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The Genus Fusarium - a Pictorial Atlas

by

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C O N T E N T S

I. PREFACE

This book is conceived as a pictorial atlas, a guide through the phytopathologically very important genus Fusarium, rather than a monograph. The illustrations contained in the book, which represent the whole range of variation of the fungal microstructure, can be compared directly with the pictures seen under the microscope. These photographs and drawings as well as a short description of the macro- and microscopic features shall ensure the identification of the taxa. The main purpose of the work at hand is to serve mycologists and plant pathologists and others interested in Fusarium as a reference book for comparison, identification and diagnoses. It is also intended as a means of pointing out vagueness and gaps in matters concerning nomenclature, systematics and plant pathology. The authors' goal will have been reached if their efforts lead to further studies and research in the field.

With consideration given to current mycological points of view, more than 90 Fusarium species or varieties are here accepted as distinct.

A key has been intentionally omitted, since it would have exhibited the incompletenesses which keys of large genera tend to contain. Nevertheless, we plan to present such a key at a later date. But to do so, further research is needed which will lead to a grouping of Fusarium species different from those of WOLLENWEBER and REINKING (1935) and BOOTH (1971a).

We are most grateful to our former colleagues at our institute, the late Dr. H. RICHTER, Dr. R. SCHNEIDER and Dr. E. SEEMÜLLER as well as to mycologists from all over the world, especially

Dr. C. BOOTH / England, Dr. D. ERSHAD / Iran, Dr. W. GAMS / Netherlands, Dr. G. LAUNDON / New Zealand, Dr. G. LIM / Singapore, Dr. W. MARASAS / South Africa, Dr. E. MÜLLER / Switzerland, Dr. P. NELSON / Pennsylvania, Dr. S. K. SUN / Taiwan, Dr. T. A. TOUSSOUN / Pennsylvania and Dr. A. YLIMÄKI / Finland for critical suggestions, the assistance in making authentic material available and in sending us pure cultures of special Fusarium species.

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II. INTRODUCTION

The concept of WOLLENWEBER and REINKING (1935) was chosen as the basis of arranging and treating each taxon to ensure a direct comparison with their works without the intension of accepting their concept completely. The results of our findings will be critically compared with those of other specialists, especially WOLLENWEBER and REINKING (1935) and BOOTH (1971a).

Each chapter of a taxon is divided into 4 sections: synonyms, description, illustration and discussion.

As a rule only those synonyms are listed that are needed to recognize the differences of our concept compared with the concepts of WOLLENWEBER and REINKING (1935), BOOTH (1971a) and other authors. Therefore we want to point out the comprehensive lists of synonyms in WOLLENWEBER and REINKING (1935), WOLLENWEBER (1931, 1943), BOOTH (1971a) and SUBRAMANIAN (1971).

The description is based almost entirely on our own observations of the fungus in culture under various conditions and consists of notes regarding macroscopic (colony - growth, aerial mycelium, pigmentation, sclerotial bodies, sporulation), microscopic (conidiophores, conidia and chlamydospores) and other features (odour).

Almost each taxonomic unit is illustrated by full-page plates consisting of drawings and photographs. They depict typical microscopic fungal structures (conidiophores, conidia and chlamydospores - if formed by the fungus). To present the whole range of morphological variation, drawings of the original diagnoses or those printed in WOLLENWEBER's "Fusaria autographice delineata" are added. They had to be used solely for those taxa of which no living culture could be obtained.

The discussion of the taxon regarding its taxonomic position and occurrence is more or less extensive depending on its degree of rareness or renown.

The entire material, consisting of notes and partly coloured drawings, left behind by WOLLENWEBER, was screened and filed with the corresponding taxa. The knowledge acquired from these notes and drawings about the origin of cultures (partly ex-holotypes), cultural characteristics and conidial measurements has been incorporated into the description of the individual species or variety. When no pure cultures were available, this material had to suffice. The description and illustration of all other taxa is based upon tens of thousands of single spore isolates which were made during the last 30 years in our institute.

As a rule the strains were cultured on 7 different substrates: wort agar, potato-dextrose agar, carrot-extract agar, oat-meal agar, ear of barley, stem of alfalfa, rice pap under natural day-night-rhythm in the laboratory at approximately 22^{o}C. The conidial samples were taken from the "Hochkultur" stage. In a few exceptional cases some isolates were irradiated with near ultraviolet light (black light) or were grown on a low nutrient medium, SNA (NIRENBERG 1976).

The microphotos were taken from squash mounts made in sterile water without adding any stains and printed at a magnification of 500. Only some pictures of the fungi in the Liseola section were taken on SNA without a coverslip, which were magnified by 200 or 250.

The cultures were received from Europe, North and South America, Asia and Australia either for comparison or identification. Most often, however, they were isolated from diseased plant material mailed to us. Only some few are ex-holotypes of which those from the twenties, thirties and forties are already quite degenerated.

Representative living cultures are preserved in soil (SCHNEIDER 1958) at our institute.

III. THE GENUS FUSARIUM

Fusarium Link - Mag. Ges. naturf. Freunde, Berlin, 3 : 10, 1809 - ex Fries 1821

Fusisporium Link - Mag. Ges. naturf. Freunde, Berlin 3 : 10, 1809 - ex Fries 1821

Selenosporium Corda - Icon. Fung. 1 : 7, 1837

Microcera Desm. - Ann. sci. nat. ser. 3, 10 : 359, 1848

Pionnotes Fries - Summa veg. scand. : 481, 1849

Sporotrichella Karst. - Med. Soc. F. F. Fennica 14 : 96, 1887

Lachnidium Giard - Compt. rend. Acad. Sci. 113 : 813 - 816, 1891

?Discocolla Prill. et Delacr. - Bull. Soc. Mycol. Fr. 10 : 86, 1894

?Rachisia Lindner - Deut. Essigind. 17 : 467, 1913

Discofusarium Petch - Trans. Br. mycol. Soc. 7 : 164, 1921

Pseudomicrocera Petch - Trans. Br. mycol. Soc. 7 : 164, 1921

?Fusidomus Grove - J. Bot., London, 67 : 201, 1929

Pseudofusarium Matsushima - Microfungi of the Solomon Islands and Papua-New Guinea, Osaka : 46, 1971

Type species! Fusarium sambucinum Fuckel - Symb. mycol. 167, 1869
Fusarium roseum Link ex Gray 1821 (nomen ambiguum)

Information about the origin and history of the genus Fusarium as well as its description can be found with WOLLENWEBER and REINKING (1935), GERLACH (1970, 1973, 1981), BOOTH (1971a), SUBRAMANIAN (1971) and DOMSCH et al. (1980).

It is mainly characterized by more or less falcate and pedicellate (macro-) conidia borne from phialides, which arise from the substrate mycelium or aerial mycelium.

Quite recently two new genera were separated from Fusarium:

1. Pseudofusarium - which we do not accept, since the conidiogenous cells which bear macroconidia are phialidic and only the microconidia are borne on polyblastic cells;
2. Gerlachia - which we do accept, since all conidiogenous cells are annellidic.

Section EUPIONNOTES Wollenw. - Phytopathology 3: 206, 1913

Fusarium aquaeductuum (Radlk. & Rabenh.) Lagerh. - Zentralbl. Bakteriol. 2. Abt. 9: 655, 1891 var. aquaeductuum

Selenosporium aquaeductuum Radlk. & Rabenh. - Hedwigia 2: 73, 1863

Teleomorph: Nectria purtonii (Grev.) Berk. - Outlines Brit. Fung. 394, 1860

Nectria applanata Fuckel - Symb. mycol., Nachtr. 1: 22, 1871

?Nectria episphaeria (Tode ex Sprengel) Fr. var. coronata Wollenw. - Z. Parasitenk. 3: 298, 1931

Descriptions: APPEL & WOLLENWEBER (1910), WOLLENWEBER (1916-1935 no. 75, 78-82, 543, 672, 673, 842, 843), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), BOOTH (1959, 1971a), JOFFE (1974), DOMSCH et al. (1980).

C o l o n i e s - slow-growing, reaching 3.0 - 3.2 cm diam. in 10 days at 25°C on PDA.

Aerial mycelium - sparse, white to pinkish, delicately floccose, partly covering the substrate.

Pigmentation - yellowish brown, salmon, red-orange.

Sclerotial bodies - not present.

Sporulation - quickly starting and generally very abundant, orange masses of pionnotal or sporodochial conidia covering the colony surface, when desiccating forming more brick-red to cinnamon coloured crusts.

Odour - if present, musk-like.

C o n i d i o p h o r e s - especially in early stages often formed as unbranched phialides arising laterally from hyphae, later more or less loosely branched.
Phialides - monophialidic, usually almost cylindric, by and large rather long (12-35 µm) and slender (2.0-3.5 µm), elegant, occasionally with a slightly marked collarette.

C o n i d i a - strongly to moderately curved, slender, falcate, with an often hooked apical cell and a barely pedicellate basal cell, predominantly with one indistinct central septum, rarely 0- or 2- to 3-septate, measuring:

0-sept.	13 x 2.4	mostly 9-22 x 1.9-3.0	(6-26 x 1.5-4.0) µm
1-sept.	26 x 2.4	mostly 16-34 x 1.9-3.0	(12-40 x 1.5-4.0) µm
2-3-sept.	35 x 2.5	mostly 33-38 x 2.2-2.5	(29-50 x 2.0-3.5) µm.

C h l a m y d o s p o r e s - never observed.

Explanation of Figure 1:
Drawing and photographs of conidia and conidiophores of strain 63669 on different substrates (x 500).

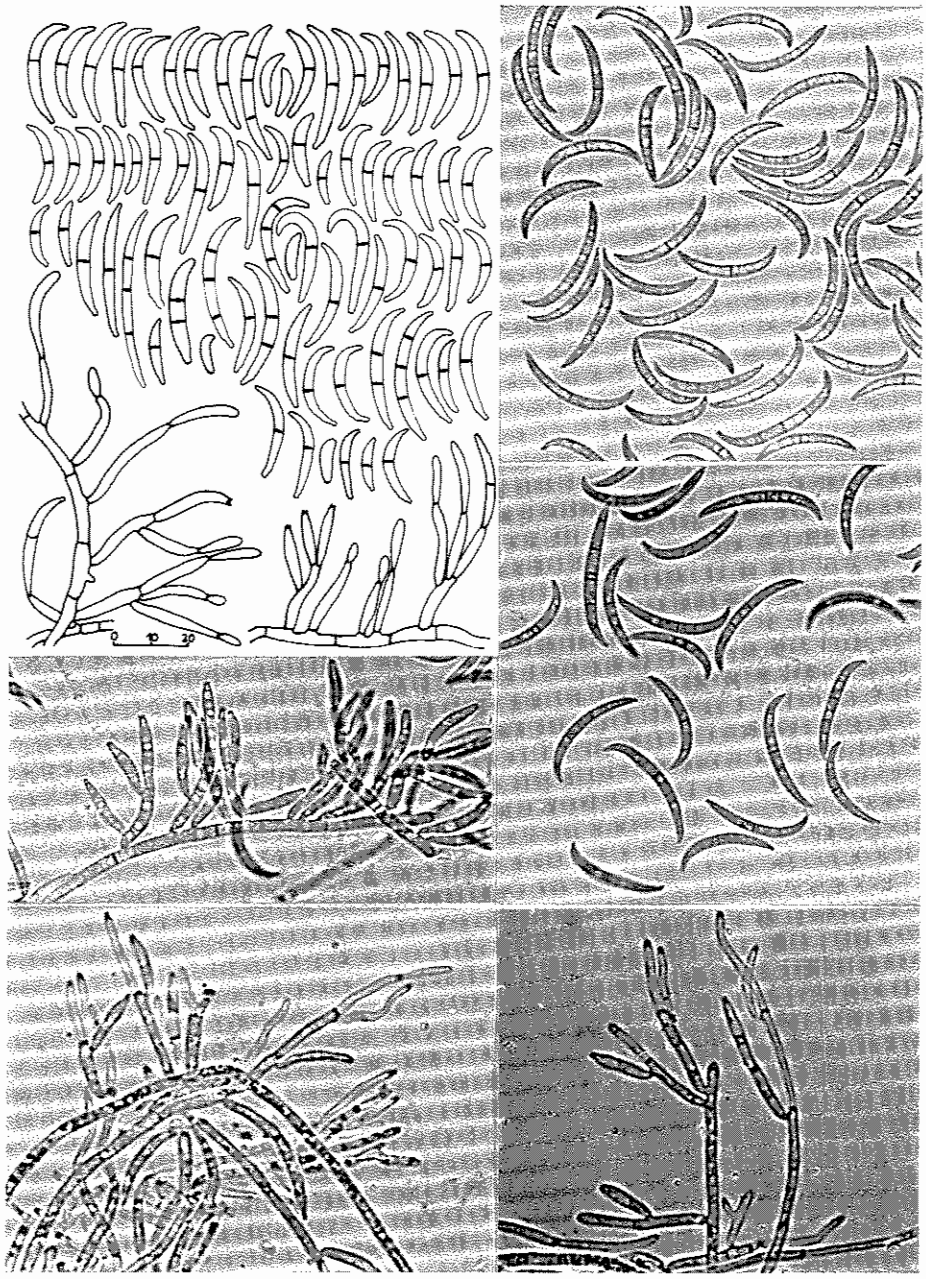

Fig. 1. Fusarium aquaeductuum var. aquaeductuum.

F. aquaeductuum var. aquaeductuum is well-known and generally accepted as distinct. It is a rather common fungus in streaming waters, water pipes, in bleeding sap of trees and on dead twigs. Frequently it is associated with other fungi. However, it seems to occur less frequently than the variety medium and less than literature would lead us to believe. This discrepancy may result from inexact identification. F. aquaeductuum var. aquaeductuum occurs on all continents, but it is perhaps more common in cooler regions. More detailed information is given by DOMSCH et al. (1980). There is no reliable report proving its active role as a plant pathogen.

Fusarium aquaeductuum (Radlk. & Rabenh.) Lagerh. var. medium Wollenw. - Z. Parasitenk. 3: 298-299, 1931

Fusarium bicellulare Kirschstein - Hedwigia 80: 136, 1941

Fusarium aquaeductuum (Radlk. & Rabenh.) Lagerh. subsp. medium (Wollenw.) Raillo - Fungi of the Genus Fusarium (Moscow): 278, 1950

Teleomorph: Nectria episphaeria (Tode ex Sprengel) Fr. - Summa Veg. Scand. 2: 388, 1849 var. epishaeria

Descriptions: WOLLENWEBER (1916-1935 no. 76, 83, 84, 185, 544, 667-671, 844-847), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), BOOTH (1959), GERLACH & ERSHAD (1970), BOOTH (1971a).

C o l o n i e s - slow-growing, reaching 2.5 - 3.5 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - absent or, if sparse, reduced to hyphal strands especially at the edge of older colonies, whitish to pinkish; colony surface appearing slimy, wrinkled or fibrillose.
Pigmentation - whitish, cream, pinkish to orange.
Sclerotial bodies - not formed.
Sporulation - starting quickly within 2 - 4 days as small, subdeveloped conidia, later macroconidia predominate in pionnotal or sporodochial slimy masses which cover the agar surface.
Odour - not perceptible.

C o n i d i o p h o r e s - arising at first laterally as single phialides from hyphae often aggregated in ropes, later irregularly or sometimes verticillately branching, if produced in sporodochial layers often densely aggregated arising from a stromatic tissue.

Phialides - monophialidic, of various shapes, if formed in the aerial mycelium generally subulate, rather long and slender, mostly 20-35 x 2.0-2.5 µm, if formed in pionnotes or sporodochia often subclavate, shorter, mostly 10-20 x 2.5-4.0 µm.

C o n i d i a - subdeveloped, 0- or 1-septate conidia sometimes rather abundant, ellipsoid to clavate; macroconidia subcylindric, moderately to strongly curved, slightly narrowing toward each end, generally with a somewhat bent apical cell and a more or less distinct pedicellate basal cell, when fully developed, predominantly 3- (to 5-)septate, measuring:

0-sept.	8 x 2.3	mostly 6-12 x 2.0-2.5	(4-25 x 1.5-3.0) µm
1-sept.	27 x 2.5	mostly 18-45 x 2.0-3.2	(13-61 x 1.5-4.0) µm
3-sept.	45 x 2.8	mostly 30-55 x 2.4-3.4	(20-64 x 1.5-4.2) µm
4-5-sept.	51 x 3.0	mostly 45-60 x 2.5-3.5	(35-78 x 2.0-4.2) µm.

C h l a m y d o s p o r e s - not observed; globose to subglobose, inflated cells formed in old conidia or hyphae.

Explanation of Figure 2:

Drawing and photographs of conidia and conidiophores of strains 62153 and 62154 on different substrates (x 500).

Fig. 2. Fusarium aquaeductuum var. medium.

F. aquaeductuum var. medium is distinguished from F. aquaeductuum var. aquaeductuum especially by longer, more robust and higher septate macroconidia. Its teleomorph Nectria episphaeria is a well-known parasite on sphaeriaceous fungi. At the present time the concept of this variety as given here and by BOOTH (1971a) is rather extensive. It includes, in addition to typical strains which proved to be the anamorph of N. episphaeria, a number of strains for which the teleomorph has not yet been found. These strains which occur in the bleeding sap of trees, in contaminated water, on paper pulp, decaying plant material and in soil closely resemble the typical anamorph of N. episphaeria in most macroscopic and microscopic characteristics. But according to BOOTH (1971a) they usually differ through the absence of typical microconidia and more uniform macroconidia of the upper size range of F. aquaeductuum var. medium.

Fusarium cavispermum Corda - Icon. Fung. 1: 3, 1837

Fusarium aquaeductuum (Radlk. & Rabenh.) Lagerh.
var. cavispermum (Corda) Raillo - Fungi
of the Genus Fusarium (Moscow): 280, 1950

Descriptions: WOLLENWEBER (1916-1935 no. 77, 849, 850), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935).

C o l o n i e s - slow-growing, reaching 3.9 - 4.4 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - mostly sparse, partly floccose or striate to fascicular, filaceous, easily collapsing and forming a flat stroma, whitish, brownish white or pink.
Pigmentation - whitish, brownish, pink, later faintly yellow-green, olive-green to olive-brown, on rice pap sometimes blue-violet.
Sclerotial bodies - sometimes present, globose, olive-brown.
Sporulation - starting in the aerial mycelium, powdery, whitish to pink, later sometimes in easily dissolving, tubercle-like small sporodochia or in slimy masses, cream to pale orange coloured, forming darker coloured resinous crusts if desiccated.
Odour - not perceptible.

C o n i d i o p h o r e s - in the only strain available a few single phialides arising laterally from hyphae were observed.
Phialides - monophialidic, straight, subcylindric, 10-30 x 2.8-4.0 µm.

C o n i d i a - often strongly curved, falcate, narrowed toward both ends, with a pointed apical and a mostly apedicellate basal cell, rather heterogenous, mainly 3- (0- to 5-)septate, measuring:

0-sept.	9 x 2.3	mostly 7-11 x 2.0-3.0	(6-14 x 1.5-4.0) µm
1-sept.	17 x 3.1	mostly 14-21 x 2.6-3.7	(11-30 x 2.0-4.5) µm
3-sept.	51 x 3.3	mostly 31-69 x 3.0-3.6	(23-90 x 2.0-4.5) µm
4-5-sept.	72 x 3.3	mostly 64-80 x 3.0-3.5	(50-90 x 3.0-4.0) µm.

C h l a m y d o s p o r e s - generally absent, exceptionally sparse in old conidia, globose (5-6 um) to subglobose.

Explanation of Figure 3:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 849 of strain 3321 (= CBS 172.31); drawing and photographs of conidia, conidiophores and chlamydospores of strain 3321 on different substrates (x 500).

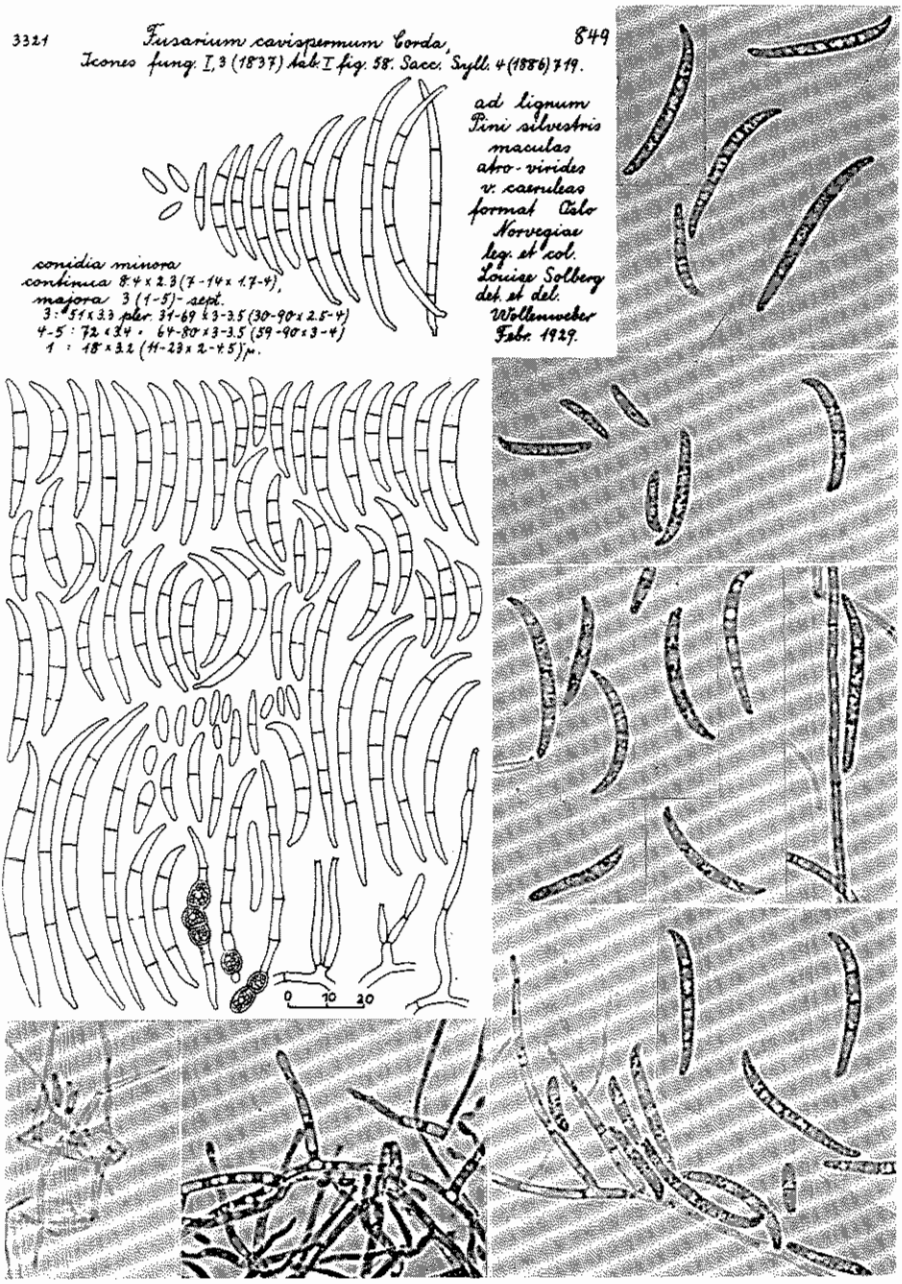

Fig. 3. Fusarium cavispermum.

This Fusarium, not mentioned by GORDON (1952), BOOTH (1971a) and SUBRAMANIAN (1971), was treated by RAILLO (1950) as a variety of F. aquaeductuum and specified by BILAI (1955) as synonymous with F. aquaeductuum, surely without having seen it. With regard to growth and pigmentation of culture and type and size of conidia, however, F. cavispermum is clearly distinct as represented by strain 3321. This strain isolated from bluish discoloured timber of Pinus sylvestris by SOLBERG in Norway and sent to WOLLENWEBER in 1929 for identification, has been preserved in the CBS/Baarn (172.31) in rather good condition. On the basis of its characteristics ascertained by re-examination, numerous remarks and drawings (including coloured ones) signed by WOLLENWEBER, F. cavispermum should be retained as a distinct species.

Fusarium melanochlorum (Casp.) Sacc. - Syll. Fung. 4: 725, 1886

Teleomorph: Nectria flavo-viridis (Fuckel) Wollenw. - Angew. Bot. 8: 186, 1926

Descriptions: WOLLENWEBER (1916-1935 no. 674, 848, 1103, 1123), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), BOOTH (1959), BOOTH (1971a), JOFFE (1974).

C o l o n i e s - slow-growing, reaching 3.2 - 3.5 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - mostly sparse, flat, sometimes high, arachnoid, floccose, fascicled, tufted, white to pale brown, pink.
Pigmentation - cream, pink, greenish, brownish, later markedly olive-green to dark grey-green; there is no other Fusarium with such colours.
Sclerotial bodies - not formed.
Sporulation - starting within a few days, scattered in the aerial mycelium, powdery, pulvinate, later conidia aggregated in slimy pink pustules or sometimes in expanded pink or salmon coloured pionnotes.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising laterally as single phialides on hyphae, later more or less irregularly, sometimes verticillately branched, often consisting of a basal cell with a cluster of phialides.
Phialides - monophialidic, those forming microconidia rather long (12-43 µm) and slender (1.8-2.5 µm), those forming macroconidia generally shorter and broader (10-25 x 3-4 µm).

C o n i d i a - micro- and macroconidia are formed, sometimes by the same conidiophore; microconidia oval to slightly curved; macroconidia subcylindric, allantoid, straight or slightly curved, with a rounded apical and an apedicellate basal cell, mostly 3- (to 7-)septate, measuring:

0-sept.	9 x 2.6	mostly 7-12 x 2.0-2.9	(5-14 x 1.5-3.5) µm
1-2-sept.	24 x 2.8	mostly 17-35 x 2.3-3.5	(10-45 x 2.0-4.2) µm
3-sept.	38 x 3.5	mostly 28-48 x 2.8-4.0	(23-55 x 2.2-4.5) µm
4-5-sept.	49 x 3.8	mostly 44-56 x 3.4-4.3	(40-63 x 3.0-5.0) µm.

C h l a m y d o s p o r e s - may occur in older desiccating cultures, mostly intercalary, globose (6-9 µm) to subglobose, with smooth walls, single, in pairs, exceptionally in short chains or in clusters.

Explanation of Figure 4:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 1123 of strain 5273; drawing of conidia and conidiophores of strains 5273 and 9831 (= CBS 202.65 = ATCC 16069); photographs of conidia and conidiophores of strain 9831 on wort agar (x 500).

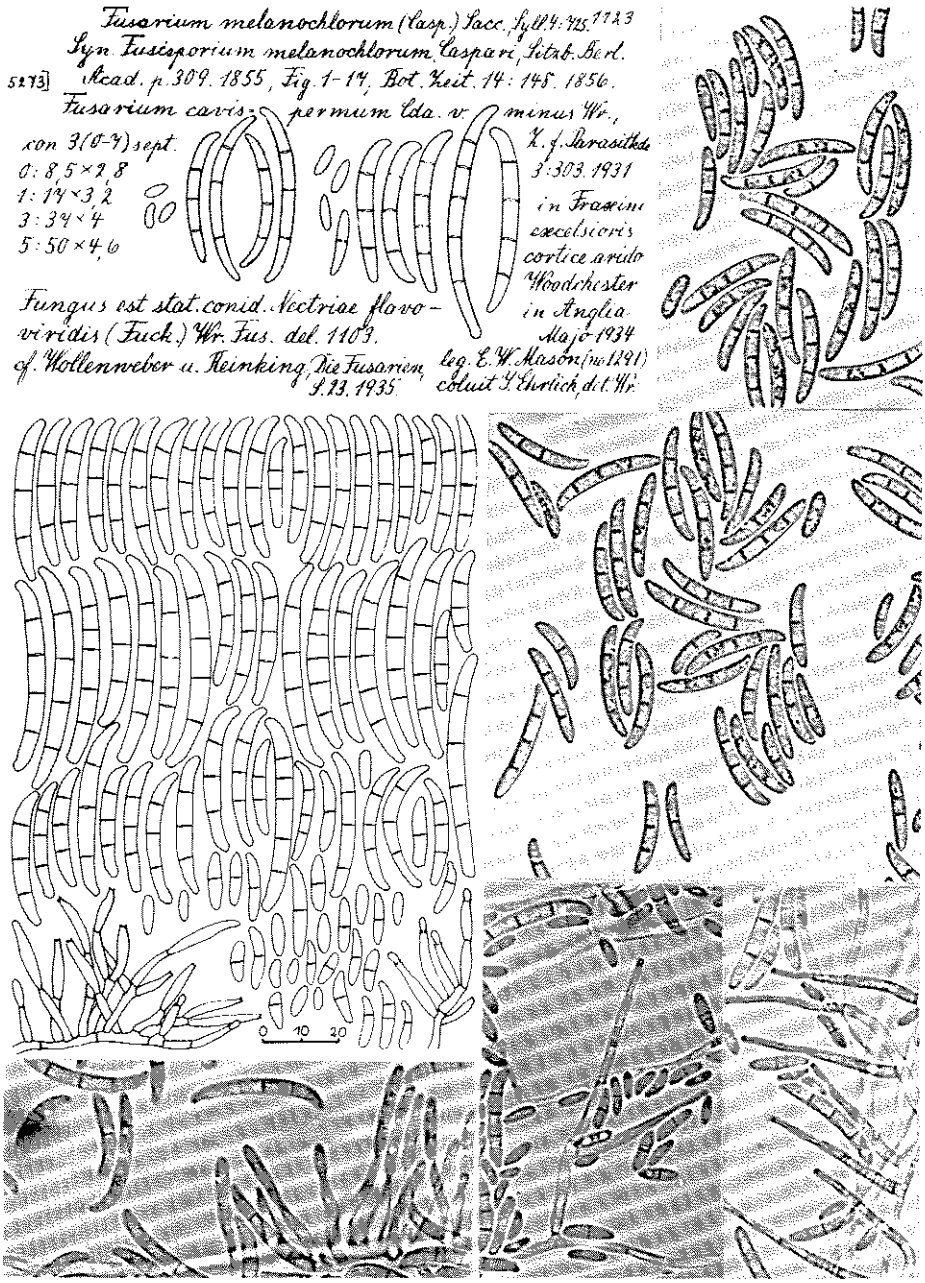

Fig. 4. Fusarium melanochlorum.

This Fusarium should be retained as a distinct species in the sense of WOLLENWEBER & REINKING (1935) and WOLLENWEBER (1943) and as presented by BOOTH (1971a) and JOFFE (1974).

In addition to 4 strains studied, illustrated and deposited by WOLLENWEBER (1916-1935), 3 strains were available as pure cultures for comparison: 2 were isolated from bark of beech trees (9831, 10303) and 1 from soil (10309).

There is nothing known about an association with plant diseases.

This species has been found in cooler regions of Europe and the USA, generally on bark of different kind of trees.

Fusarium merismoides (Corda) - Icon. Fung. 2: 4, 1838
var. merismoides

Descriptions: WOLLENWEBER (1916-1935 no. 92-109, 551, 857a), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), BUGNICOURT (1939), JAMALAINEN (1944), GORDON (1952), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE (1974), GERLACH (1977c), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - slow-growing, reaching 2.8 - 3.3 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - mostly absent or only sparse, arachnoid, easily collapsing and forming a stroma, turf-like or gelatinous, also wrinkled, fascicled, sometimes with an erumpent funiculose central area surrounded by a slimy region, whitish to pinkish.
Pigmentation - cream, peach, pinkish, salmon to orange-red.
Sclerotial bodies - not formed.
Sporulation - starting quickly within a few days, generally masses of conidia cover the substrate as slimy pionnotal layers.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, later aggregated in pionnotal slimes, more or less irregularly branched, often consisting of a basal cell with a cluster of phialides.
Phialides - monophialidic, almost cylindric or obclavate, sometimes rather long (12-32 µm) and slender (2.5-4.5 µm).

C o n i d i a - only macroconidia are formed, typical microconidia absent, great variation in size between different strains and on different media, cylindric to fusiform, straight to slightly curved, with a rounded, sometimes pointed, more or less asymmetrically bent apical cell, narrowed and often slightly constricted toward the base, but generally without a distinct pedicel, mostly 3-(0- to 7-)septate, measuring:

1-2-sept.	24 x 2.9	mostly 18-30 x 2.5-3.8	(12-35 x 2.0-4.4) µm
3-sept.	38 x 3.4	mostly 26-48 x 3.0-4.3	(18-62 x 2.5-5.2) µm
4-5-sept.	44 x 3.9	mostly 38-52 x 3.3-4.5	(28-65 x 2.9-5.2) µm.

C h l a m y d o s p o r e s - in some strains absent or very rare, in others rather abundant, globose (4-12 µm) to subglobose, with smooth walls, single, in pairs or in short chains, intercalary or terminal, in hyphae or conidia, sometimes excrescent, adhering either directly or on a short branch.

Explanation of Figure 5:

Drawing of conidia, conidiophores and chlamydospores of different strains; photographs of conidia, conidiophores and chlamydospores of strains 62249 and 62253 on different substrates (x 500).

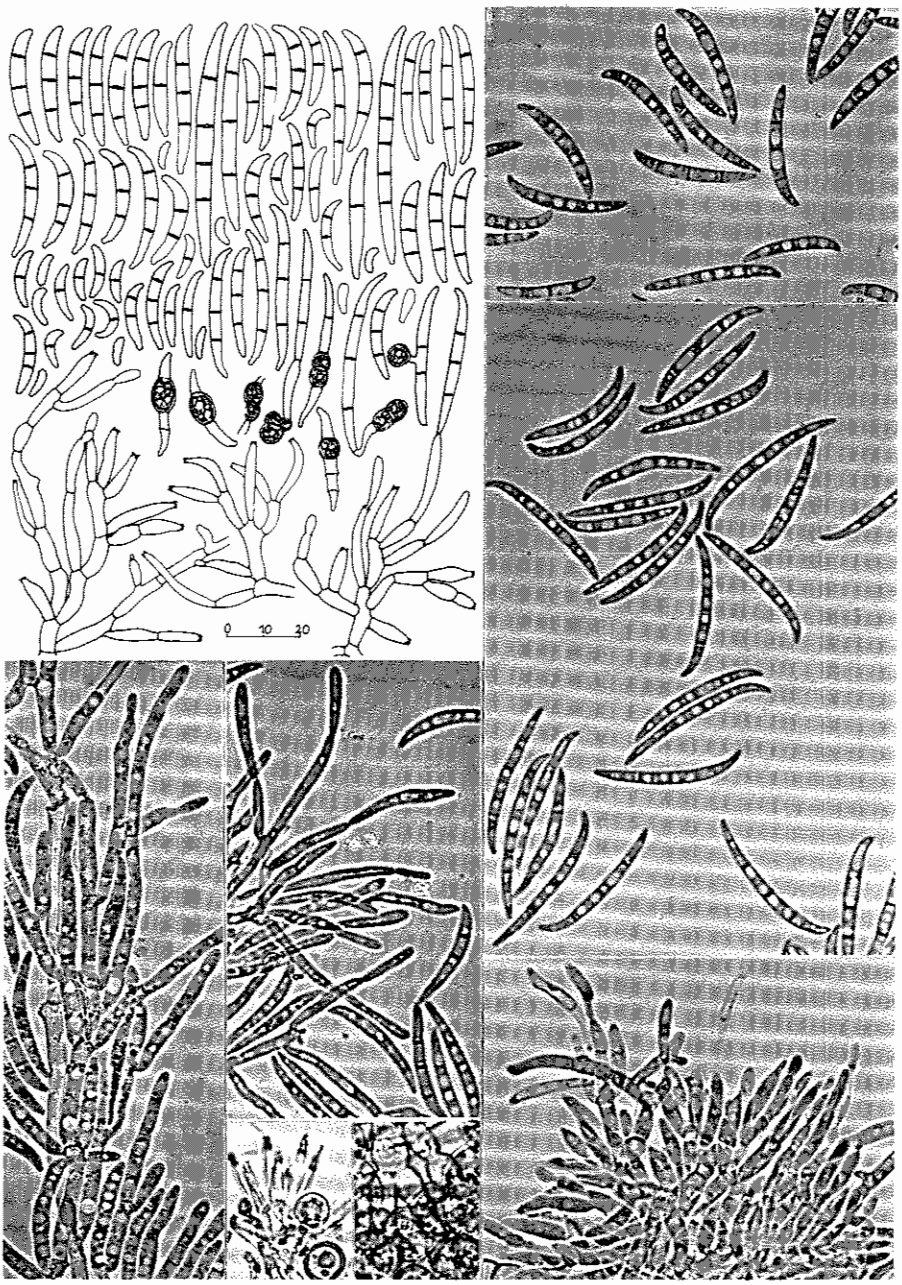

Fig. 5. Fusarium merismoides var. merismoides.

This Fusarium should be considered as distinct in the sense of WOLLENWEBER (1931) and WOLLENWEBER & REINKING (1935) including the variety majus but excluding the varieties chlamydosporale and crassum. In addition to numerous strains studied, illustrated and deposited by WOLLENWEBER (1916-1935), about 20 strains were available for comparison, many of them were isolated by H. RICHTER from slime fluxes of trees during the past years.

F. merismoides var. merismoides is fairly widespread, but more common in cooler regions. It was isolated from soils, polluted water, slime fluxes of trees, rotting plant material and many other habitats; more detailed information is given by DOMSCH et al. (1980). This fungus may cause a dry rot of potato tubers.

Fusarium merismoides Corda var. chlamydosporale Wollenw. - Z. Parasitenk. 3: 308, 1931

Descriptions: WOLLENWEBER (1916-1935 no. 856), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), GERLACH (1978).

C o l o n i e s - fast-growing, reaching 7.8 - 8.2 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - lacking.
Pigmentation - cream, peach, salmon, orange or dirty reddish.
Sclerotial bodies - not formed.
Sporulation - within a few days numerous macroconidia are borne in a thin pionnotal slime, later covering the substrate in a crust.
Odour - sometimes perceived in subcultures of strain 11002 on wort agar, as in F. redolens and in some strains of F. oxysporum.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, later more or less abundantly branched and densely aggregated in flat pionnotal slimes.
Phialides - monophialidic, almost cylindric, obclavate, rather short (8-20 µm) and wide (3-6 µm).

C o n i d i a - typical microconidia absent, but a few subdeveloped 0- or 1-septate conidia generally occur, conidia often remain over a longer period without visible septa and with granulate plasma and

vacuoles, they are more or less curved, mostly with a hooked and pointed, beak-shaped apical cell, and a distinct basal cell with a marked foot, when fully mature mostly 3-(0- to 5-)septate, measuring:

1-2-sept.	22 x 3.8	mostly 17-26 x 3.2-4.2	(13-30 x 2.6-4.5) µm
3-sept.	44 x 4.4	mostly 32-55 x 3.5-5.0	(25-64 x 3.0-5.5) µm
4-5-sept.	55 x 4.5	mostly 52-60 x 4.0-5.2	(48-77 x 3.8-6.0) µm.

C h l a m y d o s p o r e s - generally abundant, sometimes forming crusty layers, globose (5-10 µm) to subglobose, with smooth walls, single, in pairs, also in chains or in clusters, intercalary or terminal, in hyphae or conidia, sometimes excrescent, adhering either directly or on a short branch.

Explanation of Figure 6:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 856 of the type culture 1713; drawing of conidia, conidiophores and chlamydospores of strains 1713 and 11002; photographs of conidia, conidiophores and chlamydospores of strain 11002 on oatmeal agar (x 500).

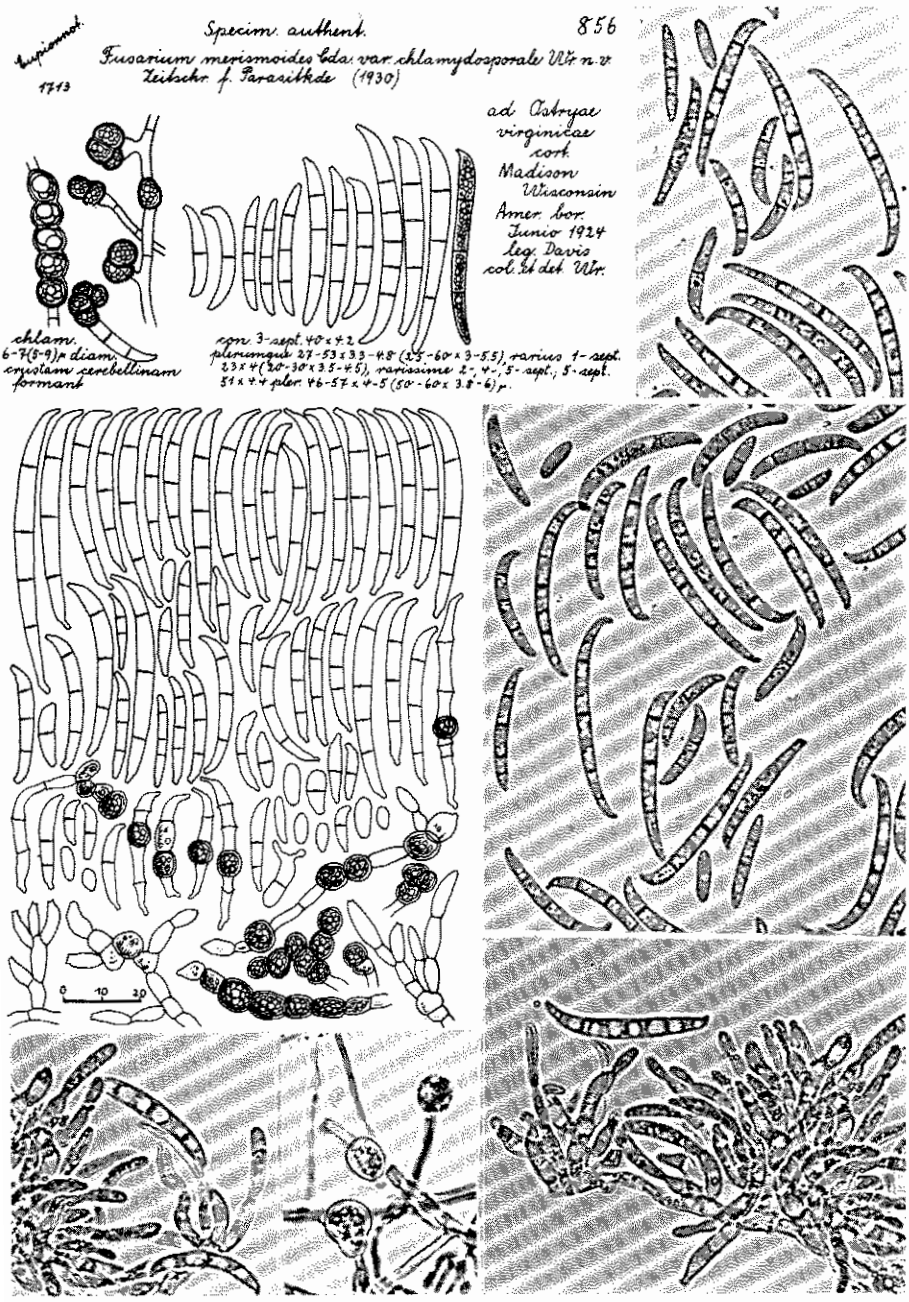

Fig. 6. Fusarium merismoides var. chlamydosporale.

This Fusarium differs from F. merismoides var. merismoides mainly by bigger and generally more curved conidia with a typical beak-shaped apex, by conspicuous chlamydospores and by the growth rate. It should be retained as a separate variety (GERLACH 1978) and is not synonymous with F. merismoides var. merismoides as treated by RAILLO (1950) and later accepted by GORDON (1952), BILAI (1955), BOOTH (1971a) and SUBRAMANIAN (1971).

The type culture (WOLLENWEBER's strain 1713 = CBS 179.31) which was isolated in 1924 from the bark of Ostrya virginica in Madison (Wisconsin/USA) is illustrated by WOLLENWEBER (1916-1935 no. 856). Another culture isolated by M. STAHL in Stuttgart (Germany) from a rotting rhizome of Asparagus officinalis was sent to us in 1968 for identification. This isolate (11002 = 62256 = CBS 798.70) corresponds with F. merismoides var. chlamydosporale in conidium morphology and other features. Evidently it is only the second strain of this Fusarium ever found. It demonstrates that this variety was correctly described by WOLLENWEBER.

Fusarium merismoides Corda var. crassum Wollenw. - Z. Parasitenk. 3: 308, 1931

Descriptions: WOLLENWEBER (1916-1935 no. 857), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), GERLACH (1972, 1978).

C o l o n i e s - slow-growing, reaching 1.5 - 3.0 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - mostly absent, if present only sparse, arachnoid, in the central area of the colony sometimes filaceous-funiculose, coremium-like erumpent or easily collapsing, later forming a smooth or somewhat felt-like stroma, whitish to pinkish.
Pigmentation - cream, pinkish, peach, salmon or orange.
Sclerotial bodies - generally lacking.
Sporulation - starting very quickly within 3-4 days; after 7-10 days slimy pionnotal masses of conidia often cover the surface of the substrates.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, when in pionnotes aggregated, loosely and irregularly, not verticillately branched.
Phialides - monophialidic, almost cylindric or obclavate, rather long (15-32 µm) and slender (2.5-4.0 µm).

C o n i d i a - almost allantoid, straight to slightly curved, with a rounded apex, narrowed toward the base but without a distinct foot, measuring:

1-2-sept.	31 x 4.6	mostly 25-37 x 4.0-5.4	(18-41 x 3.2-6.0) µm
3-sept.	52 x 5.2	mostly 37-60 x 4.5-5.7	(29-73 x 3.8-6.5) µm
4-5-sept.	60 x 5.5	mostly 50-65 x 5.2-5.8	(45-72 x 4.8-6.3) µm.

C h l a m y d o s p o r e s - occurring rarely, inconspicuous, globose (7-12 µm) to subglobose, with smooth walls, in hyphae and conidia, intercalary or sometimes terminal on a short branch, single or in pairs but not in longer chains or in clusters.

Explanation of Figure 7:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 857 of the type culture 3119; drawing of conidia, conidiophores and chlamydospores of strains 3119 and 11501; photographs of conidia and conidiophores of strain 11501 on wort agar (x 500).

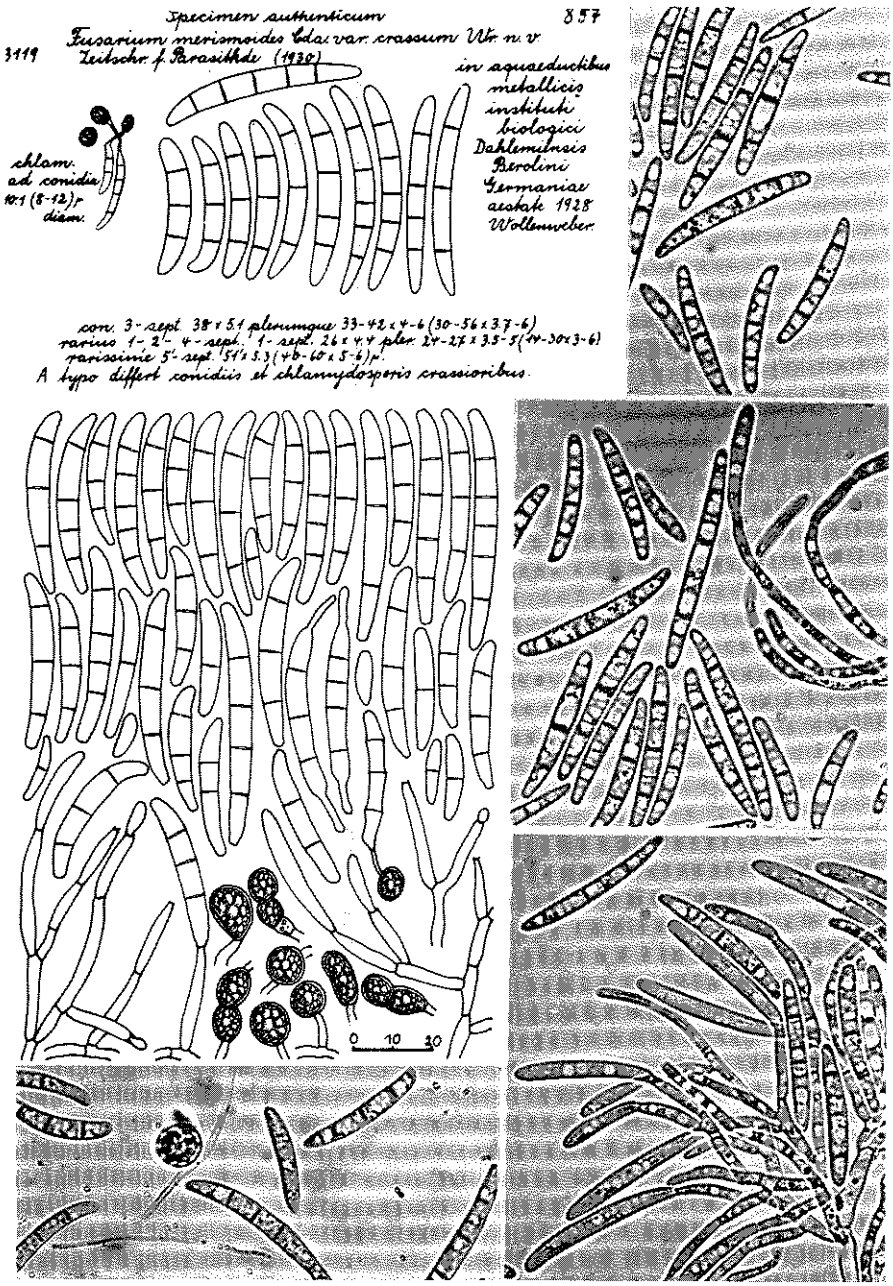

Fig. 7. Fusarium merismoides var. crassum.

This Fusarium by and large corresponds to F. merismoides var. merismoides in most macroscopic and microscopic aspects, it is, however, clearly distinct by much bigger conidia. It should be retained as a separate variety (RAILLO 1950, GERLACH 1978) and it is not synonymous with F. merismoides var. merismoides as treated by GORDON (1952) and later accepted by BILAI (1955), BOOTH (1971a) and SUBRAMANIAN (1971).

The type culture (WOLLENWEBER's strain 3119 = CBS 180.31) which was isolated in 1928 from the drinking water system of our institute is illustrated by WOLLENWEBER (1916-1935 no. 857). In 1970 this Fusarium was again found at the same location in Berlin-Dahlem. The strain isolated (11501 = 62257), precisely described and illustrated by GERLACH (1972), resembles the type culture in every detail. Another culture isolated by K. SCHAUMANN (H. 635) in 1969 from a wooden pile in sea water (harbour of Bremerhaven/Germany) and sent to us for examination was also identified by H. RICHTER as F. merismoides var. crassum (12420 = 62258).

Fusarium merismoides Corda var. acetilereum Tubaki, C. Booth & Harada - Trans. Br. mycol. Soc. 66: 355, 1976

Description: TUBAKI, BOOTH & HARADA (1976).

C o l o n i e s - slow-growing, reaching 3.5 - 4.0 cm diam. in 10 days at 25°C on PDA.

Aerial mycelium - only sparse or not visible; arachnoid, easily collapsing and forming a flat stroma, sometimes with an erumpent funiculose pinkish central area, whitish to light brown or brownish vinaceous.

Pigmentation - light brown, light yellow-brown, brown-vinaceous to dark vinaceous, especially on PDA, malt extract agar and potato-sucrose agar.

Sclerotial bodies - not formed.

Sporulation - starting within a few days, later pinkish to brownish or brown-vinaceous slimy pionnotes cover the central area or larger parts of the colony.

Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, when in pionnotes aggregated, more or less irregularly or rarely verticillately branched.

Phialides - monophialidic, sometimes sympodially proliferating, rather variable in size, sometimes obclavate, short and wide, sometimes almost cylindric, constricted at the base, long and slender (8-40 x 2.5-4.5 µm).

C o n i d i a - rather uniform, of quite the same type as in F. merismoides var. merismoides and similar to var. violaceum, cylindric to fusiform, straight to slightly curved, with a rounded, sometimes more or less pointed and bent apical cell, narrowing to the base, often with a marked foot, mostly 3-(0- to 5-) septate, measuring:

1-2-sept.	25 x 3.3	mostly 20-28 x 2.8-3.7	(16-32 x 2.5-4.0) µm
3-sept.	37 x 3.6	mostly 28-42 x 2.9-4.5	(23-47 x 2.5-5.2) µm
4-5-sept.	45 x 3.8	mostly 40-50 x 3.5-4.6	(35-55 x 3.2-5.0) µm.

C h l a m y d o s p o r e s - in older cultures more or less abundant, especially on ear of barley and oatmeal agar, globose (5-13 µm) to subglobose, with smooth walls, intercalary or terminal, in hyphae or conidia, sometimes excrescent, adhering either directly or on a short branch, single, in pairs or in short chains.

Explanation of Figure 8:

Drawing and photographs of conidia, conidiophores and chlamydospores of the type culture IMI 181488 on different substrates (x 500).

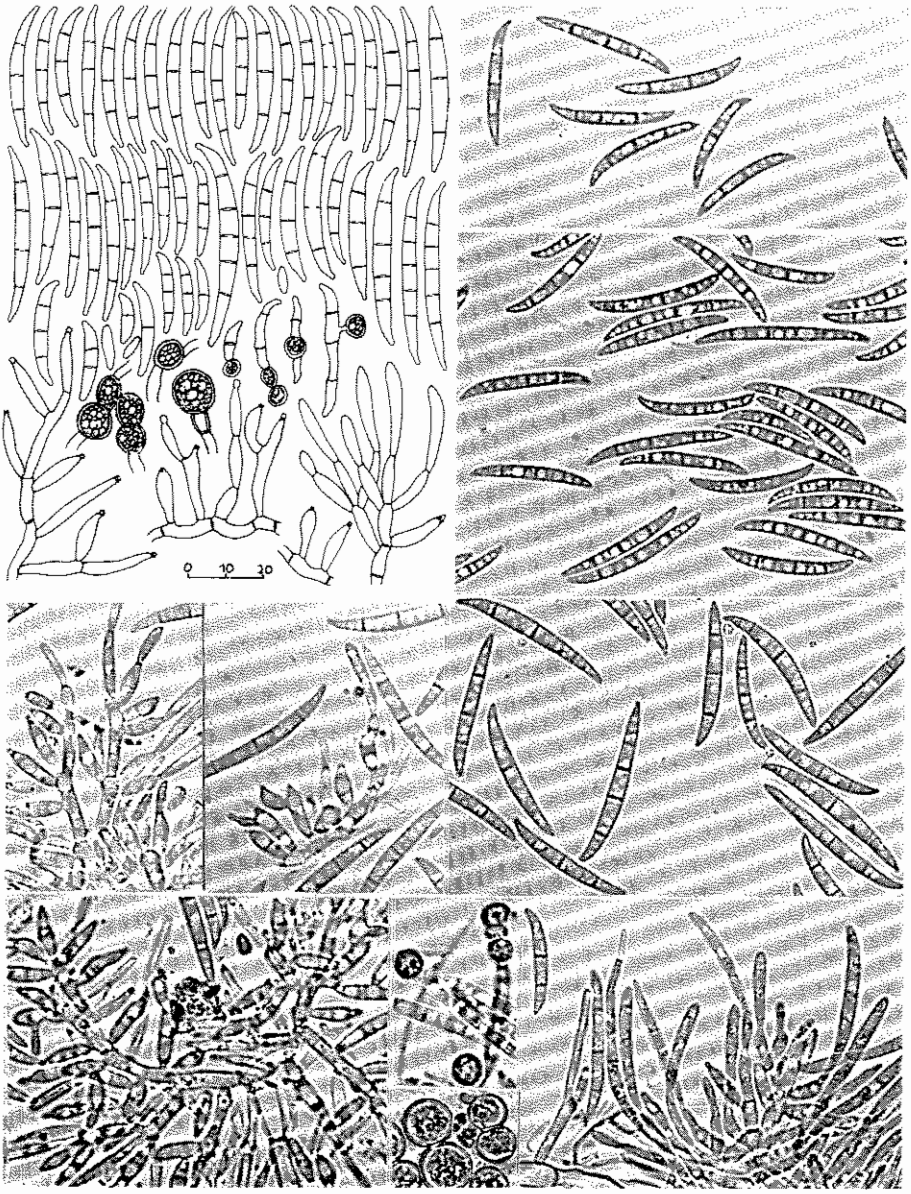

Fig. 8. Fusarium merismoides var. acetilereum.

This Fusarium differs from F. merismoides var. merismoides by the vinaceous or brown-vinaceous colour of the colony on different media and should be retained as a separate variety following TUBAKI, BOOTH & HARADA (1976). It differs also in the ability to utilize 2-butyne 1, 4 diol, an acetylene compound, as the sole source of carbon.

The type culture of this Fusarium isolated from soil near Osaka/Japan was kindly sent to us by BOOTH. It already seems to be in a somewhat degenerated state and therefore less suitable for morphological studies. Investigations on different media under various conditions, however, have shown a much broader variation in morphological characteristics than given in the diagnosis, for instance chlamydospores do occur, sometimes very abundantly. Regarding growth pattern (except pigmentation) and width of conidia there seem to be no clear differences between this strain and typical strains of F. merismoides var. merismoides, contrary to the description given by TUBAKI et al. (1976).

Fusarium merismoides Corda var. violaceum Gerlach - Phytopath. Z. 90: 34-35, 1977

Descriptions: GERLACH & ERSHAD (1970, pp. 730-1, as Fusarium spec. ?nov.), GERLACH (1977c).

C o l o n i e s - slow-growing, reaching 2.8 - 3.2 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - mostly sparse, but sometimes rather abundant, more developed than in all other members of the Eupionnotes group, appressed, arachnoid, turf-like, in the central area often higher, tufty-stranded, felt- or coremium-like, whitish to brownish, red-brown, vinaceous, violet.
Pigmentation - rose, salmon-orange, brownish, dark red-brown, carmin- to purple-violet.
Sclerotial bodies - not formed.
Sporulation - starting quickly in the aerial mycelium, later in flat, pionnotal slimes of various colours, sometimes in small erumpent sporodochium-like layers, especially in the central part of the colony.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, later more or less irregularly or rarely verticillately branched, sometimes densely aggregated in coremium-like strands.
Phialides - monophialidic, almost cylindric, slightly narrowed toward the base, on the average long and slender (10-35 x 2.0-4.0 µm).

C o n i d i a - rather uniform and less variable than in F. merismoides var. merismoides but of similar type, if optimal developed somewhat longer and with a more distinct and pointed apical and basal cell, mostly 3-(0- to 5-)septate, measuring:

0-sept.	15 x 3.0	mostly 12-19 x 2.4-3.5	(8-23 x 2.0-4.0) µm
1-2-sept.	25 x 3.3	mostly 20-30 x 2.8-3.8	(15-34 x 2.5-4.2) µm
3-sept.	39 x 3.4	mostly 30-45 x 3.0-4.0	(24-58 x 2.2-4.5) µm
4-5-sept.	44 x 3.5	mostly 40-52 x 3.0-4.1	(35-61 x 2.5-4.5) µm.

C h l a m y d o s p o r e s - not observed.

Explanation of Figure 9:

Drawing and photographs of conidia and conidiophores of the type culture 11145 (= CBS 634.76) on different substrates (x 500).

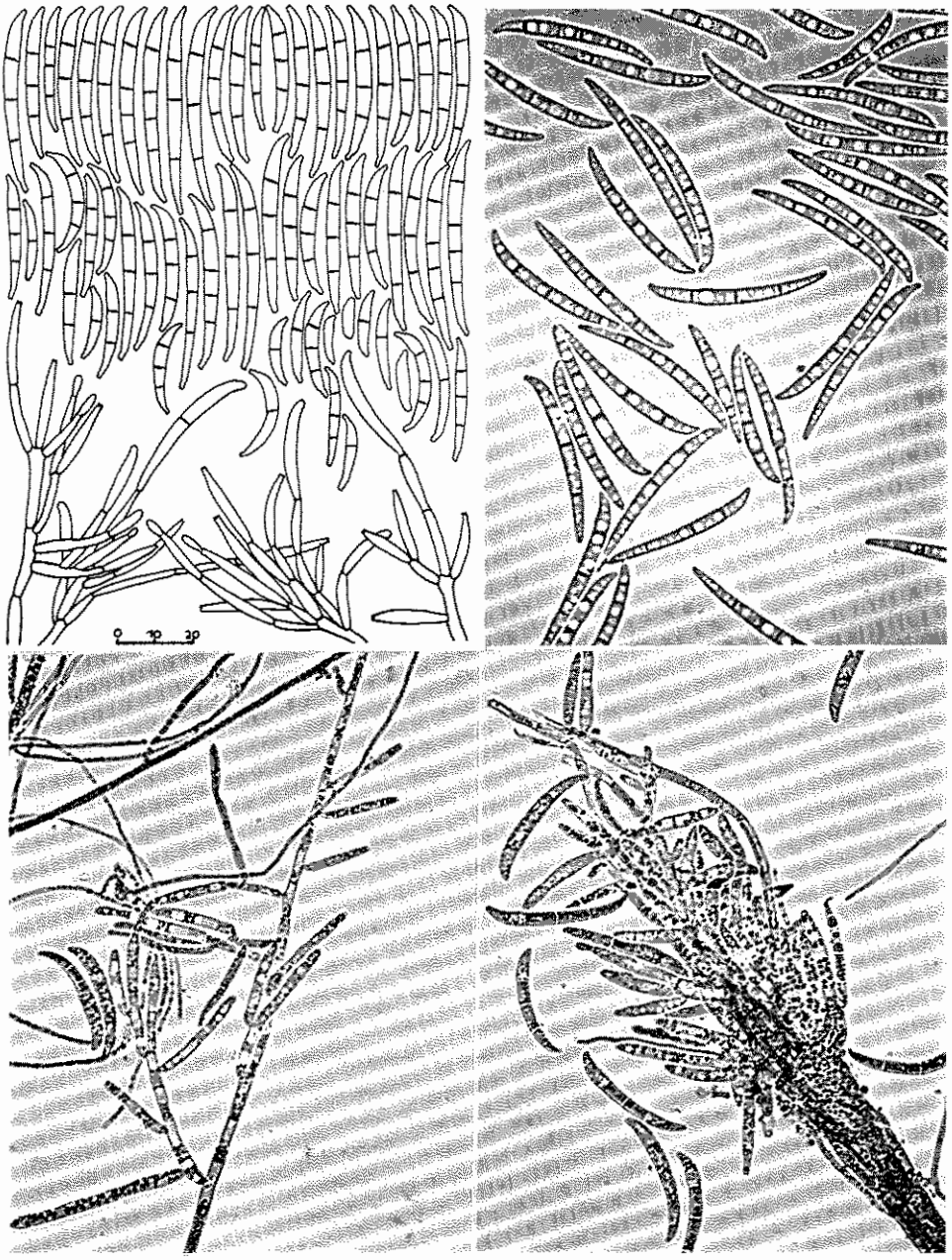

Fig. 9. Fusarium merismoides var. violaceum.

This Fusarium can be distinguished from F. merismoides var. merismoides especially by its intensive brown-violet to purple-violet pigmentation in pure culture on some substrates. Therefore, it was described as a new variety without having known about the publication of F. merismoides var. acetilereum which had appeared some months earlier. There is no doubt that the two varieties correspond in most of their morphological characteristics, but there seem to be some differences in growth and sporulation patterns as well as in the variability of conidiophores and phialides and in the formation of chlamydospores. Moreover our strain 11145 (= 62461) has been isolated in 1968 from a branch of Prunus domestica infested with San José scale insects in Iran, quite a different origin compared with that of the type culture of var. acetilereum. At present it is not possible to determin whether or not these two fusaria are identical. The reason for this difficulty is that the type strain of var. acetilereum could be studied only as a subculture in a more or less degenerated condition. More information based on a broader scale of strains belonging to these varieties is needed.

Fusarium dimerum Penzig in Sacc. - Michelia 2: 484, 1882
var. dimerum

Fusarium aquaeductuum (Radlk. & Rabenh.) Lagerh.
var. dimerum (Penzig) Raillo - Fungi of
the Genus Fusarium (Moscow): 279, 1950

Fusarium lunatum (Ell. & Ev.) v. Arx - Verh. Akad.
Wetensch. Amsterdam 51: 101, 1957

Descriptions: WOLLENWEBER (1916-1935 no. 85-87, 89-91, 548, 549, 853), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), GORDON (1952), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE (1974), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - slow-growing, reaching 3.9 - 4.5 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - mostly present, sparse, delicate, sometimes floccose, whitish to pinkish.
Pigmentation - pinkish, salmon, orange to deep apricot.
Sclerotial bodies - may be formed in some strains (corresponding var. nectrioides), sometimes numerous, very small, globose, reddish brown.
Sporulation - generally abundant and quickly starting in slimy, orange pionnotal or sometimes more sporodochium-like layers.
Odour - not perceptible.

C o n i d i o p h o r e s - in the aerial mycelium arising as single lateral phialides, later loosely, irregularly or sometimes verticillately branched, in pionnotes or sporodochia more reduced, densely aggregated whorls of numerous single phialides occur.

Phialides - monophialidic (after BOOTH 1971a polyphialides may occur), sometimes long, subcylindric to obclavate (10-32 x 2.5-4.0 µm), sometimes short and inflated, obpyriform to subglobose (6-14 x 3.0-5.0 µm).

C o n i d i a - somewhat heterogenous, mostly falcate to broadly lunate, pointed at both ends, with a barely pedicellate basal cell, in some strains most frequently 0-, rarely 1-septate, in other strains mostly 1-(to 3-) septate, measuring:

0-sept.	9 x 2.5	mostly 7-11 x 2.0-2.8	(5-16 x 1.5-3.5) µm
1-sept.	16 x 3.0	mostly 12-22 x 2.4-3.5	(7-30 x 2.0-4.2) µm
2-3-sept.	20 x 3.5	mostly 17-25 x 2.8-4.0	(9-32 x 2.0-4.2) µm.

C h l a m y d o s p o r e s - mostly intercalary in hyphae, exceptionally terminal, rarely in old conidia, globose (6-12 µm) to ovoid, smooth-walled, single, in pairs, or in chains.

Explanation of Figure 10:

Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

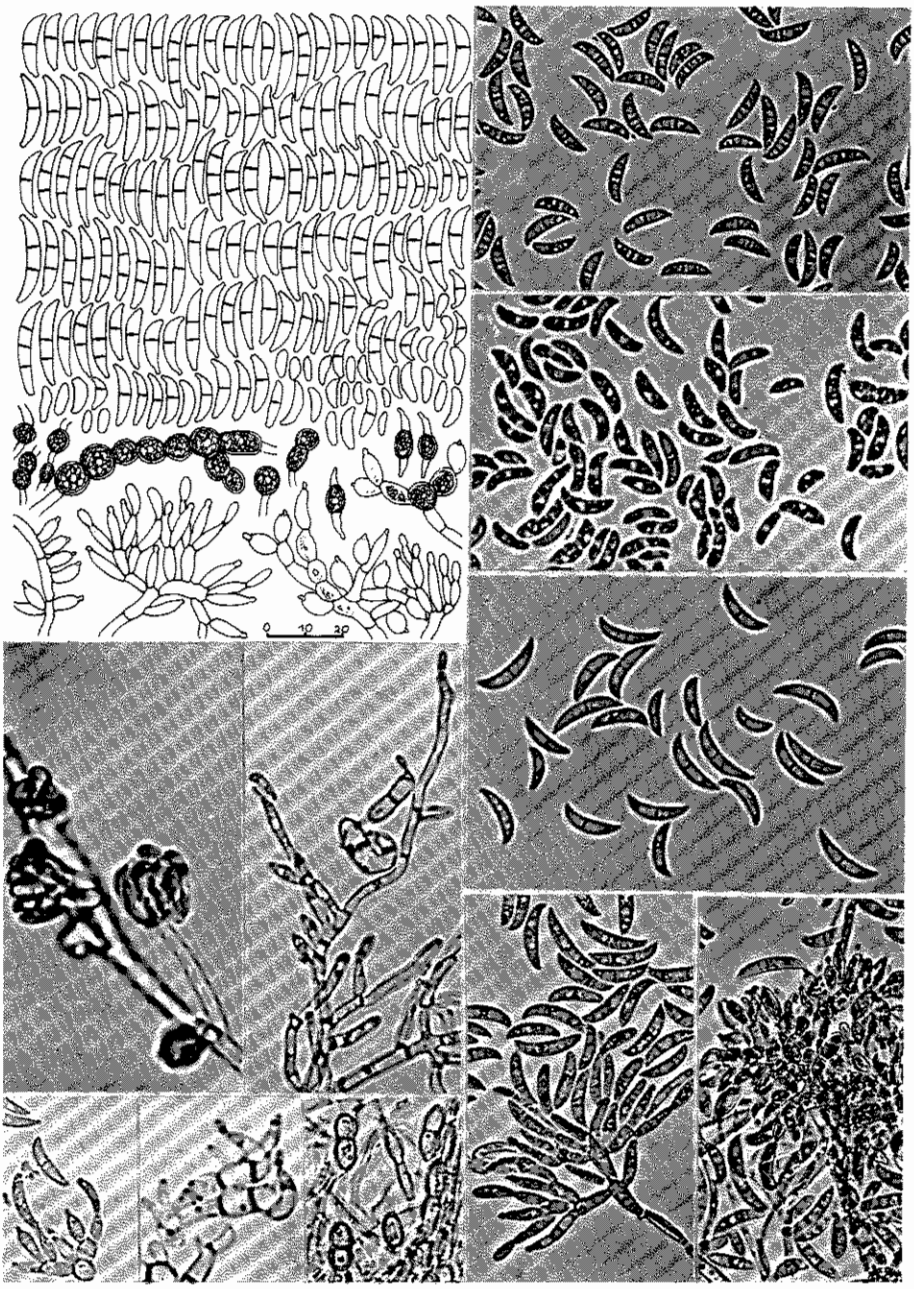

Fig. 10. Fusarium dimerum var. dimerum.

F. dimerum var. dimerum is rather common and well-known and reported from all continents. It should be treated more broadly than done originally, including several varieties distinguished by WOLLENWEBER (1931) and perhaps F. flavum, as discussed in the following. F. dimerum var. dimerum may be regarded as a typical soil fungus which occurs also on many different decaying or rotting plant substrates. There seem to be no reliable reports on its association with plant diseases.

In addition to the many strains studied and illustrated by WOLLENWEBER (1916-1935) some 20 freshly isolated cultures were available in our institute for comparison. They include several strains which correspond to the following 2 varieties no longer regarded as sufficiently distinct.

Fusarium dimerum Penzig var. nectrioides Wollenw. - Fus. autogr. delin.: 855, 1930

Descriptions: WOLLENWEBER (1916-1935 no. 855), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), BUGNICOURT (1939).

WOLLENWEBER described this variety on the basis of 2 strains isolated by REINKING from soil of banana plantations in Honduras (R 154 and R 181 = CBS 176.31, type culture). It is said to produce taller 1- and 2-septate conidia than F. dimerum var. dimerum and globose, reddish brown sclerotia which are sometimes numerously formed. From Indo-China it was reported as distinct by BUGNICOURT (1939), who isolated it from flowers of Celosia cristata. RAILLO (1950) specified it as F. aquaeductuum var. dimerum f. 1, GORDON (1952) and SUBRAMANIAN (1971), however, did not mention this variety in discussing F. dimerum. Following BILAI (1955), BOOTH (1971a) included var. nectrioides in a broad concept of F. dimerum which seems to be acceptable.

Fusarium dimerum Penzig var. pusillum (Wollenw.) Wollenw. - Fus. autogr. delin.: 851, 1930

Fusarium pusillum Wollenw. - Fus. autogr. delin.: 550, 1924

Descriptions: WOLLENWEBER (1916-1935 no. 550, 851, 852), REINKING & WOLLENWEBER (1927), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935).

Originally this variety was described as a new species, based on a strain isolated in 1919 near Berlin from potato tuber with a blackish discoloured vascular system. In 1924 REINKING sent a corresponding strain (R 115) isolated from banana fruit in Panama to WOLLENWEBER and in 1927 FISCHER sent another one (2564) isolated from barley culm in Uruguay. There are 2 further records from beet and Carica papaya (WOLLENWEBER & REINKING 1935) and 1 from man (CBS 254.50).

The fungus is very closely related to F. flavum by its macroscopic and microscopic characteristics, especially because of its mostly 0- and rarely 1-septate, relatively small conidia, the only criterion stated to distinguish this variety from F. dimerum var. dimerum. RAILLO (1950) treated this variety as synonymous with F. dimerum var. dimerum (= F. aquaeductuum var. dimerum). This concept was accepted by GORDON (1952), BILAI (1955), BOOTH (1971a) and SUBRAMANIAN (1971).

Fusarium dimerum Penzig var. violaceum Wollenw. - Fus. autogr. delin.: 854, 1930

Fusarium aquaeductuum (Radlk. & Rabenh.) Lagerh. var. dimerum (Penzig) Raillo f. 2 Raillo - Fungi of the Genus Fusarium (Moscow): 280, 1950

Descriptions: WOLLENWEBER (1916-1935 no. 854), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 8 days at 25°C on PDA.
Aerial mycelium - mostly sparse, sometimes completely absent, delicate, arachnoid or radiate, whitish, greyish brown, brown to dark violet.
Pigmentation - dirty brown, vinaceous, chestnut-brown, carmine-violet to dark violet, especially on wort agar.
Sclerotial bodies - mostly formed, sometimes very numerous, minute, globose to subglobose, brownish to dark violet.
Sporulation - quickly starting in the aerial mycelium, later developing as very small cream, pinkish to salmon pustule-like sporodochia or as dispersed pionnotal slimes, often irregularly distributed on the substrate.
Odour - not perceptible.

C o n i d i o p h o r e s - and phialides not different from F. dimerum var. dimerum.

C o n i d i a - 1-septate, somewhat taller than in typical strains of F. dimerum var. dimerum, measuring:
16.4 x 2.9 mostly 15-19 x 2.5-3.2 (10-26 x 2.0-4.0) µm
(according to WOLLENWEBER & REINKING 1935).

C h l a m y d o s p o r e s - seem to be more abundant and more striking than in strains of typical F. dimerum var. dimerum, often formed in long chains and aggregated in large clusters.

RAILLO (1950) treated this fungus as forma 2 of F. dimerum (F. aquaeductuum var. dimerum). GORDON (1952) and SUBRAMANIAN (1971) did not mention it discussing F. dimerum. In agreement with BILAI (1955), BOOTH (1971a) specified var. violaceum as synonymous with F. dimerum. This variety, however, is clearly distinct by its characteristic brownish violet to dark violet pigmentation on different substrates and of its sclerotial stromata, a feature comparable with that of the varieties F. merismoides var. acetilereum and var. violaceum.

The type culture (WOLLENWEBER's strain 2196) which was isolated by H. PAPE from a rotting fig-cactus (Opuntia ficus-indica) collected by SARDIÑA in 1926 in Spain seems to be lost. In 1974 plants of Gymnocalycium damsii (also a cactus) grown in a nursery near Frankfurt (Main) and showing dark scabbed spots were sent to us by E. LEIBER for diagnosis. In addition to typical strains of F. dimerum, 1 dark violet coloured strain corresponding to var. violaceum was isolated. This strain (63199) is deposited as the neotype in the CBS (632.76). Artificial inoculations indicated that the fungus causes limited superficial scabbed spots after wounding, similar to those observed on the spontaneously infected cactus.

Fusarium flavum (Fr.) Wollenw. - Fus. autogr. delin.: 546, 1924

Descriptions: WOLLENWEBER (1916-1935 no. 546, 547), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935).

The taxonomic position of this Fusarium based on Fusisporum flavum Fr. is uncertain. There is no cultured strain available for comparison.

According to descriptions and remarks given by WOLLENWEBER concerning his 2 strains W 277 and W 317 collected and isolated by him in 1919 from a rotting beet root and a rotting potato tuber respectively, this fungus by and large corresponds to F. dimerum (var. pusillum). Macroscopic characteristics of colonies, such as growth, pigmentation, sporulation and microscopic characteristics, such as conidiophores, phialides, chlamydospores, are not distinct. The only difference noted, were smaller conidia, which were exceptionally 1- but generally 0-septate, measuring:

8 x 1.8 mostly 7-9 x 1.7-2.0 (4-12 x 1.0-3.0) µm.

F. flavum, not mentioned by GORDON (1952) and SUBRAMANIAN (1971) in discussing F. dimerum, was treated by RAILLO (1950) as F. aquaeductuum var. flavum (Fr.) comb. nov. and equated with F. dimerum (= F. aquaeductuum var. dimerum) by BILAI (1955) as well as by BOOTH (1971a).

It may be justified to include F. flavum in a somewhat wider concept of F. dimerum, regarding the broad variation of conidia in F. dimerum var. dimerum (including var. nectrioides and var. pusillum) under different conditions and between different strains. Moreover, F. dimerum var. dimerum is rather common and often found on decaying plant material, especially on rotting potato tubers and beets, from which F. flavum also had been isolated.

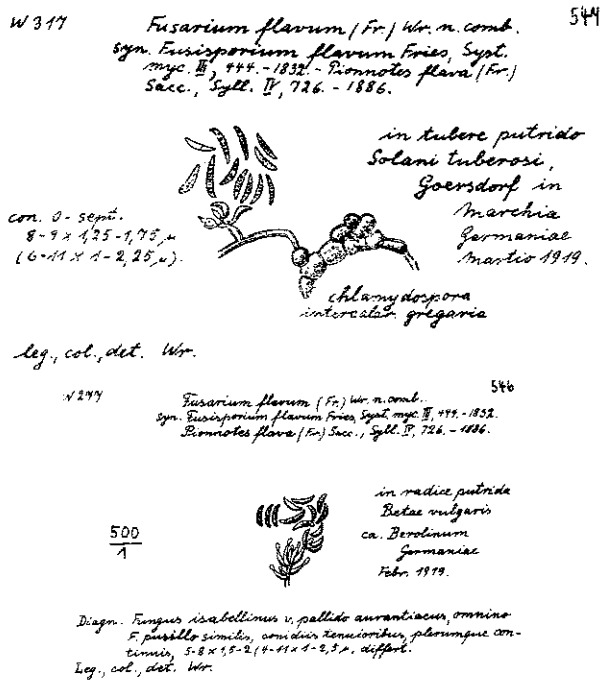

Fig. 11. Fusarium flavum.
Reproductions of WOLLENWEBER's Fus. autogr. delin. no. 546 of strain 277 and no. 547 of strain 317 (x 500).

Fusarium tabacinum (Beyma) W. Gams in Gams & Gerlagh - Persoonia 5: 179, 1968

Cephalosporium tabacinum Beyma - Zentralbl. Bakteriol. 2. Abt. 89: 239, 1933

Teleomorph: Plectosphaerella cucumerina (Lindf.) W. Gams in Domsch & Gams - Fungi in Agricultural Soils (London): 160, 1972

Micronectriella cucumeris (Klebahn) C. Booth - The Genus Fusarium: 39, 1971

Descriptions: GAMS & GERLAGH (1968), BOOTH (1971a), JOFFE (1974), DOMSCH et al. (1980).

Colonies - moderately fast-growing, reaching 5.5 - 6.5 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - generally sparse, sometimes arachnoid, floccose to felt-like or tufted, whitish to yellowish.
Pigmentation - whitish to beige or pinkish.
Sclerotial bodies - not formed.
Sporulation - starting quickly, masses of conidia cohere later in false heads forming a slimy cover on the colony surface.
Odour - not perceptible.

Conidiophores - at first arising in the aerial mycelium as lateral phialides, later sparsely branching.
Phialides - monophialidic, very variable in size; if solitarily developing in the aerial mycelium nearly cylindric, sometimes irregularly bent, very long (- 40 µm) and slender (2.5-4.5 µm); if densely aggregated doliiform, short (8-15 µm) and wide (4-6 µm), often with a distinct collarette; there are phialides whose shapes lie between these two extremes.

C o n i d i a - by and large of one type, but some differences may exist between strains and substrates used, rather delicate, thin-walled, if 1-celled often with 2 or more vacuoles and more variable in shape, if 1-septate slightly curved, with a pointed apical cell which generally narrows conically and an apedicellate basal cell, measuring:

11 x 2.8 mostly 8-14 x 2.2-3.2 (5-16 x 2.0-4.0) µm.

The conidia illustrated by BOOTH (1971a) and JOFFE (1974) include 3-septate ones which seem to be not representative; conidia with 3 septa are not mentioned by GAMS & GERLAGH (1968) and were never observed by us in any strain.

C h l a m y d o s p o r e s - never formed.

Explanation of Figure 12:

Reproduction of Figure 3 by GAMS & GERLAGH (1968); drawing and photographs of conidia and conidiophores of different strains on different substrates (x 500).

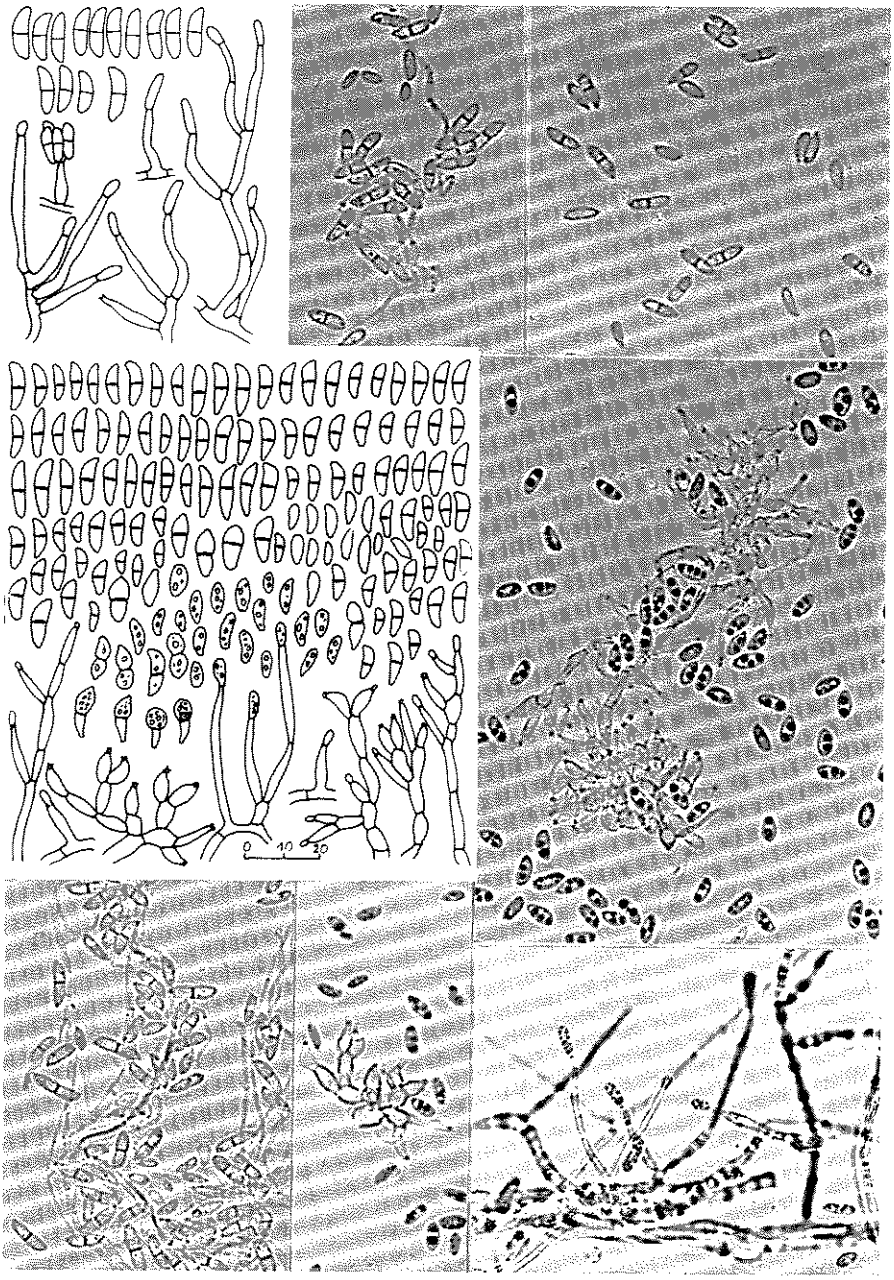

Fig. 12. Fusarium tabacinum.

F. tabacinum is a distinct species with microscopic characteristics most similar to F. dimerum var. dimerum. Nomenclature and taxonomic position of the fungus are discussed in detail by GAMS & GERLAGH (1968).

This Fusarium is quite common in arable soils, sometimes even one of the most frequent Fusarium species reported especially from the temperate zone of Europe and the USA. It seems to be often associated with decaying plant material and in some cases with diseases of tobacco, cucumber and pansies. By and large it is of comparatively minor importance as a plant pathogen. For comprehensive information see GAMS & GERLAGH (1968) and DOMSCH et al. (1980).

Fusarium epistroma (Höhnel) C. Booth - The Genus Fusarium: 66, 1971

Dendrodochium epistroma Höhnel - Sitzungsber. Akad. Wiss. Wien 1, 118: 424, 1909

Teleomorph: Nectria magnusiana Rehm ex Sacc. - Michelia 1: 294, 1878

Descriptions: BOOTH (1959, 1971a).

C o l o n i e s - slow-growing, reaching 2.3 - 2.5 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - sparse, delicate, whitish to pinkish or often completely absent.
Pigmentation - cream to peach or yellow-orange.
Sclerotial bodies - not formed.
Sporulation - not very quickly starting and not abundant, later sometimes in limited pionnotal slimes in the central area of the colony.
Odour – not perceptible.

C o n i d i o p h o r e s - formed as single lateral phialides, loosely branched or appressed, sometimes consisting of a basal cell with a cluster of phialides.
Phialides - monophialidic, rather uniform, subcylindric, 12-30 x 2.0-4.0 µm.

