A Pictorial Guide for the Identification of Mold Fungi on Sorghum Grain

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Abstract

Sorghum is one of the main staple food crops of the world's poorest and most food-insecure people. Approximately 90% of the world's sorghum areas are located in Africa and Asia. During 1992-94, 42% of the total sorghum produced worldwide was utilized for food, and 48% for animal feed. A preliminary study was conducted to understand the various storage conditions of sorghum grain, and the potential occurrence of mold fungi under such conditions. A total of 67 sorghum grain samples were collected from two surveys, 15 samples from the 1996 rainy season harvest, and 11 from the 1996/97 postrainy season harvest collected in June 1997, and 19 samples from the 1996/97 postrainy season and 22 from 1997 rainy season harvest collected in October 1997. Approximately 1 kg grain from each of the grain lots stored under various conditions (gunny bags, mud-lined baskets, metallic containers, polypropylene bags, and grains piled in a corner of a room) by farmers in rural India was collected. Each grain sample (200 grains treatment^{1}) was examined to identify fungi up to the species level. Grains with and without surface sterilization were transferred separately to pre-sterilized petri dish humid chambers under aseptic conditions. The petri dishes were incubated for 5 days at 28±1 °C in an incubator with a 12-h light cycle. Under each treatment, 200 grains (25 grains dish^{-1}) were examined for 49 mold fungi, including the species of *Aspergillus* and *Penicillium.* The major fungi observed on the grains included species of *Alternaria, Curvularia, Drechslera, Fusarium,* and *Rhizopus.* The frequency of occurrence of the various fungi on each grain sample under the various treatments was analyzed. This bulletin reports some new mold fungi on sorghum grain in India: *Alternaria longipes, Bipolaris zeicola, Curvularia affinis, C. clavata, C. fallax, C. geniculata, C. harveyi, C. ovoidea, C. pallescens, C. tuberculata, Drechslera halodes, Gonatobotrys simplex, Nigrospora oryzae, Periconia macrospinosa, Spadicoides obovata, Torula graminis,* and *Trichothecium roseum.*

Abstrait

Le Sorgho, c'est considéré comme une des cultures vivrières de base dans les nations les plus pauvres et les plus souffrantes en ce qui concerne les denrées alimentaires, au monde. A peu près 90% du sorgho cultivé au monde se trouve en Afrique et en Asie. Pendant les années 1992–1994, 42% du sorgho produit au monde a été utilisé pour l'alimentation des populations, et 48% comme fourrage pour le bétail. Une étude préliminaire a été faite pour pouvoir comprendre les différentes conditions des stocks de sorgho, et aussi, l'occurence des fongicides dans ces conditions. 67 échantillons du sorgho ont été rapportés de deux enquêtes, dont 15 de la récolte pendant la saison pluviale de 1996, et 11 de celle de 1996/97 après la saison pluviale (récoltés en juin 1997), et 19 échantillons de celle de 1996/97, et 22 de celle de 1997 pendant la saison pluviale (récoltés en octobre 1997). A peu près 1 kilo de grain de chaque stock de grain des fermiers en Inde (rurale) dans les conditions différentes (sacs à toile, paniers couvrent de boue, récipients en métal, sacs en polypropylène, et les grains stockés dans un coin d'une salle) a été ramassé. Chaque échantillon (traitement de 200 grains) a été examiné pour l'identification de la fongicide jusqu'au niveau des espèces. Les grains avec, de même que sans, stérilisation de surface, ont été individuellement transférés aux boîtes de pétri déjà stérilisées en salle humide et dans les conditions aseptiques. Les boîtes de pétri ont été incubées pendant 5 jours à une température de 28±1°C dans un incubateur avec un cycle lumineux de 12-h. Dans chaque traitement, 200 grains (25 boîtes de grains) ont été examinés pour 49 variétés différentes de fongicide, y compris l'espèce de *Aspergillus* et *Penicillium.* Les fongicides principales remarquées aux grains comprenaient les espèces de *Alternaria, Curvularia, Drechslera, Fusarium,* et *Rhizopus.* La fréquence d'occurence des différentes fongicides sur chaque échantillon de grain dans les traitements variés, a été analysée. Ce bulletin identifie quelques nouvelles fongicides sur les grains de sorgho cultivés en Inde. *Alternaria longipes, Bipolaris zeicola, Curvularia affinis, C. clavata, C. fallax, C. geniculata, C. harveyi, C. ovoidea, C. pallescens, C. tuberculata, Drechslera halodes, Gonatobotrys simplex, Nigrospora oryzae, Periconia macrospinosa, Spadicoides obovata, Torula graminis,* et *Trichothecium roseum.*

Cover Micrograph of Aspergillus flavus. (Note: The sample was critical point dried and observed under JSM35 CF Scanning Electron Microscope at 10kV.)

Front Spore head containing spiny conidia on rough conidiophore of 15 µm width.

Back Conidiophores (15 µrn width) bearing spore heads with spiny conidia.

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ICRISAT

International Crops Research Institute for the Semi-Arid Tropics

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Contents

Foreword

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) aims to help the poor by increasing the productivity of resources committed to its mandate crops while protecting the environment, through agricultural research and in concert with national agricultural research systems.

Germplasm improvement continues to be ICRISAT's main line of work, responding to a predicted increase in demand for advanced germplasm products and for source populations containing special traits. For this reason ICRISAT also serves as a world storage and trust facility for the genetic resources of sorghum, pearl millet, finger millet, pigeonpea, chickpea, and groundnut.

By recognizing and reducing the enormous crop losses that occur between harvesting and final utilization a significant contribution can be made to improving the supply of agricultural products above and beyond what may be achieved by increased primary production. Historically, the study of postharvest crop losses has largely been associated with protection of food stocks, particularly emergency grain supplies, during wartime and especially where more developed temperate countries have been involved.

The main objective of this bulletin was to compile and collate information of practical value which plant pathologists, plant quarantine experts, and seed technologists could use in handling such seed stocks both in the field and in the laboratory. This publication is the result of a fruitful cooperation between ICRISAT, India, and the Food Security Department, Natural Resources Institute (NRI), UK.

The study conducted by the authors at ICRISAT was to understand the various storage conditions of sorghum grain and the potential occurrence of mold fungi under such conditions, and the importance of individual fungi including production of mycotoxins. The information in this bulletin is based on observations of the sorghum grain samples collected from grain lots stored by farmers in gunny bags, polypropylene bags, mud-lined baskets, a corner of a room, and metallic containers in rural India. This bulletin is a ready reference for researchers working on sorghum grain mold.

Director General
International Crops Research Institute
for the Semi-Arid Tropics

Director
Genetic Resources and
Enhancement Program

Introduction

People need food, and a crop is not food until it is eaten. A program to reduce storage losses probably could result in an increase of available food in some developing countries, and might also assure that whatever increases in production occur in future would be used for the nourishment of people, not for feeding pests. Overall postharvest losses of cereals, oilseeds, and pulses have been estimated at 20% of the harvested crop in Africa, Asia, and Latin America. The Food and Agriculture Organization of the United Nations (FAO) has estimated losses of these commodities at 10% on a worldwide basis (FAO/ICRISAT 1996). In individual cases losses may be much greater and it is suggested that losses at the farm-level of 35-50% followed by 10-12% in traders' stores and further 5% in centralized stores may not be uncommon (Booth and Burden 1983).

There is little doubt that grain mold in its broadest sense constitutes one of the most important biotic constraints to sorghum *(Sorghum bicolor* (L.) Moench) improvement and production. The real and potential importance of grain mold has been emphasized for Africa, the Americas, and India (Forbes et al. 1992). Grain mold fungi have repeatedly been associated with losses in seed mass, grain density, and germination and other damage relating to storage quality, food and feed processing quality, and market value of the grain. More specifically, the effects of fungi in quality loss in stored grains are: (1) decrease in germinability; (2) discoloration of part or all of the seed or kernel; (3) heating and mustiness; (4) various biochemical changes; and (5) production of toxins that if consumed may be injurious to humans and to domestic animals.

Grain mold continues to receive much attention because of the growing concern for deleterious nature of subacute dosages of mycotoxins on animals. Mycotoxin content of grains contaminated during pre-harvest increases when the grains are stored. There are species of 32 dematiaceous hyphomycetes which produce mycotoxins and other metabolites. More species in the genera *Alternaria, Bipolaris, Curvularia, Drechslera, Exserohilum,* and *Fusarium* have been investigated for mycotoxins than those in the other fungal genera (Sivanesan 1991). In addition, species of *Aspergillus* can produce aflatoxins (Pitt 1991).

Seeds carry mycoflora which vary with the host species. This is especially true for the more deeply seated mycoflora, whilst on the surface many "accidental guests" may be carried as well. The seedborne mycoflora can be identified through the use of seed health tests. The tests are used for several purposes:

- To assess the incidence of a seedborne pathogen that may affect seed quality.
- To detect organisms of quarantine concern.
- To determine seed quality in terms of germinability and or vigor.
- To determine if pesticide treatment of the seed is necessary.

In this study, efforts were made to compile information on symptoms of 49 grain mold fungi, to detail their morphology, provide quick clues for identification, and describe their importance in terms of diseases, and mycotoxin and metabolite production.

Collection of Sorghum Samples and Storage Conditions

A total of 67 sorghum grain samples, representing hybrids, varieties, and local cultivars were collected in two surveys in rural areas of the states of Andhra Pradesh, Karnataka, and Maharashtra in India. The grain samples were collected from lots stored by farmers for food purpose in five types of storage conditions: gunny bags, mud-lined baskets, metallic containers, polypropylene bags, and piled in a corner of a room. During the first survey in June 1997, 15 samples were collected from grain lots stored after harvest in the 1996 rainy season and 11 from the 1996/97 postrainy season harvest. During the second survey in October 1997, 19 samples were obtained from 1996/97 postrainy season harvest and 22 samples from the 1997 rainy season harvest. Approximately 1 kg grain samples were collected from each lot using compartment probe (80 cm long x 2.5 cm diameter) where there was open access to the grain bulk (mud-lined basket and loose grain piles) and where access was more difficult (stacks of gunny bags and polypropylene bags), a short probe (27 cm long x 1.5 cm diameter) was used. Farmers were paid for their grain at the market rate. Care was taken not to mention to farmers that a further sample would be taken at a later stage. This was done to ensure that their subsequent behavior would not be influenced by the opportunity to sell grain.

Detection Technique

Eight hundred grains from each sample were examined to identify fungi up to the species level. Each grain sample was subjected to four treatments (200 grains treatment^{-1}):

1. Grains were surface sterilized in 1 % sodium hypochlorite (NaOCl) [prepared from Clorox® (Clorox Company, Oakland, CA 94612, USA) containing 5.25% NaOCl] without fungicide treatment.

2. Grains were sterilized in NaOCl, and treated with benomyl (0.05%) [Benefit® 50 WP (benomyl 50% WP), EID Parry (India)].

3. Grains were sterilized in NaOCl and treated with benomyl.

4. Grains were not sterilized and no benomyl treatment.

The grains were transferred to pre-sterilized petri dish humid chambers @ 25 grains dish^{-1} (Fig. 1 a, b) under aseptic conditions, and were incubated for 5 days at 28±1 °C in an incubator (Percival®) with a 12-h light cycle for observation. The fungi mentioned in this bulletin were encountered across the treatments, storage conditions, seasons, and cultivars. The effects of all these factors on mean frequency of occurrence of individual fungi are published separately.

Figure 1a. Before incubation.

Figure 1b. After incubation.

Identification and Photomicrography of Fungi

Each of the grains in the four treatments were examined under a stereoscopic microscope (Olympus C01) for grain colonization and a compound microscope (Olympus BH2) for proper identification of fungi using the scotch-tape method (Appendix 1). This method was mainly to preserve attachment of conidia to conidiophores. It was particularly useful for those fungi in which the conidia readily dislodge from conidiophores under normal procedures for slide preparation. Photomicrographs were made of the colonization of grains either by an individual fungus, or by a group of fungi using the stereoscopic microscope and for fungal structures using the compound microscope. The proper identification of fungi was confirmed by comparison with the details available in the literature, and the knowledge acquired by the senior author in the international course on identification of fungi of agricultural and environmental significance at the International Mycological Institute, Egham, Surrey, UK in 1996. In addition, most descriptions of each fungus included in this bulletin are from Standen (1945), Nelson (1959), Whitehead and Calvert (1959), Simmons (1967), Barron (1968), Ellis (1971, 1976), Barnett and Hunter (1972), Raper and Fennel (1973), Sutton (1980), Zillinsky (1983), Sivanesan (1987), Pitt (1988), Hanlin (1990), Champ et al. (1991), and Hawksworth et al. (1995).

Symptoms and Morphology

Acladium conspersum Link ex Pers.

Symptoms on grain. Colonies are effuse, often very large, cottony and pale at first, later becoming velvety and fulvous or snuff-colored (Fig. 2).

Morphology. Mycelium is mostly superficial. Conidiophores and hyphae have same thickness (6-9 µm), up to 350 µm long but usually shorter, and are subhyaline; cylindrical denticles are numerous especially on the upper part. Conidia are ellipsoidal, papillate at the base, smooth, individually subhyaline or straw-colored, fulvous in mass, 15-20 (average 17) µm x 9-14 (average 12) µm (Fig. 3).

Quick clue. Lemon-shaped conidia are present on the conidiophore.

Importance. *Acladium conspersum* is very common on dead wood and bark of many different trees and shrubs in Canada, Europe including Great Britain, and USA. Occurrence of this fungus and also the method to kill the fungus adhering to the grains for its safe consumption has been reported on sorghum by Navi et al. (1997).

