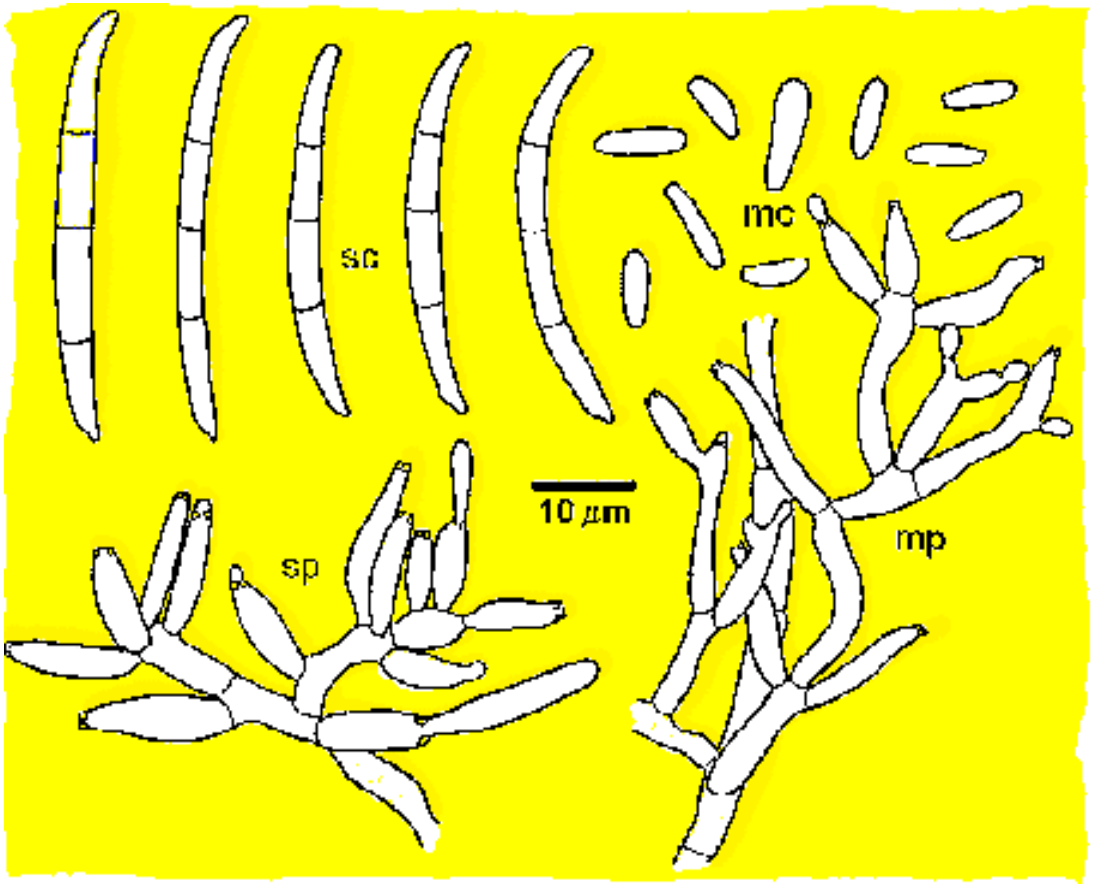
Notes

One may need to examine PDA microscopically to find round microconidia. UV is often required for production of macroconidia. Distinguished from *F. chlamydosporum* by the production of round or pip-shaped microconidia.

References

Nelson, Toussoun and Marasas. 1983. p. 70.
Booth. 1971. p. 86.
Gerlach and Nirenberg. 1982. p. 129.
Burgess, Liddell and Summerell. 1988. p. 79.
Pascoe. 1990. Mycotaxon 37: 141.