C o n i d i a - generally some subdeveloped 0- or 1-septate conidia present, mostly falcate, curved, sometimes slightly wider above the centre, with a markedly pointed apical and a mostly apedicellate basal cell, often with many vacuoles and indistinctly septate, when fully developed predominantly 3-septate, rarely 4- to 5-septate, measuring:

3-sept. 34 x 3.2 mostly 29-37 x 2.8-3.6 (19-45 x 2.3-4.2) µm.

C h l a m y d o s p o r e s - not observed by BOOTH (1971a), but occasionally present in old cultures, in conidia and hyphal cells, smooth-walled, globose to oval, comparatively small (4-9 x 3-7 µm), intercalary or terminal, single, in pairs or in short chains.

Explanation of Figure 13:

Reproduction of Figure 15 by BOOTH (1971a); drawing and photographs of conidia, conidiophores and chlamydospores of strain IMI 85601 on different substrates (x 500).

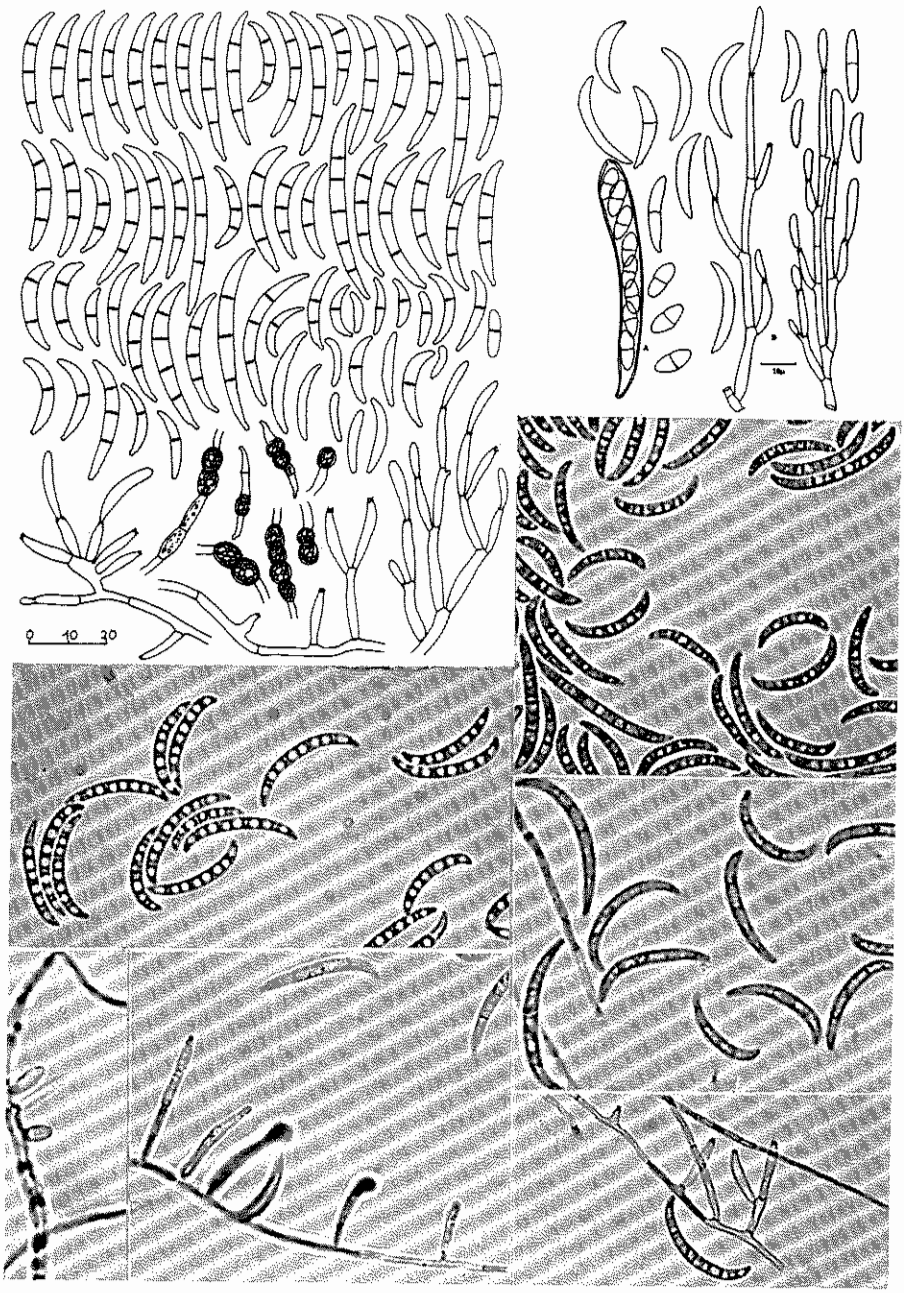

Fig. 13. Fusarium epistroma.

F. epistroma should be retained as a separate species primarily because of its distinct teleomorph. In pure culture its macroscopic and microscopic characteristics are most similar to F. aquaeductuum var. medium, at least regarding strain IMI 85601, the only one available from BOOTH. The culture kindly sent to us, was, unfortunately, infested with bacteria and mites. After being purified it was no longer in a condition optimal for morphological studies. On some of the numerous substrates used and under optimal light conditions, however, samples of very uniform and probably typical conidia could be found and therefore were incorporated in the enlarged diagnosis given above.

According to BOOTH (1971a) F. epistroma is highly specialized and found only on the perithecial stroma of Diatrypella species. It is probably a parasite, since infected perithecia fail to mature.

Section MACROCONIA Wollenw. - Angew. Bot. 8: 179, 1926

Fusarium buxicola Sacc. - Syll. Fung. 2: 518, 1883

Teleomorph: Nectria desmazierii Beccari & De Not. - Erb. critt. ital. cent. 10, no. 983, 1863 (De Not. - Sfer. ital. fasc. 1: 10, 1863)

Descriptions: WOLLENWEBER (1916-1935 no. 340, 1104a, 1104b, 1104c, 1127a, 1127b), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), BOOTH (1959, 1971a), JOFFE (1974).

The only culture available (CBS 313.34) deposited by J. EHRLICH is degenerated. Therefore, the following (incomplete) description is a combination of the data given by WOLLENWEBER in 1943 and data to be found in his original notes and drawings as well as data presented by BOOTH (1959, 1971a). WOLLENWEBER's material, preserved in our institute, includes also many records of the strain cultured by EHRLICH (Fus. autogr. delin. no. 1104c, 1127b) and another strain isolated by WOLLENWEBER and studied in pure culture (Fus. autogr. delin. no. 1127a).

C o l o n i e s - slow-growing, according to BOOTH (1971a, growth rate 0.8 cm (about the same as in F. merismoides, i.e. about 3 cm diam. in 10 days at 25°C on PDA).
Aerial mycelium - sparse, densely appressed, felt-like.
Pigmentation - cream, amber, fawn to brown, seldom somewhat blue or verdigris spotted, never red.
Sclerotial bodies - may occur, very small, globose, buff brownish to bluish.

Sporulation - starting after a few days scattered in the aerial mycelium, later masses of conidia aggregate in sporodochial droplets or small pillars on tubercle-like stroma, often confluent, forming honey-coloured pionnotal crusts.
Odour - not perceptible.

C o n i d i o p h o r e s - sparsely formed after a few days as simple short lateral phialides or branched, terminating in 2-5 phialides; later forming sporodochia.
Phialides - seem to be monophialidic, measuring 15-25 x 2.5-3.5 µm (BOOTH 1971a).

C o n i d i a - the first conidia formed may be microconidia, ellipsoid, spindle- or comma-shaped (according to WOLLENWEBER & REINKING 1935 and J. EHRLICH, cited by BOOTH 1959); macroconidia (according to BOOTH 1971a "the only form of conidia produced") broadly inequilaterally fusoid with a somewhat hooked apical cell and a wedge-shaped foot cell, mostly 3- to 5- seldom 6- to 7-septate, measuring:

0-sept.	12 x 2.7	mostly 9-14 x 2.4-3.1	(7-20 x 2.0-4.0) µm
1-sept.	24 x 3.1	mostly 23-28 x 3.0-4.0	(18-40 x 2.5-4.5) µm
3-sept.	47 x 4.4	mostly 38-59 x 3.1-5.6	(24-68 x 3.0-7.0) µm
5-sept.	61 x 5.1	mostly 52-70 x 3.5-6.2	(45-82 x 3.4-7.5) µm
7-sept.	76 x 5.7		(60-92 x 4.5-7.0) µm.

Explanation of Figure 14:
Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 1127a of strain 5248; drawing of conidia and conidiophores of strains 5248 and 5393, according to WOLLENWEBER's drawings (x 500).

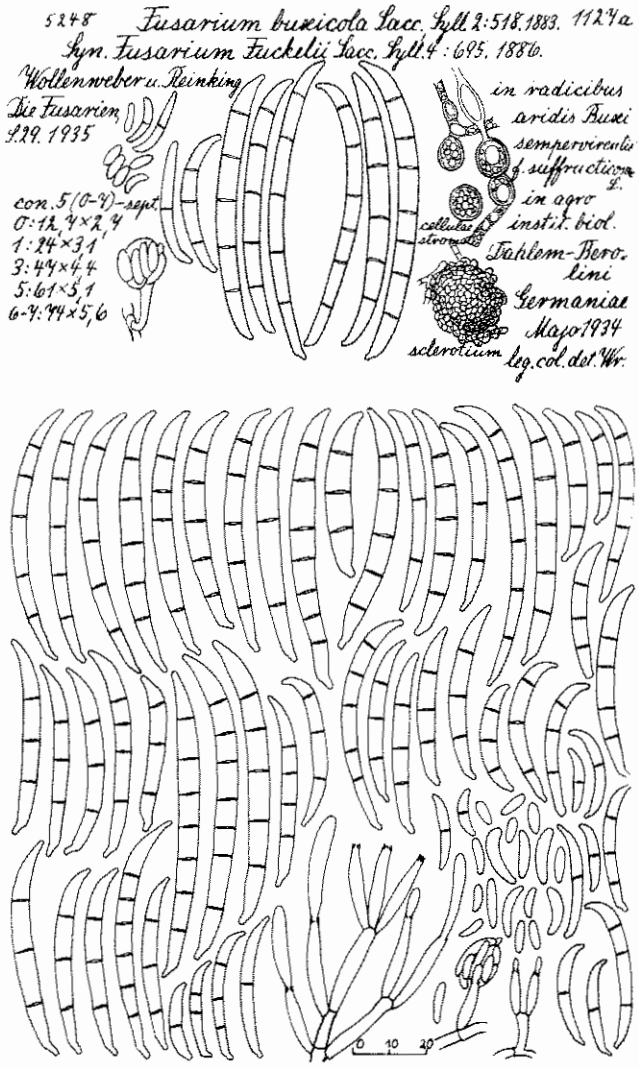

Fig. 14. Fusarium buxicola.

C h l a m y d o s p o r e s - generally absent (J. EHRLICH, cited by BOOTH 1959 "globose chlamydospores occasionally formed from the cells of the macroconidia in older cultures").

This rarely collected species is restricted to Buxus spp. It was found at several locations in Europe on branches, leaves, leaf scars and roots of rotting or withered plants of B. sempervirens and B. balearica and may be associated with premature shedding of leaves.
F. buxicola has been treated as a distinct species by WOLLENWEBER & REINKING (1935) and WOLLENWEBER (1943) and was later accepted by RAILLO (1950), BILAI (1955), BOOTH (1959, 1971a) and JOFFE (1974).

Fusarium buxicola Sacc. var. chlamydosporum Batikyan - Biol. Zh. Armen. 22: 90, 1969

Published without Latin diagnosis, and therefore invalid.

Fusarium expansum Schlecht. - Flora Berol. 2: 139, 1824

Teleomorph: Nectria stilbosporae Tul. - Carpol. 3: 71, 1865

Descriptions: WOLLENWEBER (1916-1935 no. 616, 675, 858), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943).

There is no cultured strain of F. expansum available. Therefore, the following (incomplete) description is based on the diagnosis given by WOLLENWEBER (1943) and the re-examination of the material preserved in our institute. It includes excellent drawings and many notes regarding the 2 strains 2486 (Fus. autogr. delin. no. 858) and 6005 which he himself collected, isolated and cultured.

C o l o n i e s - slow-growing, reaching about 2.0 - 2.5 cm diam. in 10 days on PDA.
Aerial mycelium - mostly sparse, appressed or completely absent.
Pigmentation - whitish to dirty pink, yellowish, amber to golden yellow.
Sclerotial bodies - sometimes numerous, globose, 0.05-0.12 cm, brownish, red-brown to chestnut.
Sporulation - starting after a few days in the aerial mycelium, later masses of conidia aggregate in flat pionnotal covers or in mostly small sporodochia, on oatmeal agar occasionally coremium-like, pinkish to orange.
Odour - not perceptible.

C o n i d i o p h o r e s - (only a few drawn by WOLLENWEBER) more or less irregularly and loosely, sometimes verticillately branched. Phialides - monophialidic, subcylindric, measuring about 18-32 x 2.0-3.8 µm.

C o n i d i a - in early stages some 0- or 1-septate conidia may occur; later they are subcylindric, slender, falcate, only slightly curved, narrowing toward both ends, with a pointed, somewhat hooked apical cell and a conical papillate or slightly pedicellate basal cell, mostly 3-(4- to 5-), exceptionally 6- to 7-septate, measuring:

0-sept.	11 x 4.1		(9-15 x 2.5-5.0) µm
1-sept.	16 x 4.7		(12-25 x 3.5-6.0) µm
3-sept.	45 x 4.2	mostly 37-53 x 3.3-4.8	(30-64 x 3.0-6.0) µm
4-sept.	61 x 4.5	mostly 53-65 x 3.3-5.1	(44-73 x 3.5-7.5) µm
5-sept.	65 x 5.0	mostly 54-69 x 4.0-6.1	(50-80 x 3.5-7.5) µm
6-7-sept.	67 x 5.0		(50-80 x 4.0-7.0) µm.

C h l a m y d o s p o r e s - generally absent or rare, in conidia or hyphae, terminal, intercalary, single or in pairs, globose (7-9 µm), pyriform.

Explanation of Figure 15:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 858 of strain 2486; drawing of conidia, conidiophores and chlamydospores of strains 2486 and 6005, according to WOLLENWEBER's drawings (x 500).

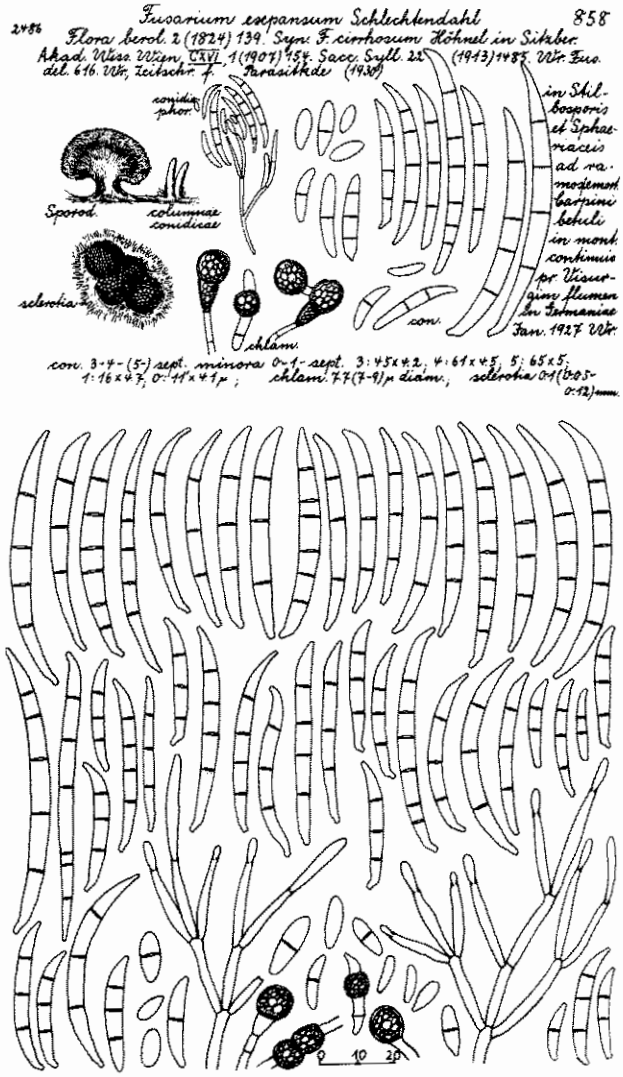

Fig. 15. Fusarium expansum.

This rarely collected and rather unknown species has been found on some ascomycetes and their anamorphs on withered branches of Acer, Carpinus, Ostrya, Sorbus and on Viscum in Europe and Canada.

F. expansum was treated as a distinct species by WOLLENWEBER & REINKING (1935) and WOLLENWEBER (1943), later RAILLO (1950) and BILAI (1955) accepted it without any further comments, while BOOTH (1971a) as well as JOFFE (1974) did not discuss it.

Fusarium sphaeriae Fuckel - Symb. mycol.: 370, 1869

Nectria leptosphaeriae Niessl in Krieger - Fungi Saxon. IV. no. 165, 1886 (Rehm - Hedwigia 26: 12, 1887)

Descriptions: WOLLENWEBER (1916-1935 no. 57, 58, 343, 350, 425, 525, 676-678, 859, 860), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), BOOTH (1959, 1971a), JOFFE (1974).

C o l o n i e s - very slow-growing, reaching 0.5 - 0.7 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - more or less abundant, floccose, filaceous, often fasciculate in the centre, easily collapsing and forming a gelatinous cover.
Pigmentation - whitish, dirty pink, pale peach, apricot to salmon-orange, on rice pap brownish, never intensely red.
Sclerotial bodies - absent.
Sporulation - after about one week starting sparsely in the aerial mycelium, later abundant in small, pink to orange pionnotes or sporodochia.
Odour - not perceptible.

C o n i d i o p h o r e s - in early stages arising as single lateral phialides on hyphae, later irregularly or verticillately branched, loosely or more often densely aggregated.
Phialides - monophialidic, subcylindric, measuring 8-30 x 3.0-4.5 µm.

C o n i d i a - in early stages some 0- and 1-septate conidia may occur; commonly robust, thick-walled, very variable, 3-septate conidia often much smaller, especially more slender than 5- or more-septate conidia, most abundant and typical on carrot agar at 10°C under near-UV light, more or less curved, nearly cylindric, narrowing toward both ends, slightly bent near the rounded or angular apex and with a pedicellate or sometimes obtuse, rounded foot cell, mostly 5-(3- to 7- exceptionally 9- to 11-)septate, measuring:

0-sept.	20 x 3.8		(16- 22 x 3.5-4.0) µm
1-sept.	33 x 4.2		(16- 75 x 2.7-6.0) µm
3-sept.	58 x 4.9	mostly 44-73 x 4.0-6.2	(35- 98 x 3.5-9.0) µm
5-sept.	71 x 5.8	mostly 57-87 x 5.2-7.6	(45-108 x 4.0-9.0) µm
7-sept.	86 x 6.5		(66-105 x 5.5-8.0) µm
9-11-sept.			(70-127 x 6.0-8.0) µm.

C h l a m y d o s p o r e s - absent or rare, in conidia or hyphae, terminal or intercalary, globose to subglobose (7-10 µm), single, in pairs or in chains.

Explanation of Figure 16:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 860 of strain 2026; drawings and photographs of conidia, conidiophores and chlamydospores of strain 63675 (= CBS 717.74) on different substrates (x 500).

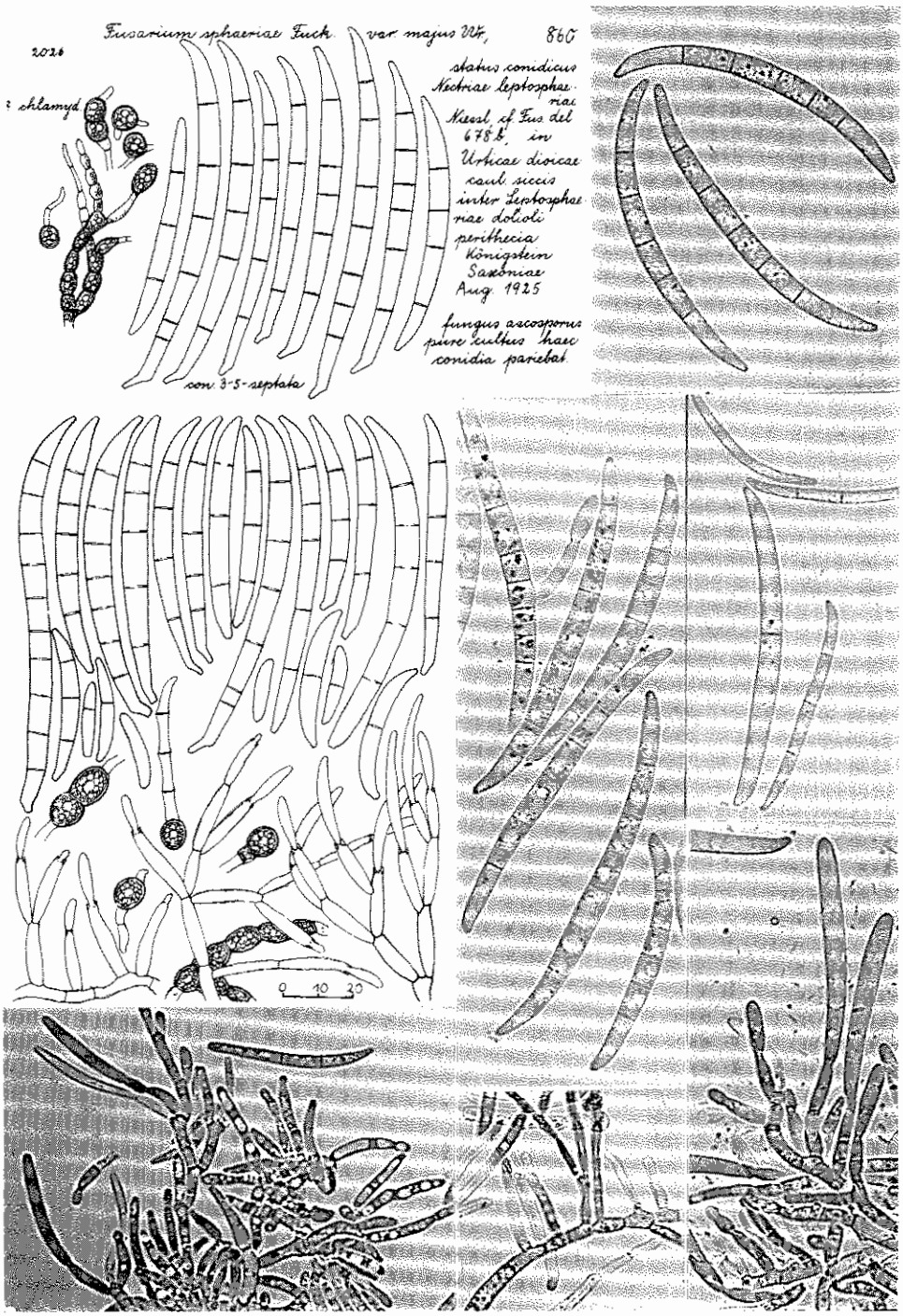

Fig. 16. Fusarium sphaeriae.

This Fusarium is not very common and has been only recorded from Europe in association with some ascomycetes (Cucurbitaria, Gibberella, Leptosphaeria, Valsaria spp.) on withered stalks of Brassica, Coronilla, Urtica and branches or stems of Clematis, Laburnum, Robinia, Sarothamnus and Ulmus. In addition to WOLLENWEBER's material, including his drawings and notes of three cultured strains, 2025 (Fus. autogr. delin. no. 859), 2026 (Fus. autogr. delin. no. 860), both isolated from Leptosphaeria doliolum on Urtica dioica, and 6839 from Cucurbitaria laburni on Laburnum vulgaris in Italy (sent to him by PEYRONEL in 1942), strain 63675 (= CBS 717.74), isolated from Coronilla emerus, was available for a thorough re-examination of the characteristics of this species.

F. sphaeriae was treated as a distinct species by WOLLENWEBER & REINKING (1935) and WOLLENWEBER (1943). It was later accepted by RAILLO (1950), BILAI (1955), BOOTH (1959, 1971a) and JOFFE (1974).

Fusarium gigas Speg. - Revue Mycol. 9: 98, 1887

Descriptions: WOLLENWEBER (1916-1935 no. 352), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), RAILLO (1950), BILAI (1955), BOOTH (1971a), JOFFE (1974).

There is no cultured strain available.
The short, incomplete descriptions given by WOLLENWEBER & REINKING (1935) and WOLLENWEBER (1943), which were accepted by RAILLO (1950) and BILAI (1955) without any comments, as well as the description given by BOOTH (1971a) are based on the 2 known exsiccatae: SPEGAZZINI - Fungi guaranitici no. 426 and B. BALANSA - Pl. du Paraguay no. 3471. According to BOOTH (1971a) F. gigas was growing from sparse mycelium on the surface of a carbonaceous sterile pyrenomycete stroma on bamboo stems in South America.
JOFFE (1974), in giving a description including growth rate, was asked for a cultured strain. According to his letter of May 1976, he had isolated 5 strains of F. gigas from kernels of barley and rye during the years 1944 - 1948, but unfortunately the material was left with his collection in the Soviet Union.
As far as one can deduce from the incomplete descriptions, the following characterization may pertain:

C o l o n i e s - very slow-growing, reaching about 1.0 - 1.5 cm diam. in 10 days at 25°C on PDA (handwritten supplement of JOFFE in a reprint of his publication).
Aerial mycelium - sparse, very delicate, arachnoid.
Pigmentation - whitish to pale pink.
Sclerotial bodies - not mentioned.
Sporulation - mainly occurring in the aerial mycelium, rarely in sporodochia or pionnotes.
Odour - not mentioned.

C o n i d i o p h o r e s - simple phialides arising from the superficially growing hyphae; no further information available.

C o n i d i a - the largest Fusarium conidia so far recorded, rather thin-walled, almost cylindric, slightly curved, narrowing at both ends with a constricted hamate apical cell and a markedly pedicellate basal cell, measuring:

9-12-sept.	100-130 x 10.0-13.0 µm (WOLLENWEBER)
10-12-sept.	135-200 x 12.5-20.0 µm (BOOTH)
5-7-sept.	54- 95 x 3.7- 6.8 µm (JOFFE)
9-10-sept.	90-127 x 5.8-10.8 µm (JOFFE)
11-12-sept.	98-148 x 7.4-13.8 µm (JOFFE).

C h l a m y d o s p o r e s - absent (JOFFE).

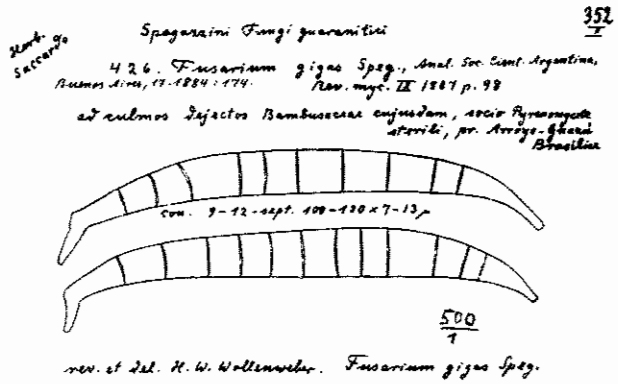

Fig. 17. Fusarium gigas.
Reproduction of WOLLENWEBER's
Fus. autogr. delin. no. 352.

Fusarium coccophilum (Desm.) Wollenw. & Reinking - Die Fusarien: 34, 1935

Teleomorph: Nectria flammea (Tul.) Dingley - Trans. R. Soc. N.Z. 79: 189, 1951

Nectria coccophila (Tul.) Wollenw. & Reinking - Die Fusarien: 34, 1935

Nectria ecoccophila Wollenw. - Zentralbl. Bakteriol. 2. Abt. 106: 118, 1943

Descriptions: WOLLENWEBER (1916-1935 no. 344-348, 351, 614, 679-682, 861-868, 1124-1126), WOLLENWEBER & REINKING (1935), DOIDGE (1938), WOLLENWEBER (1943), RAILLO (1950), BILAI (1955), GORDON (1956b), GERLACH & ERSHAD (1970), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE (1974).

C o l o n i e s - slow-growing, reaching 2.0 - 2.3 cm diam. in 10 days at 25°C on PDA.

Aerial mycelium - often sparse, sometimes rather abundant, floccose to felt-like, sometimes several aerial hyphae loosely entwined, when dry forming a cartilaginous stroma.

Pigmentation - whitish, rose, apricot to bright orange.

Sclerotial bodies - absent.

Sporulation - absent or only sparse in the aerial mycelium, under favourable cultural conditions after about 2 weeks masses of conidia are produced, forming pink, bright salmon-orange to coral-red large pionnotal or sporodochial layers.

Odour - not perceptible.

C o n i d i o p h o r e s - at first rarely formed as single lateral phialides on hyphae in the aerial mycelium, later sparsely branched, each branch terminating in 1 or 2 phialides, those of pionnotes or sporodochia densely fasciculate.

Phialides - monophialidic, cylindric to subcylindric, after the formation of the first conidium bearing a delicate flared collarette, generally rather long and slender, 18-42 x 2.5-4.0 µm.

C o n i d i a - rather thick-walled, subcylindric to falcate, slightly curved, tapering toward both ends, often with a somewhat hooked and constricted apical cell and a conical to rounded, sometimes slightly pedicellate basal cell, mostly 6- to 9-septate, septae occasionally obscure, measuring:

3-sept.	59 x 4.5	mostly 46- 66 x 4.2-4.8	(35- 72 x 4.0-5.0) µm
5-6-sept.	77 x 5.5	mostly 70- 85 x 4.5-6.0	(50- 97 x 4.2-7.0) µm
7-8-sept.	86 x 5.6	mostly 75- 95 x 4.5-6.5	(70-112 x 4.5-8.0) µm
9-sept.	95 x 5.6	mostly 85-105 x 4.5-7.0	(80-116 x 5.0-8.0) µm
10-12-sept.	117 x 6.0		(98-142 x 5.0-8.0) µm.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 18:

Drawing and photographs of conidia and conidiophores of strains 9813 and 62175 (= CBS 793.70) on different substrates (x 500).

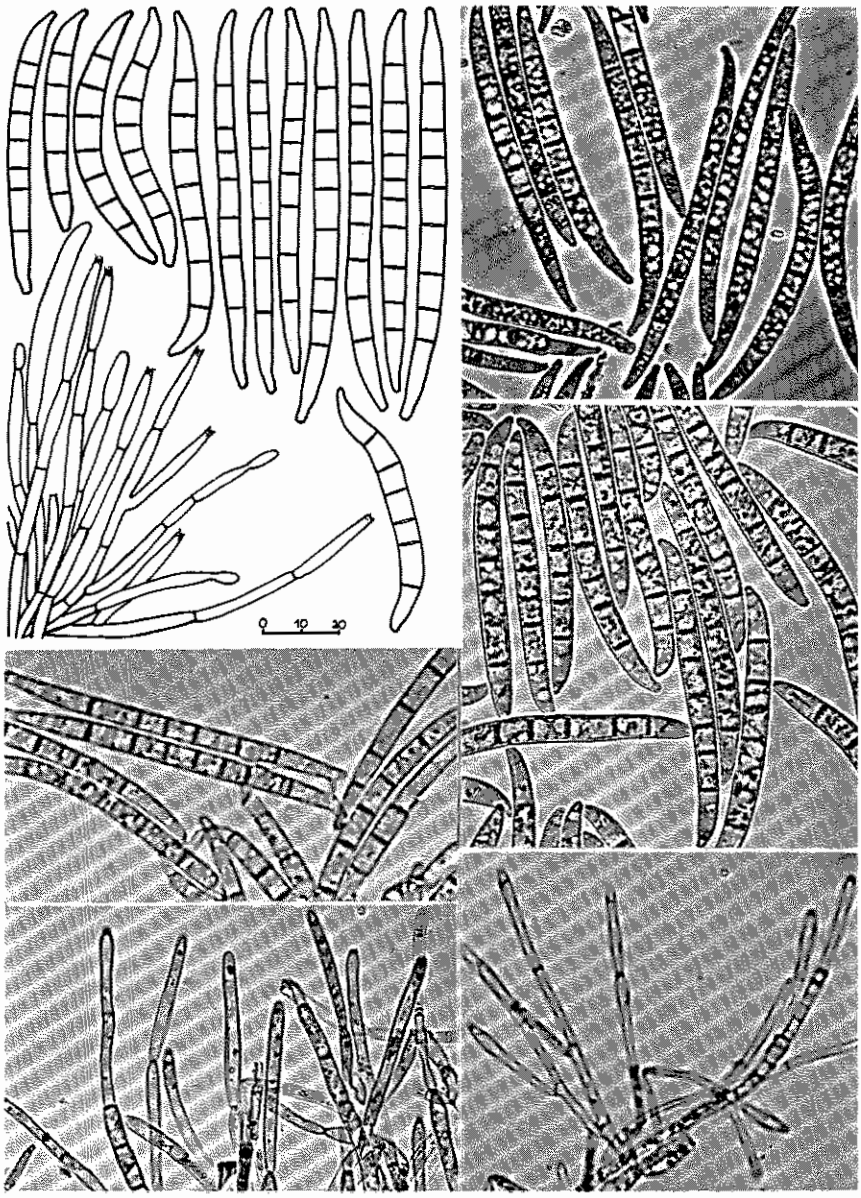

Fig. 18. Fusarium coccophilum.

This generally as distinct accepted and rather common Fusarium species predominantly occurs as a parasite of scale insects on many kinds of woody plants especially in warm, subtropical and tropical countries.

In addition to the very comprehensive material, including 9 cultured strains, studied and deposited by WOLLENWEBER, 2 recently isolated cultures were available to confirm the existence of this Fusarium: strain 9813 from a cushion gall on Miconia spec. (Costa Rica) and strain 11140 (= 62175 = CBS 793.70) associated with scale insects from a branch of Gleditsia caspica (Iran). Three other representative strains, 310.34, 302.59 (= ATCC 13408) and 215.77, are deposited in the CBS/Baarn.

Section SPICARIOIDES Wollenweber, Sherbakoff, Reinking, Johann & Bailey - J. agric. Res. 30: 841, 1925

Fusarium decemcellulare Brick - Jahresber. Ver. Angew. Bot. 6: 227, 1908

Teleomorph: Calonectria rigidiuscula (Berk. & Br.) Sacc. - Michelia 1: 313, 1878

Descriptions: WOLLENWEBER (1916-1935 no. 353, 800-802, 869, 870), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), BUGNICOURT (1939), RAILLO (1950), BILAI (1955), GORDON (1956b), BOOTH (1960), BOOTH & WATERSTON (1964a), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE (1974).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - generally abundant, floccose to fluffy or felt-like, soon appearing powdery by the production of microconidia.
Pigmentation - in the first days whitish to cream, changing to greyish rose, carmine to purple or yellowish ochre.
Sclerotial bodies - small, rough, warty, sporadically erumpent as a sometimes thick plectenchymatic stroma.
Sporulation - starting after 3 to 5 days in the aerial mycelium as microconidia cohering in chains or false heads; later whitish, cream to ochre sporodochia with macroconidia develop, often confluent.
Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores in early stages formed as single lateral phialides on hyphae, later more or less irregularly or verticillately branched; secondary conidiophores loosely or rather densely aggregated in sporodochia.

Phialides - monophialidic, generally rather long and slender, especially those forming chains of microconidia, cylindric to subcylindric, 12-40 x 2.5-4.0 µm, in sporodochia densely aggregated, conidiogenous locus surrounded by a collarette.

C o n i d i a - microconidia 0-, rarely 1-septate, subcylindric to ovoid; macroconidia large and thick-walled, cylindric to subcylindric and more or less curved with a hooked constricted apical cell and a distinct pedicellate basal cell, mostly 5- to 9-septate, less frequently 3- to 4- or 10- to 12-septate, measuring:

0-sept.	7 x 3.4	mostly 6- 9 x 3.0-4.0	(5- 11 x 2.0-5.6) µm
1-sept.	14 x 4.0	mostly 12- 20 x 4.0-4.5	(10- 28 x 2.0-5.0) µm
3-sept.	34 x 4.9	mostly 25- 42 x 4.5-5.5	(20- 67 x 3.5-6.0) µm
5-sept.	58 x 5.8	mostly 53- 64 x 4.7-6.5	(42- 76 x 4.5-8.0) µm
7-sept.	72 x 6.2	mostly 58- 78 x 5.0-7.7	(60- 95 x 4.5-8.0) µm
8-9-sept.	85 x 6.5	mostly 75- 97 x 5.0-8.0	(68-114 x 4.5-8.5) µm
11-13-sept.	94 x 6.6	mostly 80-111 x 5.3-7.5	(75-131 x 5.0-9.0) µm.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 19:

Drawing and photographs of conidia and conidiophores of strains 9784 and 9808 on different substrates (x 500).

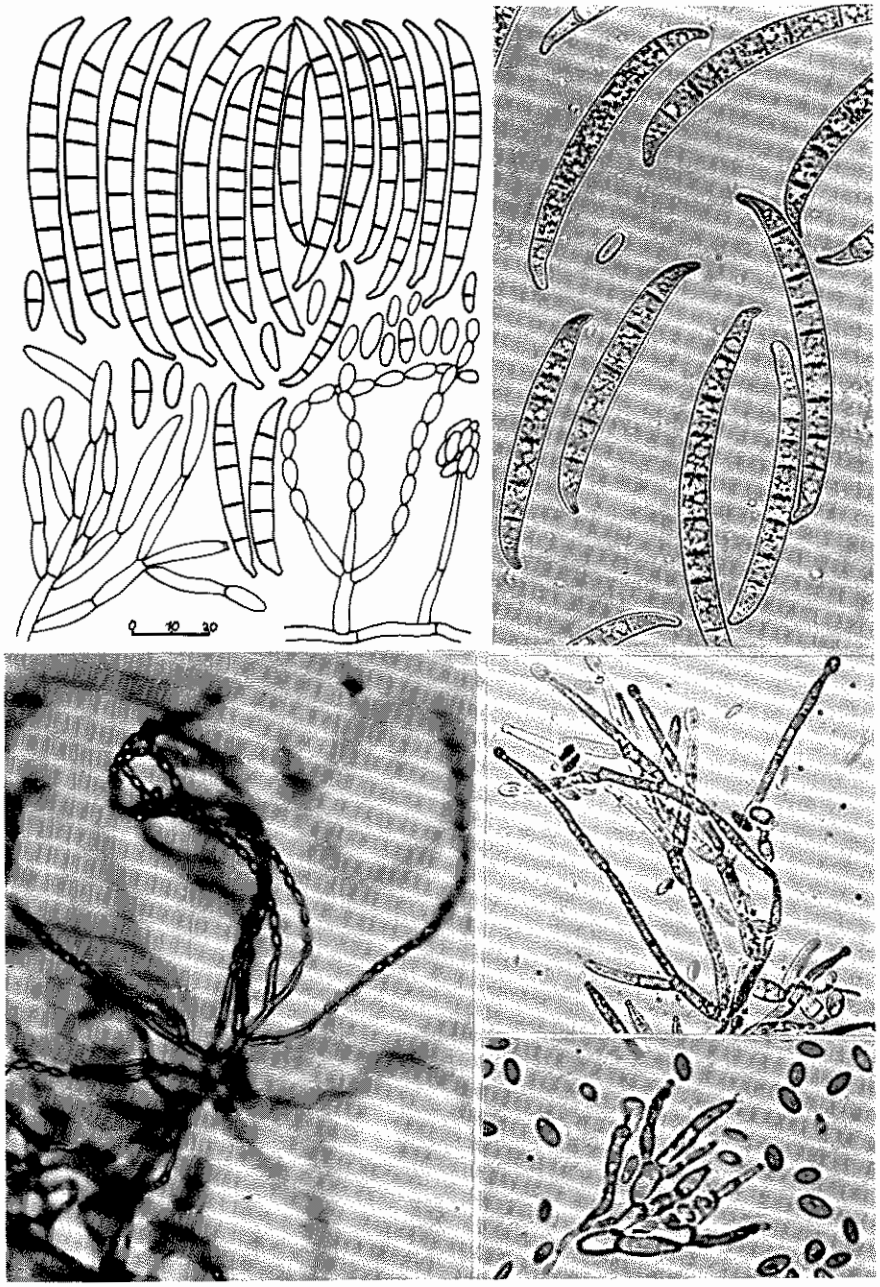

Fig. 19. Fusarium decemcellulare.

This Fusarium is rather common in tropical and subtropical regions and it is reported on host plants of about 15 different families. It occurs widely as a saprophyte or wound parasite of weakened trees, often following infection by Phytophthora spp. and injuries by insects or under unfavourable conditions, causing die-back and canker of branches, "green-point" cushion gall of buds, and pod rot of cacao, panel decay of Hevea rubber, stem canker of robusta coffee, stem rot of durian and blight of rice plants affecting also the grain (more detailed information is given by BOOTH & WATERSTON 1964a and BOOTH 1971a). F. decemcellulare is a well-known species and generally accepted as distinct. In addition to numerous strains studied, illustrated and deposited by WOLLENWEBER (1916-1935) 4 recently isolated cultures were available for comparison and 5 further strains are deposited in the CBS/Baarn.

Section SUBMICROCERA Wollenw. - Angew. Bot. 8: 182, 1926

Fusarium ciliatum Link - Species Plant. VI, 2: 105, 1825

Fusarium peltigerae Westend. - Herb. crypt. Belg., fasc. 9, no. 414, 1849

Fusarium microcera Bilai - Fusarii: 292, 1955 (pro parte)

Teleomorph: Calonectria decora (Wallr.) Sacc. - Michelia 1: 311, 1878

Descriptions: WOLLENWEBER (1916-1935 no. 54, 437, 438, 872, 1128), WOLLENWEBER & REINKING (1935), DOIDGE (1938), WOLLENWEBER (1943), GERLACH (1978), HAWKSWORTH (1979).

Macroscopic features are closely related to members of the Eupionnotes section, especially to F. aquaeductuum var. aquaeductuum and var. medium.

C o l o n i e s - slow-growing, reaching 2.4 - 2.7 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - usually sparse, sporadically more abundant, at first appearing floccose or loosely tufted, later forming a columnar, stilboid stroma.
Pigmentation - cream to pink, apricot or salmon.
Sclerotial bodies - lacking.
Sporulation - usually abundant, starting rather quickly as masses of conidia in typical sporodochia, sometimes produced on the top of the stalked stroma or in confluent pionnotal slimes, pink to orange, scarlet, fading to orange-rufous and rufous when dry.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides in the aerial mycelium, later richly but rather loosely branched, in sporodochia densely aggregated.
Phialides - monophialidic, thin-walled, rather irregular in shape, subcylindric and often slightly curved, mainly 15-30(8-40) x 2.0-3.5 µm.

C o n i d i a - in early stages some long, subcylindric 0- or 1-septate conidia, but no typical microconidia on distinct conidiogenous cells occur (HAWKSWORTH 1979), macroconidia extremely slender, delicate, falcate, straight or curved, tapering toward both ends, usually apedicellate, sometimes with a more or less subulate or rounded base, mostly 5- to 7-(3- to 7-)septate, seldom up to 10-septate or less than 3-septate, septae often obscure, measuring:

0-sept.	7 x 2.2		(4- 9 x 1.7-3.0) µm
1-sept.	14 x 2.3		(8- 34 x 2.0-3.0) µm
3-sept.	47 x 2.6	mostly 38-52 x 2.2-2.9	(20- 62 x 2.0-3.3) µm
4-5-sept.	58 x 2.5	mostly 42-65 x 2.2-3.0	(35- 90 x 1.8-3.5) µm
7-sept.	65 x 2.4		(45-105 x 1.8-3.0) µm
8-10-sept.			(90-130 x 1.8-2.8) µm.

HAWKSWORTH (1979) found in WESTENDORP's K isotype exsiccatum of no. 414 many conidia exceeding 80 µm which was given by WOLLENWEBER in Fus. autogr. delin. no. 872 as the maximum length of F. peltigerae.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 20:
Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 1128 of strain 4658; drawing of conidia, conidiophores and chlamydospores of strain 4658, according to WOLLENWEBER's drawings; photographs of conidia and conidiophores of strain 9661 on different substrates (x 500).

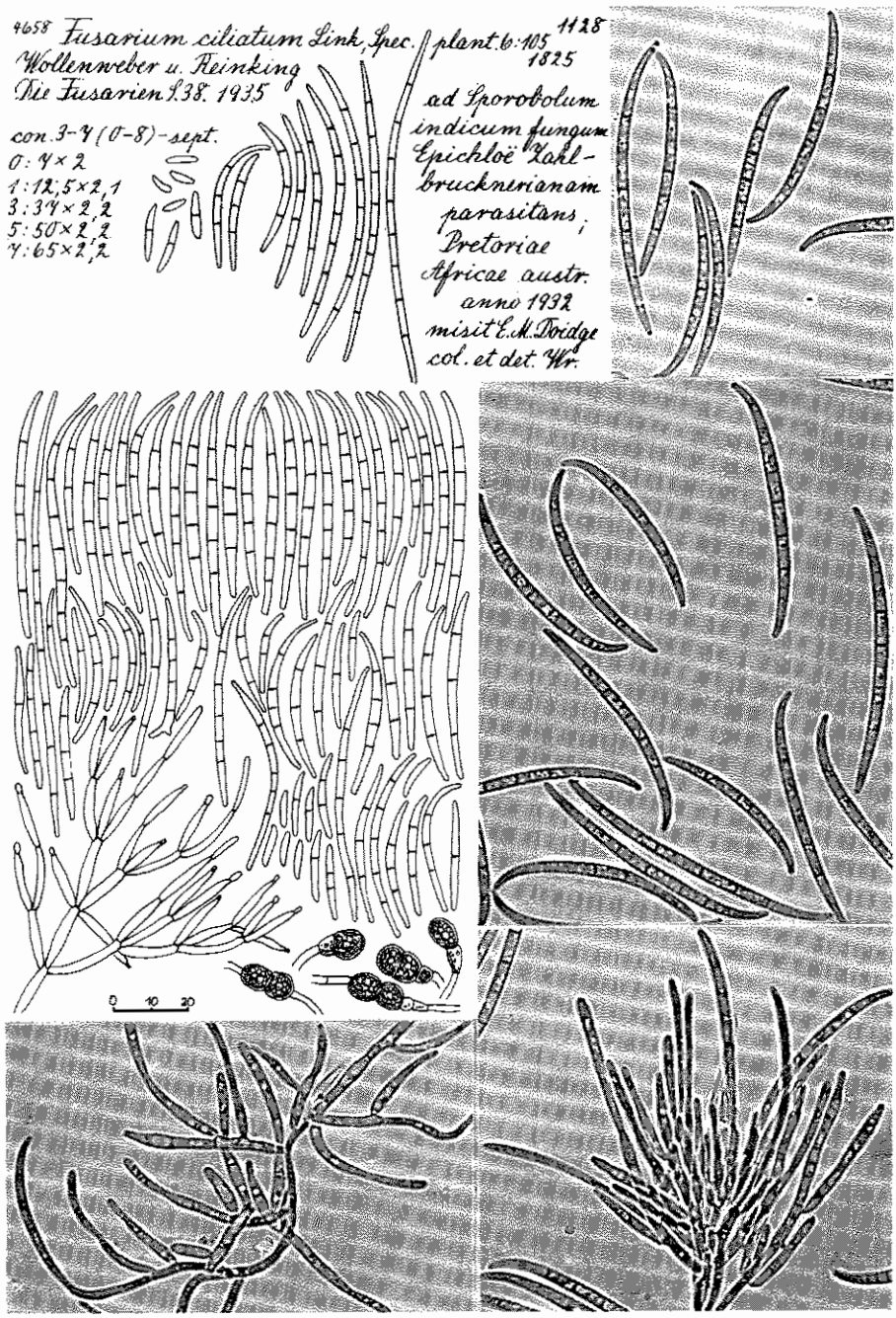

Fig. 20. Fusarium ciliatum.

F. ciliatum is found in Europe, North America and South Africa mainly on fungi (Massaria, Epichloë), decaying branches of several deciduous trees and lichens (Peltigera). There are no reliable reports of its association with plant diseases. On the basis of a number of examined herbarium specimens and a culture (4658) isolated from Epichloë zahlbruckneriana on Sporobolus indicus in 1932 (see Fig. 20), this Fusarium was recognized as a distinct species by WOLLENWEBER & REINKING (1935) and WOLLENWEBER (1943) and retained by DOIDGE (1938) and RAILLO (1950). BILAI (1955) regarded F. ciliatum (and F. juruanum) as synonymous with F. microcera Bilai. BOOTH (1971) who compared F. ciliatum with F. aquaeductuum came to no definite conclusion about the identity of either fungus. But according to HAWKSWORTH (1979) who examined F. peltigerae "there can be no doubt that this is a distinct species."
A strain (9661) isolated from a beech branch with Nectria canker in the Palatinate district of Germany in 1961 corresponds morphologically very well with F. ciliatum and is clearly different from F. aquaeductuum. This strain and WOLLENWEBER's culture 4658 are deposited in the CBS/ Baarn (191.65 and 132.35).
Calonectria decora considered to be its teleomorph by WOLLENWEBER (1943) was recently described in detail and illustrated by PIROZYNSKI (1975).

Fusarium cerasi Roll. & Ferry - Revue Mycol. 14: 170, 1892

F. cerasi was treated by RAILLO (1950) as a distinct species and by BILAI (1955) as a variety of F. microcera. BOOTH (1971a) assumed that this fungus is a Septoria. It was already excluded from Fusarium by WOLLENWEBER (1943, p. 123). It is probably identical with Micropera drupacearum Lév. the anamorph of Dermea cerasi (Pers. ex Mérat) Fr.

Section PSEUDOMICROCERA (Petch) Wollenw. - Angew. Bot. 8: 181, 1926

Fusarium coccidicola P. Henn. - Englers Bot. Jahrb. 34: 57, 1903

Fusarium juruanum P. Henn. - Hedwigia 43: 398, 1904

Fusarium microcera Bilai - Fusarii: 292, 1955 (pro parte)

Teleomorph: Calonectria diploa (Berk. & Curt.) Wollenw. - Angew. Bot. 8: 193, 1926

Descriptions: WOLLENWEBER (1916-1935 no. 162, 169, 196, 633-636, 809, 873-878), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), RAILLO (1950), GORDON (1956b), GERLACH & ERSHAD (1970), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE (1974).

C o l o n i e s - very slow-growing, reaching 1.3 - 1.5 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - usually rather sparse, sometimes partly covering the substrate, floccose to fasciculate, felt-like.
Pigmentation - whitish to pinkish, salmon, bright orange-red, occasionally somewhat carmine.
Sclerotial bodies - not formed.
Sporulation - scarcely in the aerial mycelium, mostly in numerous orange-coloured sporodochia, forming large groups, or in flat pionnotal layers.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising very rarely in the aerial mycelium as single lateral phialides, later irregularly or verticillately branched, densely, palisade-like aggregated in sporodochia or pionnotes.

Phialides - monophialidic, cylindric to subcylindric, rather long and slender, mostly 16-30 x 2.0-3.5 µm, usually with a distinct collarette.

C o n i d i a - occasionally some 0- or 1-septate conidia occur, macroconidia falcate to sublunate, gradually tapering toward both ends, often with a somewhat subulate or apiculate base, rarely pedicellate, generally 3- to 5-septate, septae often obscure, measuring:

3-sept.	68 x 3.5	mostly 60-73 x 3.2-3.8	(40- 85 x 2.5-4.5) µm
4-sept.	73 x 3.7	mostly 63-80 x 3.2-4.0	(51- 92 x 2.7-4.8) µm
5-sept.	87 x 3.8	mostly 75-98 x 3.2-4.4	(60-121 x 3.0-5.0) µm.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 21:
Drawing and photographs of conidia and conidiophores of strain 11137 (= CBS 735.79) on different substrates (x 500).

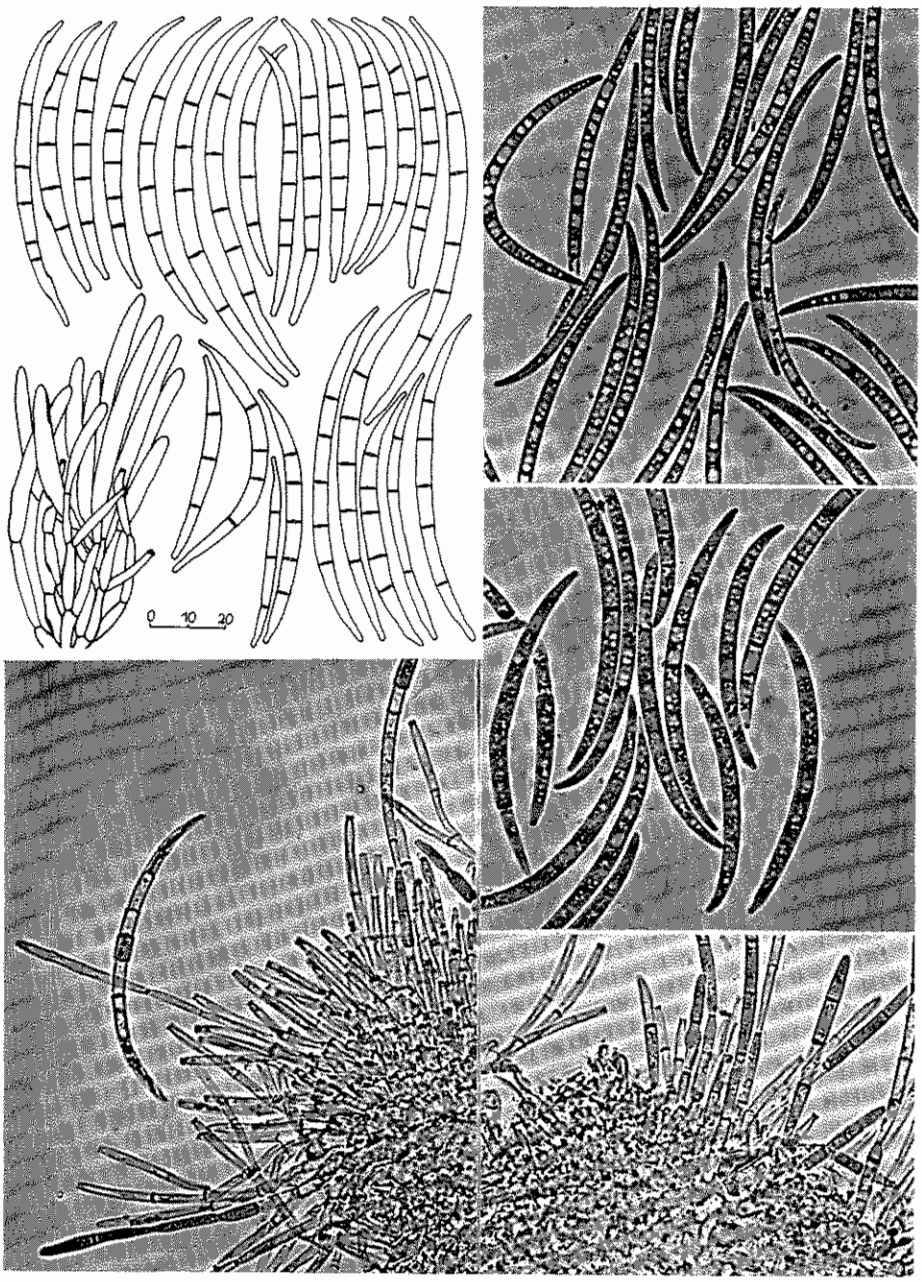

Fig. 21. Fusarium coccidicola.

F. coccidicola is rather common on various scale insects on leaves and branches of many plants, especially Citrus. It is reported from subtropical and tropical regions but not from Europe.
It is generally accepted as a clearly distinct species. Very abundant material was studied by WOLLENWEBER including 7 cultured strains one of which is available in the CBS/Baarn (133.35). In addition 3 very typical strains were recently isolated from Lepidosaphes spec. on Ficus carica and San José scale insects on Prunus domestica (11137 = CBS 735.79) in Iran.

Fusarium orthoconium Wollenw. - Fus. autogr. delin.: 637, ed. 2, 1926

Microcera orthospora Sydow - Ann. mycol. 22: 317, 1924

Fusarium microcera Bilai var. orthoconium (Wollenw.) Bilai - Fusarii: 293, 1955

Descriptions: WOLLENWEBER (1916-1935 no. 637), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), RAILLO (1950), BILAI (1955).

This Fusarium is a doubtful species represented by a single specimen found by ATKINSON on the bark of a living trunk of Nothofagus spec., York Bay, Wellington, New Zealand, in March, 1920 and described by H. SYDOW as Microcera orthospora in 1924. It was examined by WOLLENWEBER who transferred this fungus to Fusarium as F. orthoconium because the epithet orthosporum was already used in Fusarium by SACCARDO. The drawings and notes of WOLLENWEBER deposited in our institute provide no further information. Therefore, a translation of the diagnosis given by WOLLENWEBER and REINKING (1935) and WOLLENWEBER (1943) must suffice despite its incompleteness:

Sporodochia breaking through cracks of the bark are of different size, mostly 2 - 8 mm in diameter, hard, thick, intensely salmon or orange-red with a powdery somewhat twisted lobulate surface, about 2 mm thick. Sterile hyphae prostrate, cylindric-filaceous, up to 200 x 2-4 µm, hyaline, thick-walled, unbranched or sparsely branched. Conidiophores branched, generally short, 15-40 x 1.0-1.5 µm. Conidia hyaline, straight or slightly curved, cylindric-fusiform, tapering toward both ends, obscurely 3- to 4-(to 5-)septate, 42-68 x 3.0-4.0 µm, not constricted, with a conical apical cell and a conical obtuse, rarely apiculate basal cell.

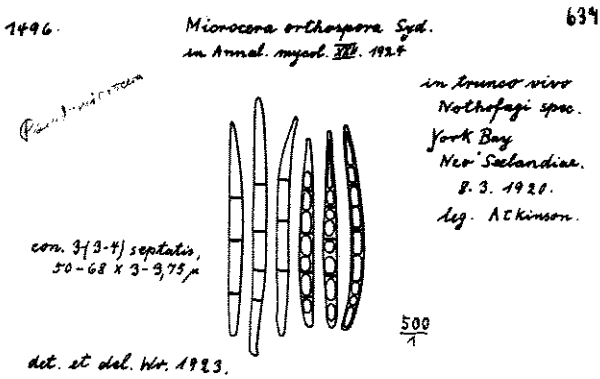

Fig. 22. Fusarium orthoconium.
Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 637 (ed. 1) of the type specimen 1496.

Section ARACHNITES Wollenw. - Ann. mycol. 15: 2, 1917

Fusarium kuehnii (Fuckel) Sacc. - Syll. Fung. 4: 714, 1886

Fusisporium kuehnii Fuckel - Symb. mycol.: 371, 1869

Fusisporium devastans Kühn - Krankh. Culturgew. (Berlin): 32, 1858 (nom. inval.)

Descriptions: WOLLENWEBER (1916-1935 no. 67-70), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), RAILLO (1950), BILAI (1955).

The taxonomic position of this fungus is doubtful. Obviously, F. kuehnii has never been cultured and also WOLLENWEBER's short description is based on exsiccata, except for one sample (W-198) which he found living on the bark of Ulmus campestris in Berlin-Dahlem in 1916 (Fus. autogr. delin. no. 70):

Mycelium whitish to pale cream, cobweb-like, effused, consisting of slender branched hyphae, at length dissolving; conidia scattered in hyphal flocks, sometimes forming clay-coloured sporodochia, barely visible to the naked eye, more or less lunate, 1-septate, 9 x 2.2 mostly 8-10 x 2.0-2.6 (7-14 x 1.5-4.0) µm. Chlamydospores not observed.

It was reported from Europe mainly on the bark of trunks of various deciduous trees (Acer, Aesculus, Populus, Ulmus) covering lichens and mosses, frequently associated with Corticium centrifugum.

HAWKSWORTH (1979), in discussing Fusisporium kuehnii noted: "KÜHN (1858: 32) described the damage this fungus caused to lichens but provided no description himself and for this reason a new name was introduced for the taxon by FUCKEL. No material of KÜHN's appears to be extant and, as in introducing the name Fusisporium kuehnii FUCKEL also cited his own exsiccata, that is designated as the lectotype for this epithet here. The isolectotypes examined comprise either Physcia adscendens or Xanthoria parietina, or both these species, overgrown by white funiculose hyphae which are sterile. The superficial appearance of the material suggests that the species may be Athelia arachnoidea (Berk.) Jül., as was also proposed by KEISSLER (1930: 524), but in the absence of sclerotia and

basidia some doubt must remain".

If this fungus is really a Fusarium it may be equated with F. dimerum (sensu lato) as was proposed by BOOTH (1971a).

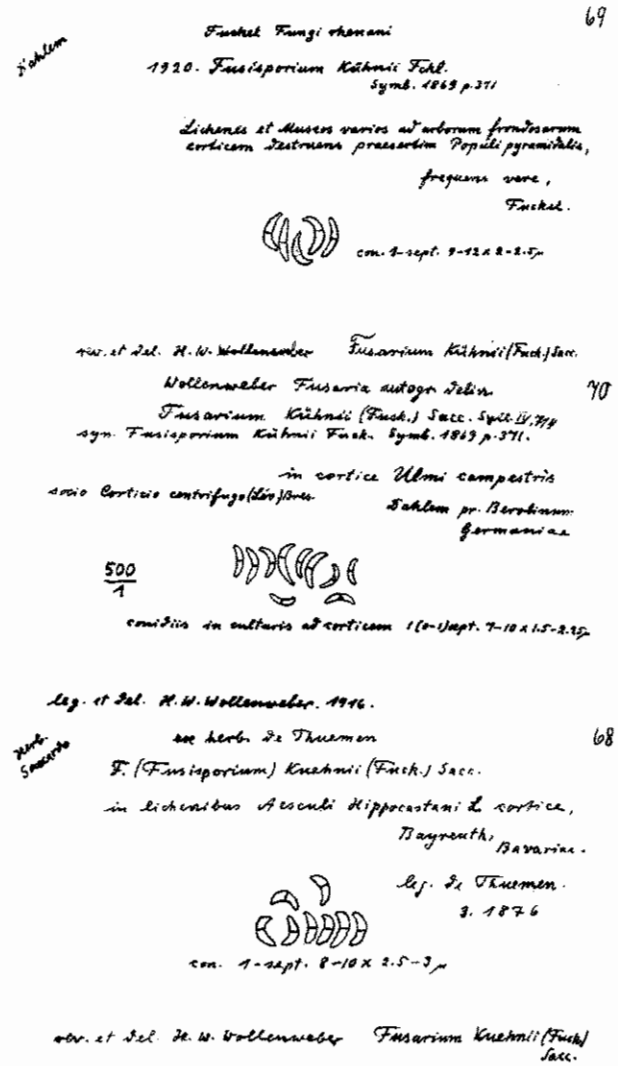

Fig. 23. Fusarium kuehnii.

Reproductions of WOLLENWEBER's Fus. autogr. delin. no. 68, 69, 70.

Fusarium larvarum Fuckel - Symb. mycol.: 369, 1869 var. larvarum

Fusarium nivale (Fr.) Ces. var. larvarum (Fuckel) Bilai - Fusarii: 295, 1955

Teleomorph: Nectria aurantiicola Berk.& Br. - J. Linn. Soc. 14: 117, 1873

Descriptions: WOLLENWEBER (1916-1935 no. 223-225, 576, 879, 1129), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), RAILLO (1950), BILAI (1955), GERLACH & ERSHAD (1970), BOOTH (1971a), JOFFE (1974), GERLACH (1977c).

C o l o n i e s - slow-growing, reaching 2.2 - 2.5 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - whitish, delicate, floccose to filaceous-fasciculate, most abundant around sporodochia, sparser toward the margin of the colony.
Pigmentation - cream, yellowish pink to bright yolk-yellow, older cultures becoming amber to brownish.
Sclerotial bodies - absent.
Sporulation - at first scarcely in the aerial mycelium, later small, droplet-like, globose, orange sporodochia develop and are scattered over the surface of the substrate.
Odour - not perceptible.

C o n i d i o p h o r e s - arising in the aerial mycelium laterally on hyphae as single phialides, in sporodochial layers fasciculate, palisade-like aggregated, sparsely branched, mostly irregularly, seldom verticillately.

Phialides - monophialidic, single or in groups of 2-3, cylindric to subulate, rather long and slender, mostly 12-20(8-25) x 2.5-3.0 (2.0-3.3) µm, often with a collarette.

C o n i d i a - very uniform in size, allantoid to vaguely falcate, sublunate, with a pointed apex and a commonly not very marked foot-cell, 1- to 3-(exceptionally 4- to 5-)septate, measuring:

1-sept.	16 x 3.1	mostly 14-18 x 2.8-3.3	(10-24 x 2.5-3.5) µm
3-sept.	22 x 3.3	mostly 18-28 x 3.0-3.5	(14-32 x 2.5-4.5) µm
4-5-sept.	30 x 4.0		(24-36 x 3.0-5.2) µm.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 24:

Drawing and photographs of conidia and conidiophores of strain 62239 (= CBS 738.79) on different substrates (x 500).

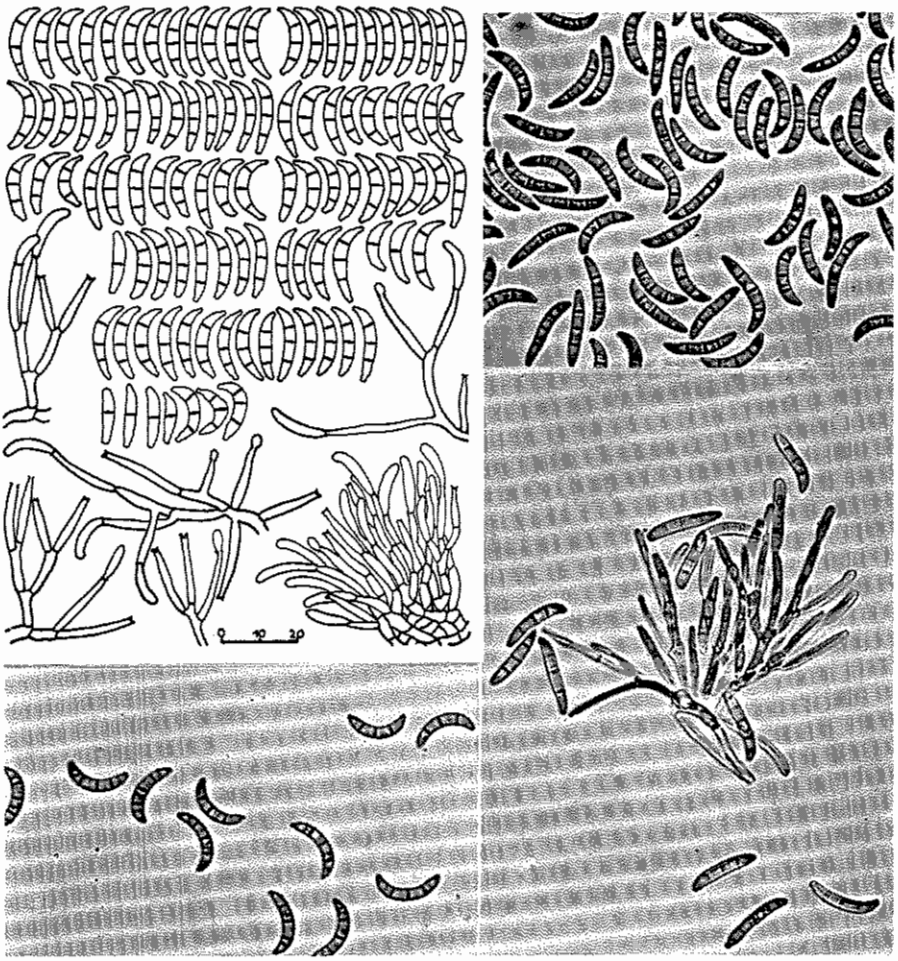

Fig. 24. Fusarium larvarum var. larvarum.

This Fusarium generally accepted as distinct occurs predominantly as a parasite of scale insects on many kinds of woody plants in warmer, especially subtropical and tropical regions, often in association with other entomogenous fungi.

In addition to 5 specimens and 2 cultured strains examined and deposited by WOLLENWEBER, a very typical freshly isolated strain could be used for detailed studies. This culture (62239 = 11138) isolated in 1968 from a San José scale insect on a living branch of Prunus domestica in Iran is available in the CBS/Baarn (738.79) as well as 2 further strains deposited by WOLLENWEBER (169.30) and GORDON (158.57).

Fusarium larvarum Fuckel var. rubrum Gerlach - Phytopath. Z. 90: 38, 1977

Descriptions: GERLACH & ERSHAD (1970, pp. 738-9, as Fusarium spec. ?nov.), GERLACH (1977c).

C o l o n i e s - slow-growing, reaching 2.2 - 2.6 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - generally sparse, appressed, felt-like to floccose, sporadically abundant and tufted.
Pigmentation - rose-red, carmine, purple to vinaceous, often with a brownish tinge, never pale or intensely yellow as in F. larvarum var. larvarum.
Sclerotial bodies - sometimes present, very small, of different size, mostly covered by the aerial mycelium.
Sporulation - generally scarce, at first only a few conidia formed in the aerial mycelium, later small, globose, orange sporodochia occur only sporadically.
Odour - not perceptible.

C o n i d i o p h o r e s - almost of the same variability as in var. larvarum.
Phialides - generally somewhat shorter and wider and more often slightly inflated in the centre or toward the base than in var. larvarum, mostly with a collarette.

C o n i d i a - very uniform in size, similar to var. larvarum but by and large somewhat wider and more curved, especially in the apical part, and often with a marked pedicellate base, mostly 3-septate, measuring:

1-sept.			(8-21 x 2.8-3.5) µm
3-sept.	25 x 3.8	mostly 22-30 x 3.0-4.5	(13-35 x 2.8-5.0) µm.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 25:

Drawing and photographs of conidia and conidiophores of the type culture 62460 (= CBS 638.76) on different substrates (x 500).

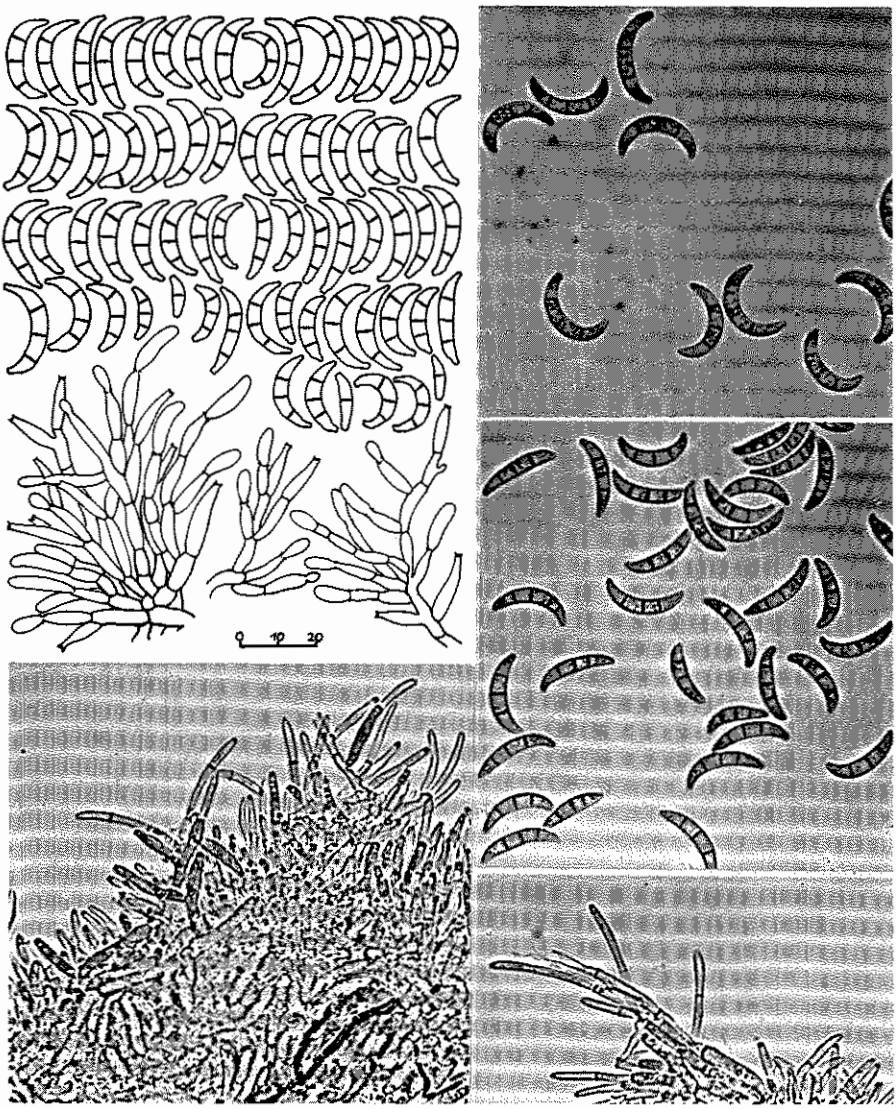

Fig. 25. Fusarium larvarum var. rubrum.

This Fusarium was described as distinct from F. larvarum var. larvarum mainly because of the striking difference in colour regarding its aerial mycelium, stroma and soluable pigmentation on several substrates used for culture. It is represented by the type strain 62460 (= CBS 638.76) only which was isolated in 1968 from a San José scale insect on a living branch of Prunus domestica in Iran.

Fusarium nivale Ces. ex Sacc. - Syll. Fung., Suppl. 1-4: 390, 1886
var. nivale

Teleomorph: Monographella nivalis (Schaffnit) E. Müller - Rev. Mycol. 41: 132, 1977 var. nivalis

Calonectria nivalis Schaffnit - Mykol. Zentralbl. 2: 257, 1913

Griphosphaeria nivalis (Schaffnit) E. Müller & v. Arx - Phytopath. Z. 24: 356, 1955

Micronectriella nivalis (Schaffnit) C. Booth - The Genus Fusarium: 42, 1971

Calonectria graminicola (Berk. & Br.) sensu Wollenw. - Phytopathology 3: 34, 1913 (non Nectria graminicola Berk. & Br. - Ann. Mag. nat. Hist. 3. ser. 3: 376, 1859)

Descriptions: WOLLENWEBER (1916-1935 no. 51-53, 71-74, 88, 523, 524, 545, 880, 881), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), JAMALAINEN (1943), GORDON (1952), BOOTH (1971a, 1971 b), SUBRAMANIAN (1971), JOFFE (1974), MÜLLER (1977), GAMS & MÜLLER (1980), DOMSCH et al. (1980), NIRENBERG (1981).

Colonies - fast-growing, reaching 7.2 - 8.0 cm diam. in 8 days at 25°C on PDA (but see DOMSCH et al. 1980).

Aerial mycelium - more or less sparse, cobweb-like, loose to fasciculate, densely floccose or felt-like.

Pigmentation - whitish, pale pink, peach, apricot to amber.

Sclerotial bodies - absent.

Sporulation - under daylight or near-UV light after about 7-10 days abundant in small, slimy, pale orange sporodochia which may become cinnamon-brown if drying up or in powdery masses, predominantly at the margin of the colony.

Odour - not perceptible.

C o n i d i o p h o r e s - arising laterally as single annelides or sparsely branched on hyphae, becoming densely aggregated in mature sporodochia.
Conidiogenous cells - are not phialides, but annelides, generally short, subcylindric, doliiform to obpyriform, 6-15 x 2.2-4.0 µm, showing a percurrently elongating annellated apical zone, particularly distinctly visible under SEM (GAMS & MÜLLER 1980).

C o n i d i a - only one type formed, falcate, slightly to strongly curved, tapering toward each end, usually with a pointed apex and a somewhat wedge-shaped, obtuse to rounded base, not pedicellate, mostly 1-(0- to 3-, exceptionally 4- to 7-)septate, measuring:

0-sept.	10 x 2.4	mostly 8-12 x 2.0-2.8	(5-18 x 2.0-4.0) µm
1-sept.	16 x 2.8	mostly 13-18 x 2.4-3.0	(9-23 x 2.2-4.5) µm
2-3-sept.	23 x 3.0	mostly 19-27 x 2.8-3.8	(13-36 x 2.3-4.5) µm
4-7-sept.	25 x 3.3		(19-34 x 2.5-4.2) µm.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 26:
Drawing and photographs of conidia and conidiophores of strains 62051 (Agrostis), 62279 (Poa), 63245 (Triticum) and 63322 (Lolium) on different substrates (x 500).

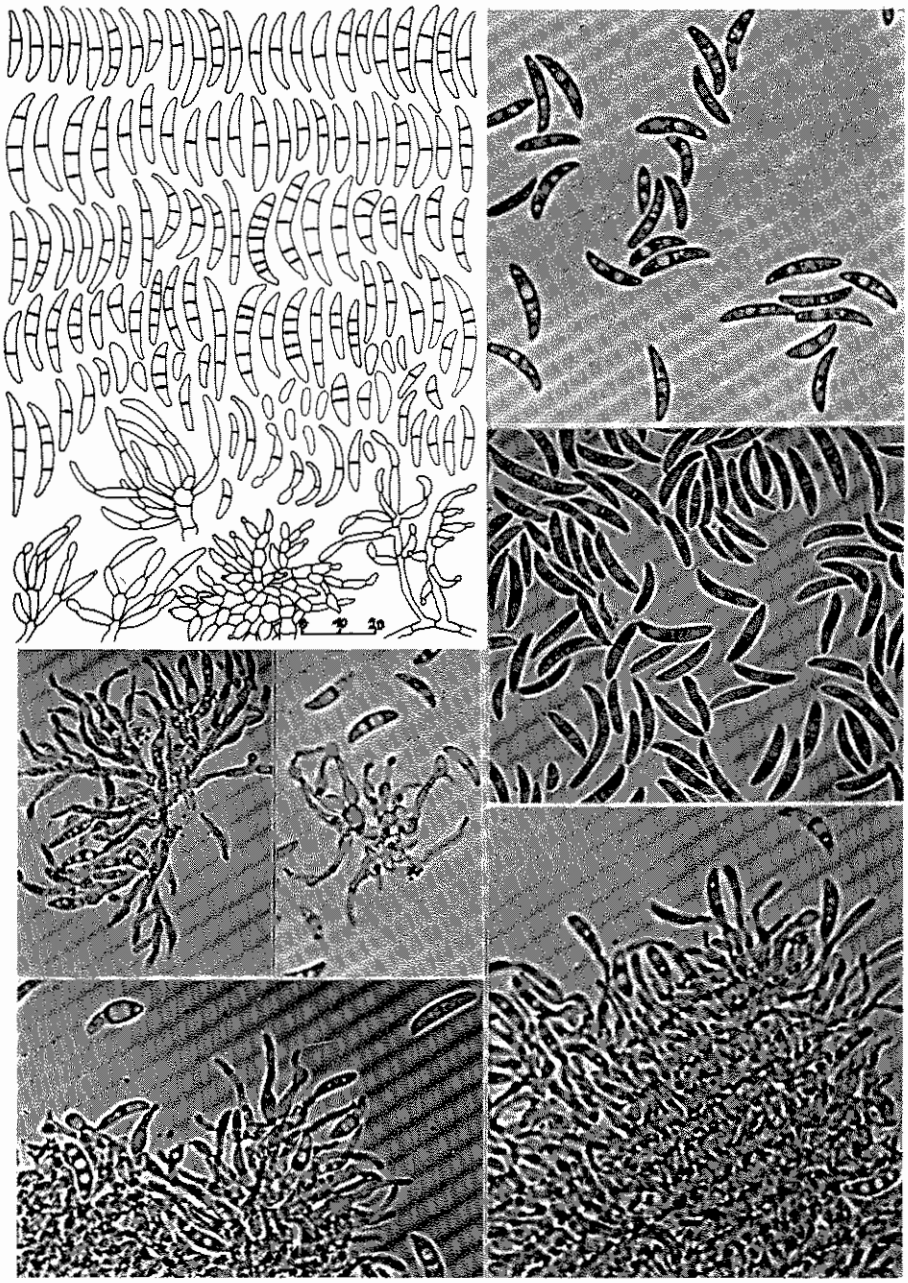

Fig. 26. Fusarium nivale var. nivale.

This fungus is well-known as a major pathogen ("snow mould") of cereals and grasses, especially in cold to temperate regions of the northern hemisphere, but also in Australia and New Zealand; records from the tropics are doubtful. It causes pre-emergence blight, root rot, culm rot, head blight, leaf blight and sometimes total losses of winter-sown wheat and rye (more detailed information and literature are given by BOOTH 1971a, 1971b and DOMSCH et al. 1980).

Some 40 strains isolated from numerous cereals and grasses from different European countries were studied during the past years. Representative strains available in the CBS/Baarn are 146.68, 162.77, 112.78, 113.78, 319.78 and 320.78 according to GAMS & MÜLLER (1980). They correctly segregated F. nivale from Fusarium because of its annellate (not phialidic) conidiogenous cells and its amphisphaeriaceous (not hypocreaceous) teleomorph and assigned it to a new genus, Gerlachia, as G. nivalis (Ces. ex Sacc.) W. Gams. & E. Müll. var. nivalis.

Fusarium nivale Ces. ex Sacc. var. majus Wollenw. - Fus. autogr. delin.: 882, 1930

Teleomorph: Monographella nivalis (Schaffnit) E. Müller var. neglecta (Krampe) W. Gams & E. Müller - Neth. J. Pl. Path. 86: 49, 1980

Calonectria graminicola (Berk. & Br.) sensu Wollenw. var. neglecta Krampe - Angew. Bot. 8: 252, 1926

Descriptions: WOLLENWEBER (1916-1935 no. 808, 882), KRAMPE (1926), WOLLENWEBER (1926, 1931), WOLLENWEBER & REINKING (1935), GAMS & MÜLLER (1980), NIRENBERG (1981).

There are no conspicuous differences between F. nivale var. majus and var. nivale either in growth rate, macroscopic features of the colonies, conidiophores and conidiogenous cells or in ecology. F. nivale var. majus is, however, clearly distinguished by much wider, predominantly 3-(1- to 7-, very rarely 8- to 10-)septate conidia, measuring:

1-2-sept.	18 x 5.3	mostly 15-25 x 4.2-6.0	(12-30 x 3.8-7.5) µm
3-sept.	26 x 5.3	mostly 22-32 x 4.5-5.5	(18-37 x 3.5-6.5) µm
4-5-sept.	31 x 5.5	mostly 28-33 x 4.8-6.0	(19-40 x 4.5-7.0) µm
6-10-sept.	29 x 5.7		(22-40 x 4.8-6.7) µm.

Some 20 strains recently isolated from wheat and rye grass were studied. Representative cultures deposited in the CBS/Baarn are 177.29, 256.61, 111.78, 741.79, all isolated from wheat.
Together with F. nivale var. nivale (and Rhynchosporium oryzae Hashioka & Ikegami) this variety was assigned to the genus Gerlachia as G. nivalis (Ces. ex Sacc.) W. Gams & E. Müll. var. major (Wollenw.) W. Gams & E. Müll. (1980).

Fusarium nivale (Fr.) Ces. var. oryzae Zambettakis - Rev. Mycol., Suppl. colon. 2: 110, 1950

Descriptions: ZAMBETTAKIS (1950), SACCAS (1950).

This fungus was published without Latin diagnosis and it is unknown in culture to BOOTH (1971a) and to us. It was recorded from Equatorial-Africa on panicles of rice. Because of its conidia, somewhat longer than those of F. nivale var. majus, it was described as a distinct variety. The drawings and description given by ZAMBETTAKIS (1950) suggest that it might be F. semitectum and we agree with BOOTH (1971b) that tropical records of F. nivale, especially those on rice, need further confirmations.

Fusarium stoveri C. Booth - The Genus Fusarium: 37-38, 1971

Teleomorph: Micronectriella stoveri C. Booth - Mycol. Pap. 94: 3, 1964

Descriptions: BOOTH (1964, 1971a).

No cultured strain of this extremely slow-growing fungus was available from BOOTH. It was suggested to be a weak parasite on banana leaves and was recorded from Honduras, Fiji and New Calednonia. BOOTH (1971a) described it as follows: "Growth rate 0.3 cm. Ascospores and conidia germinate readily but growth is slow and it should be noted that they are extremely sensitive to acid. On slightly acidified potato sucrose

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Explanation of Figure 27:
Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 882 of the type culture 1661; drawing and photographs of conidia and conidiophores of strains 62281 (Triticum), 62282 (Lolium) and 63244 (Triticum) on different substrates (x 500).