Figure 2 x67

Figure 3 x956

Acremonium strictum W. Gams

Teleomorph. *Cephalosporium acremonium* Corda
Cephalosporium madurae Padhye, Sukapure, & Thirumalachar

Symptoms on grain. Colony on grain is compact, slow-growing, white to pale and becomes slate gray or black with age (Fig. 4). Hyphae are hyaline, septate, simple or branched, and are often grouped together forming threads and along the sides of the threads numerous solitary conidiophores are formed, each with a globule of spores. Infected grain may show white streaks on the grain surface.

Morphology. Conidiophores, arising directly and singly at right angles from the vegetative hyphae, are hyaline, short, tapered towards the tip, and measure 30-60 μm in length and 1.5 μm in width at the base (Fig. 5).

Quick clue. The characteristic of *Acremonium* is the ball of spores produced at the apex of solitary, tapering conidiophores, usually borne at right angles to the hyphae.

(Note: The genus can be readily confused with other genera such as *Gliomastix, Verticillium*, and microconidial *Fusarium* or *Cylindrocarpon.* Nevertheless, it is perhaps one of the easiest fungi to identify at the genus level and one of the most difficult in which to make species determinations.)

Importance. *Acremonium strictum* is distributed worldwide, but is more frequent in the tropics. It causes acremonium wilt of sorghum (Bandyopadhyay et al. 1987) and black bundle disease of maize *(Zea mays* L). The latter is a late season disease which is common in USA and other countries.

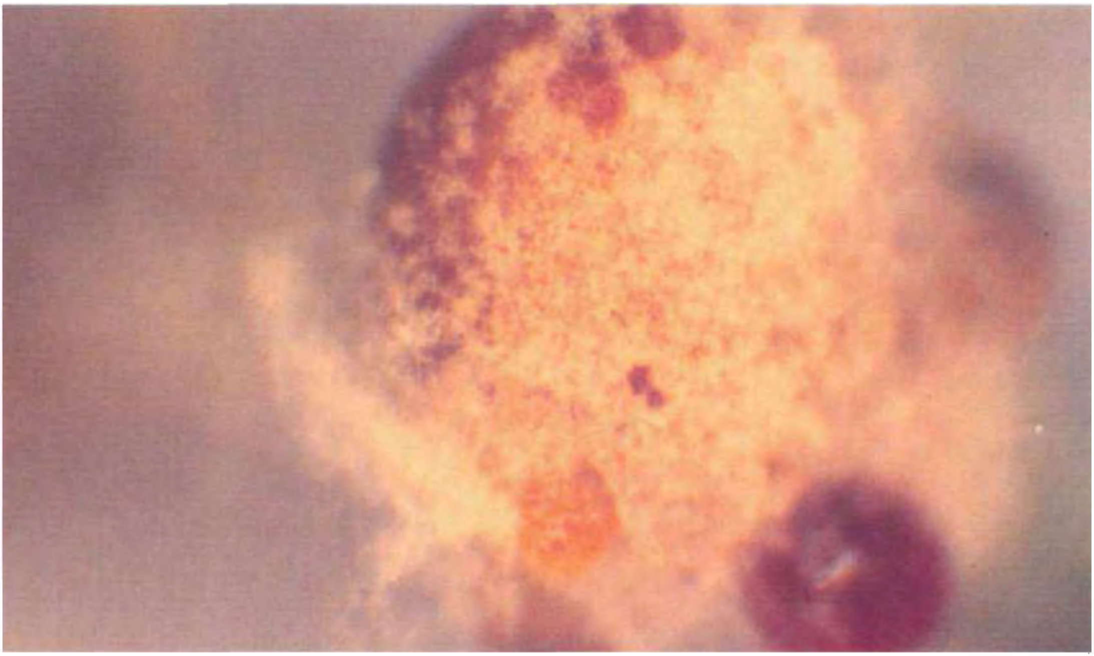

Figure 4 x12

Figure 5 x 5085

Alternaria alternata (Fr.) Keissler

Symptoms on grain. The fungus produces woolly or powdery chains of dark brown conidia of variable lengths and shapes. The color of the colony is usually extremely variable between olive green to dark brown (Fig. 6a, b).

Morphology. The mycelium may be either sparse or abundant and variable in color, usually light olive green to brown. Hyphae are dark brown, thick, septate, and branched. Conidiophores are simple, erect, 40-50 µm long, 2-6 µm thick, and often clustered. Conidiophores produce dark pigmented conidia in an acropetal succession of simple or branched chains. These chains normally branch at the beak of a spore, or sometimes from the short lateral projection of the beak. Conidia have transverse and oblique septa, measure 10-18 x 20-65 µm, and are ovoid to obovoid, obclavate, obpyriform, ellipsoidal, uniform, with an elongated terminal cell (Fig. 7). Conidia often have a short conical or cylindrical beak which is about one third the length of the conidium, and measure 2-5 x 10-20 µm. Surface walls are either smooth or verrucose and pale to mid-golden brown.

Quick clue. Chains of conidia are produced at the beak of a spore, or sometimes from the short lateral projection of the beak.

Importance. The fungus is distributed worldwide and is usually seedborne. It causes leaf spot on several hosts and blight of pigeonpea (*Cajanus cajan* (L.) Millsp.), chickpea (*Cicer arietinum* L), and groundnut (*Arachis hypogaea* L). Several metabolites and toxins have been isolated from *A. alternata:* tentoxin (Templeton 1972), AF-toxins I and II (Maekawa et al. 1984), alkaloids (Rizk et al. 1985), alternariol (Logrieco et al. 1990), and mannitol (Combe et al. 1970).

Figure 6a x17

Figure 6b x42

Figure 7 X18

Alternaria brassicicola (Schwein.) Wiltshire

Helminthosporium brassicicola Schweinitz
Macrosporium cheiranthi Fr. var *circinans* Berk. & Curt.
Alternaria circinans (Berk. & Curt.) Bolle.
Alternaria oleracea Milbraith.

Symptoms on grain. Colonies are amphigenous, effuse, dark olivaceous brown to dark blackish brown, and velvety. Dark brown to almost black, circular (1-10 mm diameter), zonate spots are formed (Fig. 8).

Morphology. The mycelium is immersed; hyphae are branched, septate, hyaline at first, later turn brown or olivaceous brown, inter- and intracellular, smooth, and 1.5-7.5 µm thick. The conidiophores arise singly or in groups of 2-12 or more, and emerge through the stomata. They are usually simple, erect or ascending, straight or curved, occasionally geniculate, more or less cylindrical but often slightly swollen at the base, septate, pale to mid-olivaceous brown, smooth, 70 µm long, and 5-8 µm thick. The conidia are usually produced in chains of 20 or more, sometimes branched, acropleurogenous, and arise through small pores in the conidiophore wall. They are straight, nearly cylindrical, usually tapering, slightly towards the apex or obclavate, with the basal cell rounded, the beak usually almost non-existent, the apical cell being more or less rectangular or resembling a truncated cone, occasionally better developed but then always short and thick, with 1-11, mostly less than 6 transverse septa and usually few but up to 6 longitudinal septa, often slightly constricted at the septa, pale to dark olivaceous brown, smooth or becoming slightly warted with age, 18-130 µm long, 8-20 µm thick in the broadest part, with the beak 1/6 the length of the conidium and 6-8 µm thick (Fig. 9).

Quick clue. Conidia are nearly cylindrical, usually tapering, the beak usually almost non-existent.

Importance. "Brassicicolon A" metabolite was isolated from *Alternaria brassicicola* (Ciegler and Lindenfelser 1969). The fungus causes leaf spot of crucifers.

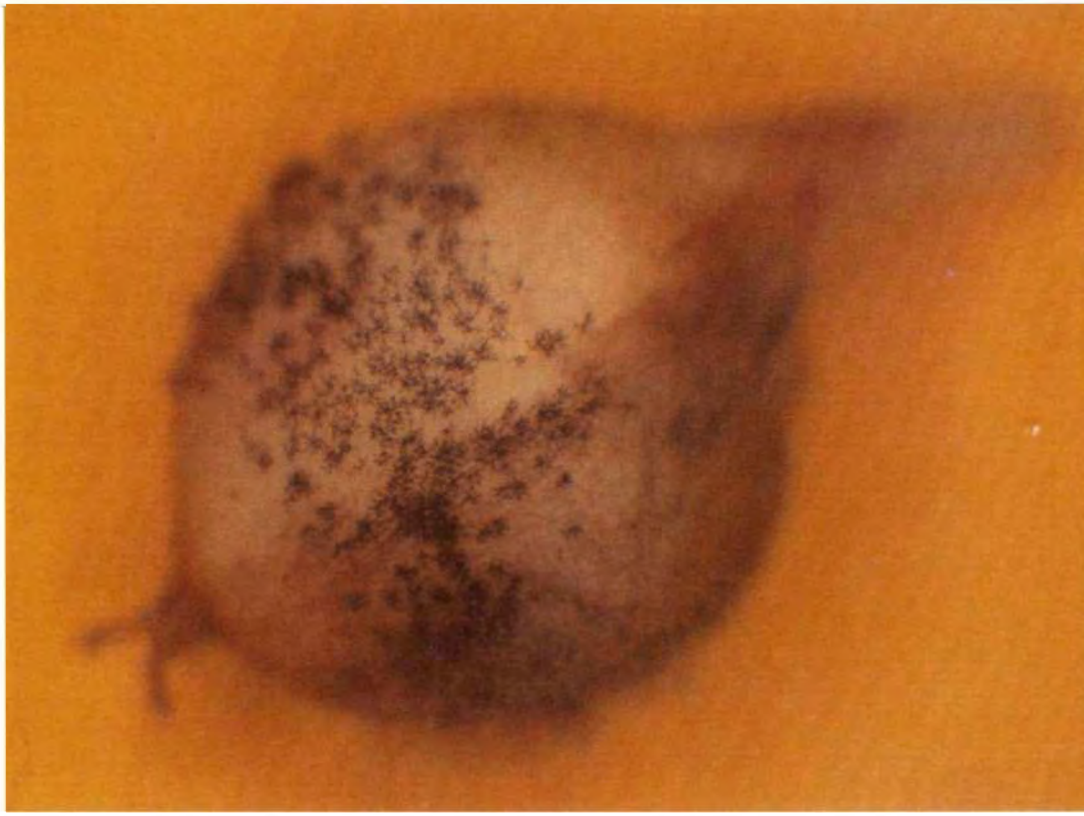

Figure 8 x17

Figure 9 x 1749

Alternaria longipes (Ellis & Everh.) Mason

Macrosporium longipes Ellis & Everh.

Symptoms on grain. Colonies are amphigenous. The spots which appear first are orbicular, brown, and frequently zonate (Fig. 10). The entire grain eventually becomes brown and the spots then appear a shade paler than the surrounding areas (Fig. 10).

Morphology. Conidiophores arise singly or in groups, erect or ascending, simple or loosely branched, straight or flexuous, cylindrical, septate, rather pale olivaceous brown, 80 µm long, 3-5 µm thick, with 1 or several conidial scars. Conidia are sometimes solitary but usually in chains, obclavate, rostrate, pale to mid-pale brown, smooth or verruculose, overall length 35-110 (average 69) µm, body of conidium 11-21 (average 14) µm thick in the broadest part, tapering gradually into the pale brown beak which is usually 1/3 to 1/2 the total length, 2-5 µm thick and often slightly swollen at the tip; there are 3-7, usually 5-6 transverse septa and 1 to several longitudinal or oblique septa (Fig. 11).

Quick clue. Refer Figure 11.

Importance. On tobacco (Nicotiana tabacum L), A. longipes causes brown spot. But this is the first report of its occurrence on sorghum in India.

Figure 10 x56

Figure 11 x686

Alternaria longissima Deighton & MacGarvie

Symptoms on grain. Colony on grain is brown to blackish brown (Fig. 12).

Morphology. Mycelium is partly superficial and partly immersed. Conidiophores are erect or ascending, simple or occasionally branched, straight or slightly flexuous, sometimes geniculate, somewhat swollen at the apex, septate, pale to mid-pale brown, smooth below, verruculose at and sometimes below the apex, 150 µm long, 3-5 µm thick, with one to several conidial scars. Conidia are solitary or catenulate, extremely variable in shape and size, pale straw colored to brown. They are usually very long (up to 500 µm), *Cercospora*-like, obclavate or with a basal sub-cylindric portion of few to several cells and a very long, narrow septate beak (Fig. 13). They have 5-40 transverse septa. Conidia are 4-17 µm thick in the broadest part and about 2.5 µm thick at the apex. Shorter conidia, variable in shape and often with a few longitudinal or oblique septa, are also formed. Conidia are thin-walled, smooth except around the base where they are often verruculose. Dark brown, multicellular, muriform chlamydospores 16-42 x 16-34 µm sometimes occur, both on natural substrata and in culture.

Quick clue. Very long, *Cercospora*-like conidium is a distinct feature of *A. longissima.*

Importance. The fungus was previously reported on sorghum along with method(s) to kill the fungus adhering to the grains for safe use of grains for consumption (Navi et al. 1997). Metabolites isolated from *A. longissima* include tenuazonic acid, cellulase, and polygalacturonase (von Ramm and Lucas 1963; Mikami et al. 1971).

Figure 12 x13

Figure 13 x1102

Alternaria tenuissima (Kunze ex Pers.) Wiltshire

Helminthosporium tenuissimum Kunze in C.G. & T.F.L. Nees
Macrosporium tenuissimum Fr.

Symptoms on grain. Golden brown to black growth on the seed surface (Fig. 14).