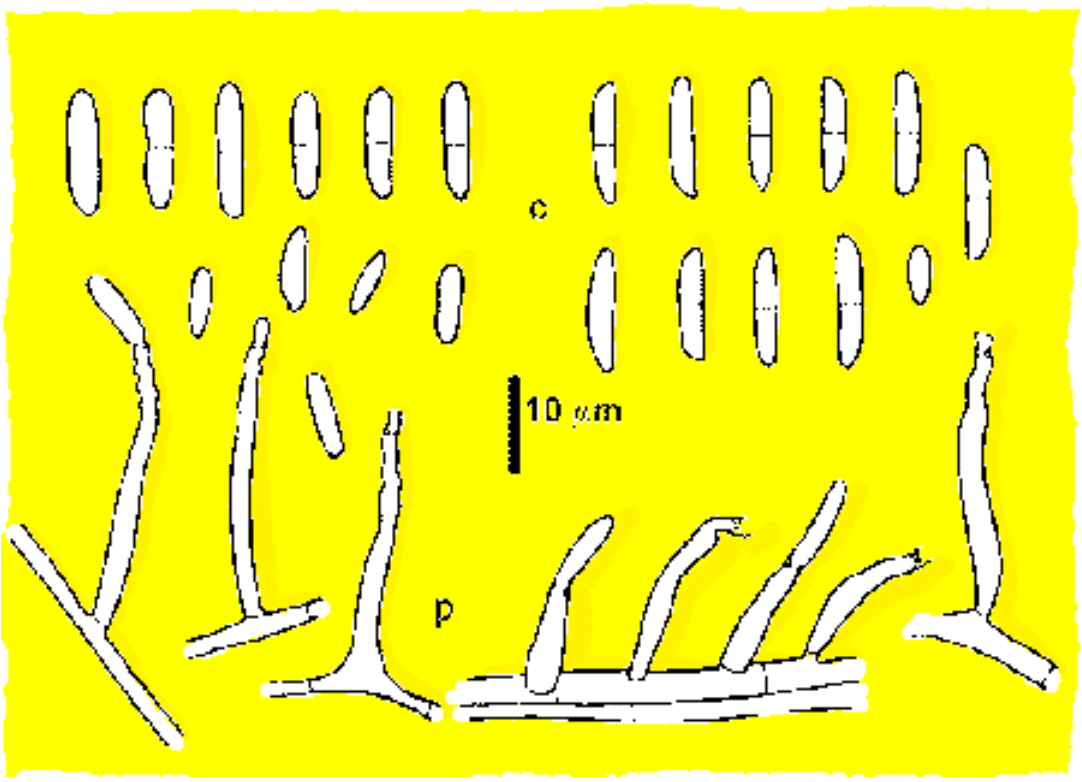
NOTES ON THE SPECIES



Fusarium subglutinans (Wollenw. & Reinking) Nelson *et al.*

Alternate names: *F. sacchari* var. *subglutinans* (Wollenw. & Reinking) Nirenberg.
F. moniliforme var. *subglutinans* Wollenw. & Reinking
Section: *Liseola*
Teleomorph: *Gibberella subglutinans* (Edwards) Nelson, Toussoun & Marasas (= *G. fujikuroi* var. *subglutinans* Edwards)
Diagnostic characters
Microconidia ellipsoidal to fusiform, produced in dry heads from polyphialides in the aerial mycelium. Macroconidia of type B, narrow, straight. Chlamydospores not produced.
Notes
Macroconidia are often sparsely produced, and may only be formed with UV. Distinguished from *F. sporotrichioides* by absence of round or pip-shaped microconidia in the aerial mycelium, the relatively straight rather than curved macroconidia, and the absence of chlamydospores. The polyphialides are usually more slender, with longer conidiogenous extensions, than those of *F. sporotrichioides*. Two apparently reproductively isolated mating populations are associated with anamorphs identifiable as *F. subglutinans*.
References
Nelson, Toussoun and Marasas. 1983. p. 135.
Booth. 1971. p. 127.
Gerlach and Nirenberg. 1982. p. 325.
Burgess, Liddell and Summerell. 1988. p. 92.
Pascoe. 1990. Mycotaxon 37: 150.