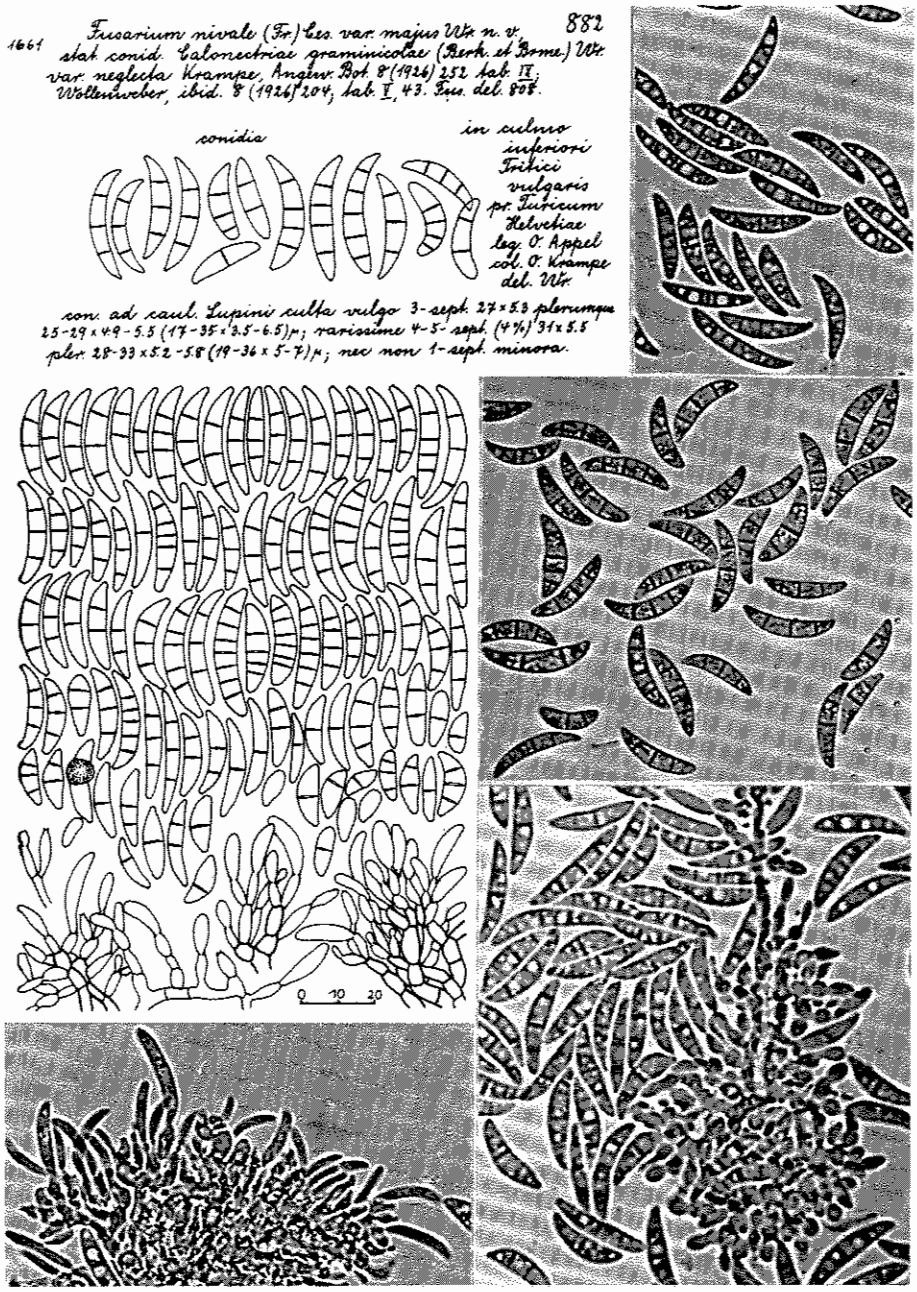

Fig. 27. Fusarium nivale var. majus.

agar growth was abnormal and the colony measured 1 cm diam. after 3 weeks at 21°C. The surface was strongly orange coloured and deeply convoluted. No conidia were formed and the hyphae were distorted by frequent globose swellings.

Growth was more natural and conidial shape more normal on V8 juice medium at pH 6.5-7. The surface of the agar was covered in 7 days with a pionnotes-like growth, deep orange in colour and of slimy appearance but with a sparse, salmon-white, floccose mycelial growth round the edge.

No true microconidia developed, but macroconidia formed in large numbers and when mature measured 30-52 x 3-5 µm. They are cylindrical to allantoid, 1-3-septate, with rounded or pointed ends and usually with a distinct basal foot cell. In older cultures the conidia are more fusoid and distinctly septate".

While the manuscript was being prepared for publication a culture of F. stoveri (82.239 = 64268) isolated from banana leaves from The Cook Islands was sent to us by G. I. SAMUELS / New Zealand. We share his opinion that this fungus does not belong to the genus Fusarium since its conidiogeneous cells are not phialidic.

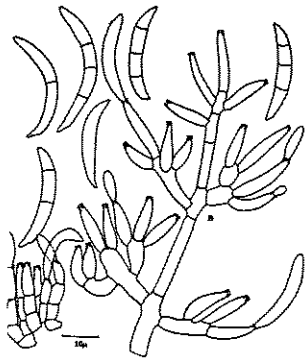

Fig. 28. Fusarium stoveri.
Partial reproduction of Figure 3 by BOOTH (1971a) (x 500).

Section SPOROTRICHIELLA Wollenw. in Lewis - Bull. Maine agric. Exp. Stn 219: 256, 1913

Monograph by SEEMÜLLER (1968).

Fusarium poae (Peck) Wollenw. in Lewis - Bull. Maine agric. Exp. Stn 219: 254-258, 1913

Fusarium sporotrichiella Bilai var. poae (Peck) Bilai - Fusarii: 277, 1955 (pro parte)

Descriptions: LEWIS (1913), WOLLENWEBER (1916-1935 no. 110, 554, 885, 1130), WOLLENWEBER (1917), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), JAMALAINEN (1943b), GORDON (1952), SEEMÜLLER (1968), SUBRAMANIAN (1971), BOOTH (1971a, 1971c), JOFFE (1974), HORNOK (1975), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - very fast-growing, reaching 7.5 - 8.0 cm diam. in 4 days at 25°C on PDA.

Aerial mycelium - abundant, loose and fluffy, in older cultures pannose, mostly whitish, less often pale pink.

Pigmentation - some strains whitish cream, flesh to peach, others carmine, wine-red, sometimes pale violet tones appear, however, ochre and brown colours very seldom occur.

Sclerotial bodies - absent.

Sporulation - starting after one week in the aerial mycelium as microconidia cohering in false heads, giving the culture a powdery appearance, now and then cream sporodochia or pionnotes appear on the agar surface, producing mainly microconidia, sometimes a few subdeveloped macroconidia are interspersed.

Odour - in young cultures characteristically fruity, peach-like, in older ones repulsively sweetish.

C o n i d i o p h o r e s - primary conidiophores arising laterally from hyphae in the aerial mycelium, at first unbranched, becoming loosely branched to densely branched later; transition to secondary conidiophores not clearly discernible being indistinguishable from the former. Phialides - always monophialidic with a comparably distinct collarette, mostly short and inflated, 6-18 µm long and 3-6 µm wide.

C o n i d i a - microconidia mostly napiform, seldom pyriform, apiculate, predominantly 1-celled, sometimes 1-septate; macroconidia produced rarely on high nutrient media, on low nutrient media under near-UV irridiation formed more often, falcate but mostly straight, with many vacuoles, mainly 3-septate, measuring:

0-sept.	7 x 6.4	mostly 6-10 x 5.5-7.4	(5-16 x 4.0-9.0) µm
1-sept.	13 x 5.7	mostly 9-17 x 4.6-7.4	(8-21 x 3.5-9.9) µm
2-3-sept.	24 x 5.1		(13-38 x 3.6-8.0) µm
4-5-sept.	39 x 5.4		(26-56 x 4.0-7.0) µm.

C h l a m y d o s p o r e s - true chlamydospores not observed, but in older cultures inflated cells with thickened walls and granulated plasma occur.

Explanation of Figure 29:
Drawing and photographs of conidia, conidiophores and chlamydospore-like cells of strains 10317 and 10426 (= CBS 446.67) on different substrates (x 500).

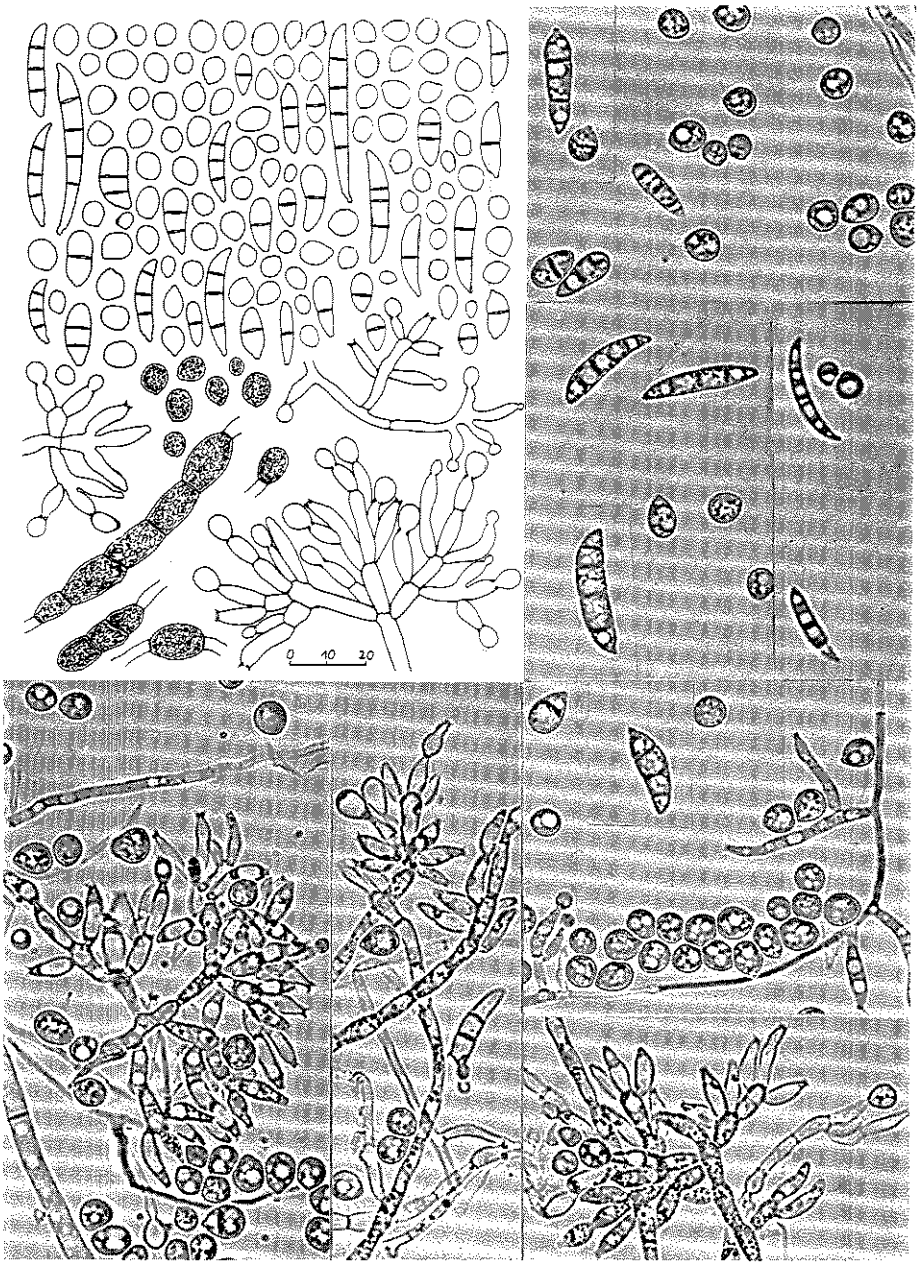

Fig. 29. Fusarium poae.

F. poae is characterized by very fast-growing colonies producing mainly napiform conidiogenous cells. The conidiogenous locus is surrounded by a distinct collarette and the fungus produces a strong odour in culture.

It is associated in nature very often with the mite, Siteroptes graminum, which feeds on F. poae and contributes to its distribution. F. poae is isolated especially from all parts of grasses, cereals, fruits and from soils all over the world. It is weakly pathogenic to maize, carnations and fruits. For further information in morphology and biology confer SEEMÜLLER (1968).

Fusarium chlamydosporum Wollenw. & Reinking - Phytopathology 15: 156, 1925 var. chlamydosporum

Fusarium sporotrichioides Sherb. subsp. minus (Wollenw.) Raillo - Fungi of the Genus Fusarium (Moscow): 196, 1950 (pro parte)

Fusarium sporotrichiella Bilai var. sporotrichioides (Sherb.) Bilai - Fusarii: 277, 1955 (pro parte)

Fusarium fusarioides (Frag. & Cif.) C. Booth - The Genus Fusarium: 88, 1971

Pseudofusarium purpureum Matsushima - Microfungi of the Solomon Islands and Papua - New Guinea (Osaka): 47, 1971

Fusarium sporotrichioides Sherb. var. chlamydosporum (Wollenw. & Reinking) Joffe - Mycopath. Mycol. Appl. 53: 211, 1974

Descriptions: WOLLENWEBER (1916-1935 no. 883), WOLLENWEBER & REINKING (1925), REINKING & WOLLENWEBER (1927), WOLLENWEBER & REINKING (1935), DOIDGE (1938), WOLLENWEBER (1943), SEEMÜLLER (1968), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE (1974), HORNOK (1975), GERLACH (1977c), DOMSCH et al. (1980).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 8 days at 25°C on PDA.

Aerial mycelium - abundant, loosely to densely floccose, felt-like, somewhat powdery at the surface, whitish, rose to bright pink.

Pigmentation - flesh, pink, carmine, wine-red to brown-red.

Sclerotial bodies - in young cultures very seldom and atypic as plectenchymatic cushions, in old cultures occasionally as small blackish knots present.

Sporulation - starting after 4 days in the aerial mycelium as microconidia, singly, giving the culture a powdery appearance; sporodochia or sporodochial layers are built on oatmeal agar only under near-UV light, flesh, orange to ochraceous.

Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally from hyphae in the aerial mycelium, at first unbranched, becoming loosely branched later; secondary conidiophores loosely to densely branched. Conidiogenous cells - those of primary conidiophores polyblastic with up to 10 conidiogenous loci, often proliferating (8-18 x 2.0-3.0 µm); those of secondary conidiophores always monophialidic (10-16 x 2.0-3.0 µm).

C o n i d i a - microconidia always ovoid to fusoid, mostly 1-celled but also 1- to 3-septate; macroconidia falcate, slightly bent, widest in the upper third, tapering toward both ends, with a short, somewhat hooked apical cell and a not markedly pedicellate basal cell, mostly 3-septate, but also some 5-septate may occur, measuring:

0-sept.	9 x 2.8	mostly 9-10 x 2.4-3.0	(5-14 x 1.9-4.2) µm
1-sept.	14 x 3.3	mostly 12-15 x 3.0-3.7	(9-17 x 2.8-4.2) µm
3-sept.	32 x 3.5	mostly 30-34 x 3.0-3.9	(21-41 x 2.4-4.5) µm
4-5-sept.	38 x 4.0	mostly 36-38 x 3.4-4.2	(25-47 x 3.2-4.5) µm.

C h l a m y d o s p o r e s - abundant, globose to subglobose, smooth-walled to verrucose, terminal or intercalary in hyphae, single (7-17 µm), in pairs, chains or clusters, in old cultures brownish coloured.

Explanation of Figure 30:

Drawing and photographs of conidia, conidiophores, chlamydospores and hyphal swellings of strains 10357 (= CBS 445.67 = IMI 96270) and 62170 on different substrates (x 500).

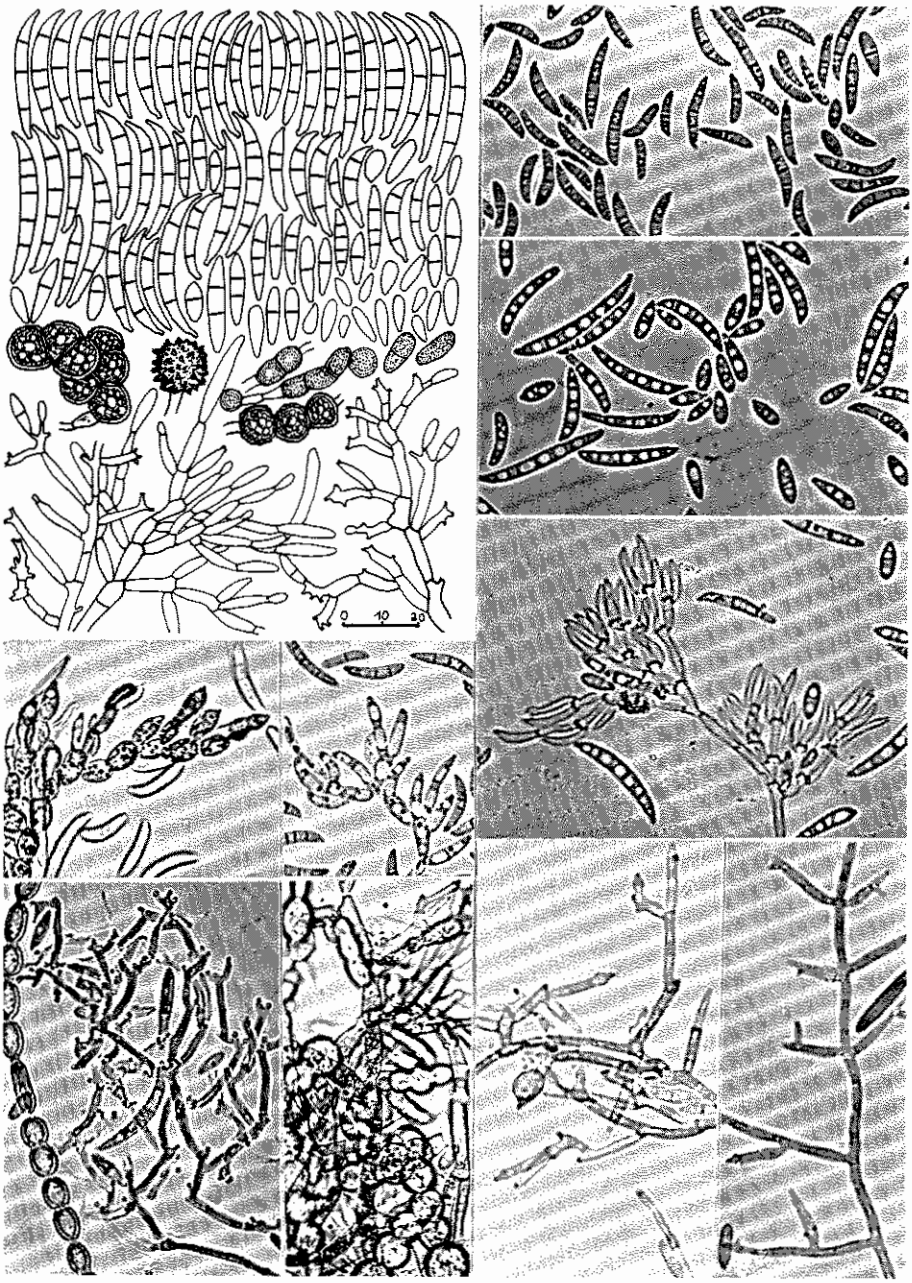

Fig. 30. Fusarium chlamydosporum var. chlamydosporum.

WOLLENWEBER & REINKING (1925) typified this Fusarium with strain R 38 isolated from the crown of a banana plant in Honduras. There is no reason to declare F. chlamydosporum a nomen confusum as done by BOOTH (1971a) (cf. also DOMSCH et al. 1980). It is characterized by pink to carmine pigments in the substrate mycelium on wort agar or PDA, by ovoid microconidia borne singly on polyblastic cells and never forming sporodochia without near-UV irridiation. This fungus occurs worldwide and is isolated from soils and the rhizosphere of many plants (DOMSCH et al. 1980). It might be considered a saprophyte, though a moderate pathogenicity was established in infection tests by SEEMÜLLER (1968) toward pea seedlings.

Fusarium chlamydosporum Wollenw. & Reinking var. fuscum Gerlach - Phytopath. Z. 90: 41, 1977

Description: GERLACH (1977c).

This variety differs from F. chlamydosporum var. chlamydosporum only in its pigmentation which is always beige to coffee brown but never red. The 3 existing strains (62053 = CBS 635.76, 63347 and 63612) were isolated in South Africa from Cynodon lemfuensis and in Australia from Pennisetum clandestinum and from soil. Its suspected association with a blight of P. clandestinum has not yet been established.

Explanation of Figure 31:

Drawing and photographs of conidia, conidiophores and chlamydospores of the type culture 62053 (= CBS 635.76) and strains 63347 and 63612 on different substrates (x 500).

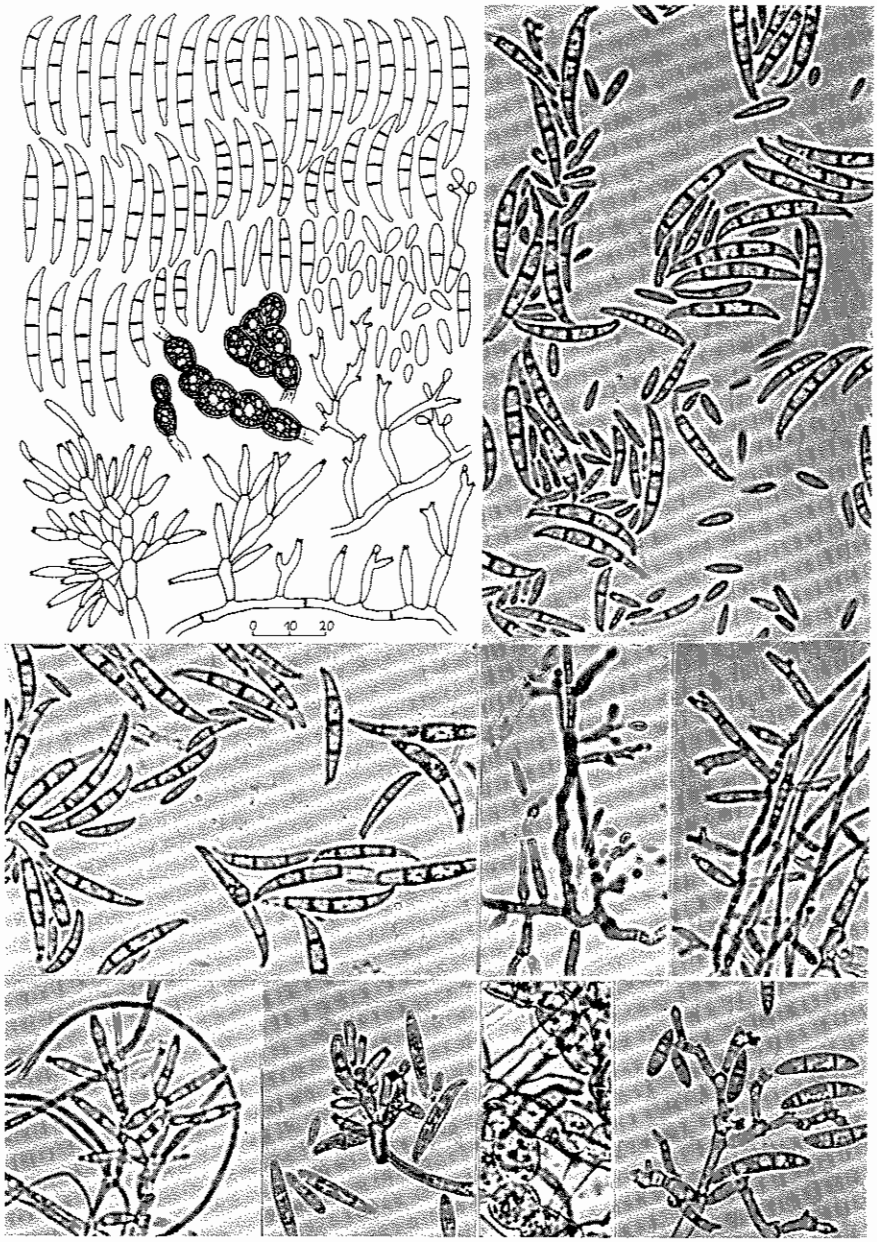

Fig. 31. Fusarium chlamydosporum var. fuscum.

Fusarium tricinctum (Corda) Sacc. - Syll. Fung. 4: 700, 1886

Fusarium citriforme Jamalainen - Valt. Maatalouskoet. Julk. 123: 11, 1943

Fusarium sporotrichioides Sherb. var. tricinctum (Corda) Raillo - Fungi of the Genus Fusarium (Moscow): 197, 1950

Fusarium sporotrichiella Bilai var. tricinctum (Corda) Bilai - Fusarii: 278, 1955

Descriptions: WOLLENWEBER (1916-1935 no. 122-126, 555-558, 1131), WOLLENWEBER & REINKING (1935), BENNETT (1935), WOLLENWEBER (1943), JAMALAINEN (1943b), SEEMÜLLER (1968), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE (1974), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - moderately fast-growing, reaching 4.5 - 6.0 cm diam. in 10 days at 25°C on PDA.

Aerial mycelium - abundant, densely cottony, growing somewhat retarded and uneven, giving the culture a cushion-like appearance, growing margin more or less irregularly lobed, intensively carmine, wine-red to purple, occasionally also white or ochre.

Pigmentation - intensively carmine, wine-red or dark red, on rice pap cream to peach.

Sclerotial bodies - regularly and abundantly built, round to cauliflower shaped, often cream to ochre, but also wine-red, brown, blue-grey to black.

Sporulation - starting after one week in the aerial mycelium as microconidia cohering in false heads, giving the culture a powdery appearance, sometimes also borne in sporodochia or pionnotes; sporodochia which bear macroconidia are seldom formed before 6 weeks and are of orange to flesh colour, but on low nutrient media under near-UV irridiation they are formed within 1 week.

Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally from hyphae in the aerial mycelium or on the agar surface, at first unbranched, later loosely branched, consisting of long and slender cells giving them an elegant appearance; secondary conidiophores more densely branched. Phialides - always monophialidic, conidiogenous locus of primary conidiophores surrounded by a distinct collarette, cylindric, comparatively long and slender, 10-30 x 1.6-2.5 µm, those of sporodochia usually shorter, measuring 10-16 x 2.3-3.4 µm.

C o n i d i a - microconidia napiform, pyriform and very often citriform, mostly 1-celled, seldom 1-septate; macroconidia are quite slender, falcate even lunate, widest in the centre and tapering evenly to each end, apical and basal cell almost equally long, the latter usually distinctly pedicellate, typically 3- to 5-septate, measuring:

0-sept. p.	9 x 5.7	mostly 8-11 x 4.6-7.5	(4-14 x 3.6-9.0) µm
1-sept.	16 x 3.2	mostly 11-21 x 2.8-3.8	(8-27 x 2.0-4.5) µm
3-sept.	32 x 3.7	mostly 24-46 x 3.2-4.1	(19-58 x 2.9-5.0) µm
5-sept.	40 x 4.0	mostly 33-50 x 3.6-4.6	(25-60 x 3.1-5.0) µm.

p. = pyriform

C h l a m y d o s p o r e s - only occasionally formed, they are built mostly intercalary in hyphae, less often terminal, in chains or clusters, 7-18 µm wide.

Explanation of Figure 32:

Drawing and photographs of conidia, conidiophores and chlamydospores of strains 10390, 10458 (= CBS 449.67) and 11332 on different substrates (x 500).

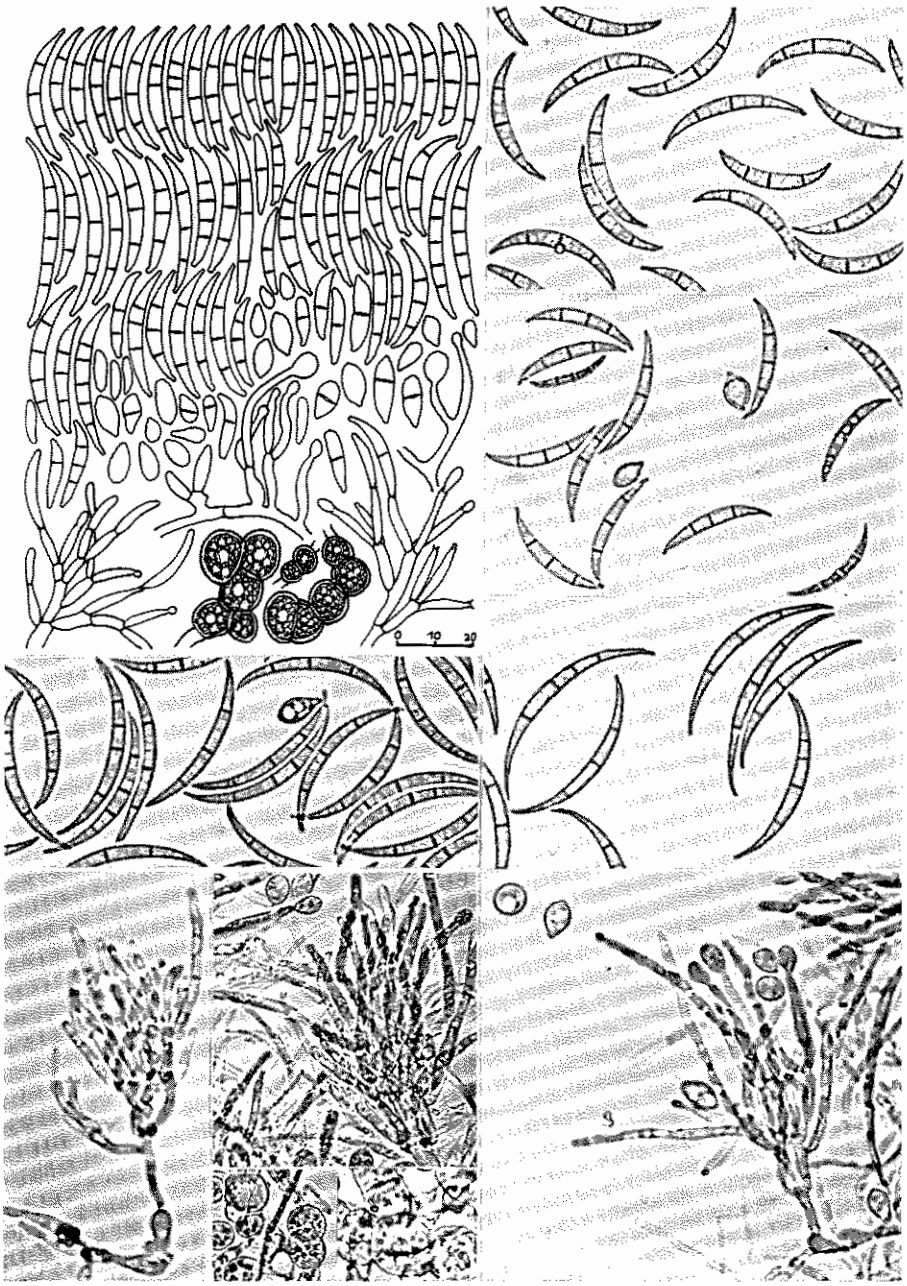

Fig. 32. Fusarium tricinctum.

F. tricinctum is distinguished from other Fusarium species forming pyriform microconidia, by its retarded growth, its monophialidic, slender, comparatively long conidiogenous cells of its primary conidiophores and its almost lunate macroconidia if borne in sporodochia.

This fungus is isolated especially from soils, cereals, grasses, potatoes and numerous other plants from all over the world. In infection tests it was found to be highly pathogenic to wheat seedlings (root rot) and carnations (bud rot). It is less pathogenic to maize (halm rot), lupine (root rot) and apples (fruit rot) (SEEMÜLLER 1968). His monograph provides further details on F. tricinctum regarding taxonomic and biological aspects.

Fusarium sporotrichioides Sherb. - Mem. Cornell Univ. agric. Exp. Stn 6: 183, 1915 var. sporotrichioides

Fusarium sporotrichiella Bilai var. sporotrichioides (Sherb.) Bilai - Fusarii: 277, 1955

Descriptions: SHERBAKOFF (1915), WOLLENWEBER (1916-1935 no. 111, 884, 887-889), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), JAMALAINEN (1943b), GORDON (1952), SEEMÜLLER (1968), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE (1974), HORNOK (1975), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - very fast-growing, reaching 7.5 - 8.0 cm diam. in 4 days at 25°C on PDA.
Aerial mycelium - abundant, loose, lanuginose, at first whitish, later yellowish, pinkish to reddish brown if discoloured by the substrate mycelium.
Pigmentation - at first whitish to rose, later carmine, wine-red to reddish brown, sometimes purple or even violet tinges appear, on rice pap characteristically dark ochre.
Sclerotial bodies - occur regularly on most substrates, oval or of irregular shape, dark red to dark brown.
Sporulation - starting quickly in the aerial mycelium as microconidia, single or cohering in false heads; sporodochia appear not at all or rarely, but under near-UV light they are formed regularly, flesh, ochre to orange.
Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally from hyphae in the aerial mycelium, at first unbranched, becoming irregularly or verticillately branched, rami arranged loosely to densely; secondary conidiophores densely branched.

Conidiogenous cells - those of primary conidiophores blastic and polyblastic with 2 to 5 conidiogenous loci (8-20 x 2.4-4.0 µm), proliferating, under near-UV light also phialidic (12-30 x 2.4-3.6 µm); those of secondary conidiophores monophialidic only (10-18 x 2.4-4.2 µm).

C o n i d i a - microconidia of 2 types, either napiform to pyriform, apiculate, predominantly 1-celled, sometimes 1-septate, or ovoid, fusoid to slightly falcate, apiculate to indistinctly pedicellate 0- to 3-septate; macroconidia falcate, mostly slightly curved, widest in the upper third, tapering toward both ends, with a comparatively short and strongly bent apical cell and an often indistinct foot cell, 3- to 5-septate, measuring:

0-sept. p.	8 x 6.1	mostly 6- 9 x 5.3-7.1	(5-12 x 4.0-9.5) µm
1-sept. p.	11 x 6.3	mostly 9-14 x 5.1-7.1	(7-19 x 4.0-9.7) µm
0-sept. f.	10 x 3.2	mostly 8-11 x 3.0-3.6	(5-14 x 2.0-4.2) µm
1-sept. f.	14 x 3.7	mostly 13-16 x 3.2-4.2	(6-26 x 2.2-4.8) µm
3-sept. f.	30 x 4.3	mostly 21-34 x 3.6-5.0	(17-49 x 3.0-6.4) µm
3-sept.	32 x 4.1	mostly 29-36 x 3.7-4.8	(21-48 x 3.0-5.5) µm
5-sept.	43 x 4.6	mostly 40-46 x 4.1-5.3	(32-58 x 3.8-6.0) µm.

p. = pyriform
f. = fusoid

C h l a m y d o s p o r e s - abundantly formed in hyphae, intercalary, seldom terminal, single (7-15 µm), globose to subglobose, ochraceous to brownish.

Explanation of Figure 33:
Drawing and photographs of conidia, conidiophores and chlamydospores of strains 8145, 10329 and 10362 (= CBS 447.67) on different substrates (x 500).

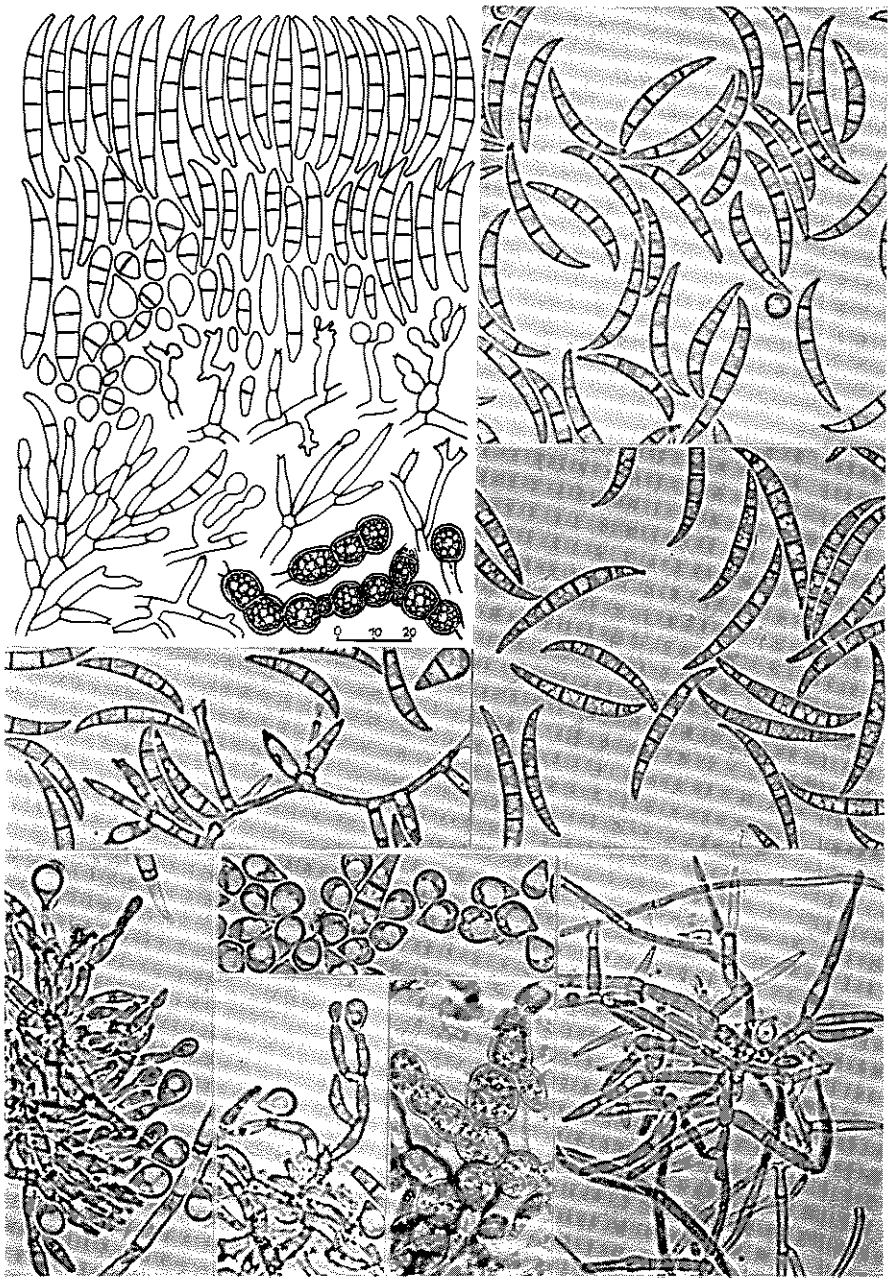

Fig. 33. Fusarium sporotrichioides var. sporotrichioides.

This variety produces two types of conidia in the aerial mycelium: one pyriform the other fusoid to subfalcate. They are borne on blastic cells with one conidiogenous locus or more, but also on phialides. The type of conidiogenous cell formed is apparently influenced by the substrate, light and temperature. F. sporotrichioides var. sporotrichioides is furthermore characterized by rarely producing sporodochia but abundantly producing chains or clusters of chlamydospores. On the basis of its blastic conidiogenous cells BOOTH (1971a) transferred this fungus from the Sporotrichiella section to the Arthrosporiella section (sensu BOOTH).

F. sporotrichioides occurs worldwide and is found in soils and on plant material. SEEMÜLLER (1968) described this Fusarium as polyphag, being highly pathogenic to conifers, peas, lupines, carnations and apples though somewhat less to wheat and maize. If humans, other mammals or birds eat heavily infested grains they may become crippled or even die because of the mycotoxines produced by this fungus. For further information confer SEEMÜLLER (1968) and DOMSCH et al. (1980).

Fusarium sporotrichioides Sherb. var. minus Wollenw. - Fus. autogr. delin.: 886, 1930

Fusarium sporotrichioides Sherb. subsp. minus (Wollenw.) Raillo - Fungi of the Genus Fusarium (Moscow): 196, 1950 (pro parte)

Descriptions: WOLLENWEBER (1916-1935 no. 886), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), SEEMÜLLER (1968).

C o l o n i e s - very fast-growing, reaching 7.5 - 8.0 cm diam. in 6 days at 25°C on PDA.

F. sporotrichioides var. minus differs from F. sporotrichioides var. sporotrichioides by a less luxuriously developed aerial mycelium, tinged whitish to pink, never yellowish or intensively red, by the lack of sclerotial bodies and sporodochia and by somewhat thicker conidia of the aerial mycelium. Regarding its pathogenicity it is also similar to F. sporotrichioides var. sporotrichioides but less aggressive (cf. SEEMÜLLER 1968). The fusion or separation of these two fungi depends upon the observer's point of view as is the case with F. semitectum var. semitectum and var. majus.

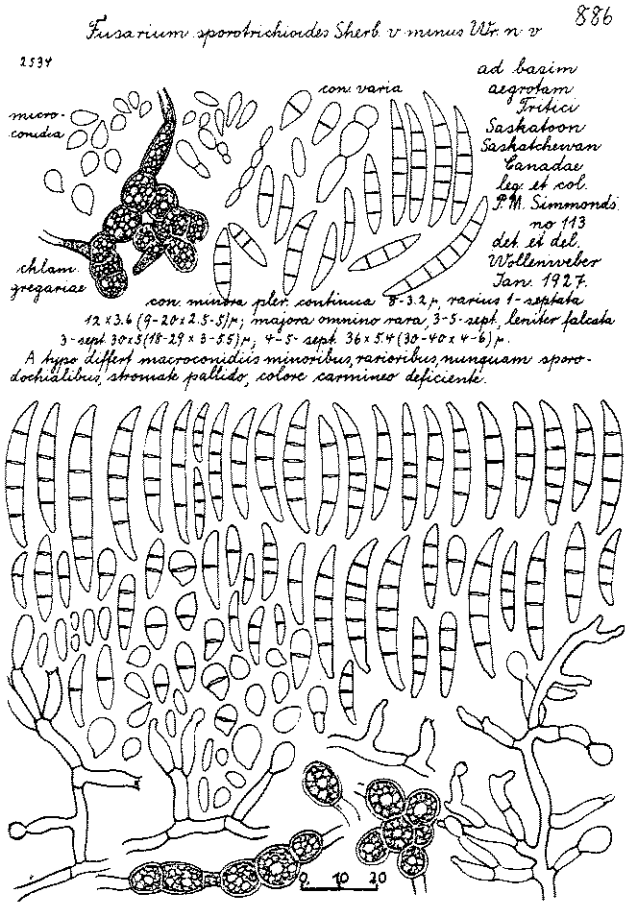

Fig. 34. Fusarium sporotrichioides var. minus. Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 886 of the type culture 2534; drawing of micro- und macroconidia, conidiophores and chlamydospores of strains 10339 and 10360 (= CBS 448.67) (x 500).

Section ROSEUM Wollenw. - Phytopathology 3: 32, 1913

Fusarium graminum Corda - Icon. Fung. 1: 3, 1837

Fusarium corallinum Sacc. - Nuovo G. bot. ital. 8: 196, 1876

Fusarium paspali P. Henn. - Engl. Jahrb. 38: 129, 1905

Fusarium paspalicola P. Henn. - Monsunia 1: 38, 1899

Fusarium heterosporum Nees ex Fr. var. paspalicola (P. Henn.) Wollenw. - Z. Parasitenk. 3: 349, 1931

Descriptions: WOLLENWEBER (1916-1935 no. 129, 132, 137, 138, 150, 157, 298, 299, 891, 1134), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), GERLACH & ERSHAD (1970), GERLACH (1978).

C o l o n i e s - fast-growing, reaching 7.8 - 8.2 cm diam. in 8 days at 25°C on PDA.

Aerial mycelium - rather abundant, floccose to felt-like, tufted.

Pigmentation - whitish, flesh, pale rose to peach, yellowish, finally ochraceous to sometimes reddish-brown; intensively red, violet and bluish pigmentation absent.

Sclerotial bodies - usually lacking, sometimes small, flat, pale buff sclerotial stromata present.

Sporulation - very scarce in the aerial mycelium, generally masses of conidia develop after some days in bright orange, salmon to coral-red, comparatively compact sporodochia or in expanded pionnotal layers which become crusty and darker when drying.

Odour - not perceptible.

C o n i d i o p h o r e s - initially arising as single lateral phialides on hyphae, later loosely irregularly or verticillately branched, each branch terminating in 1-3 phialides, densely aggregated in sporodochia or pionnotes.
Phialides - monophialidic, cylindric to subcylindric, generally rather slender and short, mostly 10-15 (8-20) x 2.5-3.5 (2.0-4.5) µm.

C o n i d i a - very variable in size, in most samples falcate but almost straight, slender with a nearly cylindric or slightly inequilaterally curved middle part, an elongated, narrowing, often distinctly constricted apical cell and a distinctly pedicellate basal cell, in other samples conidia more compact, fusoid to lanceolate with a somewhat swollen middle part and shorter apical cell, predominantly 3-septate, rarely 0- to 2-septate, sometimes with a high percentage of 4- or 5-septate conidia, measuring:

0-sept.	11 x 3.0	mostly 8-13 x 2.5-4.0	(5-17 x 2.0-5.0) µm
1-sept.	19 x 3.2	mostly 15-23 x 2.5-4.0	(11-25 x 2.0-5.0) µm
3-sept.	33 x 3.2	mostly 28-40 x 2.5-4.5	(20-53 x 2.0-5.5) µm
4-5-sept.	45 x 3.7	mostly 40-52 x 3.0-4.5	(32-70 x 2.5-5.8) µm.

C h l a m y d o s p o r e s - not observed.

Explanation of Figure 35:
Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 891 of strain 2097; drawing and photographs of conidia and conidiophores of strains 62224 (= 11113) and 62228 (= CBS 737.79) on different substrates (x 500).

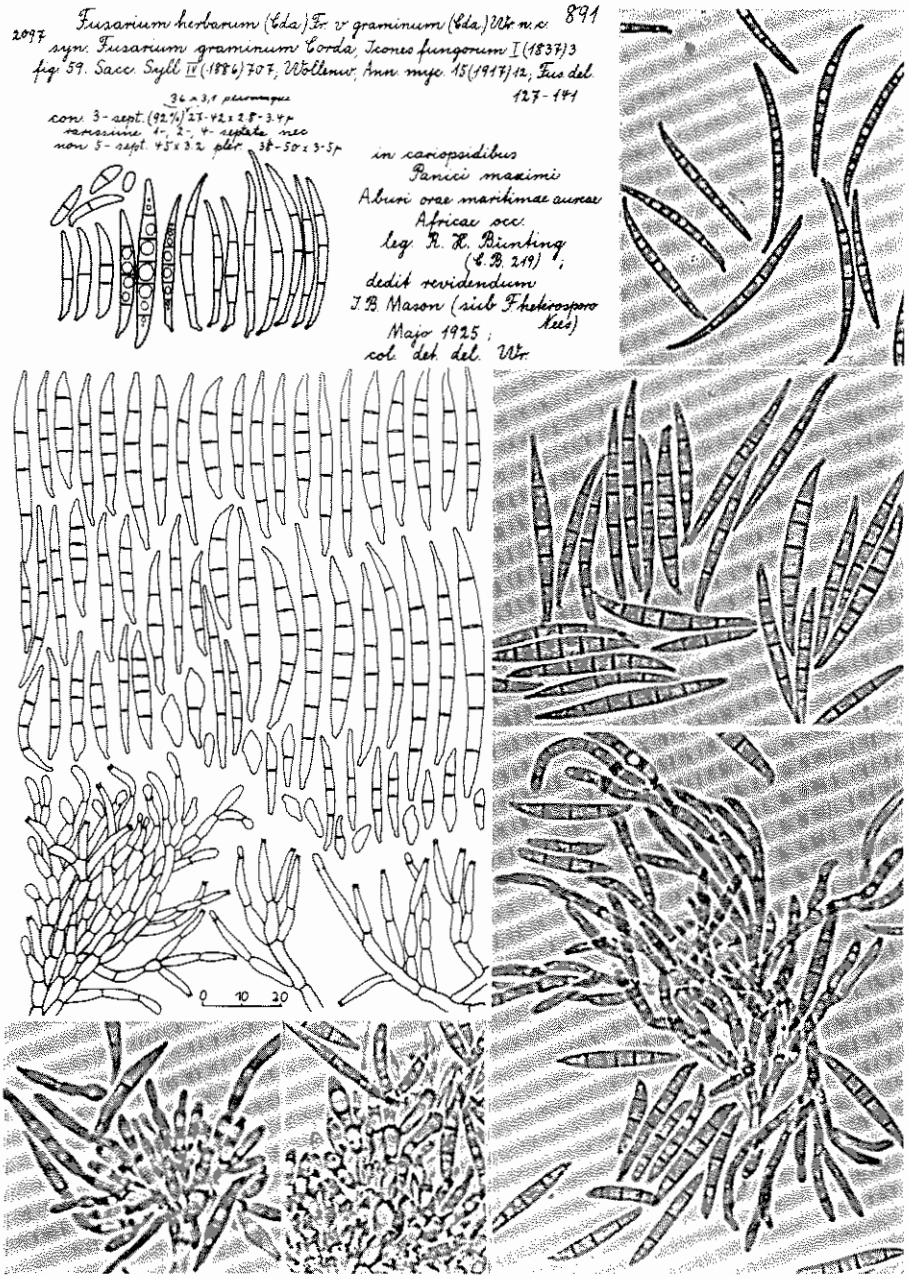

Fig. 35. Fusarium graminum.

This Fusarium was first treated by WOLLENWEBER (1930, Fus. autogr. delin. no. 891) as a variety of F. herbarum, but later as a distinct species (WOLLENWEBER & REINKING 1935, WOLLENWEBER 1943). DOIDGE (1938), BUGNICOURT (1939) and JOFFE (1974) did not mention the fungus. Probably without having examined herbarium specimens or studied cultured strains, RAILLO (1950) called it F. avenaceum var. graminum. For BILAI (1955) it was synonymous with F. avenaceum var. herbarum. GORDON (1952) and SUBRAMANIAN (1971) considered this Fusarium identical with F. avenaceum, BOOTH (1971a), however, with F. heterosporum.

F. graminum should be accepted as a separate species distinct from F. avenaceum (f. 1) as well as from F. heterosporum. This contention is based on a re-examination of WOLLENWEBER's drawings and notes deposited in our institute and on studies of 10 cultured strains during the past years. Seven strains were isolated in Iran in 1968, occurring very abundantly on the inflorescences of Paspalum dilatatum (GERLACH & ERSHAD 1970), 1 strain (62228 = CBS 737.79) was found on Cynodon dactylon in Ethiopia and 2 strains (R 2100, R 2230) isolated by L. BURGESS from Paspalum dilatatum in Queensland/Australia were sent to us for comparison by P. NELSON/Pennsylvania in 1976. All of them are identical in macroscopic and microscopic features and correspond with those herbarium specimens and cultured strains which were identified by WOLLENWEBER as F. graminum. But furthermore they correspond with some others he designated as F. heterosporum var. paspalicola or F. avenaceum (f. 1) (Fus. autogr. delin. no. 132, 150, 157, 298, 299, 1134). It seems that F. graminum is to be found only on gramineous plants, predominantly on inflorescences infected with ergot or on ergot itself and especially in warmer regions.

Fusarium avenaceum (Fr.) Sacc. - Syll. Fung. 4: 713, 1886
var. avenaceum

Teleomorph: Gibberella avenacea R.J. Cook - Phytopathology 57: 735, 1967

Descriptions: WOLLENWEBER (1916-1935 no. 127, 128, 130-136, 139-161, 163, 164, 178-184, 186-194, 560-568, 572-574, 892, 894-899, 1132, 1133), WOLLENWEBER & REINKING (1935), DOIDGE (1938), WOLLENWEBER (1943), JAMALAINEN (1943b), GORDON (1952), SCHNEIDER (1958a), SCHNEIDER (1958b), BOOTH & WATERSTON (1964b), COOK (1967), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE (1974), HORNOK (1975), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - moderately fast-growing, reaching 5.0 - 8.0 cm diam. in 10 days at 25°C on PDA, considerable differences between strains, degenerating rapidly by subculturing; culture variants either merely pionnotal, then reddish without aerial mycelium, or with whitish aerial mycelium, arranged in radiating strands, sterile.
Aerial mycelium - abundant, loosely fluffy to cottony, whitish with a dash of rose.
Pigmentation - cream, pink, rose to carmine with yellowish to ochre tinges, becoming red-brown to brown with age.
Sclerotial bodies - present, small, but usually characteristically cauliflower-like erumpent, beige, bluish black or black.
Sporulation - on high nutrient media starting after 4 to 6 weeks as bright orange sporodochia on sclerotial bodies, on low nutrient media also as conidia in the aerial mycelium, which are borne singly or in false heads.
Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally in the aerial mycelium, sparsely and irregularly branching; secondary conidiophores richly and densely branched.
Conidiogenous cells - those of primary conidiophores blastic or phialidic, sometimes sympodially proliferating, very rarely with 2 conidiogenous loci, subcylindric, slender (12-30 x 2.2-3.8 µm), those of secondary conidiophores phialidic, also slender, but somewhat shorter (12-21 x 2.0-3.0 µm).

C o n i d i a - those of primary conidiophores ovoid to fusoid, comparatively plump, mostly 0- to 3-septate, occasionally 5-septate; those of secondary conidiophores falcate, sometimes only slightly bent, sometimes strongly curved, slender, widest in the upper third, with an elongated, elegantly curved, acuminate apical cell and a distinct pedicellate basal cell, mostly 5-septate but occasionally also 7-septate, measuring:

1-sept. f.	20 x 3.1	mostly 18-22 x 2.8-3.2	(12-26 x 2.2-4.0) µm
3-sept. f.	28 x 4.3	mostly 25-30 x 4.0-4.2	(22-44 x 3.8-5.0) µm
3-sept.	46 x 3.6	mostly 45-50 x 3.2-3.8	(34-66 x 2.2-4.3) µm
5-sept.	58 x 3.4	mostly 48-65 x 3.0-4.0	(31-98 x 2.0-5.5) µm.

f. = fusoid

C h l a m y d o s p o r e s - absent.

Explanation of Figure 36:
Drawing and photographs of different strains on different substrates (x 500).

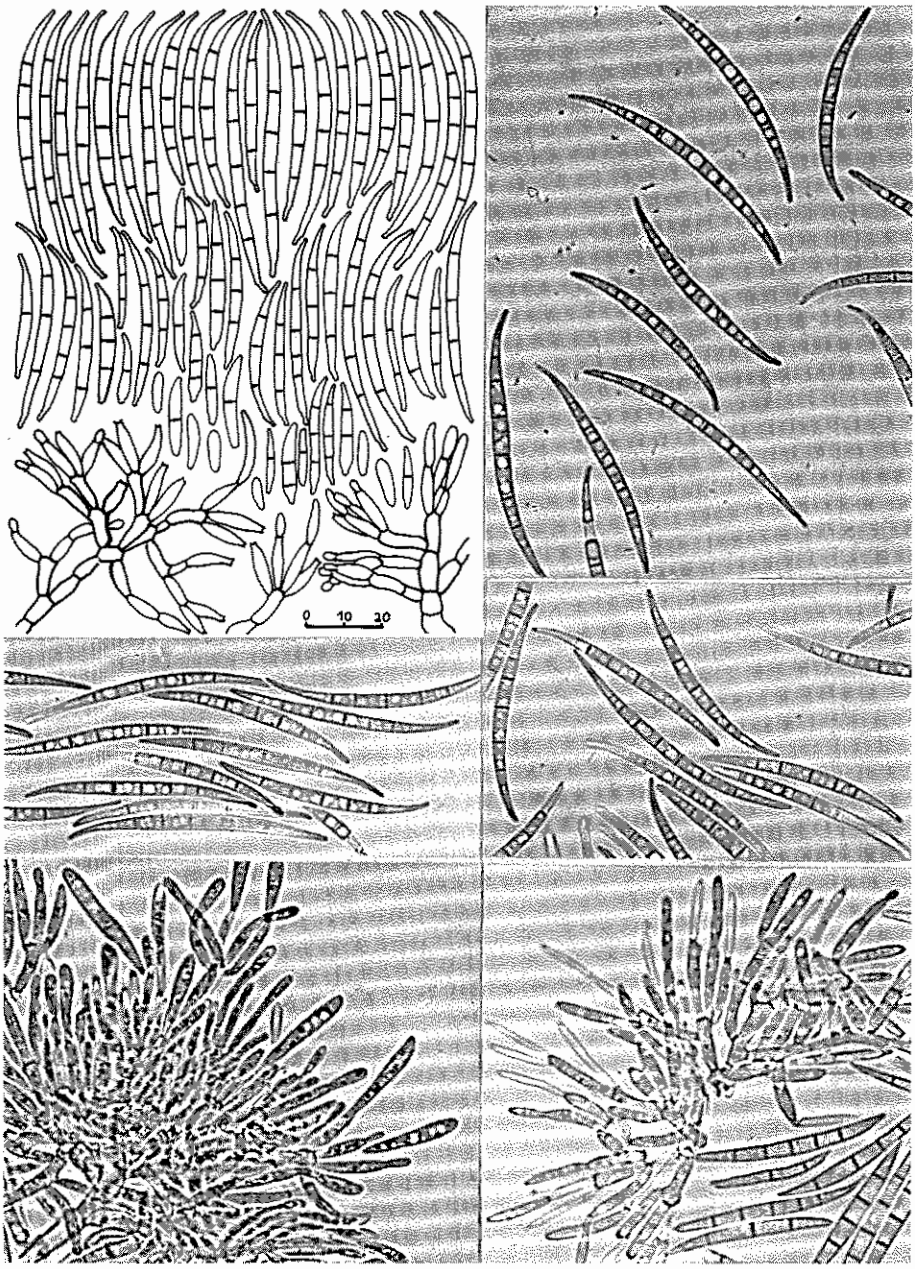

Fig. 36. Fusarium avenaceum var. avenaceum.

Fusarium avenaceum var. avenaceum was described by FRIES as Fusisporium avenaceum in 1832 on oats. SACCARDO transferred the fungus correctly to the genus Fusarium. This fungus is generally accepted as a distinct species, though in a somewhat varying concept.

F. avenaceum var. avenaceum occurs world-wide, but especially in the temperate zones. Most often it is isolated from cereals, but also from numerous other plants. It is believed to be a saprophyte or a weak parasite. Under conditions unfavourable to its host, it may become extremely aggressive, causing damping-off, root rots and stalk rots as well as fruit rots. For further information confer SCHNEIDER (1958), BOOTH (1971a) and DOMSCH et al. (1980).

Fusarium avenaceum (Fr.) Sacc. f. 1 Wollenw. & Reinking - Die Fusarien: 55, 1935

Descriptions: WOLLENWEBER (1916-1935 no. 174-176, 571, 890), WOLLENWEBER & REINKING (1935), DOIDGE (1938), WOLLENWEBER (1943), JAMALAINEN (1943b).

This Fusarium was described as differing from F. avenaceum var. avenaceum in the pigmentation of the stroma which is whitish to flesh coloured or yellowish, but never carmine. It is documented in our institute by WOLLENWEBER's notes and drawings of about 30 specimens and was later accepted by DOIDGE (1938) and JAMALAINEN (1943b) who reported some further isolates from South Africa and Finland, respectively. It was not mentioned by BUGNICOURT (1939), GORDON (1952-1960), BILAI (1955), SUBRAMANIAN (1971) and JOFFE (1974). BOOTH (1971a) did not keep it separately following RAILLO (1950).
A culture (63863) freshly isolated from maize tassels in Germany and sent to us for identification by W. MARASAS in 1978 (as strain SS-25), corresponds exactly with forma 1 demonstrating that such a type really occurs in nature.

Fusarium avenaceum (Fr.) Sacc. var. pallens Wollenw. - Fus. autogr. delin.: 575, 1924

Fusarium avenaceum (Fr.) Sacc. subsp. volutum (Wollenw. & Reinking) Raillo - Fungi of the Genus Fusarium (Moscow): 188, 1950

Descriptions: WOLLENWEBER (1916-1935 no. 575), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943).

This variety is typified by WOLLENWEBER's strain 1605 (Fus. autogr. delin. no. 575) which he isolated from ear of rye in Germany in 1923.

He described it with conidia being cream to yellowish ochraceous in mass, not orange-red coloured, very slender and generally somewhat more curved than in F. avenaceum var. avenaceum. No further corresponding strain has ever been found. Regarding the broad variation of these characters in nature and culture it may be acceptable to include this variety into the latter as done by GORDON (1952), BOOTH (1971a) and SUBRAMANIAN (1971). RAILLO (1950) treated the fungus as F. avenaceum subsp. volutum, BILAI (1955) as a synonym of F. avenaceum var. herbarum.

Fusarium avenaceum (Fr.) Sacc. var. fabae Yu - Phytopathology 34: 392, 1944

Fusarium avenaceum (Fr.) Sacc. f. fabae (Yu) Yamamoto - Sci. Rep. Hyogo Univ. Agric., Agric. Biol. Ser., 2(1): 60, 1955

According to BOOTH (1971a) this fungus is actually F. oxysporum Schl. f. sp. fabae Yu & Fang (Phytopathology 38: 590, 1948).

Fusarium avenaceum (Fr.) Sacc. var. volutum Wollenw. & Reinking - Die Fusarien: 56, 1935

Fusarium avenaceum (Fr.) Sacc. subsp. volutum (Wollenw. & Reinking) Raillo var. triseptatum Raillo - Fungi of the Genus Fusarium (Moscow): 189, 1950

Descriptions: WOLLENWEBER (1916-1935 no. 171, 172, 893), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943).

Explanation of Figure 37:

Reproductions of WOLLENWEBER's Fus. autogr. delin. no. 172 and 893; drawing of conidia of strain 3750, according to WOLLENWEBER's drawings (x 500).

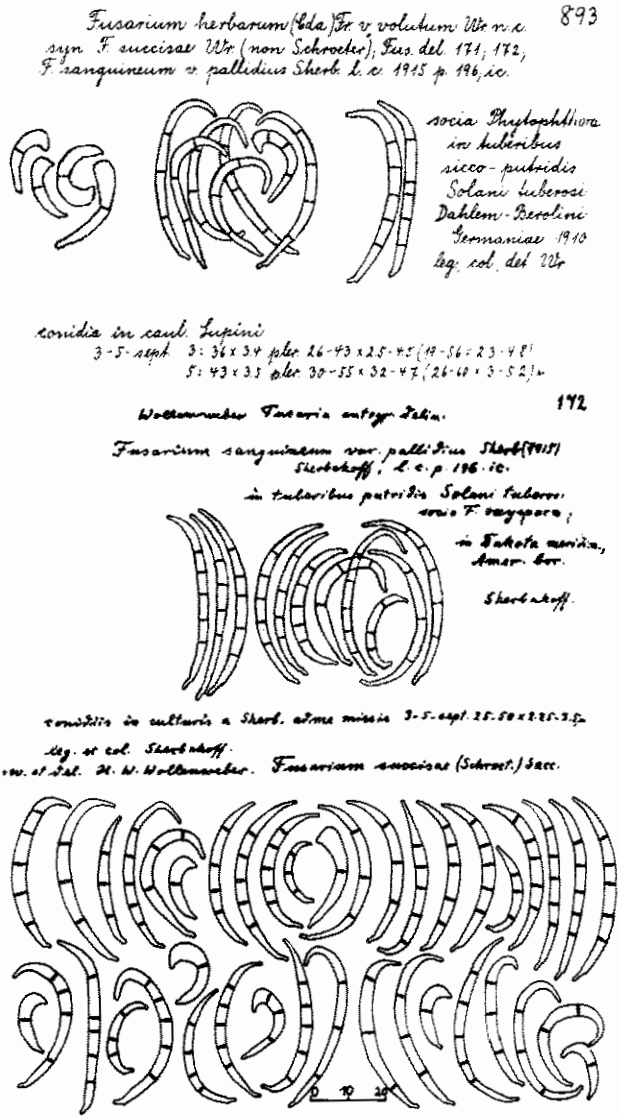

Fig. 37. Fusarium avenaceum var. volutum.

There is no representative strain of F. avenaceum var. volutum available, and there are only drawings and notes of 2 cultures by WOLLENWEBER preserved (Fus. autogr. delin. no. 171=893 and 172). Both strains were isolated from rotting potato tubers, one in Berlin-Dahlem in 1910 by WOLLENWEBER himself and the other one in South Dakota by SHERBAKOFF. Moreover this very rare Fusarium was reported from roots of tobacco and maize in the USA (WOLLENWEBER 1943). It was separated as a distinct variety because of its generally strongly curved, uncinate, often nearly convoluted conidia which sometimes become vinaceous, violet to rufous in mass (orange coloured in F. avenaceum var. avenaceum).

RAILLO (1950) treated it as F. avenaceum subsp. volutum var. triseptatum and BILAI (1955) considered the fungus as synonymous with F. avenaceum var. herbarum. GORDON (1959) included it in F. avenaceum var. avenaceum which was accepted by BOOTH (1971a) and SUBRAMANIAN (1971). With regard to the characteristic shape of the conidia, however, it may be justified to consider this Fusarium as a distinct variety.

Fusarium detonianum Sacc. - Syll. Fung. 4: 708, 1886

Fusarium avenaceum (Fr.) Sacc. var. detonianum (Sacc.) Raillo - Fungi of the Genus Fusarium (Moscow): 188, 1950

Descriptions: WOLLENWEBER (1916-1935 no. 195, 900), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), JAMALAINEN (1944), GERLACH (1978).

C o l o n i e s - very fast-growing, reaching 7.5 - 8.0 cm diam. in 6 days at 25°C on PDA; in macroscopic features not distinguishable from F. avenaceum.

Aerial mycelium - in freshly isolated cultures abundant, loosely fluffy to cottony, felt-like, in subcultures becoming ever sparser, finally completely lacking, whitish with a rose tinge.

Pigmentation - pale rose, rose-red, peach to dark vinaceous, sometimes patches of ochraceous, reddish brown to cinnamon colours occur, violet or bluish pigments absent.

Sclerotial bodies - sometimes large and numerous in freshly isolated cultures, of irregular shape and brownish or reddish colour.

Sporulation - starting after a few days in the aerial mycelium as not fully developed, comparatively small conidia, later more or less numerous sporodochia developing on sclerotial stroma and expanded pionnotal layers occur which are orange-, salmon- to cinnamon coloured.

Odour - not perceptible.

C o n i d i o p h o r e s - initially arising as single lateral phialides on hyphae, later sparsely branched, densely aggregated in sporodochial or pionnotal layers.

Phialides - generally monophialidic, sometimes proliferating, subcylindric, 8-25 x 2.5-4.0 µm.

C o n i d i a - tall, falcate, slightly to strongly curved, tapering toward both ends, with a rather long, pointed, sometimes barely hooked apical cell and a generally distinct pedicellate basal cell, mostly 5- to 7-septate, less frequently 3- to 4- or 8- to 11-septate, measuring:

3-4-sept.	53 x 3.5	mostly 41- 65 x 3.2-3.8	(27- 81 x 2.8-5.5) µm
5-sept.	78 x 3.6	mostly 68- 85 x 3.1-3.9	(46-117 x 2.7-5.3) µm
6-7-sept.	96 x 4.0	mostly 88-102 x 3.3-4.3	(75-118 x 3.0-5.3) µm
8-11-sept.	93 x 4.0	mostly 86-104 x 3.5-4.5	(70-122 x 3.0-5.2) µm.

C h l a m y d o s p o r e s - not observed, but in drying conidia inflated cells with thick walls very rarely present.

Explanation of Figure 38:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 900 of strain 2345 (= CBS 174.31); drawing and photographs of conidia and conidiophores of strain 11273 (= CBS 736.79) on different substrates (x 500).

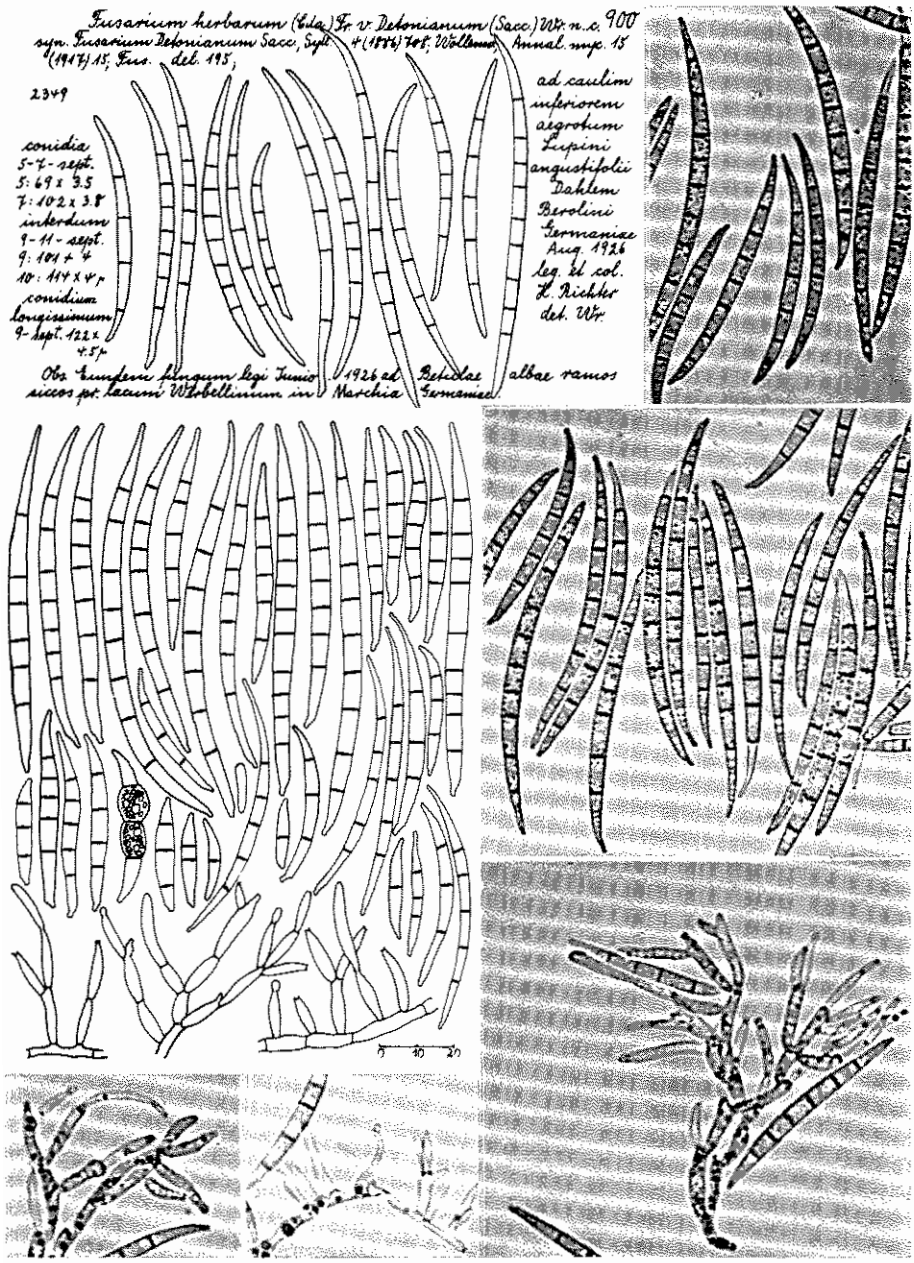

Fig. 38. Fusarium detonianum.

To differentiate this Fusarium from F. avenaceum it was consequantly designated by WOLLENWEBER (1931) as F. herbarum var. detonianum. Later, however, WOLLENWEBER & REINKING (1935) and WOLLENWEBER (1943) recognized it again as a distinct species. DOIDGE (1938), BUGNICOURT (1939) and GORDON (1952) gave no comment on this Fusarium. JAMALAINEN (1944) reported 3 different strains of this species isolated from cereal grains in Finland and illustrated the conidia. RAILLO (1950) regarded this Fusarium as a separate variety, but BILAI (1955), as well as BOOTH (1971a), considered it identical with F. avenaceum. A strain (11273 = 62194 = CBS 736.79) was isolated by H. RICHTER in 1969 from the cut surface of a stump of Betula verrucosa which produces much larger and higher septate conidia than the numerous strains of F. avenaceum studied for comparison. This isolate seems to confirm that F. detonianum should be recognized as a distinct species or at least as a variety of F. avenaceum as proposed by RAILLO (1950).

Fusarium arthrosporioides Sherb. - Mem. Cornell Univ. agric. Exp. Stn 6: 175, 1915

Descriptions: SHERBAKOFF (1915), WOLLENWEBER (1916-1935 no. 559, 901), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), JAMALAINEN (1944), GORDON (1952), BOOTH (1971a), JOFFE (1974).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 8 days at 25°C on PDA.
Aerial mycelium - abundant, loosely fluffy to cottony, whitish with a dash of rose.
Pigmentation - cream, pink, rose to carmine or purple with yellowish to ochre tinges, becoming red-brown to brown with age.
Sclerotial bodies - present, mostly small, occasionally cauliflower-like erumpent, beige, bluish black or black.
Sporulation - starting after 5 days in the aerial mycelium as single conidia or cohering in false heads, sometimes giving the culture a somewhat powdery appearance; occasionally small, pale brick sporodochia are formed after about 4 weeks.
Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally on hyphae in the aerial mycelium, branching loosely and irregularly; secondary conidiophores are formed at first as single phialides laterally on hyphae of the substrate mycelium, early branching irregularly and loosely, later densely.
Conidiogenous cells - those of primary conidiophores blastic or phialidic, often sympodially proliferating, sometimes with 2 or 3 conidiogenous loci, cylindric, slender (8-26 x 2.0-3.8 µm), those of secondary conidiophores always phialidic, also slender, but shorter and somewhat wider (7-11 x 2.1-4.0 µm).

C o n i d i a - those of primary conidiophores ovoid to fusoid, 0- to 3-septate, sometimes up to 5-septate, resembling those in F. avenaceum var. avenaceum; those of secondary conidiophores, which are formed in sporodochia either pyriform and 0- to 2-septate, or falcate, mostly only slightly curved, slender, widest in the upper third, with an elegantly curved, acuminate apical cell and a distinct basal cell, 3- to 5-septate, measuring:

0-sept. p.	6 x 4.0	mostly 5- 8 x 3.5-4.5	(4- 9 x 3.0-5.5) µm
1-sept. f.	17 x 3.2	mostly 15-20 x 2.5-3.8	(12-26 x 2.2-4.5) µm
3-sept. f.	27 x 4.0	mostly 26-30 x 3.8-4.0	(19-39 x 3.5-5.0) µm
3-sept.	45 x 3.3	mostly 40-46 x 3.0-3.5	(34-54 x 2.5-4.0) µm
5-sept.	56 x 3.5	mostly 54-60 x 3.3-3.8	(45-71 x 2.8-4.5) µm.

p. = pyriform
f. = fusoid

C h l a m y d o s p o r e s - absent.

Explanation of Figure 39:
Reproduction of Figure 20 by SHERBAKOFF (1915); reproduction of WOLLENWEBER's Fus. autogr. delin. no. 901 of strain 2787; drawing and photographs of conidia and conidiophores of strains 4128 (= CBS 173.32), 11326 and 12315 on different substrates (x 500).

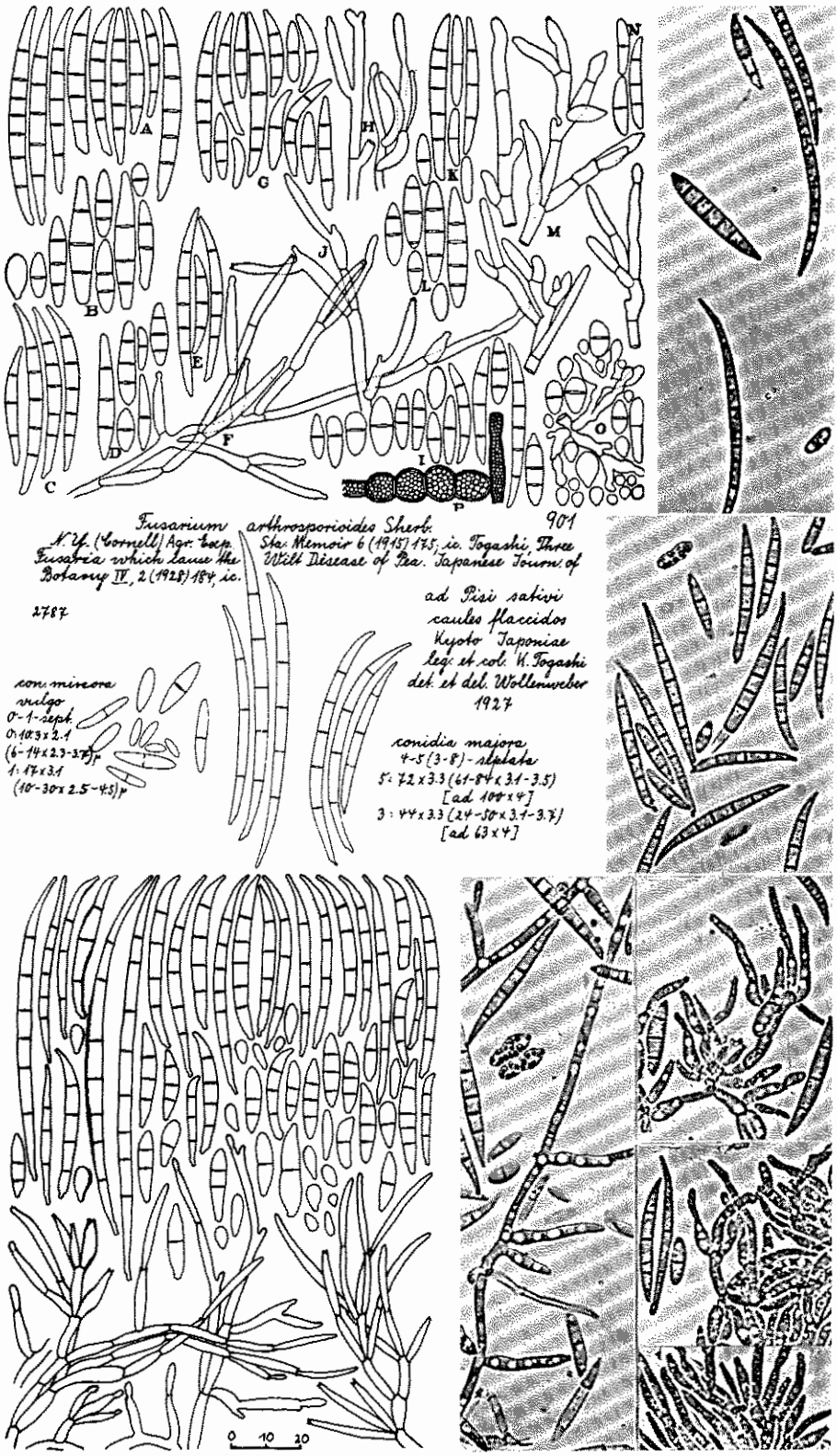

Fig. 39. Fusarium arthrosporioides.

F. arthrosporioides was first described by SHERBAKOFF (1915) and was accepted by WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), JAMALAINEN (1944), GORDON (1952), BOOTH (1971a) - inexplicably placing it into the Gibbosum section - and JOFFE (1974) as a distinct species. BUGNICOURT (1939) and DOIDGE (1938) did not mention the fungus, whereas RAILLO (1950) and BILAI (1955) considered it synonymous with F. anguioides.

Though F. arthrosporioides is quite similar to F. avenaceum var. avenaceum, it differs culturally from it by not producing prominent, orange sporodochia and by forming pyriform conidia. Even SHERBAKOFF himself became unsure about its identity (McKEE 1952). Therefore it is not surprising that the 2 fungi have been and continue to be confused. Even in our institute the differences were found only recently for which reason no photograph of the pyriform conidia could be shown in our figure. Until now F. arthrosporioides was only reported from the temperate zones, causing dry rots of potato tubers and carrots and being pathogenic also to conifer seedlings and clover.

Section ARTHROSPORIELLA Sherb. - Mem. Cornell Univ. agric. Exp. Stn 6: 161, 1915

Fusarium semitectum Berk. & Rav. in Berkeley - Grevillea 3: 98, 1875
var. semitectum

Pseudofusarium fusarioideum Matsushima - Microfungi of the Solomon Islands and Papua - New Guinea (Osaka): 47, 1971

Pseudofusarium semitectum (Berk. & Rav.) Matsushima - Icones microfungorum a Matsushima lectorum (Kobe): 119, 1975

Descriptions: WOLLENWEBER (1916-1935 no. 112, 906, 1135), WOLLENWEBER & REINKING (1925), REINKING & WOLLENWEBER (1927), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), GORDON (1952), GERLACH & ERSHAD (1970), BOOTH (1971a), SUBRAMANIAN (1971 - as F. incarnatum), JOFFE (1974), HORNOK (1975), BOOTH (1978c), DOMSCH et al. (1980).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 8 days at 25°C on PDA.

Aerial mycelium - generally abundant, densely floccose to tufted, appearing powdery by scattered conidia.

Pigmentation - whitish, flesh, peach, gradually changing to ochraceous, avellaneous and finally buff-brown; red, violet or bluish pigmentation lacking.

Sclerotial bodies - mostly absent, if present small, flat, pale brownish.

Sporulation - scattered only in the aerial mycelium, starting after a few days, typical sporodochia or pionnotes absent.

Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides in the aerial mycelium, later loosely, irregularly, rarely verticillately branched. Phialides - mostly monophialidic, often sympodially proliferating, sometimes forming polyphialides with 2 or 3, sometimes 4 conidiogenous loci, more or less slender, cylindric to subcylindric, 8-25 x 2.5-5.0 µm.

C o n i d i a - rather thick-walled, predominantly straight and spindle-shaped to lanceolate, sometimes slightly curved and falcate, gradually tapering toward each end and with a hooked apical and a mostly indistinct, conical or wedge-shaped, apedicellate, sometimes apiculate basal cell, mostly 3-, often 4- to 5-septate, rarely 0- to 2- or 6- to 7-septate, measuring:

0-sept.	9 x 2.8	mostly 7-12 x 2.3-3.5	(4-17 x 2.0-4.0) µm
1-sept.	14 x 3.3	mostly 11-16 x 2.7-4.0	(8-22 x 2.0-4.5) µm
3-sept.	24 x 4.2	mostly 20-30 x 3.6-4.8	(13-50 x 2.5-6.5) µm
5-sept.	34 x 4.5	mostly 26-40 x 3.8-5.5	(23-50 x 2.8-6.4) µm
7-sept.	45 x 5.0		(36-57 x 4.0-6.5) µm.

C h l a m y d o s p o r e s - often sparse, mostly intercalary, globose to subglobose, usually with smooth walls, single 6-10 µm diam., 1- to 2-celled or in short chains.

Explanation of Figure 40:

Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

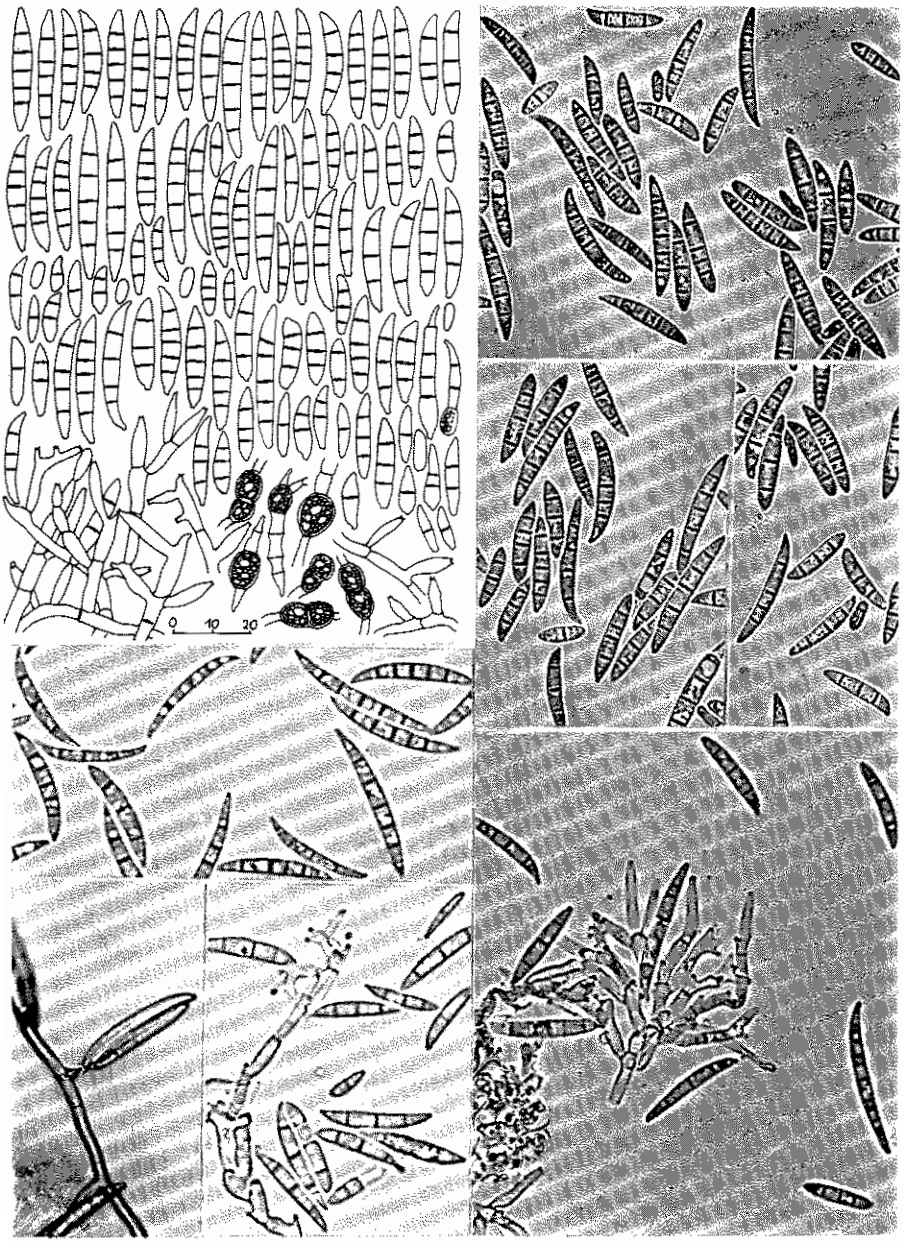

Fig. 40. Fusarium semitectum var. semitectum.

In addition to WOLLENWEBER's notes and drawings of numerous cultures some twenty strains from different continents were available for comparison during the past years. In agreement with WOLLENWEBER & REINKING (1935) F. semitectum was generally accepted as a clearly distinct species; GORDON (1952, 1956b) and SUBRAMANIAN (1971) included also var. majus. Some representative strains deposited by WOLLENWEBER, GORDON and others are preserved in the CBS/Baarn.

F. semitectum is extremely widespread and common in the tropics and subtropics but also found in Mediterranean and occasionally in temperate regions mainly occurring on plant tissues. It is of major economic importance as a causal agent of storage rot of various tropical crops, especially fruits and potatoes, acting as a weak or wound parasite. More detailed information regarding its regional distribution, host plants, pathogenic behaviour and other aspects is given by BOOTH (1978c) and DOMSCH et al. (1980).