Morphology. Conidiophores are solitary or in groups, simple or branched, straight or flexuous, more or less cylindrical, septate, pale or mid-pale brown, smooth, with one or several conidial scars, up to 115 µrn long, and 4 µm thick. Conidia are solitary or in short chains, straight or curved, obclavate or ellipsoidal tapering gradually to the beak which is up to half the length of the conidium, usually shorter, sometimes tapered to a point but more frequently swollen at the apex where there may be several scars; pale to clear mid-golden brown, usually smooth, sometimes minutely verruculose generally with 4-7 transverse and several longitudinal or oblique septa, and slightly or not constricted at the septa; overall length 22-95 (average 54) µm, 8-19 (average 13.8) µm thick in the broadest part, beak 2-4 µm thick, and swollen apex 4-5 µm wide (Fig. 15).

Quick clue. Refer Figure 15.

Importance. *Alternaria tenuissima* is extremely common and recorded on a wide range of plant species, usually as a secondary invader rather than a primary parasite. It produces tenuazonic acid (Davies et al. 1977). It has been reported to cause leaf spot of pigeonpea. It produces the same toxins as *A. alternata.*

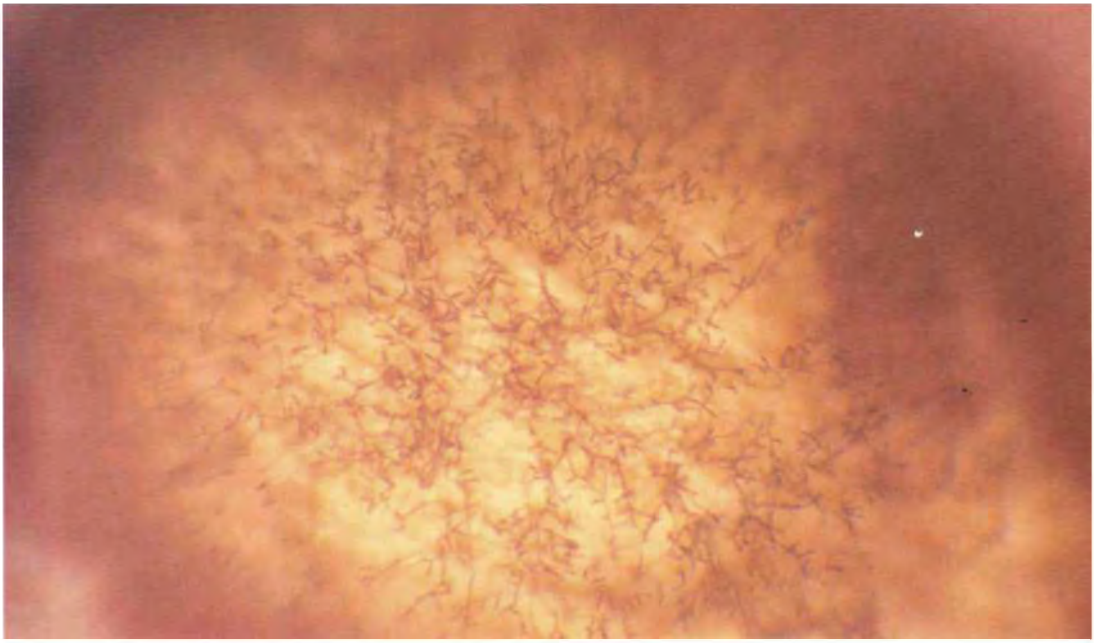

Figure 14 x51

Figure 15 x2046

Aspergillus candidus Link

Symptoms on grain. Conidial heads are persistently white or become yellowish cream with age (Fig. 16a); typically globose when young, often splitting with age, or approaching columnar in small heads (Fig. 16b).

Morphology. Conidiophores are smooth, colorless or slightly yellow in terminal areas. Vesicles are typically globose to subglobose and fertile over the entire surface. Sterigmata typically in two series, with primary series often much enlarged, sometimes varying greatly in size within the same head (Fig. 17). Conidia are globose or subglobose and smooth.

Quick clue. Absence of pigmentation and smooth conidia. White conidial heads are present.

Importance. *Aspergillus candidus* is widely distributed in nature. It is encountered most commonly on stored cereal grains and on grain products. It has been revealed frequently in necropsies of birds and mammals at the Paris Zoological Gardens. It is a thermo-tolerant fungus, capable of growing at 40-50°C, and is xerophilic (Raper and Fennel 1973).

Figure 16a x36

Figure 16b x436

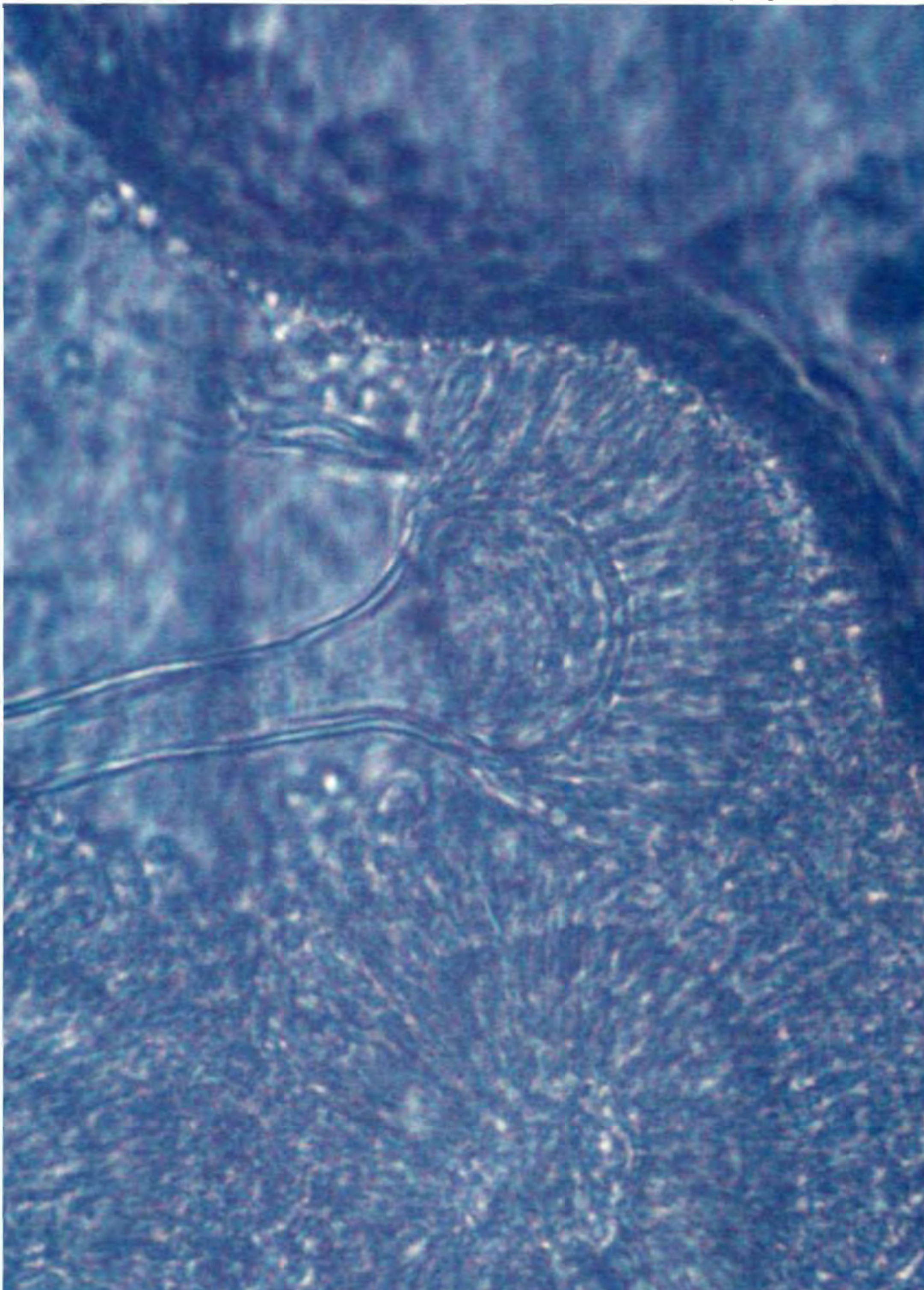

Figure 17 x 1980

Aspergillus flavus Link

Symptoms on grain. Colony on seed is usually spreading and very light yellow-green, deep yellow-green, olive brown, or brown (Fig. 18a). Conidiophores are swollen apically and bear numerous conidia-bearing cells (phialides) with conidia in long, dry chains. Conidial heads are typically spherical, splitting into several poorly defined columns, rarely exceeding 500-600 µm diameter, but mostly 300-400 µm (Fig. 18b).

(Note: Severely infected sorghum grains are discolored and shrivelled.)

Morphology. Conidiophores are heavy walled, hyaline, coarsely roughened, and usually <1 mm in length, with 10-20 µm diameter just below the apex. Apices are elongated when young, becoming subspherical to spherical, 10-65 (am in diameter, but commonly 25-45 µm. There can be one or two series of conidia-bearing cells (phialides and supporting cells) depending on the species. Supporting cells are usually 6-10 x 4-6 µm but sometimes up to 15-16 x 8-9 µm in diameter. Phialides measure 6-10 x 3-5 µm (Fig. 19a). Conidia are typically spherical to subspherical, conspicuously spiny, variable, 3-6 µm in diameter, and sometimes oval or pear-shaped at first and occasionally remaining so (Fig. 19b).

Quick clue. *Aspergillus flavus* is recognized by the light yellow-green, deep yellow-green, olive brown, or brown, compact, spherical or columnar spore heads.

Importance. Aflatoxins produced by *A. flavus* are toxic to humans and animals, and reduce grain palatability for feed or food. Seed infection can reduce germination. Production of large numbers of air-disseminated spores can cause respiratory diseases in humans and animals (Raper and Fennel 1973). *Aspergillus flavus* has been used more widely in industry than any other group of molds, particularly for the production of enzymes.

Figure 18a x11

Figure 18b x37

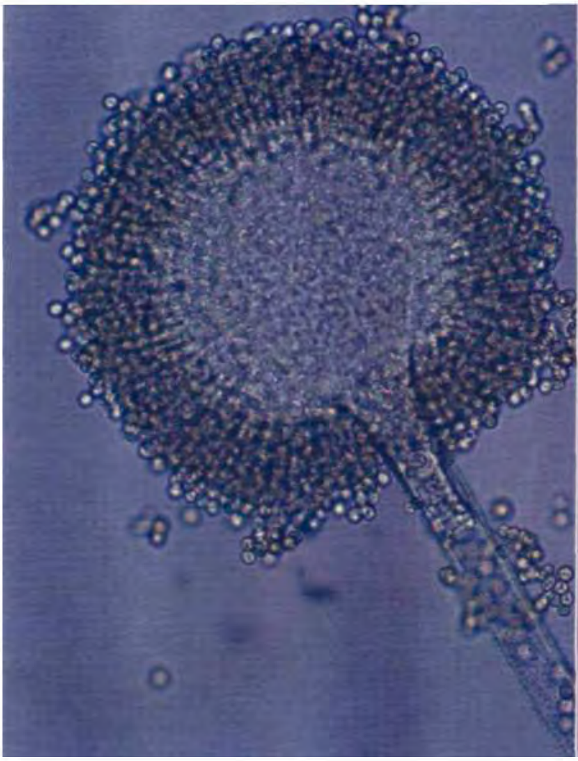

Figure 19a x502

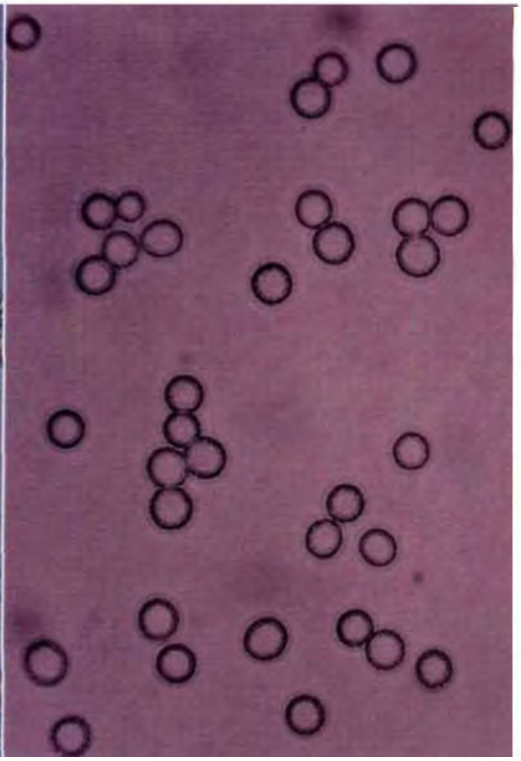

Figure 19b X1130

Aspergillus niger van Tieghem

Symptoms on grain. Colony on seed grows slowly, consisting of a compact to fairly loose white to faintly yellow basal mycelium, which bears abundant erect and usually crowded conidial structures, typically carbon black but sometimes deep brown-black, covering the entire colony except for a narrow growing margin (Fig. 20). Conidial heads are typically large and black, compact at first, spherical, or split into two or more loose to reasonably well-defined columns, and commonly reach 700-800 µm in diameter.

(Note: Severely infected sorghum grains are discolored and shrivelled.)

Morphology. Conidiophores are smooth, hyaline or faintly brownish near the apex and up to 3 µm in length and 15-20 µrn in diameter. Apices are spherical or nearly so, up to 75 µm in diameter but often quite small. Two series of conidia-bearing cells (supporting cells and phialides) are produced, but in some heads only phialides are present. Supporting cells are of varying lengths and sometimes septate, but when mature usually 20-30 µrn long. Phialides are more uniform in length, usually 7-10 x 2-3 µm. Conidia are typically spherical at maturity, often very rough or spiny, mostly 4—5 µm diameter, and very dark in color or with conspicuous longitudinal striations (Fig. 21).