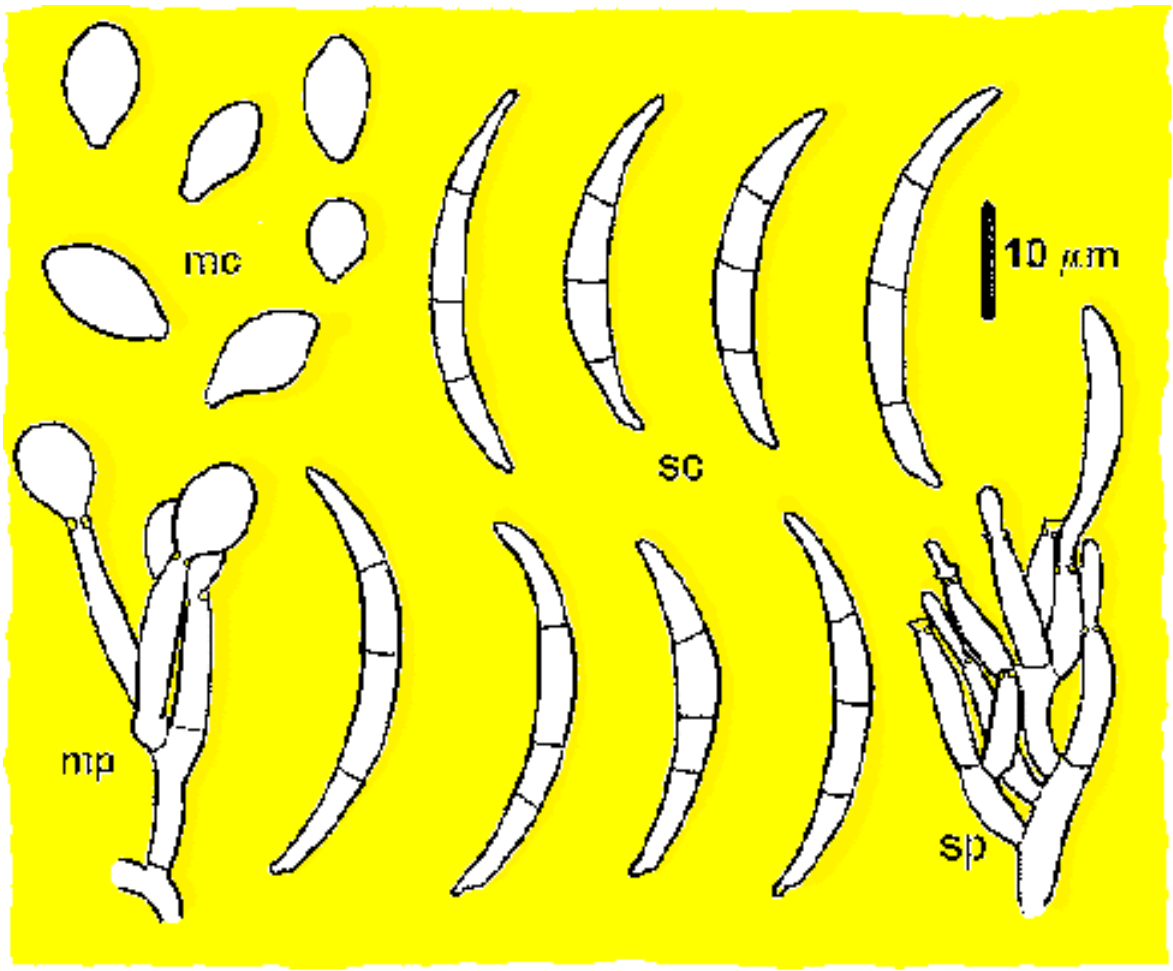
NOTES ON THE SPECIES



Plectosporium tabacinum (Beyma) Palm et al.

Alternate name: *Fusarium tabacinum* (Beyma) Gams
Teleomorph: *Plectosphaerella cucumerina* (Lindf.) Gams
Diagnostic characters
Short, one-septate conidia produced on a slow to moderately fast growing, cream coloured, slimy colony. Phialides typically have a wavy tip.
Notes
Although this fungus bears little resemblance to true *Fusarium* species, it is frequently received at the National Identification Service with a preliminary identification of *Fusarium* sp.
References
Booth. 1971. p. 39.
Gerlach and Nirenberg. 1982. p. 57.