Fusarium semitectum Berk. & Rav. in Berkeley var. majus Wollenw. - Z. Parasitenk. 3: 325-327, 1931

Descriptions: WOLLENWEBER (1916-1935 no. 113-116, 552, 907-910), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), BUGNICOURT (1939), BOOTH (1971a), SUBRAMANIAN (1971 - as F. incarnatum), JOFFE (1974), HORNOK (1975).

C o l o n i e s - fast-growing, reaching 7.0 - 8.0 cm diam. in 10 days at 25°C on PDA.

This Fusarium was described as a distinct variety of F. semitectum because of its often higher septate conidia, measuring:

0-sept. 9 x 2.9	mostly 6-12 x 2.2-3.2	(5-15 x 2.0-4.0) um
1-sept. 17 x 3.0	mostly 14-21 x 2.5-3.4	(9-24 x 2.5-4.0) um
3-sept. 24 x 3.6	mostly 19-29 x 3.0-4.5	(13-40 x 2.5-4.8) um
5-sept. 39 x 4.3	mostly 30-48 x 3.7-4.8	(29-52 x 2.5-6.0) um
7-sept. 51 x 5.1	mostly 44-61 x 4.3-6.0	(45-70 x 3.7-6.2) um
9-sept. 60 x 5.3		(50-70 x 4.0-6.0) um.

In addition to about 30 cultures studied by WOLLENWEBER some twenty were identified during our investigations in the past years. To a certain extend it may be a question of personal estimation whether or not to distinguish between var. semitectum and var. majus. In any case, there is a considerable variability in septation depending on such factors as substrate and light. There are no striking differences regarding regional distribution, ecological aspects, host plants and pathogenic behaviour.

Three representative cultures of F. semitectum var. majus are available in the CBS/Baarn (145.44, 190.60, 132.73 = IMI 128222 = ATCC 24388). In agreement with WOLLENWEBER it was accepted as a distinct variety by DOIDGE (1938), BUGNICOURT (1939), RAILLO (1950), BILAI (1955 - with F. diversisporum and F. concolor as synonyms), BOOTH (1971a), JOFFE (1974) and HORNOK (1975). GORDON (1952, 1956b), however, as well as SUBRAMANIAN (1971 - F. semitectum = F. incarnatum) did not keep var. majus separate.

Fusarium semitectum Berk. & Rav. var. violaceum Batikyan & Abramyan - Biol. Zh. Armen. 22: 59, 1969

Published without Latin diagnosis.

Explanation of Figure 41:

Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

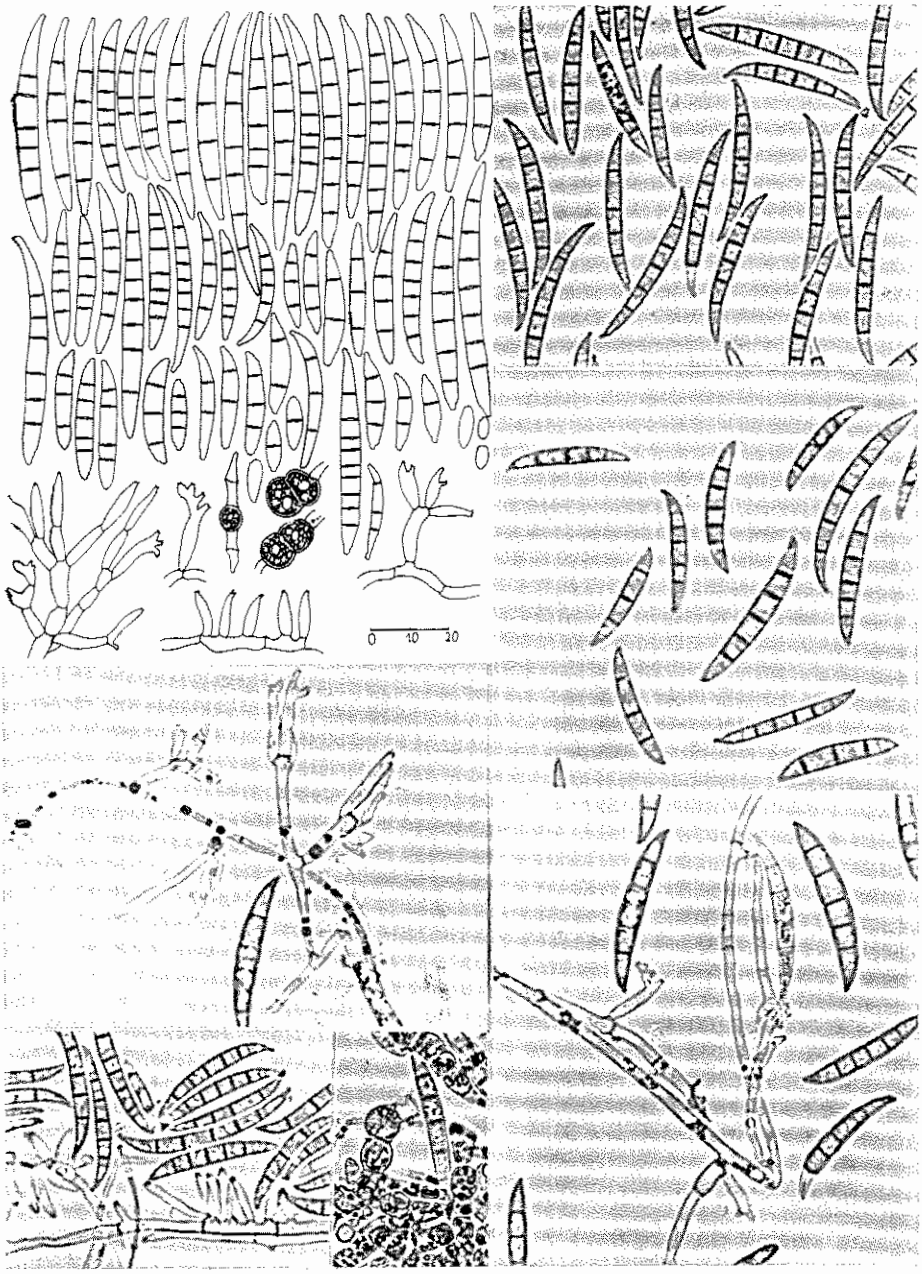

Fig. 41. Fusarium semitectum var. majus.

Fusarium camptoceras Wollenw. & Reinking - Phytopathology 15: 158, 1925

Descriptions: WOLLENWEBER (1916-1935 no. 904, 905), WOLLENWEBER & REINKING (1925), REINKING & WOLLENWEBER (1927), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), BUGNICOURT (1939), RAILLO (1950), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE (1974).

C o l o n i e s - very fast-growing, reaching 7.0 - 8.0 cm diam. in 6 days at 25°C on PDA.
Aerial mycelium - generally abundant, floccose to tufted, appearing powdery by scattered conidia, whitish, beige to sienna.
Pigmentation - whitish, beige, pinkish buff to honey, dark ochraceous and finally cinnamon to dark brown.
Sclerotial bodies - not formed.
Sporulation - only scattered in the aerial mycelium, starting after a few days, sporodochial or pionnotal layers completely absent.
Odour - not perceptible.

C o n i d i o p h o r e s - only formed in the aerial mycelium, often loosely irregularly, very rarely verticillately branched.
Conidiogenous cells - predominantly polyblastic, generally with 2 or 3, rarely 4 conidiogenous loci, rather variable in length (10-35 µm) and width (2.5-5.0 µm).

Explanation of Figure 42:
Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 904 of the type culture R 42; drawing and photographs of conidia, conidiophores and chlamydospores of strain 9810 (= CBS 193.65 = IMI 112500 = ATCC 16065) on different substrates (x 500).

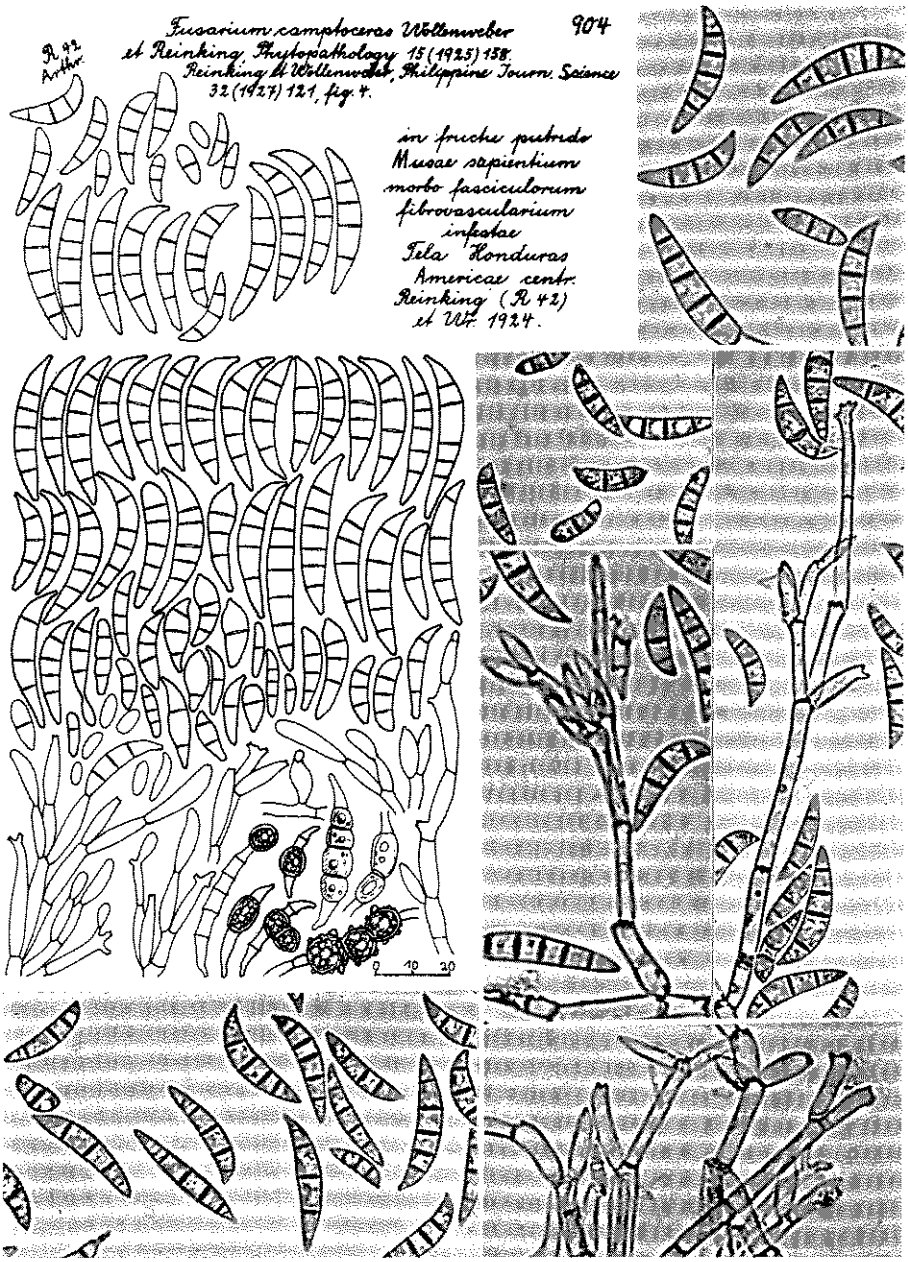

Fig. 42. Fusarium camptoceras.

C o n i d i a - 0- to 1-septate conidia, if formed, long-ellipsoid to oval or occasionally almost turbinate, large conidia falcate, mostly strongly, distinctly inequilaterally curved, widest in the middle or toward the upper third of the conidium, tapering gradually toward both ends with a more or less constricted, pointed apical cell and a conical to slightly pointed basal cell, mostly 3- to 5-septate, rarely 2-, exceptionally 6- to 7-septate, measuring:

0-sept.	11 x 3.4	(7-16 x 2.5-4.0) µm
1-sept.	16 x 3.7	mostly 13-18 x 3.4-4.0 (11-21 x 3.0-4.7) µm
2-sept.	19 x 3.9	(12-32 x 3.5-5.3) µm
3-sept.	27 x 5.2	mostly 25-30 x 4.2-4.8 (18-37 x 3.8-6.0) µm
4-sept.	31 x 5.5	mostly 27-33 x 4.5-6.0 (25-45 x 4.0-6.8) µm
5-sept.	37 x 5.4	mostly 32-40 x 4.5-6.0 (28-56 x 4.0-7.0) µm
6-sept.	39 x 5.3	(25-58 x 4.5-6.0) µm
7-sept.	43 x 5.2	(35-54 x 4.3-5.8) µm.

The illustration of the conidia by BOOTH (1971a) does not satisfactorily portray the specific characteristics and is therefore misleading.

C h l a m y d o s p o r e s - more or less abundant, terminal or intercalary, globose to subglobose, smooth-walled or verrucose, single (7-12 µm), in pairs, chains or clusters.

In addition to the material - including the type culture - deposited by WOLLENWEBER 3 freshly isolated strains were studied. F. camptoceras is apparently not very common and is restricted to subtropical and tropical regions; it does not have any importance as a plant pathogen. It is generally accepted as a very characteristic and distinct species, but BILAI (1955), surprisingly, considered it a synonym of F. culmorum.

Fusarium concolor Reinking - Zentralbl. Bakteriol. 2. Abt. 89: 512, 1934

Descriptions: REINKING (1934), WOLLENWEBER (1916-1935 no. 1136), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), RAILLO (1950), GORDON (1952), BOOTH (1971a), JOFFE (1974), HORNOK (1975).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - not very abundant, sometimes floccose to felt-like, soon becoming powdery by scattered microconidia, whitish to incarnadine, sometimes tinged cherry by the substrate mycelium.
Pigmentation - whitish, beige, yellowish buff, occasionally rose-red.
Sclerotial bodies - always lacking.
Sporulation - starting very early in the aerial mycelium as powdery aggregations or slimy masses, rarely forming typical sporodochia.
Odour - not perceptible.

C o n i d i o p h o r e s - as far as could be observed in the rather deteriorated type culture - developing as single phialides laterally on hyphae or sparsely branched; in strain 63778 (= CBS 217.78) which agrees in every detail with the type culture and which was identified as F. concolor, however, conidiophores often richly branched.
Conidiogenous cells - only monophialidic in the sparsely sporulating type culture, mostly 8-20 x 3-5 µm, but in the aerial mycelium of strain 63778 typically polyblastic cells with 2 or 3 conidiogenous loci occur.

C o n i d i a - typical microconidia formed on distinct polyblastic cells abundantly scattered in the aerial mycelium, obovoid, fusoid and slender, similar to those formed in F. chlamydosporum, 0- to 1-(up to 2-)septate; macroconidia falcate, straight to slightly curved, with a fairly constricted apical cell and a conical obtuse, subpedicellate basal cell, predominantly 3- to 5-septate, occasionally 6- to 7-(up to 9-)septate, measuring:

0-sept.	13 x 3.0	mostly 11-15 x 2.8-3.2 (9- 18 x 2.4-3.5) µm
1-sept.	20 x 3.4	mostly 17-24 x 3.0-3.8 (12- 32 x 2.5-4.5) µm
3-sept.	39 x 3.9	mostly 31-51 x 3.6-4.2 (24- 70 x 3.0-5.5) µm
4-sept.	61 x 4.5	mostly 55-67 x 4.2-4.8 (47- 70 x 3.6-5.5) µm
5-sept.	64 x 4.7	mostly 52-69 x 4.3-5.1 (46- 95 x 3.7-6.0) µm
6-sept.	67 x 5.0	mostly 60-79 x 4.5-5.3 (56- 80 x 4.0-5.5) µm
7-sept.	73 x 4.9	mostly 68-80 x 4.5-5.3 (62-100 x 4.0-5.7) µm.

The figures given by BOOTH (1971a) and JOFFE (1974) are not typical.

C h l a m y d o s p o r e s - rather abundant, intercalary and terminal, in hyphae and conidia, globose to subglobose, smooth- or sometimes rough-walled, single (7-12 µm), in pairs, chains or occasionally in clusters.

Explanation of Figure 43:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 1136 of the type culture 2607 (= CBS 183.34 = IMI 112502); drawing and photographs of strain 2607 on different substrates (x 500).

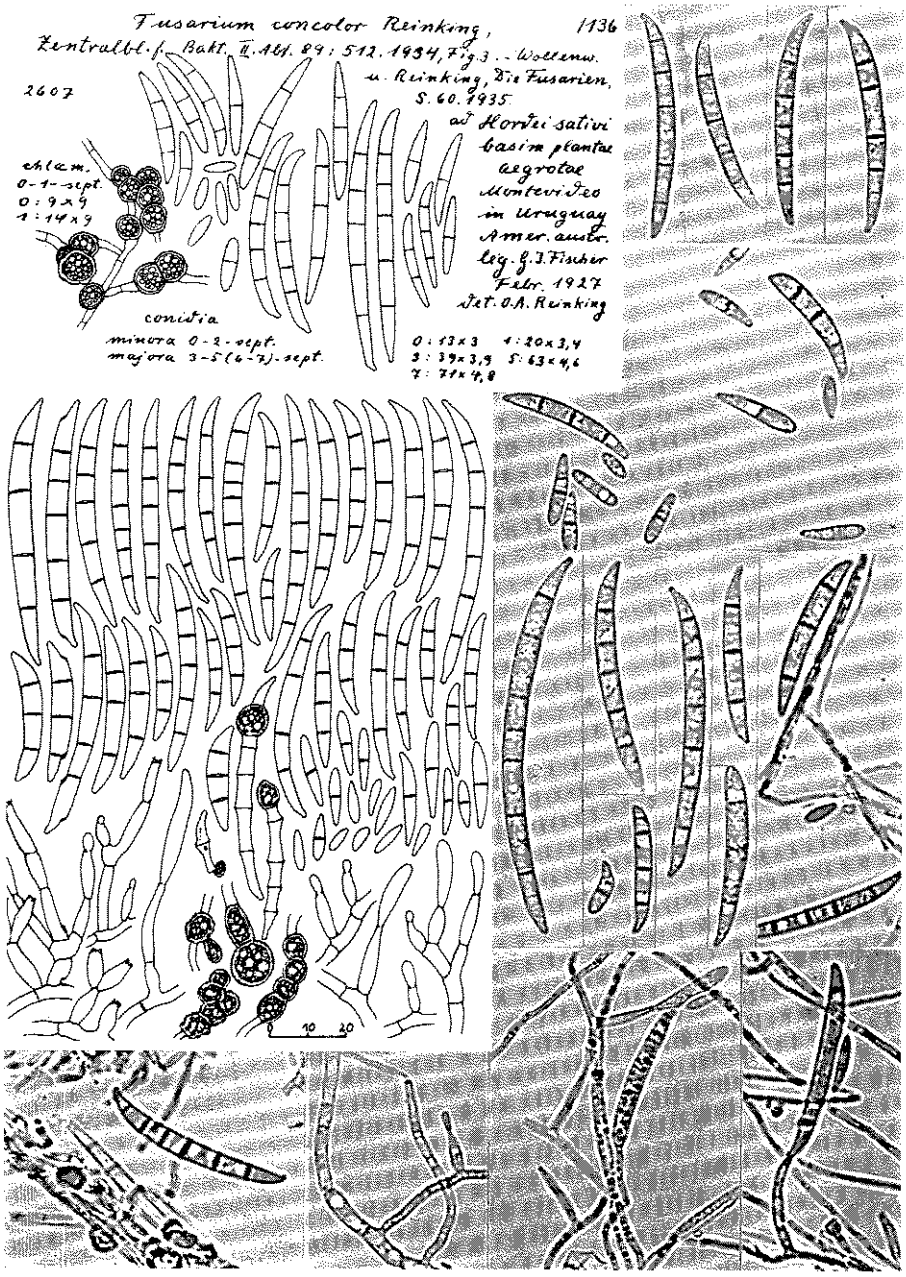

Fig. 43. Fusarium concolor.

F. concolor was based on a single culture isolated by G.J. FISCHER from the base of a diseased barley plant near Montevideo/Uruguay in 1927 and sent to REINKING who described the fungus as a new species. This strain (2607) deposited in the CBS/Baarn (183.34) by REINKING was also thoroughly studied by WOLLENWEBER and illustrated (Fus. autogr. delin. no. 1136); all his notes and drawings are preserved in our institute. The strongly deteriorated type culture still produces micro- and very typical macroconidia on some substrates under daylight. Two other strains studied by WOLLENWEBER (signed as SHERBAKOFF no. 34 isolated from soil in 1934 and as GORDON # 6 = 6024 isolated from soil in Manitoba/Canada in 1936) belong probably to the same Fusarium species. A culture (MRC 653 = 63778 = CBS 217.78), which was isolated from Pennisetum typhoides and sent to us by C.J. RABIE (NRIND/South Africa) for identification in 1977, completely agrees with F. concolor in all the characteristics described by REINKING (1934), WOLLENWEBER & REINKING (1935) and WOLLENWEBER (1943). But in addition to phialides it abundantly produces polyblastic cells forming microconidia only.

F. concolor was not mentioned by DOIDGE (1938), BUGNICOURT (1939) and SUBRAMANIAN (1971). RAILLO (1950), GORDON (1952, 1954b, 1959), BOOTH (1971a), JOFFE (1971) and HORNOK (1975) accepted it as a distinct species, but BILAI (1955), surprisingly, treated it (together with F. diversisporum) as synonymous with F. semitectum var. majus. The descriptions and illustrations given by BOOTH, although allegedly based on the type culture, and those given by JOFFE and HORNOK are misleading; probably also the reports given by KRUG (1940), REDDY (1974) and LATCH et al. (1976) are derived from a misidentification of a Fusarium of the Gibbosum group.

Fusarium diversisporum Sherb. - Mem. Cornell Univ. agric. Exp. Stn 6: 161-166, 1915

Descriptions: SHERBAKOFF (1915), WOLLENWEBER (1916-1935 no. 118, 553, 911, 912), REINKING & WOLLENWEBER (1927), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), GERLACH & ERSHAD (1970), GERLACH (1978).

C o l o n i e s - moderately fast-growing, reaching 4.8 - 6.5 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - abundant, loosely fluffy to cottony, whitish.
Pigmentation - yellowish pink, clay colour, dark yellow-brown.
Sclerotial bodies - absent.
Sporulation - starting within a few days in the aerial mycelium as single conidia or cohering in false heads, giving the culture a somewhat powdery appearance; small or large pinkish cinnamon sporodochia are sometimes formed after a month, also confluent to sporodochial layers.
Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally on hyphae in the aerial mycelium, branching loosely and irregularly; secondary conidiophores arise at first as single lateral phialides on hyphae of the substrate mycelium, later branching densely.
Conidiogenous cells - those of primary conidiophores blastic or phialidic, proliferating, sometimes with 2 conidiogenous loci, cylindric, slender (13-29 x 2.5-3.0 µm); those of secondary conidiophores always phialidic, somewhat shorter and wider (10-19 x 2.8-3.2 µm).

C o n i d i a - those of primary conidiophores ovoid to fusoid, also slightly falcate, mostly 0- to 3-septate, but also occasionally up to 9-septate, relatively wide; those of secondary conidiophores falcate, slightly bent, slender, tapering toward both ends, with an elongated, elegantly curved apical cell and a pedicellate basal cell, mostly 3- to 5-septate, measuring:

3-sept. f.	28 x 4.3	(19- 37 x 4.0-5.3) µm
5-sept. f.	48 x 4.2	(37- 61 x 4.1-5.5) µm
7-9-sept. f.		(60-100 x 4.2-5.5) µm
3-sept.	36 x 3.2	(20- 48 x 2.4-3.5) µm
5-sept.	48 x 3.6	(35- 70 x 2.7-4.5) µm.

f. = fusoid

C h l a m y d o s p o r e s - absent, but sometimes inflated, thick-walled cells occur in hyphae or conidia of old cultures.

Explanation of Figure 44:

Reproduction of Figure 16 by SHERBAKOFF (1915); reproduction of WOLLENWEBER's Fus. autogr. delin. no. 911 of strain 1903 (= CBS 144.44); drawing and photographs of conidia, conidiophores and chlamydospore-like cells of strain 11129 (= CBS 795.70) on different substrates (x 500).

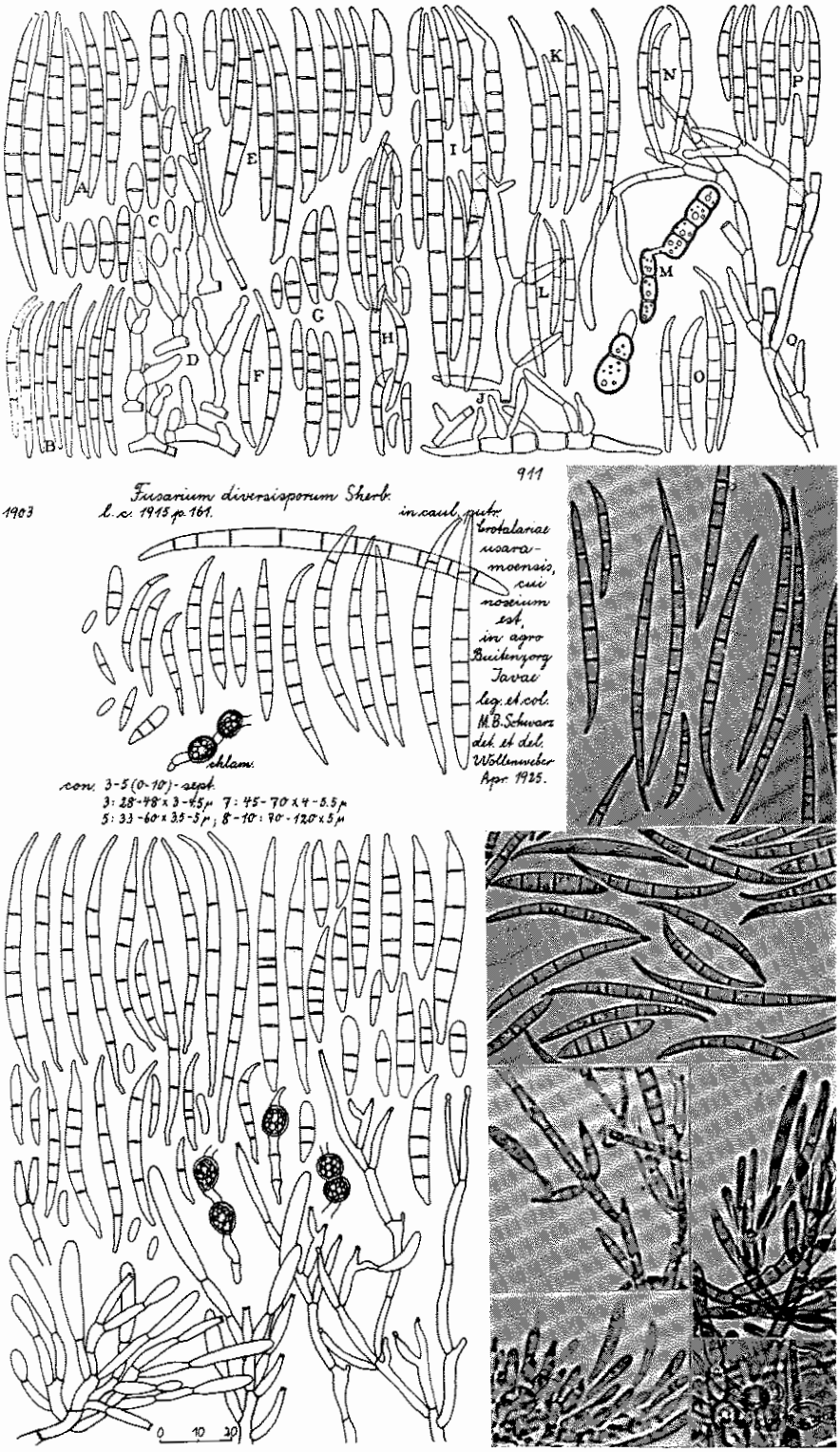

Fig. 44. Fusarium diversisporum.

This species, first described on rotten potato tubers (SHERBAKOFF 1915), was also isolated from other substrates and accepted as distinct by WOLLENWEBER (1916-1935), WOLLENWEBER (1931), REINKING & WOLLENWEBER (1927) and WOLLENWEBER & REINKING (1935). DOIDGE (1938), BUGNICOURT (1939) and JOFFE (1974) did not mention this Fusarium. GORDON (1952) regarded it as synonymous with F. semitectum var. semitectum and var. majus, which was later accepted by SUBRAMANIAN (1971 - as F. incarnatum). Whereas RAILLO (1950) treated it as identical with F. semitectum var. majus only, which was also the opinion of BILAI (1955) and BOOTH (1971a).

In 1968 a Fusarium isolated in Iran from a branch of Prunus domestica infested with San José scale insects appeared to be F. diversisporum (GERLACH & ERSHAD 1970). In pure culture this isolate (11129 = CBS 795.70) produces on a number of substrates the various conidial forms described for F. diversisporum. This strain is not identical with F. semitectum var. semitectum or F. semitectum var. majus, however, it looks similar to F. anguioides. Therefore further research is needed to decide if F. diversisporum is really a distinct species.

Fusarium anguioides Sherb. - Mem. Cornell Univ. agric. Exp. Stn 6: 169-172, 1915

Fusarium anguioides Sherb. var. caudatum Sherb. - Mem. Cornell Univ. agric. Exp. Stn 6: 173-175, 1915

Fusarium anguioides Sherb. f. 1 & f. 2 Raillo - Fungi of the Genus Fusarium (Moscow): 165, 1950

Fusarium avenaceum (Fr.) Sacc. var. anguioides (Sherb.) Bilai - Fusarii: 258, 1955

Descriptions: SHERBAKOFF (1915), WOLLENWEBER (1916-1935 no. 902, 903), REINKING & WOLLENWEBER (1927), WOLLENWEBER & REINKING (1935), BUGNICOURT (1939), WOLLENWEBER (1943), JAMALAINEN (1944).

C o l o n i e s - moderately fast-growing, reaching 4.8 - 5.3 cm diam. in 10 days at 25°C on PDA.

Aerial mycelium - abundant to almost absent, loosely fluffy to cottony, whitish with a dash of rose.

Pigmentation - cream, pink, rose to carmine or yellowish to ochre, becoming yellowish brown or red-brown to brown with age.

Sclerotial bodies - absent, but pinkish orange plectenchymatic stroma may occur.

Sporulation - starting within a few days in the aerial mycelium as single conidia or seldom cohering in false heads, giving the culture a somewhat powdery appearance; small orange to cinnamon or brick sporodochial layers are formed in about 4 weeks.

Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arise laterally on hyphae in the aerial mycelium, branching loosely and irregularly; secondary conidiophores arise at first as single lateral phialides on hyphae of the substrate mycelium, later branching loosely.
Conidiogenous cells - those of primary conidiophores blastic or phialidic, proliferating, very rarely with 2 conidiogenous loci, cylindric, slender (8-23 x 2.5-3.8 µm); those of secondary conidiophores always phialidic, of similar size (15-25 x 3.0-4.0 µm).

C o n i d i a - those of primary conidiophores ovoid to fusoid, mostly 0- to 3-septate, but higher septations also occur; those of secondary conidiophores falcate, slightly bent to anguiform, slender, tapering toward both ends, with an elongated, elegantly curved apical cell and a pedicellate basal cell, mostly 5- to 7-septate, measuring:

1-3-sept. f.	27 x 4.4	(20-38 x 3.9-5.3) µm
5-sept.	55 x 4.2	(33-80 x 3.0-5.4) µm
7-sept.	78 x 4.7	(53-96 x 4.0-6.1) µm.

f. = fusoid

C h l a m y d o s p o r e s - absent, but sometimes inflated, thick-walled cells occur in hyphae or conidia of old cultures.

Explanation of Figure 45:
Reproduction of Figure 18 by SHERBAKOFF (1915); reproduction of WOLLENWEBER's Fus. autogr. delin. no. 903 of strain R 236; drawing and photographs of conidia, conidiophores and chlamydospore-like cells of strain 2888 (= CBS 172.32) on different substrates (x 500).

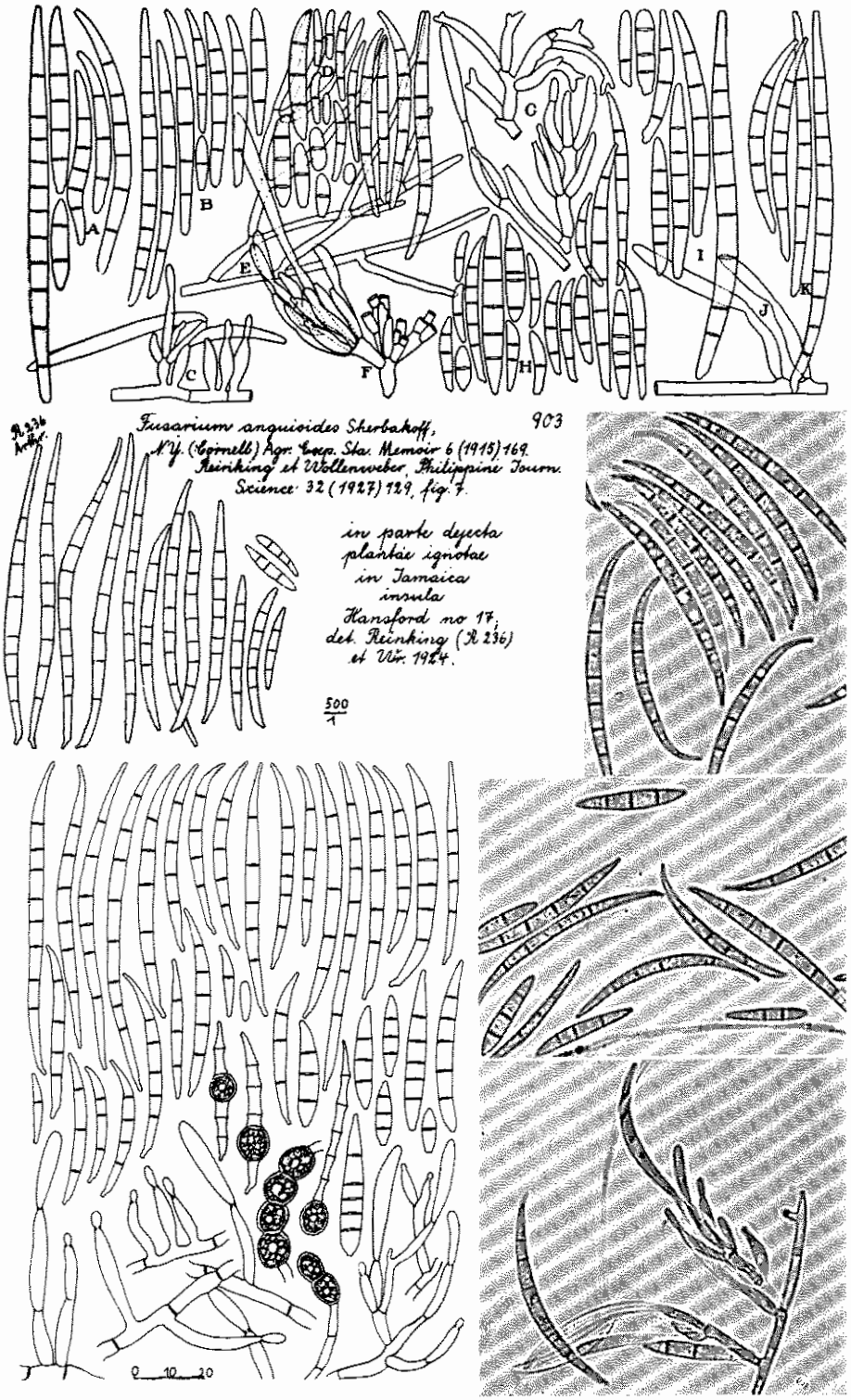

Fig. 45. Fusarium anguioides.

This species, first described on rotten potato tubers (SHERBAKOFF 1915), was later isolated also from other plants. It was accepted as distinct by WOLLENWEBER (1916-1935), REINKING & WOLLENWEBER (1927), WOLLENWEBER & REINKING (1935), BUGNICOURT (1939), WOLLENWEBER (1943), JAMALAINEN (1944) and RAILLO (1950). DOIDGE (1938), GORDON (1952), SUBRAMANIAN (1971) and JOFFE (1974) did not mention this Fusarium. BILAI (1955) treated the fungus (together with F. longipes) as a variety of F. avenaceum and BOOTH (1971a) as synonymous with F. avenaceum. The only available culture deposited as F. anguioides seems to be CBS 172.32 which was illustrated by WOLLENWEBER in Fus. autogr. delin. no. 902. This culture, although degenerated, produces very uniform and typical conidia in pionnotes. It corresponds in microscopical characteristics with strain 11129 of F. diversisporum. Therefore the two species may be considered synonymous. In any case F. diversisporum, F. anguioides and F. semitectum need a careful re-investigation on a broader scale.

Section GIBBOSUM Wollenw. - Phytopathology 3: 31, 1913

Provisionally treated in the sense of GORDON (1952).

Fusarium equiseti (Corda) Sacc. - Syll. Fung. 4: 707, 1886 sensu Gordon - Can. J. Bot. 30: 225, 1952 var. equiseti

Fusarium gibbosum Appel & Wollenw. - Arb. Kais. Biol. Anst. Land- Forstwirtsch. Berlin-Dahlem 8: 185-190, 1910 emend. Bilai - Fusarii: 261-263, 1955 (pro maxima parte)

Teleomorph: Gibberella intricans Wollenw. - Z. Parasitenk. 3: 332, 1931

Descriptions: WOLLENWEBER (1916-1935 no. 202-208, 210, 211, 596, 597, 919, 920), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), BUGNICOURT (1939), GORDON (1952), JOFFE & PALTI (1967), GERLACH & ERSHAD (1970), BOOTH (1971a), SUBRAMANIAN (1971 - as F. aurantiacum), JOFFE (1974), HORNOK (1975), BOOTH (1978a), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - generally fast-growing or very fast-growing, reaching 6.0 - 8.0 cm diam. in 6 days at 25°C on PDA; considerable differences between different strains.
Aerial mycelium - usually abundant, loosely floccose, sometimes more felt-like, in some strains only sparse, whitish to peach, ochraceous or buff-brown.
Pigmentation - beige, yellowish brown, ochraceous, amber, avellaneous, buff-brown to coffee-brown, sometimes blackish brown, never red, vinaceous, violet or bluish.
Sclerotial bodies - often present, sometimes rather abundant, of different shape and size, pale brownish, becoming dark brown.
Sporulation - in most strains only sparse in the aerial mycelium or lacking, in some sporodochia or expanded pionnotes formed early and abundantly, at first pale, yellowish ochraceous to salmon, when desiccating becoming honey to cinnamon-brown or brighter coloured.
Odour - not perceptible.

C o n i d i o p h o r e s - initially arising as single lateral phialides in the aerial mycelium or branching loosely, when formed in sporodochia very densely branched, compact, terminating in 1-3 or more phialides. Phialides - monophialidic, usually short, compact, obclavate to doliiform, mostly 10-15 µm long and 3-4 µm wide.

C o n i d i a - only macroconidia formed, sometimes few or numerous 0- to 1-septate conidia present, very great differences in size and shape between different strains, rather thick-walled, typically falcate, parabolic or hyperbolic, gradually tapering toward both ends, somewhat curved with a more blunt apical cell (corresponding to var. bullatum) or strongly bent mainly in the central part with a more or less distinctly elongated, straight or whip-like bent apical cell (corresponding to F. scirpi var. filiferum) and a very distinctly pedicellate basal cell, mostly 3- to 5-(up to 7-)septate, less frequently 0- to 2-, exceptionally 8- to 12-septate, measuring:

0-sept.	9 x 2.8	mostly 7-12 x 2.5-3.3	(5- 18 x 2.0-6.0) µm
1-sept.	14 x 3.1	mostly 10-17 x 2.5-3.6	(8- 24 x 2.0-4.5) µm
3-sept.	27 x 3.9	mostly 15-35 x 2.8-5.0	(10- 55 x 2.3-6.5) µm
4-5-sept.	46 x 4.4	mostly 25-65 x 3.0-5.5	(20- 87 x 2.8-6.0) µm
6-7-sept.	59 x 4.8	mostly 45-70 x 4.0-5.5	(30- 90 x 3.5-6.0) µm
8-12-sept.	69 x 5.3	mostly 55-83 x 4.5-6.0	(51-132 x 3.5-6.3) µm.

C h l a m y d o s p o r e s - early and abundantly formed in hyphae, less frequently in conidia, most often intercalary, solitary, in pairs, frequently forming chains or clusters, globose to subglobose (8-20 µm), smooth- or rough-walled, becoming ochraceous.

Explanation of Figure 46:
Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

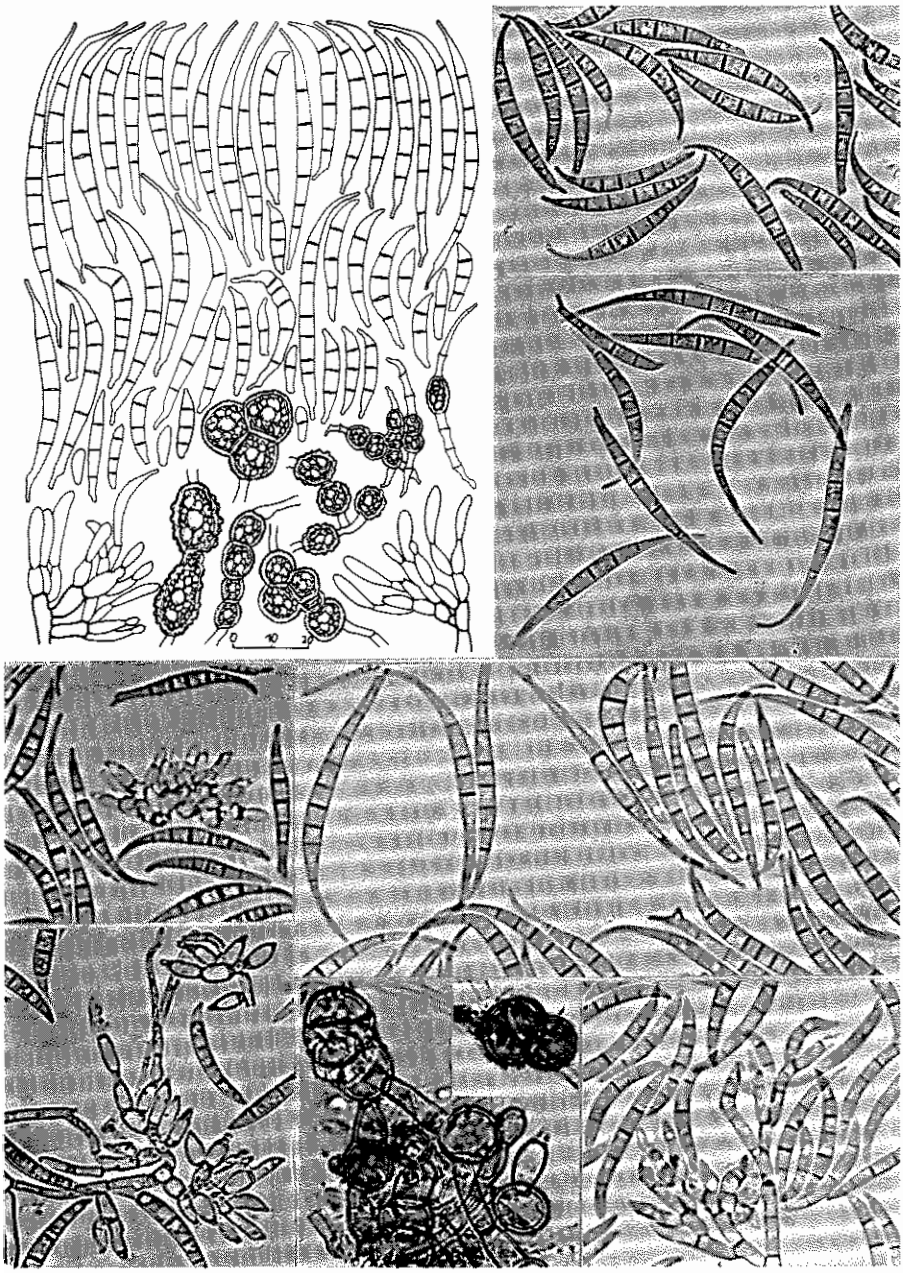

Fig. 46. Fusarium equiseti var. equiseti.

F. equiseti sensu Gordon was accepted and retained unchanged by many authors (JOFFE & PALTI 1967, GERLACH & ERSHAD 1970, BOOTH 1971a, SUBRAMANIAN 1971, JOFFE 1974, BOOTH 1978a, DOMSCH et al. 1980). It includes all species and varieties of the section Gibbosum without red pigmentation although shape and size of the conidia of the two extreme types (F. equiseti var. bullatum - F. scirpi var. filiferum) differ very strongly indeed. On the basis of hundreds of isolates studied by WOLLENWEBER and us we tend to distinguish different species or varieties as already proposed by JOFFE (1974) with regard to var. caudatum. The differences between strains of F. equiseti sensu Gordon are at least as great as in Gibbosum fusaria with a red pigmentation, which were accepted as 3 distinct species by GORDON (1952) or as varieties by JOFFE (1974).

This Fusarium is a cosmopolitan soil fungus and has been isolated from roots, crowns, stems, leaves, fruits, seeds, tubers and other parts of very numerous plant species, cereals in particular, including maize, in temperate to subtropical areas. As a plant pathogen it is most frequently recorded in connexion with root, tuber, stem and fruit rots. By and large, the fungus seems to be only mildly parasitic and of comparatively minor economic importance. JOFFE & PALTI (1967), however, stated that in Israel its pathogenic capabilities have been underestimated. More detailed information is given by BOOTH (1971a), BOOTH (1978a) and DOMSCH et al. (1980).

Fusarium equiseti (Corda) Sacc. var. bullatum (Sherb.) Wollenw. - Z. Parasitenk. 3: 331, 1931

Fusarium bullatum Sherb. - Mem. Cornell Univ. agric. Exp. Stn 6: 198-201, 1915

Fusarium gibbosum Appel & Wollenw. emend. Bilai var. bullatum (Sherb.) Bilai - Fusarii: 263-264, 1955

Teleomorph: Gibberella intricans Wollenw. - Z. Parasitenk. 3: 332, 1931

Descriptions: SHERBAKOFF (1915), WOLLENWEBER (1915-1935 no. 117, 209, 810, 913-918), WOLLENWEBER & REINKING (1925), REINKING & WOLLENWEBER (1927), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), BUGNICOURT (1939), RAILLO (1950).

The concept of GORDON (1952) to include this variety in F. equiseti was accepted by BOOTH (1971a), SUBRAMANIAN (1971 - as F. aurantiacum) and JOFFE (1974); but we prefer to retain it as a distinct variety.

Fusarium scirpi Lamb. & Fautr. - Revue Mycol. 16: 111, 1894

Descriptions: WOLLENWEBER (1916-1935 no. 198-201, 212-218, 595, 598, 922, 926-929, 1137), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), RAILLO (1950).

The concept of GORDON (1952) to include this species in F. equiseti was accepted by BOOTH (1971a), SUBRAMANIAN (1971 - as F. aurantiacum), JOFFE (1974) and DOMSCH et al. (1980); but we prefer to keep it separate from F. equiseti s. str.

Fusarium scirpi Lamb. & Fautr. var. caudatum Wollenw. - Z. Parasitenk. 3: 336-337, 1931

Fusarium caudatum Wollenw. - J. agric. Res. 2: 262, 1914

Fusarium equiseti (Corda) Sacc. var. caudatum (Wollenw.) Joffe - Mycopathol. Mycol. Appl. 53: 220-221, 1974

Descriptions: WOLLENWEBER (1916-1935 no. 599, 600, 934, 935), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), BUGNICOURT (1939), JOFFE (1974).

The concept of GORDON (1952) to include this variety in F. equiseti was accepted by BOOTH (1971a) and SUBRAMANIAN (1971 - as F. aurantiacum); but later JOFFE (1974) treated it again as a distinct variety which may be justified.

Fusarium scirpi Lamb. & Fautr. var. filiferum (Preuss) Wollenw. - Z. Parasitenk. 3: 337-338, 1931

Descriptions: WOLLENWEBER (1916-1935 no. 219-222, 601, 936), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), BUGNICOURT (1939), RAILLO (1950).

The concept of GORDON (1952) to include this variety in F. equiseti was accepted by BOOTH (1971a), SUBRAMANIAN (1971 - as F. aurantiacum) and JOFFE (1974); but we prefer to retain it as a distinct variety.

Fusarium compactum (Wollenw.) Gordon - Can. J. Bot. 30: 224, 1952

Fusarium scirpi Lamb. & Fautr. var. compactum Wollenw. - Z. Parasitenk. 3: 333, 1931

Fusarium equiseti (Corda) Sacc. var. compactum (Wollenw.) Joffe - Mycopathol. Mycol. Appl. 53: 220, 1974

Descriptions: WOLLENWEBER (1916-1935 no. 924, 925), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), JOFFE (1974).

C o l o n i e s - moderately fast-growing, reaching 4.5 - 5.5 cm diam. in 10 days at 25°C on PDA.

Aerial mycelium - villous-floccose, appressed, arachnoid, usually rather sparse, whitish to pink-ochraceous, on some substrates pale carmine spots tinged with stroma pigments occur.

Pigmentation - from beige, yellowish brown, buff to coffee-brown, in freshly isolated cultures sometimes intensively carmine, becoming pale or lacking in culture variants.

Sclerotial bodies - may be formed but not abundantly, small, globose to subglobose, sometimes of irregular shape, pale ochraceous to buff-brown.

Sporulation - sporadically in the aerial mycelium, sporodochia produced early, often confluent, forming expanded pionnotal covers, masses of conidia yellowish ochraceous to coffee-brown, becoming paler when desiccating, clay-yellow to incarnadine.

Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides in the aerial mycelium, later branching loosely, when forming sporodochial or pionnotal layers, very densely branched, compact, often terminating in more than 3 phialides.

Phialides - monophialidic, very compact, short and wide, obclavate to doliiform, often with a distinct collarette, mostly 10-15 µm long and 3-4 µm wide.

C o n i d i a - differ from typical F. scirpi and other species or varieties included in F. equiseti sensu Gordon in being more compact with a distinct, pointed, often somewhat hooked but not filamentously elongated apical cell; it has a distinctly pedicellate basal cell and rather thick walls, is distinctly septate, having cells of about equal size including the apical and the basal cell, mostly 5-septate, less frequently 3- to 4-septate and only exceptionally 6- to 7-septate, measuring:

3-4-sept.	27 x 4.7	mostly 25-31 x 4.2-5.4	(16-42 x 3.5-6.0) µm
5-sept.	41 x 4.9	mostly 35-47 x 4.3-6.0	(30-55 x 3.5-6.5) µm
6-7-sept.	43 x 5.0	mostly 39-48 x 4.8-5.3	(37-52 x 4.2-6.0) µm.

C h l a m y d o s p o r e s - rather quickly and abundantly formed, predominantly in hyphae, mostly intercalary, solitary, in pairs, frequently in chains or clusters, globose (8-15 µm), smooth or often verrucose.

Explanation of Figure 47:

Drawing and photographs of conidia, conidiophores and chlamydospores of strain 63575 on different substrates (x 500).

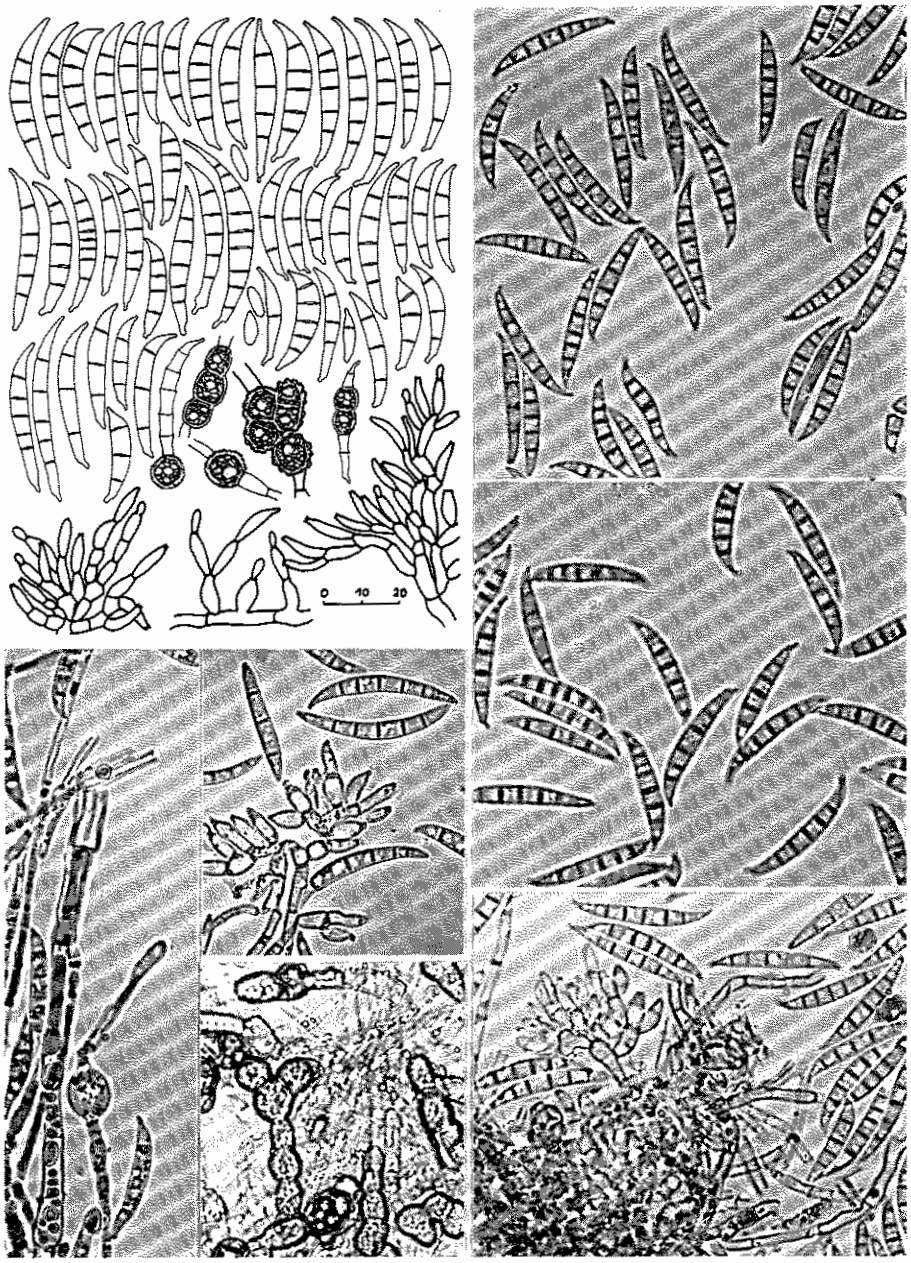

Fig. 47. Fusarium compactum.

F. compactum is typified by strain 2355, isolated from discoloured cotton thread and sent to WOLLENWEBER for identification by S.J. ASHBY/Kew in 1926. The fungus was described as a new variety and illustrated by WOLLENWEBER (1916-1935 no. 924) as well as another culture (2620) which was also isolated from discoloured cotton thread (in Uerdingen/Germany) and sent to him by RABANUS in 1927 (no. 925). The drawings and notes deposited by WOLLENWEBER in our institute include only two further strains of the corresponding type (with carmine pigmentation and "compact" macroconidia): 4382, isolated from a withered cotton plant in Texas and sent by SHERBAKOFF (no. 1153^{3c}), and 6028, isolated from a diseased culm base of a wheat plant (Triticum durum) in Canada and sent by GORDON in 1936. Four cultures, isolated from the bark of a tree (Fus. autogr. delin. no. 923), Beta, Papaver and Pirus, represent forma 1 (WOLLENWEBER 1931) without red pigmentation which was later treated as synonymous by WOLLENWEBER & REINKING (1935). GORDON (1952) retained var. compactum as distinct, but gave it specific rank. However, he transferred forma 1 to F. equiseti because of the lacking carmine pigmentation. This transfer was accepted by SUBRAMANIAN (1971). F. compactum (Wollenw.) Raillo and forma 1 Raillo (1950) are misleading and do not represent the same types of fusaria on which the concepts of WOLLENWEBER (1931) and GORDON (1952) were based. BOOTH (1971) did not keep F. compactum separate from F. equiseti, but JOFFE (1974) treated it again as a distinct variety.

During the past years we found only a single strain (63575) among hundreds of Gibbosum fusaria which could be assigned to F. compactum: LEV 10256, isolated from rotting alfalfa crown in New Zealand and sent to us by G.F. LAUNDON in 1976 for identification.

Fusarium acuminatum Ell. & Kellerm. - Proc. Acad. Sci. Philadelphia: 441, 1895

Fusarium scirpi Lamb. & Fautr. var. acuminatum (Ell. & Kellerm.) Wollenw. - Z. Parasitenk. 3: 335-336, 1931

Fusarium scirpi Lamb. & Fautr. subsp. acuminatum (Ell. & Kellerm.) Raillo - Fungi of the Genus Fusarium (Moscow): 177, 1950

Fusarium gibbosum Appel & Wollenw. emend. Bilai var. acuminatum (Ell. & Kellerm.) Bilai - Fusarii: 263, 1955 (pro parte)

Teleomorph: Gibberella acuminata Wollenw. - Zentralbl. Bakteriol. 2. Abt. 106: 190, 1943

Gibberella acuminata C. Booth - The Genus Fusarium: 161, 1971

Descriptions: WOLLENWEBER (1916-1935 no. 165-168, 170, 569, 930-933, 1107-1108), REINKING & WOLLENWEBER (1927), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), JAMALAINEN (1944), GORDON (1952), GERLACH & ERSHAD (1970), BOOTH (1971a), SUBRAMANIAN (1971 - as F. hippocastani), JOFFE (1974), HORNOK (1975), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - very fast-growing, reaching 7.8 - 8.2 cm diam. in 6 days at 25°C on PDA.

Aerial mycelium - usually rather abundantly formed, villous-floccose, in subcultures more felt-like appressed or almost lacking, whitish, pink, pale ochraceous, occasionally partly carmine tinged with stroma pigments.

Pigmentation - variable, in fresh cultures carmine to blood-red, purple, later ochraceous, amber to brown.

Sclerotial bodies - occasionally present, mainly on rice pap, pale to buff-brown, darker brown or greenish blue to dark blue, erumpent, of different shape and size.

Sporulation - usually starting rather quickly and abundantly, in some strains and in subcultures, however, rather sparse or almost lacking, sporodochia and pionnotal layers salmon to bright orange.

Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides in the aerial mycelium, later branching loosely, when forming sporodochia densely branched, terminating in 1-4 phialides.
Phialides - monophialidic, cylindric to subcylindric or slightly doliiform, rather slender, with a collarette, mostly 12-20 µm long and 3-4 µm wide.

C o n i d i a - only macroconidia formed, but often some subdeveloped 0-1-(rarely 2-)septate conidia present, in sporodochial samples very uniform, equilaterally curved, slender, mostly with a moderately elongated, pointed apical cell and a distinctly pedicellate basal cell, predominantly 5- (3- to 5-)septate, exceptionally 0- to 2- or 6- to 7-septate, measuring:

0-sept.	9 x 3.0	mostly 7-12 x 2.7-3.3	(4-17 x 2.0-5.0) µm
1-sept.	15 x 2.9	mostly 13-18 x 2.4-3.8	(11-22 x 2.0-4.2) µm
3-sept.	31 x 3.5	mostly 24-37 x 3.0-4.2	(16-51 x 2.5-4.8) µm
4-5-sept.	45 x 4.1	mostly 35-50 x 3.4-4.6	(27-62 x 3.0-5.5) µm
6-7-sept.	55 x 4.3	mostly 47-60 x 3.5-4.8	(41-80 x 3.2-5.4) µm.

C h l a m y d o s p o r e s - predominantly intercalary in hyphae, less frequently in conidia, globose to subglobose, usually smooth-walled, single (8-15 µm), but mostly in pairs, chains or clusters, becoming brownish.

Explanation of Figure 48:
Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

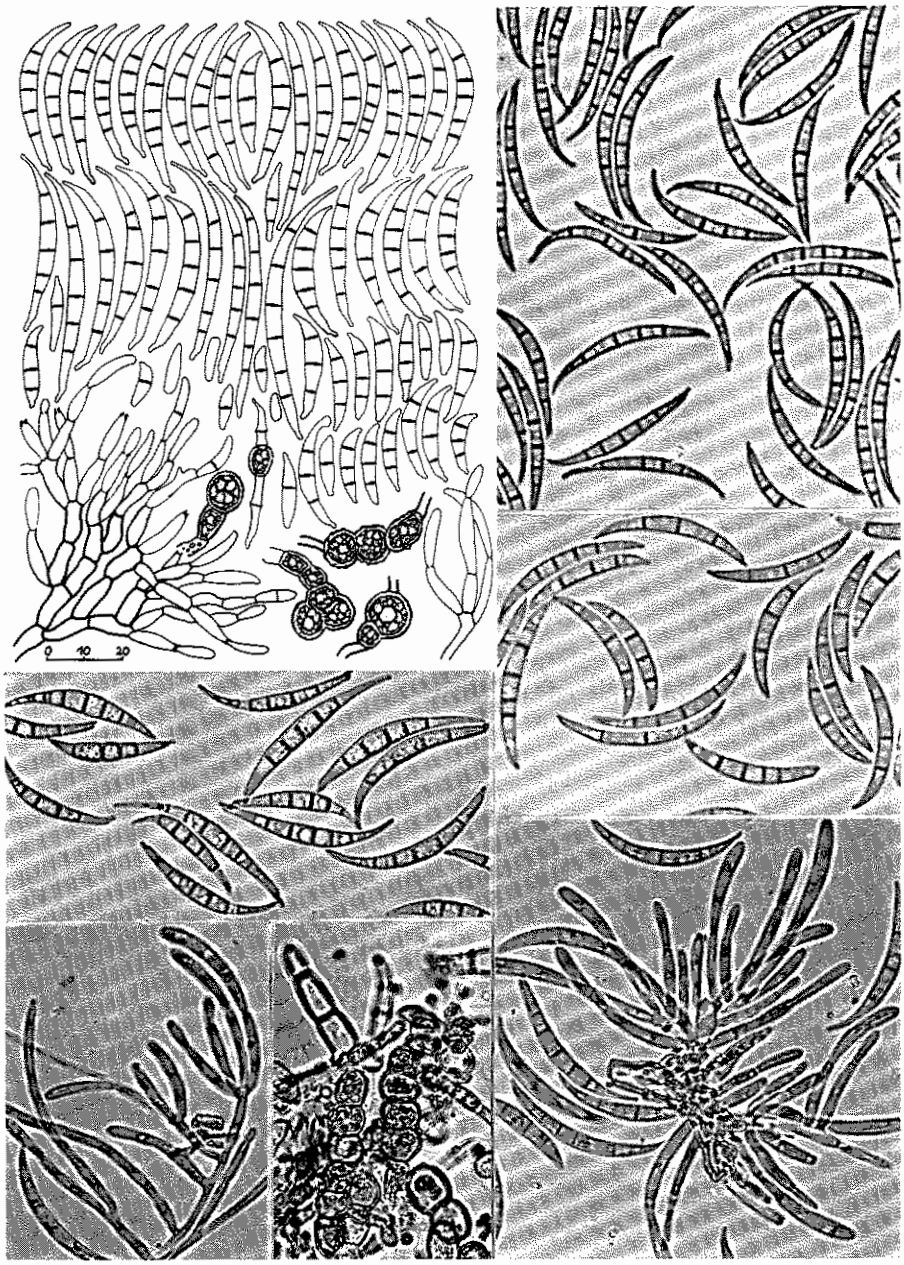

Fig. 48. Fusarium acuminatum.

F. acuminatum was described in 1895 as a distinct species. For correct author citation (Ellis & Kellerm. - not Everhart) see note by SUBRAMANIAN (1971 p. 719). It was subsequently designated as a variety of F. scirpi by WOLLENWEBER (1931) and as a subspecies by RAILLO (1950). For GORDON (1952), F. scirpi was synonymous with F. equiseti. He considered var. acuminatum worthy of species rank on account of its carmine colonies and its distinct teleomorph. Subsequently the fungus was again treated as a species by most authors. JOFFE (1974), however, following BILAI (1955) reduced the rank once more, calling it F. equiseti var. acuminatum.

During the past years we have studied about 30 isolates; at least 4 strains are available in the CBS/Baarn.

F. acuminatum is distributed worldwide and has been recorded on a wide range of plants, on several insects and very often in soils of temperate and tropical areas. Regarding its distribution in nature and its pathogenic capabilities it is rather similar to F. equiseti, but occurring less frequently. More detailed information is given by BOOTH (1971a) and DOMSCH et al. (1980).

Fusarium longipes Wollenw. & Reinking - Phytopathology 15: 160, 1925

Fusarium scirpi Lamb. & Fautr. var. longipes (Wollenw. & Reinking) Wollenw. - Z. Parasitenk. 3: 337, 1931

Fusarium avenaceum (Fr.) Sacc. var. anguioides (Sherb.) Bilai - Fusarii: 258 (pro parte)

Fusarium equiseti (Corda) Sacc. var. longipes (Wollenw. & Reinking) Joffe - Mycopathol. Mycol. Appl. 53: 221, 1974

Descriptions: WOLLENWEBER (1916-1935 no. 937), WOLLENWEBER & REINKING (1925), REINKING & WOLLENWEBER (1927), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), BUGNICOURT (1939), SUBRAMANIAN (1971), JOFFE (1974), GERLACH (1978).

C o l o n i e s - very fast-growing, reaching 7.2 - 8.0 cm diam. in 6 days at 25°C on PDA.

Aerial mycelium - mostly rather abundant, floccose to tufted, often growing in concentric rings, whitish to carmine, interspersed with ochre tones.

Pigmentation - very similar to F. acuminatum, from beige, ochre, amber to olive-brown, rose, pale vinaceous to strong carmine or blood-red.

Sclerotial bodies - usually present, but not abundant, comparatively small, variable in shape and colour, pale brownish to reddish brown or carmine.

Sporulation - starting in a few days in the aerial mycelium, later abundantly in ochre to orange erumpent sporodochia, sometimes producing small columns or expanded pionnotes, soon covering the central and later wider parts of the colony.

Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single phialides in the aerial mycelium, later branching loosely, when forming sporodochia, densely branched.
Phialides - monophialidic, usually rather compact, predominantly obclavate to doliiform, mostly 8-15 µm long and 3.0-4.0 µm wide.

C o n i d i a - only macroconidia formed, but often a few 0- or 1-septate conidia present, extremely variable in shape and size, if formed in the aerial mycelium often distinctly smaller, more compact and with a relatively short pedicellate basal cell, if formed in sporodochia or pionnotes falcate, elongated, parabolically to hyperbolically curved, with an attenuate, very long, whip-like apical cell and a very conspicuous stipitate foot cell, mostly 5- to 7-septate, less frequently 3- to 4- or 8- to 12-septate, measuring:

3-sept.	54 x 3.3	mostly 40- 72 x 2.8-3.6	(27- 79 x 2.2-4.0) µm
4-5-sept.	79 x 3.5	mostly 62-102 x 2.8-3.8	(36-119 x 2.5-4.5) µm
6-7-sept.	92 x 3.3	mostly 75-111 x 2.2-4.2	(54-133 x 2.0-4.5) µm
8-9-sept.	101 x 3.0	mostly 80-125 x 2.5-3.7	(57-142 x 2.0-4.0) µm
10-12-sept.	108 x 3.3	mostly 87-132 x 2.7-4.0	(68-145 x 2.2-4.5) µm.

C h l a m y d o s p o r e s - formed rather abundantly and early in hyphae, less frequently in conidia, predominantly intercalary, solitary, globose to subglobose (6-13 µm), often in pairs or chains, sometimes forming clusters, smooth-walled to verrucose, finally brownish or reddish tinged.

Explanation of Figure 49:
Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 937 of the type culture R 34; drawing and photographs of conidia, conidiophores, and chlamydospores of strains 11422 (= IMI 112211a) and 62061 (= CBS 739.79) on different substrates (x 500).

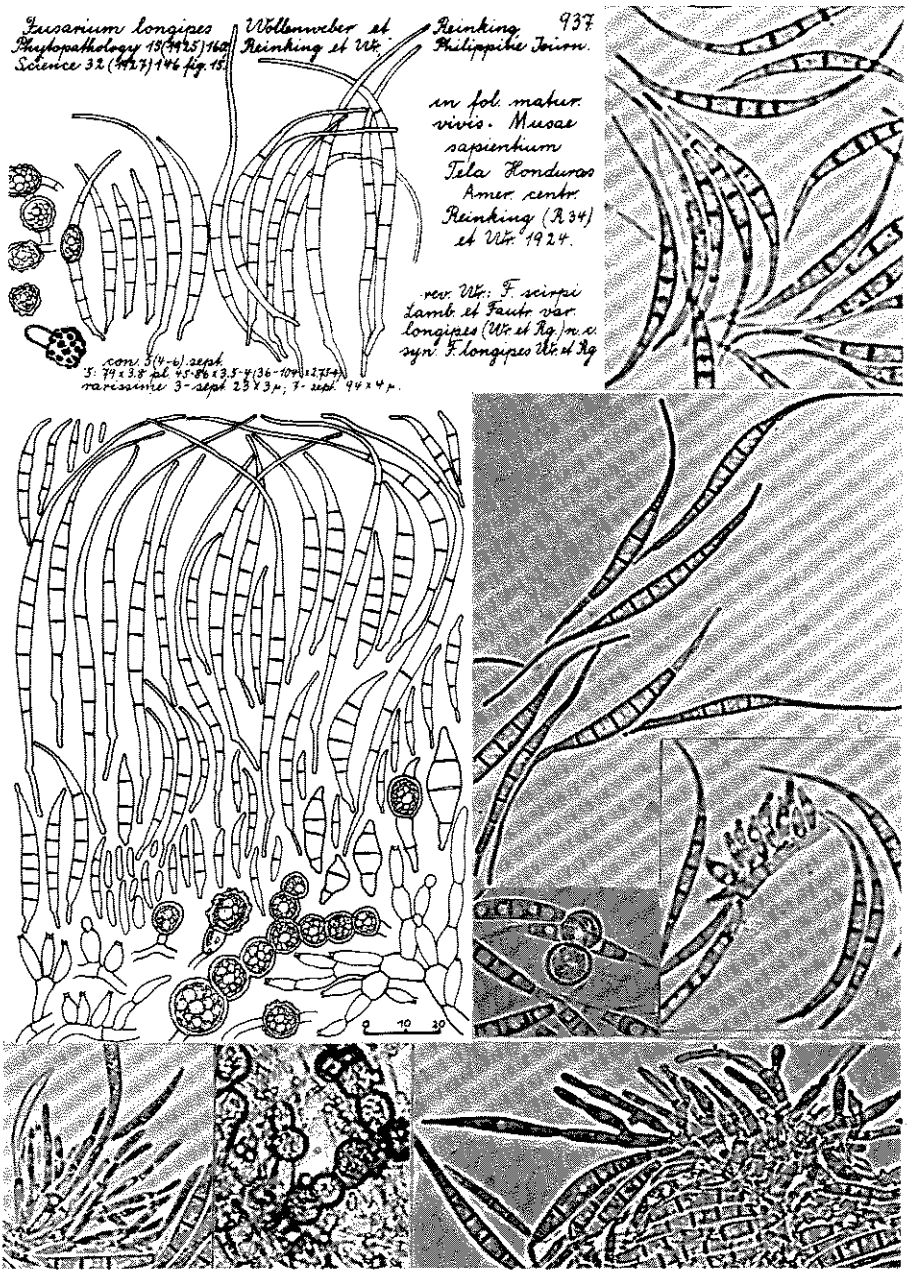

Fig. 49. Fusarium longipes.

This Fusarium is based on an isolate (R 34) from banana leaves in Honduras and was described by WOLLENWEBER & REINKING (1925) as a new species and retained by REINKING & WOLLENWEBER (1927). Later, however, it was classified as a variety of F. scirpi (WOLLENWEBER 1931, WOLLENWEBER & REINKING 1935). BUGNICOURT (1939) isolated it from numerous plant species in Indo-China and presented a detailed and illustrated description. RAILLO (1950) and GORDON (1952) promoted this Fusarium again to species rank which was accepted by SUBRAMANIAN (1971) and GERLACH (1978). BILAI (1955) regarded it as synonymous with F. avenaceum var. anguioides. Surprisingly, BOOTH (1971a) considered it identical with F. equiseti, while JOFFE (1974) treated the fungus as a variety of F. equiseti.

An isolate of the Gibbosum group (IMI 112211a) which was obtained from G. TAYLOR/Manchester in 1970 and which produces an intensive red pigment on a number of media was identified as F. longipes. Corresponding Fusarium strains were isolated from tropical seeds (S.B. MATHUR/ Copenhagen, personal communication, 1971) and repeatedly from soil in West Malaysia and Singapore, of which 4 strains were sent to us in 1974 by GLORIA LIM for identification; one strain (62061) is deposited in the CBS/Baarn (739.79).

This Fusarium which is obviously restricted to subtropical and tropical regions of Central America, southeast Asia, India and the Sovietunion should be retained as a very characteristic and clearly distinct species.

There are no reliable reports on its association with plant diseases.

Fusarium brachygibbosum Padwick - Mycol. Pap. 12: 11, 1945

Descriptions: PADWICK (1945), SUBRAMANIAN (1971).

BOOTH (1971a) treated the fungus as synonymous with F. semitectum, but SUBRAMANIAN (1971) mentioned it as a distinct species. In describing F. brachygibbosum, PADWICK (1945) wrote:

"Aerial mycelium on potato dextrose agar abundant, white and rose, medium blood coloured, remaining unaltered on addition of sodium hydroxide; on steamed rice abundant, white, medium fulvous. Sclerotia on potato dextrose agar and steamed rice at 20°C, but not at 30°C, up to 2 mm diam., white to amber. Typical microconidia lacking in aerial mycelium; conidia when present continuous or 1-3-septate, ovoid to fusiform, the septate spores slightly curved. Macroconidia scattered thinly on the agar surface on potato dextrose agar at 20°C but not at 30°C, 0-5-septate, septa distinct, conidia often hyperbolically curved, with somewhat tapering apex and tapering or rarely slightly foot-celled base, the central cells broad.

Conidia:	0-sept.	2.5 x 7.0	(1.8-3.2 x 4.6-10.7) µm
	1-sept.	2.4 x 9.3	(1.8-3.6 x 6.4-12.5) µm
	2-sept.	2.8 x 13.5	(1.8-3.6 x 11.4-17.8) µm
	3-sept.	3.5 x 18.9	(2.1-5.3 x 13.5-35.6) µm
	4-sept.	4.0 x 26.9	(3.2-5.3 x 19.6-35.6) µm
	5-sept.	4.8 x 33.4	(4.3-5.3 x 28.5-40.9) µm.

Chlamydospores terminal and intercalary, single and in chains, generally 1-celled and globose, 12.4 (10.7-15.3) µm, occasionally 2-celled, smooth, granular.

Isolated from diseased seedlings of Sorghum vulgare Pers., Parbhani, Hyderabat, Dn., India. Culture sent by Dr. Syeed Vaheeduddin, September, 1940. Type culture deposited in the Indian Fungous Culture Collection, I.A.I.R., New Delhi.

The spores of this Fusarium most nearly resemble, in the curvature of their dorsal lines and in their attenuated tips, those of the section Gibbosum; but they are rarely and only slightly foot-celled and their ratio of length to breadth (7:1) in 5-septate spores is much narrower than typical Gibbosum which vary from 10:1 to 20:1. Furthermore, the chlamydospores are as commonly terminal as intercalary, whereas in Gibbosum they are normally intercalary. The spores are altogether too small for sub-section Trichothecioides, and generally too thick for Neesiola, of the section Discolor. Members of both the subsections Neesiola and Saubinetii form macrospores typically in sporodochia and pionnotes, and none of them possesses the bulging of the middle cells typical of the Hyderabad fungus, nor yet the degree of dorsiventrality found frequently in the 5-septate spores. The species is best placed within the section Gibbosum, and is readely distinguished from related species by its short, stout spores."

According to the description and figure given by PADWICK this Fusarium is obviously not identical with F. semitectum as suggested by BOOTH (1971a). It is a member of the Gibbosum group most similar to F. compactum or F. acuminatum.

Fusarium equiseti (Corda) Sacc. var. intermedium Saccas - Agron. trop., Nogent, 10: 49, 1955

Published without Latin diagnosis.

Section FUSARIUM (Section DISCOLOR Wollenw. - Phytopathology 3: 31, 1913)

Fusarium heterosporum Nees ex Fr. - Syst. mycol. 3: 472, 1832
var. heterosporum

Descriptions: WOLLENWEBER (1916-1935 no. 292-297, 300-304, 602-604), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), BOOTH (1971a), JOFFE (1974), HORNOK (1975), BOOTH (1978b).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 8 days at 25°C on PDA.
Aerial mycelium - usually abundant, floccose to felt-like.
Pigmentation - whitish, pale peach, flesh, yellowish to ochraceous, finally amber to brownish red; distinct carmine, vinaceous, violet or bluish colours completely lacking.
Sclerotial bodies - usually absent, rarely some pale buff-brown, small, flat sclerotia present.
Sporulation - nearly absent or only sparse in the aerial mycelium, later forming rather large, bright orange sporodochial or pionnotal masses of conidia, but the ability to sporulate may soon become lost by subculturing.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, loosely branched, those of sporodochia often densely, irregularly or verticillately branched.
Phialides - monophialidic, cylindric to subcylindric, sometimes doliiform to almost ellipsoid and on the average rather short and closely appressed in sporodochial layers, measuring mostly 10-15 x 2.5-3.0 µm.

C o n i d i a - in the beginning rather variable in size, but very uniform in samples from sporodochia, falcate, generally rather straight and only slightly curved, sometimes dorsiventral, with a somewhat elongated or slightly hooked apical and a distinct pedicellate basal cell, predominantly 3- to 5-septate, often some 0- to 2-septate conidia may be present, measuring:

0-sept.	11 x 3.0	mostly 9-16 x 2.6-3.3	(6-20 x 2.2-4.0) µm
1-sept.	17 x 3.0	mostly 11-22 x 2.8-3.3	(10-26 x 2.0-4.0) µm
3-sept.	27 x 3.2	mostly 18-37 x 2.4-4.3	(15-51 x 2.0-5.2) µm
4-5-sept.	35 x 3.8	mostly 28-43 x 3.5-4.5	(25-54 x 2.4-5.5) µm.

C h l a m y d o s p o r e s - generally sparse, mostly intercalary in hyphae, single, globose to subglobose (8-13 µm), in pairs, short chains or clusters, smooth-walled to slightly rough-walled.

Explanation of Figure 50:

Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

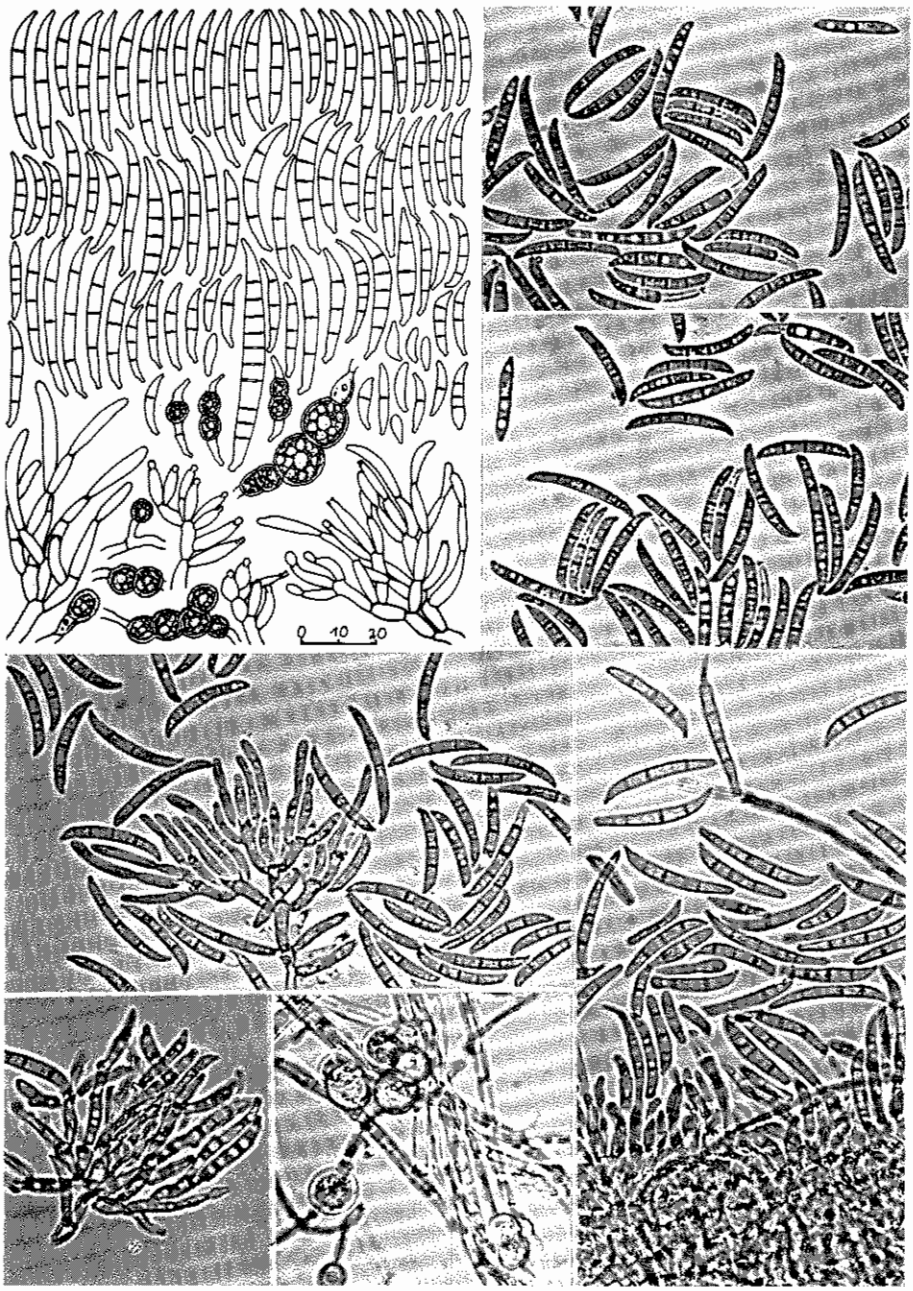

Fig. 50. Fusarium heterosporum var. heterosporum.

This Fusarium was not mentioned by DOIDGE (1938), BUGNICOURT (1939), JAMALAINEN (1943a) or SUBRAMANIAN (1971). BILAI (1955), GORDON (1959), BOOTH (1971a), JOFFE (1974), HORNOK (1975) and BOOTH (1978b) treated it as a separate species and accepted the concept of RAILLO (1950) who considered F. reticulatum identical. The concept presented by BOOTH (1971a) who also regarded F. graminum as synonymous with F. heterosporum (1978b), is too comprehensive; the conidia he drew in 1971 are misleading and not representative of F. heterosporum in the sense of WOLLENWEBER & REINKING (1935). But we think that F. heterosporum, F. reticulatum and F. graminum are distinct as is shown in our descriptions of the respective species. Our opinion is based on numerous notes and drawings of specimens and cultured strains deposited by WOLLENWEBER and 9 additional strains isolated during the past years from inflorescences of different gramineous plants infested with ergot.
Representative strains isolated from Claviceps purpurea are available in the CBS/Baarn (252.52, 391.68).

Fusarium heterosporum Nees ex Fr. f. sp. aleuritidis Saccas & Drouillon - Agron. trop. 6: 251, 1951

Reported from Central Africa on Aleurites spp., published without Latin diagnosis.

Fusarium heterosporum Nees ex Fr. var. congoense (Wollenw.) Wollenw. - Z. Parasitenk. 3: 350, 1931

Fusarium congoense Wollenw. - Fus. autogr. delin.: 307, 1916

Descriptions: WOLLENWEBER (1916-1935 no. 306, 307, 612, 1140, 1141), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938).

This Fusarium, initially described as a distinct species based on a strain isolated in 1907 from ovaries of Bromus unioloides infected with Ustilago bromivora in South Africa (according to DOIDGE 1938, p. 371), is documented in our institute by WOLLENWEBER's drawings and notes, including his correspondence with DOIDGE. This strain belonged to a collection of 8 specimens of which 6 were studied as cultured strains. All were found on ovaries of different gramineous hosts infected with ergot or smut in different parts of South Africa. This variety has larger, higher septate conidia than var. heterosporum and produces carmine pigmentation on some substrates.

BUGNICOURT (1939), BILAI (1955), SUBRAMANIAN (1971) and JOFFE (1974) did not mention this fungus. GORDON (1959) and BOOTH (1971a) treated it synonymous with F. heterosporum var. heterosporum following RAILLO (1950).

This Fusarium could not be re-examined since no cultured strain was available. According to the material deposited by WOLLENWEBER and the detailed description by DOIDGE (1938), however, there may actually exist such a type justifying a separate variety.

Explanation of Figure 51:

Reproductions of WOLLENWEBER's Fus. autogr. delin. no. 307 of the type culture and no. 1141 of strain 4311; drawing of conidia, conidiophores and chlamydospores, according to WOLLENWEBER's drawings of 6 different strains (x 500).