Quick clue. *Aspergillus niger* is recognized by the production of compact, greenish black, brownish black, purplish black, or carbon black, spherical or columnar spore heads.

Importance. Seed infection can reduce germination. Production of large numbers of air-disseminated spores can cause respiratory diseases in man and animals. *Aspergillus niger* is worldwide in distribution and occurs in and upon the greatest variety of substrata including grains, forage products, spoiled fruits and vegetables, exposed cotton textiles and fabrics, leather, dairy products, and other protein-rich substrata (Raper and Fnnel 1973).

Figure 20 x14

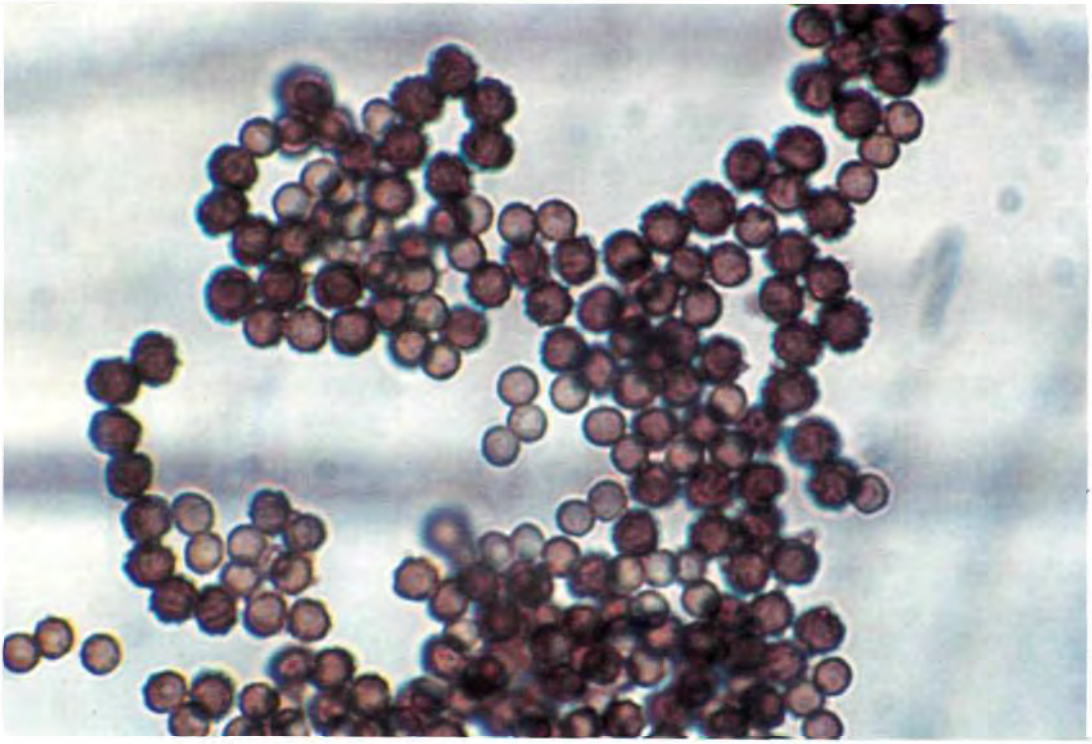

Figure 21 x1617

Bipolaris australiensis (M.B. Ellis) Tsuda & Ueyama

(*Bipolaris* species "with" *Cochliobolus* teleomorph)
Drechslera australiensis M.B. Ellis
Helminthosporium australiense Bugnicourt

Teleomorph. *Cochliobolus australiensis* (Tsuda & Ueyama) Alcorn

Symptoms on grain. Conidial colonies are effuse, gray to blackish brown, and velvety. Hyphae are pale to dark brown, smooth, and septate. Stromata are erect, straight, cylindrical, and black (Fig. 22).

Morphology. Conidiophores are single, flexuous, geniculate, septate, smooth, cylindrical, reddish brown, up to 150 µm long and 3-7 µm thick, having verruculose, conidiogenous nodes. Conidia are straight, ellipsoidal or oblong, rounded at the ends, pale brown to mid-reddish brown, usually 3-, rarely 4-5 distoseptate, 14—40 x 6-11 µm (Fig. 23).

The species is heterothallic and the teleomorph is obtained by pairing opposite compatible monoconidial isolates in Sach's agar media with sterilized rice straw. Ascomata on rice straw are globose to subglobose, black, superficial on columnar to flat stromata, 375-940 µm in diameter with a long cylindrical ostiolar beak 250-1250 x 90-125 µm. Pseudoparaphyses are filamentous, hyaline, septate, and branched. Asci are cylindrical to long, 100-182 x 8.5-15 µm clavate, vestigial bitunicate, short pedicellate, with 1-8 spores. Ascospores are parallel to partly or closely coiled in a helix in the ascus, filiform, somewhat tapering towards the ends, flagelliform at the ends, hyaline to very pale brown, 3-13 septate, 81-206 x 2.5-5.6 µm.

Quick clue. Verruculose conidiogenous nodes are present.

Importance. Production of mycotoxin by the fungus is unknown. *Cochliobolus australiensis* causes leaf spot of pearl millet (*Pennisetum glaucum* (L.) R. Br.) (Chand and Singh 1966) and leaf blight of citronella grass (*Cymbopogan winterianus* Jowitt.) (Ramaiah and Chandrashekar 1981) in India.

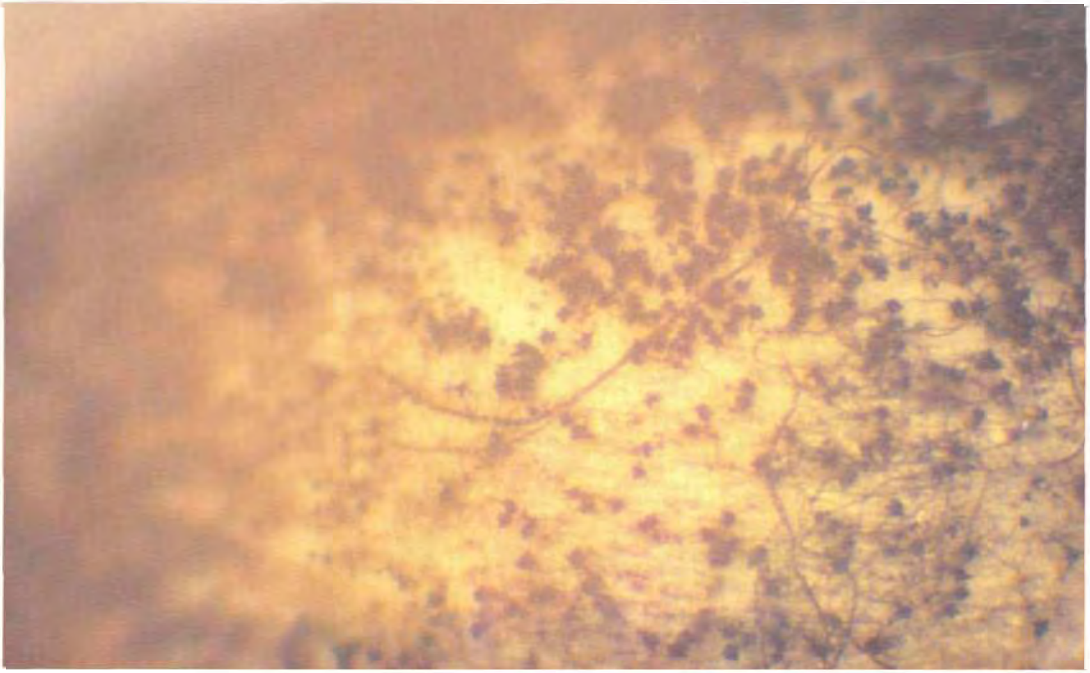

Figure 22 x49

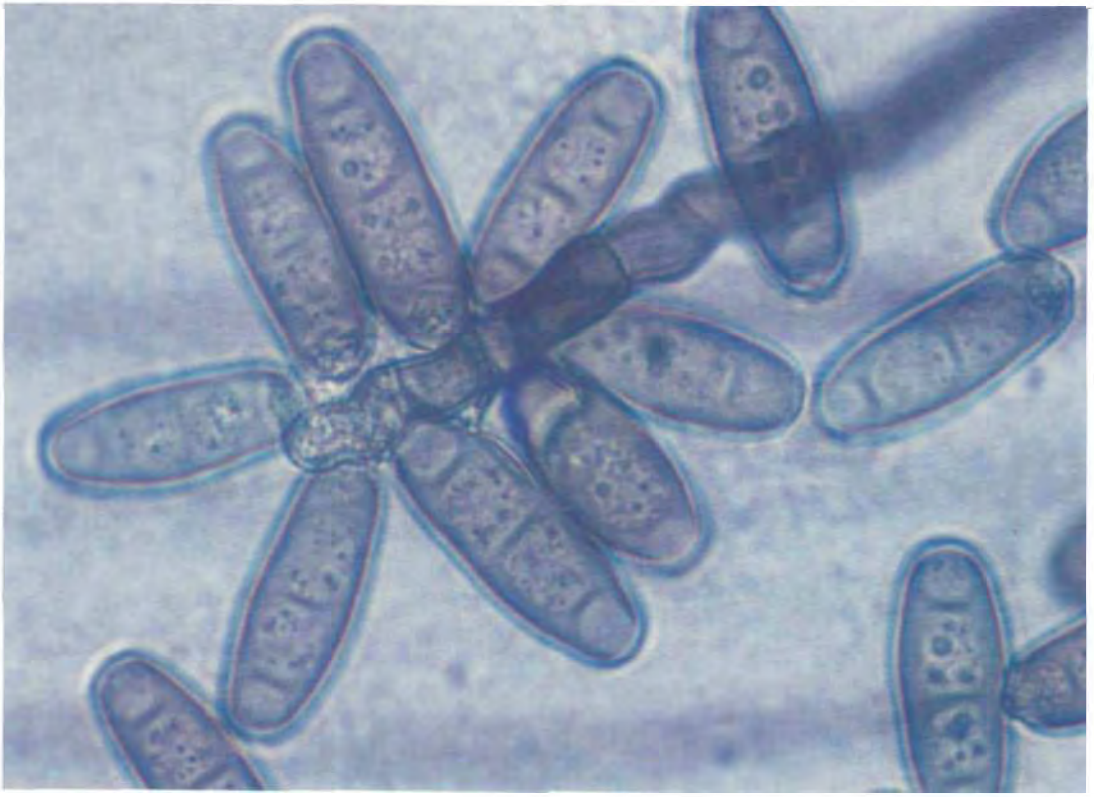

Figure 23 x1452

Bipolaris halodes (Drechsler) Shoem.

(*Bipolaris* species "without" *Cochliobolus* teleomorph)
Drechslera halodes (Drechsler) Subram. & Jain
Bipolaris rostrata (Drechsler) Shoem.
Drechslera rostrata (Drechsler) Richardson & Fraser
Exserohilum halodes (Drechsler) Leonard & Suggs
Exserohilum rostratum (Drechsler) Leonard & Suggs Imp.
Helminthosporium appatternae K.S. Deshpande & K.S. Deshpande
Helminthosporium halodes Drechsler
Helminthosporium rostratum Drechsler
Helminthosporium halodes Drechsler var *tritici* Mitra
Helminthosporium halodes Drechsler var *elaeidicola* Kovachich.
Luttrellia rostrata (Drechsler) Gonorstai

Symptoms on grain. Stromata are formed on seeds and are erect, simple or branched, cylindrical, dark, blackish brown to start, up to 2 x 1 μm (Fig. 24).

Morphology. Conidiophores are up to 200 μm long, 5-8 μm thick, septate, cylindrical, olivaceous brown, paler towards the apex, simple, and geniculate. Conidia are straight to slightly curved, ellipsoidal to narrowly obclavate or rostrate, brown or olivaceous, thick-walled, except in a small subhyaline region at the apex and a similar region surrounding the hilum which protrudes as a darkened cylinder or truncate cone from the end of the basal cell, basal septum darker and thicker than the other septa, up to 18-distoseptate, 15-200 x 7-29 μm (Fig. 25). Germination occurs from the subhyaline region of the end cells and germ tubes grow semiaxially.

(Note: Teleomorph is absent.)

Quick clue. A small subhyaline region is present at the apex of the conidium.

Importance. It is a seedborne fungus and is widely distributed. Mycotoxin production by this fungus is unknown. It commonly occurs on grasses, and many other plant species, soil, and textiles (Sivanesan 1987).

Figure 24 x26

Figure 25 x1320

Bipolaris maydis (Nisikado & Miyake) Shoem.

(*Bipolaris* species "with" *Cochliobolus* teleomorph)
Helminthosporium maydis Nisikado & Miyake
Drechslera maydis (Nisikado & Miyakae) Subram. & Jain

Teleomorph. *Cochliobolus heterostrophus* (Drechsler) Drechsler

Symptoms on grain. Colony on seed is pale to mid-dark golden brown with some white aerial mycelium, and moderate in density (Fig. 26). A black matted mold may cover the affected grain and can reduce germination.

Morphology. Conidiophores are mid- to dark brown, medium to long, commonly long, slender, straight or curved, single or in groups of 2 or 3, pale near the apex, smooth, up to 700 µm long, and 5-10 µm thick, and bear conidia at wide intervals. Conidia are distinctly curved, broad in the middle, sharply tapering towards rounded ends, pale to mid-dark golden brown, smooth, 5-11 septate, mostly 70-160 µm long, 15-20 µm thick in the broadest part; and point of attachment is dark, often flat, and 3-5 µm wide (Fig. 27).

Pseudothecia contain asci with four slender, thread-like, 5-9 septate ascospores (6-7 x 130-340 µm) arranged in parallel coils. Pseudothecia rarely occur under natural conditions.