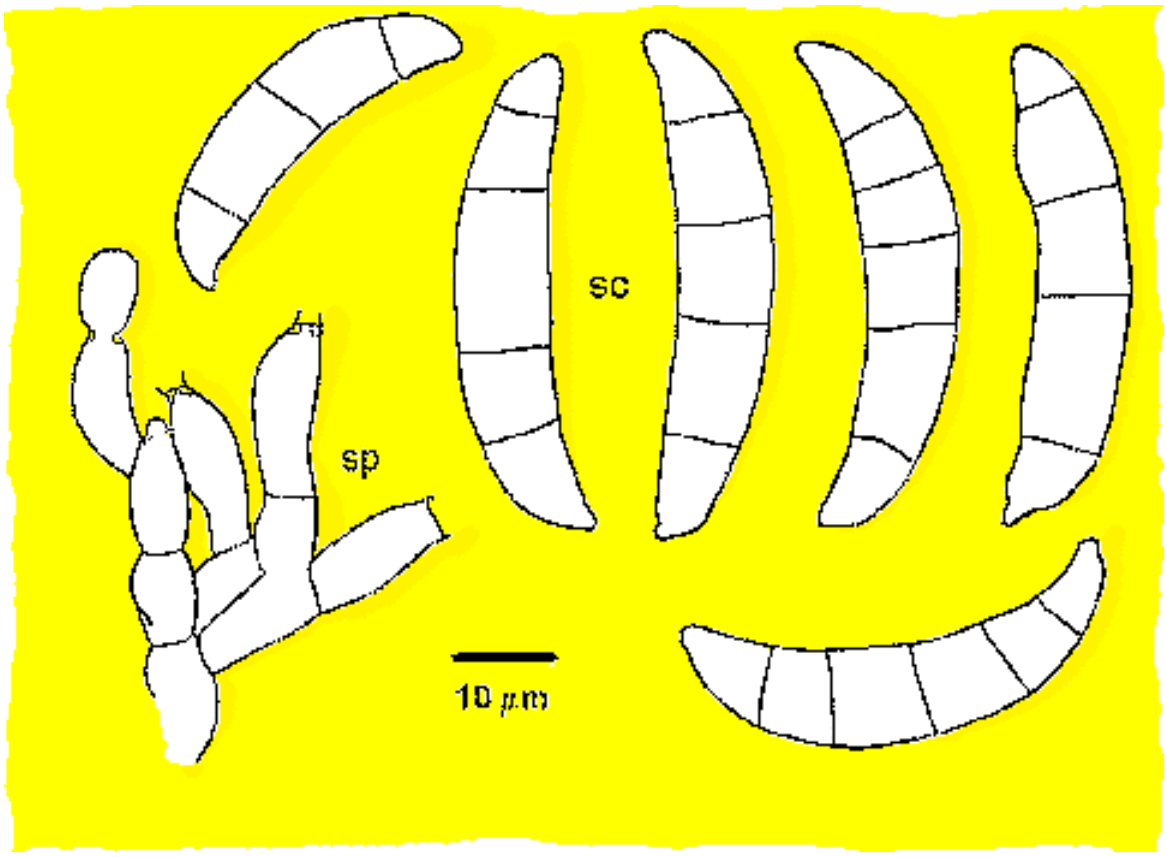
NOTES ON THE SPECIES



Fusarium tricinctum (Corda) Sacc.

Section: *Sporotrichiella*
Teleomorph: *Gibberella tricincta* El-Gholl, McRitchie, Schoulties & Ridings
Notes
May have to examine PDA microscopically for citriform microconidia.
References
Nelson, Toussoun and Marasas. 1983. p. 67.
Booth. 1971. p. 83.
Gerlach and Nirenberg. 1982. p. 125.
Burgess, Liddell and Summerell. 1988. p. 77.