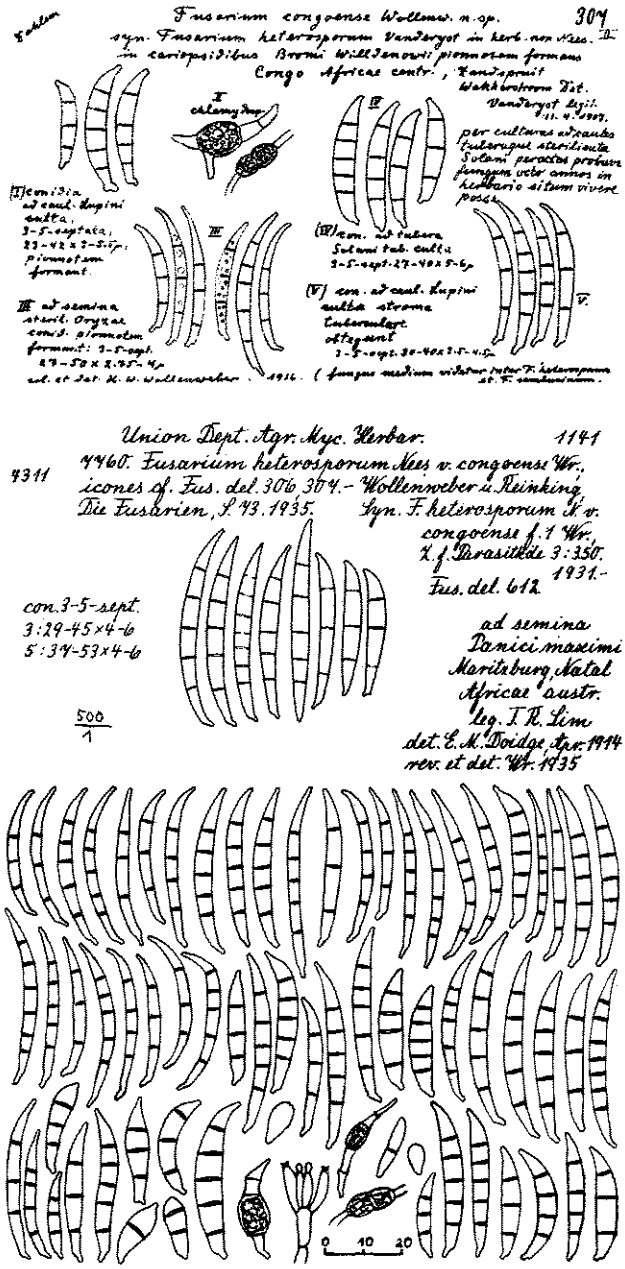

Fig. 51. Fusarium heterosporum var. congoense.

Fusarium reticulatum Montagne - Ann. Sci. nat. 20, sér. 2: 379, 1843 var. reticulatum

Fusarium heterosporum Nees ex Fr. f. 2 Raillo - Fungi of the Genus Fusarium (Moscow): 217, 1950 (pro parte)

Teleomorph: Gibberella cyanea (Sollm.) Wollenw. - Fus. autogr. delin.: 39, 1916

? Gibberella gordonii C. Booth - The Genus Fusarium: 177, 1971

Descriptions: WOLLENWEBER (1916-1935 no. 39, 119-121, 938, 939, 1138), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), GERLACH & ERSHAD (1970), GERLACH (1978).

C o l o n i e s - moderately fast-growing, reaching 6.5 - 7.5 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - generally abundant, floccose to villose, whitish, pale rose, ochraceous.
Pigmentation - whitish, pale rose, ochraceous to buff-brown, intensive carmine to purple.
Sclerotial bodies - present in freshly isolated strains, sometimes abundant, usually flat, rather variable in shape and colour, globose or cauliflower-like, pale brownish, dark buff-brown to dark violet, finally blackish blue.
Sporulation - starting early in the aerial mycelium, later in distinct, pustule-like, cream to pale orange coloured sporodochia, often confluent, on some substrates very scarce.
Odour - not perceptible.

C o n i d i o p h o r e s - early developing as single lateral phialides on hyphae or loosely branching, later in sporodochia or pionnotes more densely aggregated, irregularly or verticillately branched.

Phialides - monophialidic, cylindric to subcylindric or almost doliiform, on the average rather short and wide, often with a collarette, measuring mostly 10-15 x 3.0-3.5 µm.

C o n i d i a - only formed as macroconidia, rather uniform in shape, fairly slender, falcate, only slightly curved, narrowing toward both ends, with a somewhat elongated and almost pointed apical and a distinct pedicellate basal cell, predominantly 3- to 5-septate, rarely 0- to 2-septate, measuring:

0-sept.	9 x 2.6	mostly 8-12 x 2.4-3.0	(6-15 x 2.0-3.5) µm
1-sept.	17 x 2.8	mostly 14-20 x 2.5-3.2	(10-23 x 2.3-4.0) µm
3-sept.	27 x 3.3	mostly 22-36 x 3.0-4.3	(17-44 x 2.5-5.0) µm
4-sept.	32 x 3.5	mostly 30-36 x 3.3-3.8	(26-45 x 2.5-5.2) µm
5-sept.	38 x 3.6	mostly 34-46 x 3.3-4.0	(28-54 x 2.8-5.5) µm.

C h l a m y d o s p o r e s - besides more or less long chains of widely swollen hyphal cells, typical chlamydospores may occur, by and large not abundant, in chains or clusters in hyphae, sometimes brownish, rarely in conidia, globose to subglobose, smooth-walled, single (7-12 x 6-10 µm) or in pairs.

Explanation of Figure 52:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 938 of strain 1966 (= CBS 190.31); drawing and photographs of conidia, conidiophores and chlamydospores of strain 63657 (= CBS 473.76) on different substrates (x 500).

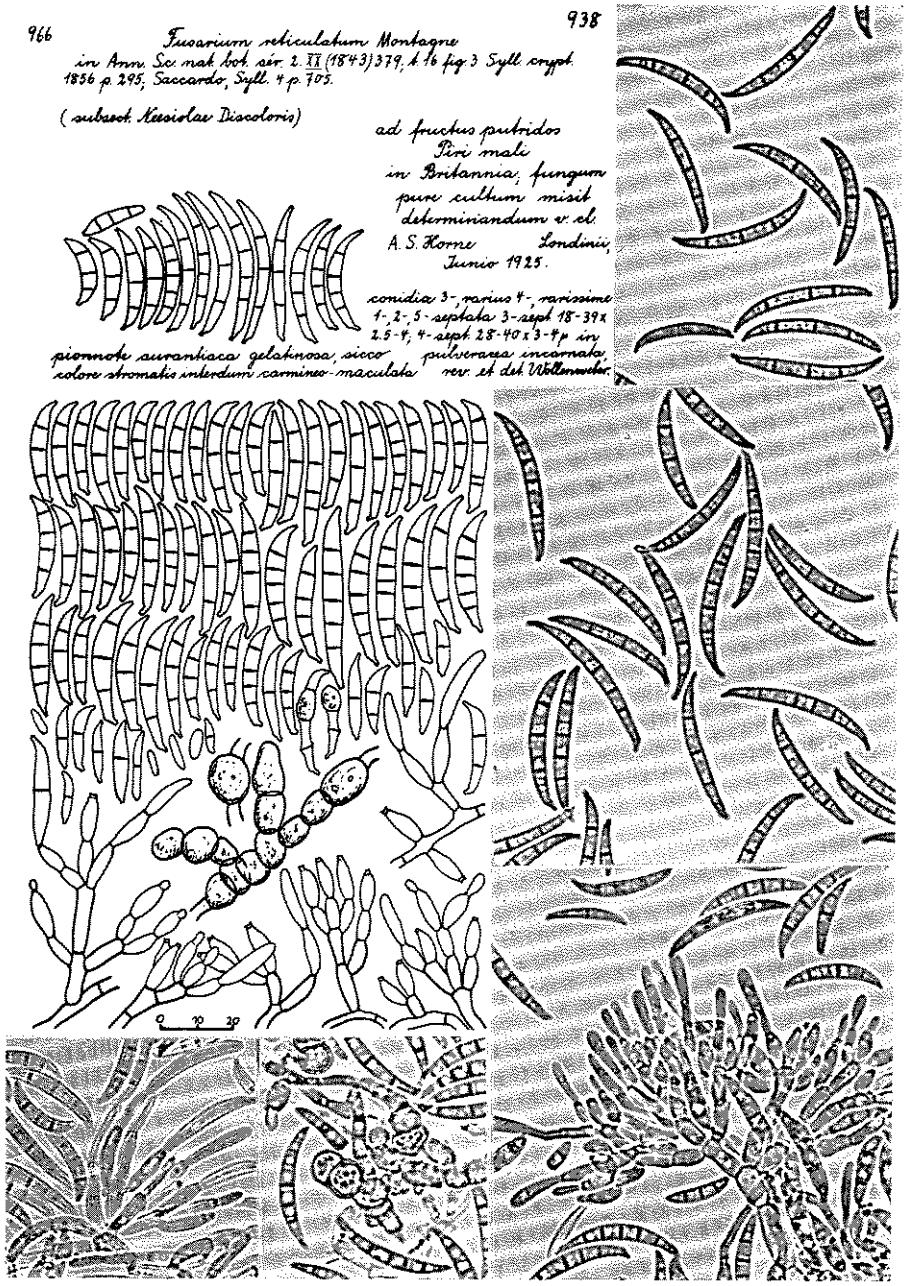

Fig. 52. Fusarium reticulatum var. reticulatum.

This Fusarium, retained by WOLLENWEBER (1931) and WOLLENWEBER & REINKING (1935) as a species distinct from F. heterosporum, was also acknowledged by GORDON (1956a) as a separate taxon. Later, however, GORDON (1959), BILAI (1955) and BOOTH (1971a, 1978b) adopted the opinion of RAILLO (1950) that F. reticulatum is synonymous with F. heterosporum. DOIDGE (1938), BUGNICOURT (1939), SUBRAMANIAN (1971) and JOFFE (1974) did not mention this Fusarium.

On the basis of WOLLENWEBER's original material including 5 cultured strains and of a fresh culture (63657 = CBS 473.76) isolated from a bark lesion of Sophora japonica in northern Germany, we consider it again as a separate species. This opinion has been confirmed by studying strain IMI 61306 sent to us as F. compactum, strain 9408 (= Yb 5A) isolated by W. GAMS from humus soil in the Alps and strain 63555 (= R 2709) isolated from a root lesion of Paspalum dilatatum in Australia and sent for comparison by P. NELSON/Pennsylvania.

F. reticulatum is clearly distinguished from F. heterosporum in macroscopic characters such as growth and pigmentation as well as in the type of the conidia. Moreover, F. heterosporum sensu stricto is apparently restricted to gramineous plants, often occurring on inflorescences infected with ergot or smut. Therefore a distinct difference between the biological activities of the two fungi is evident.

Fusarium reticulatum Montagne f. 1 Wollenw. in Wollenweber & Reinking Die Fusarien: 74, 1935

Descriptions: WOLLENWEBER (1916-1935 no. 1139), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943).

This Fusarium was described as being different from F. reticulatum because of its sometimes slightly taller conidia and the absence of carmine pigmentation. It is represented by drawings and comments of 3 strains studied by WOLLENWEBER in culture: 4672 isolated in 1932 from Beta vulgaris, Syracuse/USA, 5114 isolated in 1933 from cheese by W. HENNEBERG, Kiel/Germany (see Fus. autogr. delin. no. 1139) and 6270 isolated in 1937 from timber pulp by G. GOIDÀNICH, Rome/Italy. There are no further records by other authors, except GORDON (1959) and BOOTH (1971a) who treated the fungus as synonymous with F. heterosporum in the sense of RAILLO (1950).

Fusarium reticulatum Montagne var. negundinis (Sherb.) Wollenw. - Z. Parasitenk. 3: 351, 1931

Fusarium negundi Sherb. in Hubert - J. agric. Res. 26: 451, 1923

Fusarium heterosporum Nees ex Fr. var. negundinis (Sherb.) Raillo - Fungi of the Genus Fusarium (Moscow): 217, 1950

Descriptions: HUBERT (1923), WOLLENWEBER (1916-1935 no. 940), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), RAILLO (1950).

SHERBAKOFF described this fungus originally as a distinct species, but WOLLENWEBER (1931) treated it as a variety of F. reticulatum having higher septate and somewhat longer conidia. He studied and illustrated the type culture (Fus. autogr. delin. no. 940) which was isolated by E. HUBERT in 1921/22 as the causal agent of red stain of boxelder (Acer negundo) occurring in Madison/Wisconsin. WOLLENWEBER deposited a subculture in the CBS/Baarn (183.31). To the best of our knowledge there is no other published record of this fungus and no culture available. RAILLO (1950) considered it a separate variety of F. heterosporum in a broader concept. BILAI (1955) and BOOTH (1971a), however, treated it synonymous with F. heterosporum. GORDON (1952-1959) and other authors did not mention this Fusarium.

The peculiarities of this fungus may be insufficient to separate it as a distinct variety. The above mentioned strain 63657 (= CBS 473.76) which was isolated from Sophora, was studied over a long period on a number of substrates under different conditions. It showed such a broad variation with regard to the number of septa and to the size of conidia that it is not possible to decide whether it should be classified as F. reticulatum var. reticulatum or var. negundinis.

Fusarium sambucinum Fuckel - Symb. mycol.: 167, 1869 var. sambucinum

Fusarium sambucinum Fuckel f. 2, 3, 4, 5 Wollenw. - Z. Parasitenk. 3: 357-358, 1931

Fusarium sambucinum Fuckel var. minus Wollenw. - Z. Parasitenk. 3: 358, 1931

Teleomorph: Gibberella pulicaris (Fr. ex. Fr.) Sacc. - Michelia 1: 43, 1877 var. pulicaris

Descriptions: WOLLENWEBER (1916-1935 no. 27-29, 31-36, 311-320, 322, 323, 325, 326, 515, 516, 607, 611, 941, 942, 1110-1114b, 1142-1145), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), JAMALAINEN (1943a), GORDON (1952), BOOTH (1971a), SUBRAMANIAN (1971 - as F. maydis), BOOTH (1973b), JOFFE (1974), HORNOK (1975), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - fast-growing, reaching 5.5 - 8.0 cm diam. in 10 days at 25°C on PDA; considerable differences between different strains.
Aerial mycelium - generally very abundant, floccose to felt-like or tufted, whitish to rose or pale brown.
Pigmentation - whitish, yellowish, rose, greyish red, bay to blood coloured, on neutral or slightly alkaline media more bluish.
Sclerotial bodies - in freshly isolated cultures usually rather abundant and conspicuous, often formed as rough, cauliflower-like stilboid sclerotial plectenchyma, up to 1 cm high and mostly buff to dark brown in colour.
Sporulation - starting sparsely in the aerial mycelium, later in most strains sporodochia on erumpent sclerotial stroma usually abundant, rose to ochraceous or pale salmon, sometimes tinged with stroma pigments, finally confluent.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, later sparsely branching, in sporodochia or pionnotes densely, irregularly or verticillately branched, mostly terminating in 2-4 phialides.
Phialides - monophialidic, cylindric, subcylindric to obclavate or doliiform, often with a collarette, mostly 14-18 x 3.8-4.5 µm.

C o n i d i a - rather uniform in type and size, compact and thick-walled, distinctly septate, with cells equally long and wide, falcate, more or less dorsiventrally curved, with a rather short, abruptly inward bent, attenuate and constricted apical and a distinctly pedicellate basal cell, usually 3- to 5-septate, measuring:

3-sept.	28 x 4.7	mostly 22-35 x 4.0-5.2	(16-48 x 3.0-6.0) µm
4-5-sept.	35 x 5.1	mostly 26-44 x 4.0-5.6	(20-56 x 3.5-6.0) µm
6-7-sept.	42 x 5.2	mostly 37-50 x 4.5-5.6	(33-58 x 3.7-6.0) µm.

C h l a m y d o s p o r e s - usually not very abundant, intercalary, terminal or rarely lateral, in hyphae or conidia, globose to subglobose, smooth-walled, single (6-12 µm), in pairs, chains or clusters.

Explanation of Figure 53:
Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

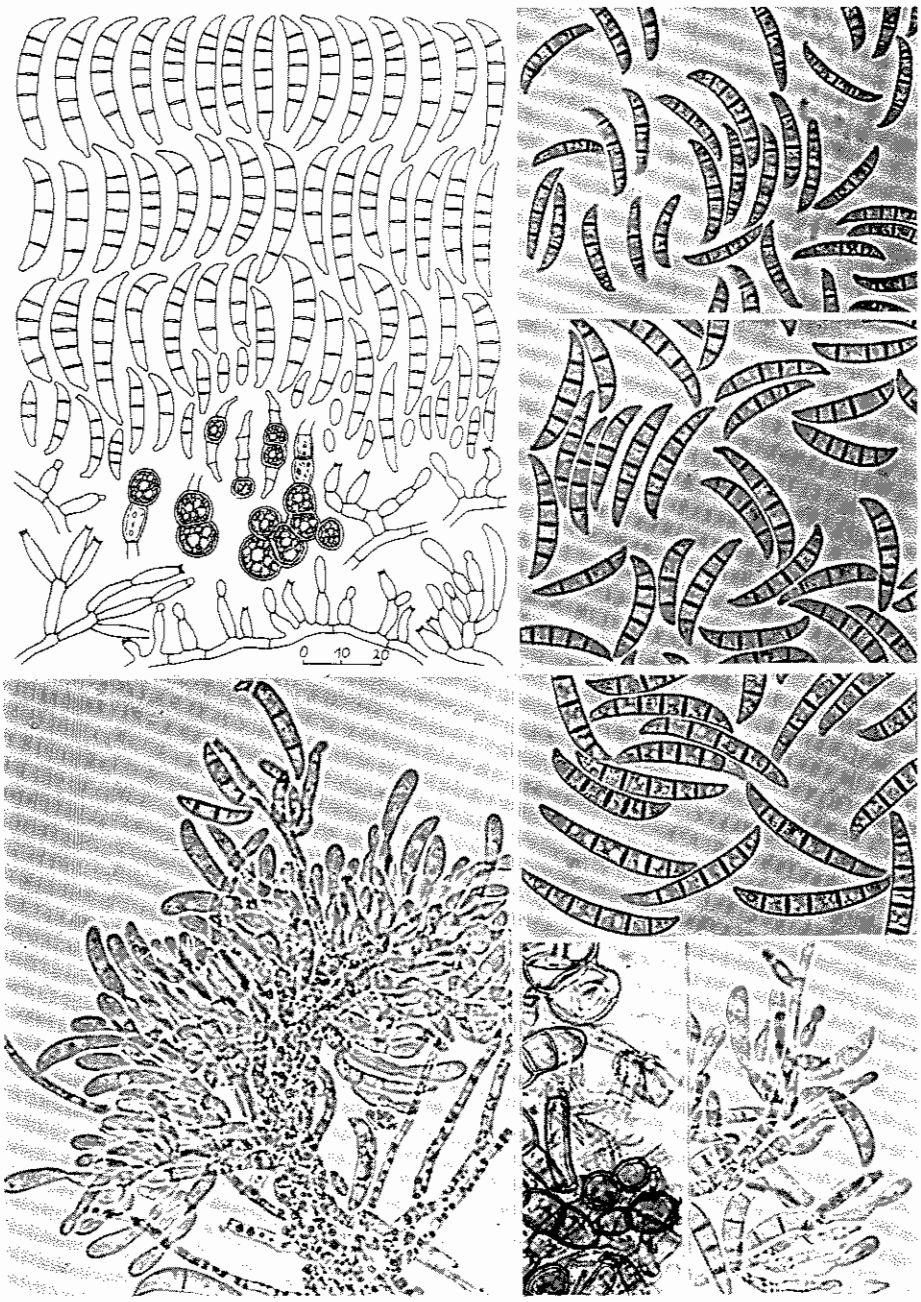

Fig. 53. Fusarium sambucinum var. sambucinum.

F. sambucinum is a well known species and is accepted by many authors, though their concepts vary somewhat. Our treatment of F. sambucinum var. sambucinum includes all varieties and forms which were distinguished by WOLLENWEBER (1931) and WOLLENWEBER & REINKING (1935) except forma 1 (= var. coeruleum) and forma 6 (= F. sulphureum).

F. sambucinum is the type of the genus Fusarium. The 3 specimens deposited by LINK (1809) as F. roseum represent 3 different fungi (WOLLENWEBER Fus. autogr. delin. no. 138, 311, 354). In 1821 GRAY designated one of them as the holotype (cf. WOLLENWEBER Fus. autogr. delin. no. 311) citing only stems of a malvaceous plant (? Althaea rosea) as the substrate of F. roseum in the validating text. Therefore the correct name of this Fusarium would be Fusarium roseum Link ex Gray. SNYDER & HANSEN (1945) used this name for all fusaria of the sections Arthrosporiella, Roseum, Gibbosum and Discolor making it a source of error (nomen ambiguum).

This Fusarium is cosmopolitan and especially common in temperate and Mediterranean regions. It is associated with various plant diseases including canker and die-back in woody plants, and also hops, root and seedling rots, fruit and storage rots of numerous cultivated plants. With the exception of a causal agent of hop canker, F. sambucinum var. sambucinum is of comparatively minor economic importance as a plant pathogen. Many records (see BOOTH 1971a, 1973b) of its role as a primary pathogen are open to doubt.

More detailed information with regard to its regional distribution, behaviour as a plant pathogen and ecological aspects is given by DOMSCH et al. (1980) and BOOTH (1971a, 1973b).

Fusarium sambucinum Fuckel var. coeruleum Wollenw. - Ann. mycol. 15: 55, 1917 - Fus. autogr. delin.: 321

Fusarium sambucinum Fuckel f. 1 Wollenw. - Z. Parasitenk. 3: 356, 1931

Teleomorph: Gibberella pulicaris (Fr. ex Fr.) Sacc. var. minor Wollenw. - Z. Parasitenk. 3: 356, 1931

Descriptions: WOLLENWEBER (1916-1935 no. 321, 324, 608-610, 1115-1117 b), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), GORDON (1952), BOOTH (1971a), JOFFE (1974).

C o l o n i e s - fast-growing, reaching 6.5 - 8.0 cm diam. in 10 days at 25°C on PDA; considerable differences between strains.
Aerial mycelium - generally very abundant, floccose to felt-like or tufted, whitish to rose, dark purple to blackish blue tinges occur.
Pigmentation - as in var. sambucinum, with the exceptions of blackish blue-violet sclerotia and stroma.
Sclerotial bodies - also usually very abundant and variable in size, often dark violet to blackish blue in colour.
Sporulation - no differences to var. sambucinum.
Odour - in most strains absent, in one strain (9306), however, rather intensive aromatic odour present, suggesting lilac as generally occurring in F. redolens and in some strains of F. oxysporum.

C o n i d i o p h o r e s - and phialides of about the same morphology as in var. sambucinum.

C o n i d i a - generally of the same type as in var. sambucinum, but in some strains taller (which is one of the differentiating criteria according to WOLLENWEBER 1931 and WOLLENWEBER & REINKING 1935), in others, however, wider, with a more curved upper part and a distinctly pointed apical cell, 3-, but mostly 4- to 5-septate, exceptionally 6- to 7-septate, measuring:

3-sept.	29 x 4.4	mostly 26-35 x 3.8-5.0	(20-38 x 3.0-5.5) µm
	34 x 5.4	mostly 30-39 x 4.3-5.8	(23-46 x 3.6-6.0) µm
4-sept.	33 x 4.9	mostly 29-40 x 4.0-5.5	(23-42 x 4.0-6.0) µm
	38 x 5.4	mostly 33-45 x 4.5-5.8	(28-49 x 4.0-6.5) µm
5-sept.	35 x 4.9	mostly 28-42 x 4.2-5.5	(24-46 x 4.0-6.0) µm
	41 x 5.4	mostly 35-48 x 4.5-5.8	(30-52 x 4.0-6.5) µm
7-sept.	42 x 5.3		(35-50 x 4.0-6.0) µm.

C h l a m y d o s p o r e s - in some strains rather abundant and striking, on the average larger than in F. sambucinum var. sambucinum, predominantly intercalary in hyphae, single (8-15 µm) but more often in chains and clusters.

Explanation of Figure 54:

Drawing and photographs of conidia, conidiophores and chlamydospores of strains 11425 and 63867 (= TOUSSOUN R 3860) on different substrates (x 500).

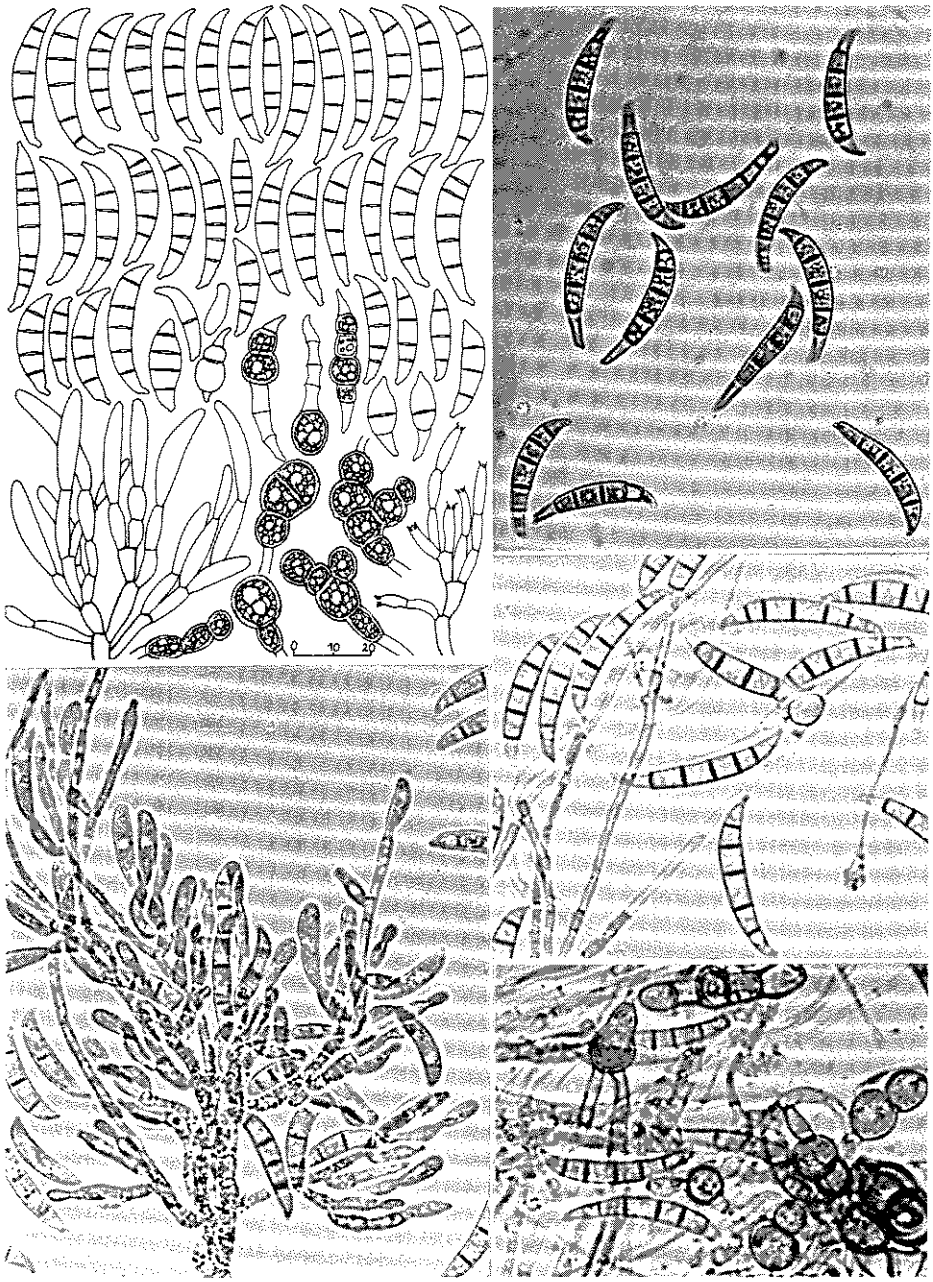

Fig. 54. Fusarium sambucinum var. coeruleum.

This Fusarium was initially described as a distinct variety. The type culture (W - 99) isolated in 1915 from a dead twig of Sambucus nigra in Germany was illustrated by WOLLENWEBER (Fus. autogr. delin.no. 321). Later he treated it as forma 1 of the 6 forms he proposed to distinguish in F. sambucinum. As its differential characteristics he stated dark bluish pigmented sclerotia and stroma besides somewhat taller conidia. DOIDGE (1938), BUGNICOURT (1939), JAMALAINEN (1943a), BILAI (1955) and SUBRAMANIAN (1971) did not mention the fungus. It was regarded as synonymous with F. sambucinum by RAILLO (1950) who divided it partly into other varieties and forms. GORDON (1952 1959), BOOTH (1971a) and JOFFE (1974) accepted it once more as a distinct variety. The conidia illustrated by BOOTH (1971a) which are rather different from those he presented for var. sambucinum are largely of the same type as in several of the 15 isolates studied and identified by WOLLENWEBER as var. coeruleum (= f. 1) and as in some of our isolates of which 7 largely correspond with var. coeruleum: 7633 from Quercus, 9306 from Brassica, 12475 from hop, 63107 from soil (all from Germany), 11425 from soil (England), 63867 (= TOUSSOUN R 3860) and 63868 (= TOUSSOUN R 3863) from native pasture (Australia). Three cultured strains are available in the CBS/Baarn: 184.31, 263.50, 130.73 (= IMI 160850 = ATCC 24385). There seems to be no reliable report of its association with plant diseases.

Considering the rather unclear and confused situation as shown above, it may be justifiable to include this fungus also in F. sambucinum in a wider concept as formerly already done with other varieties or forms.

Fusarium sulphureum Schlecht. - Flora Berol.: 139, 1824

Fusarium sambucinum Fuckel f. 6 Wollenw. - Z. Parasitenk. 3: 358, 1931

Fusarium sambucinum Fuckel f. 3 Raillo (non Wollenw.) - Fungi of the Genus Fusarium (Moscow): 210, 1950

?Fusarium trichothecioides Wollenw. in Jamieson & Wollenweber - J. Wash. Acad. Sci. 2: 146-152, 1912

?Fusarium sambucinum Fuckel var. trichothecioides (Wollenw.) Bilai - Fusarii: 268, 1955

?Fusarium tuberivorum Wilcox & Link - Res. Bull. Nebraska agric. Exp. Stn 1: 48, 1913

Teleomorph: Gibberella cyanogena (Desm.) Sacc. - Syll. Fung. 2: 555, 1883

Descriptions: WOLLENWEBER (1913), SHERBAKOFF (1915), CARPENTER (1915), WOLLENWEBER (1916-1935 no. 327-329), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), GORDON (1952), GERLACH & ERSHAD (1970), BOOTH (1971a), SUBRAMANIAN (1971), HORNOK (1975), BOOTH (1978d).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 8 days at 25°C on PDA.

Aerial mycelium - in the beginning rather abundant, delicate floccose to felt-like, becoming powdery or slimy by scattered masses of conidia.

Pigmentation - whitish, cream, yellowish, peach to ochraceous, buff-brown, finally slightly cinnamon coloured, never distinct red, carmine, purple or violet.

Sclerotial bodies - not abundant and usually not striking, predominantly flat, ochraceous to buff-brown, but exceptionally also a few greenish blue to dark blue sclerotia may occur.

Sporulation - starting very quickly, within a few days usually masses of conidia are formed in the mycelium, confluent, forming expanded

slimes, cream, pinkish, bright salmon to orange and finally cinnamon coloured when desiccating, sporodochia erumpent from sclerotial plectenchyma only formed sparsely.
Odour - not perceptible.

C o n i d i p h o r e s - and phialides of about the same morphology as in F. sambucinum.

C o n i d i a - only macroconidia formed, but occasionally some sub-developed 0- to 2-septate conidia may be present, on the average of the same shape and variability as in F. sambucinum (and also F. trichothecioides) depending on the substrates used, occasionally with a somewhat more gradually tapering apical and a less pedicellate basal cell, mostly 3- to 5-septate, measuring:

1-sept.	17 x 4.0	mostly 14-20 x 3.7-4.2	(8-26 x 3.5-5.5) µm
3-sept.	29 x 4.8	mostly 24-41 x 4.5-5.5	(16-45 x 3.0-7.0) µm
4-5-sept.	38 x 5.1	mostly 28-45 x 4.5-6.0	(24-52 x 3.8-7.0) µm
6-sept.			(39-51 x 5.0-7.0) µm.

C h l a m y d o s p o r e s - occurrence and morphology as in F. sambucinum.

Explanation of Figure 55:
Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

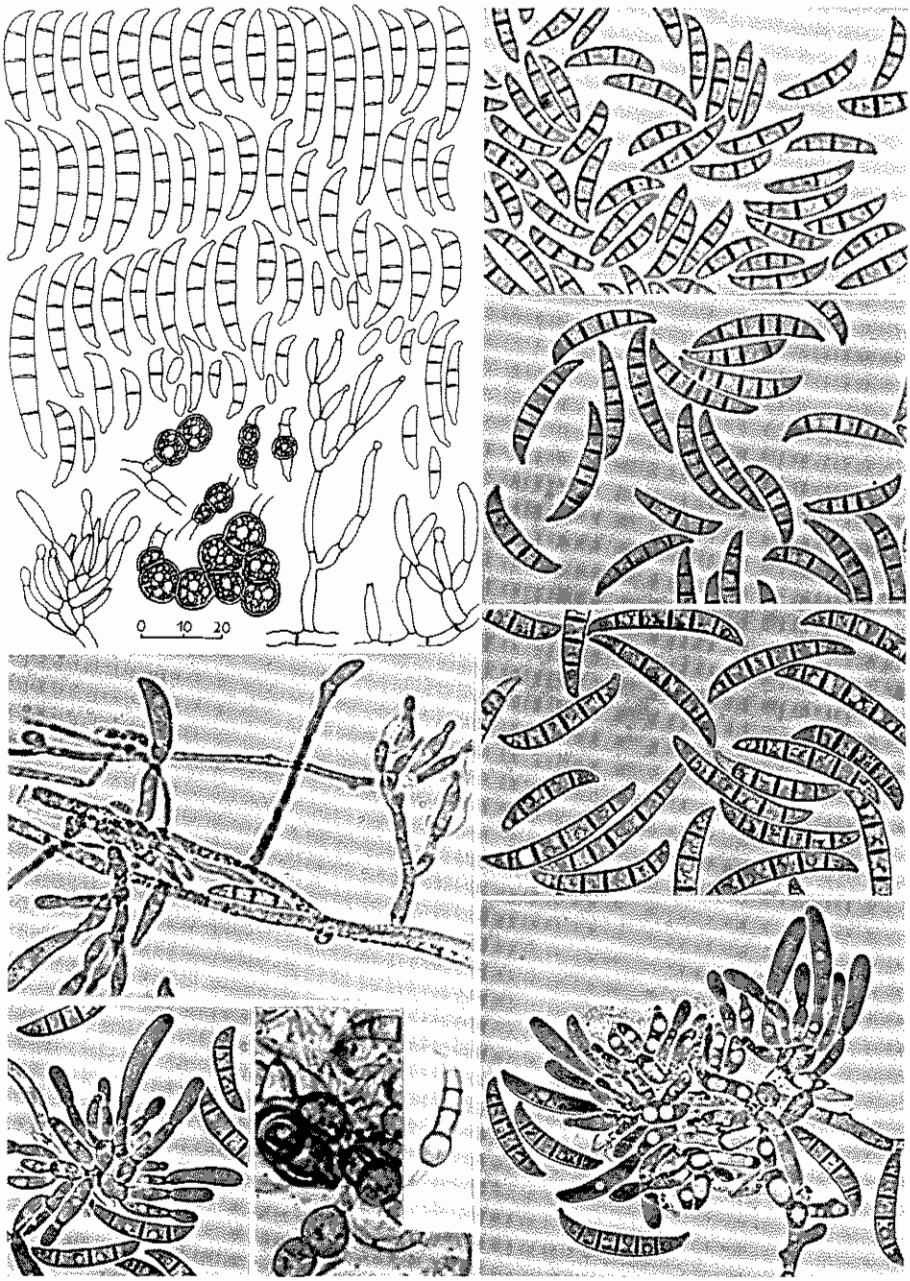

Fig. 55. Fusarium sulphureum.

This Fusarium is widely known among plant pathologists and was accepted as F. sambucinum f. 6 (WOLLENWEBER & REINKING 1935, DOIDGE 1938, GORDON 1952, GERLACH & ERSHAD 1970). BOOTH (1971a), however, considered it worthy of species rank. He once more introduced its original name F. sulphureum. In agreement with SUBRAMANIAN (1971), HORNOK (1975) and BOOTH (1978d), we also prefer to use this name. RAILLO (1950) treated the fungus as f. 3 in her superfluously varied concept of F. sambucinum. BUGNICOURT (1939), BILAI (1955) and JOFFE (1974) did not mention this Fusarium.

F. sulphureum was reported from all continents and is economically most important as a causal agent of a dry rot of stored potato tubers. Sometimes it is associated with F. sambucinum which mostly occurs as a saprophyte. The losses due to this pathogen can be extremely high. F. sulphureum has been isolated from about 20 plant species, from animals, from poultry feed and from soil. For further information see BOOTH (1978d).

The question as to whether or not F. trichothecioides can actually be distinguished from F. sulphureum is discussed in details under F. trichothecioides. In our opinion it is correct to consider it a synonym as was done by GORDON (1959) and SUBRAMANIAN (1971).

Fusarium flocciferum Corda - Sturm's Deutschl. Flora 2: 17, 1828

Fusarium flocciferum Corda f. 1 Raillo - Fungi of the Genus Fusarium (Moscow): 215, 1950

Teleomorph: ? Gibberella heterochroma Wollenw. - Ann. mycol. 15: 52, 1917

Descriptions: WOLLENWEBER (1916-1935 no. 40-42, 308-310, 517, 1146), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), RAILLO (1950), GERLACH & ERSHAD (1970), BOOTH (1971a), DOMSCH et al. (1980).

Colonies - very fast-growing, reaching 6.5 - 8.0 cm diam. in 4 days at 25°C on PDA.
Aerial mycelium - rather abundant, floccose-villose, tomentose to tufted, whitish, rose to carmine with a dash of yellow.
Pigmentation - initially ochraceous, yellowish, rose, changing to intensive carmine with golden, chestnut-brown to dark brown patches.
Sclerotial bodies - in fresh isolates usually abundant, erumpent, of different shape and size, globose to cauliflower-like, up to 6 mm, pale brown to buff-brown with greenish blue or carmine hues.
Sporulation - sporodochia only rarely produced, if present light rose, isabelline to flesh-coloured, ochraceous to pale orange.
Odour - not perceptible.

Conidiophores - at first arising as single phialides in the aerial mycelium, later loosely branched, in sporodochia more densely and irregularly or verticillately branched, terminating in 2-3 phialides.
Phialides - monophialidic, predominantly cylindric to subcylindric, shorter ones more doliiform to obclavate, mostly 15-20 µm long and 3.5-4.5 µm wide.

C o n i d i a - formed only as macroconidia, rather uniform in type, somewhat slender, fusoid to subfalcate or almost lunate, with a pointed or slightly hooked apical cell and an usually distinctly pedicellate basal cell, rather thick-walled, mostly 3- to 5-septate, exceptionally 0- to 2- and very rarely 6- to 7-septate, measuring:

3-sept.	30 x 4.3	mostly 26-37 x 3.6-5.0	(17-48 x 3.0-5.4) µm
4-sept.	37 x 4.5	mostly 33-42 x 4.0-5.2	(29-58 x 3.2-5.8) µm
5-sept.	43 x 4.6	mostly 36-50 x 4.0-5.3	(29-70 x 3.5-5.8) µm
7-sept.	44 x 5.0		(36-63 x 4.0-6.0) µm.

C h l a m y d o s p o r e s - abundantly produced, globose to subglobose (8-13 up to 20 µm), smooth or rough-walled, mostly intercalary in hyphae, forming chains or clusters, often reddish brown, rarely formed in conidia, but then comparatively small.

Explanation of Figure 56:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 1146 of strain 4270b; drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

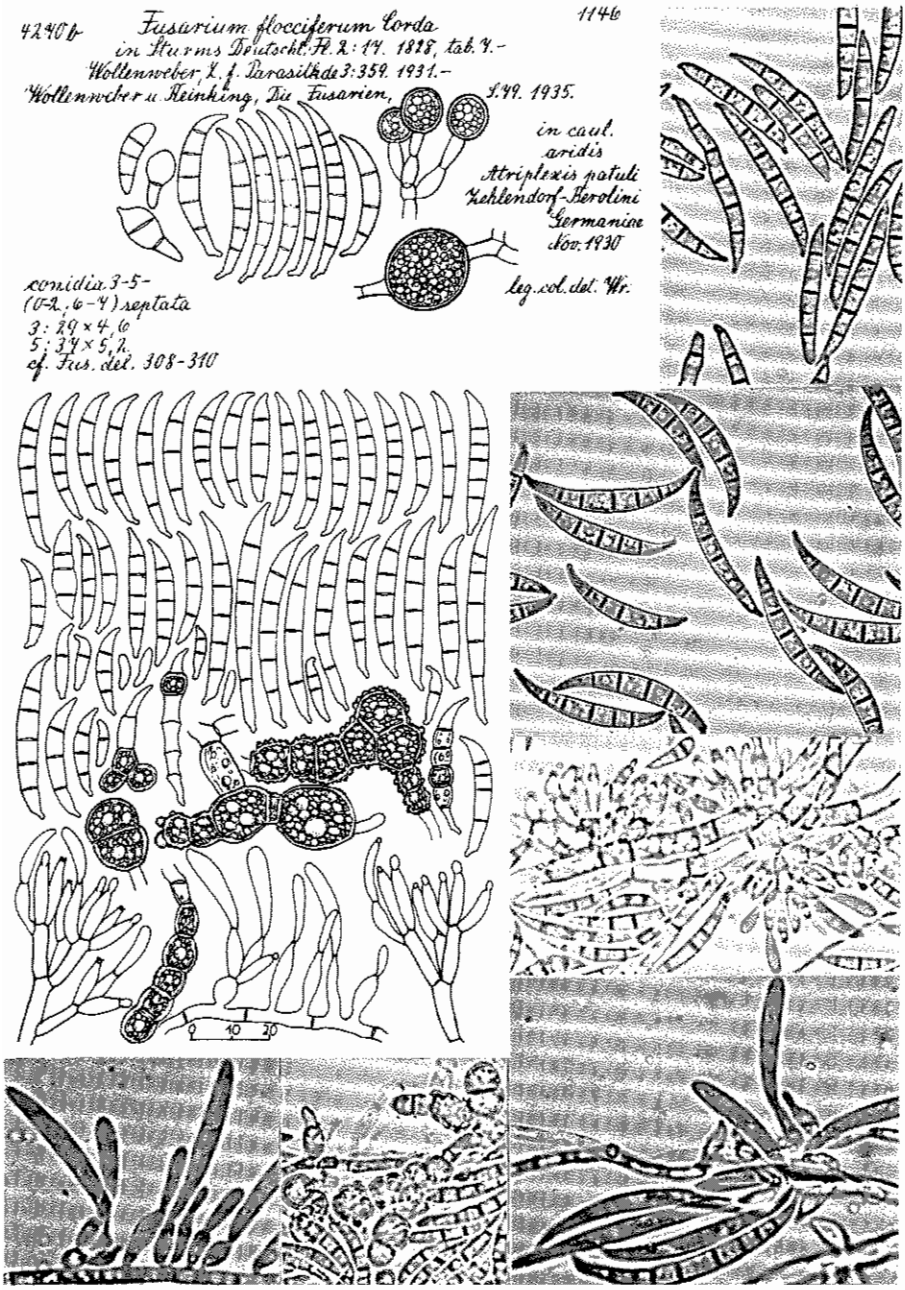

Fig. 56. Fusarium flocciferum.

F. flocciferum was treated as a distinct species, most similar to F. graminearum though with smaller conidia, by WOLLENWEBER (1916-1935), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), RAILLO (1950), GERLACH & ERSHAD (1970), BOOTH (1971a) and DOMSCH et al. (1980). DOIDGE (1938), BUGNICOURT (1939), JAMALAINEN (1943a), GORDON (1944-1960), SUBRAMANIAN (1971), JOFFE (1974) and HORNOK (1975) did not mention this Fusarium. BILAI (1955), surprisingly, considered it synonymous with F. heterosporum.
In addition to some twenty cultured strains studied by WOLLENWEBER and documented by drawings and notes in our institute, 8 further strains were isolated during the past years from decaying parts of different plant species confirming the separate identity of F. flocciferum. Two representative cultures are deposited in the CBS/Baarn (821.68, 792.70).

This Fusarium was recorded from several European countries, from North America and from Iran and it seems to be largely restricted to temperate regions. F. flocciferum occurs mainly on fruits, stems, twigs, roots and bulbs of various plants and also in soils and is of minor importance as a plant pathogen. It is known to cause disorders in beds of cultivated mushrooms and has also been reported as causing black rot in potatoes in the northwestern states of the USA and damping off of lupine and beet seedlings. More information is given by DOMSCH et al. (1980).

Fusarium culmorum (W.G. Smith) Sacc. - Syll. Fung. 11: 651, 1895 var. culmorum

Fusarium culmorum (W.G. Smith) Sacc. var. cerealis (Cooke) Wollenw. - Z. Parasitenk. 3: 362, 1931

Fusarium discoloriformis Raillo - Fungi of the Genus Fusarium (Moscow): 180, 1950

Fusarium sambucinum Fuckel var. cerealis (Cooke) Raillo - Fungi of the Genus Fusarium (Moscow): 211, 1950

Descriptions: SHERBAKOFF (1915), WOLLENWEBER (1916-1935 no. 330-337, 341, 342, 613, 921, 943-947, 1147-1149), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), JAMALAINEN (1943a), GORDON (1952), BOOTH & WATERSTON (1964c), GERLACH & ERSHAD (1970), BOOTH (1971a), SUBRAMANIAN (1971 - as F. cerealis), JOFFE (1974), HORNOK (1975), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - very fast-growing, reaching 7.8 - 8.5 cm diam. in 5 days at 25°C on PDA.
Aerial mycelium - usually very abundant, floccose, pilose-villose to loosely lanuginose, whitish, yellowish brown, ochraceous to rose or red-brown, pale carmine.
Pigmentation - from yellowish brown or ochraceous to intensively red, red-brown or deep carmine, purple.
Sclerotial bodies - usually not formed.
Sporulation - starting quickly in the aerial mycelium which appears somewhat powdery, after about 1 week sporodochia are visible, often confluent, bright salmon to cinnamon, red-brown.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, later in sporodochia densely and irregularly or verticillately branched.

Phialides - always monophialidic, predominantly compact, subcylindric or almost doliiform to obclavate, mostly 15-20 µm long and 3.5-5.0 µm wide, with a distinct collarette.

C o n i d i a - formed only as macroconidia, but mostly some subdeveloped 0- to 2-septate conidia present, considerable differences in size occur between strains or samples from different substrates, some on the average rather short and wide, others longer (corresponding "var. cerealis"), thick-walled, distinctly septate, slightly brown to purple when desiccating, falcate, slightly curved, strongly dorsiventral, gradually or abruptly narrowing toward each end, with a rather short subterminally often slightly constricted, almost pointed apical cell and a distinctly pedicellate basal cell, mostly 5-septate, less frequently 3- to 4-septate or exceptionally 6- to 9-septate, measuring:

3-sept.	29 x 6.0	mostly 24-36 x 4.5-6.8	(18-44 x 3.7-8.5) µm
5-sept.	41 x 6.3	mostly 32-50 x 4.8-7.5	(23-74 x 4.0-9.0) µm
6-9-sept.	53 x 6.3	mostly 42-57 x 5.5-7.5	(36-75 x 4.0-9.0) µm.

C h l a m y d o s p o r e s - usually not very common, mostly intercalary in hyphae, but also in conidia, globose to oval, single (8-16 µm), in chains or clusters, mostly smooth-walled, often brownish.

Explanation of Figure 57:

Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

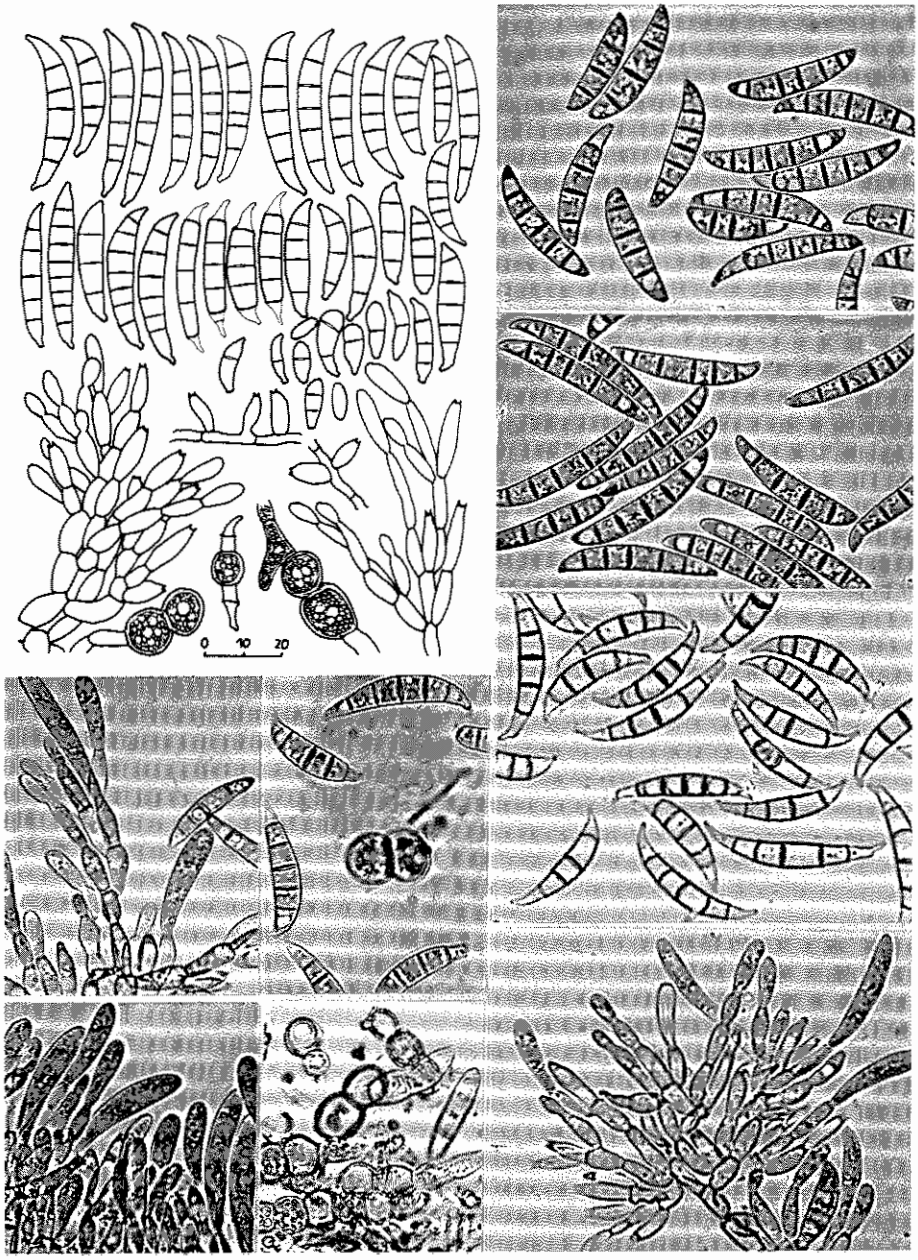

Fig. 57. Fusarium culmorum var. culmorum.

F. culmorum was accepted by WOLLENWEBER & REINKING (1935), DOIDGE (1938) and JAMALAINEN (1943a) with a separate variety which was based on Fusisporium cerealis Cooke and which was later treated by RAILLO (1950) as a variety of F. sambucinum. GORDON (1952), however, and subsequently GERLACH & ERSHAD (1970), SUBRAMANIAN (1971) and DOMSCH et al. (1980) did not keep this variety separate but used F. culmorum in a wider concept. While BOOTH & WATERSTON (1964c), BOOTH (1971a), JOFFE (1974) and HORNOK (1975) did not mention var. cerealis, BILAI (1955), surprisingly, described it as synonymous with such extremely different species as F. camptoceras, F. tumidum and F. bactridioides.

F. culmorum is a common cosmopolitan species predominantly occurring in temperate regions, less frequently in the subtropics and the tropics. It occurs on an extremely wide range of host plants and is economically most important as a causal agent of cortical rots. It is associated with a pre-emergence blight of seedlings, a seedling blight, a root and foot rot and a head blight of wheat, barley, rye and oats. Furthermore it causes a stem and a cob rot of maize, brown patch of turf, a foot rot of asparagus, carnations, leek and peas and storage rots of apple, sugar beet and others. More detailed information is given by BOOTH & WATERSTON (1964c), BOOTH (1971a) and DOMSCH et al. (1980).

During the past 30 years more than 150 strains of F. culmorum have been isolated from about 40 different plant species and studied in our institute.

Fusarium buharicum Jaczewski ex Babayan & Temereyenkoyea - Mater. Mikol. Fitopat. Ross. (Leningrad) 8: 216, 1929

Fusarium sambucinum Fuckel var. sublunatum (Reinking) Bilai - Fusarii: 267-268, 1955 (pro parte)

Descriptions: JACZEWSKI (1929), LETOV (1929), WOLLENWEBER (1943), RAILLO (1950), GERLACH & ERSHAD (1970), GERLACH & SCHARIF (1970), BOOTH (1971a).

C o l o n i e s - fast-growing, reaching 7.0 - 8.0 cm diam. in 8 days at 25°C on PDA.
Aerial mycelium - generally sparse, floccose or felt-like, often completely lacking, whitish to pale cream or peach.
Pigmentation - pale incarnadine, light pinkish brown, ochraceous to salmon, partly aeruginous, greyish to dark blue or nearly black.
Sclerotial bodies - early and often abundantly formed, single, globose to subglobose or aggregated to cauliflower-like bodies, up to 5 mm, showing the same variation in colours as the stroma.
Sporulation - very early starting, abundant in expanded flat, slimy layers, sometimes pustule-like sporodochia on sclerotial stroma present; conidia in masses also changing from pale rose to dark blue-violet or nearly black, corresponding with the pigmentation of the stroma.
Odour - not perceptible.

C o n i d i o p h o r e s - initially formed as single lateral phialides on hyphae, sometimes sparsely branched, later in sporodochial layers densely and irregularly or verticillately branched.
Phialides - subcylindric to doliiform or obclavate, rather short and wide, mostly 8-20 x 3-5 µm.

C o n i d i a - formed only as macroconidia, a few 0- or 1-septate sub-developed conidia may be present, comparatively robust and thick-walled, distinctly septate, generally rather straight, subcylindric, only slightly curved, with a short apical cell narrowing abruptly in a hook and a distinctly pedicellate foot cell, predominantly 5-septate, often 3- to 4-septate, exceptionally 6- to 8-septate, measuring:

0-sept.			(7-12 x 4.2-5.0) µm
1-sept.	22 x 4.1	mostly 15-30 x 3.5-4.6	(11-46 x 3.3-5.0) µm
3-sept.	37 x 5.1	mostly 32-42 x 4.5-6.2	(24-54 x 3.5-7.5) µm
4-sept.	47 x 5.5	mostly 38-52 x 4.5-6.5	(33-65 x 4.0-7.5) µm
5-sept.	54 x 5.7	mostly 45-65 x 5.0-6.5	(29-82 x 4.4-7.5) µm
6-sept.	58 x 5.6		(46-77 x 4.4-6.5) µm
7-sept.	57 x 5.7		(44-66 x 5.3-6.7) µm
8-sept.	83 x 5.9		(80-87 x 5.3-6.5) µm.

The conidia and conidiophores illustrated by BOOTH (1971a) are much too large compared with the given magnification.

C h l a m y d o s p o r e s - early formed, generally abundant and striking, intercalary and terminal, in the aerial mycelium and especially in conidia, often excrescent, adhering either directly or on a short branch of about 10-20 µm in length, globose to subglobose, single (8-12 µm), in pairs, chains or clusters, generally smooth-walled and hyaline, occasionally slightly rough and pale brown.

Explanation of Figure 58:

Drawing and photographs of conidia, conidiophores and chlamydospores of strains 11176 (= CBS 178.35) and 11122 (= CBS 796.70 = IMI 141195 = ATCC 24135) on different substrates (x 500).

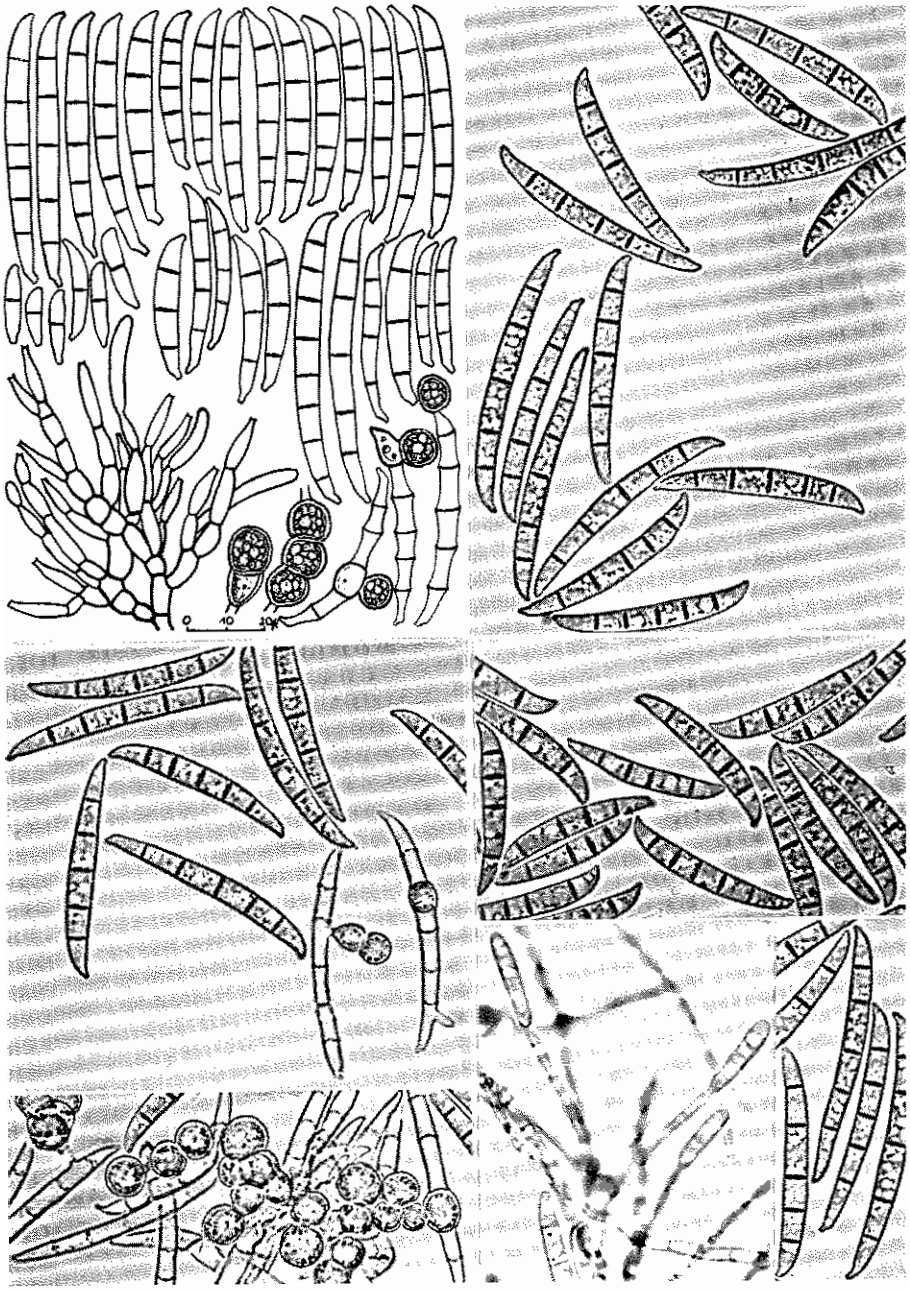

Fig. 58. Fusarium buharicum.

F. buharicum, which was initially found and repeatedly described as a serious pathogen causing a collar rot of 'Buchara' and other local varieties of cotton in central and southeastern USSR, especially in Usbekistan, is represented by a culture deposited in the CBS/Baarn (178.35) by A.I. RAILLO in 1935. This strain, thoroughly studied and deposited with drawings and notes in our institute by WOLLENWEBER, should be accepted as the neotype. Though this culture proved to be rather deteriorated, it produced still quite typical conidia (GERLACH & SCHARIF 1970). Another representative strain (11122 = CBS 796.70 = IMI 141195 = ATCC 24135) was isolated together with many others from stem lesions of kenaf (Hibiscus cannabinus), a malvaceous plant like cotton, in the Iranian provinces of Mazandaran and Gilan. More detailed information about the occurrence of F. buharicum as an important root, crown and stem rot pathogen of kenaf, about the morphology of the fungus and about the results of comparative investigations with strains of Iranian and Russian origin, is given by GERLACH & ERSHAD (1970) and GERLACH & SCHARIF (1970).

Although not mentioned by DOIDGE (1938), BUGNICOURT (1939), GORDON (1952-1960), SUBRAMANIAN (1971) or JOFFE (1974), this distinct and characteristic Fusarium was correctly treated as a separate species by RAILLO (1950) and BOOTH (1971a). BILAI (1955), surprisingly, combined it with F. sublunatum, which is without any doubt quite different from F. buharicum, under the designation F. sambucinum var. sublunatum.

Fusarium sublunatum Reinking - Zentralbl. Bakteriol. 2. Abt. 89: 510, 1934 var. sublunatum

Fusarium sambucinum Fuckel var. sublunatum (Reinking) Bilai - Fusarii: 267-268, 1955 (pro parte)

Descriptions: REINKING (1934), WOLLENWEBER (1916-1935 no. 1150), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), RAILLO (1950), GERLACH (1977a), GERLACH (1978).

C o l o n i e s - very slow-growing, reaching 1.0 - 1.2 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - either absent or sparsely developed, arachnoid, appressed, hairy to filaceous.
Pigmentation - pale, beige, rose to cinnamon, in older, desiccating cultures tinged vinaceous.
Sclerotial bodies - mostly present, sometimes abundant, of different shape, globose, single or aggregated in cauliflower-like bodies, up to 0.5 mm, dark blue to olive.
Sporulation - rather early and very abundant, sporodochial layers incarnadine-rose to bright salmon, finally covering large parts of the surface of the colony.
Odour - not perceptible.

C o n i d i o p h o r e s - in the beginning formed as single lateral phialides on hyphae, later densely aggregated in sporodochial layers, more or less irregularly or verticillately branched, terminating in 2-3 phialides.
Phialides - always monophialidic, subcylindric to doliiform or nearly obclavate, comparatively compact, thick-walled, mostly 12-20 x 3-4.5 µm, sometimes wider, occasionally with an indistinct collarette.

C o n i d i a - only macroconidia formed, but often a few subdeveloped 0- to 2-septate conidia present, falcate, generally rather strongly, inequilaterally curved, very variable in width, with a rather long, often distinctly constricted, hooked apical cell and a very distinctly pedicellate basal cell, predominantly 5- less frequently 3- to 4-septate, exceptionally 6- to 8-septate, measuring:

0-sept.	13 x 3.8	mostly 10-16 x 3.5-4.0	(8-20 x 3.0-4.5) µm
1-2-sept.	22 x 3.8	mostly 20-27 x 3.5-4.0	(16-32 x 3.2-4.7) µm
3-4-sept.	40 x 5.2	mostly 30-48 x 4.8-6.0	(26-77 x 4.0-7.0) µm
5-sept.	56 x 5.9	mostly 48-66 x 5.4-6.8	(41-81 x 4.8-7.5) µm
6-sept.	63 x 5.9	mostly 60-66 x 5.8-6.2	(49-68 x 5.3-6.8) µm
7-sept.	69 x 5.9	mostly 62-75 x 5.6-6.2	(58-90 x 5.6-6.8) µm
8-sept.	77 x 6.7		(72-81 x 6.2-7.4) µm.

C h l a m y d o s p o r e s - very abundant in hyphae and conidia, often excrescent, adhering either directly or on a short branch of about 10-20 µm in length, intercalary and terminal, globose to subglobose, smooth-walled, single (6-10 µm), in pairs, chains or clusters.

Explanation of Figure 59:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 1150 of the type culture 5238 (= CBS 189.34); drawing and photographs of conidia, conidiophores and chlamydospores of the type culture on different substrates (x 500).

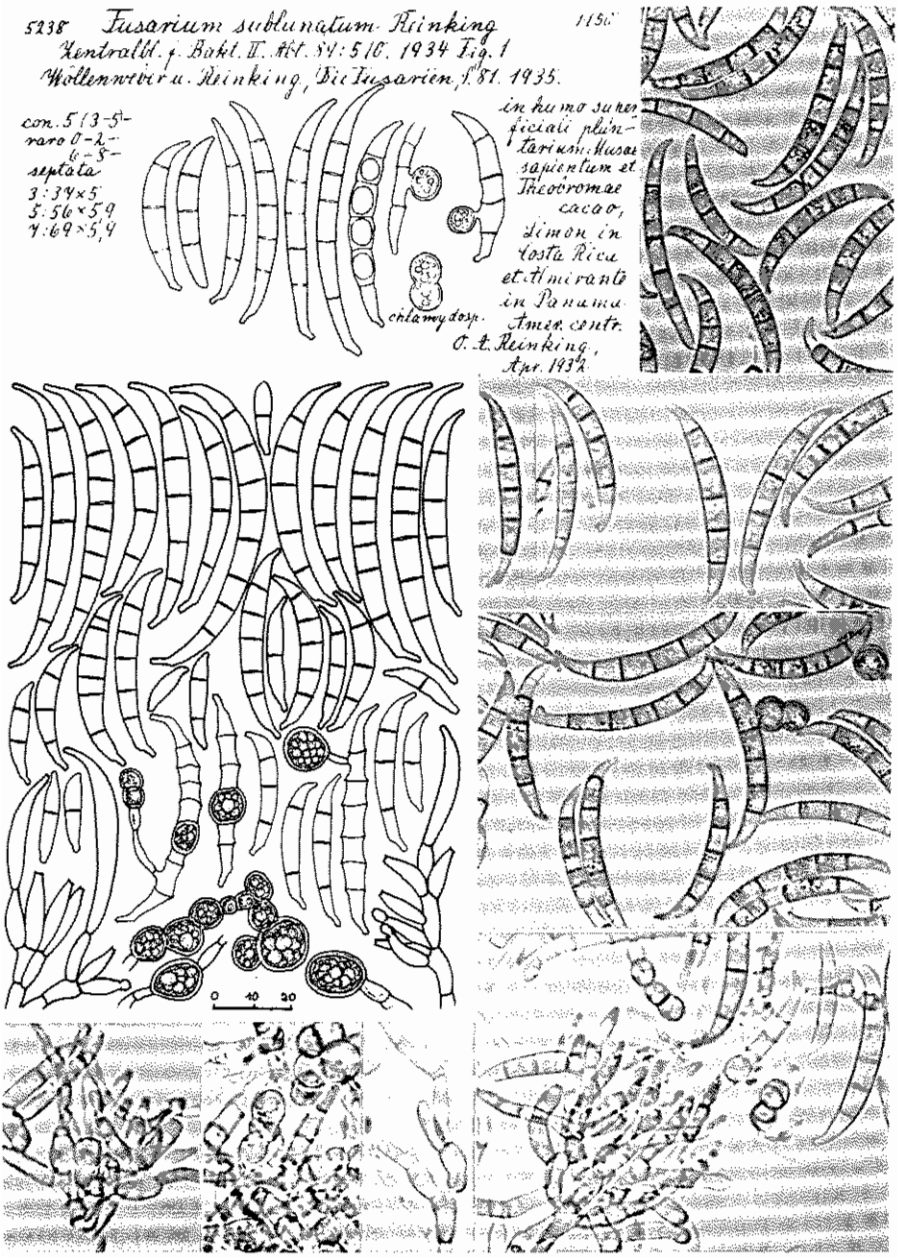

Fig. 59. Fusarium sublunatum var. sublunatum.

This species was based on cultures isolated by REINKING (1934) from soils of a banana plantation in Costa Rica and a cacao plantation in Panama. The type culture (5238) deposited by REINKING in the CBS/Baarn (189.34) was studied in every detail and illustrated by WOLLENWEBER (Fus. autogr. delin. no. 1150) and preserved as a pure culture in our institute. Apparently this Fusarium was not found again. DOIDGE (1938), BUGNICOURT (1939), GORDON (1952-1960), SUBRAMANIAN (1971) and JOFFE (1974) did not mention this fungus. RAILLO (1950) retained F. sublunatum as a distinct species, BILAI (1955) considered it a variety of F. sambucinum (together with F. buharicum); BOOTH (1971a) equated it with F. tumidum.

The extremely deteriorated type culture (5238) continues to produce very uniform and typical conidia. The comprehensive re-examinations confirmed without doubt that F. sublunatum is different from F. sambucinum and F. tumidum and should be accepted both as a characteristic and distinct species.

Fusarium sublunatum Reinking var. elongatum (Reinking) Reinking in Wollenweber & Reinking - Die Fusarien 82, 1935

Fusarium elongatum Reinking - Zentralbl. Bakteriol. 2. Abt. 89: 511, 1934

Descriptions: REINKING (1934), WOLLENWEBER (1916-1935 no. 1151), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), GERLACH (1977a).

C o l o n i e s - very slow-growing, reaching 1.5 - 1.8 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - generally sparse, delicate, mostly arachnoid to slightly floccose, whitish to rose.
Pigmentation - pale brown, ochraceous, later partly aeruginous to dark blue.
Sclerotial bodies - sometimes occurring abundantly, pale grey to blackish blue-violet, often very small, forming a more or less expanded crusty cover, or single, rather large, globose, reaching 0.25-1.5 mm, sometimes completely lacking.
Sporulation - early starting in sporodochia or in pionnotes, incarnadine to salmon-orange, later sometimes aeruginous to dark blue like the colours of the stroma.
Odour - not perceptible.

C o n i d i o p h o r e s - no information is given on them in the diagnosis by REINKING (1934) and WOLLENWEBER & REINKING (1935). In the pionnotal type culture no differences compared with var. sublunatum could be found.
Phialides - monophialidic, subcylindric to doliiform, 10-25 x 3-4.5 µm.

C o n i d i a - only macroconidia formed, but a few subdeveloped 0- to 2-septate conidia may be present, falcate, generally rather straight, subcylindric, but in some samples rather strongly curved, variable in width, with a more or less hooked apical cell and a distinctly pedicellate basal cell, mostly 5-septate, often 3- to 4-septate, exceptionally 6- to 11-septate; according to REINKING (1934), WOLLENWEBER & REINKING (1935) and WOLLENWEBER (1943) measuring:

0-sept.	16 x 3.4		(14-19 x 3.0-3.8) µm
1-2-sept.	22 x 3.5		(19-27 x 3.0-3.8) µm
3-sept.	40 x 4.4	mostly 37-43 x 3.9-4.8	(33-47 x 3.8-5.8) µm
4-sept.	48 x 5.0	mostly 49-50 x 5.0-5.1	(47-53 x 4.8-5.8) µm
5-sept.	61 x 4.9	mostly 44-72 x 4.3-5.8	(43-78 x 3.8-6.0) µm
6-sept.	77 x 5.0	mostly 70-85 x 4.5-5.5	(69-87 x 4.5-5.5) µm
7-sept.	84 x 5.0	mostly 81-87 x 4.6-5.5	(80-89 x 4.3-5.8) µm
8-9-sept.	88 x 4.9		(87-89 x 4.8-5.0) µm
11-sept.	111 x 5.0		µm.

C h l a m y d o s p o r e s - abundant in hyphae and conidia, often excrescent, adhering either directly or on a short branch of about 10-20 µm in length, intercalary and terminal, mostly smooth-walled, sometimes rough-walled to warty, globose to subglobose, single (7-12 µm), in pairs, chains or clusters.

Explanation of Figure 60:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 1151 of the type culture 5237 (= CBS 190.34); drawing and photographs of conidia, conidiophores and chlamydospores of the type culture on different substrates (x 500).

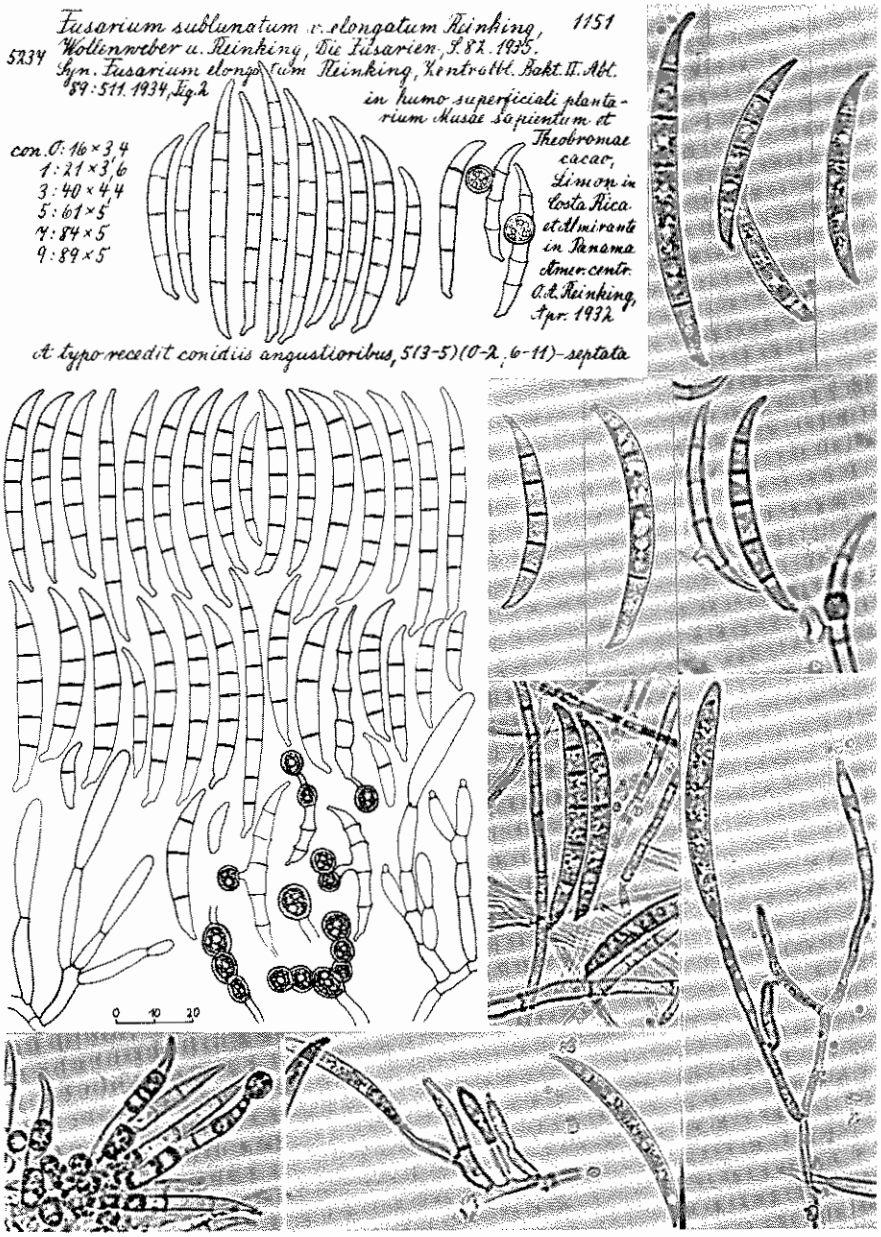

Fig. 60. Fusarium sublunatum var. elongatum.

This Fusarium, originally described by REINKING (1934) as a separate species, was also (like var. sublunatum) based on isolates from soils of a banana plantation in Costa Rica and of a cacao plantation in Panama. The type culture (5237) deposited by REINKING in the CBS/Baarn (190. 34) was studied as a fresh isolate and illustrated by WOLLENWEBER (Fus. autogr. delin. no. 1151). His numerous notes and drawings, including coloured ones, are preserved in our institute. Not mentioned by DOIDGE (1938), BUGNICOURT (1939), GORDON (1952-1960), BILAI (1955), SUBRAMANIAN (1971) or JOFFE (1971), the fungus was treated as synonymous with F. sublunatum var. sublunatum by RAILLO (1950) and considered to be identical with F. tumidum by BOOTH (1971a) which is quite astonishing.

In our re-examination of the type culture obtained from the CBS/Baarn the isolate proved to be macroscopically completely degenerated; but typical macroconidia were formed on some substrates after several weeks. They were, however, very similar in shape and size to those of var. sublunatum from which var. elongatum is mainly distinguished by taller conidia (WOLLENWEBER & REINKING 1935). The material deposited by WOLLENWEBER includes drawings of conidia from cultures on rice and potato stem which are 5-septate measuring on the average 54 x 6.1 µm and 55 x 5.5 µm respectively, and which fit exactly into the diagnosis given for var. sublunatum. We propose therefore to accept the treatment of RAILLO who did not consider the fungus a separate variety.

Fusarium graminearum Schwabe - Flora Anhaltina 2: 285, 1838

Teleomorph: Gibberella zeae (Schw.) Petch - Ann. mycol. 34: 260, 1936

Descriptions: WOLLENWEBER (1916-1935 no. 43-49, 338-339, 354-357, 811, 812, 948, 1109), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), JAMALAINEN (1943a), GORDON (1952), BOOTH (1971a, 1973a), JOFFE (1974), HORNOK (1975), GERLACH (1977a), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - very fast-growing, reaching 7.5 - 8.0 cm diam. in 5 days at 25°C on PDA.
Aerial mycelium - generally rather abundant, floccose, whitish, later brownish to rose. with yellow tips.
Pigmentation - rather variable, changing from whitish, pinkish, golden yellow, ochraceous to greyish rose, crimson, finally becoming dark purple to vinaceous with a dash of brown.
Sclerotial bodies - occasionally present in freshly isolated cultures, not abundant and not striking, rather small, pale brown or reddish, sometimes covered with conidial slimes.
Sporulation - very scarce in the mycelium, also forming ochraceous to light orange sporodochial layers, very sparse or completely lacking especially in subcultures; sporulation can be induced by near-UV irradiation; ascospore isolates seem to sporulate more abundantly.
Odour - never perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, those of sporodochia or pionnotal layers loosely to densely and often verticillately branched.
Phialides - monophialidic, cylindric to subcylindric, occasionally almost doliiform, generally more slender than in F. culmorum, mostly 15-25 µm long and 2.5-3.5 µm wide.

C o n i d i a - only macroconidia formed, rather variable in size, in some samples rather short and wide, in others long and slender, falcate, usually rather straight, occasionally stronger curved, with a somewhat elongated, slightly constricted, pointed apical and a distinctly pedicellate basal cell, mostly 5- to 6-septate, less frequently 3- to 4-, exceptionally 7- to 9-septate, measuring:

3-sept.	40 x 4.2	mostly 29-51 x 3.5-5.2	(21- 66 x 3.0-6.0) µm
4-sept.	46 x 4.6	mostly 39-54 x 4.0-5.3	(23- 59 x 3.0-5.8) µm
5-sept.	51 x 4.9	mostly 41-60 x 4.3-5.5	(28- 72 x 3.2-6.0) µm
7-sept.	73 x 5.4	mostly 61-82 x 4.5-6.5	(50- 88 x 4.0-7.0) µm
9-sept.	80 x 5.5	mostly 61-96 x 4.5-7.0	(55-106 x 4.0-8.0) µm.

C h l a m y d o s p o r e s - usually rather scarce, sometimes completely absent, when present mostly intercalary in hyphae, seldom in conidia, single, globose to oval (8-12 µm), in pairs or in short chains, sometimes pale brown.

Explanation of Figure 61:

Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

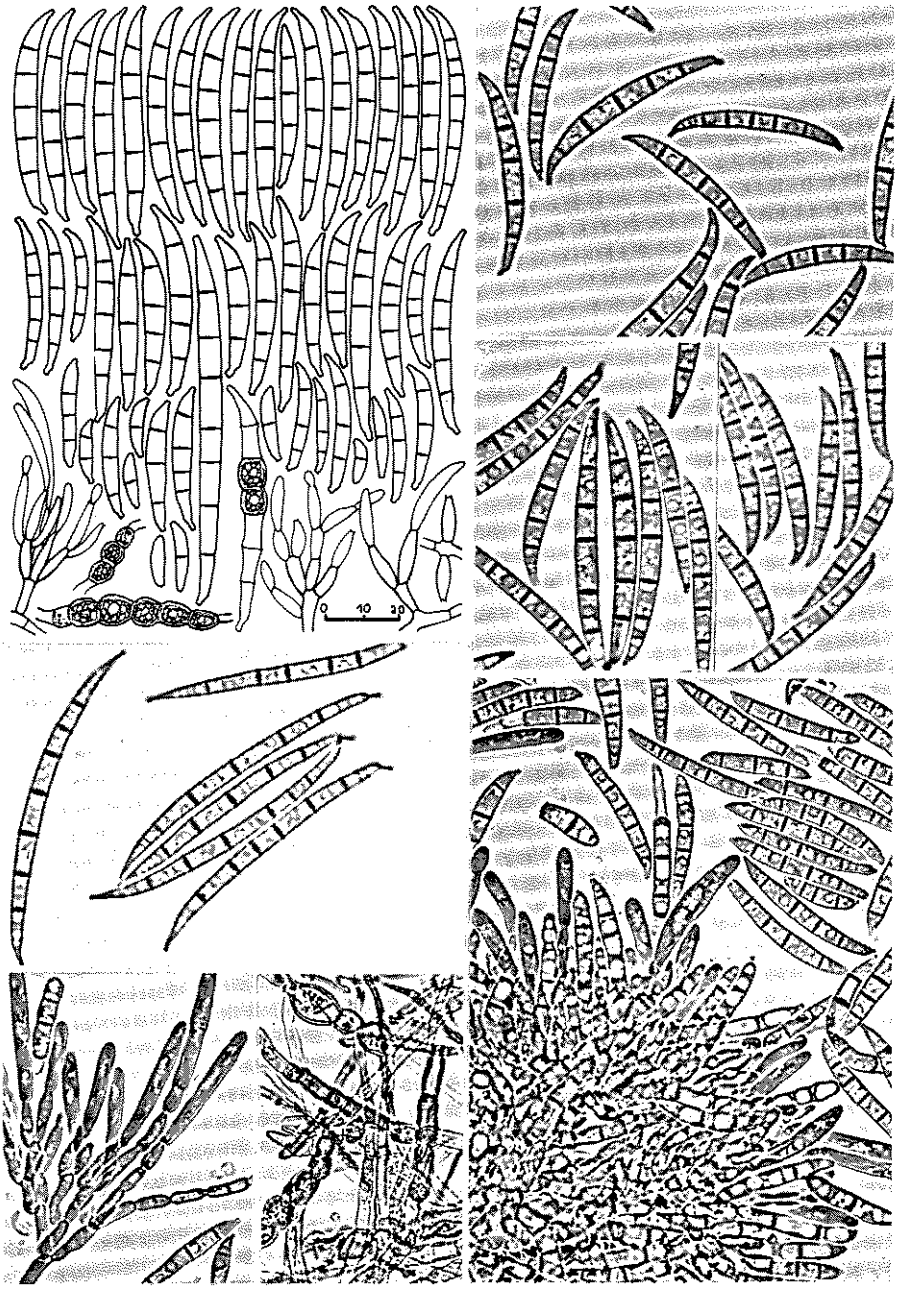

Fig. 61. Fusarium graminearum.

F. graminearum is a well-known species and generally accepted in the original concept. It occurs world-wide as a pathogen of gramineous hosts, especially on maize and rice in warmer regions and on wheat, oats, barley, rye and grasses in temperate regions, causing pre- and post-emergence blight, root and foot rot, crown rot, culm decay, head or kernel blight (scab or ear scab) and cob rot. In some cases it has also been proved to cause leaf rot, flower rot and die-back in carnations and in some other ornamentals and is recorded to infect tomato, potato, pea and clover. In Australia 2 different pathogenic strains were found, one restricted to maize and the other with a wider host range on various cereals and grasses. More detailed information is given by BOOTH (1971a, 1973a) and DOMSCH et al. (1980).

More than 40 isolates from different cereals and grasses were studied in our institute during the past 20 years. At least 13 cultured strains are deposited in the CBS/Baarn.

Fusarium robustum Gerlach - Phytopath. Z. 88: 36, 1977

Description: GERLACH (1977a).

C o l o n i e s - very fast-growing, reaching 6.0 - 8.0 cm diam. in 6 days at 25°C on PDA; growth rate as well as all other features ascertained from more or less deteriorated subcultures.
Aerial mycelium - sometimes rather abundant, hairy to densely floccose or more appressed and felt-like, sometimes completely lacking.
Pigmentation - from whitish, pale rose, ochraceous to chestnut-brown with carmine-purple areas, finally dark brown-vinaceous.
Sclerotial bodies - may be present, small, flat, pale brown to reddish.
Sporulation - starting after about 1 week rather sparse in the mycelium, pionnotal or small sporodochial layers abundant or sparse, depending on the substrate and the condition of the culture, salmon to cinnamon; sporulation is enhanced by near-UV irradiation.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, later, especially in sporodochia, densely and irregularly or verticillately branched.
Phialides - always monophialidic, subcylindric to slightly doliiform, 8-22 µm long and 3-5 µm wide.

C o n i d i a - only macroconidia formed, sometimes a few small 0- to 2-septate conidia present, type of conidia between F. graminearum and F. sublunatum, falcate, generally rather straight, only moderately inequilaterally curved, rather thick-walled, with a subterminally distinctly constricted, almost hooked apical cell and a very distinctly pedicellate basal cell, mostly 5- to 6-septate, less frequently 3- to 4-, exceptionally 7- to 8-septate, measuring:

3-sept.	33 x 4.4		(18-62 x 3.2-5.8) µm
4-sept.	40 x 4.8		(24-64 x 3.8-6.2) µm
5-sept.	50 x 5.2	mostly 43-58 x 4.5-6.0	(35-67 x 3.6 -6.7) µm
6-sept.	57 x 5.2	mostly 48-65 x 4.5-6.0	(42-72 x 3.6-7.0) µm
7-sept.	59 x 4.9		(42-76 x 3.6-6.5) µm
8-sept.	63 x 5.9		(53-78 x 5.0-6.5) µm.