Quick clue. Conidia are light brown, slender, typically curved, and tapering sharply towards both ends. The curvature is more pronounced than in any other related species. Conidiophores are usually long, slender, alternately bent, and bearing conidia at wide intervals.

Importance. *Bipolaris maydis* is distributed worldwide but predominantly in the tropics and subtropics. There are quarantine restrictions in many countries including Malaysia. Maize germplasm with male sterile T cytoplasm also has quarantine restrictions. *Bipolaris maydis* produces four host-specific toxins of race T and *C. heterostrophus* produces ophiobolin B, ophiobolin C, ophiobolin F, anhydroophiobolin A, 6-epiophiobolin A, and geranylnerolidol (Ishibashi 1962; Nozoe et al. 1965, 1966; Canonica et al. 1966; Tsuda et al. 1967; Cordell 1974; Karr et al. 1974, 1975; Payne and Yoder 1978; Sugawera et al. 1987).

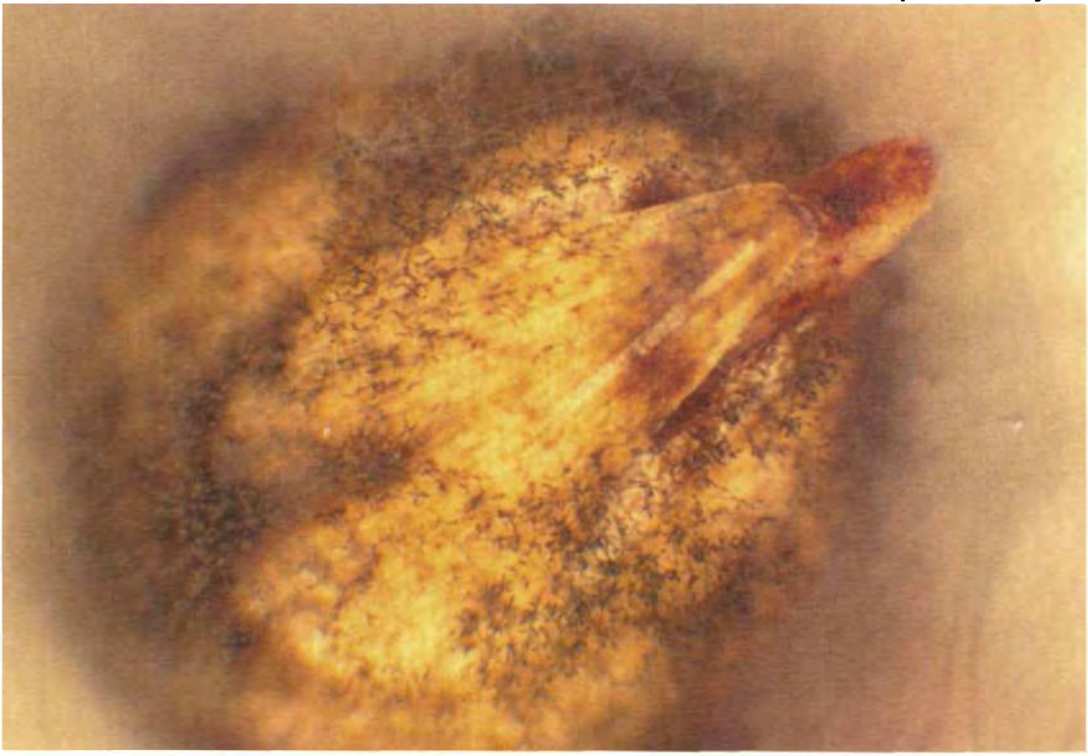

Figure 26 x22

Figure 27 x568

Bipolaris sacchari (E. Butler) Shoem.

(*Bipolaris* species "without" *Cochliobolus* teleomorph)
Helminthosporium sacchari E. Butler
Drechslera sacchari (E. Butler) Subram. & Jain

Symptoms on grain. Stromata are formed on seeds and are erect, simple or branched, cylindrical, dark, blackish brown to start, up to 2 x 1 mm (Fig. 28).

Morphology. Conidiophores are single or in small groups, often from groups of dark cells which form a loose stroma, straight to flexuous, mid- to dark brown or olivaceous brown, paler towards the apex, septate, smooth, cylindrical, up to 200 µm long, 5-8 µm thick; in culture up to 700 µm long and 10 µm thick. Conidiogenous nodes are smooth to slightly verruculose. Conidia are slightly curved, rarely straight, cylindrical or narrowly ellipsoidal, mid-pale to mid-yellow golden brown, 5-9 (commonly 8) distoseptate, 35-96 x 9-17 µm, hilum 2-3 µm wide (Fig. 29).

(Note: Teleomorph is absent.)

Quick clue. Groups of dark cells and slightly curved distoseptate conidia are formed.

Importance. *Bipolaris sacchari* produces helminthosporoside (Beier et al. 1982) and three isomeric host-specific toxins (Macko et al. 1983). It causes eye spot and seedling blight of sugarcane (*Saccharum officinarum* L.) and leaf spots of grasses.

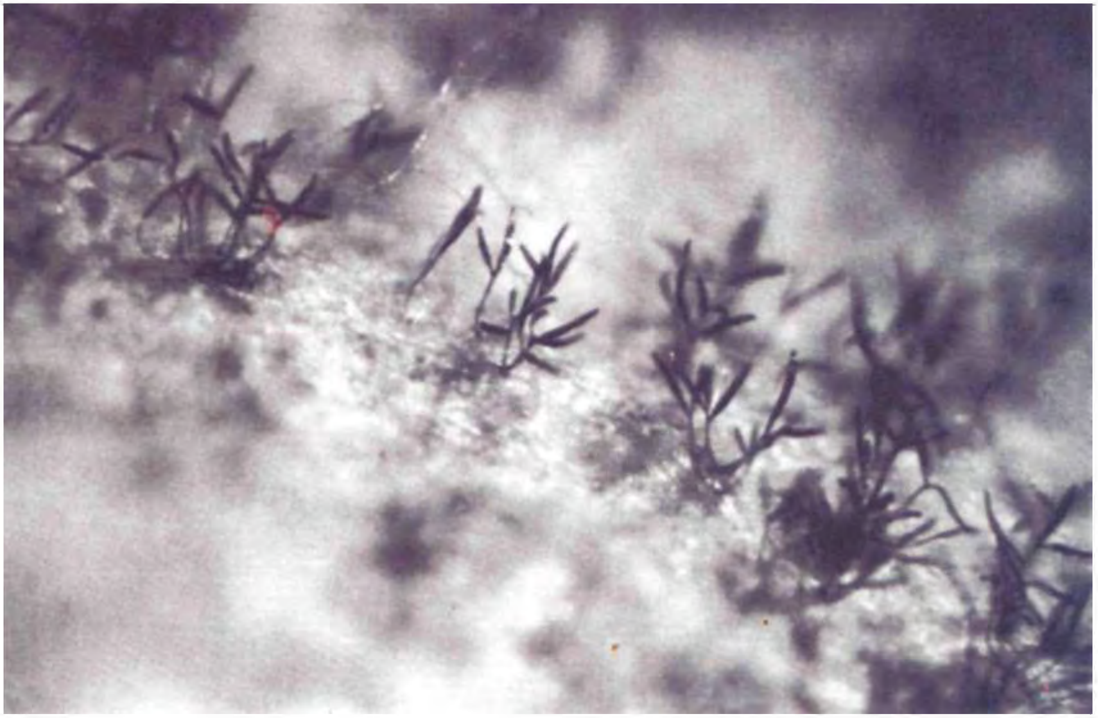

Figure 28 x521

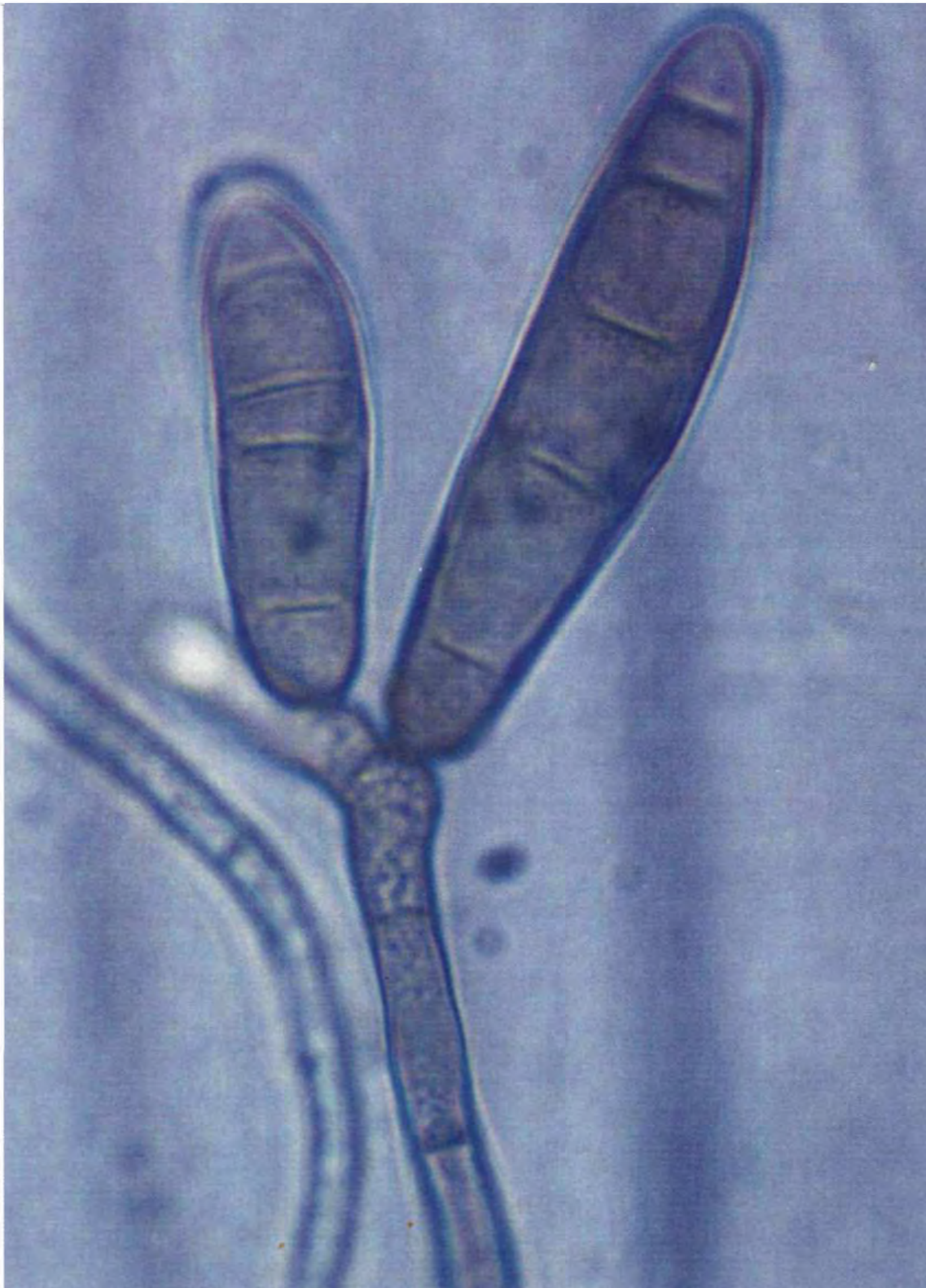

Figure 29 x1980

Bipolaris spicifera (Bainier) Subram.

(*Bipolaris* species "with" *Cochliobolus* teleomorph)
Helminthosporium spiciferum (Bainier) Nicot
Helminthosporium tetramera McKinney
Curvularia spicifera (Bainier) Boedijn

Teleomorph. *Cochliobolus spicifer* Nelson

Symptoms on grain. Colony on seed is brown, gray or black, hairy, cottony or cushion-like and spreads loosely with abundant brownish conidiophores, single or in clusters of 2-3 (Fig. 30). Many small conidia are produced at very short intervals, giving rise to a bottle-brush appearance. Colonies strongly resemble those of *Curvularia* spp.

Morphology. Conidiophores are brown and curved, with obvious and numerous scars resulting in an irregular zigzag appearance. Conidia are short, typically 3-septate, light to dark brown, oval, curved to straight with rounded ends, and measure 20-40 µm x 9-14 µm. Conidia are lighter in color towards the terminal cells.

Ascomata are black, spherical to oval, curved, 460-710 x 350-650 µm, with an inverted cone-shaped neck and pore. Asci are cylindrical to club-shaped, straight to slightly curved, with 1-8 spores and 130-160 x 12-20 µm. Ascospores are parallel to closely coiled in the ascus, thread-like, somewhat tapered at the ends, 6-16 septate, hyaline, and 135-240 x 3-7 µm (Fig. 31).

Quick clue. Under the dissecting microscope, conidia appear to be clustered for some length on the conidiophores, giving the appearance of a bottle-brush. Conidia are very small and typically 3-septate, almost cylindrical, more or less uniform in size, and the end cells have subhyaline areas towards their terminal ends.