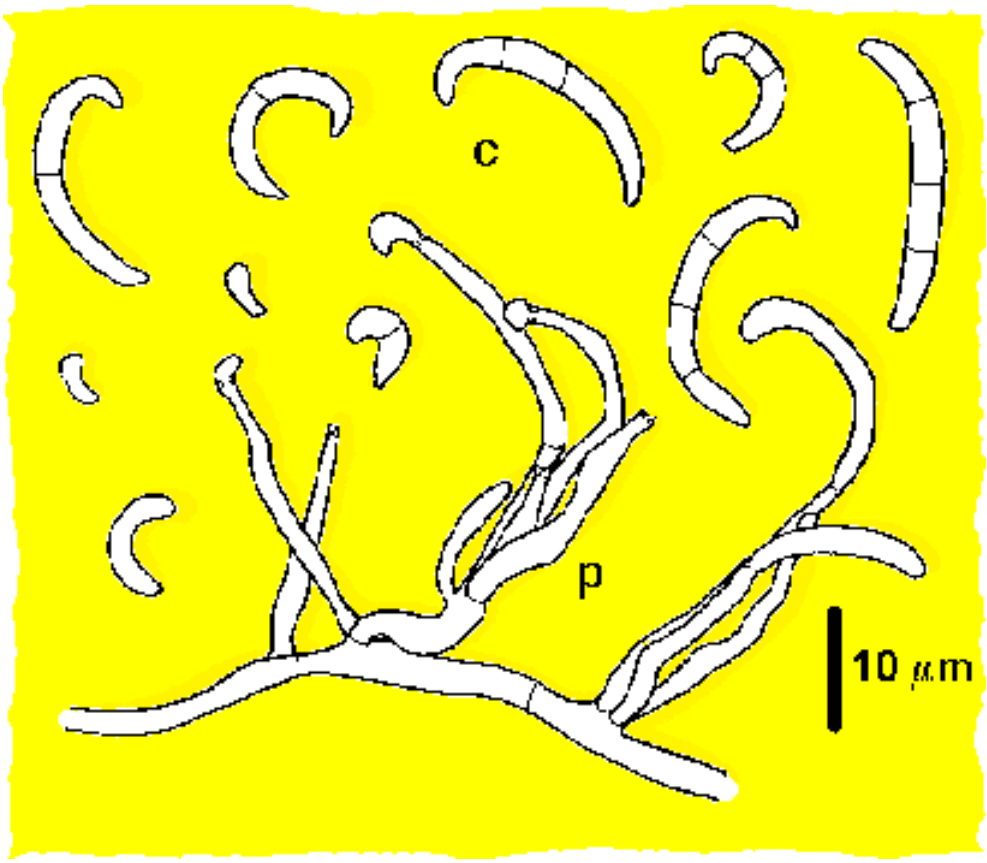
NOTES ON THE SPECIES



Fusarium tumidum Sherb.

Section: *Discolor*
Teleomorph: *Gibberella tumida* Broadhurt & Johnston
References
Nelson, Toussoun and Marasas. 1983. p. 162.
Booth. 1971. p. 57.
Gerlach and Nirenberg. 1982. p. 253.

NOTES ON THE SPECIES



Fusarium xylarioides Steyaert

Section: *Lateritium*
Teleomorph: *Gibberella xylarioides* Heim & Saccas
References
Nelson, Toussoun and Marasas. 1983. p. 166.
Booth. 1971. p. 115.
Gerlach and Nirenberg. 1982. p. 297.

Source of illustrations

Fusarium acuminatum

16 day old culture on SNA. Source of culture uncertain, no. 6227-1.

Fusarium anthophilum

13 day old culture on banana leaf agar (NRRL 13602).

Fusarium aquaeductuum

7 day old culture on SNA, isolated from water, Canada, Nova Scotia, King's County, Canning, by E. Stark, 1978 (DAOM 169250).

Fusarium avenaceum

12 day old culture on SNA, isolated from alfalfa (*Medicago sativa*), Canada, Quebec, Matane, by J. G. Martin, August 1988 (identification service 90M-65, # 411).

Fusarium beomiforme

11 day old culture on banana leaf agar, isolated from soil, Australia, Queensland, Rockhampton (ex-type culture NRRL 13606).

Fusarium camptoceras

20 day old culture on SNA (NRRL 13382).

Fusarium chlamydosporum

7 day old culture on SNA, isolated from air conditioning system, Canada, Quebec, Montreal, 1990 (identification service 91M-63 # 1).

Fusarium coccophilum

Herbarium specimen on scale insect, Indonesia, Java, herb. Saccardo no. 2355 (PAD, isotype of *Corallomyces brachysporus*) (from Seifert, 1990, Mem. N. Y. Bot. Gard. 59: 109-154).

Fusarium compactum

8 day old culture on SNA, isolated from soil by W. L. Gordon # 3496 (DAOM 170854).

Fusarium crookwellense

7 day old culture on CLA, isolated from soil in a wheat field, Canada, Ontario, Ottawa, by B. Grylls, October 1990 (no number).

Fusarium culmorum

From two strains:

- Sporodochial phialides and upper row of conidia from a 7 day old culture on SNA, isolated from red spring wheat (*Triticum aestivum*), Canada, Ontario, Ottawa, by R. Clear, 1991 (identification service 92M-235).

- Lower conidia from an 11 day old culture on SNA isolated from wheat (*Triticum aestivum*), Canada, Prince Edward Island, by W. Johnston (identification service 90M-189 # F10).