C h l a m y d o s p o r e s - in older cultures generally rather abundant and striking, in hyphae and conidia, intercalary or terminal, smooth-walled, globose to subglobose, single (6-19 µm), in pairs, chains or clusters; sometimes nearly all cells of old conidia are chlamydospore-like thickened, especially on wort agar.

Explanation of Figure 62:

Drawing and photographs of conidia, conidiophores and chlamydospores of the type culture 63667 (= CBS 637.76) on different substrates (x 500).

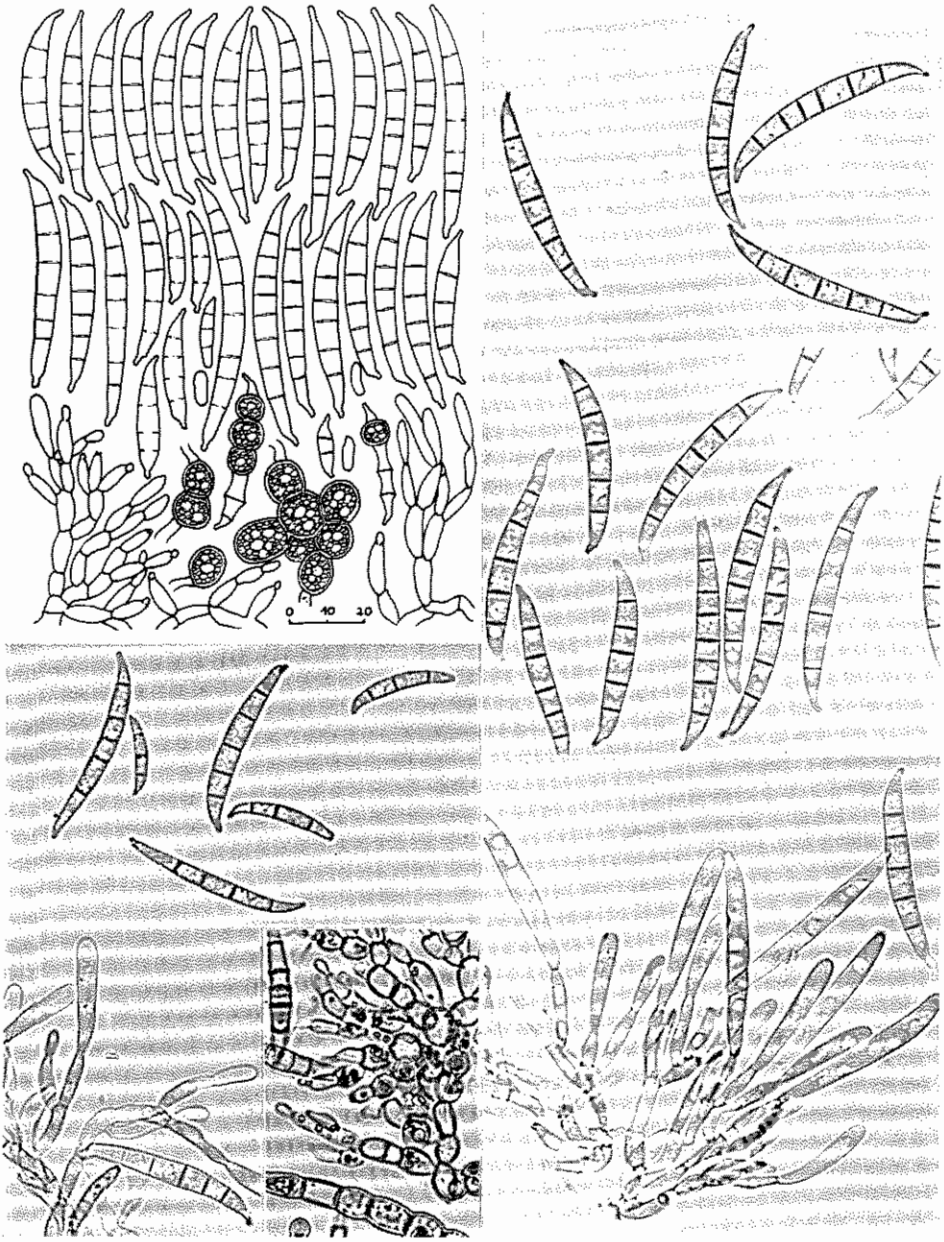

Fig. 62. Fusarium robustum.

This Fusarium recently described as a new species is represented by the type culture 63667 deposited in the CBS/Baarn (637.76). It was isolated from a culture containing additionally F. eumartii (? or F. illudens). The dual culture was initially isolated from a rotting stem of Araucaria angustifolia in Argentina and was sent to us for identification by W. RADTKE in 1973 after repeated subculturing. Therefore the description of F. robustum given above may be somewhat incomplete. More detailed information, especially about its distinction from F. graminearum, F. sublunatum and its variety elongatum, is given in the paper by GERLACH (1977a).

Another culture (63558) which nearly corresponds in morphological aspects to 63667 may for the present be placed most favourably in F. robustum. It was donated to us by T.A. TOUSSOUN/Pennsylvania in 1976 for comparison as strain R 2770 "CROOKWELL" isolated from plant debris in Australia.

Fusarium lunulosporum Gerlach - Phytopath. Z. 88: 283, 1977

Descriptions: GERLACH (1970, p. 45, plate II, 11 - as Fusarium spec. ? nov.), GERLACH (1977b), GERLACH (1978, p. 118, plate VI, 34-36 - as Fusarium spec. ? nov.).

C o l o n i e s - fast-growing, reaching 7.0 - 8.0 cm diam. in 9 days at 25°C on PDA.
Aerial mycelium - generally sparse or lacking, if present appressed, arachnoid to long filaceous.
Pigmentation - rather intensive and variable, from yellowish brown, salmon-rose to chestnut-brown, carmine-purple, finally dark brown-vinaceous.
Sclerotial bodies - generally lacking.
Sporulation - starting very quickly in the mycelium, within a few days numerous dots of aggregated masses of conidia develop, soon becoming confluent, forming a thin, slimy pionnotal layer, later when desiccating powdery crustaceous and ochraceous to cinnamon coloured.
Odour - not perceptible.

C o n i d i o p h o r e s - arising as single lateral phialides on hyphae, sometimes sparsely branched, later in sporodochial pustules or pionnotal layers densely and mostly irregularly, less frequently verticillately branched, terminating in not more than 3 phialides.
Phialides - monophialidic, subcylindric to doliiform or obclavate, comparatively compact, measuring 7-18 x 3.2-5.0 µm.

C o n i d i a - only macroconidia formed, but sometimes a few 0- to 2-septate conidia present (generally hyaline but in some samples especially from PDA some brownish to dark vinaceous discoloured ones occur), very uniform, falcate to lunate, long and slender, with an elongated, distinctly constricted and pointed apical cell and a striking, generally rather long pedicellate basal cell, mostly 5-septate, often 3- to 4-, exceptionally 6-septate, measuring:

3-sept.	40 x 3.8	mostly 32-55 x 3.2-4.5	(28-63 x 2.6-5.0) µm
4-sept.	58 x 4.3	mostly 49-68 x 3.9-4.7	(44-74 x 3.7-4.9) µm
5-sept.	70 x 4.5	mostly 55-81 x 4.1-5.2	(44-89 x 3.7-6.1) µm
6-sept.	76 x 4.5		(69-85 x 4.0-5.2) µm.

C h l a m y d o s p o r e s - in older cultures mostly present, but not very abundant, intercalary or terminal, smooth-walled, globose to oval, single (5-12 µm), in pairs or short chains, in hyphae or in desiccating conidia, sometimes excrescent, adhering either directly or on a short branch.

Explanation of Figure 63:

Drawing and photographs of conidia, conidiophores and chlamydospores of the type culture 62459 (= 11048 = CBS 636.76) on different substrates (x 500).

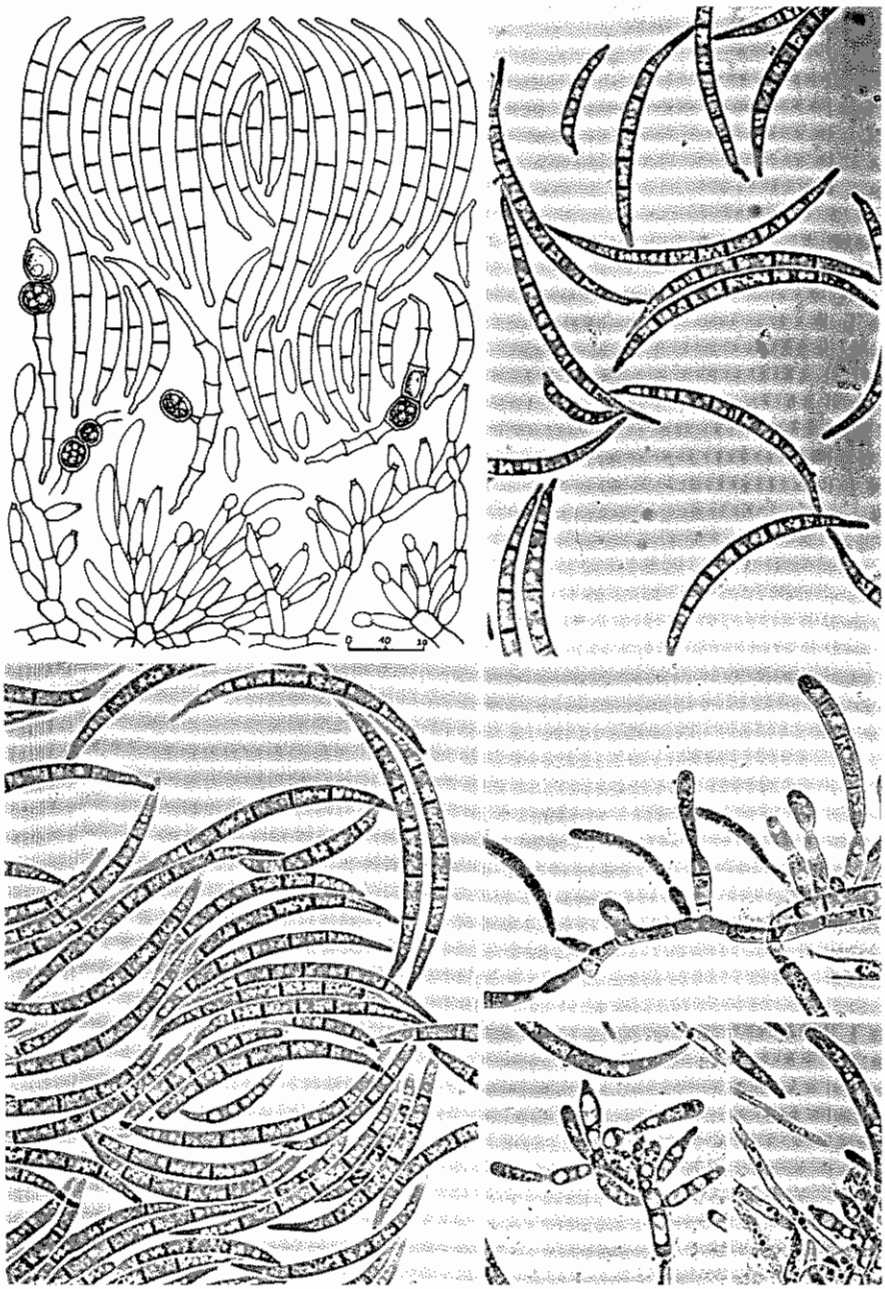

Fig. 63. Fusarium lunulosporum.

This Fusarium recently described as a new species is represented solely by the type culture 11048 (= 62459) deposited in the CBS/Baarn (636.76). It was isolated in 1968 from a grapefruit imported from South Africa which was damaged mainly by Colletotrichum gloeosporioides. Grapefruits, sweet oranges, lemons and apples artificially inoculated by wounding the skin indicated that the fungus causes a fruit rot.
This Fusarium is mainly characterized and distinguished from other species of the section Fusarium by its crescent shaped conidia which, by and large, are most similar to those of F. sublunatum though longer and more slender.

Fusarium tumidum Sherb. - Phytopathology 18: 148, 1928 var. tumidum

Descriptions: SHERBAKOFF (1928), WOLLENWEBER (1916-1935 no. 950-952), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), RAILLO (1950), BOOTH (1971a), JOFFE (1974).

C o l o n i e s - fast-growing, reaching 7.8 - 8.2 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - rather abundant, floccose to felt-like, occasionally tufted, zonate.
Pigmentation - beige, ochraceous, buff to olive-brown or chestnut-brown, but never carmine, purple or violet to dark blue as in F. tumidum var. coeruleum.
Sclerotial bodies - absent.
Sporulation - starting sparsely after about 2 weeks in the mycelium, macroconidia in mass greyish rose to pale orange, ochraceous to olive-brown or cinnamon-brown, small sporodochia or pionnotes generally not abundantly scattered over the surface of the colony.
Odour - not perceptible.

C o n i d i o p h o r e s - after about 10 days developing as single lateral phialides on hyphae, later densely and irregularly or sometimes verticillately branched when formed in sporodochia or pionnotes.
Phialides - monophialidic, subcylindric to obclavate, comparatively compact, 10-27 x 4.5-7.0 µm, thick-walled, with a marked collarette.

C o n i d i a - often some small, oval to obovate, 1-celled or 1-septate conidia present, macroconidia falcate, sometimes rather straight, subcylindric, but mostly more or less inequilaterally curved, thick-walled, with a short constricted, hooked, occasionally obtuse apex and a short conical or marked pedicellate base, mostly 3- to 5-septate, rarely 6- to 8-septate, exceptionally 9- to 10-septate, measuring:

0-sept.	15 x 5.3		(12- 21 x 4.5- 8.0) µm
1-sept.	21 x 7.6	mostly 22-25 x 6.0- 8.0	(12- 35 x 5.0- 8.5) µm
3-sept.	33 x 7.6	mostly 25-45 x 6.0- 9.0	(12- 50 x 4.0-11.5) µm
4-5-sept.	48 x 8.5	mostly 34-61 x 6.0-10.0	(25- 88 x 5.5-11.0) µm
6-7-sept.	63 x 9.1	mostly 56-88 x 7.0-11.7	(35-100 x 6.0-14.0) µm
8-10-sept.	85 x 10.5	mostly 73-96 x 9.5-11.5	(70-112 x 6.0-14.0) µm.

C h l a m y d o s p o r e s - rarely formed, generally intercalary in hyphae, only exceptionally in desiccated conidia, globose to subglobose, single (8-15 µm), in pairs, short chains or clusters, with smooth or sometimes rough walls.

Explanation of Figure 64:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 952 of strain 2681; drawing and photographs of conidia, conidiophores and chlamydospores of strains 2681 and 63572 (= CBS 486.76) on different substrates (x 500).

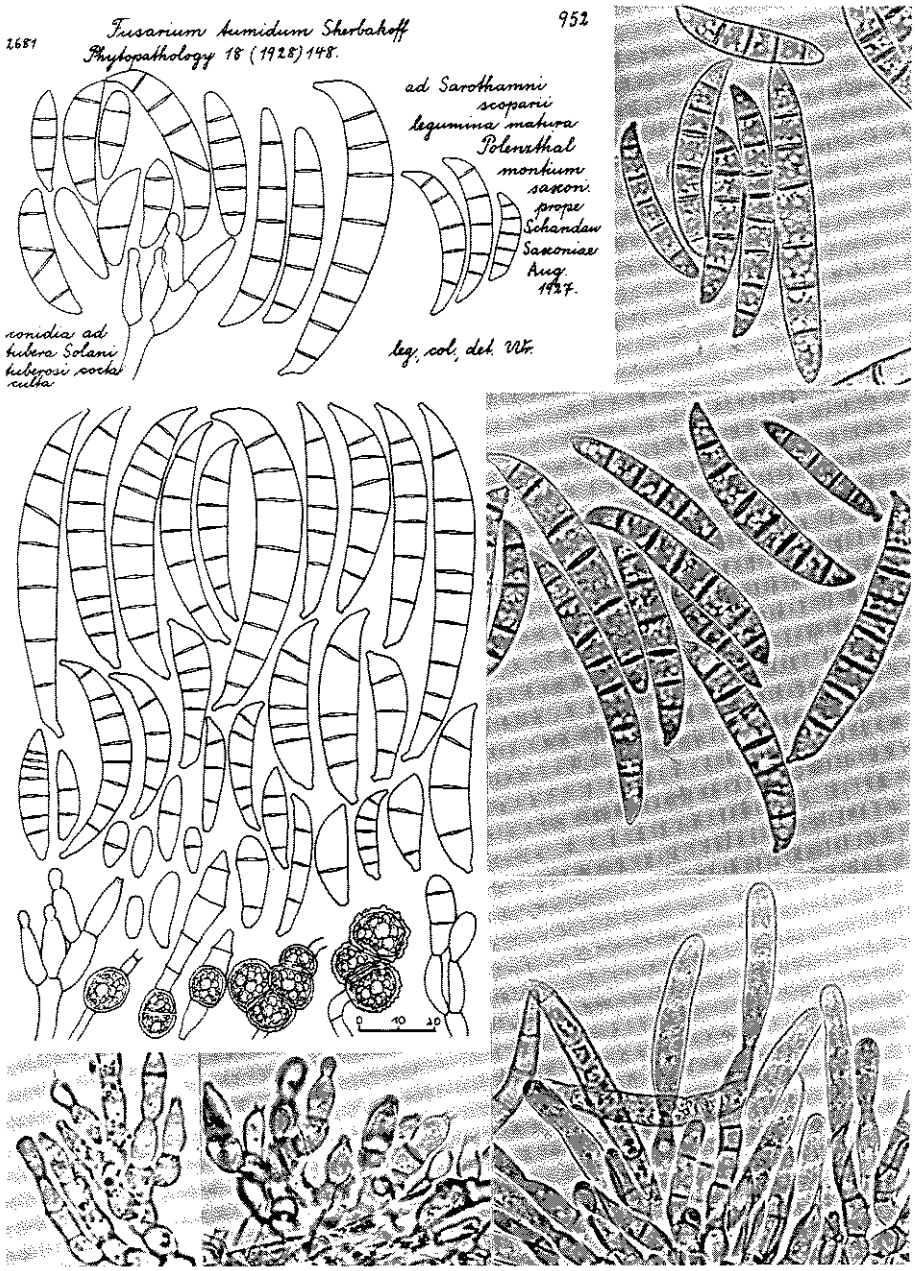

Fig. 64. Fusarium tumidum var. tumidum.

The description of F. tumidum by SHERBAKOFF (1928) as a new species is based on specimens collected by W. KRIEGER from decaying or dried pods of Sarothamnus (Cytisus) scoparius in the Polenz valley (Saxony/ Germany) in 1916. They were deposited as F. sarcochroum (Desm.) Sacc. in KRIEGER, Fungi saxonici, 2499, and SYDOW, Mycotheca germanica, 1797. Both samples were examined and illustrated by WOLLENWEBER (Fus. autogr. delin. no. 951, 950). In August 1927 he found this Fusarium again at exactly the same location; he isolated, cultured, described and illustrated the strain (2681) (Fus. autogr. delin. no. 952) and deposited the drawings and measurements of hundreds of conidia in our institute. The only available cultured strain of this species (63572 = CBS 486.76) was isolated from lupine in New Zealand (strain LEV 10162) and sent to us for identification by G.F. LAUNDON in 1976.

Without giving any references, BOOTH (1971a) stated, that this species was reported in association with branch necrosis or canker of both Hevea brasiliensis and Theobroma cacao and as a causal agent of tracheomycosis of Xylopia, occurring in the tropics, predominantly in southeast Asia and Central Africa. These reports, however, lack confirmation.

F. tumidum var. tumidum was not mentioned by DOIDGE (1938), BUGNICOURT (1939), GORDON (1952-1960) or SUBRAMANIAN (1971). It is accepted as a distinct species by RAILLO (1950), BOOTH (1971a) and JOFFE (1974), but astonishingly treated by BILAI (1955) together with F. bactridioides, F. camptoceras and others as synonymous with F. culmorum. It is clearly distinguished by its very large, robust conidia, the widest ones in Fusarium, except for F. gigas.

Fusarium tumidum Sherb. var. coeruleum Bugnicourt - Encycl. mycol. 11: 83, 1939

Descriptions: BUGNICOURT (1939), WOLLENWEBER (1943).

As far as we know no representative culture of this Fusarium is available.

The type culture (no. 37) was isolated in 1936 by BUGNICOURT from a branch of Hevea brasiliensis damaged by Corticium salmonicolor in Indo-China. Our re-examination of a strain deposited by R. HEIM in the CBS (128.40) has proved it to differ from F. tumidum var. coeruleum and is very similar to F. eumartii. A sub-culture of the type specimen was sent by BUGNICOURT to WOLLENWEBER in 1937 who studied it in every detail. His notes and numerous drawings, including coloured ones, deposited in our institute confirm the separate identity of this Fusarium. Its tendency to produce more clavate macroconidia and the occurrence of strong blue-violet, deep blue to dark olive pigments in the stroma on most substrates - in contrast to F. tumidum var. tumidum and var. humi - justify the recognition of the fungus as a separate variety. It should not equated with var. tumidum as proposed by BOOTH (1971a). RAILLO (1950), GORDON (1952-1960), BILAI (1955), SUBRAMANIAN (1971) and JOFFE (1974) did not mention this Fusarium.

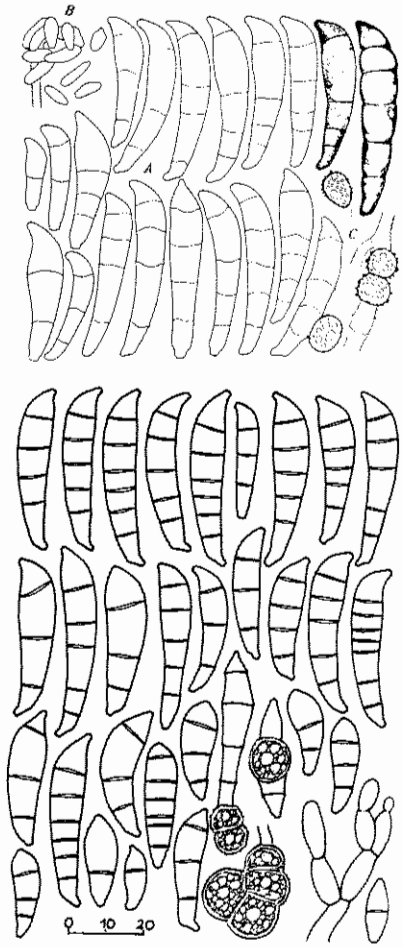

Fig. 65. Fusarium tumidum var. coeruleum.
Reproduction of Figure 12 (p. 85) by BUGNICOURT (1939); drawing of conidia, conidiophores and chlamydospores of the type culture BUGNICOURT no. 37 (= 6174) according to WOLLENWEBER's drawings (x 500).

Fusarium tumidum Sherb. var. humi Reinking - Zentralbl. Bakteriol. 2. Abt. 89: 513, 1934

Descriptions: REINKING (1934), WOLLENWEBER (1916-1935 no. 1152), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), RAILLO (1950).

This Fusarium was isolated by O.A. REINKING from soil in Honduras in 1931. He described it as a distinct variety because of its macroconidia, which are longer than in var. tumidum, generally 3-septate, and in mass cream-coloured, measuring:

1-sept.	30 x 8.5 µm	
2-sept.	33 x 10.4	mostly 28-37 x 10.3-10.5 µm
3-sept.	42 x 8.8	mostly 37-48 x 6.8-10.7 (28-52 x 6.0-12.0) µm
4-sept.	49 x 8.6	mostly 43-55 x 7.6- 9.5 (43-56 x 7.3-10.0) µm
5-sept.	51 x 8.9	mostly 45-54 x 8.4- 9.5 (40-67 x 7.5-12.5) µm.

There is no representative culture of F. tumidum var. humi available. Our recent re-examination of the type culture (CBS 191.34) deposited by REINKING and allegedly identical with WOLLENWEBER's 5236 showed it to be another species corresponding to F. eumartii. Therefore it was withdrawn from the CBS collection.

WOLLENWEBER's notes and numerous drawings of the type strain, preserved in our institute, correspond to the diagnosis of REINKING which was later also accepted by RAILLO (1950). Not mentioned by DOIDGE (1938), BUGNICOURT (1939), GORDON (1952-1960), SUBRAMANIAN (1971) or JOFFE (1974), this Fusarium was astonishingly treated by BILAI (1955) together with F. tumidum, F. bactridioides, F. camptoceras and others as synonymous with F. culmorum.

BOOTH (1971a) is propably correct in not considering var. humi as clearly distinct, since the broad variation of the macroconidia in F. tumidum var. tumidum depends on the substrates used and other culture conditions.

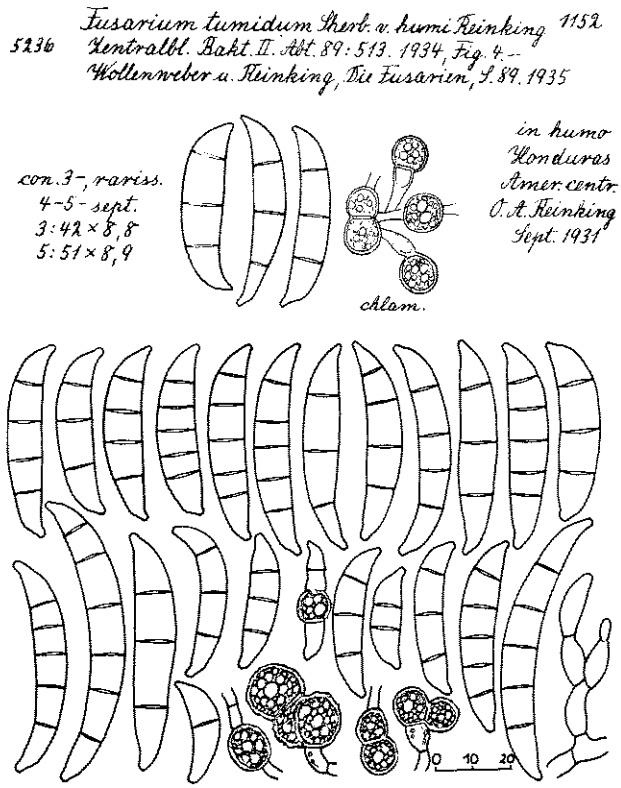

Fig. 66. Fusarium tumidum var. humi.
Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 1152 of the type culture 5236; drawing of conidia, conidiophores and chlamydospores of the type culture according to WOLLENWEBER's drawings (x 500).

Fusarium macroceras Wollenw. & Reinking - Phytopathology 15: 166, 1925

Descriptions: WOLLENWEBER & REINKING (1925), REINKING & WOLLENWEBER (1927), WOLLENWEBER (1916-1935 no. 949), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), RAILLO (1950), BILAI (1955).

This species was based on a single culture isolated by REINKING from mature pods of Phaseolus vulgaris in Honduras (R 95) and deposited by WOLLENWEBER in the CBS/Baarn (146.25). Our re-examination of the type culture showed it to be quite atypical. Only masses of 0-septate or 1-septate microconidia are formed by the completely deteriorated strain CBS 146.25. It is either contaminated by a Martiella-Fusarium or was mistakenly labeled in the collection. Therefore our description must be limited to the original diagnosis and to the notes and drawings of WOLLENWEBER deposited in our institute:

"Stroma floccose, rosy white, or dense plectenchymatic, yellow, ochraceous, and carmine. Conidia scattered, lanceolate or sickle-shaped, dorsi-ventral, constricted at the top end, conical at the base, apedicellate; conidia in sporodochia and pionnotes, elongate, slightly sickle-shaped, attenuated at both ends, pedicellate, 5- to 7-septate, fewer 1- to 4- or 8- to 9-septate, very seldom up to 14-septate; chlamydospores rare or lacking." Conidia measuring:

3-sept.	32 x 5.3	mostly 29-34 x 4.0-6.3	(24- 46 x 3.0-8.0) µm
5-sept.	46 x 5.5	mostly 45-47 x 5.0-6.3	(35- 67 x 3.5-8.0) µm
7-sept.	66 x 5.5	mostly 59-79 x 4.5-6.3	(47- 80 x 4.0-7.0) µm
8-9-sept.	72 x 5.5	mostly 59-79 x 4.3-6.3	(50-100 x 4.0-6.0) µm
10-11-sept.	86 x 5.5	mostly 80-93 x 5.0-6.3	(63-111 x 4.0-7.0) µm
12-14-sept.			(85-130 x 4.0-7.0) µm.

F. macroceras, not mentioned by DOIDGE (1938), BUGNICOURT (1939), GORDON (1952-1960), SUBRAMANIAN (1971) or JOFFE (1974), was accepted by RAILLO (1950) and BILAI (1955) as a distinct species. BOOTH (1971a), however, considered it surprisingly synonymous with F. trichothecioides. Without any doubt, F. macroceras is clearly distinguished from all other fusaria, especially because of its very characteristic macroconidia, and should be retained as a separate species.

Explanation of Figure 67:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 949 of the type culture R 95 (= CBS 146.25); drawing of conidia of the type culture according to WOLLENWEBER's drawings (x 500).

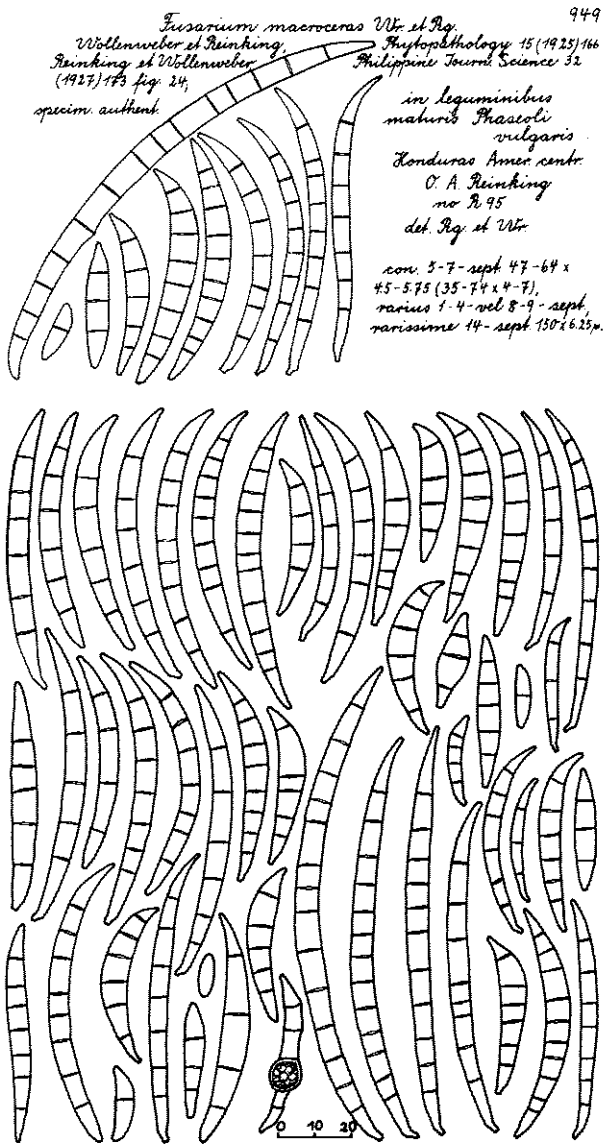

Fig. 67. Fusarium macroceras.

Fusarium trichothecioides Wollenw. in Jamieson & Wollenweber - J. Wash. Acad. Sci. 2: 146-152, 1912

Fusarium tuberivorum Wilcox & Link - Res. Bull. Nebraska agric. Exp. Stn 1: 48, 1913

Fusarium sambucinum Fuckel var. trichothecioides (Wollenw.) Bilai - Fusarii: 268, 1955

Descriptions: JAMIESON & WOLLENWEBER (1912), SHERBAKOFF (1915), WOLLENWEBER (1916-1935 no. 305), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), RAILLO (1950), BILAI (1955), BOOTH (1971a), JOFFE (1974).

This Fusarium was first found by JAMIESON and nearly at the same time by CARPENTER (1915), SHERBAKOFF (1915) and others in different regions of the USA, causing decay (powdery dry rot) of potato tubers, especially under storage conditions. The original diagnosis given for the fungus is as follows:

"In general appearance this fungus closely resembles Trichothecium roseum (Link); conidia in nature as a rule not in sporodochia, but, in pure culture the sporodochium or pionnotes stage also occurs: Conidia of the former 1-3-septate, medium size, 15-26 x 4-5.25 microns, formed as a slightly curved comma, ellipsoidally rounded on both sides; conidia of the latter type 3-5 septate, 24-42 x 4.5-5.5 microns; form of the Discolor type. Conidia masses and plectenchyma salmon colored to carrot red when slightly moist, but lighter and usually rosy-white when powdery dry and intermixed with mycelium. Yellowish to brown stromata may be formed. Conidiophores of the comma type, mostly irregularly branched, with prominent sterigmata, the arrangement of which is scattered, or especially at the top, trifurcate. Conidiophores in the sporodochia more highly developed, like those of F. discolor (a synonym of F. sambucinum). Chlamydospores seldom occur, and when present are intercalary, in chains or single."

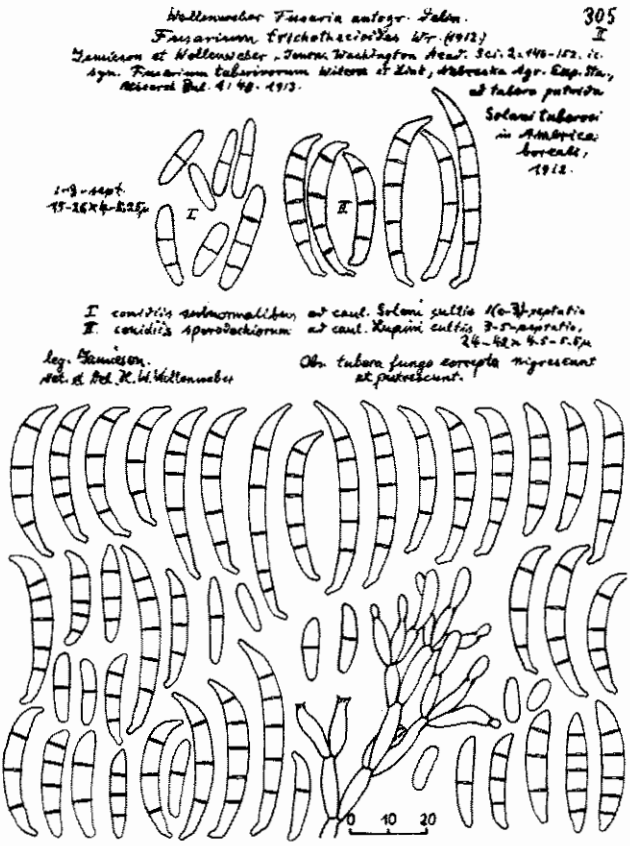

Fig. 68. Fusarium trichothecioides.

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 305 of the type culture; drawing of conidia and conidiophores of the type culture according to WOLLENWEBER's drawings (x 500).

The type culture was studied and illustrated by WOLLENWEBER (Fus. autogr. delin. no. 305). The original notes and those of a strain he got from SHERBAKOFF are preserved in our institute. Concerning SHERBAKOFF's isolate WOLLENWEBER noted larger conidia, completely corresponding to those formed by F. sulphureum. But he wrote nothing about the so-called comma type of their apparently polyblastic conidiophores which are also lacking in the descriptions later given by WOLLENWEBER (1931) and WOLLENWEBER & REINKING (1935). Neither the type culture nor another one from the period of initial discovery (1912-1915) was preserved.

F. trichothecioides, not mentioned by DOIDGE (1938) or BUGNICOURT (1939), was retained as a distinct species by RAILLO (1950) and BOOTH (1971a), however, without any remarks about the specimens examined. BILAI (1955) treated the fungus as a variety of F. sambucinum which was accepted by JOFFE (1974), but GORDON (1959) as well as SUBRAMANIAN (1971) considered F. trichothecioides synonymous with F. sulphureum (= F. sambucinum f. 6) which seems to be justified (GERLACH & ERSHAD 1970). During the past 20 years we studied some 30 isolates from potato tubers with dry rot from different European countries, from Iran and of overseas, all were approximately of the same type and were identified as F. sulphureum. They also correspond to the culture IMI 82762 (= CBS 136.73 = ATCC 24394) isolated from a potato tuber with dry rot in NSW. / Australia and deposited by R.J. CONROY in 1971. This strain is apparently the only one listed as F. trichothecioides in a representative culture collection. In our opinion, it is not possible to distinguish F. trichothecioides from F. sulphureum.

Fusarium bactridioides Wollenw. - Science, N.S. 79: 572, 1934

Descriptions: WOLLENWEBER (1934), WOLLENWEBER (1916-1935 no. 1153), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), RAILLO (1950).

C o l o n i e s - slow-growing, reaching 3.8 - 4.2 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - rather abundant, floccose to lanuginose, pale incarnadine.
Pigmentation - pale rose to salmon, dark blue-violet.
Sclerotial bodies - apparently absent.
Sporulation - starting with powdery agglomerations of smaller conidia in the mycelium, later typical macroconidia are formed in sporodochia or more frequently in pionnotes, in mass incarnadine to rose-orange, often more or less dark blue-violet tinged by stroma pigments, sporodochia occasionally pillar-like erumpent.
Odour - not perceptible.

C o n i d i o p h o r e s - as far as could be observed in the re-examined degenerated type culture, formed as single or sparsely branched lateral phialides on hyphae, densely aggregated in slimy layers especially on oatmeal agar.
Phialides - monophialidic, subcylindric to doliiform, comparatively compact, mostly 10-16 x 3-5 µm.

C o n i d i a - apparently formed as micro- and macroconidia; microconidia sometimes numerously scattered in the aerial mycelium, 1-celled or less frequently 1- to 2-septate, oval to ellipsoid or subclavate; macroconidia cylindric or fusiform, mostly rather straight or only slightly curved, with a slightly constricted and somewhat hooked, sometimes rather blunt or rounded apical cell and a comparatively short, wedge-shaped, only indistinctly pedicellate basal cell, predominantly 3- to 5-septate, rarely 6-septate, occasionally 7- to 11-septate, measuring:

0-sept.	8 x 3.7	mostly 6- 9 x 3.4-3.9	(5-14 x 3.0-5.0) µm
1-2-sept.	13 x 4.7	mostly 11-15 x 4.2-5.1	(7-26 x 3.0-6.5) µm
3-sept.	32 x 5.6	mostly 24-42 x 5.2-6.0	(17-48 x 4.2-7.0) µm
4-sept.	38 x 6.1	mostly 30-48 x 5.5-6.7	(28-57 x 4.7-7.5) µm
5-sept.	41 x 6.0	mostly 31-50 x 5.5-6.8	(25-67 x 4.8-8.0) µm
6-sept.	51 x 6.5		(36-71 x 5.6-7.5) µm
7-11-sept.	54 x 6.3		(30-70 x 5.0-8.0) µm.

C h l a m y d s p o r e s - sparse, intercalary, single, globose to subglobose (7-12 µm), rarely in pairs, smooth-walled.

Explanation of Figure 69:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 1153 of the type culture 4748 (= CBS 177.35); drawing and photographs of conidia, conidiophores and chlamydospores of the type culture on different substrates (x 500).

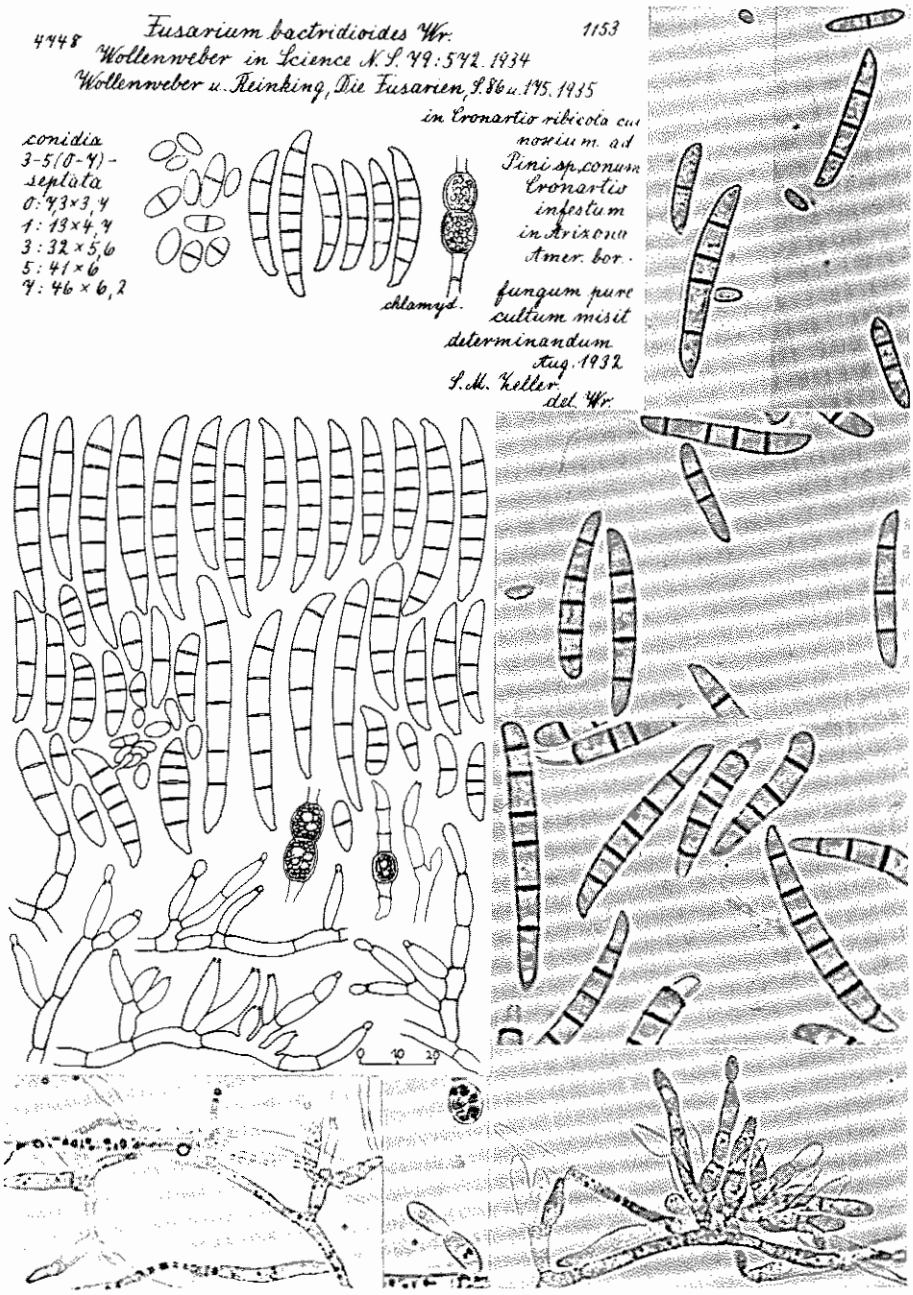

Fig. 69. Fusarium bactridioides.

F. bactridioides was found by A. HINCKLEY on a mummified cone of Pinus leiophylla from the Chiricahua Mountains in Arizona. The fungus was parasitizing Cronartium conigenum which had attacked the cone. In March 1932 HINCKLEY sent this material to L.N. GOODDING, cooperating with the Oregon Experiment Station in Corvallis, who isolated this Fusarium and S.M. ZELLER transmitted subcultures to WOLLENWEBER for identification. The type culture (4748) deposited in the CBS/Baarn (177.35) was studied in every detail and illustrated by WOLLENWEBER (Fus. autogr. delin. no. 1153). This Fusarium species does not seem to have been found again. DOIDGE (1938), BUGNICOURT (1939), GORDON (1952-1960), SUBRAMANIAN (1971) and JOFFE (1974) did not mention this fungus. RAILLO (1950) retained F. bactridioides as a distinct species, BILAI (1955) considered it synonymous with F. culmorum and BOOTH (1971a) as synonymous with F. trichothecioides, not accepting the specific features of F. bactridioides stated by WOLLENWEBER. Our re-examination of the type culture showed it to be rather deteriorated. But it still produces quite typical macroconidia on some substrates after exposure to daylight. These correspond completely to those described and illustrated by WOLLENWEBER. They are clearly different from conidia formed in F. culmorum and F. trichothecioides (= F. sulphureum), confirming that F. bactridioides is a separate species.

Section LATERITIUM Wollenw. - Ann. mycol. 15: 2, 1917

Fusarium lateritium Nees ex Link - Spec. plant. 6 (2): 106, 1824
var. lateritium

Fusarium lateritium Nees ex Link var. minus Wollenw. - Z. Parasitenk. 3: 375, 1931

Fusarium lateritium Nees ex Link var. mori Desm. - Ann. Sci. nat. II. 8:10, 1837

Teleomorph: Gibberella baccata (Wallr.) Sacc. - Syll. Fung. 2: 553, 1883 var. baccata

Gibberella baccata (Wallr.) Sacc. var. moricola (De Not.) Wollenw. - Z. Parasitenk. 3: 377, 1931

Descriptions: WOLLENWEBER (1916-1935 no. 5-25, 226, 228-285, 513, 570, 577-593, 813-816, 953, 955-961, 1118, 1154), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), GORDON (1952), RAILLO (1950), GERLACH & ERSHAD (1970), BOOTH (1971a, 1971d), SUBRAMANIAN (1971), JOFFE (1974), DOMSCH et al. (1980).

C o l o n i e s - slow-growing, reaching 1.8 - 3.5 cm diam. in 10 days at 25°C on PDA; colony margin usually irregularly lobed.
Aerial mycelium - rather sparse, lanuginose to tufted, whitish to flesh, beige-rose to salmon.
Pigmentation - reaching from beige, pale salmon to ochraceous-brown, agar surface sometimes with colours corresponding to sclerotial bodies; distinct red-violet, carmine, purple or vinaceous pigmentation lacking.
Sclerotial bodies - mostly present in freshly isolated cultures, small, globose to subglobose, pink, buff-brown, grey-green to dark blue or almost black.
Sporulation - starting rather quickly, after a few days numerous sporodochia develop, abundantly formed on sclerotia, masses of conidia deep orange, confluent, sometimes finally covering wide parts of the surface as a cinnamon layer.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, later branching loosely, in sporodochia densely branched, often appearing gnarled.
Phialides - monophialidic, sometimes polyphialidic, often percurrently proliferating, cylindric to subcylindric, somewhat gnarled, mostly 10-20 x 3.0-4.0 µm.

C o n i d i a - only macroconidia formed, some small 0- to 1-septate conidia usually present in the mycelium, sporodochial conidia very uniform in shape and size, almost straight in the central part, with a hooked apical and a distinct pedicellate basal cell, predominantly 3-, often 4- to 5-, exceptionally 6- to 7-septate, measuring:

0-sept.	9 x 2.9	mostly 7-13 x 2.5-4.0	(5-22 x 2.5-6.0) µm
1-sept.	22 x 3.5	mostly 15-30 x 3.0-4.5	(11-35 x 2.0-5.0) µm
3-sept.	33 x 3.6	mostly 21-42 x 2.8-4.4	(13-52 x 2.0-5.0) µm
4-5-sept.	43 x 3.8	mostly 30-55 x 3.0-4.7	(24-84 x 2.5-5.0) µm
6-7-sept.	56 x 3.9	mostly 49-70 x 3.2-4.5	(32-84 x 3.0-5.0) µm.

The conidia illustrated by BOOTH (1971d) are much too large when compared with the given magnification.

C h l a m y d o s p o r e s - sparse, intercalary in hyphae or conidia, globose to subglobose, single (8-12 µm) or in pairs; chlamydospore-like swellings in hyphae sometimes present.

Explanation of Figure 70:
Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

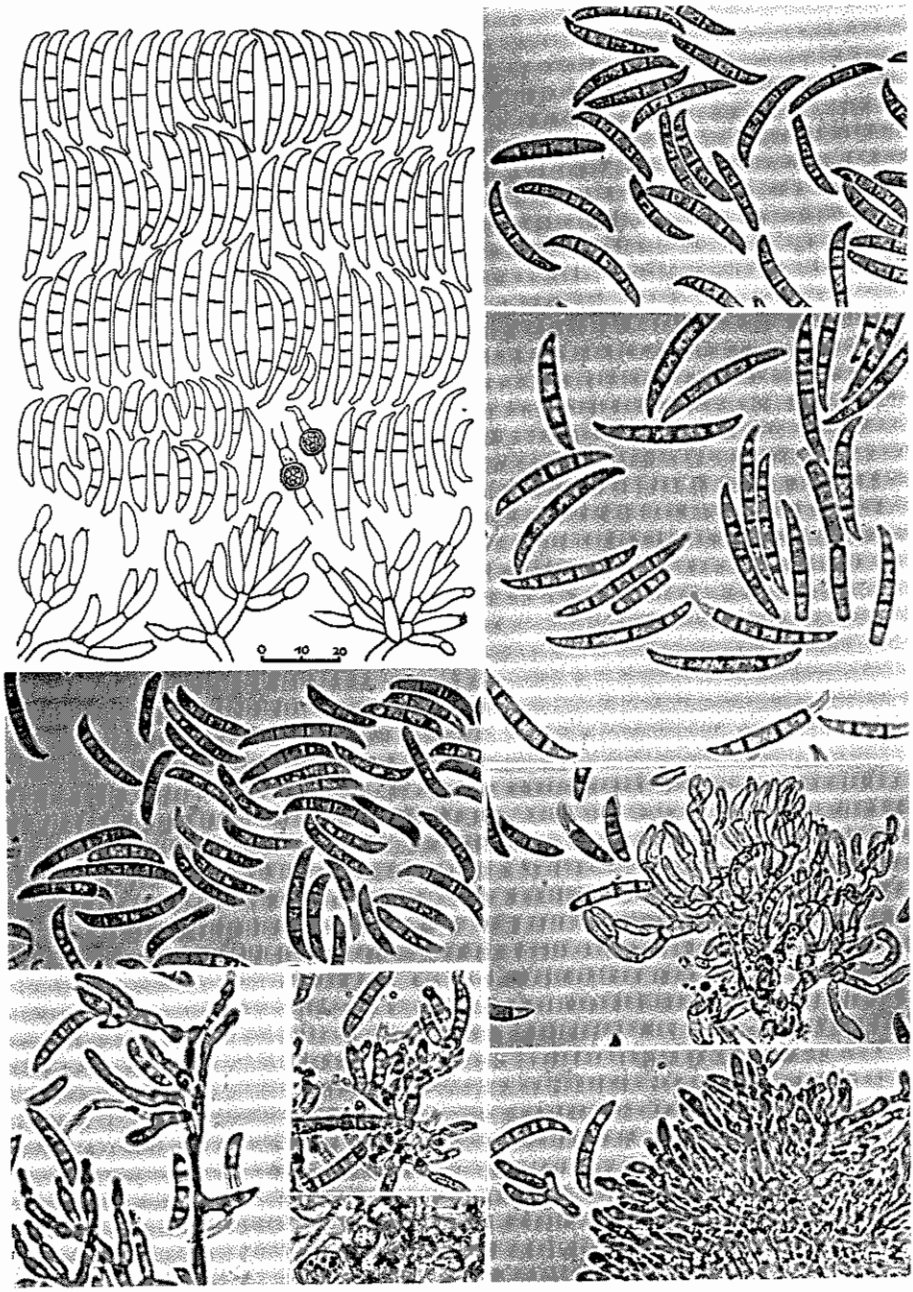

Fig. 70. Fusarium lateritium var. lateritium.

F. lateritium is generally accepted as a distinct species, but in a concept differing somewhat with regard to the varieties which are discussed in the description of the following taxa.

It occurs worldwide on numerous species of woody plants, in the soil and on other matrices in temperate and tropical regions. As a wound parasite it is responsible for die-back, twig blight, collar rot, canker, leaf spot, fruit rot and other diseases. It may sometimes cause losses of some economic importance. Differences in pathogenicity of isolates from different hosts were shown by cross inoculation experiments. Until now 4 formae speciales have been described: f. sp. pini, f. sp. ciceris, f. sp. cerealis, f. sp. mori. Forma specialis ciceris, however, has been transfered to F. oxysporum and f. sp. pini is considered to be F. sacchari var. subglutinans (DWINELL 1978). The pathogenic abilities of the other 2 fungi are not so strongly host specific as to justify their treatment as formae speciales when compared with those distinguished in F. oxysporum. More detailed information is given by BOOTH (1971a, 1971d) and DOMSCH et al. (1980).

Fusarium lateritium Nees ex Link var. uncinatum (Wollenw.) Wollenw. - Z. Parsitenk. 3: 375, 1931

Fusarium uncinatum Wollenw. - Ann. mycol. 15: 54, 1917

This Fusarium was originally described as a distinct species and later designated by WOLLENWEBER as a separate variety of F. lateritium. It differs in its conidia which are subulate, falcate, narrowing at both ends and which are strongly hooked, more slender and less septate. It is a foot rot and wilt pathogen of Cajanus cajan. Not mentioned by DOIDGE (1938) or BUGNICOURT (1939), it was treated synonymous with F. lateritium by RAILLO (1950), GORDON (1952), BILAI (1955) and BOOTH (1971a p. 217). SUBRAMANIAN (1971), however, considered it identical with F. udum Butler which seems to be restricted to India. BOOTH (also 1971a but p. 113) agreed with this opinion.

There is no doubt that the treatment by SUBRAMANIAN is correct.

Fusarium lateritium Nees ex Link var. microconidium Batikyan & Abramyan - Biol. Zh. Armen. 22: 60, 1969

Published without Latin diagnosis.

Fusarium lateritium Nees ex Link var. buxi C. Booth - The Genus Fusarium: 112-113, 1971

Teleomorph: Gibberella buxi (Fuckel) Winter in Rabenhorst - Krypt. Flora 2: 103, 1887

Gibberella baccata (Wallr.) Sacc. var. major Wollenw. - Z. Parasitenk. 3: 384, 1931 (fide BOOTH 1971a)

BOOTH (1971a) gave the following description of the fungus in culture:

"Growth rate 3.5 cm. Single ascospore or single conidial cultures pale rose to peach with floccose to felted aerial mycelium. From below pale peach becoming tinged with reddish-violet.
Macroconidia only are formed and these develop initially from lateral phialides in the aerial mycelium but later they are produced in sporodochia formed on the surface of the agar. Aerial conidiophores are simple lateral branches terminating in two or three phialides or producing two or three apical metulae 8-15 x 3-5 µm which in turn terminate in phialides, 15-20 x 3-4.5 µm. Conidia formed from conidiophores in the aerial mycelium tend to be longer and somewhat narrower than those produced from sporodochia. Conidia from aerial mycelium 0- to 3-septate, 40-65 x 4-4.5 µm. Conidia from sporodochia 3-septate but later becoming 6- to 7-septate without increase in length, 40-45 x 4.5-6 µm.
Chlamydospores occur in the aerial mycelium and in older cultures develop in the cells of the conidia. They are globose, hyaline, smooth-walled and measure 10-15 µm diam."

This diagnosis does not state convincing characteristics which justify a separate variety to F. lateritium var. lateritium or to var. majus which is also recorded on Buxus (WOLLENWEBER 1931). Its teleomorph G. baccata var. major is given by BOOTH as synonymous with G. buxi, the teleomorph of his F. lateritium var. buxi.

Fusarium lateritium Nees ex Link var. majus (Wollenw.) Wollenw. - Z. Parasitenk. 3: 383-384, 1931

Fusarium lateritium Nees ex Link subsp. majus (Wollenw.) Raillo - Fungi of the Genus Fusarium (Moscow): 270, 1950

Teleomorph: Gibberella baccata (Wallr.) Sacc. var. major Wollenw. - Z. Parasitenk. 3: 384, 1931

Descriptions: WOLLENWEBER (1916-1935 no. 26, 286, 593, 594, 962, 963, 1119, 1120), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - usually not very abundant, rather delicate, felt-like or with areas more tufted, often interspersed with expanded pionnotal layers, initially whitish to pink, yellowish to cinnamon, later tinged with the colour of the plectenchymatous stroma.
Pigmentation - beige, ochraceous, cinnamon, reddish brown; carmine, purple or vinaceous colours absent.
Sclerotial bodies - mostly present, formed as flat, sometimes cauliflower-like or globose erumpent sclerotia, tan to buff-brown, bluish or finally blue-black.
Sporulation - usually very abundant and quickly developing as in var. lateritium, after 1-2 weeks extensive parts of the surface of the colony are covered with salmon to deep orange, reddish brown, cinnamon sporodochial or pionnotal slimes.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, later loosely branching and densely aggregated when forming sporodochia and pionnotes.

Phialides - monophialidic, occasionally percurrently proliferating, predominantly somewhat gnarled subcylindric to doliiform, comparatively compact, mostly 10-20 µm long and 3.0-4.0 µm wide.

C o n i d i a - only macroconidia formed, but usually some small 0- to 2-septate conidia present, shape not markedly different from var. lateritium, with the exception of its tendency to form higher septate, longer and somewhat wider conidia, predominantly 5-septate, less frequently 3- to 4- or 6-septate and exceptionally 7- to 9-septate, measuring:

0-sept.	8 x 3.0		(6-11 x 2.5-3.5) µm
1-sept.	21 x 3.4	mostly 13-30 x 2.7-4.5	(11-35 x 2.5-5.0) µm
3-sept.	35 x 3.5	mostly 30-42 x 2.5-4.4	(20-52 x 2.3-5.0) µm
5-sept.	53 x 4.0	mostly 46-64 x 3.5-4.7	(44-74 x 3.5-5.0) µm
7-sept.	66 x 4-1	mostly 52-72 x 3.2-4.5	(50-84 x 3.5-5.0) µm.

C h l a m y d o s p o r e s - may be present, in hyphae or conidia, intercalary, terminal or laterally excrescent, adhering either directly or on a short branch, globose to subglobose, smooth-walled, single (7-10 µm) or in pairs.

Explanation of Figure 71:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 286 of strain W 10-4; drawing and photographs of conidia, conidiophores and chlamydospores of strain 62246 (x 500).

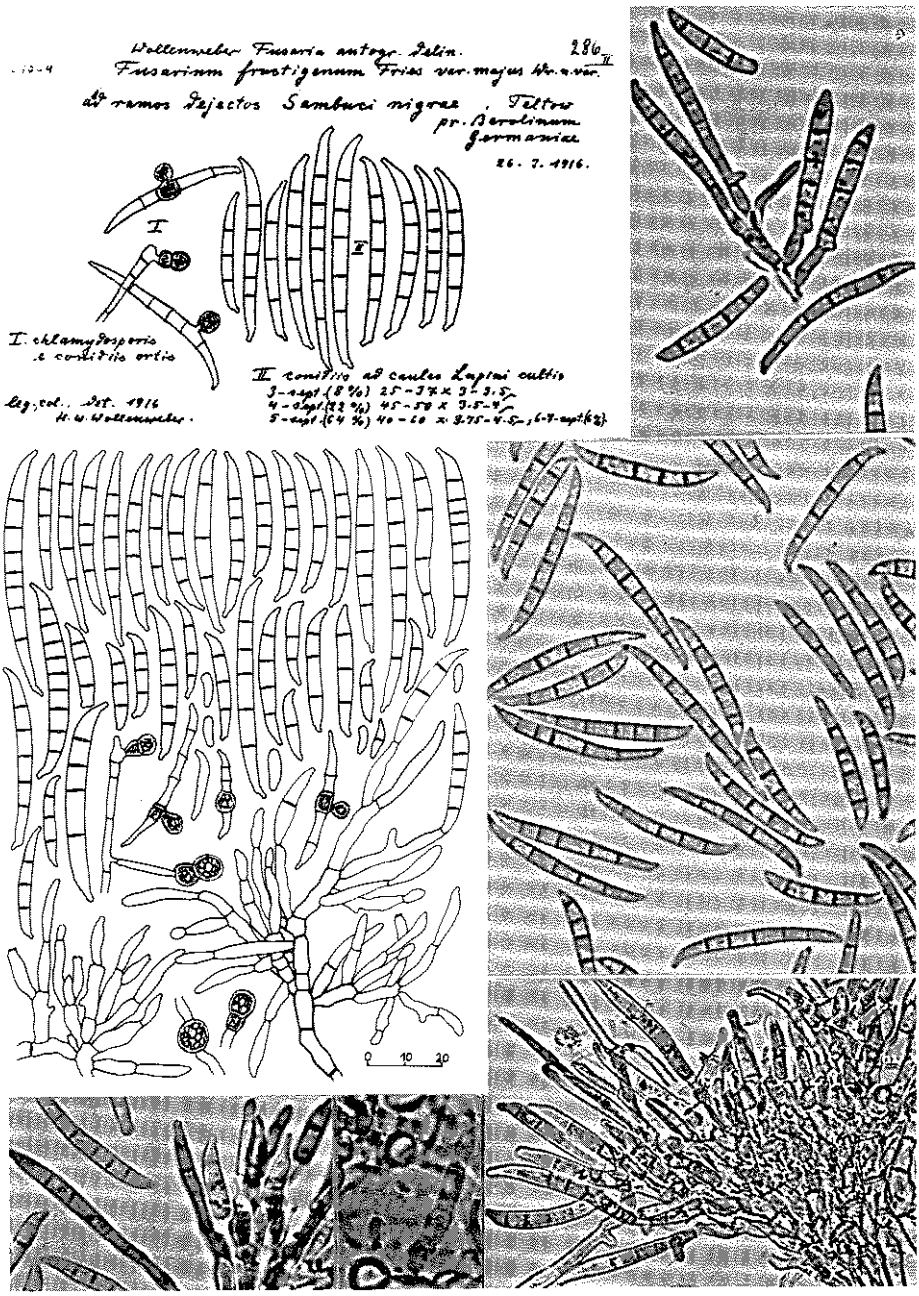

Fig. 71. Fusarium lateritium var. majus.

F. lateritium var. majus was separated by WOLLENWEBER (1931) because of its conidia higher septate and larger than in F. lateritium. Later it was accepted by WOLLENWEBER & REINKING (1935) and RAILLO (1950 - as subspecies) but most authors did not treat it as different. The notes and drawings of F. lateritium var. majus deposited by WOLLENWEBER in our institute are derived from 16 specimens, 12 of which were studied as cultured strains. All cultures were isolated from the bark of branches or from fruits of woody plants (Acacia, Albizzia, Buxus, Citrus, Cydonia, Gleditsia, Populus, Sambucus, Tilia, Vitis) by himself or sent to him for identification from European countries, North America, Australia and Java.

Among the numerous strains of F. lateritium personally studied during the past 30 years there was only one (62246) which largely corresponded with var. majus. It was isolated by H. RICHTER from an Eriosoma gall on a leaf of Ulmus scabra in Badgastein/Austria in September 1973.

Considering the broad variation in strains of F. lateritium var. lateritium and the generally accepted wider species concept including most of the varieties and forms described as distinct by WOLLENWEBER (and also var. buxi as proposed above) it may be appropriate to withdraw var. majus as a separate variety.

Fusarium lateritium Nees ex Link var. longum Wollenw. - Z. Parasitenk. 3: 385, 1931

Descriptions: WOLLENWEBER (1916-1935 no. 964, 965), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938).

C o l o n i e s - slow-growing, reaching 2.8 - 3.4 cm diam. in 10 days at 25°C on PDA; colony margin usually irregularly lobed; macroscopic rather similar to F. lateritium var. lateritium.
Aerial mycelium - not abundant, on carrot and oatmeal agar only very sparse, usually floccose, arachnoid appressed or somewhat felt-like, whitish to salmon.
Pigmentation - from beige, salmon to pink-orange, with slightly brown areas; distinct red (deep carmine to port-wine) pigmentation as given for F. stilboides (BOOTH & WATERSTON 1964d) lacking.
Sclerotial bodies - present, formed as small, globose to subglobose, pale or brownish to grey-greenish and dark blue sclerotia, usually not striking.
Sporulation - abundant and quickly starting, after 5-6 days numerous small globose sporodochia occur particularly on carrot agar and alfalfa stem, bearing salmon or bright orange coloured masses of macroconidia which are rather uniform and distinctly septate, finally confluent forming expanded layers.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides on hyphae, later loosely branching, in sporodochia or pionnotal layers more densely aggregated and irregularly or verticillately branched.

Phialides - monophialidic, rather slender, cylindric to subcylindric, with a very distinct collarette, mostly 15-30 µm long and 2.5-3.5 µm wide, occasionally with an extremely inflated rhomboid terminal cell.

C o n i d i a - only macroconidia formed, but some small 0- to 1-septate conidia may be present in the mycelium, usually rather straight or slightly curved, almost cylindric, gradually tapering toward both ends, with a slightly hooked and pointed apical cell and a distinctly pedicellate basal cell, mostly 5-septate, less frequently 3- to 4- or 6- to 7-septate, exceptionally up to 9-septate, measuring:

0-1-sept.	11 x 2.7	mostly 9-14 x 2.5-3.0	(7-20 x 2.0-3.5) µm
3-sept.	42 x 3.7	mostly 30-48 x 3.4-4.2	(19-55 x 3.0-4.5) µm
5-sept.	59 x 4.6	mostly 50-68 x 4.0-5.0	(41-82 x 3.5-5.6) µm
7-sept.	77 x 4.9	mostly 69-82 x 4.2-5.4	(56-92 x 4.0-6.0) µm
9-sept.	86 x 4.9	mostly 82-90 x 4.6-5.4	(78-95 x 4.0-6.0) µm.

C h l a m y d o s p o r e s - sparse, intercalary in hyphae, single (8-12 µm) or in pairs; chlamydospore-like swellings may occur.

Explanation of Figure 72:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 964 of the type culture 1839b; drawing and photographs of conidia and conidiophores of strain 63665 (= CBS 633.76) on different substrates (x 500).

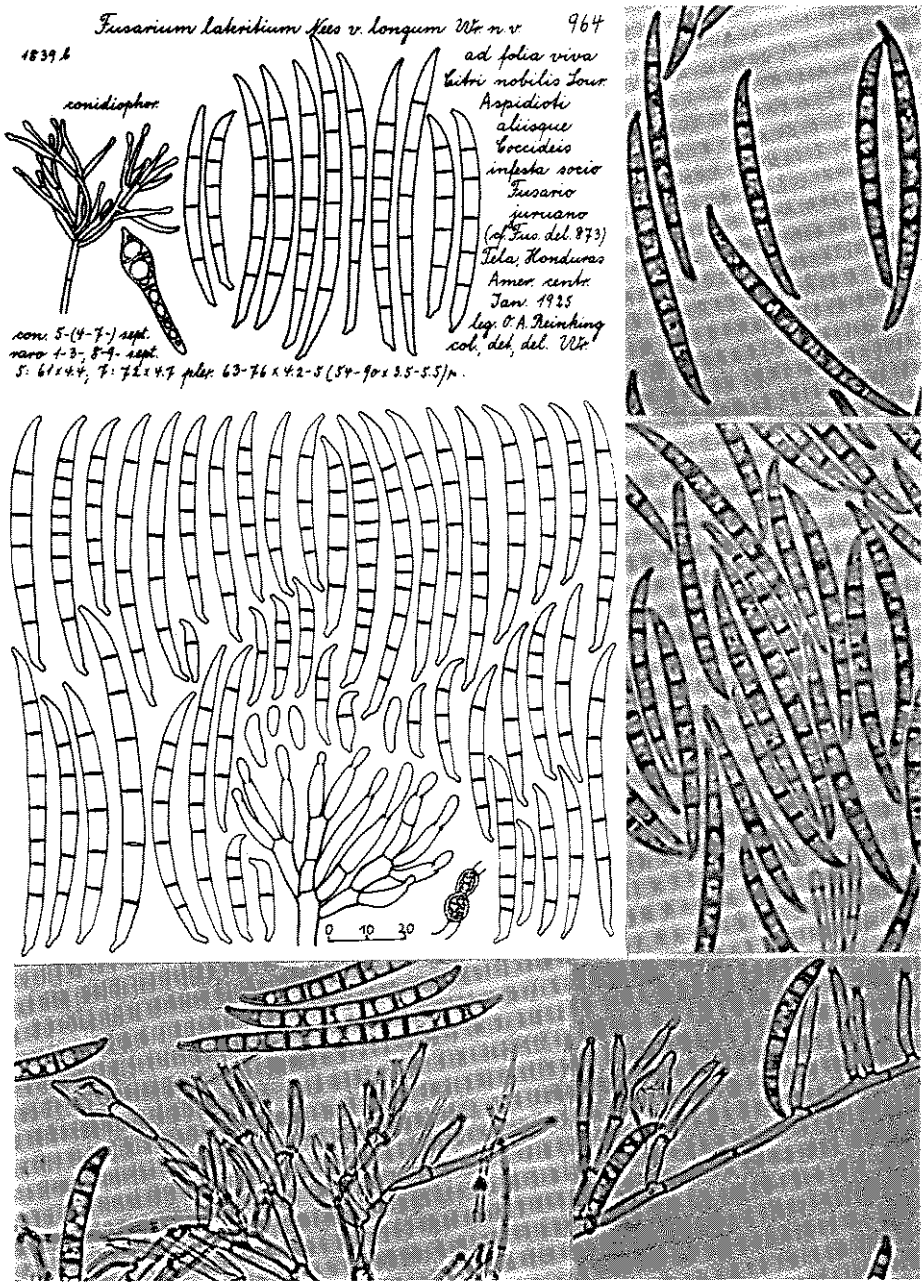

Fig. 72. Fusarium lateritium var. longum.

F. lateritium var. longum is typified by strain 1839b described and illustrated by WOLLENWEBER in Fus. autogr. delin. no. 964 (see Fig. 72) which was isolated from a Citrus leaf infested with scale insects in Honduras and collected by REINKING in 1925. Drawings, including coloured ones, of this strain and of 10 further cultured isolates (7 from Citrus and 3 from coffee) are preserved in our institute. F. lateritium var. longum was accepted as a distinct variety because of its much longer and higher septate conidia (WOLLENWEBER 1931). Later also WOLLENWEBER & REINKING (1935) and DOIDGE (1938) who added some further records on Citrus and Coffea from South Africa accepted this variety. In agreement with RAILLO (1950), the fungus together with the forms A1 and A2 described by STOREY in 1932 was regarded as synonymous with F. stilboides by BILAI (1955), BOOTH & WATERSTON (1964d) and BOOTH (1971a). Not mentioned by BUGNICOURT (1939) or JOFFE (1974), it was included in F. lateritium by GORDON (1952) and SUBRAMANIAN (1971) who accepted this species in the sense of SNYDER & HANSEN (1945). Our opinion that F. lateritium var. longum is clearly distinct from F. stilboides by its pigmentation and its conidial characteristics was confirmed by a culture (63665) which we received for identification in 1976 from G.F. LAUNDON as strain LEV 10851c. It was isolated from a Citrus fruit in New Zealand. The culture is available in the CBS/Baarn (6 33.76).

This Fusarium is recorded from tropical and subtropical regions of Africa, America, Asia and Australia, occurring most often on Coffea and Citrus. It may be of some importance as a fruit rot, collar rot and bark rot pathogen. Regarding its geographical distribution, its host range and its pathogenicity, it may be compared with F. stilboides.

Fusarium stilboides Wollenw. - Fus. autogr. delin.: 615, 1924
var. stilboides

Fusarium stilboides Wollenw. f. 1 Raillo - Fungi of the Genus Fusarium (Moscow): 271, 1950

Fusarium lateritium Nees ex Link var. stilboides (Wollenw.) Bilai - Fusarii: 266, 1955 (pro parte)

Teleomorph: Gibberella stilboides Gordon ex C. Booth - The Genus Fusarium: 119-120, 1971

Descriptions: WOLLENWEBER (1916-1935 no. 615, 967, 968), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), BUGNICOURT (1939), RAILLO (1950), GORDON (1956b), BOOTH & WATERSTON (1964d), BOOTH (1971a), JOFFE (1974).

Colonies - moderately fast-growing, reaching 6.5 - 7.2 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - abundant, floccose, somewhat powdery in fresh isolates, in subcultures more felt-like, whitish to rose.
Pigmentation - usually rather intensive, from pink, salmon, orange-red to carmine-red, reddish brown, partly violet to bluish black.
Sclerotial bodies - occasionally present, dark bluish, globose or irregularly shaped, small (0.3-0.6 mm).
Sporulation - initially scattered in the aerial mycelium, later usually numerous bright orange coloured sporodochia formed, mostly small and globose, sometimes pillar-like erumpent or confluent to more or less expanded layers.
Odour - not perceptible.

Conidiophores - at first arising as single lateral phialides in the aerial mycelium, branching later; in sporodochia more densely aggregated and branched.
Phialides - monophialidic, occasionally showing proliferations, subcylindric, 10-20 x 3-5 µm.

C o n i d i a - usually a few 0- to 3-septate conidia present, developing in the aerial mycelium; conidia of sporodochia comparatively long and straight, almost cylindric in the center, only slightly curved, gradually tapering toward each end, with a somewhat elongated, sometimes subterminally constricted, pointed apical cell and a distinctly pedicellate basal cell, mostly 5- to 7-(3- up to 16-)septate, measuring:

0-sept.	7 x 2.7	mostly 6- 10 x 2.5-2.9	(4- 13 x 2.2-3.2) µm
1-sept.	15 x 3.2	mostly 12- 18 x 3.0-3.5	(9- 21 x 2.8-5.7) µm
3-sept.	42 x 3.3	mostly 35- 56 x 3.0-3.7	(16- 73 x 2.7-5.0) µm
4-sept.	58 x 3.9	mostly 47- 70 x 3.1-4.5	(37- 84 x 3.0-5.2) µm
5-sept.	68 x 4.4	mostly 57- 85 x 4.0-5.0	(40-104 x 3.3-6.0) µm
6-sept.	76 x 4.5	mostly 70- 86 x 4.2-5.2	(56-111 x 3.5-5.8) µm
7-sept.	81 x 4.5	mostly 70- 96 x 4.3-5.1	(62-120 x 3.5-6.0) µm
8-16-sept.	85 x 4.7	mostly 75-105 x 4.3-5.1	(69-160 x 3.8-6.0) µm.

C h l a m y d o s p o r e s - usually a few chlamydospore-like swellings occur, but less frequently in conidia than in hyphae, predominantly intercalary, smooth-walled, globose to subglobose, single (6-12 µm), in pairs or chains.

Explanation of Figure 73:

Reproduction of WOLLENWEBER's Fus. autogr. delin.no. 967 of strains 2442 and 2444a; drawing and photographs of conidia, conidiophores and chlamydospore-like swellings of strains 62427, 62429 and 63887 (= CBS 746.79) on different substrates (x 500).

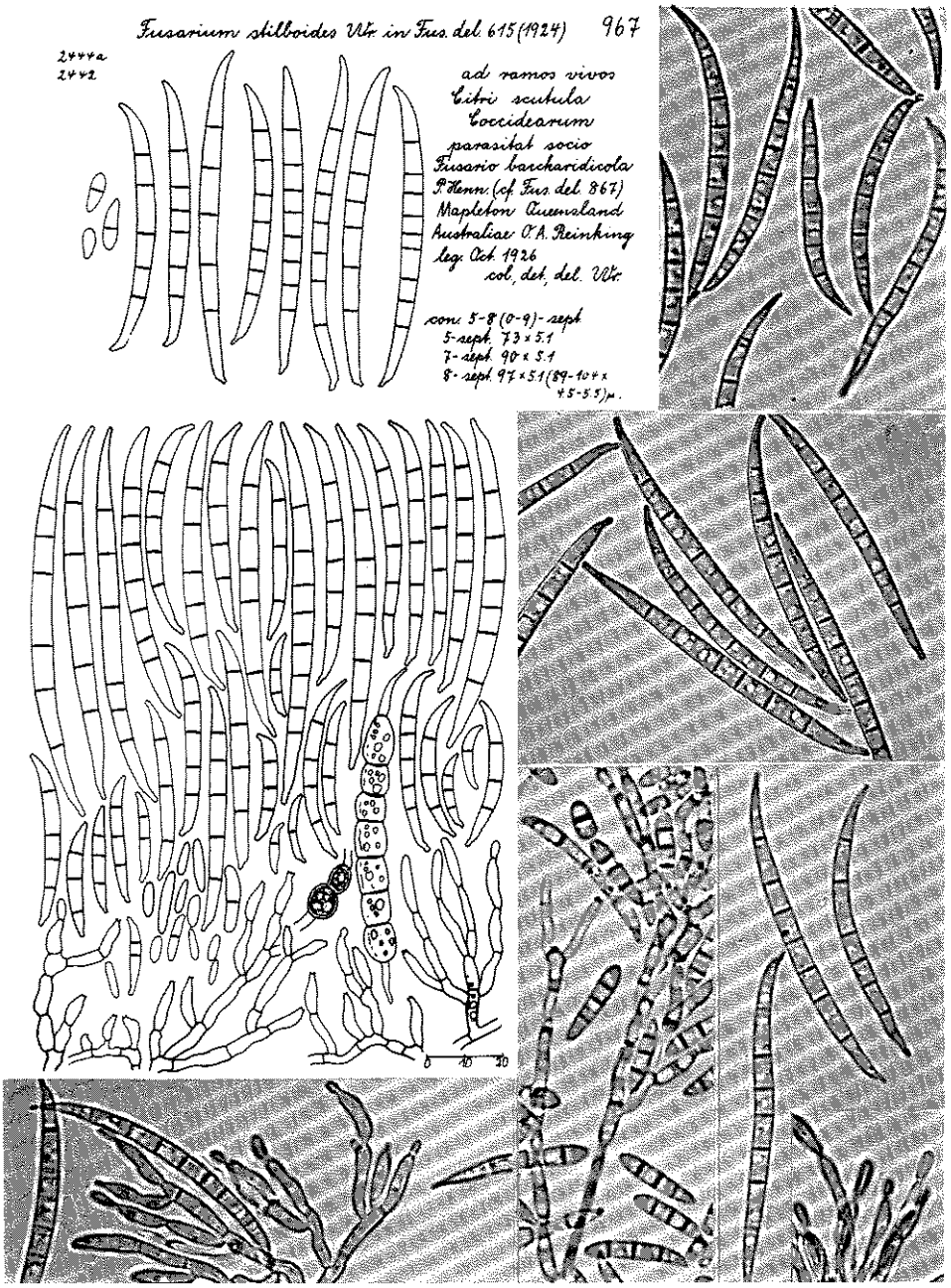

Fig. 73. Fusarium stilboides var. stilboides.

F. stilboides is a very characteristic species and generally accepted as distinct (DOIDGE 1938, BUGNICOURT 1939, RAILLO 1950, GORDON 1956b, BOOTH & WATERSTON 1964d, BOOTH 1971a and JOFFE 1974). However, BILAI (1955) treated it as a variety of F. lateritium. GORDON (1952) and SUBRAMANIAN (1971) accepted the proposal of SNYDER & HANSEN (1945) who considered it synonymous with F. lateritium.

In addition to the notes and drawings of 8 cultured strains deposited by WOLLENWEBER, 11 further isolates were available for comparison during the past years. One strain (63887) isolated from Citrus fruit in New Zealand is preserved in the CBS/Baarn (746.79).

F. stilboides is only recorded from the tropics and subtropics. It causes bark diseases and fruit rots and occurs particularly on Citrus and coffee, where it is best known and sometimes economically important (for detailed information see BOOTH & WATERSTON 1964d and BOOTH 1971a).

Fusarium stilboides Wollenw. var. minus Wollenw. - Z. Parasitenk. 3: 386, 1931 emend. Bugnicourt - Encycl. mycol. 11: 92, 1939

Descriptions: WOLLENWEBER (1916-1935 no. 966), WOLLENWEBER & REINKING (1925), REINKING & WOLLENWEBER (1927), WOLLENWEBER (1931), BUGNICOURT (1939), WOLLENWEBER (1943).

F. stilboides var. minus was initially described as a distinct variety with less septate conidia (WOLLENWEBER 1931), but not kept separate by WOLLENWEBER & REINKING (1935). It was recognized by BUGNICOURT (1939) again as a different variety. Following RAILLO (1950) and BOOTH (1971a), we also prefer to include the fungus in a somewhat wider concept of F. stilboides.

Fusarium sarcochroum (Desm.) Sacc. - Michelia 1: 534, 1879

Selenosporium sarcochroum Desm. - Ann. sci. nat. sér. 3, 14: 112, 1850

Fusarium sarcochroum (Desm.) Sacc. f. 1 Raillo - Fungi of the Genus Fusarium (Moscow): 272, 1950

Teleomorph: Gibberella pseudopulicaris Wollenw. - Z. Parasitenk. 3: 387-388, 1931

Descriptions: WOLLENWEBER (1916-1935 no. 30, 287-291, 514, 817), WOLLENWEBER et al. (1925), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), RAILLO (1950), BILAI (1955).

C o l o n i e s - moderately fast-growing, reaching 4.8 - 5.2 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - generally rather abundant, floccose to lanuginose, whitish to pink or pale amber.
Pigmentation - whitish, beige, pink to yellowish, ochraceous, finally buff-brown to chestnut; red colours absent.
Sclerotial bodies - more or less abundantly formed, of different size, shape and colour, almost globose to cauliflower-like (0.1-0.5 mm), pale brown, chestnut, grey- or blue-green to dark blue.
Sporulation - quickly starting in the mycelium, giving the colony a somewhat powdery appearance, later sporodochial layers usually rather abundantly formed, macroconidia in mass golden-yellow to orange, salmon, brick-red when desiccating.
Odour – not perceptible.

C o n i d i o p h o r e s - initially arising as single lateral phialides on hyphae, branching later sparsely, in sporodochia or pionnotes more abundantly, irregularly or sometimes verticillately branched and densely aggregated; no distinct conidiophores seem to be formed from which small 0- to 3-septate conidia develop.

Phialides - monophialidic, proliferations may occur, cylindric to subcylindric, often somewhat irregularly bent and changing in width, with a distinct collarette, mostly 12-20 µm long and 3.0-4.0 µm wide.

C o n i d i a - 0- to 3-septate conidia of different type scattered in the mycelium, oval, spindle- or pear-shaped; macroconidia falcate, slightly curved, almost cylindric, with a mostly short constricted, somewhat hooked apical cell and a rather distinctly pedicellate basal cell, mostly 5-(3- to 7-)septate, measuring:

1-sept.	20 x 5.7	mostly 13-23 x 4.2-7.0	(9-35 x 3.0-8.0) µm
3-sept.	31 x 4.4	mostly 24-37 x 3.7-6.0	(15-47 x 3.0-7.5) µm
5-sept.	44 x 4.8	mostly 37-53 x 3.7-5.6	(28-63 x 3.0-6.0) µm
7-sept.	54 x 5.2	mostly 48-65 x 4.5-5.8	(42-74 x 4.0-6.2) µm.

C h l a m y d o s p o r e s - usually lacking, only a few observed in conidia, smooth-walled, globose (6-10 µm).

Explanation of Figure 74:

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 290 of strain W-195; drawing of conidia and chlamydospores of different strains according to WOLLENWEBER's drawings; photographs of conidia and conidiophores of strain 63714 (= CBS 745.79) on different substrates (x 500).

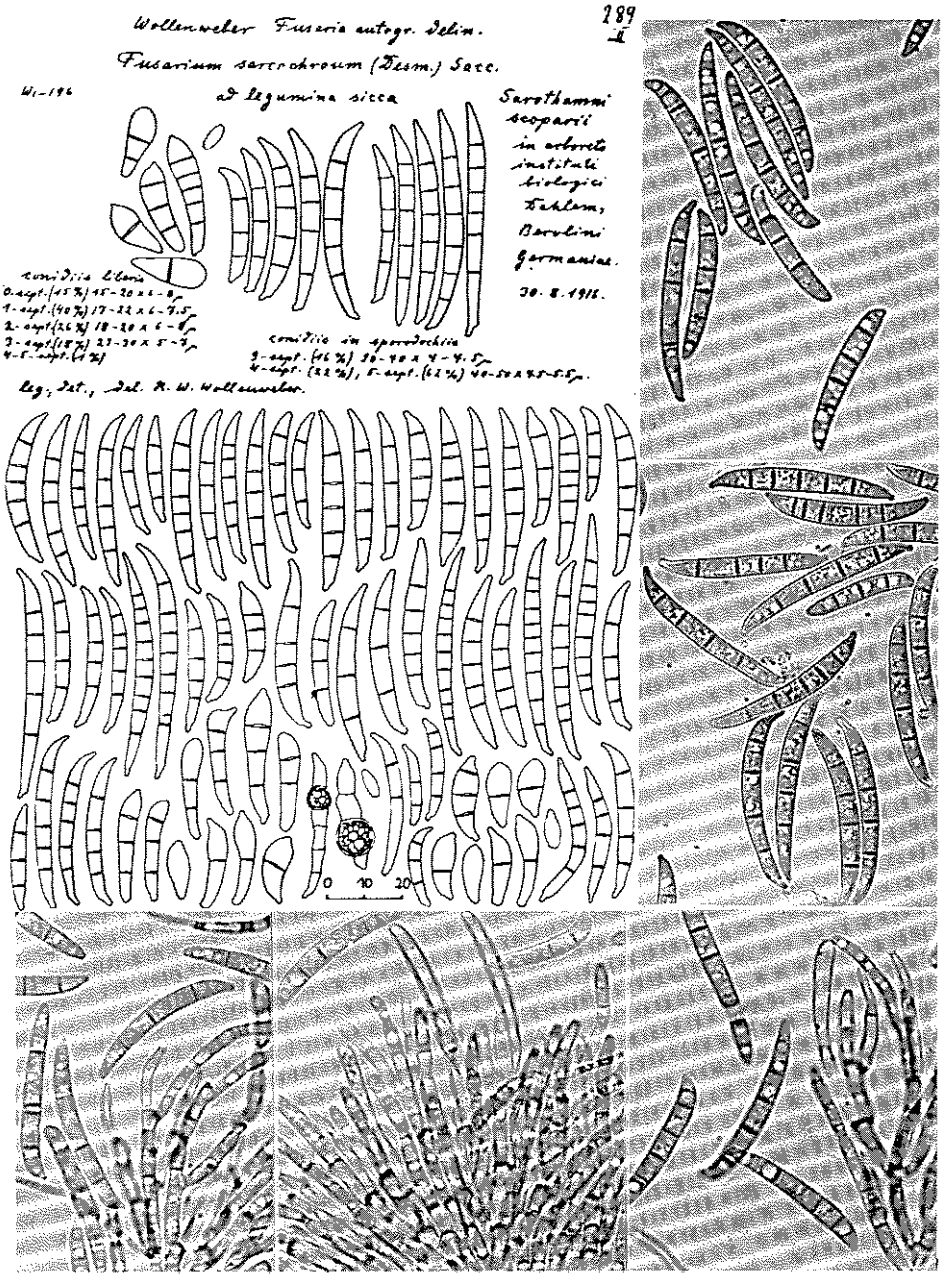

Fig. 74. Fusarium sarcochroum.