Importance. *Bipolaris spicifera* is distributed worldwide and is very common in tropical and subtropical areas. The mycotoxins isolated from *B. spicifera* are spiciferone A and cynodontin metabolites and those from *C. spicifera* are curvularin and D-mannitol (Combe et al. 1968; Nakajima et al. 1989). The main diseases caused by *B. spicifera* are foot rot (or common root rot) of winter wheat (*Triticum aestivum* L.) and mycotic keratitis in humans. A subcutaneous mycosis in cat and horses is also induced by C. *spicifer.*

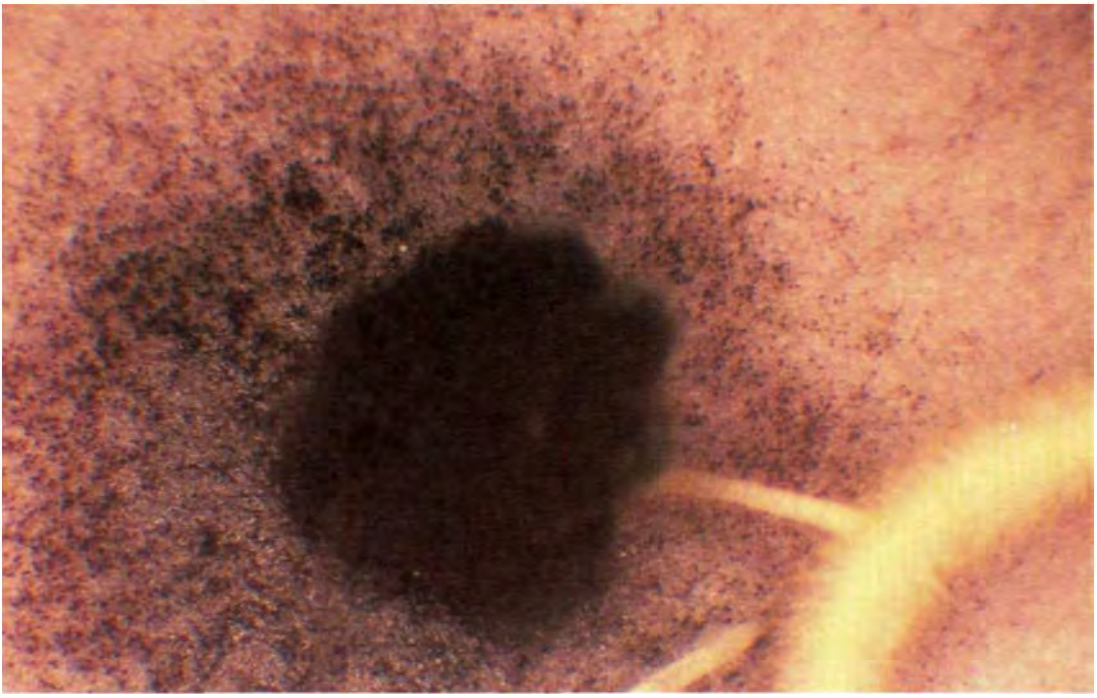

Figure 30 x10

Figure 31 x1353

Bipolaris zeicola (Stout) Shoem.

(*Bipolaris* species "with" *Cochliobolus* teleomorph)
Helminthosporium carbonum Ullstrup
Helminthosporium zeicola Stout
Drechslera carbonum (Ullstrup) Sivan
Drechslera zeicola (Stout) Subram. & Jain

Teleomorph. *Cochliobolus carbonum* Nelson

Symptoms on grain. Grains are covered by very dark brown to black mycelium which gives a characteristic charcoal appearance. Conidia are also visible (Fig. 32).

Morphology. Conidiophores are single or in small groups, straight to flexuous, mid- to dark brown or olivaceous brown, up to 250 µm long, 5-8 µm thick, smooth, septate, and cylindrical. Conidiogenous nodes are verruculose with the surface wall below them granulose. Conidia are curved or sometimes straight, occasionally almost cylindrical but usually broad in the middle and tapering towards the rounded ends, 6-12 (commonly 7-8) distoseptate, 30-100 x 12-18 µm, often finally becoming dark or very dark brown or olivaceous brown, with the end cells sometimes remaining tapered than the middle cells (Fig. 33). The surface is often granulose and hilum is not very conspicuous.

The species is heterothallic and the teleomorph is obtained by pairing opposite mating single conidial isolates in Sach's agar media holding sterilized maize leaf segments or barley *(Hordeum vulgare* L.) grains at 24°C (Nelson 1959). Ascomata are black, globose to ellipsoidal, 355-550 x 320-420 µm, with setae over the upper half of the wall mixed with conidiophores, and with a well-defined sub-conical to paraboloid ostiolar beak 60-200 µm long. Pseudoparaphyses are filiform, hyaline, septate, and branched. Asci are cylindrical to clavate, short-stalked, straight to slightly curved, 1-8 spored, vestigial bitunicate, 160-257 x 18.0-27.5 (am. Ascospores are filiform or flagelliform, somewhat tapering towards the ends, hyaline, 5-9 septate, 180-307 x 6-10 µm, often surrounded by a thin hyaline mucilaginous sheath.

Quick clue. Distoseptate dark to dark brown conidia are present.

Importance. *Bipolaris zeicola* is distributed worldwide. There are quarantine restrictions for Indonesia, Egypt, and Chile. *Bipolaris zeicola* produces HC-toxins I, II, III, IV, and CHS polypeptide (Ramussen and Scheffer 1988), and *C carbonum* produces carbtoxinine and victoxinine (Nishimura et al. 1966; Pringle and Scheffer 1967). *Cochliobolus carbonum* is reported on maize from many countries including India. This is the first report on sorghum in India.

Figure 32 x53

Figure 33 x1320

Botrytis cinerea Pers. ex Pers.

Teleomorph. *Botryotinia fuckeliana* (de Bary) Whetzel

Symptoms on grain. Colony on seed is white or gray or grayish-brown, and spreading for a short distance around the affected seed (Fig. 34).

Morphology. Conidiophores are brown, tall, upright or nearly so, septate and branched, up to 30 µm wide and 2 µm long. The branches are constricted at their point of origin and quickly collapse when removed from a moist atmosphere. Conidia occur in clusters at the swollen rounded apices and at intervals along with conidiophores on short blunt teeth. Conidia are oval or egg-shaped, often with a slightly projecting point of attachment, colorless to pale brown, and measure 6-18 x 4 - 1 µm (Fig. 35).

Fairly large, black, irregular sclerotia can be produced, but not normally within the period of a seed health test. They are rather flat in appearance and measure 5 x 2 x 2 µm.

Quick clue. The funugs is characterized by stout, brown, branched conidiophores supporting glistening gray heads of pale conidia, which can be observed under low magnification of **a** binocular microscope.

Importance. The fungus is a common gray mold, frequently parasitic, and produces abscisic acid, botrydial, botrylacton, citric acid, and thermostable toxins (Fehlhaber et al. 1974; Kamoen and Jamart 1974; Lyon 1977; Welmer et al. 1979; Morooko et al. 1986). However, it is not noted as a toxigenic species.

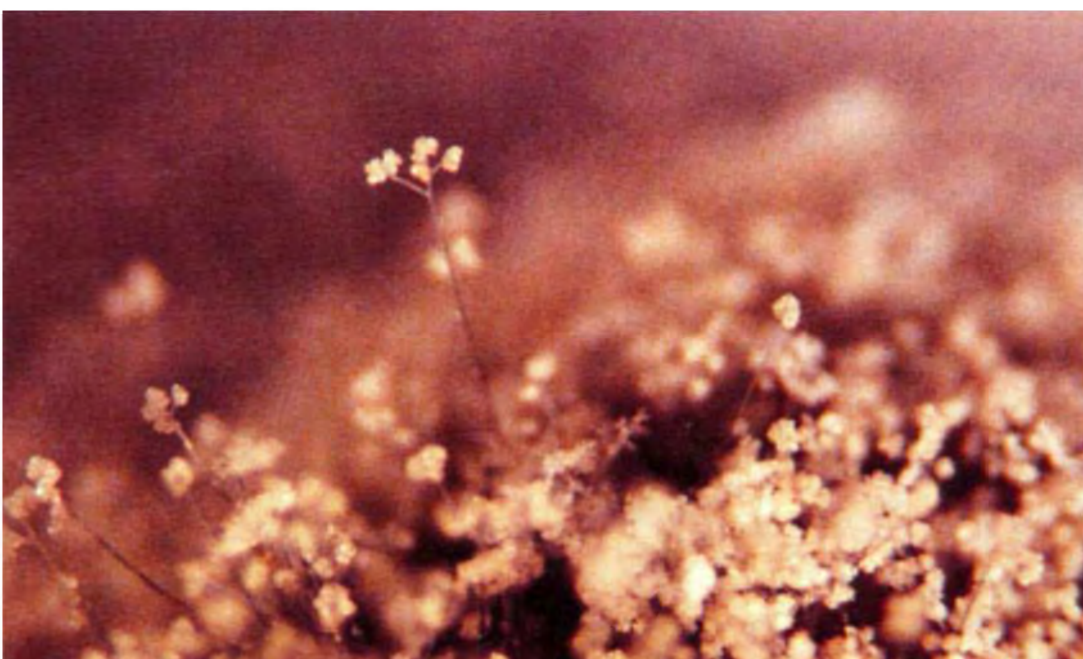

Figure 34 x131

Figure 35 x858

Chaetomium oryzae

Symptoms on grain. Colony on seed is white with the density of mycelium varying from light to dense. The perithecia are found on the seed surface beneath the aerial white mycelium (Fig. 36).

Morphology. Perithecia are spherical or elongate, with a pore opening, and a dark, membranous, cellular wall which is covered with conspicuous hairs of various types (Fig. 37).

Asci are hyaline, usually club-shaped but in a few cases cylindrical, and contain eight ascospores. Ascospores are one-celled and in most cases lemon-shaped. They are extruded through the pore opening either as a mass amongst the hairs or as a column depending on conditions.

Quick clue. Colonies of *Chaetomium* species can be readily recognized by the presence of perithecia with many stiff dark terminal hairs with ornamentation.

Importance. *Chaetomium* is distributed worldwide. It has no significance in crop production. However, it is a common saprophyte and secondary invader. Seeds of low germinating capacity are sometimes found to be heavily contaminated with *Chaetomium* (Skolko and Groves 1953).

Figure 36 x23

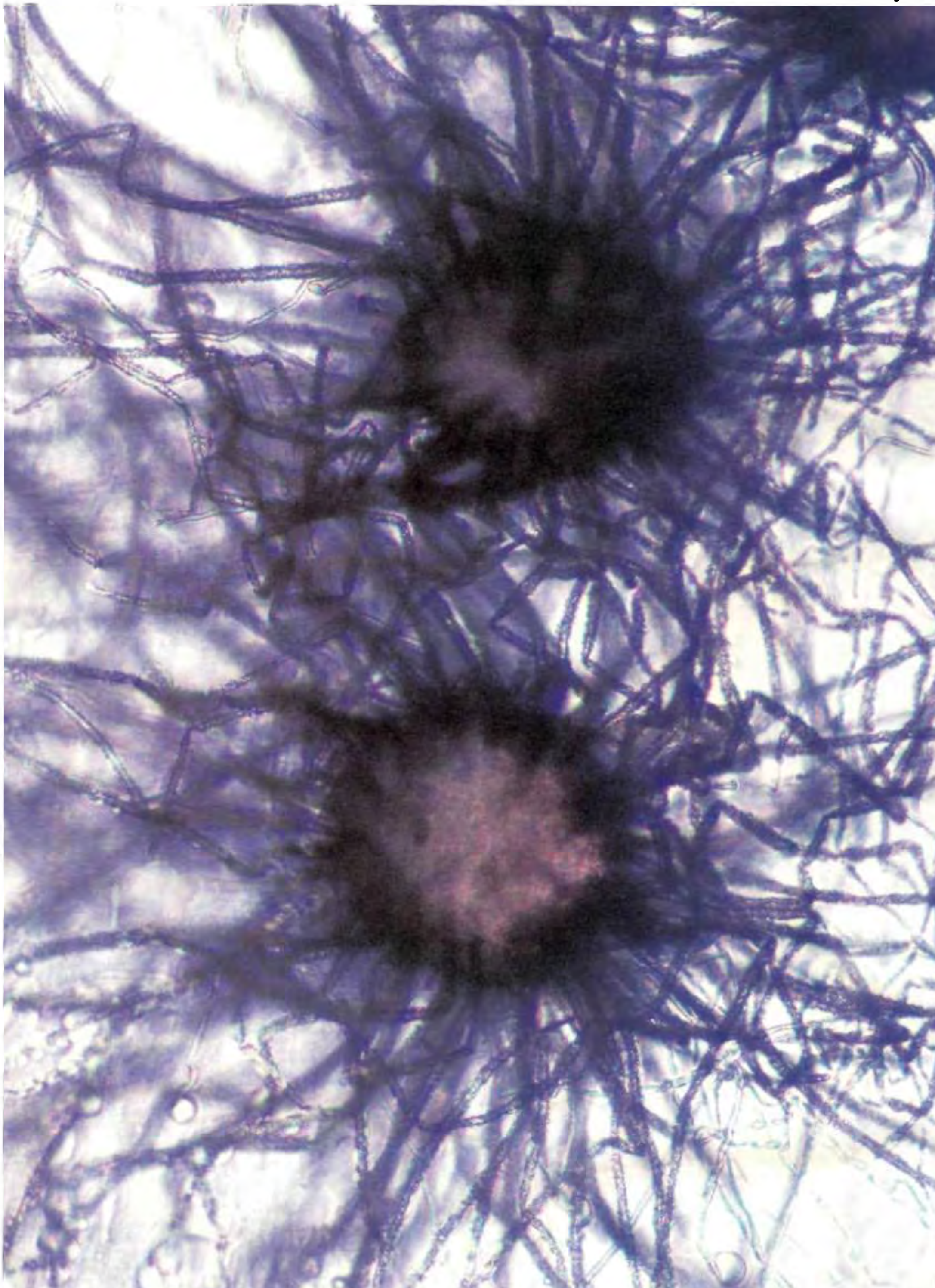

Figure 37 x396

Cladosporium oxysporum Berk. & Curt.

Symptoms on grain. Colonies are effuse, pale gray or grayish brown, thinly hairy on natural substrata (Fig. 38); cottony or loosely felted in culture.