Fusarium decemcellulare

13 day old culture on banana leaf agar (NRRL 13412).

Fusarium dimerum

7 day old culture on banana leaf agar (NRRL 13262).

Fusarium dlamini

21 day old culture on SNA, isolated from soil, Republic of Transkei, Butterworth, July 1982 (ex-type culture NRRL 13164).

Fusarium equiseti

From three strains:

- Mycelial conidiophores and conidia, and three central sporodochial conidia from a 7 day old culture on SNA, isolated from soil in a wheat field, Canada, Ontario, Ottawa, by B. Grylls, Oct. 1990 (34-d-3-2).

- Sporodochial phialides from a 7 day old culture on SNA, isolated from cantaloupe *Cucumis melo* by P. Millette, Canada, Quebec, St. Régis (identification service 91M-107 # 467).

- Chlamydospores and upper left sporodochial conidium from a 7 day old culture on CLA isolated from roots of clover, *Trifolium pratense*, Canada, Nova Scotia, Truro, by R. B. Porth, 1978.

Fusarium graminearum

From two strains:

- Sporodochial phialides from 10 day old culture on SNA isolated from wheat (*Triticum aestivum*), Canada, Prince Edward Island, by W. Johnston (identification service 90M-189 # F16).

- Conidia from 8 day old culture on SNA isolated from wheat (*Triticum aestivum*), Canada, Quebec, near Chatham, by Gordon Neish, August 1980 (DAOM 178148).

Fusarium graminum

13 day old culture on banana leaf agar, isolated from Balsam wooly aphid, Canada, New Brunswick, Fredericton, by W. L. Gordon no. 2857-5A89 (DAOM 194235 = ATCC 15628, as *F. heterosporum*).

Fusarium heterosporum

13 day old culture on SNA (NRRL 13101).

Fusarium larvarum

7 day old culture on SNA, isolated from the scale insect *Quadraspidiotus perniciosus* on *Prunus vulgaris*, Iran, Prov. Gilan, by Gerlach et Ershad, Oct. 1968 (NRRL 13301 = CBS 738.79).

Fusarium lateritium

13 day old culture on SNA (NRRL 15630).

Fusarium merismoides

25 day old culture on SNA, isolated from roots of ?*Sasa*, Taiwan, Taichung Co., Ho-Huan-Shan, leg. R. J. Bandoni no. 9101, 4 July 1990 (DAOM 212320).

Fusarium moniliforme

From a culture on potato sucrose agar, isolated from a banana shoot (*Musa*), Thailand-Kampuchea border near Poipet, by H. B. Schiefer, 19 Feb. 1982 (DAOM 183571).

Fusarium napiforme

Mycelial phialides, ellipsoidal conidia and chlamydospores from dried culture, isolated from *Pennisetum typhoides* caryopsis, Namibia, Ovambo (holotype, DAOM 196924).

Sporodochial conidia redrawn from Marasas *et al.*, Mycologia 79: 910-914.

Microdochium nivale (Fusarium nivale)

7 day old culture on SNA, isolated from grass, Canada, British Columbia, West Vancouver, 1994 (identification service 95M-9 #94-1139).

Fusarium nygamai

14 day old culture on SNA, isolated from soil, Australia (ex-type culture DAOM 211959).

Fusarium oxysporum

7 day old culture on CLA, isolated from cucumber (*Cucumis sativus*) in greenhouse, Greece, Crete by D. Vakalounakis, 1990. (identification service 90M-6, # AK1).

Fusarium pallidoroseum

16 day old culture on SNA, isolated from Brome grass, Canada, Saskatchewan, Floral district, by D. Smith, 7 July 1985 (DAOM 213285).

Fusarium poae

From two strains:

- Sporodochial phialides from a 12 day old culture on CLA, isolated from maize (*Zea mays*), Switzerland, Zurich, by A. Visconti, 1990 (DAOM 212321).
- Sporodochial conidia, mycelial phialides and conidia from a 14 day old CLA culture from the same source (DAOM 212322).

Fusarium polyphialidicum

Sporodochial conidia redrawn from Marasas *et al.*, 1986, Mycologia 78: 678-682. Mycelial phialides and conidia from 8 day old culture on SNA, isolated from plant debris in soil, South Africa, Transvaal, Nelspruit, July 1984 (ex-type culture, NRRL 13459).