F. sarcochroum, based on Selenosporium sarcochroum described by DEZMAZIÈRES in 1850, was transferred by SACCARDO to Fusarium. It was accepted by WOLLENWEBER (1916-1935, 1931) as a distinct species on the basis of the diagnosis only. This Fusarium species is represented in our institute by drawings and notes of 3 herbarium specimens and 6 cultured strains which WOLLENWEBER isolated and studied. It was later also accepted by WOLLENWEBER & REINKING (1935), RAILLO (1950) and BILAI (1955). DOIDGE (1938), BUGNICOURT (1939), JAMALAINEN (1943, 1944) and JOFFE (1974) did not mention the fungus. GORDON (1952, 1956b) and SUBRAMANIAN (1971) treated it as synonymous with F. lateritium in the sense of SNYDER & HANSEN (1945). BOOTH (1971a) thought it identical with F. sambucinum. His statement (p. 107): "available material of F. sarcochroum suggests that it should be placed in F. sambucinum" raises the question, whether or not he had actually re-examined the type specimen. However, there is no doubt that F. sarcochroum is clearly different from F. sambucinum and from all other Fusarium species. A recently received culture (63714) confirmed this opinion. It was isolated together with F. lateritium from sporodochia on twigs of Viscum album collected and sent to us by E. MÜLLER/Zürich in February 1977 to verify his identification as F. sarcochroum. This strain is deposited in the CBS/Baarn (745.79) and is probably at present the only culture available.

F. sarcochroum is rather scarce and seems to be restricted to the temperate regions of Europe and the USA. It was recorded on decaying parts of various hardwood trees and woody plants.

Fusarium inflexum R. Schneider in Schneider & Dalchow - Phytopath. Z. 82: 80, 1975

Description: SCHNEIDER & DALCHOW (1975).

C o l o n i e s - moderately fast-growing, reaching 5.0 - 5.5 cm diam. in 10 days at 25°C on PDA, margin usually irregularly lobed.
Aerial mycelium - sparsely formed on all media, delicate, arachnoid to slightly felt-like, initially whitish, later greyish beige to pale flesh.
Pigmentation - from pale yellowish or light salmon to ochraceous; intensively red, bluish or dark brown colours never observed.
Sclerotial bodies - absent, but older, desiccating cultures often covered with an ochraceous grey-brown, sometimes rugose crust formed by masses of chlamydospores and disintegrating hyphal cells.
Sporulation - extremely sparse, usually only in cultures on oatmeal agar and sometimes on barley ear irridiated with near-UV light, conidia scattered in the mycelium, sporodochia or pionnotes never formed.
Odour - not perceptible.

C o n i d i o p h o r e s - at first arising as single lateral phialides in the mycelium, later irregularly branched.
Phialides - mostly monophialidic, but less frequently also with 2 conidiogenous loci, often proliferating, subcylindric to doliiform, 7-15 µm long and 3-5 µm wide.

C o n i d i a - only macroconidia formed, falcate, strongly curved, widest often in the upper half, usually with a strongly hooked and pointed apical cell and a more or less distinctly pedicellate basal cell, mostly 1- to 2-septate, optimal developed 3-septate, measuring:

0-sept.	12 x 3.1	mostly 8-15 x 2.9-3.4	(5-23 x 2.0-5.0) µm
1-sept.	20 x 3.7	mostly 14-31 x 3.1-4.3	(11-37 x 2.8-5.0) µm
2-sept.	25 x 4.0	mostly 19-33 x 3.4-4.5	(13-39 x 3.0-5.0) µm
3-sept.	29 x 4.1	mostly 24-35 x 3.5-4.6	(19-43 x 3.0-5.0) µm.

C h l a m y d o s p o r e s - very early and abundantly formed dominating the microscopic pictures, in hyphae and conidia, intercalary or terminal, short-stalked on hyphae, subglobose to oval, pear-shaped or of irregular shape, smooth-walled, occasionally somewhat rough, later slightly yellow-brown, very large, 1-celled 7-20 x 7-15 µm, 2-celled 14-28 x 9-14 µm, in chains or clusters.

Explanation of Figure 75:

Drawing and photographs of conidia, conidiophores and chlamydospores of the type culture 63203 (= CBS 716.74) and strain 63121 on different substrates (x 500).

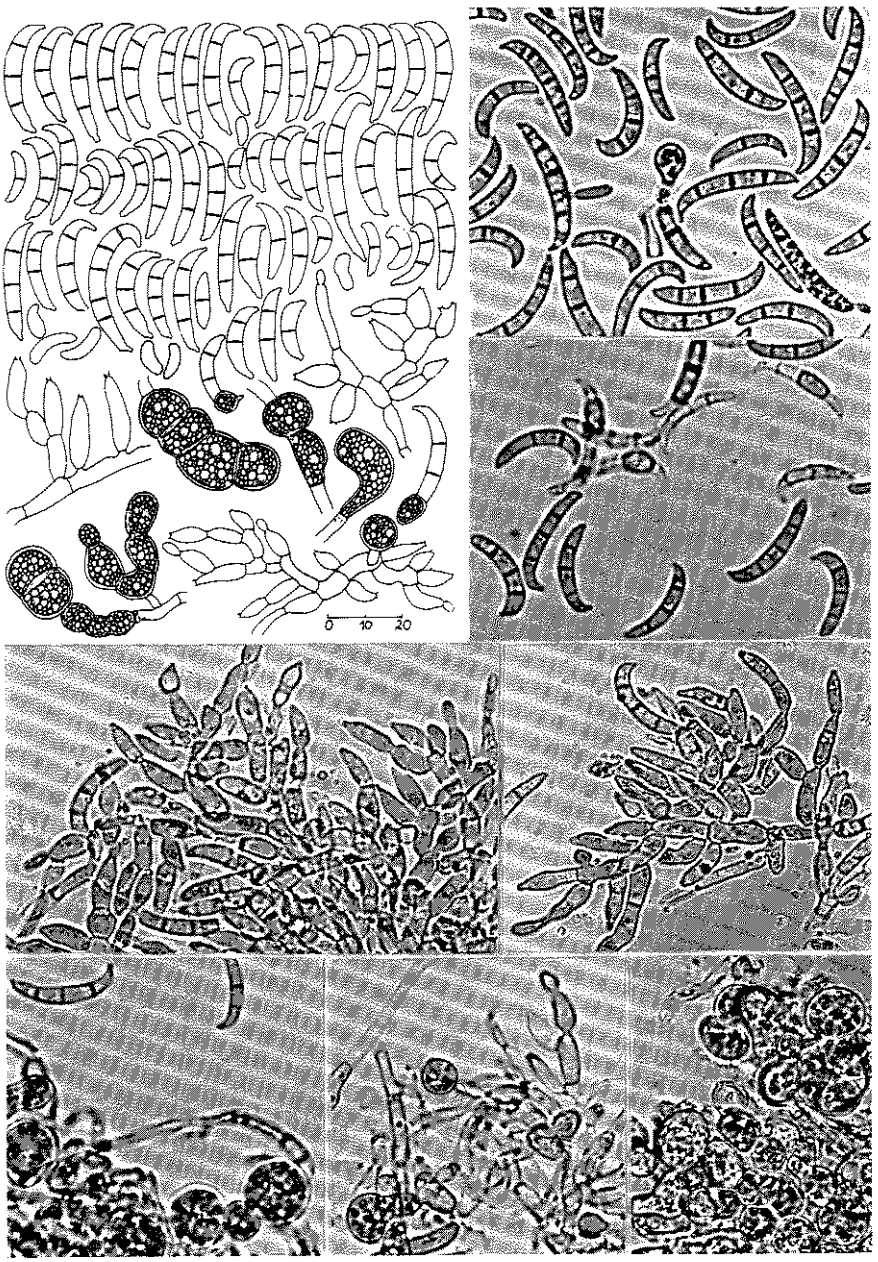

Fig. 75. Fusarium inflexum.

F. inflexum shows some similarity to F. udum Butler, but it differs mainly in the absence of typical microconidia, in the distinctly wider conidia, which have only a weak pedicellate basal cell, and especially in the extremely early and very abundant production of large chlamydospores.

The fungus was repeatedly isolated from brownish discoloured vascular systems of wilted broad beans (Vicia faba) in a vegetable growing area called "Vierlanden" near Hamburg and proved by various infection experiments to be the causal pathogen. Negative results of infection experiments with V. sativa, V. villosa, Pisum sativum, Lupinus albus, L. luteus, L. angustifolius, Phaseolus vulgaris, Cajanus cajan and Crotalaria juncea support the assumption that this Fusarium is specialized on Vicia faba. The type culture 63203 is deposited in the CBS/Baarn (716.74).

There seems to exist no further report of a corresponding strain.

Fusarium xylarioides Steyaert - Bull. Soc. Roy. Bot. Belg. 80 (2. sér. 30): 42, 1948

Fusarium oxysporum Schlecht.f. xylarioides (Steyaert) Delassus - Bull. sci. Minist. Colon. Sect. Agric. trop. 5: 347, 1954

Fusarium lateritium Nees ex Link f. sp. xylarioides (Steyaert) Gordon - Can. J. Bot. 43: 1317, 1965

Teleomorph: Gibberella xylarioides Heim & Saccas in Heim - Rev. Mycol. 15: Suppl. colon. no. 2, 97, 1950

Descriptions: STEYAERT (1948), HEIM (1950), BOOTH & WATERSTON (1964e), BOOTH (1971a), JOFFE (1974), BLITTERSDORFF & KRANZ (1976), GERLACH (1978).

C o l o n i e s - moderately fast-growing, reaching 5.8 - 6.5 cm diam. in 10 days at 25°C on PDA.

Aerial mycelium - usually sparse, appressed arachnoid to villous, sometimes floccose in the central part.

Pigmentation - whitish, greyish pink to greyish orange, peach to pale violet, with areas bluish brown to dark blue-violet.

Sclerotial bodies - extremely striking and abundantly formed in freshly isolated cultures, quite variable in size and shape, yellowish to buff-brown, finally dark blue to black, subglobose, cauliflower-like, often erumpent, branched, mostly 1-5 mm large.

Sporulation - starting within a few days as unicellular conidia in the mycelium, sometimes giving the culture a slightly powdery appearance, after about 3 weeks small flat or somewhat erumpent sporodochia or confluent pionnotal slimes may develop especially on wort and malt agar, masses of conidia cream to pink or pale peach to salmon, sometimes also tinged by stroma pigments.

Odour - not perceptible.

C o n i d i o p h o r e s - initially formed as single lateral phialides on hyphae, producing 1-celled conidia cohering in false heads, in sporodochia or pionnotes loosely and irregularly or verticillately branched, terminating in a group of 2 to 4 phialides.
Phialides - monophialidic, no proliferations and no polyphialides observed, rather slender and delicate, cylindric to subcylindric, curved, often with a distinct collarette, mostly 10-15 µm long and 2.5-3.0 µm wide.

C o n i d i a - unicellular conidia allantoid, septate ones very delicate and slender, falcate to navicular, strongly curved, often with a very distinctly constricted, hooked apical cell and usually with a pedicellate basal cell, 1 - to 3-septate, measuring:

0-sept.	10 x 2.1	mostly 7-14 x 1.8-2.3	(4-17 x 1.5-2.5) µm
1-sept.	18 x 2.4	mostly 14-23 x 2.1-2.6	(11-30 x 1.5-3.0) µm
2-sept.	23 x 2.6	mostly 19-26 x 2.4-2.8	(16-32 x 1.8-3.0) µm
3-sept.	27 x 2.8	mostly 23-30 x 2.5-3.0	(20-35 x 2.3-3.4) µm.

C h l a m y d o s p o r e s - usually rather sparse, intercalary or terminal, smooth- or occasionally rough-walled, subglobose to oval, single (8-15 µm), in chains or clusters.

Explanation of Figure 76:
Drawing and photographs of conidia, conidiophores and chlamydospores of strains 62457 (= IMI 127629), 62458 (= ATCC 36327) and 62721 (= CBS 749.79) on different substrates (x 500).

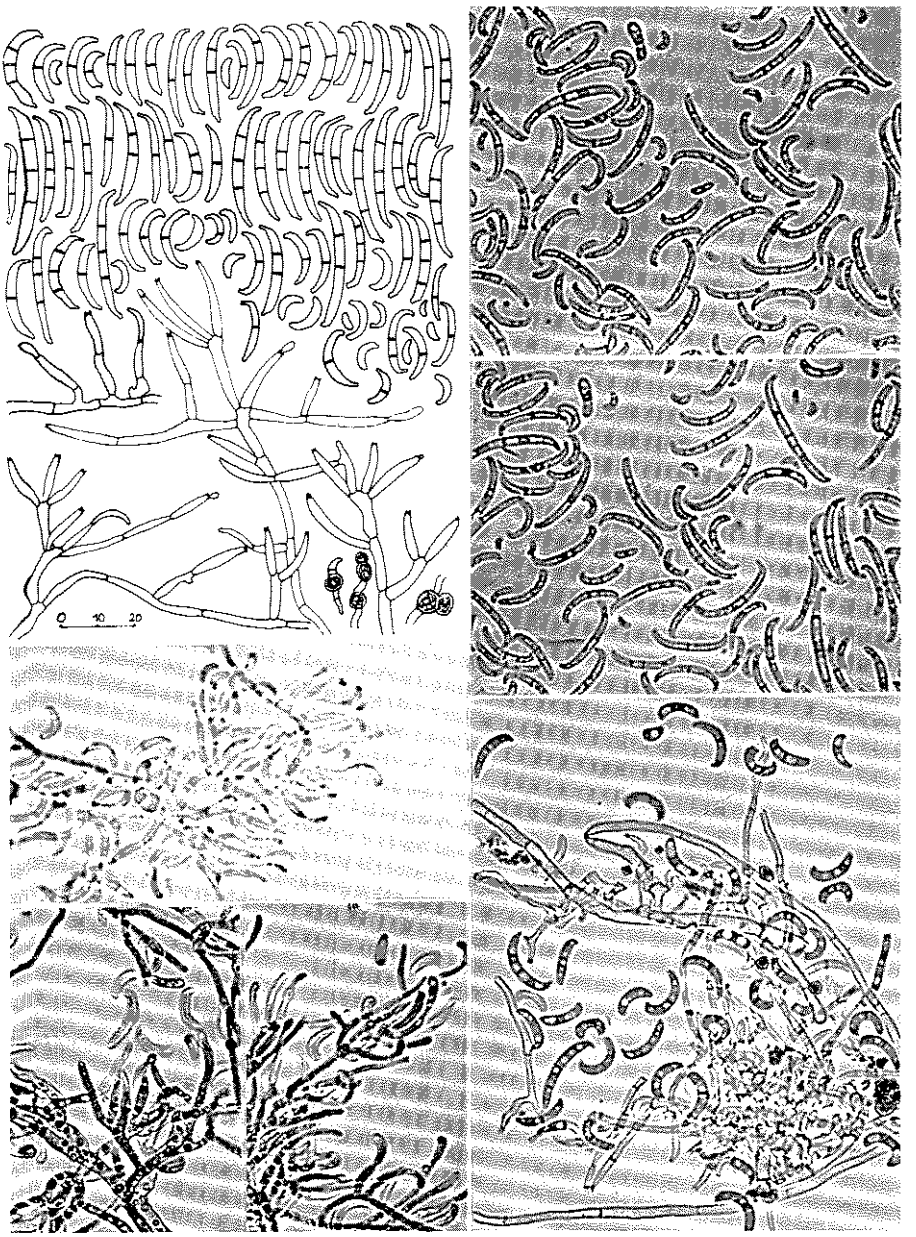

Fig. 76. Fusarium xylarioides.

F. xylarioides was first described by STEYAERT as a distinct species. Later it was transferred to F. oxysporum as f. xylarioides by DELASSUS. GORDON (1965) treated it as a forma specialis of F. lateritium. Like many other authors working with the fungus, BOOTH & WATERSTON (1964e), BOOTH (1971a), JOFFE (1974), BLITTERSDORFF & KRANZ (1976) and GERLACH (1978) correctly recognized it again as a separate, very characteristic species. The sex-linked morphologic characteristics described by BOOTH (1971a) for F. xylarioides are doubtful. STEYAERT and other authors, who have studied this Fusarium, have only observed and described a fungus identical with BOOTH's so called "female" strain as the anamorph of Gibberella xylarioides. Numerous cultures, derived from single ascospores of perithecia from various areas in Africa, have produced only this type and all attempts to mate these isolates with the "male" strain of BOOTH which morphologically corresponds to F. stilboides have not resulted in the production of perithecia (GERLACH 1978).

F. xylarioides causes a tracheomycosis of coffee. The pathogen invades the vascular system and after a short incubation period it causes rapid wilting and finally the death of the tree. It is recorded from different countries of Central and West Africa and also from Ethiopia where serious damage occurred on different cultivars of various Coffea species. It was first observed on C. excelsa, but meanwhile cultivars of C. canephora, C. dewevrei, C. liberica and C. arabica have also proved susceptible. More detailed information is given by BOOTH & WATERSTON (1964e), BOOTH (1971a) and especially by BLITTERSDORFF & KRANZ (1976).

Section LISEOLA Wollenweber, Sherbakoff, Reinking, Johann & Bailey - J. agric. Res. 30: 841, 1925

Monograph by NIRENBERG (1976).

Fusarium verticillioides (Sacc.) Nirenberg - Mitt. Biol. Bundesanst. Land- Forstwirtsch. Berlin-Dahlem 169: 26, 1976

Oospora verticillioides Sacc. - Fungi ital. Fig. 789, 1881 - Michelia 2: 546, 1882

Fusarium moniliforme Sheldon - Rep. Nebraska agric. Exp. Stn 17: 23-32, 1904

Fusarium moniliforme Sheldon sensu Wollenw. & Reinking - Die Fusarien: 98-99, 1935 (pro parte)

Teleomorph: Gibberella moniliformis Wineland - J. agric. Res. 28: 909-922, 1924

Descriptions: NIRENBERG (1976, 1981).

C o l o n i e s - very fast-growing, reaching 7.5 - 8.0 cm diam. in 6 days at 25°C on PDA.

Aerial mycelium - generally abundant, loosely pannose, white to buff, later vinaceous if discoloured by the substrate.

Pigmentation - light beige to dark vinaceous, a characteristic violet rim occurs on the periphery of the medium in agar slant tubes.

Sclerotial bodies - rare, bluish black, possibly stages of immature perithecia.

Sporulation - starting quickly within 2 days in the aerial mycelium as microconidia attached to each other in long chains, very seldom cohering in false heads; sporodochia produced very rarely and then late, bearing macroconidia but sometimes only microconidia.

Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally from hyphae in the aerial mycelium, at first unbranched, later sparsely branched; secondary conidiophores strongly and densely branched. Phialides - always monophialidic, almost cylindric, slender, mostly 14-32 µm long and 2.0-3.5 µm wide, those of sporodochia somewhat shorter, measuring 11-21 x 2.5-4.5 µm.

C o n i d i a - microconidia clavate with a flattened base, mostly 1-celled, exceptionally with 1 or 2 septa; macroconidia delicate, slender, falcate but rather straight, broadest just below the apical cell which is often somewhat constricted and curved, foot cell distinct, typically 3- or 5-septate, measuring:

0-sept.	8 x 2.9	mostly 7-10 x 2.4-3.2	(4-19 x 1.5-4.5) µm
3-sept.	34 x 3.2	mostly 30-46 x 2.7-3.6	(18-61 x 2.0-4.2) µm
5-sept.	54 x 3.4	mostly 47-58 x 3.1-3.6	(39-73 x 2.4-4.3) µm.

C h l a m y d o s p o r e s - absent, however, inflated cells with thickened walls occur.

Explanation of Figure 77:

Drawing and photographs of conidia and conidiophores of strain 11782 (= CBS 218.76 = IMI 202875) on different substrates (x 500, except centre row, left x 200).

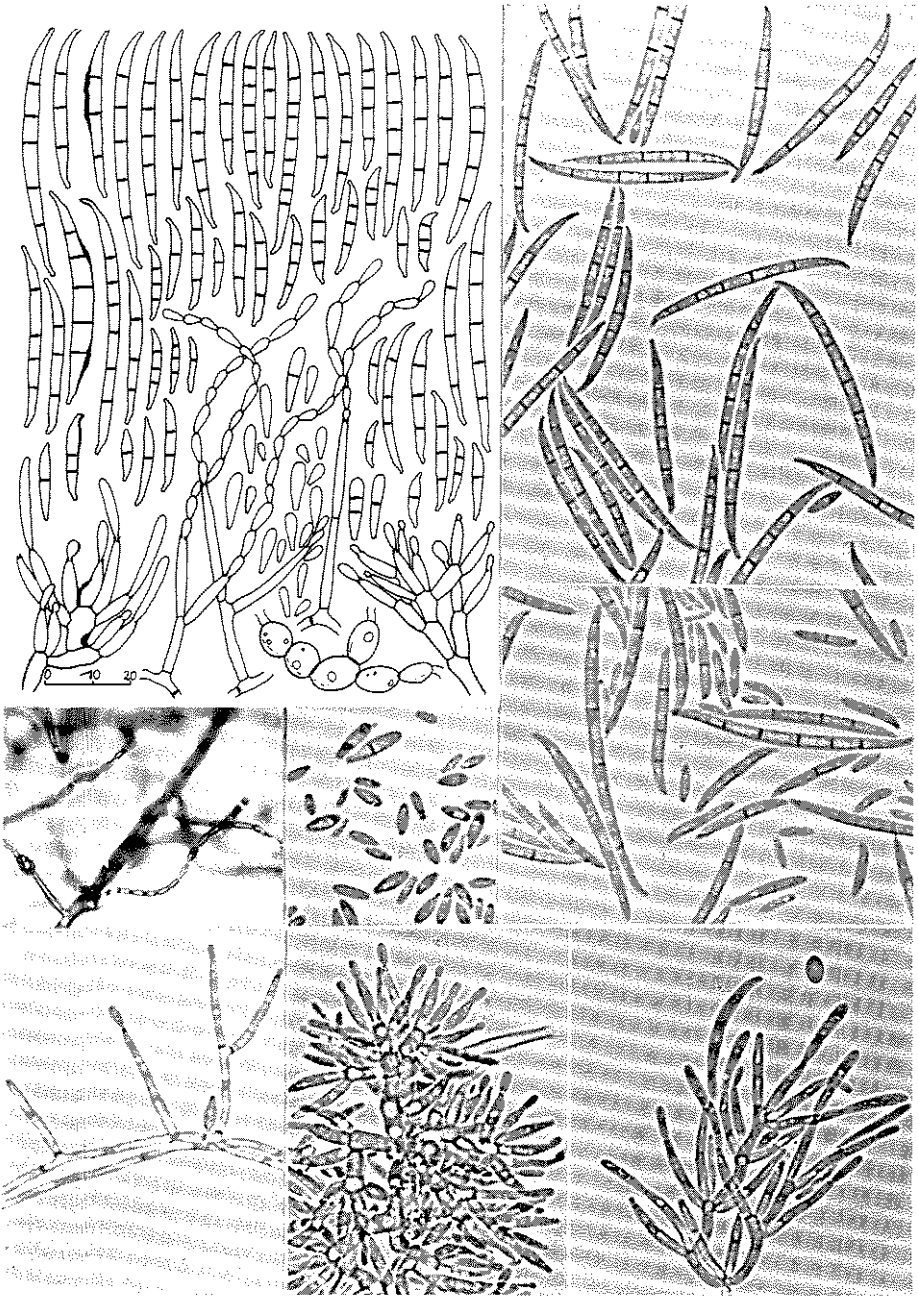

Fig. 77. Fusarium verticillioides.

F. verticillioides is distinguished from all other species of the Liseola section forming clavate microconidia by producing phialides with only one conidiogenous locus. This species is the one that produces the toxin moniliformin, in contrast to F. sacchari var. subglutinans and F. proliferatum var. proliferatum (MARASAS 1980). F. verticillioides is one of the most important pathogens on maize in warmer climates, causing a stalk and cob rot. It also is said to be pathogenic on sugar cane (pokkah boeng or curly top) and on rice, but it is not responsible for the elongation of rice seedlings, the bakanae disease.
For more detailed information regarding morphology and biology confer NIRENBERG (1976, 1981).

Fusarium fujikuroi Nirenberg - Mitt. Biol. Bundesanst. Land- Forstwirtsch. Berlin-Dahlem 169: 32, 1976

Teleomorph: Gibberella fujikuroi (Sawada) Wollenw. - Z. Parasitenk. 3: 514, 1931 var. fujikuroi

Lisea fujikuroi Sawada - Trans. Nat. Hist. Soc. Formosa 31: 131-133, 1917

Gibberella fujikuroi (Sawada) S. Ito in Ito & Kimura - Rep. Hokkaido Nat. agric. Exp. Stn 27: 28, 1931

Descriptions: WOLLENWEBER (1931), BOOTH & WATERSTON (1964f), NIRENBERG (1976).

C o l o n i e s - fast-growing, reaching 7.0 - 8.0 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - abundant, fluffy, lanuginose, not felt-like, whitish to pale pink.
Pigmentation - initially buff, later rust to brick.
Sclerotial bodies - not observed.
Sporulation - starting quickly as macroconidia on the agar surface, soon forming sporodochia, which assume cauliflower-shaped bodies on ear of barley and which end in small columns and spirals; production of microconidia quite restricted, on high nutrient media forming false heads, on low nutrient media short chains.
Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally on hyphae in the aerial mycelium, unbranched or sparsely branched; secondary conidiophores strongly and densely branched.
Phialides - those of primary conidiophores mostly monophialidic, seldom polyphialidic and then with no more than two conidiogenous loci, almost

cylindric, slender, mostly 12-32 µm long and 2.2-4.0 µm wide, those of sporodochia somewhat shorter 12-18 x 2.8-4.0 µm.

C o n i d i a - microconidia clavate with a flattened base, mostly 1-celled, rarely 1-septate; macroconidia usually 3- to 5-septate, of the same type as the macroconidia of F. verticillioides, however, on the average somewhat wider, measuring:

0-sept.	8 x 2.9	mostly 7-10 x 2.5-3.3	(5-13 x 2.1-4.7) µm
3-sept.	40 x 3.6	mostly 33-48 x 3.0-3.9	(22-59 x 2.5-4.7) µm
5-sept.	55 x 3.8	mostly 50-59 x 3.6-3.9	(43-65 x 3.3-4.4) µm.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 78:

Drawing and photographs of conidia and conidiophores of the type culture 12428 (= CBS 221.76 = IMI 202879) on different substrates (x 500, except centre row, 2. and 3. picture from left x 200).

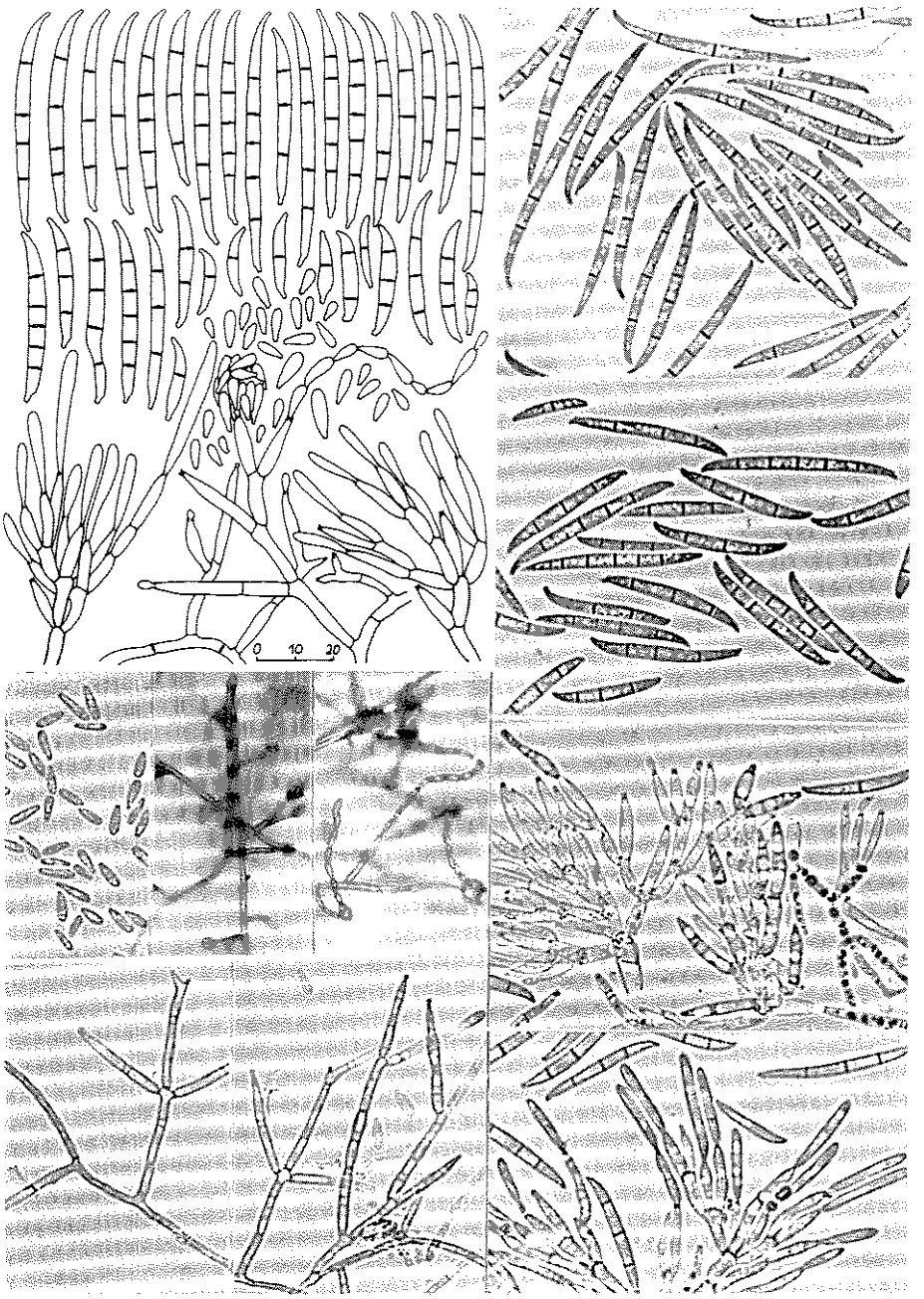

Fig. 78. Fusarium fujikuroi.

F. fujikuroi is distinguished from the varieties of F. proliferatum by slight but numerous differences: the aerial mycelium is of cottony appearance, sporodochia are produced in abundance, it forms seldom polyphialides only, bears no pyriform microconidia and its teleomorph is known and occurs on rice halms very often. This species is the only one of the Liseola section that produces gibberellic acid in high quantities and therefore is responsible for the elongation of rice seedlings (bakanae disease). Apparently it occurs only on rice in Asia and Australia. More information about this fungus can be found in the monograph by NIRENBERG (1976) dealing with the Liseola section.

Fusarium proliferatum (Matsushima) Nirenberg - Mitt. Biol. Bundesanst. Land- Forstwirtsch. Berlin-Dahlem 169: 38, 1976 var. proliferatum

Cephalosporium proliferatum Matsushima - Microfungi of the Solomon Islands and Papua-New Guinea (Osaka): 11, 1971

Fusarium moniliforme Sheldon sensu Wollenw. & Reinking - Die Fusarien: 98-99, 1935 (pro parte)

Description: NIRENBERG (1976).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 8 days at 25°C on PDA.
Aerial mycelium - abundant, pannose, later tufts of white "patch-mutants" appear, white to pinkish buff, in older cultures pale to dark vinaceous.
Pigmentation - buff, grey-lilac, brick to brown-vinaceous.
Sclerotial bodies - black, formed abundantly along the periphery of oat-meal agar in slant-tubes and on rice pap.
Sporulation - starting early within 2 days in the aerial mycelium as micro-conidia attached to each other in long chains or cohering in false heads; sporodochia appear after two weeks in some strains, rarely in others.
Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arise laterally on hyphae in the aerial mycelium, initially unbranched, later loosely branched; secondary conidiophores densely ramose.
Phialides - sometimes monophialidic, but very often polyphialidic with more than two conidiogenous loci, also proliferating, slender, almost cylindric 11-32 µm long and 2.3-3.5 µm wide, those of sporodochia often

ventricose usually with one conidiogenous locus but also with two loci, measuring 12-23 x 3.2-4.2 µm.

C o n i d i a - microconidia primarily clavate with a flattened base, in older cultures on wort agar and rice pap also pyriform up to 40 %, usually 1-celled, exceptionally 1-septate; macroconidia falcate but rather straight, somewhat broader than those of F. fujikuroi, with a distinct foot cell, usually 3- or 5-septate, widest on ear of barley and rice pap, measuring:

0-sept.	p.	9 x 6.2	mostly 7-11 x 4.7-7.7	(5-15 x 3.3-12.4) µm
	c.	8 x 2.6	mostly 7- 9 x 2.2-3.2	(3-16 x 1.2- 5.3) µm
3-sept.		39 x 3.7	mostly 30-46 x 3.3-4.1	(19-59 x 2.6- 5.0) µm
5-sept.		54 x 3.9	mostly 47-58 x 3.4-4.4	(39-79 x 3.0- 5.0) µm.

p. = pyriform
c. = clavate

C h l a m y d o s p o r e s - absent.

Explanation of Figure 79:

Drawing and photographs of conidia and conidiophores of strain 11341 (= CBS 217.76 = IMI 202873) on different substrates (x 500, except centre row, 2. picture from left x 250).

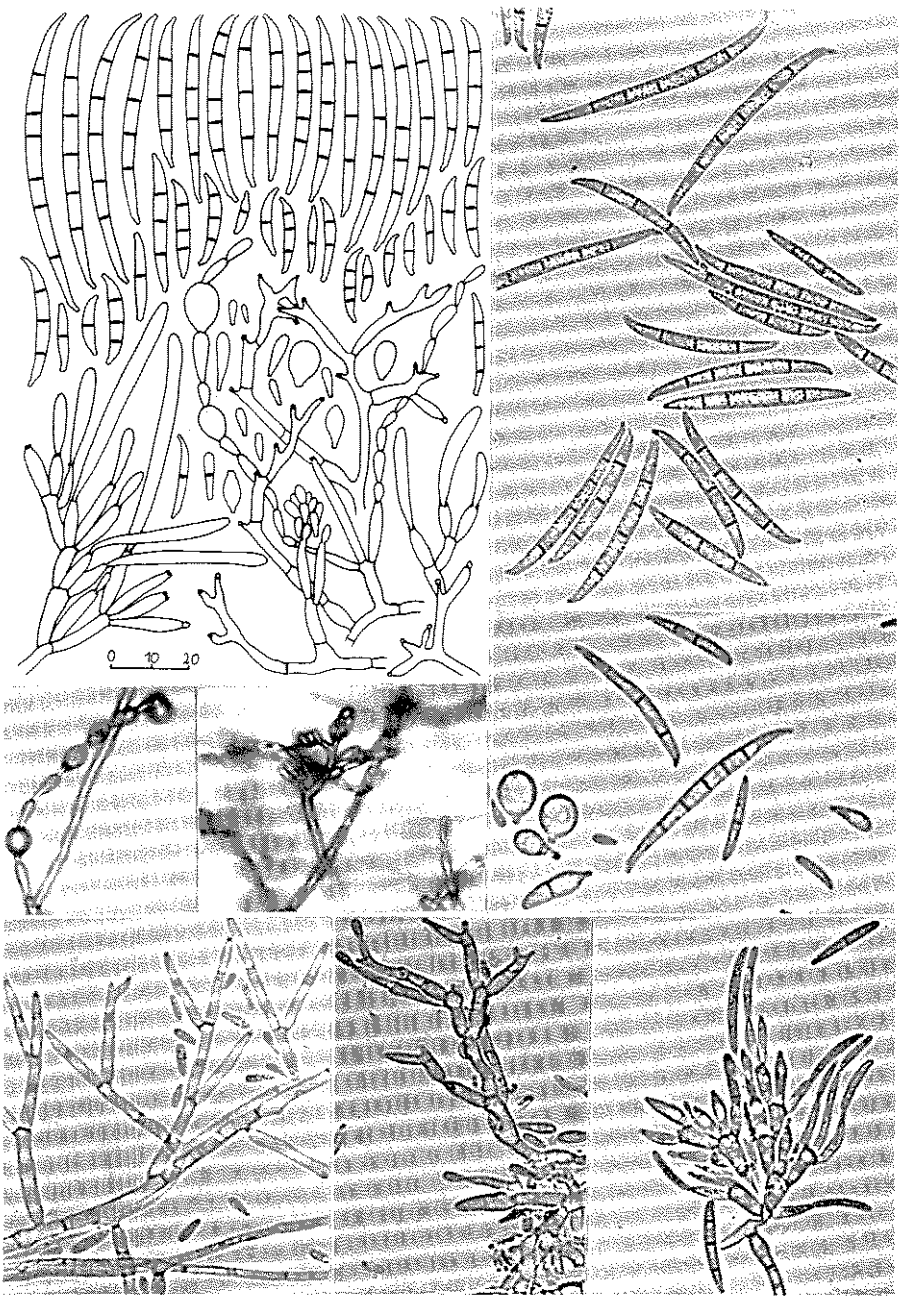

Fig. 79. Fusarium proliferatum var. proliferatum.

F. proliferatum var. proliferatum is characterized by clavate and pyriform microconidia together with proliferating conidiophores ending in phialides with one or more than one conidiogenous locus. This variety occurs on rice, figs and orchids to mention only some of its host plants, and is responsible for foot rots, fruit rots and leaf spots.
Further detailed information is available in NIRENBERG (1976), especially with regard to phytopathological aspects.

Fusarium proliferatum (Matsushima) Nirenberg var. minus Nirenberg - Mitt. Biol. Bundesanst. Land- Forstwirtsch. Berlin-Dahlem 169: 43, 1976

Fusarium moniliforme Sheldon var. minus Wollenw. - Z. Parasitenk. 3: 397, 1931 (pro parte)

Fusarium moniliforme Sheldon sensu Wollenw. & Reinking - Die Fusarien: 98-99, 1935 (pro parte)

Description: NIRENBERG (1976).

C o l o n i e s - fast-growing, reaching 7.8 - 8.2 cm diam. in 8 days at 25°C on PDA; some strains, however, only moderately fost-growing.
Aerial mycelium - densely pannose, seldom pinkish buff, mostly light grey-lilac becoming blue-violet or dark vinaceous.
Pigmentation - rarely buff, usually changing from brick to dark vinaceous or blue-violet.
Sclerotial bodies - black or apricot coloured, erumpent in large numbers on rice pap and oatmeal agar, on the latter often covered by the aerial mycelium.
Sporulation - starting after 2 days as microconidia cohering in false heads on high nutrient media or attached in short chains on low nutrient media; macroconidia usually appear only when irradiated with near-UV light.
Odour - in most strains weak, but strong in others, sweetish.

C o n i d i o p h o r e s - primary conidiophores initially unbranched, later more or less loosely ramose arising laterally on hyphae in the aerial mycelium; seondary conidiophores densely ramose.
Phialides - those of primary conidiophores usually proliferating with one conidiogenous locus or two loci, slender, almost cylindric, 10-26 µm long and 2.0-2.6 µm wide, those of secondary conidiophores monophialidic

also slender and almost cylindric, measuring 12-18 x 2.2-3.8 µm.

C o n i d i a - microconidia always clavate with a flattened base, on SNA never 1- or 2-septate; macroconidia as a rule produced only under near-UV light, fragile, subfalcate to needle-like, apical cell less constricted than those of other members of the Liseola section, foot cell distinct; mostly 3-septate, measuring:

0-sept.	9 x 2.9	mostly 8-10 x 2.6-3.7	(3-20 x 1.7-4.8) µm
3-sept.	35 x 2.9	mostly 24-42 x 2.5-3.3	(18-55 x 2.0-4.0) µm
5-sept.	55 x 3.4	mostly 50-57 x 3.0-3.9	(36-71 x 2.0-4.5) µm.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 80:

Drawing and photographs of conidia and conidiophores of the type culture 11730 (= CBS 216.76 = IMI 202874) on different substrates (x 500, except centre and lower row, 2. picture from left x 200).

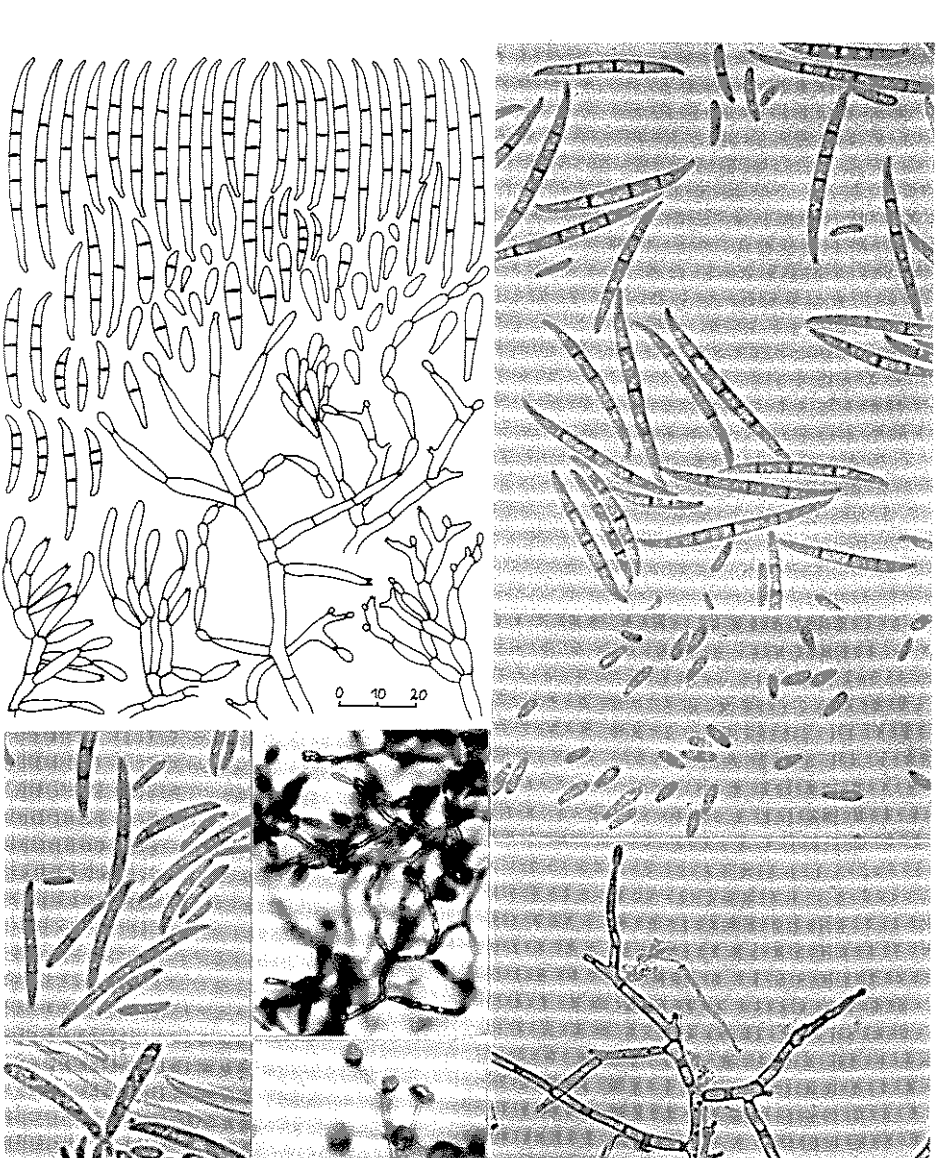

Fig. 80. Fusarium proliferatum var. minus.

F. proliferatum var. minus is distinct from F. proliferatum var. proliferatum by producing only clavate microconidia cohering to each other in false heads or short chains. It forms macroconidia only when irridiated with near-UV light, which are somewhat needle-like, more slender and often smaller. This variety consists of three growing types. But all of them have one feature in common: as hosts they prefer thick-leaved plants like Sansevieria spp., Dracaena spp. and Gasteria spp., on which they may cause severe leaf lesions.

A more extensive description is given by NIRENBERG (1976) in her work on the Liseola section.

Fusarium annulatum Bugnicourt - Rev. Gén. Bot. 59: 17, 1952

Descriptions: BUGNICOURT (1952), NIRENBERG (1976).

C o l o n i e s - fast-growing, reaching 7.8 - 8.2 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - flat-growing, lanuginose, grey or stained wine-red by the substrate.
Pigmentation - brown to bluish wine-red.
Sclerotial bodies - absent.
Sporulation - starting soon after 3 days in the aerial mycelium as microconidia cohering in false heads or in chains; only on oatmeal agar macroconidia are borne, appearing in cinnamon-coloured pionnotes after 1 week.
Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arise laterally on hyphae in the aerial mycelium, unbranched or ramose; secondary conidiophores not observed, being surely due to the condition of the culture which is that of a mycelial variant.
Phialides - monophialidic or polyphialidic, then often with more than two conidiogenous loci, often proliferating, slender, almost cylindric, 11-34 µm long and 2.4-3.2 µm wide.

C o n i d i a - microconidia always clavate with a flattened base, usually 0-septate, rarely 1-septate; macroconidia falcate, strongly curved to convoluted, predominantly with a distinct foot cell, usually 3-septate, rarely 5-septate, measuring:

0-sept.	9 x 2.6		(6-14 x 2.0-3.9) µm
1-sept.	23 x 3.2	mostly 22-24 x 3.1-3.2	(14-33 x 2.5-4.1) µm
3-sept.	30 x 3.1		(20-62 x 3.0-3.2) µm.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 81:

Drawing and photographs of conidia and conidiophores of the type culture 12294 (= CBS 258.54 = IMI 202878) on different substrates (x 500, except lower row, 2. and 3. picture from left x 200).

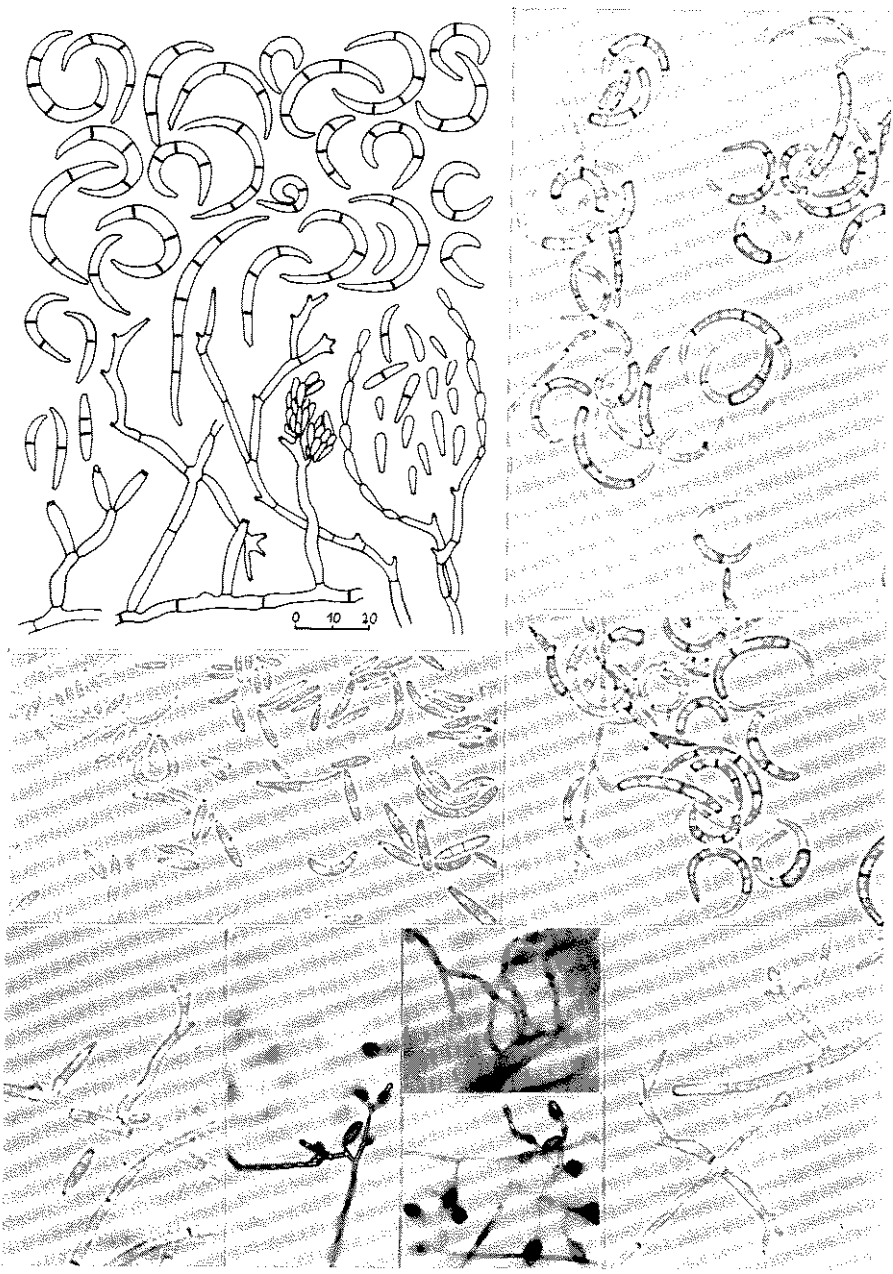

Fig. 81. Fusarium annulatum.

The description of F. annulatum is based solely upon 1 strain, namely the ex-holotypus CBS 258.54 deposited by BUGNICOURT in 1954, which exists only as a mycelial variant. By the conspicuous shape of its macroconidia which resembles that of F. succisae it is definitely a separate species. BUGNICOURT reported this fungus as a pathogen of rice in Indonesia.

Fusarium sacchari (Butler) W. Gams - Cephalosporium-artige Schimmelpilze (Hyphomycetes) (Stuttgart): 218, 1971
var. sacchari

Cephalosporium sacchari Butler in Butler & Khan - Mem. Dep. Agric. India, Bot. Ser. 6: 185, 1913

Fusarium moniliforme Sheldon var. subglutinans Wollenw. & Reinking - Phytopathology 15: 163, 1925 (pro parte)

Descriptions: GAMS (1971), SUBRAMANIAN (1971), NIRENBERG (1976).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 8 days at 25°C on PDA.
Aerial mycelium - generally abundant, floccose, pannose, whitish, later dark vinaceous if discoloured by the substrate.
Pigmentation - buff to dark ochre, on rice pap typically intensive wine-red with a black line at the periphery of the substrate surface.
Sclerotial bodies - blue-black, frequently formed in the aerial mycelium.
Sporulation - starting quickly after 2 days in the aerial mycelium as microconidia cohering always in false heads; macroconidia almost never formed without near-UV irradiation.
Odour - not perceptible in most strains, in some, however, basidiomycete-like.

C o n i d i o p h o r e s - primary conidiophores arising laterally on hyphal strands, loosely ramose, giving a garland-like impression, those of sporodochia densely ramose.
Phialides - monophialidic, on primary conidiophores mostly polyphialidic with more than two loci, also with a strong tendency to proliferate, slender, almost cylindric, mostly 17-30 µm long and 2.5-3.8 µm wide, those

of secondary conidiophores somewhat shorter, measuring 12-24 x 2.5-3.8 µm.

C o n i d i a - microconidia oval and slender, mostly 1-celled; macroconidia rarely formed even under near-UV irradiation, falcate but rather straight with a slightly constricted apical cell and a distinct foot cell, as a rule with two distinct, round vacuoles in each cell, mostly 3-septate, measuring:

0-sept.	10 x 2.6	mostly 7-11 x 2.4-3.1	(4-18 x 1.8-4.0) µm
3-sept.	37 x 3.4	mostly 33-43 x 3.3-3.5	(24-52 x 2.5-4.1) µm
5-sept.	42 x 3.7		(35-49 x 3.3-4.1) µm.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 82:

Drawing and photographs of conidia and conidiophores of strain 63340 (= CBS 223.76 = IMI 202881) on different substrates (x 500, except lower row, centre x 250).

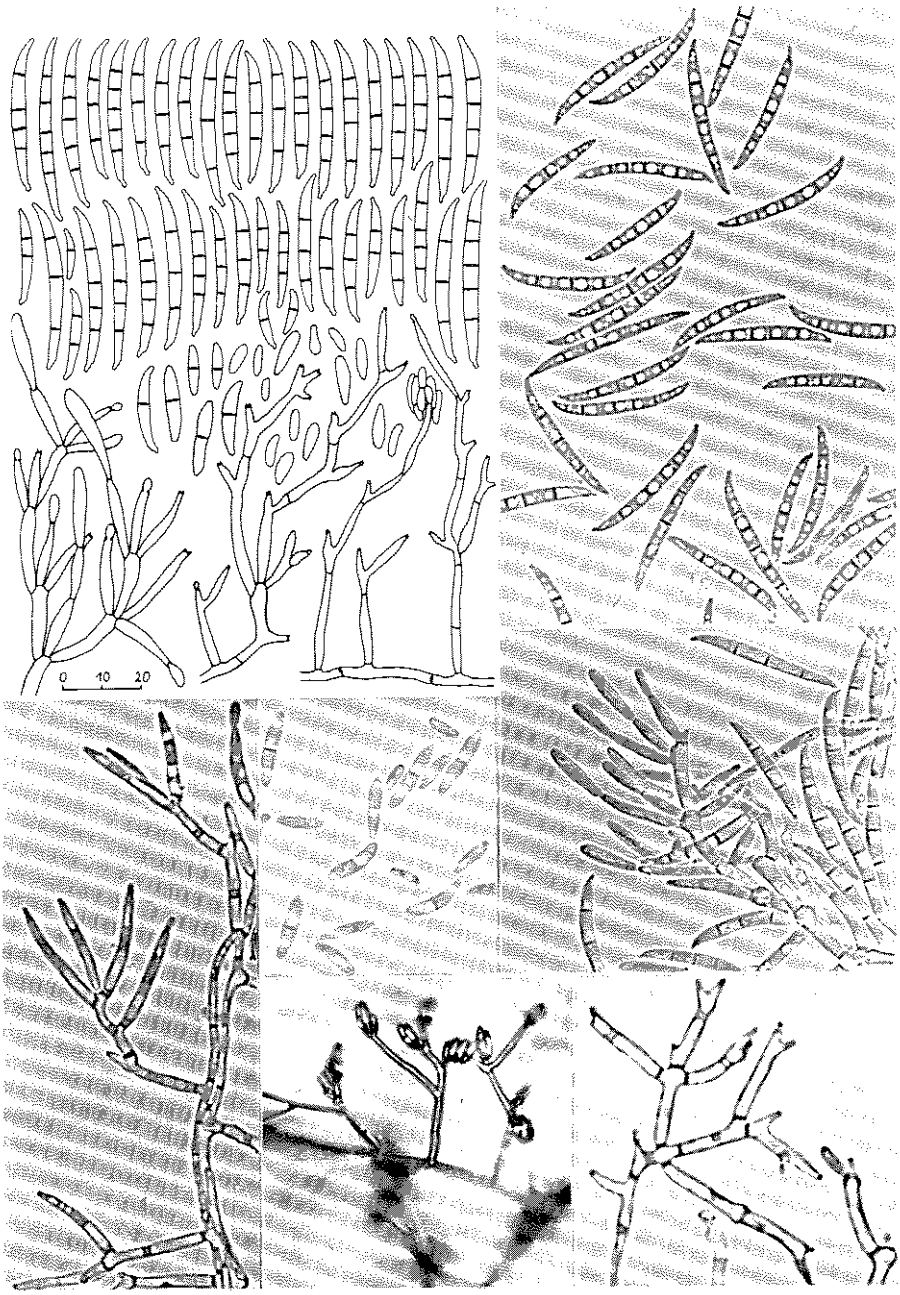

Fig. 82. Fusarium sacchari var. sacchari.

F. sacchari var. sacchari is closely related to F. sacchari var. subglutinans. But on the basis of its narrower microconidia, its ability to produce sporodochia only rarely even under near-UV irradiation and its higher temperature optimum (27.5 versus 25.0°C) - not to speak of slight cultural differences - it is thought to be worth for retaining as a separate variety. This variety is the most important fungus causing bokkah boeng (curley top) of sugar cane.
In addition to it F. verticillioides, F. proliferatum var. proliferatum, F. sacchari var. subglutinans and F. anthophilum may be isolated from diseased plants. For further details confer NIRENBERG (1976).

Fusarium sacchari (Butler) W. Gams var. subglutinans (Wollenw. & Reinking) Nirenberg - Mitt. Biol. Bundesanst. Land- Forstwirtsch. Berlin-Dahlem 169: 53, 1976

Fusarium moniliforme Sheldon var. subglutinans Wollenw. & Reinking - Phytopathology 15: 163, 1925 (pro parte)

Teleomorph: Gibberella fujikuroi (Sawada) Wollenw. var. subglutinans Edwards - Agric. Gaz. N.S.W. 44: 895, 1933

Descriptions: EDWARDS (1933), BOOTH & WATERSTON (1964g), NIRENBERG (1976, 1981).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 8 days at 25°C on PDA.
Aerial mycelium - usually abundant, pannose, pinkish buff to greyish ochre.
Pigmentation - buff, brownish vinaceous to dark vinaceous, often interspersed by buff, peach to sienna or dark ochre sporodochial slimes.
Sclerotial bodies - relatively rare, black, possibly properithecia.
Sporulation - starting quickly after 2 days in the aerial mycelium as microconidia cohering always in false heads, again 2 days later subdeveloped macroconidia appear between them; after 1 week sporodochia begin to form and may cover most of the culture after 3 weeks.
Odour - occasionally weakly sweetish.

C o n i d i o p h o r e s - primary conidiophores arising laterally from hyphae in the aerial mycelium, initially not branched, later loosely ramose; secondary conidiophores densely ramose.
Phialides - monophialidic, but those of primary conidiophores often

polyphialidic and proliferating, slender, almost cylindric, 6-33 µm long and 3.0-4.0 µm wide, those of sporodochia somewhat shorter, measuring 12-25 x 2.5-3.5 µm.

C o n i d i a - microconidia oval, ellipsoid or allantoid, often apiculate, 1-celled, but also 1-, 2- and 3-septate, transition to macroconidia in flux; macroconidia falcate but rather straight, often with a hamate, constricted apical cell and a distinct foot cell, mostly 3-septate, but also 5-septate, measuring:

0-sept.	11 x 3.1	mostly 9-12 x 2.5-3.5	(4-20 x 1.5-4.7) µm
3-sept.	39 x 4.0	mostly 27-54 x 3.4-4.2	(20-62 x 3.0-5.5) µm
5-sept.	59 x 4.1	mostly 53-63 x 3.5-4.5	(40-73 x 3.2-5.2) µm.

C h l a m y d o s p o r e s - absent, however, inflated cells with thickened walls occur.

Explanation of Figure 83:

Drawing and photographs of conidia and conidiophores of strains 10351 (= CBS 215.76 = IMI 202872), 10830 and 12060 on different substrates (x 500).

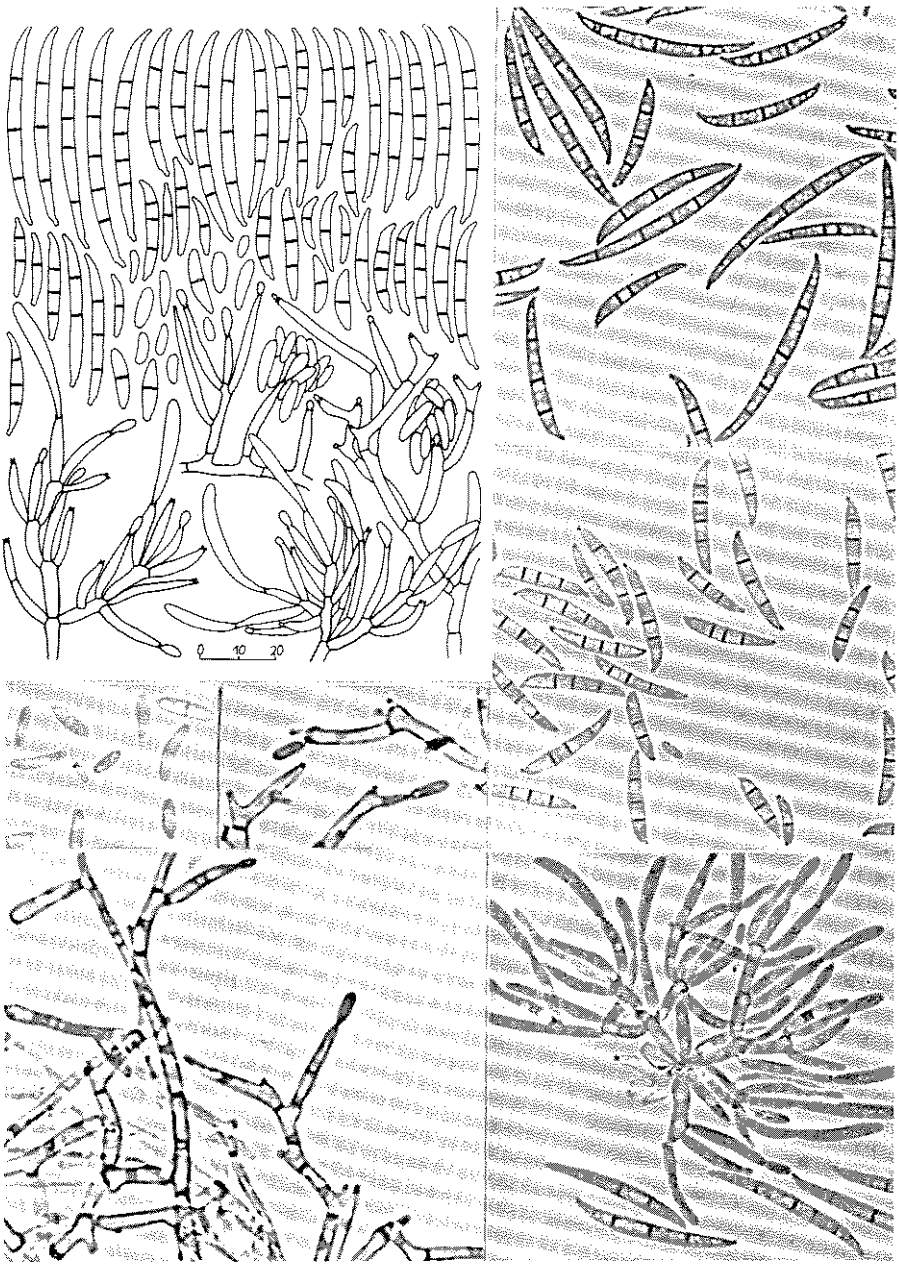

Fig. 83. Fusarium sacchari var. subglutinans.

In F. sacchari var. subglutinans types with different sizes of macroconidia (and ascospores) are combined. It occurs like F. verticillioides on a wide range of host plants, of which the most important is maize, where this variety also causes a stalk and cob rot. The pathogenicity of the 2 fungi depends upon climate and variety of maize.

The microphoto by BOOTH (1971, Plate 11:C) does not show microconidia of F. moniliforme var. subglutinans as stated, but rather those of a species or variety that produces its microconidia in chains, because the microconidia of the picture are clavate with a flattened base.

A detailed delineation of the fungus regarding its morphology and biology can be found in the monograph by NIRENBERG (1976).

Fusarium sacchari (Butler) W. Gams var. elongatum Nirenberg - Mitt. Biol. Bundesanst. Land- Forstwirtsch. Berlin-Dahlem 169: 59, 1976

Fusarium moniliforme Sheldon var. subglutinans Wollenw. & Reinking - Phytopathology 15: 163, 1925 (pro parte)

Descriptions: SAUTHOFF & GERLACH (1959), SCHNEIDER & PLATE (1967, 1968), NIRENBERG (1976).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 8 days at 25°C on PDA.
Aerial mycelium - in some strains often rather sparse in others abundant, pilose-pannose or pannose, whitish, pink -buff, pink-vinaceous to vinaceous if stained by the substrate.
Pigmentation - buff to dark vinaceous.
Sclerotial bodies - commonly on all media, greenish black to black.
Sporulation - starting quickly after 2 days in the aerial mycelium as microconidia cohering always in false heads, after 1 week sporodochia or pionnotes begin to form slowly in a few cultures, but in most strains macroconidia are produced only under near-UV irradiation.
Odour - in some strains strongly sweetish.

C o n i d i o p h o r e s - primary conidiophores arising laterally from hyphae in the aerial mycelium, initially not branched, later loosely ramose; secondary conidiophores densely ramose.
Phialides - monophialidic, those of primary conidiophores often polyphialidic and proliferating, slender, almost cylindric, 17-30 µm long, 2.2-2.8 µm wide, those of sporodochia somewhat shorter, measuring 14-24 x 2.8-3.2 µm.

C o n i d i a - microconidia oval, ellipsoid to fusiform, often apiculate, mostly 1-celled; macroconidia falcate, some rather straight, with a very slightly bent apical cell and a distinct foot cell, mostly 3- to 5-septate, measuring:

0-sept.	9 x 2.8	mostly 8-11 x 2.5-3.3	(4-22 x 1.5-4.7) µm
3-sept.	39 x 3.3	mostly 34-55 x 2.9-3.7	(20-70 x 2.3-4.5) µm
5-sept.	54 x 3.5	mostly 43-74 x 3.1-4.0	(32-99 x 2.0-4.7) µm.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 84:

Drawing and photographs of conidia and conidiophores of the type culture 12293 (= CBS 220.76 = IMI 202877) and strain 11091 on different substrates (x 500).

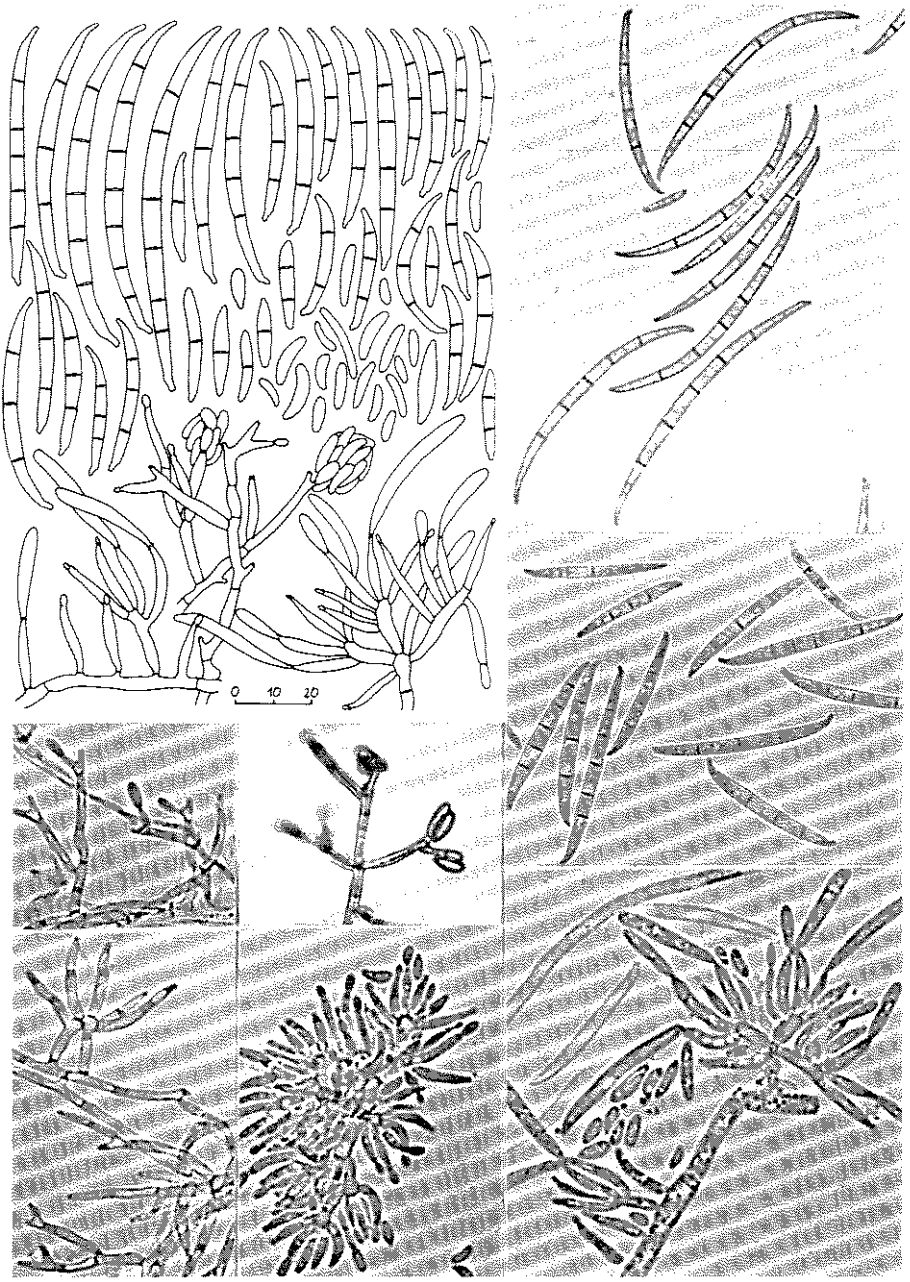

Fig. 84. Fusarium sacchari var. elongatum.

F. sacchari var. elongatum comprises all strains that form oval to allantoid microconidia solely in false heads and falcate often rather straight macroconidia, which do not belong to F. sacchari var. sacchari or F. sacchari var. subglutinans. F. sacchari var. elongatum has a lower optimal and maximum temperature and also longer macroconidia than F. sacchari var. sacchari. It is delimited from F. sacchari var. subglutinans by a lower maximum temperature, more slender macroconidia and the absence of its teleomorph. F. sacchari var. elongatum is pathogenic neither to sugar cane nor to maize. This variety obviously includes more or less strongly specialized pathotypes like the pathogen causing a bulb rot on Nerine and Vallota (SCHNEIDER & PLATE 1967 , 1968) and that causing a leaf spot on Haemanthus (SAUTHOFF & GERLACH 1959). For further information confer NIRENBERG (1976).

Fusarium succisae (Schröter) Sacc. - Syll. Fung. 10: 724, 1892

Fusisporium succisae Schröter - Hedwigia 12: 180, 1874

Fusarium moniliforme Sheldon var. anthophilum (A. Braun) Wollenw. - Z. Parasitenk. 3: 397, 1931 (pro parte)

Fusarium sporotrichiella Bilai var. anthophilum (A. Braun) Bilai - Fusarii: 278, 1955 (pro parte)

Descriptions: WOLLENWEBER (1916-1935 no. 173,1162), LEMESLE (1930), WOLLENWEBER (1931), NIRENBERG (1976).

C o l o n i e s - fast-growing, reaching 7.8 - 8.0 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - abundant, pannose, whitish to grey-violet to vinaceous.
Pigmentation - initially pinkish buff, later bluish vinaceous.
Sclerotial bodies - frequently erumpent, peach to black-blue, especially conspicuous on rice pap, because of their cauliflower-like shape.
Sporulation - starting quickly after 3 days in the aerial mycelium as microconidia cohering always in false heads, sporodochia are formed after 2 or 3 months, stained grey-violet by the substrate, contrasting the bright orange sporodochia that occur on the flowers of Succisa pratensis.
Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally from hyphae in the aerial mycelium, unbranched or loosely branched; secondary conidiophores more densely branched.

Phialides - monophialidic, those of primary conidiophores also occasionally polyphialidic, slender, almost cylindric, 12-26 µm long and 2.4-3.0 µm wide, those of sporodochia somewhat shorter, measuring 10-17 x 2.8-4.0 µm.

C o n i d i a - microconidia oval, ellipsoid, some more allantoid and apiculate, usually 1-celled; macroconidia falcate, rather straight or curved to convolute on the natural substrate, in culture always curved to convolute and more slender, usually 3-septate, measuring:

0-sept.	9 x 3.2	mostly 9-10 x 2.9-3.4	(6-16 x 2.2-4.9) µm
3-sept.	24 x 3.2	mostly 22-26 x 3.0-3.4	(11-60 x 2.4-4.0) µm
5-sept.	38 x 3.6		(19-66 x 3.0-4.2) µm.

C h l a m y d o s p o r e s - absent.

Explanation of Figure 85:

Drawing and photographs of conidia and conidiophores of strains 12287 (= CBS 219.76 = IMI 202876) and 63162 on different substrates (x 500, except lower row, centre x 200).

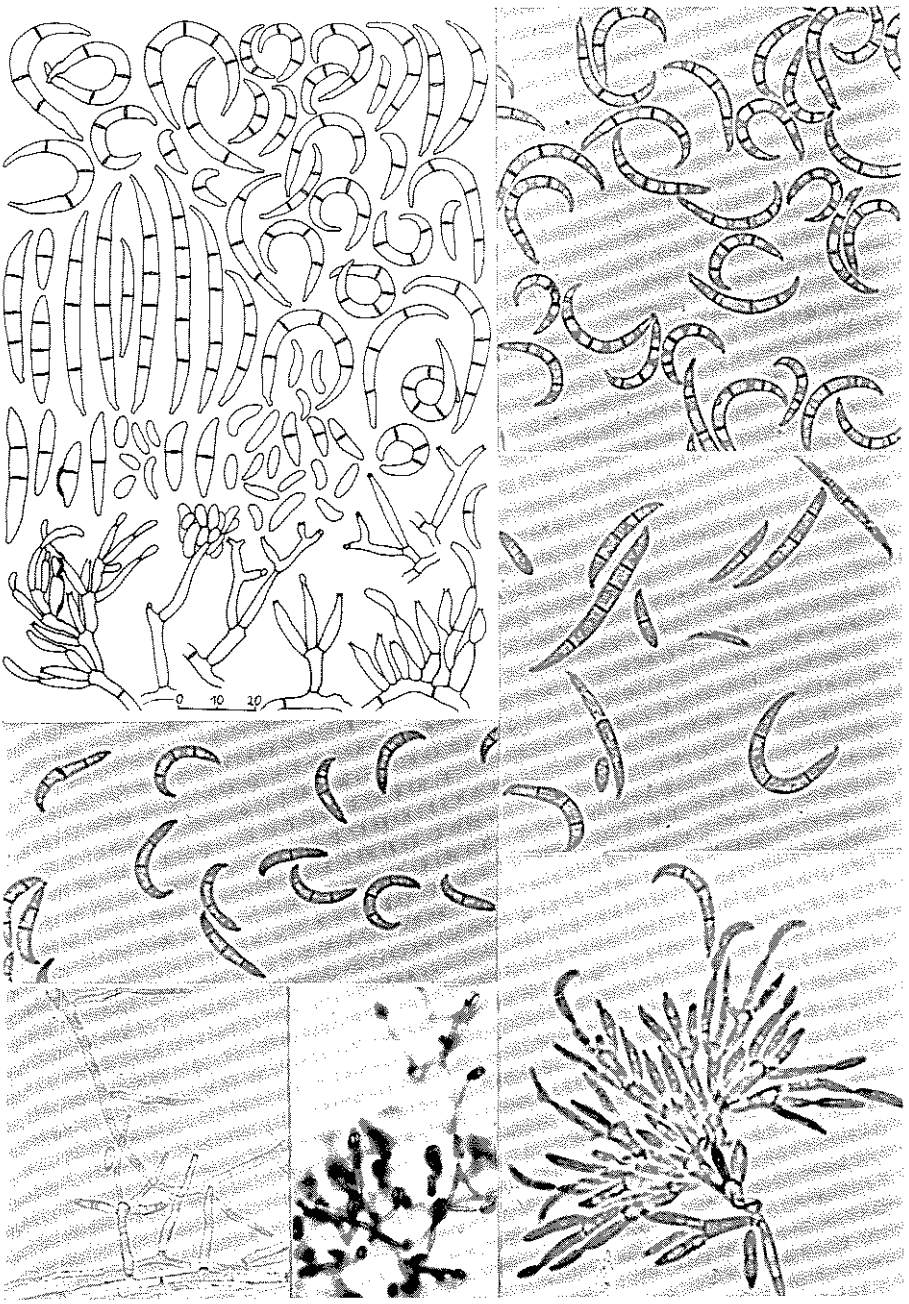

Fig. 85. Fusarium succisae.

F. succisae can be easily differentiated from the other taxa of the Liseola section with oval microconidia by the conspicuous form of its macroconidia. They resemble the ones of F. annulatum. F. succisae apparently is a specialized species, since it was isolated only from devil's bit (Succisa pratensis), where it induces a flower rot. This disease has been hitherto observed only in Germany.

For more information of the morphology and delimitation of this species see NIRENBERG (1976).

Fusarium anthophilum (A. Braun) Wollenw. - Ann. mycol. 15: 14, 1917

Fusisporium anthophilum A. Braun in Rabenhorst - Fungi europaei Nr. 1964, 1875

Fusarium moniliforme Sheldon var. anthophilum (A. Braun) Wollenw. - Z. Parasitenk. 3: 397, 1931 (pro parte)

Fusarium anthophilum (A. Braun) Wollenw. f. 1, f.2 Raillo - Fungi of the Genus Fusarium (Moscow): 263-264, 1950

Fusarium sporotrichiella Bilai var. anthophilum (A. Braun) Bilai - Fusarii: 278, 1955 (pro parte)

Descriptions: WOLLENWEBER (1916-1935 no. 177, 975), NIRENBERG (1976, 1981).

C o l o n i e s - fast-growing, reaching 7.0 - 8.0 cm diam. in 8 days at 25°C on PDA.

Aerial mycelium - abundant, pannose, pinkish buff, pale vinaceous with grey-blue tips, vinaceous.

Pigmentation - buff to dark vinaceous.

Sclerotial bodies - occasionally erumpent through the aerial mycelium, black.

Sporulation - starting quickly after 2 days in the aerial mycelium as microconidia cohering always in false heads; after 1 week sporodochia and pionnotes are frequently formed bearing macroconidia, salmon or cinnamon sometimes stained vinaceous by the substrate.

Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally from hyphae in the aerial mycelium, initially unbranched, later loosely ramose; secondary conidiophores which bear macroconidia - compared to those of other Liseola species and varieties - also loosely branched and always consisting of slender cells, those which bear pyriform microconidia more densely branched.

Phialides - monophialidic, those of primary conidiophores often polyphialidic and proliferating, if monophialidic slender and almost cylindric, 8-26 µm long, 2-4 µm wide, those of sporodochia also slender and cylindric, measuring 10-18 x 2.5-3.5 µm.

C o n i d i a - microconidia in the beginning of the fungal development on low nutrient media mainly pyriform, later almost cylindric to allantoid prevailing, both types apiculate; macroconidia falcate but rather straight, slender, with a slightly bent apical cell and a distinct foot cell, mostly 3- to 5-septate, measuring:

0-sept.	p.	7 x 4.6	mostly 5- 8 x 3.5-5.7	(4-13 x 1.5-9.0) µm
	c.	8 x 2.4	mostly 6- 9 x 1.6-3.1	(4-16 x 1.2-3.9) µm
3-sept.		40 x 3.2	mostly 32-46 x 3.0-3.5	(23-60 x 2.3-4.0) µm
5-sept.		54 x 3.5	mostly 51-58 x 3.3-3.6	(41-85 x 2.6-4.5) µm.

p. = pyriform
c. = cylindric

C h l a m y d o s p o r e s - absent.

Explanation of Figure 86:
Drawing and photographs of conidia and conidiophores of strains 8998, 11158 and 63270 (= CBS 222.76 = IMI 202880) on different substrates (x 500, except centre x 200).

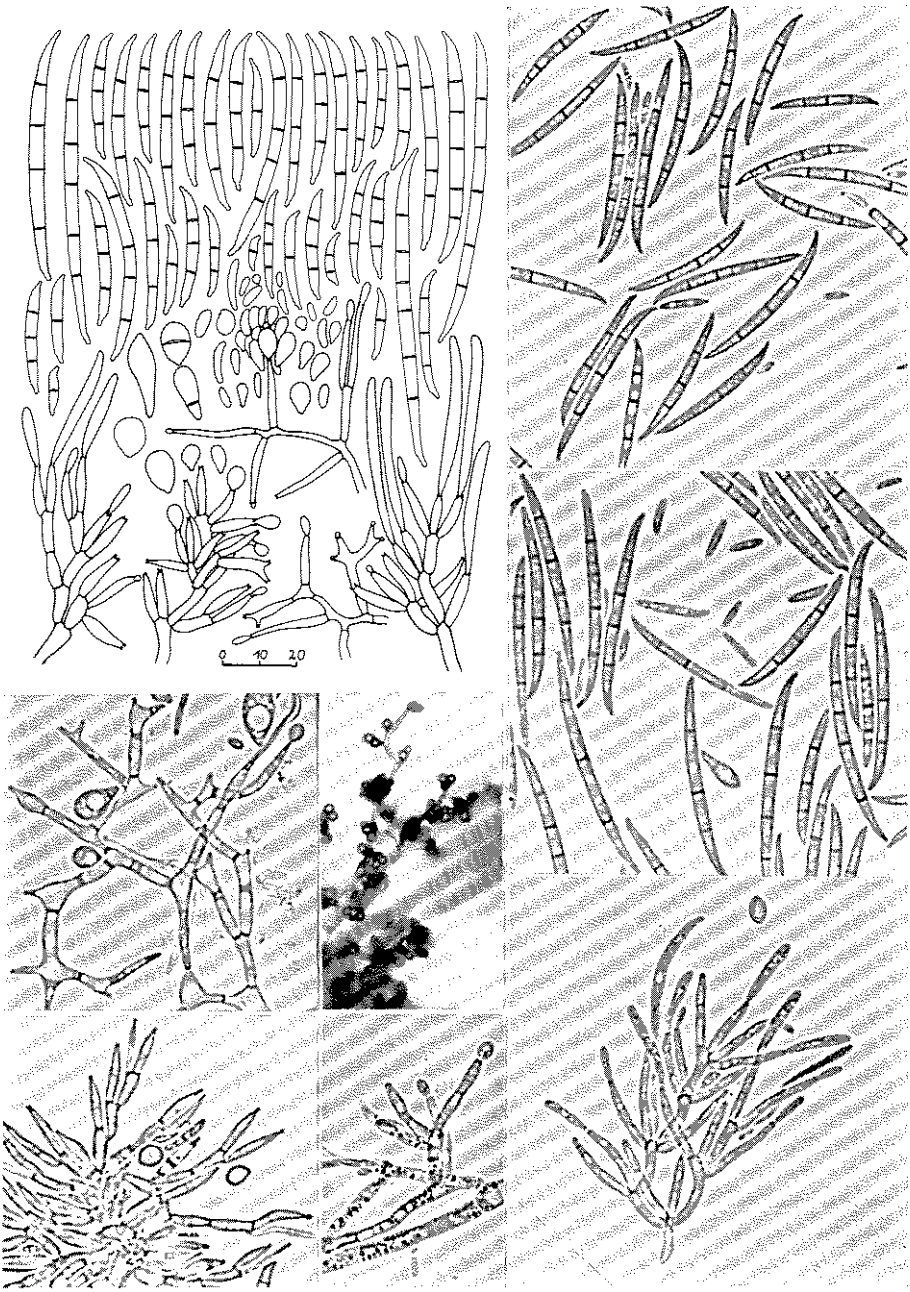

Fig. 86. Fusarium anthophilum.

F. anthophilum can easily be identified by the presence of 2 different types of microconidia - pyriform and almost cylindric to allantoid - cohering always in false heads. Furthermore, the macroconidia are very uniform, almost straight but never curved let alone convoluted as those of F. succisae. Strains can be isolated from many different plants, but until now no pathogenicity has been proved. Reference is again made to the monograph of NIRENBERG (1976).

Fusarium lactis Pirotta & Riboni - Arch. Lab. Bot. Crittogam. Univ. Pavia 2: 316, 1879

Fusarium moniliforme Sheldon var. lactis (Pirotta & Riboni) Bilai - Fusarii: 283-284, 1955

Descriptions: WOLLENWEBER (1916-1935 no. 1155a, 1155b, 1156a, 1156b), WOLLENWEBER & REINKING (1935), WOLLENWEBER (1943), RAILLO (1950), BILAI (1955).

F. lactis is characterized by PIROTTA & RIBONI as a fungus forming microconidia in chains and a few small falcate macroconidia, occurring on milk. Their description is furnished with a drawing, showing conidiophores with an outline of a polyphialide in addition to conidia. Therefore one can deduce that F. lactis is identical with F. proliferatum var. proliferatum or F. proliferatum var. minus.

Later WOLLENWEBER examined isolates from milk products (no. 1155a, 1155b) as well as isolates from plants like Ficus carica (no. 1156a) and Pirus malus (no. 1156b). In infection tests they all produced a fruit rot indicating their identity with a variety of F. proliferatum. He mentioned too the existance of somewhat pyriform microconidia in these cultures. Using milk as a medium for those Liseola Fusaria that produce clavate microconidia, no preference for this substrate could be detected in any of the strains. This finding may be explained by the fact that F. lactis always was associated with other fungi like Oospora lactis and Mucor spec. when isolated from milk in former times. No type material is available and the delimitation of the species is based mainly on the occurrence of small macroconidia, which is true for many strains of F. verticillioides, F. proliferatum var. proliferatum and var. minus. Therefore, F. lactis has to be considered a nomen confusum.