Morphology. Conidiophores are macronematous, straight or slightly flexuous, distinctly nodose, pale or mid-pale brown, smooth, up to 500 µm long or sometimes even longer in culture, 3-5 µm thick, with terminal and intercalary swellings of 6-8 µm diameter. Conidia arise from terminal swellings, which later become intercalary, in simple or branched chains. Conidia are cylindrical, rounded at the ends, ellipsoidal, limoniform or subspherical, subhyaline or pale olivaceous brown, smooth, 5-30 x 3-6 µm (Fig. 39).

Quick clue. *Cladosporium* is characterized by erect, pigmented conidiophores with chains of conidia in tree-like heads. This genus can frequently be identified by the distinctive lemon-shaped conidia, which have well marked, dark attachment scars and show considerable variation in size and septation within and between species.

Importance. Heavily infected sorghum grains may have dark green to black blotches, or streaks that extend from the grain tips. The fungus is common, widely distributed in the tropics on dead leaves and stems of herbaceous and woody plants. Many saprophytic species are commonly encountered on seeds. *Cladosporium* is usually associated with frost damage and wet weather. Black head molds are caused by saprophytic or weakly parasitic species and are usually associated with insect infestations, lodging, nutrient deficiencies, and/or wet weather at maturation and harvest.

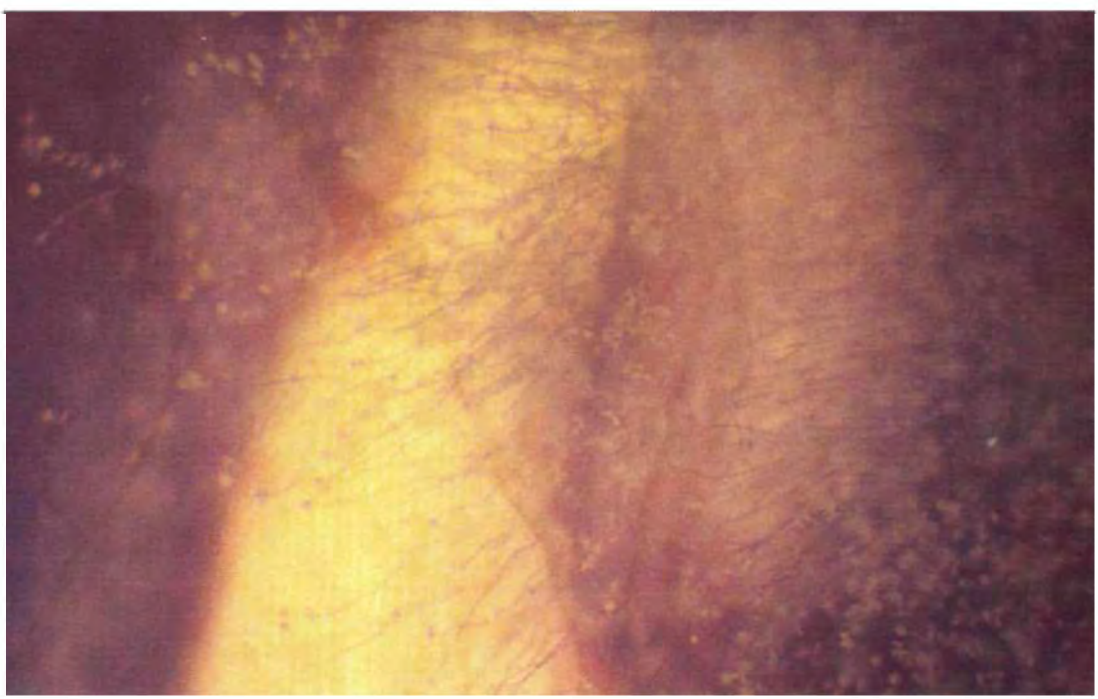

Figure 38 x52

Figure 39 x3102

Cladosporium sphaerospermum Penz.

Symptoms on grain. Colony on seed spreads loosely or occasionally small, point-like, cushion-like, cotton-like groups or with tufts, or hairy (Fig. 40a). It is often olive green but also sometimes gray, light brownish yellow, brown or dark blackish brown (Fig. 40b). Colonies are relatively slow growing and produce little aerial mycelium but normally sporulate freely. Conidiophores are produced in dense stands from the seed.

(Note: Heavily infected sorghum grains may have dark green to black blotches, or streaks that extend from the grain tips.)

Morphology. Mycelium is hyaline, becoming dark, septate, smooth or finely rough, 3-4 µm wide. Conidiophores arise laterally from the mycelium or are formed terminally on the hyphae, brown, smooth or finely roughened, septate, variable in length, up to about 160 µm long, 3-4 µm wide. Conidial heads are composed of branched chains of spores, a large proportion of which are globose. Conidia are brown, echinulate (echinulation not readily seen at x600), the majority globose or subglobose or rather ellipsoidal, continuous, 4-6 µm in diameter; a smaller number of larger spores are more irregular in shape, globose, ovoid, ellipsoidal with both ends pointed or pointed at one end and with two or more pretensions at the other, sometimes septate, 6-14 x 4-6 µm (Fig. 41).

Quick clue. *Cladosporium sphaerospermum* is characterized by erect, pigmented conidiophores with chains of conidia in tree-like heads. The genus can frequently be identified by the distinctive lemon-shaped conidia, which have well marked, dark attachment scars and show considerable variation in size and septation within and between species. Tree-like heads of conidiophores can be readily observed by using the scotch-tape method (see Appendix 1) under the microscope at low power (x100).

Importance. The fungus is a very common cosmopolitan species. It occurs as secondary invader on many plant species and has been isolated from air, soil, foodstuff, paint, textiles, and occasionally from man and animals.

Figure 40a X15

Figure 40b x46

Figure 41 x2640

Colletotrichum graminicola **(Cesati) Wilson**

Colletotrichum sublineolum Henn. Kab & Bubak

Teleomorph. *Glomerella graminicola* Politis

Symptoms on grain. Visible symptoms are dark brown to black acervuli scattered on grain surface (Fig. 42). These acervuli are irregular in shape and consist of dark setae. Sometimes acervuli are also formed on the glumes.

Morphology. Acervuli are rounded or elongate, separate or confluent, superficial, erumpent, with conspicuous multicellular, darkly pigmented setae, and 70-300 µm in diameter. The acervuli consist of a gelatinous or mucoid, salmon orange colored conidial mass. Conidiophores are hyaline, single-celled, falcate, fusiform, spindle shaped, with acute apices, and measure 19-28.9 x 3.3-4.8 µm. Setae are brown with a dark swollen base and a pale rounded tip (Sutton 1980) (Fig. 43).

Quick clue. Conidia are sickle-shaped and single celled.

Importance. *Colletotrichum graminicola* is widespread. It causes anthracnose of sorghum and many other plant species.

Figure 42 x37

Figure 43 x396

Curvularia affinis Boedijn

(*Curvularia* species "without" *Cochliobolus* teleomorph)

Symptoms on grain. Colonies are effuse, gray, brown or blackish brown, hairy, cottony or cushion-like and spread loosely (Fig. 44). Stromata are cylindrical, black, and unbranched.

Morphology. Conidiophores arise singly or in groups, terminally and laterally on the hyphae, also on stromata when these are present. On natural substrata, conidiophores are erect, simple, straight or flexuous, sometimes geniculate, septate, brown, paler near the apex, smooth, up to 200 μm long, often swollen at the base (9-11 μm), 6-8 μm thick just above the basal swelling, and 3-4 μm at the apex; in culture simple or loosely branched, flexuous, often geniculate, septate, pale brown to brown, smooth, up to 400 μm long, 2-3 μm thick at the base broadening to 4-5 μm near the apex. Conidia are straight or curved, broadly fusiform to ellipsoidal, usually 4-, occasionally 5-distoseptate, cell at each end pale brown, intermediate cells brown, middle cell sometimes darker, 27-49 (average 32) μm long, 8-13 (average 10) μm thick in the broadest part (Fig. 45).

(Note: Teleomorph is absent.)

Quick clue. Conidia are often curved but seldom geniculate, 32 x 10 μm.

Importance. *Curvularia affinis* is isolated from rice (*Oryza sativa* L), maize, and some dicotyledon hosts, and soil. This probably is a new report on sorghum grain from India.

Figure 44 x16

Figure 45 x3300

Curvularia clavata Jain

(*Curvularia* species "without" *Cochliobolus* teleomorph)

Symptoms on grain. Colonies are grayish brown or brown and cottony (Fig. 46).

Morphology. Conidiophores arise terminally and laterally on the hyphae, simple, straight or flexuous, sometimes geniculate, septate, pale brown to brown, smooth, up to 150 µm long, 2-6 µm thick, narrower at the base, and thicker towards the apex. Conidia are straight or occasionally slightly curved, usually clavate, sometimes truncate at the base, 3-distoseptate, smooth, 17-29 (average 23) µm long, 7-13 (average 9.6) µm thick in the broadest part (Fig. 47). The hilum is not or very slightly protuberant, basal cell is pale brown and other cells are brown or dark brown.

(Note: Teleomorph is absent.)

Quick clue. Conidia are straight or almost straight, symmetrical, and clavate.

Importance. *Curvularia clavata* is distributed worldwide especially in the tropics and is frequently encountered as a pathogen or saprophyte. It causes serious losses in tropical regions, but is a minor pathogen in temperate regions. An unidentified toxin produced by *C. clavata* has been reported (Olufolaji1986).

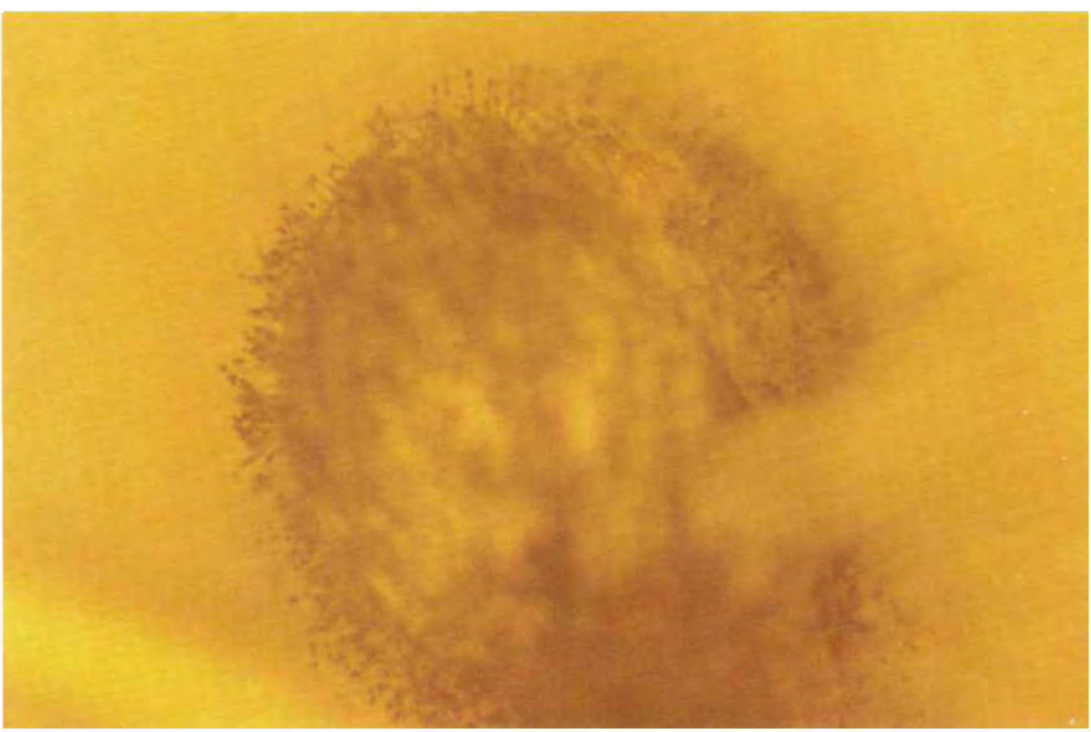

Figure 46 x29

Figure 47 x2739

Curvularia eragrostidis (Henn.)

(*Curvularia* species "with" *Cochliobolus* teleomorph)

Teleomorph. *Cochliobolus eragrostidis* (Tsuda & Ueyama) Sivanesan comb. nov.
Pseudocochliobolus eragrostidis Tsuda & Ueyama
Brachysporium eragrostidis P. Hennings
Spondylocladium maculans Bancroft

Symptoms on grain. Colony on seed is brown, gray, or black, hairy, cottony or cushion-like and spreads loosely (Fig. 48).

Morphology. Conidiophores are solitary or in groups, simple or rarely branched, straight or curved, sometimes geniculate near the apex, multiseptate, brown to light brown, variable in length up to 5 µm diameter. Conidia are 3-distoseptate, ellipsoidal or barrel-shaped, the middle septum almost median appearing as a black band, with brown to dark brown central cells and paler end cells, rather smooth, 18-37x 11-20 µm (Fig. 49). Stromata are formed on rice straw or other substrata.

The species is heterothallic and the teleomorph is obtained by pairing compatible conidial isolates in Sach's agar media containing sterilized rice straw (Tsuda and Ueyama 1985). Ascomata are superficial, globose, black, 375-750 x 375-750 µm, with protruding ostiolar beaks, developing from columnar or flat stromata firmly adhering to the substrate at the base; ostiolar beak 250-1125 x 85-190 µm, with a hyaline apex. Asci are vestigial bitunicate, almost cylindrical with a short stalk, 1-8 spored, 150-240 x 12.5-22 µm, among filamentous pseudoparaphyses. Ascospores are hyaline, filiform or flagelliform, 175-240 x 3.8-6.3 µm, 12-22 septate, parallel to loosely coiled in the ascus or rarely coiled in a helix.