Fusarium proliferatum

13 day old culture on SNA, isolated from barley (*Hordeum vulgare*) Canada, Alberta, Charlie Lake, by D. Smith (DS257).

Fusarium reticulatum

(1) 13 day old culture on banana leaf agar (NRRL 13319).

(2) from a culture on SNA isolated from *Rhododendron* sp., Canada, Quebec, Montreal, by M. Legare, August 1991 (DAOM 213213).

Fusarium sambucinum

From two strains:

- Sporodochial phialides and conidia on left of figure: 12 day old culture on SNA, isolated from cucumber (*Cucumis sativus*), Canada, Quebec, St. Côme, by M. A. Carrieri, 1991 (identification service 91M-73, # A0012).

- Conidia on right of figure from a 7 day old culture on SNA, isolated from roots of Douglas fir (*Pseudotsuga menziesii*), Canada, British Columbia, by P. Axelrood, 1992 (#FD5).

Fusarium scirpii

7 day old culture on banana leaf agar (NRRL 13402).

Fusarium solani

From two strains:

- Leftmost sporodochial phialides, three central sporodochial conidia, single aerial mycelium phialide from a 7 day old culture on SNA, isolated from soil in wheat field, Canada, Ontario, Ottawa, by B. Grylls, Oct. 1990 (# 34-d-1-4).

- Rightmost sporodochial phialides, 3 left sporodochial conidia, rightmost aerial mycelium phialides and conidia from a 7 day old culture on CLA, isolated from lumber in an experimental house, Canada, Ontario, 1989 (12S and 14T).

Fusarium sporotrichioides

From two strains:

- Sporodochial phialides and conidia and mycelial conidia from a 7 day old culture on SNA, isolated from wheat debris, Canada, Ontario, Ottawa, by B. McQuade # W30-S91-1, Oct. 1991 (DAOM213385).

- Mycelial phialides and chlamydospores from a 7 day old culture on SNA, isolated from soil at the same location, by B. Grylls (no. 122).

Fusarium subglutinans

From two strains:

- Sporodochial phialides, conidia and mycelial phialides from a 13 day old culture on SNA, isolated from corn (*Zea mays*) caryopsis, Canada, Ontario, Ottawa, by Gordon Neish, 14 November 1994 (DAOM 194909).

- Mycelial conidia, from a culture received from R. Clear, Canadian Grain Commission, Winnipeg, Canada, grown on Czapek Yeast Agar with 20% sucrose.

Plectosporium tabacinum (Fusarium tabacinum)

From two strains:

- Left hand side from a culture isolated from *Taraxacum officinale*, Canada, Saskatchewan, Regina, by K. Mortensen # 92-12-13, 1992 (identification service 93M-8).

- Right hand side from a culture isolated from *Ambrosia artemisiifolia*, Canada, Ontario, by K. Mortensen # 91-12-B, 1991 (identification service 91M-178).

Fusarium tricinctum

From two strains:

- Sporodochial phialides and conidia from a 13 day old culture on banana leaf agar; isolated from wheat (*Triticum aestivum*), Canada, Ontario, Ottawa, by K. A. Seifert, 1993 (93-23-H- 30).

- Mycelial phialides and conidia from a 13 day old culture on SNA (NRRL 13638).

Fusarium tumidum

Herbarium specimen. Sydow's Mycotheca Germanica # 1797, of *Sarothamnus scoparius*, Switzerland, 1916, leg. W. Kreiger (DAOM, as *Fusarium sarcochroum*).

- *Fusarium xylarioides*

8 day old culture on banana leaf agar, isolated from trunk of *Coffea* sp., Ivory Coast, by J. Nicot (DAOM 194239).

References

The taxonomic data used in this program is derived primarily from the following texts:

- Nelson, P. E., T. A. Toussoun and W. F. O. Marassas. 1983.

Fusarium species, an illustrated manual for identification. Pennsylvania State University, University Park and London. 193 pp.

- Booth, C. 1971.

The genus *Fusarium*. Commonwealth Mycological Institute, Kew. 237 pp.

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The genus *Fusarium* - a pictorial atlas. Mitt. Biol. Bund. Land-Forst. 209. 406 pp.

- Burgess, L. W., C. M. Liddell and B. A. Summerell. 1988.

Laboratory manual for *Fusarium* research, 2nd ed. University of Sydney, Sydney. 156 pp.

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