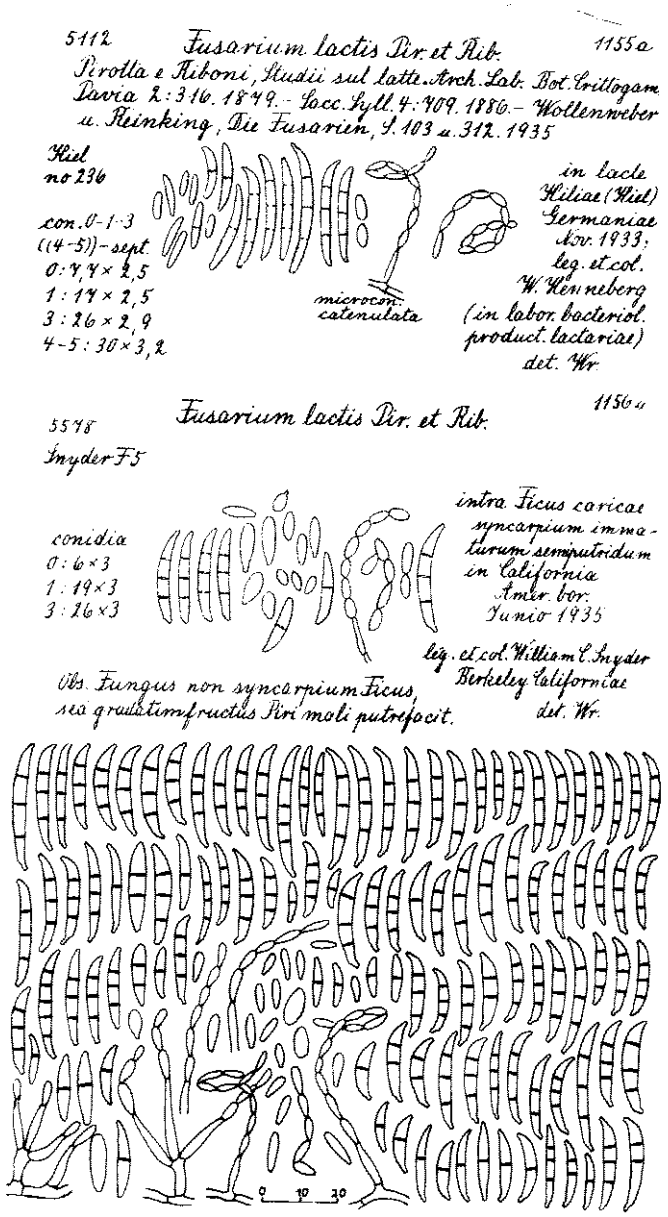

Fig. 87. Fusarium lactis.

Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 1155a of strain 5112 and no. 1156a of strain 5578; drawing of conidia and conidiophores of 6 different strains, according to WOLLENWEBER's drawings (x 500).

Fusarium neoceras Wollenw. & Reinking - Phytopathology 15: 164, 1925

Descriptions: WOLLENWEBER (1916-1935 no. 977), WOLLENWEBER & REINKING (1925), REINKING & WOLLENWEBER (1927), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), RAILLO (1950).

F. neoceras was characterized by WOLLENWEBER & REINKING (1925) by unicellular ovoid to fusoid microconidia cohering always in false heads and by large macroconidia. The authors mention also that the macroconidia are borne more often in pionnotes than in sporodochia and that sclerotial bodies are absent. Both characters imply that they already described a 'mycelial variant'. The ex-holotypus CBS 147.25 exists in such a deteriorated state that it produces only a few microconidia on monophialidic or polyphialidic conidiogenous cells. For this reason it was correct to place it as a synonym of F. sacchari by GAMS (1971). It cannot be determined to which variety of F. sacchari the fungus belongs since the type specimen is missing. The description would best fit some strains of F. sacchari var. elongatum.

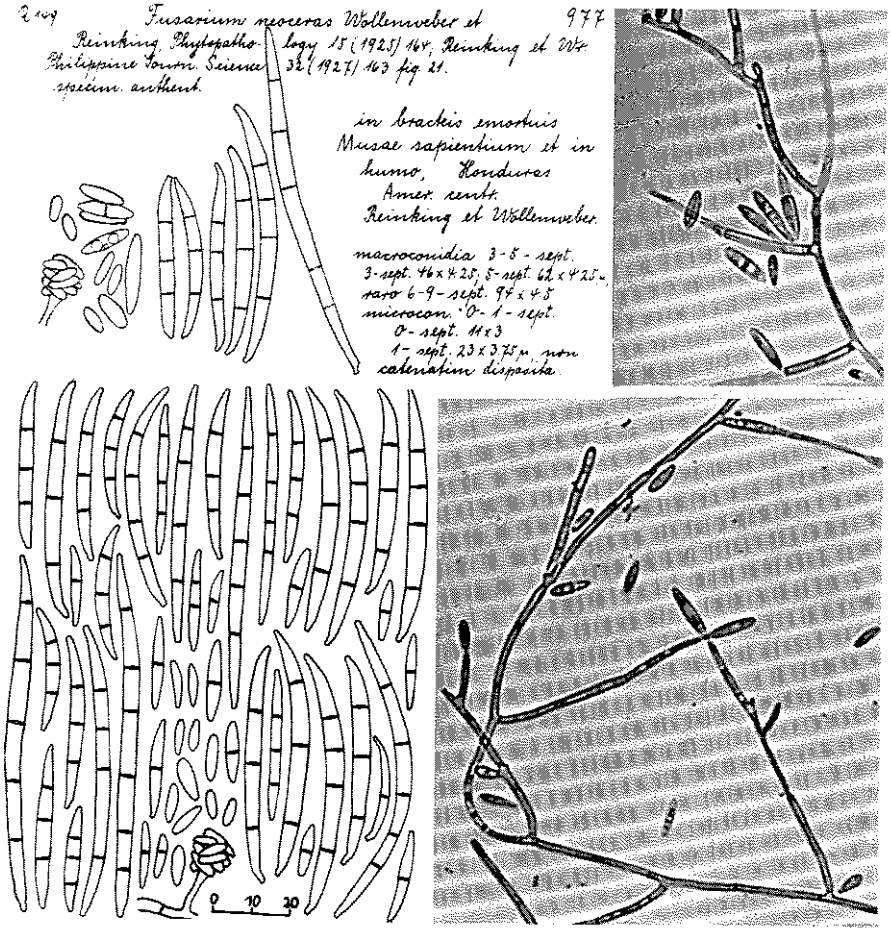

Fig. 88. Fusarium neoceras.
Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 977 of the type culture R 149; drawing according to WOLLENWEBER's drawings, and photographs of conidia and conidiophores of the type culture (CBS 147.25) (x 500).

Section ELEGANS Wollenw. - Phytopathology 3: 28, 1913

Fusarium oxysporum Schlecht. - Flora Berol. 2: 139, 1824 emend. Snyder & Hansen - Amer. J. Bot. 27: 64-67, 1940 var. oxysporum (pro maxima parte)

Fusarium bulbigenum Cooke & Massee - Grevillea 16: 49, 1887

Fusarium vasinfectum Atkinson - Bull. Alabama agric. Exp. Stn 41: 19, 1892

Fusarium tracheiphilum E.F. Smith - Bull. U.S.Dep. Agric. 17: 46, 1899

Fusarium dianthi Prill. & Delacr. - Compt. rend. Acad. Sci. 129: 744-745, 1899

Fusarium lini Bolley - Proc. Soc. Promot. agric. Sci. 21: 1-4, 1902

Fusarium orthoceras Appel & Wollenw. - Arb. Kais. Biol. Anst. Land-Forstwirtsch. Berlin-Dahlem 8: 141-156, 1910

Fusarium conglutinans Wollenw. - Phytopathology 3: 30, 1913

Fusarium angustum Sherb. - Mem. Cornell Univ. agric. Exp. Stn 6: 203-205, 1915

Fusarium bostrycoides Wollenw. & Reinking - Phytopathology 15: 166, 1925

F. oxysporum in the extremely wide concept of SNYDER and HANSEN is one of the most variable Fusarium species regarding macroscopic as well as microscopic characteristics. Nevertheless numerous distinct types and formae speciales which were initially described as species or varieties can be distinguished by specific features.

Descriptions: APPEL & WOLLENWEBER (1910), WOLLENWEBER (1913), SHERBAKOFF (1915), WOLLENWEBER (1916-1935), WOLLENWEBER & REINKING (1925), REINKING & WOLLENWEBER (1927), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), BUGNICOURT (1939), WOLLENWEBER (1943), JAMALAINEN (1944), RAILLO (1950), GORDON (1952), BILAI (1955), GERLACH (1961), BOOTH & WATERSTON (1964h), GORDON (1965), ARMSTRONG & ARMSTRONG (1968), GERLACH & ERSHAD (1970), BOOTH (1970), HOLLIDAY (1970a, b, c, d, e, f), SUBRAMANIAN (1970a, b, c), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE (1974), JOFFE et al. (1974), HORNOK (1975), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 (6.0 - 8.5) cm diam. in 8 days at 25°C on PDA; considerable differences between different strains.
Aerial mycelium - usually rather abundant, comparatively delicate, loosely floccose, becoming felt-like, in some isolates sparsely developed and more arachnoid or hairy-funiculose flat appressed, in other ones, which very quickly form expanded pionnotal slimes almost lacking, whitish, peach, often with a purple or violet tinge.
Pigmentation - very variable, extending from pale beige, salmon, rose to strong purple, vinaceous and dark bluish violet, sometimes greyish blue or greenish blue areas interspersed.
Sclerotial bodies - abundant, sparse or absent, of different size and shape, globose to subglobose, cauliflower-like, pale, buff-brown, greyish blue or greenish blue to deep violet.

Explanation of Figure 89:
Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

Fig. 89. Fusarium oxysporum var. oxysporum.

Sporulation - starting quickly in the aerial mycelium producing microconidia cohering in false heads, never forming chains; macroconidia at first solitarily scattered, later formed in pale salmon to bright orange, pustule-like erumpent, globose sporodochia or in pionnotal slimes, in some strains occurring very abundantly, in others only sparsely or lacking (corresponding to F. orthoceras).
Odour - not perceptible in most strains; very strong and typical in others (f. sp. tulipae, strains of f. sp. cubense, f. sp. cactacearum), suggesting lilac.

C o n i d i o p h o r e s - primarily formed as short (in contrast to F. solani), single, lateral phialides on hyphae or loosely branched in the aerial mycelium, later in sporodochial or pionnotal layers densely irregularly or verticillately branched.
Phialides - monophialidic, those of primary conidiophores mostly subcylindric, 8-14 µm long and 2.5-3.0 µm wide; those of secondary conidiophores are more variable in shape, cylindric, subcylindric to slightly obclavate and usually longer, measuring 10-25 x 2.0-4.5 µm.

C o n i d i a - microconidia 1- or 2-celled, cylindric to ellipsoid, oval, straight to slightly curved or reniform; macroconidia falcate, usually moderately curved, subcylindric, equally and gradually tapering toward both ends, with a pointed, sometimes slightly hooked apical cell and a mostly rather distinctly pedicellate basal cell, usually predominantly 3-septate, in some strains frequently 4- or 5- (very seldom 6- or 7-) septate, measuring:

0-sept.	7 x 2.6	mostly 5- 9 x 2.4-3.0	(4-13 x 2.0-3.5) µm
1-sept.	13 x 3.4	mostly 10-16 x 2.8-3.5	(8-24 x 2.2-4.6) µm
3-sept.	35 x 4.2	mostly 27-42 x 3.0-4.7	(18-54 x 2.7-6.0) µm
4-sept.	41 x 4.4	mostly 34-50 x 3.3-5.1	(25-56 x 2.7-6.0) µm
5-sept.	45 x 4.5	mostly 37-55 x 3.3-5.4	(26-62 x 2.8-6.0) µm
7-sept.	48 x 4.5	mostly 40-55 x 3.5-5.5	(34-78 x 3.0-6.0) µm.

C h l a m y d o s p o r e s - generally abundant, in hyphae and conidia, terminal or intercalary, smooth- or rough-walled, globose to subglobose, single (7-11 µm), in pairs, short chains or occasionally in clusters.

The fungus is economically the most important member of the genus Fusarium being distributed world-wide and being extremely common in a wide range of soils. It is a causal agent of vascular wilts, damping-off and rots on hundreds of different host plants. About over hundred formae speciales and races exist within F. oxysporum which are more or less host-specific on woody plants, field crops, vegetables and particularly, on ornamentals (BOOTH & WATERSTON 1964h, GORDON 1965, ARMSTRONG & ARMSTRONG 1968, BOOTH 1970, HOLLIDAY 1970a-f, SUBRAMANIAN 1970a,b,c, BOOTH 1971a, SUBRAMANIAN 1971).

Fusarium oxysporum Schlecht. var. meniscoideum Bugnicourt - Encycl. mycol. 11: 111-114, 1939

Descriptions: BUGNICOURT (1939), WOLLENWEBER (1943).

There is no representative culture of this Fusarium available because CBS 221.49, deposited by R. HEIM as F. oxysporum var. meniscoideum, is completely degenerated.

The diagnosis given by BUGNICOURT (1939) and reproduced by WOLLENWEBER (1943) without any comment is based on 2 isolates from roots of Xeranthemum and Thea in Indo-China. They were separated as a distinct variety because of their strongly curved meniscoid macroconidia. In all the other macroscopic and microscopic features, however, they fit in F. oxysporum in the species concept of SNYDER and HANSEN. Therefore, following GORDON (1952), this Fusarium was treated by BOOTH (1971a) as synonymous with F. oxysporum, which may be accepted.

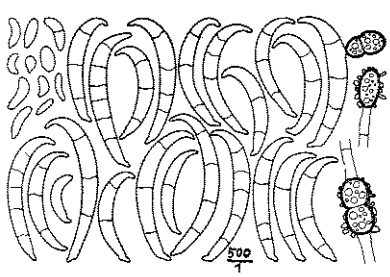

Fig. 90. Fusarium oxysporum var. meniscoideum. Reproduction of Figure 19 (p. 112) by BUGNICOURT (1939) (x 500).

Fusarium redolens Wollenw. - Phytopathology 3: 29-30, 1913

Fusarium redolens Wollenw. var. solani Sherb. - Mem. Cornell Univ. agric. Exp. Stn 6: 205, 1915

Fusarium oxysporum Schlecht. emend. Synder & Hansen - Amer. J. Bot. 27: 64-67, 1940 (pro parte)

Fusarium oxysporum Schlecht. var. redolens Gordon - Can. J. Bot. 30: 238, 1952

Fusarium solani (Mart.) Sacc. var. redolens Bilai - Fusarii: 288, 1955

Descriptions: WOLLENWEBER (1913), SHERBAKOFF (1915), WOLLENWEBER (1916-1935 no. 394, 395), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), RAILLO (1950), GORDON (1952), BILAI (1955), GERLACH (1961), GERLACH & PAG (1961), HANTSCHKE (1961), BOOTH & WATERSTON (1964i), BOOTH (1971a), JOFFE (1974), DOMSCH et al. (1980).

C o l o n i e s - very fast-growing, reaching 6.8 - 8.0 cm diam. in 6 days at 25°C on PDA.

Aerial mycelium - usually rather abundant, hairy-funiculose, later appearing somewhat powdery, whitish, beige to greyish beige or pale amber.

Pigmentation - pale beige, incarnadine to ochre, finally reddish brown; never distinct red, vinaceous or bluish.

Sclerotial bodies - mostly present, but sparsely formed, small, of different shape, cream, pale amber to buff-brown.

Sporulation - starting very quickly, producing microconidia on phialides in the aerial mycelium, which cohere in false heads, later cream, beige rarely salmon to orange, flat, slimy pionnotal or sporodochial layers develop, most often produced on oatmeal agar, less frequently and sometimes lacking on other substrates.

Odour - almost always present and rather strong, suggesting lilac.

C o n i d i o p h o r e s - primary conidiophores arising as single lateral phialides in the aerial mycelium; secondary conidiophores of pionnotes or sporodochia densely branched.
Phialides - monophialidic, those of primary conidiophores usually subcylindric to obclavate and rather short, mostly 8-15 µm long and 3.5-4.0 µm wide; those of secondary conidiophores densely branched, cylindric to subcylindric, mostly 15-25 µm long and 2.5-3.5 µm wide.

C o n i d i a - microconidia 1- or 2-celled, subcylindric to oval, slightly larger than in F. oxysporum; macroconidia falcate, usually only slightly curved, widest in the upper third, rather thick-walled, with a hooked and pointed, sometimes constricted apical cell and a more or less distinctly pedicellate basal cell, 3- to 5-septate, measuring:

0-sept.	9 x 3.1	mostly 6-15 x 2.4-4.0	(4-21 x 1.9-5.7) µm
1-sept.	18 x 3.9	mostly 13-26 x 3.0-5.0	(9-36 x 2.3-6.0) µm
3-sept.	34 x 4.8	mostly 25-46 x 4.4-5.5	(17-58 x 2.9-7.0) µm
4-sept.	40 x 5.0	mostly 32-50 x 4.4-5.8	(26-58 x 3.7-6.9) µm
5-sept.	44 x 5.2	mostly 36-52 x 4.7-6.0	(32-59 x 4.0-6.8) µm.

C h l a m y d o s p o r e s - in hyphae and conidia, intercalary or terminal, mostly smooth-walled, globose to subglobose, single (6-14 µm), in pairs or short chains.

Explanation of Figure 91:
Drawing and photographs of conidia, conidiophores and chlamydospores of strains 62379, 62390 (= CBS 248.61 = ATCC 16067) and 63204 on different substrates (x 500).

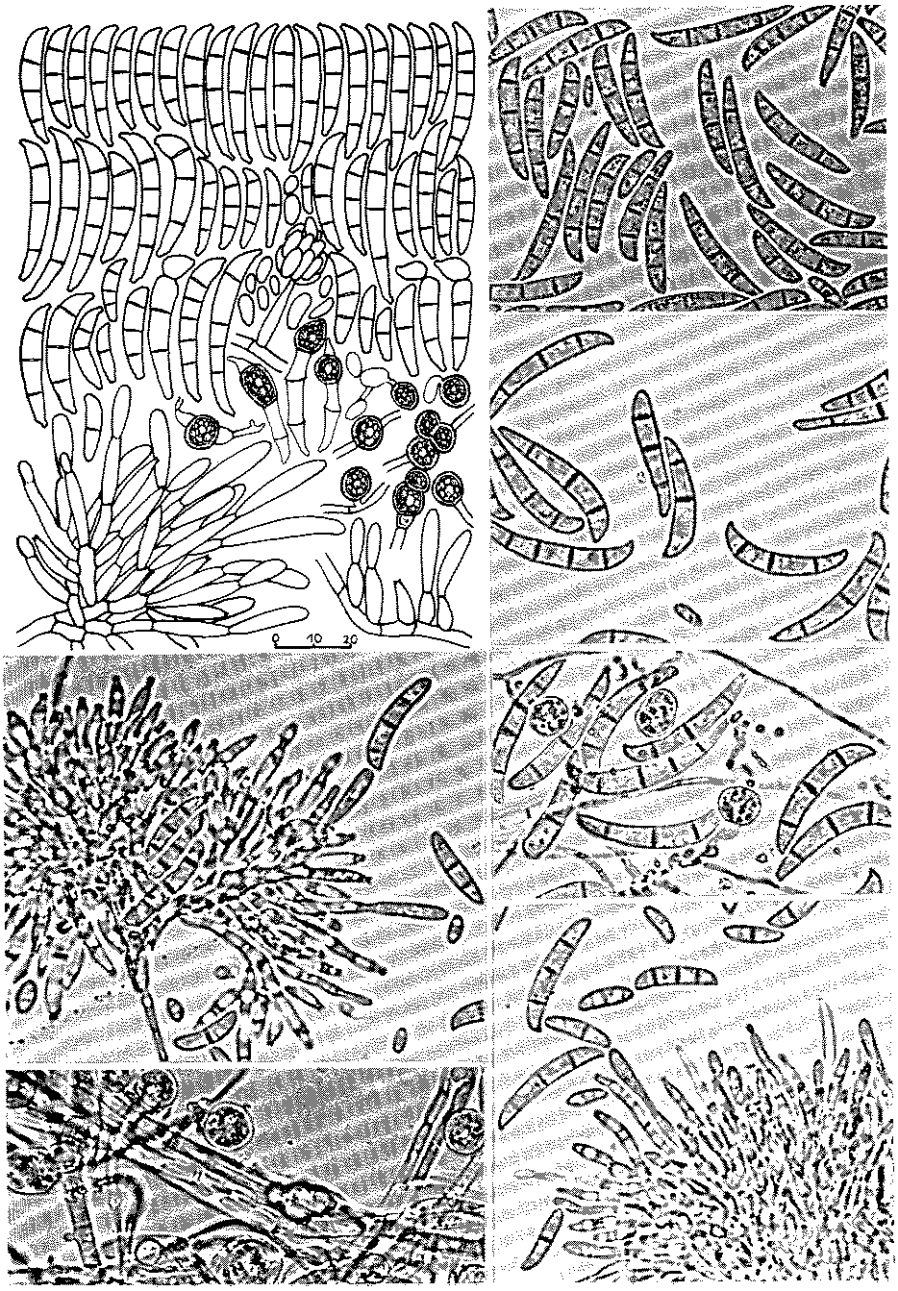

Fig. 91. Fusarium redolens.

F. redolens is a rather common soil-borne fungus occurring particularly in temperate regions. It has been recorded on very numerous host plants, especially peas, carnations, bulbous plants and spinach, causing wilts or damping-off and root rots or foot rots. It is clearly distinct and should be retained as a separate species. For more information see GERLACH (1961), BOOTH & WATERSTON (1964i) and DOMSCH et al. (1980).

Two specialized forms causing wilt diseases of carnations or spinach are known:

Fusarium redolens Wollenw. f. sp. dianthi Gerlach in Gerlach & Pag - Phytopath. Z. 42: 349-361, 1961 (GERLACH & PAG 1961, HANTSCHKE 1961).

Fusarium redolens Wollenw. f. sp. spinaciae (Sherb.) C.V. Subramanian - Hyphomycetes (New Delhi): 690, 1971

Fusarium spinaciae Sherb. in Hungerford - Phytopathology 13: 205-209, 1923

Fusarium oxysporum Schlecht. emend. Snyder & Hansen f. spinaciae (Sherb.) Snyder & Hansen - Amer. J. Bot. 27: 66, 1940

Fusarium redolens Wollenw. f. 1 Wollenw. - Z. Parasitenk. 3: 426, 1931

Descriptions: WOLLENWEBER (1916-1935 no. 1022, 1193), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), DOIDGE (1938), JAMALAINEN (1944), RAILLO (1950).

This forma described for strains without an aromatic odour in pure culture, was included in F. redolens by GORDON (1952). Regarding the situation in F. oxysporum, where strains with or without odour are not distinguished as different taxa, the procedure of GORDON can be accepted.

Fusarium udum Butler - Mem. Dep. Agric. India, Bot. Ser. 2: 54, 1910

Fusarium butleri Wollenw. - Phytopathology 3: 38, 1913

Fusarium uncinatum Wollenw. - Ann. mycol. 15: 54, 1917

Fusarium lateritium Nees ex Link var. uncinatum (Wollenw.) Wollenw. - Z. Parasitenk. 3: 375, 1931

Fusarium oxysporum Schlecht. emend. Snyder & Hansen f. udum (Butler) Snyder & Hansen - Amer. J. Bot. 27: 66, 1940

Fusarium udum Butler var. cajani Padwick - Indian J. agric. Sci. 10: 877, 1940

Fusarium lateritium Nees ex Link f. cajani (Padwick) Gordon - Can. J. Bot. 30: 232, 1952

Descriptions: WOLLENWEBER (1916-1935 no. 227, 954), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), BOOTH (1971a), SUBRAMANIAN (1971), BOOTH (1978e).

C o l o n i e s - fast-growing, reaching 7.8 - 8.2 cm diam. in 8 days at 25°C on PDA.

Aerial mycelium - usually sparsely developed or almost lacking, felt-like, densely floccose to funiculose, whitish to pale pink or greyish purple tinged.

Pigmentation - yellowish, pinkish, becoming rose-buff to purple-violet.

Sclerotial bodies - sometimes present, not abundant, globose to subglobose, cauliflower-like, from pale buff to dark bluish violet.

Sporulation - starting quickly, slimy aggregations of small conidia scattered in the aerial mycelium, soon some salmon or pale pink sporodochia formed, sometimes confluent, covering wide parts of the surface of the colony.

Odour - not perceptible.

C o n i d i o p h o r e s - initially arising as single lateral phialides or loosely branched in the aerial mycelium, later in sporodochia or pionnotes densely verticillately or irregularly branched.
Phialides - monophialidic, subcylindric to obclavate or almost doliiform, often with a distinct collarette, mostly 8-15 µm long and 2.5-3.5 µm wide.

C o n i d i a - rather thin-walled, 1- or 2-celled conidia ovoid to fusoid, often slightly curved, reniform, taller conidia falcate, subulate, narrowing toward both ends, with a sometimes strongly hooked and pointed apical cell and a distinctly pedicellate basal cell, predominantly 3-septate, less frequently 4- or 5- (exceptionally up to 7-) septate, measuring:

0-sept.	9 x 2.4	mostly 8-10 x 2.0-2.9	(5-13 x 1.5-3.5) µm
1-sept.	15 x 2.5	mostly 13-17 x 2.0-3.0	(11-20 x 1.5-4.0) µm
3-sept.	27 x 3.0	mostly 20-32 x 2.3-3.7	(17-46 x 2.0-4.2) µm
4-5-sept.	43 x 3.4	mostly 38-50 x 2.9-4.0	(31-62 x 2.5-4.4) µm.

C h l a m y d o s p o r e s - usually intercalary in hyphae, less frequently in conidia, smooth-walled, globose to subglobose, single (8-12 µm), in pairs, chains or clusters.

Explanation of Figure 92:
Drawing and photographs of conidia, conidiophores and chlamydospores of strains 62449 and 62451 (= CBS 747.79) on different substrates (x 500).

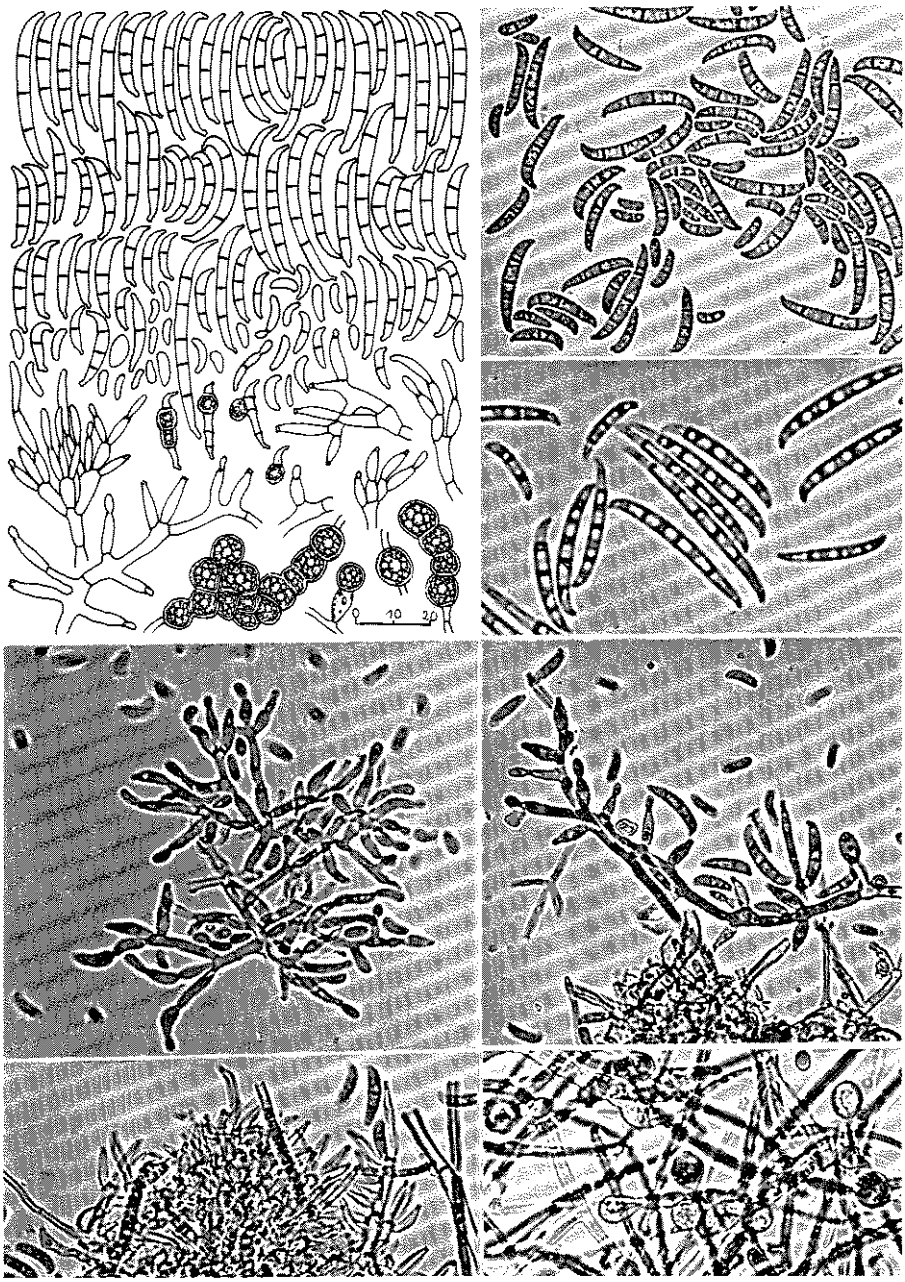

Fig. 92. Fusarium udum.

F. udum is accepted as a clearly distinct species and included in the Elegans group by SUBRAMANIAN (1971). Two representative strains are available in the CBS/Baarn (178.32, 747.79).

The fungus is soil-borne and causes a serious wilt disease of pigeon pea (Cajanus cajan) in various parts of India where this crop is grown. Records of the fungus from other countries (see BOOTH 1971a) need to be confirmed.

More detailed information is given by SUBRAMANIAN (1971), BOOTH (1971a, 1978e).

One specialized form is known to cause a typical vascular wilt of sun hemp (Crotalaria juncea) in various parts of India, USA and probably Brazil:

Fusarium udum Butler f. sp. crotalariae (Kulkarni) C.V. Subramanian in Booth - The Genus Fusarium: 114, 1971

Fusarium vasinfectum Atkinson var. crotalariae Kulkarni - Indian J. agric. Sci. 4: 994, 1934

Fusarium udum Butler var. crotalariae Padwick - Indian J. agric. Sci. 10: 877, 1940

Fusarium udum Butler var. crotalariae (Kulkarni) Padwick - Indian J. agric. Sci. 11: 673, 1941

Fusarium lateritium Nees ex Link f. crotalariae (Padwick) Gordon - Can. J. Bot. 30: 232, 1952

Section MARTIELLA Wollenw. - Phytopathology 3: 30, 1913

Fusarium javanicum Koorders - Verh. Koninkl. Akad. Wetensch. Amsterdam, II, 13: 247-248, 1907
var. javanicum

Fusarium radicicola Wollenw. - J. agric. Res. 2: 257-258, 1914

Fusarium ensiforme Wollenw. & Reinking - Phytopathology 15: 169, 1925

Fusarium javanicum Koorders var. radicicola (Wollenw.) Wollenw. - Z. Parasitenk. 3: 286, 1931

Fusarium javanicum Koorders var. ensiforme (Wollenw. & Reinking) Wollenw. - Z. Parasitenk. 3: 483, 1931

Fusarium solani (Mart.) Sacc. emend. Snyder & Hansen - Amer. J. Bot. 28: 740, 1941 (pro parte)

Fusarium solani (Mart.) Sacc. f. radicicola (Wollenw.) Snyder & Hansen - Amer. J. Bot. 28: 740, 1941

Teleomorph: Nectria ipomoeae Halsted - Rep. New Jersey agric. Exp. Stn 12: 281, 1892

Hypomyces ipomoeae (Halsted) Wollenw. - Phytopathology 3: 34, 1913

Descriptions: WOLLENWEBER (1913), WOLLENWEBER (1916-1935 no. 56, 349, 423, 424, 426-428, 632, 823-827, 1023-1028), REINKING & WOLLENWEBER (1927), WOLLENWEBER & REINKING (1935), DOIDGE (1938), BUGNICOURT (1939), WOLLENWEBER (1943), JOFFE & PALTI (1970, 1972), JOFFE (1974), GERLACH (1978).

C o l o n i e s - fast-growing, reaching 7.8 - 8.2 cm diam. in 10 days at 25°C on PDA, macroscopically similar to F. solani.
Aerial mycelium - generally rather sparse, floccose, felt-like, whitish, beige, slightly yellowish, pale greenish, brownish.

Pigmentation - rather variable, cream, avellaneous, amber, grey-greenish, brownish, in some strains aeruginous, later red-brown, olive, coffee-brown to brownish violet.
Sclerotial bodies - generally lacking, if present small, not striking, of various shapes, beige, pale buff, olive to grey-greenish.
Sporulation - usually starting very quickly in the aerial mycelium as microconidia cohering in false heads; macroconidia early and abundantly formed in cream, amber or grey-greenish sporodochia or pionnotes, soon covering wide parts of the colony or forming powdery, cream crusts when desiccating.
Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally from hyphae in the aerial mycelium, at first unbranched, later sparsely branched; secondary conidiophores densely, mostly irregularly, less frequently verticillately branched.
Phialides - monophialidic, with a rather distinct collarette; those producing microconidia comparatively long and slender (18-40 x 2.0-3.5 µm); those producing macroconidia shorter, subcylindric to doliiform (10-25 x 3.0-4.0 µm).

C o n i d i a - microconidia oval, ellipsoid, ovoid, oblong, almost subcylindric to sometimes allantoid, 0- or 1-septate; macroconidia falcate, but rather straight, mostly with an almost cylindric central part, with a somewhat elongated, slightly narrowing and hooked, more or less pointed or blunt apical cell and a mostly distinct pedicellate basal cell, usually 3- to 5-septate, 4- and 5-septate conidia often predominant, rarely 6- to 7-septate, measuring:

Explanation of Figure 93:
Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 424; drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

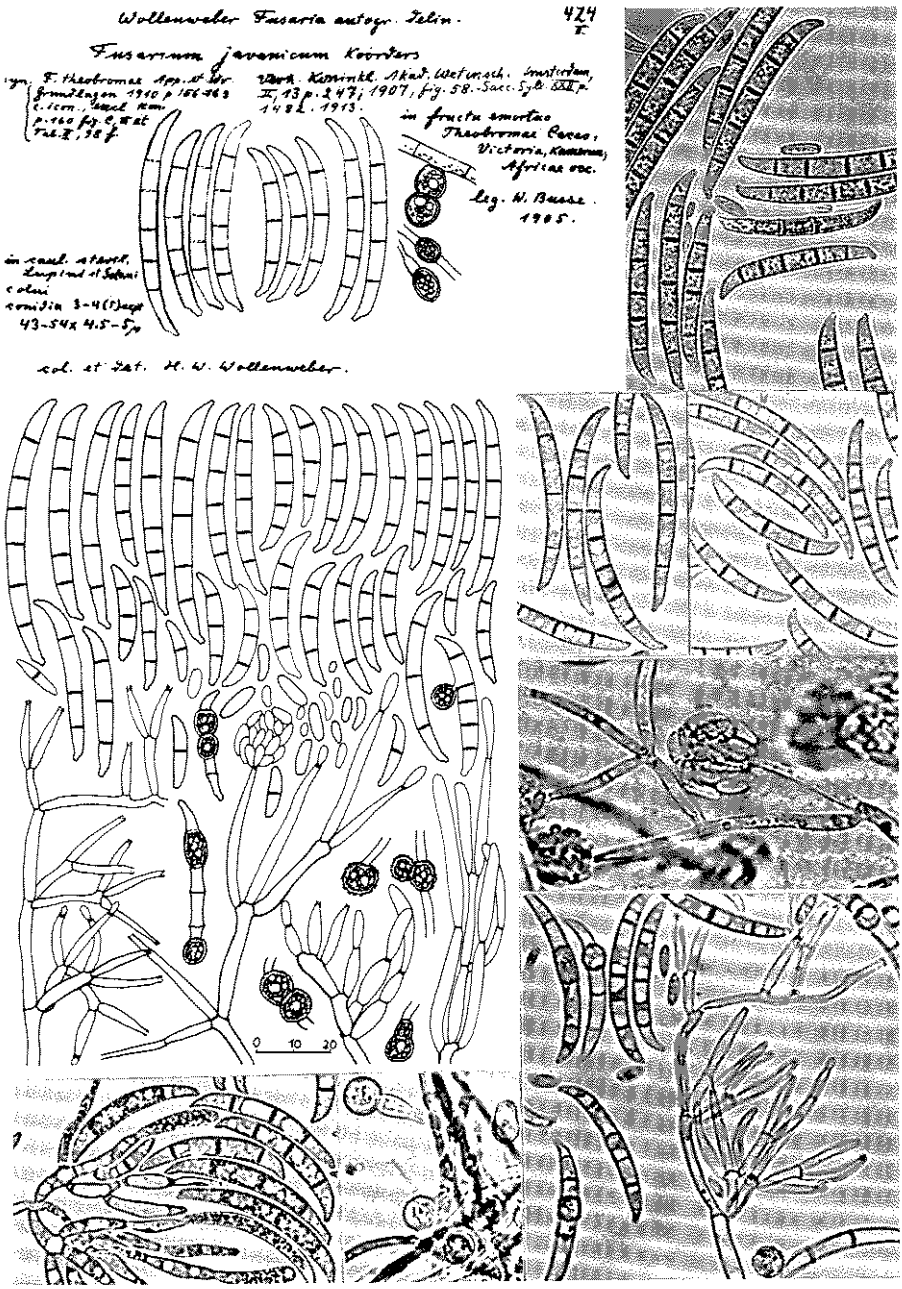

Fig. 93. Fusarium javanicum var. javanicum.

0-sept.	8 x 3.0	mostly 6-10 x 2.7-3.3	(4-12 x 2.4-4.1) µm
1-sept.	16 x 3.6	mostly 12-18 x 3.4-4.0	(8-30 x 3.0-4.2) µm
3-sept.	37 x 4.5	mostly 28-47 x 3.8-5.0	(20-56 x 3.3-6.0) µm
5-sept.	54 x 4.7	mostly 45-62 x 4.5-5.0	(32-71 x 3.7-6.0) µm
6-sept.	63 x 4.9	mostly 58-70 x 4.5-5.5	(52-80 x 4.2-6.0) µm
7-sept.	69 x 4.9		(58-82 x 4.5-5.7) µm.

C h l a m y d o s p o r e s - in older cultures mostly present, but not very abundant, terminal or intercalary, in hyphae or conidia, sometimes excrescent and adhering usually directly at the cell wall, globose to subglobose, single (6-10 µm), in pairs, exceptionally in short chains, smooth-walled to slightly verrucose.

F. javanicum was recognized as morphologically different from F. solani and retained as a distinct species by many authors (WOLLENWEBER 1916-1935, WOLLENWEBER & REINKING 1935, DOIDGE 1938, BUGNICOURT 1939, WOLLENWEBER 1943, RAILLO 1950, BILAI 1955). The contrary opinion which was advanced by SNYDER & HANSEN (1941) combined F. javanicum as well as other Martiella fusaria with F. solani. This broader concept was also accepted by GORDON (1952, 1956a and b), BOOTH & WATERSTON (1964j), BOOTH (1971a) and SUBRAMANIAN (1971), with the exclusion of F. coeruleum. JOFFE & PALTI (1970, 1972) and PALTI & JOFFE (1971) in Israel, however, revived the old concept of 2 different species. On the basis of numerous isolates studied by us during the past years, this step appears to be correct (GERLACH & ERSHAD 1970, GERLACH 1972). Our treatment of F. javanicum provisionally includes all varieties formerly described as distinct. Further study is needed to determine wether or not these can be distinguished.

F. javanicum is a rather common fungus found on rotting parts of numerous plants especially in warmer regions and in green-houses. Because of the varying species concept, however, the reports on its distribution and its role as a plant pathogen must be considered with some reservation. Without any doubt, several plant diseases ascribed by different authors to formae speciales of F. solani in the too comprehensive sense of SNYDER & HANSEN (1941) actually concern F. javanicum var. javanicum or its varieties radicicola or ensiforme. This was for instance demonstrated by JOFFE & PALTI (1970, 1972) and PALTI & JOFFE (1971) for the rot pathogen of cucumber, melons, squash and other cucurbits.

Fusarium javanicum Koorders var. chrysanthemi-leucanthemi Batikyan - Biol. Zh. Armen. 22: 86, 1969

Published without Latin diagnosis.

Fusarium javanicum Koorders var. sclerotii Batikyan - Biol. Zh. Armen. 22: 85, 1969

Published without Latin diagnosis.

Fusarium martiellae-discolorioides Batikyan - Biol. Zh. Armen. 22: 87, 1969

Published without Latin diagnosis.

Fusarium solani (Mart.) Sacc. - Michelia 2: 296, 1881 var. solani

Fusarium solani (Mart.) Appel & Wollenw. - Arb. Kais. Biol. Anst. Land- Forstwirtsch. Berlin-Dahlem 8: 64-78, 1910

Fusarium solani (Mart.) Appel & Wollenw. var. minus Wollenw. - Ann. mycol. 15: 55, 1917

Fusarium solani (Mart.) Appel & Wollenw. var. striatum (Sherb.) Wollenw. - Z. Parasitenk. 3: 451, 1931

Fusarium solani (Mart.) Appel & Wollenw. var. martii (Appel & Wollenw.) Wollenw. - Z. Parasitenk. 3: 451, 1931

Fusarium solani (Mart.) Appel & Wollenw. var. aduncisporum (Weimer & Harter) Wollenw. - Z. Parasitenk. 3: 483, 1931

Fusarium solani (Mart.) Sacc. emend. Snyder & Hansen - Amer. J. Bot. 28: 740, 1941 (pro parte)

Teleomorph: Nectria haematococca Berk. & Br. var. brevicona (Wollenw.) Gerlach in Nelson, Toussoun & Cook - Fusarium: Diseases, Biology, and Taxonomy. The Pennsylvania State University Press, University Park & London, Chapter 36: 422, 1981

Hypomyces haematococcus (Berk. & Br.) Wollenw. var. breviconus Wollenw. - Fus. autogr. delin.: 828, 1930

Nectria cancri Rutgers - Ann. Jard. Buitenzorg 27, 2. Ser. 12: 62, 1913

Hypomyces haematococcus (Berk. & Br.) Wollenw. var. cancri (Rutgers) Wollenw. - Z. Parasitenk. 3: 472, 1931

Descriptions: APPEL & WOLLENWEBER (1910), CARPENTER (1916), SHERBAKOFF (1915), WOLLENWEBER (1916-1935 no. 55, 396-406, 411-421, 630, 631, 828, 829, 1029-1035, 1194-1198), WOLLENWEBER (1917), REINKING & WOLLENWEBER (1927), WOLLENWEBER (1931), REINKING & WOLLENWEBER (1935), DOIDGE (1938), BUGNICOURT (1939), CARRERA (1939), JAMALAINEN (1943b), WOLLENWEBER (1943), GORDON (1952), BOOTH & WATERSTON (1964j), GERLACH &

ERSHAD (1970), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE & PALTI (1972), JOFFE (1974), HORNOK (1975), DOMSCH et al. (1980), NIRENBERG (1981).

C o l o n i e s - fast-growing, reaching 7.3 - 8.0 cm diam. in 8 days at 25°C on PDA.
Aerial mycelium - usually rather sparse, delicate, felt-like, locally floccose, sometimes zonate, cream, buff, amber to grey-greenish or pale aeruginous.
Pigmentation - rather variable, predominantly cream, buff, often with aeruginous or bluish brown tinges.
Sclerotial bodies - often present, but not striking, small, flat or somewhat erumpent, buff, olive to aeruginous or bluish.
Sporulation - generally starting very quickly in the aerial mycelium as microconidia cohering in false heads; soon also masses of macroconidia are produced abundantly in cream to buff or greenish sporodochia or pionnotes, usually covering after a few days wide parts of the colony.
Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally from hyphae in the aerial mycelium, at first unbranched, later sparsely branched; secondary conidiophores in sporodochial or pionnotal layers densely, irregularly or verticillately branched.
P hialides - monophialidic, mostly with a rather distinct collarette; those producing microconidia very long and slender (15-40 x 2.0-3.0 µm); those producing macroconidia shorter, subcylindric to slightly obclavate or doliiform (10-25 x 3.0-4.5 µm).

C o n i d i a - microconidia 1- or 2-celled, oval, ellipsoid to subcylindric, on the average larger than in F. oxysporum; macroconidia rather thick-walled, subcylindric, only slightly curved, with a short and blunt apical and an indistinctly pedicellate basal cell, often indistinctly septate, predominantly 3-septate, less frequently 4- or 5-septate, exceptionally up to 7-septate, measuring:

0-sept.	10 x 3.5	mostly 8-13 x 3.2-4.0	(5-17 x 2.8-5.0) µm
1-sept.	18 x 4.5	mostly 15-22 x 4.2-5.3	(12-27 x 3.7-7.0) µm
3-sept.	36 x 5.3	mostly 27-50 x 4.2-6.0	(22-58 x 3.5-7.0) µm
4-5-sept.	41 x 5.3	mostly 34-55 x 4.2-6.0	(28-62 x 3.5-7.0) µm
6-7-sept.	58 x 5.4	mostly 45-68 x 4.5-6.0	(41-82 x 3.8-6.5) µm.

C h l a m y d o s p o r e s - more or less abundant, terminal or intercalary in hyphae and conidia, smooth-walled or rough-walled to warty, globose to subglobose, single (6-11 µm), in pairs, chains or clusters.

Explanation of Figure 94:

Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

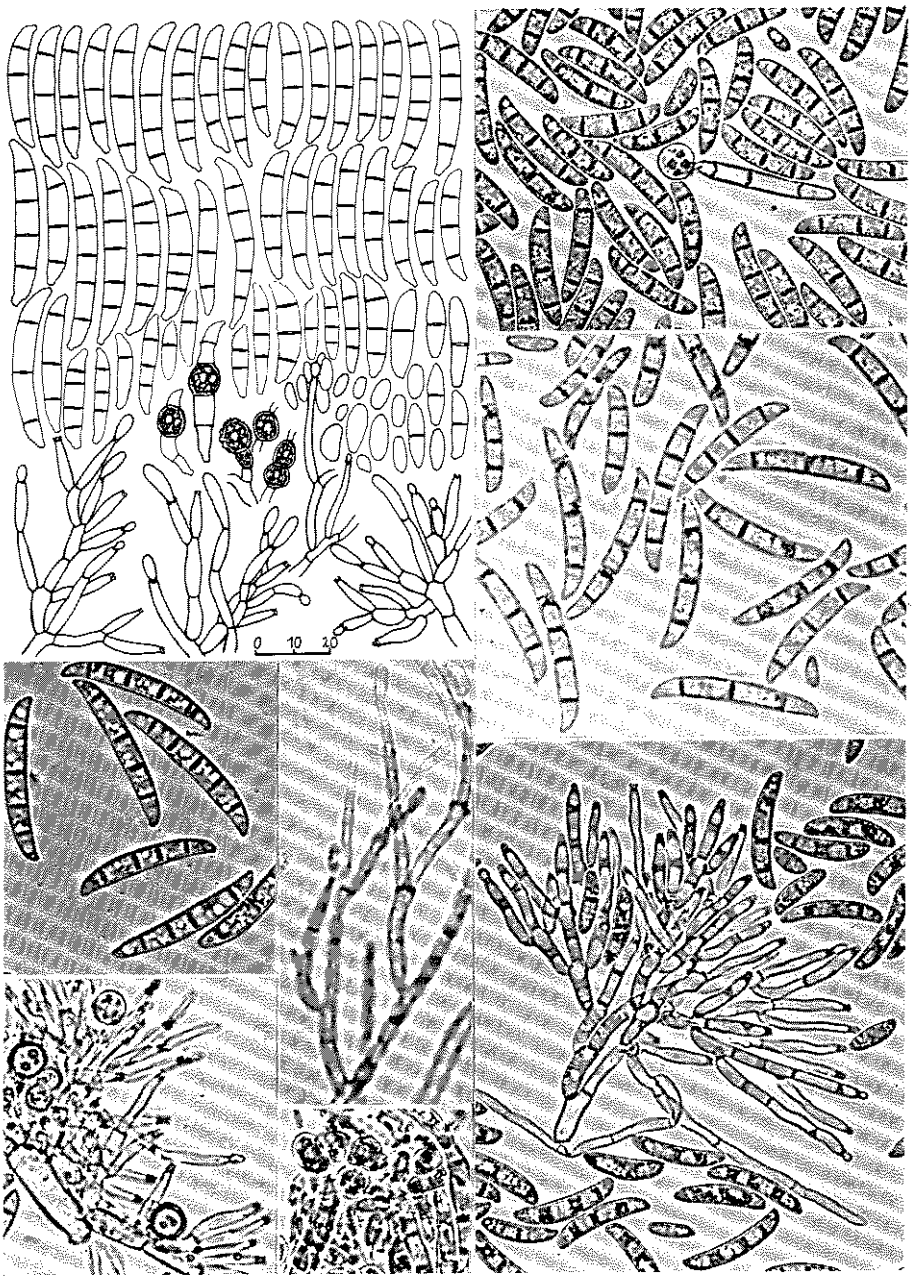

Fig. 94. Fusarium solani var. solani.

F. solani is one of the most common and best-known species, but treated differently in various species concepts. We prefer not to accept the fungus in the broad sense of SNYDER & HANSEN (1941) but to keep F. javanicum, F. eumartii and F. coeruleum separate as morphologically distinc. Because of the various species concepts of different authors, the reports on the occurrence, the pathogenic capabilities, the economic importance of F. solani and on other aspects must be interpreted with some caution. F. solani s.s. was found on very numerous plants and in the soil, especially in temperate regions, generally somewhat less frequently than F. oxysporum. It is proved to cause damping off, root rot, foot rot, stem cankers and is often found associated with wounds or with localized infections caused by other fungi or attacking hosts weakened by unfavourable conditions or following virus infections or nematode damage.

More than 15 formae speciales are more or less restricted to particular host plants, of which some are locally of major economic importance. More detailed information is given by BOOTH (1971a), JOFFE & PALTI (1972) and DOMSCH et al. (1980).

Fusarium coeruleum (Libert) ex Sacc. - Syll. Fung. 4: 705, 1886

Fusarium solani (Mart.) Sacc. var. coeruleum (Libert) Bilai - Fusarii: 287, 1955

Fusarium solani (Mart.) Sacc. var. coeruleum (Sacc.) C. Booth - The Genus Fusarium: 51, 1971

Teleomorph: ? Hypomyces asclepiadis Zerova - J. Bot. Inst. Acad. Sci. Ukraine 11: 101-104, 1937

Descriptions: APPEL & WOLLENWEBER (1910), CARPENTER (1915), SHERBAKOFF (1915), WOLLENWEBER (1916-1935 no. 407-410), WOLLENWEBER & REINKING (1935), ZEROVA (1937), DOIDGE (1938), WOLLENWEBER (1943), JAMALAINEN (1943b), RAILLO (1950), GORDON (1952), BILAI (1955), BOOTH (1971a), SUBRAMANIAN (1971), JOFFE (1974), LANGERFELD (1978).

C o l o n i e s - moderately fast-growing, reaching 5.6 - 6.2 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - usually rather sparse, floccose, felt-like, beige, amber, grey-violet to bluish.
Pigmentation - rather variable, depending on substrate and light, beige, amber, buff, grey-violet, but typically bluish to deep blue-purple.
Sclerotial bodies - mostly lacking, if present not striking, small, flat or pustule-like, of different colour.
Sporulation - in freshly isolated cultures rather abundant, starting quickly in the aerial mycelium, soon forming masses of conidia in sporodochia or pionnotes, cream, buff, grey-violet to blue-purple, confluent, covering wide parts of the colony.
Odour - not perceptible.

C o n i d i o p h o r e s - initially arising as single lateral phialides in the aerial mycelium or branching loosely, when formed in sporodochia or pionnotes very densely branched.

Phialides - monophialidic, with a distinct collarette, almost cylindric, rather slender, mostly 15-25 µm long and 2.5-3.5 µm wide.

C o n i d i a - some subdeveloped 0- or 1-septate conidia often present, but no typical microconidia are formed on distinct conidiogenous cells, subcylindric, only slightly curved, with an obliquely conical, blunt apical cell and an obtuse, somewhat papillate, never distinctly pedicellate basal cell, often indistinctly septate, mostly 3-septate, less frequently 4- to 5-septate, measuring:

0-sept.	14 x 4.5	mostly 10-17 x 4.2-4.8	(8-22 x 3.2-5.2) µm
1-sept.	19 x 4.7	mostly 15-24 x 4.4-5.0	(11-31 x 3.5-6.0) µm
3-sept.	36 x 5.1	mostly 28-45 x 4.5-5.5	(21-50 x 4.2-6.0) µm
4-5-sept.	43 x 5.2	mostly 33-57 x 4.5-6.0	(30-60 x 4.0-6.5) µm.

The illustration of the conidia by BOOTH (1971a) does not satisfactorily portray the specific characteristics and is therefore misleading.

C h l a m y d o s p o r e s - terminal or intercalary, more or less abundantly formed in conidia and hyphae, globose to subglobose, smooth-walled, single (7-10 µm), in pairs, chains or clusters.

Explanation of Figure 95:

Drawing and photographs of conidia, conidiophores and chlamydospores of different strains on different substrates (x 500).

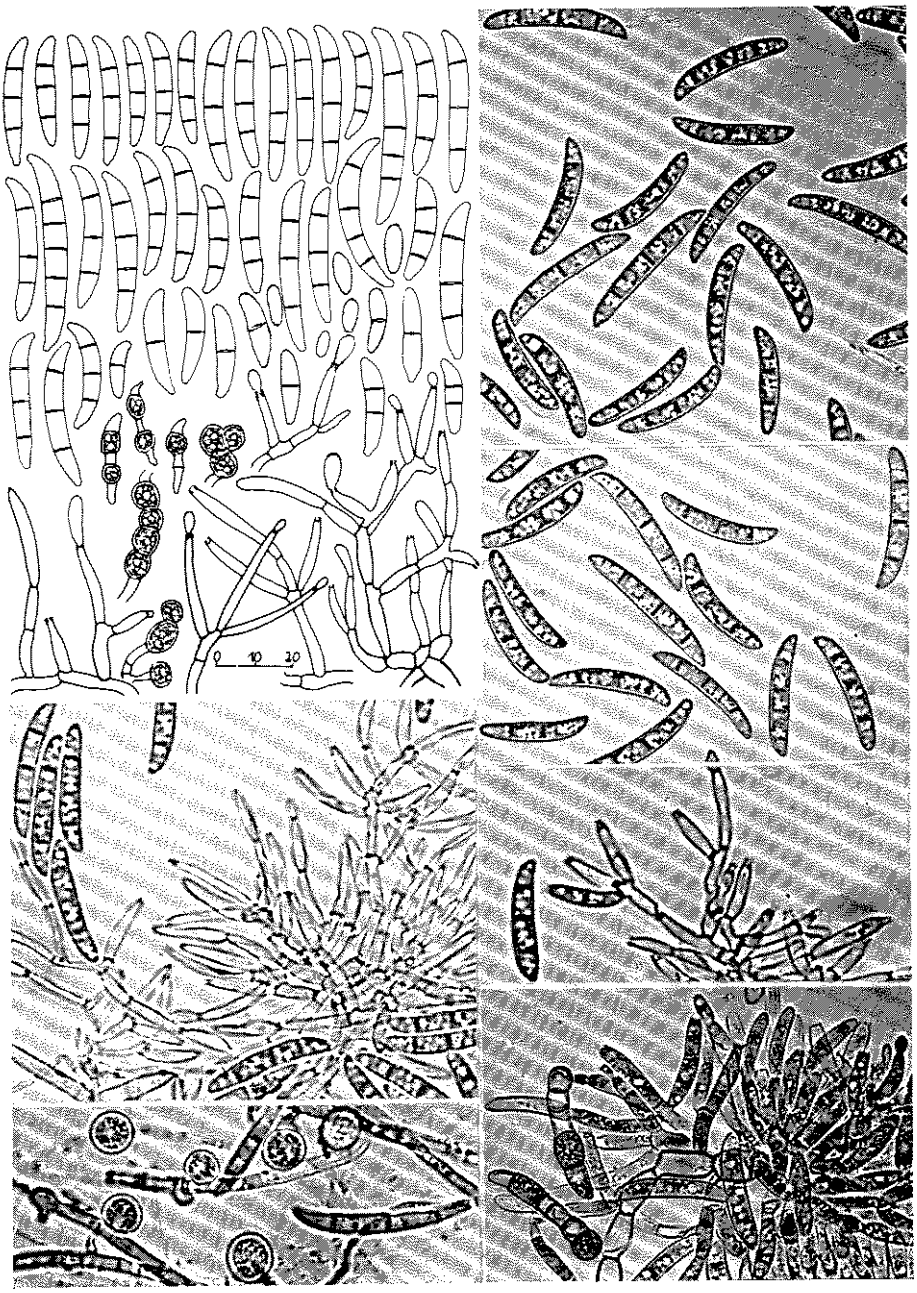

Fig. 95. Fusarium coeruleum.

F. coeruleum is clearly distinguished from F. solani and F. javanicum by its characteristic pigmentation, the absence of typical microconidia formed on distinct conidiogenous cells and by its pathogenic capabilities. In agreement with WOLLENWEBER & REINKING (1935) it was later retained as a separate species by DOIDGE (1938), WOLLENWEBER (1943), JAMALAINEN (1943b), RAILLO (1950), GORDON (1952) and SUBRAMANIAN (1971), while BOOTH (1971a) and JOFFE (1974) treated it as a variety of F. solani as proposed by BILAI (1955).

This Fusarium is widely distributed being certainly present in all the potato-growing regions of the northern hemisphere and also in Australia and New Zealand. As the causal agent of a dry or white rot of stored potatoes it causes heavy losses. The fungus was also isolated from numerous other plants. More detailed information is given by BOOTH (1971a), SUBRAMANIAN (1971) and LANGERFELD (1978).

Fusarium eumartii Carpenter - J. agric. Res. 5: 204, 1915

Fusarium solani (Mart.) Appel & Wollenw. var. eumartii (Carpenter) Wollenw. - Z. Parasitenk. 3: 452, 1931

Fusarium solani (Mart.) Sacc. f. eumartii (Carpenter) Snyder & Hansen - Amer. J. Bot. 28: 740, 1941

Teleomorph: Nectria haematococca Berk. & Br. - J. Linn. Soc. (Bot.) 14: 116, 1873 var. haematococca

Hypomyces haematococcus (Berk. & Br.) Wollenw. - Angew. Bot. 8: 191, 1926

Descriptions: CARPENTER (1915), WOLLENWEBER (1916-1935 no. 422, 830-832), WOLLENWEBER (1926, 1931), WOLLENWEBER & REINKING (1935), BUGNICOURT (1939), WOLLENWEBER (1943), BOOTH (1960), GERLACH & ERSHAD (1970), GERLACH (1978), DOMSCH et al. (1980).

C o l o n i e s - rather fast-growing, reaching 6.8 - 7.5 cm diam. in 10 days at 25°C on PDA, macroscopically similar to F. solani.
Aerial mycelium - generally rather sparse, floccose, felt-like, often zonate, whitish, beige, pale greenish, brownish, seldom grey-violet.
Pigmentation - very variable, whitish, beige, cream, ivory yellow, avellaneous, grey-greenish, bluish or brownish violet.
Sclerotial bodies - mostly lacking, if present small, not striking, of various shapes, beige, pale buff, olive to grey-greenish.
Sporulation - usually starting very quickly in the aerial mycelium as microconidia cohering in false heads; macroconidia in cream, amber or grey-greenish sporodochia or pionnotes, soon forming slimy covers on wide parts of the colony.
Odour - not perceptible.

C o n i d i o p h o r e s - primary conidiophores arising laterally from hyphae in the aerial mycelium, at first unbranched, later sparsely branched; secondary conidiophores in sporodochia or pionnotes strongly and densely branched.
Phialides - monophialidic, mostly with a distinct collarette, those producing microconidia rather long and slender (18-40 x 2.0-3.5 µm), those producing macroconidia shorter, subcylindric to doliiform (10-25 x 3.0-4.0 µm).

C o n i d i a - microconidia 1- or 2-celled, oval, ellipsoid to subcylindric; macroconidia thick-walled, falcate, straight to moderately curved, subcylindric, tapering toward the blunt, hooked apical cell and the mostly pedicellate basal cell, mainly 5- to 7-septate, less frequently 3- to 4- or 8- to 12-septate, measuring:

0-sept.	8 x 3.2	mostly 6-11 x 2.7-4.2	(4-14 x 2.2-5.0) µm
1-sept.	21 x 4.3	mostly 15-24 x 3.5-4.8	(11-28 x 3.0-5.5) µm
3-sept.	38 x 5.2	mostly 28-43 x 4.3-6.0	(22-63 x 4.0-6.6) µm
4-sept.	54 x 5.6	mostly 43-62 x 4.7-6.5	(38-68 x 4.4-7.2) µm
5-sept.	59 x 5.8	mostly 52-68 x 5.3-6.8	(36-85 x 5.0-8.0) µm
6-sept.	67 x 5.9	mostly 62-75 x 5.5-7.0	(53-87 x 5.2-8.0) µm
7-9-sept.	75 x 6.4	mostly 65-80 x 5.7-7.3	(60-92 x 5.0-8.0) µm.

C h l a m y d o s p o r e s - more or less abundant, terminal or intercalary, globose to subglobose, single (6-10 µm), in pairs, rarely in chains or clusters, smooth-walled, occasionally rough-walled, sometimes becoming pale brown.

Explanation of Figure 96:
Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 422 of the type culture; drawing and photographs of conidia, conidiophores and chlamydospores of strain 11748 (= 62215 = CBS 487.76) on different substrates (x 500).

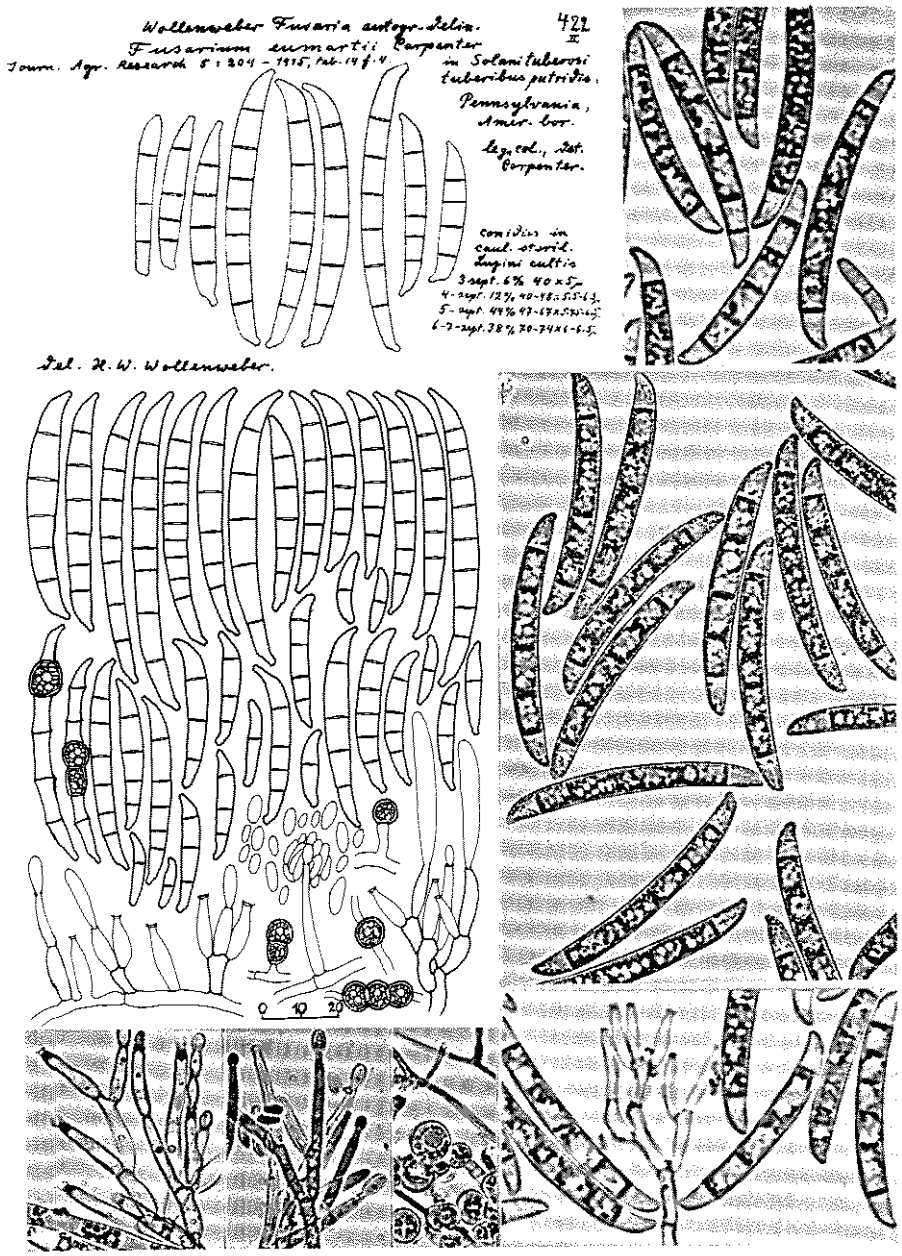

Fig. 96. Fusarium eumartii.

F. eumartii is based on a strain isolated by CARPENTER (1915) in Pennsylvania from a rotting potato tuber. WOLLENWEBER re-examined and illustrated the type culture sent to him by CARPENTER in 1916 (cf. Fus. autogr. delin. no. 422) and described the fungus as a variety of F. solani, which was later accepted by WOLLENWEBER & REINKING (1935), BUGNICOURT (1939), WOLLENWEBER (1943), RAILLO (1950) and BILAI (1955). Corresponding to the opinion of SNYDER & HANSEN (1941), however, GORDON (1959) and BOOTH (1971a) did not consider this Fusarium morphologically distinct and presented it as F. solani f. sp. eumartii. DOIDGE (1938), JAMALAINEN (1943a), SUBRAMANIAN (1971) and JOFFE (1974) did not mention it. Some strains isolated from rotting bases of potato shoots and from potato tubers in Argentina by W. RADTKE in 1972 and a strain from Gabun correspond completely in their morphological characteristics to the description of F. eumartii. They deviate from F. solani in their much wider, longer and predominantly 5- to 7-septate macroconidia. It appears therefore acceptable to retain F. eumartii as a separate species. This Fusarium was often reported in association with canker, die-back and other diseases on various host plants, e.g. Coffea, Theobroma, Hevea, Citrus, Ficus, Manihot and many others (WOLLENWEBER & REINKING 1935, BUGNICOURT 1939, WOLLENWEBER 1943, GERLACH & ERSHAD 1970). There remains some doubt, however, whether or not these reports concern the same fungus, which is known as a potato pathogen and which is regionally of major economic importance in North America and South America.

Fusarium illudens C. Booth - The Genus Fusarium: 54, 1971

Teleomorph: Nectria illudens Berkeley in Hooker - Flora Novae-zealandiae 2: 203, 1855

Description: BOOTH (1971a).

No culture could be obtained from BOOTH who described this Fusarium as follows:

"In culture colonies on potato sucrose agar are white to pale yellowish-brown with floccose to felted mycelium, growth rate 3.3 cm. Later slimy pustules of macroconidia, cream to light brown, form from sporodochia on the surface of the agar. Sparse microconidia are formed from simple or branched conidiophores scattered in the aerial mycelium. They are clavate to fusiform with rounded ends and measure 6-8 x 2-3.5 µ. Macroconidiophores also develop initially in the aerial mycelium as loose penicillately branched conidiophores with terminal phialides. The phialides are cylindrical with a wide apical pore and measure 22-28 x 4-5 µ. Later the macroconidia are formed from sporodochia; they are curved, cylindrical but tapering slightly towards the rounded to slightly beaked apex and the basal foot cell. They are 3-6-septate and measure

3-4 septate 30-65 x 6.0-6.5 µ.
5-6 septate 50-80 x 6.5-7.0 µ.

Chlamydospores are rare.

Type culture from Melicytus, Auckland, New Zealand, J.M. DINGLEY (IMI 15564)."

This Fusarium is very similar to F. eumartii, but according to BOOTH (1971a) its teleomorph has considerable larger ascospores than Nectria haematococca. It may be possible that former records of F. eumartii on plants other than potatoes in the tropics, e.g. Coffea, Theobroma, Hevea, Ficus, Manihot and many others referred to F. illudens and that F. eumartii may be a parasite restricted to potato plants in North and South America.

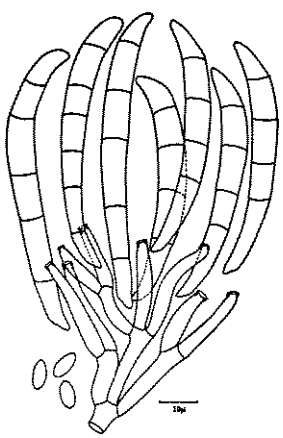

Fig. 97. Fusarium illudens. Partial reproduction of Figure 9 by BOOTH (1971a) (x 500).

Fusarium caucasicum Letov - Material Mikol. Fitopat. Ross. Leningrad VIII, Part. 1: 225, 1929

Fusarium martii Appel & Wollenw. var. caucasicum (Letov) Raillo - Fungi of the Genus Fusarium (Moscow): 227, 1950

Descriptions: LETOV (1929), WOLLENWEBER (1943).

C o l o n i e s - fast-growing, reaching 7.5 - 8.0 cm diam. in 8 days at 25°C on PDA.
Aerial mycelium - rather abundant, densely floccose, sometimes more felt-like or tufted, whitish, cream and yellowish with slightly greenish or bluish tinges.
Pigmentation - cream, lemon-yellow on rice pap, intensely blue on some agar media, but on potato or carrot slices the pigment formation is much weaker.
Sclerotial bodies - and distinct plectenchymatic tissues never observed.
Sporulation - at first starting within a few days in the aerial mycelium as microconidia cohering in false heads; later masses of rather uniform macroconidia are formed in greyish yellow or dirty sky-blue sporodochial or pionnotal layers, becoming dark blue with age.
Odour - not perceptible.

C o n i d i o p h o r e s - arising at first in the aerial mycelium as single phialides or loosely ramose laterally on hyphae, later in sporodochia or pionnotes densely, mostly irregularly, sometimes verticillately branched.
Phialides - monophialidic, those forming microconidia almost cylindric, rather long and slender (15-30 x 2.0-3.0 µm), those forming macroconida usually shorter and wider (8-20 x 2.5-4.0 µm) and often with a marked collarette.

C o n i d i a - microconidia oval, ellipsoid, often elongated, sometimes reniform or almost comma-shaped, mostly 1-celled, less frequently 1-septate; macroconidia almost cylindric, rather straight, with a gradually narrowing, rounded apical cell and an almost conical apedicellate basal cell, usually 3-septate, rarely 2- or 4- to 5-septate, measuring:

0-sept.	11 x 3.5	mostly 9-16 x 3.0-4.2	(6-20 x 1.5-6.6) µm
1-2-sept.	27 x 5.2	mostly 24-33 x 4.5-6.0	(22-40 x 3.0-6.8) µm
3-sept.	44 x 6.0	mostly 32-50 x 4.8-6.5	(32-64 x 3.0-7.2) µm
4-5-sept.	47 x 6.3	mostly 43-52 x 5.0-6.8	(36-65 x 3.0-7.2) µm.

C h l a m y d o s p o r e s - rather abundant in older cultures, usually smooth-walled, rarely rough-walled, globose to subglobose, single (7-15 µm), in pairs, chains or clusters, intercalary or terminal in hyphae and conidia, occasionally excrescent, adhering either directly or on a short branch.

Explanation of Figure 98:

Reproduction of WOLLENWEBER's drawings of the type culture CBS 179.35 (his strain 6002) isolated by LETOV from cotton in 1928; drawing and photographs of conidia, conidiophores and chlamydospores of strain CBS 179.35 on different substrates (x 500).

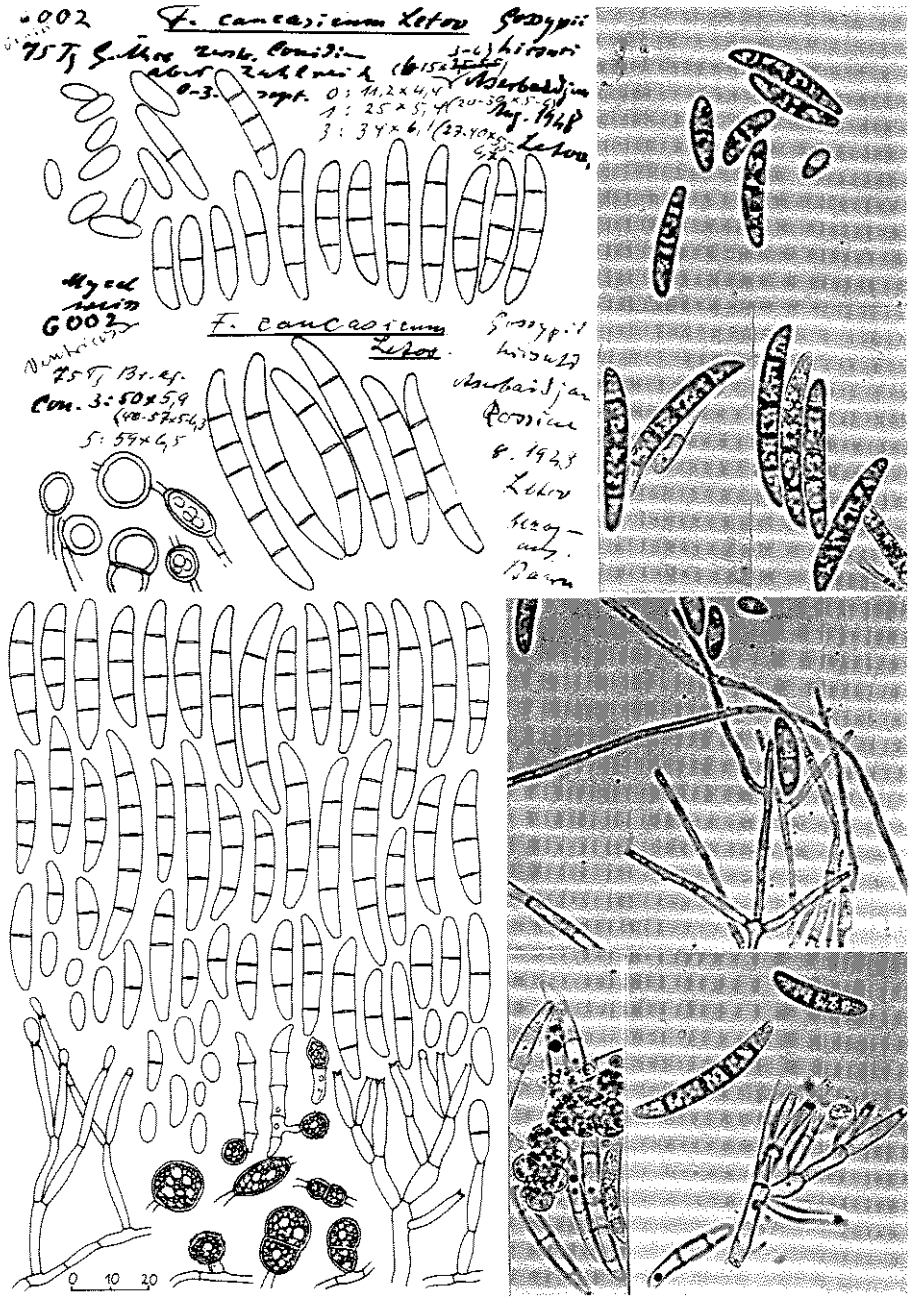

Fig. 98. Fusarium caucasicum.

F. caucasicum was described as a new species by LETOV (1929) and proved to be the causal agent of a seedling blight, a root and foot rot of cotton in Azerbaijan/Soviet-Union resulting in sudden wilting and death of the plants. In his description he pointed out the main differences between the new species and F. coeruleum, F. solani and F. buharicum. F. caucasicum is represented by strain CBS 179.35 (= IFO 5979), isolated by LETOV in 1928 and deposited by RAILLO. This strain is the only one available. It was re-examined by WOLLENWEBER (his strain 6002) and us. Though degenerated with regard to macroscopic characteristics, the culture still produces some typical micro- and macroconidia on distinct phialides.

The taxonomic position of this Fusarium is unclear. WOLLENWEBER (1943) accepted it as a distinct species intermediate between the sections Martiella and Ventricosum because of its apedicellate conidia. On his drawings of the type culture he noted that F. caucasicum is not a quite typical member of the section Martiella. But since F. coeruleum also has never distinct pedicellate conidia, there is no reason in his opinion to exclude F. caucasicum from the section Martiella. RAILLO (1950) treated the fungus as F. martii var. caucasicum without any comment. BILAI (1955) did not mention this Fusarium. BOOTH (1971a) considered it possible to be synonymous with F. coeruleum with which it certainly corresponds in most macroscopic and microscopic characteristics. F. coeruleum, however, does not show typical microconidia borne on distinct conidiogenous cells.

Section VENTRICOSUM Wollenw. - Phytopathology 3: 32, 1913

Fusarium ventricosum Appel & Wollenw. - Arb. Kais. Biol. Anst. Land-Forstwirtsch. Berlin-Dahlem 8: 55, 1910

Fusarium cuneiforme Sherb. - Mem. Cornell Univ. agric. Exp. Stn 6: 129, 1915

Fusarium solani (Mart.) Appel & Wollenw. var. ventricosum (Appel & Wollenw.) Joffe - Mycopathol. Mycol. Appl. 53: 226, 1974

? Fusarium argillaceum (Fr.) Sacc. - Syll. Fung. 4: 718, 1886

? Fusarium solani (Mart.) Appel & Wollenw. var. argillaceum (Fr.) Bilai - Fusarii: 288, 1955

Teleomorph: Nectria ventricosa C. Booth - The Genus Fusarium: 55, 1971

Hypomyces solani Reinke & Berth. - Zersetzung der Kartoffel durch Pilze (Berlin): 27-39, 1879 (non Nectria solani Reinke & Berth. 1879)

Hyponectria solani (Reinke & Berth.) Petch - J. Bot. 75: 220, 1937

Nectriopsis solani (Reinke & Berth.) C. Booth - Mycol. Pap. 74: 8, 1960

Descriptions: APPEL & WOLLENWEBER (1910), WOLLENWEBER (1913), WOLLENWEBER (1916-1935 no. 429-431, 833), SHERBAKOFF (1915), WOLLENWEBER (1917, 1931), WOLLENWEBER & REINKING (1935), RAILLO (1950), BILAI (1955), BOOTH (1960, 1971a), JOFFE (1974), DOMSCH et al. (1980).

C o l o n i e s - slow-growing, reaching 3.8 - 4.2 cm diam. in 10 days at 25°C on PDA.

Aerial mycelium - usually rather abundant, sometimes sparse, floccose to felt-like or tufted to funiculose, often showing a distinct zonation, whitish, light grey to pale ochre.

Pigmentation - whitish, greyish beige, dirty pink to pale yellow-brown; reddish, bluish or violet colours lacking.
Sclerotial bodies - not formed.
Sporulation - comparatively sparse, starting in the aerial mycelium after a few days as microconidia cohering in false heads; later occasionally small aggregations of pale cream masses of conidia may occur, which are deposited directly on the substrate; distinct sporodochia or expanded pionnotal layers are never formed.
Odour - not perceptible.

C o n i d i o p h o r e s - formed in the aerial mycelium, at first unbranched, septate, with an apical phialide, sometimes longer than 100 µm, later generally loosely branched, often near the base, long branches repeatedly septate, occasionally densely aggregated.
Phialides - monophialidic, almost cylindric, gradually narrowing toward the tip, very long (25-55 µm) and slender (2.0-3.0 µm), often with a distinct collarette.

C o n i d i a - almost straight to slightly curved, more or less wedge-shaped, most often widest just above the center, but sometimes widest toward the base, rather thick-walled, with a blunt, somewhat rounded apical cell and a basal cell usually apedicellate, occasionally slightly papillate, gradually tapering (cuneiform), when fully developed 3-septate, but often 0- to 2-septate, very rarely 4- to 6-septate, measuring:

Explanation of Figure 99:
Reproduction of WOLLENWEBER's Fus. autogr. delin. no. 431 (as F. argillaceum); drawing and photographs of conidia, conidiophores and chlamydospores of strain 62452 (= CBS 748.79) on different substrates (x 500).

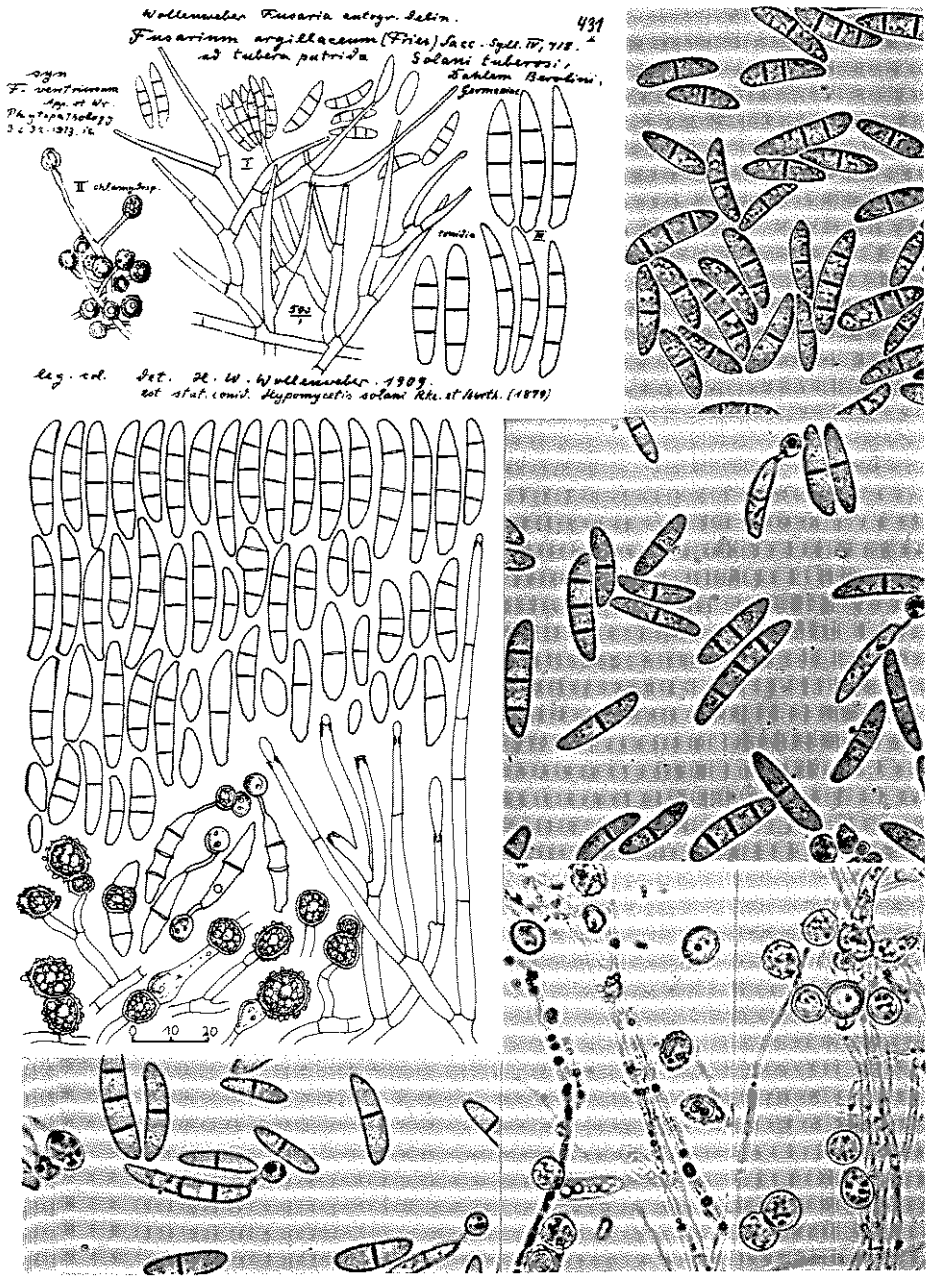

Fig. 99. Fusarium ventricosum.

0-sept.	13 x 4.3	mostly 10-16 x 3.5-5.2	(7- 19 x 3.0-6.0) µm
1-2-sept.	24 x 5.5	mostly 19-32 x 4.8-6.2	(14- 43 x 4.5-7.5) µm
3-sept.	32 x 5.8	mostly 28-45 x 5.0-8.0	(22- 67 x 4.0-9.5) µm
4-6-sept.			(44-107 x 5.0-9.0) µm.

C h l a m y d o s p o r e s - starting after about 1 week, abundant, conspicuous and characteristic, in the beginning smooth-walled, later rough-walled, even warted, globose to subglobose, single (5-14 µm), in pairs, small chains or clusters, intercalary and terminal, in hyphae and conidia, sometimes excrescent, adhering either directly or on a short, sometimes longer (up to 20 µm) branch.

F. ventricosum is a clearly distinct and a generally accepted species. It is found in Europe, the USA and the Near East, occurring in soil and on decaying plant substrates, particularly rotting potato tubers, but also on beets, melons, groundnuts, tomatoes and other plants. It is by and large rather seldom and of no importance as a plant pathogen or a storage rot fungus. More detailed information is given by BOOTH (1960) and DOMSCH et al. (1980).

At least 3 strains are available in the CBS/Baarn, including strain 62452 (= CBS 748.79).

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BOOTH, C.: Fusarium semitectum. C.M.I. Descript. Pathogenic Fungi and Bacteria. 1978c, No. 573.

BOOTH, C.: Fusarium sulphureum. C.M.I. Descript. Pathogenic Fungi and Bacteria. 1978d, No. 574.

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