Quick clue. Conidia are symmetrical, and middle septum is usually truly median appearing as a black band.

Importance. The fungus was also isolated by Adiver and Anahosur (1994) from sorghum grain samples. Mycotoxin production of this fungus is unknown. This fungus is widely distributed on cereals, dicotyledons, and other substrata.

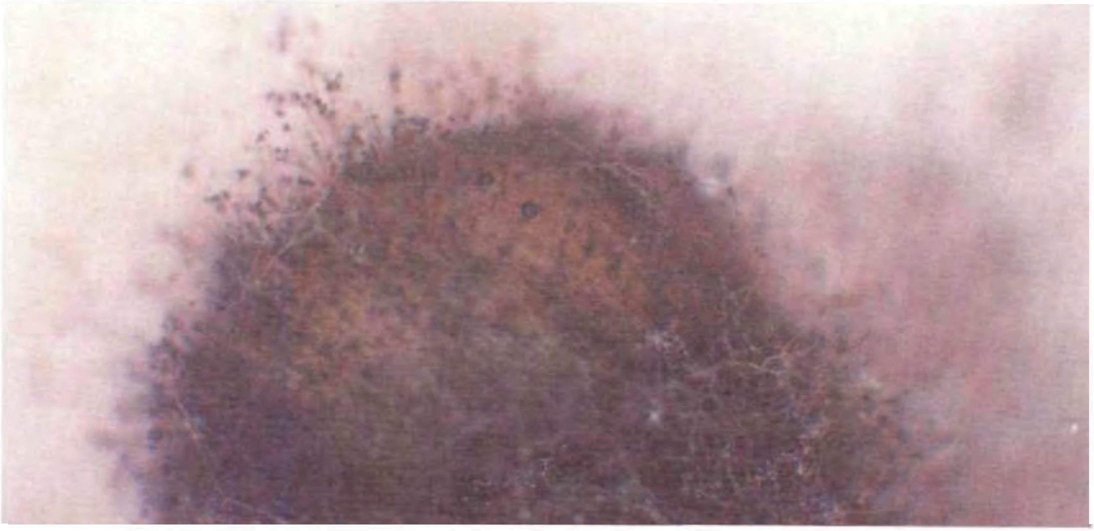

Figure 48 x28

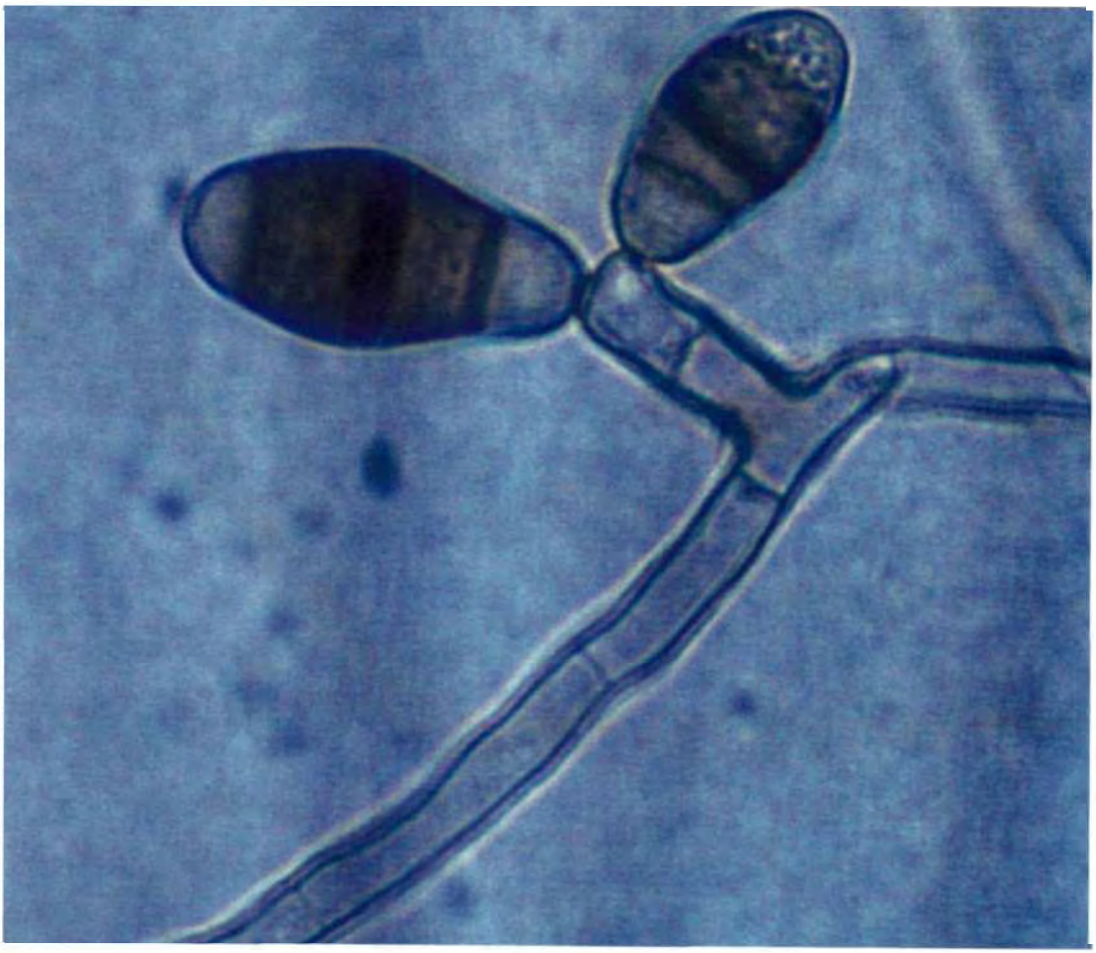

Figure 49 x1419

Curvularia fallax Boedijn

(*Curvularia* species "without" *Cochliobolus* teleomorph)

Symptoms on grain. Colonies are effuse, blackish brown, velvety or cottony. Stromata are up to 7 mm long, often branched, black, formed frequently on potato-dextrose agar and always on grains.

Morphology. Conidiophores arise singly or in groups, terminally and laterally on the hyphae, also on stromata, simple or loosely branched, straight or flexuous, sometimes geniculate, reddish brown, often paler near the apex, smooth, septate; on natural substrata up to 250 µm long and swollen at the base (11-16 µm diameter), and in culture up to 1 mm long and 4-6 µm thick. Conidia are straight or slightly curved, broadly fusiform or ellipsoidal, almost always 4-distoseptate, smooth; cell at each end is subhyaline or very pale brown, and intermediate cells are mid-pale brown to brown. On natural substrata conidia are 24-26 (average 30) µm long, 10-16 (average 12.2) µm thick in the broadest part, in culture 24-38 (average 30.6) µm x 9-15 (average12.3) µm (Fig. 50).

(Note: Teleomorph is absent.)

Quick clue. Conidia are often curved but seldom geniculate, 30 x 12.2 µm. Stromata are branched.

Importance. The fungus has a wide host range (species of *Oryza, Panicum, Sorghum,* and a variety of dicotyledonous hosts). It is also isolated from air, house dust, soil, and wood. Probably this is a new report of the occurrence of *C. fallax* on sorghum grain in India. However, *C. fallax* has been reported on rice in India.

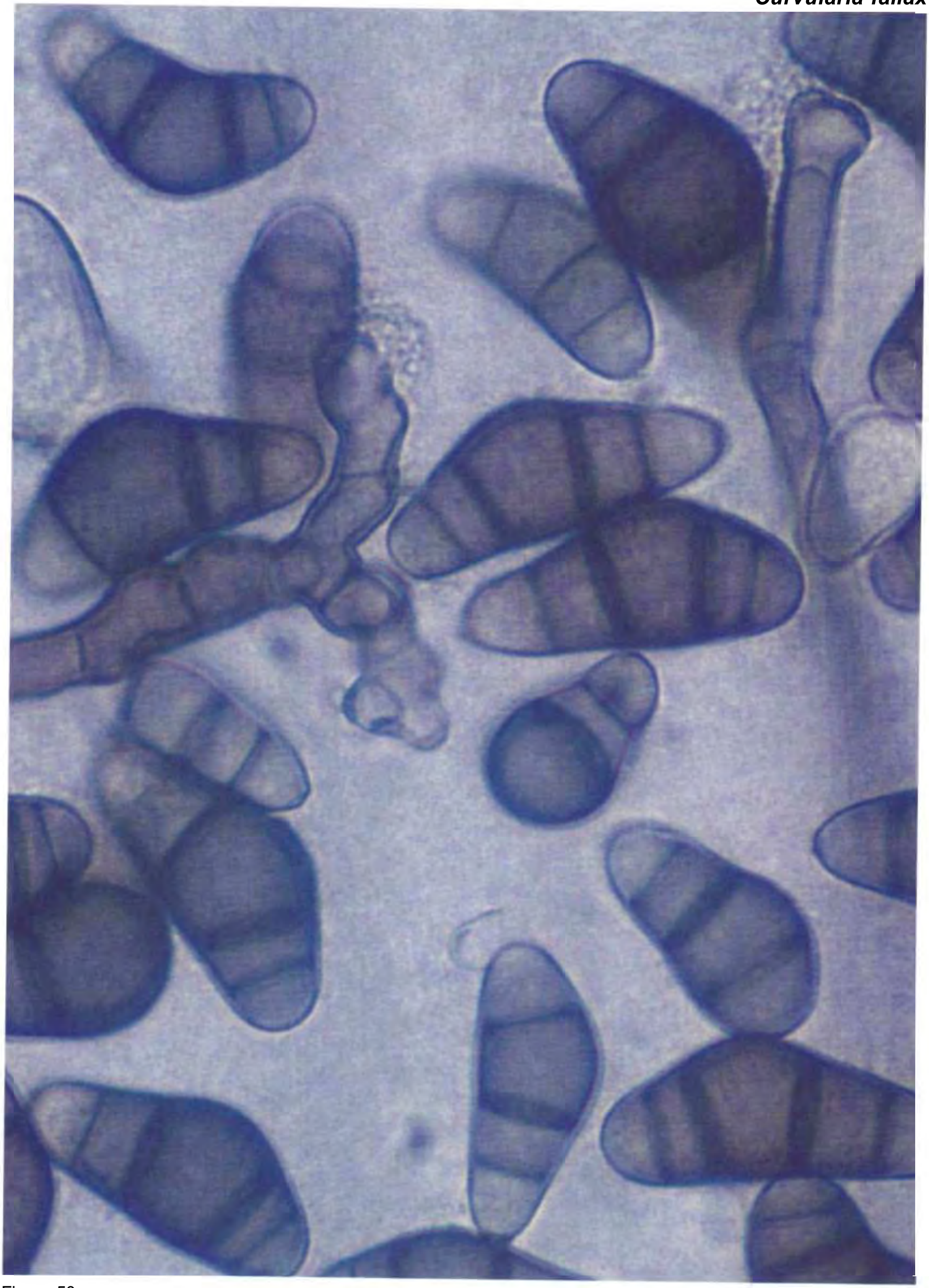

Figure 50 x1980

Curvularia geniculata (Tracy & Earle) Boedijn

(*Curvulaha* species "with" *Cochliobolus* teleomorph)

Teleomorph. *Cochliobolus geniculatus* Nelson

Symptoms on grain. Colony on seed is brown, gray, or black, hairy, cottony or cushion-like and spreads loosely (Fig. 51).

Morphology. Conidiophores are up to 600 µm long. Conidia are usually curved, geniculate, fusiform, 3-4 distoseptate but almost always 4-distoseptate, rarely 5-distoseptate, smooth, 26-48 x 8-13 µm on natural substrata and 18-37 x 8-14 µm in culture (Fig. 52). The end cells are subhyaline or very pale brown, intermediate cells brown to dark brown, and the central cell usually dark brown and swollen.

The species is heterothallic and the teleomorph is obtained by pairing compatible conidial isolates in Sach's agar media containing sterilized barley grains at 24°C under constant artificial light (Nelson 1964). Ascomata are free or frequently develop on a columnar stroma, up to 830 µm broad. Asci are 1-8 spored, cylindrical, vestigial bitunicate, and 170-290 x 15-20 µm among filamentous pseudoparaphyses. Ascospores are somewhat tapered at the ends, filiform, 6-16 septate, 160-270 x 4-7 µm, coiled in a helix inside the ascus.

Quick clue. Conidia are often distinctly geniculate, curved, and tapering gradually towards each end.

Importance. *Curvularia geniculata* and its teleomorph is known to produce 1,4,5,8-tetrahydroxy-2,6-dimethylanthraquinone metabolite (Combe et al. 1968). This is a new report of its occurrence on sorghum grain in India. However, the frequency of occurrence was less (only 24 grains were colonized out of 20,800 grains).

Figure 51 x48

Figure 52 x1680

Curvularia harveyi Shipton

(*Curvularia* species "without" *Cochliobolus* teleomorph)

Symptoms on grain. Colonies are effuse, grayish brown, cottony to velvety (Fig. 53).

Morphology. Conidiophores arise singly or in groups, terminally and laterally on the hyphae, simple or occasionally branched, straight or flexuous, sometimes geniculate, septate, pale brown to brown, smooth, up to 250 µm long, 3-7 µm thick. Conidia are straight or slightly curved, cylindrical to ellipsoidal, with a markedly protuberant hilum at the base, rounded at the apex, and almost always 3-distoseptate, but rarely 1-4 distoseptate (Fig. 54).

(Note: Teleomorph is absent.)

Quick clue. Conidia are cylindrical to ellipsoidal with protuberant hilum at the base.

Importance. Occurrence of *C. harveyi* has been reported only on *Triticum* sp from Australia. This is a new report of its occurrence on sorghum grain in India.

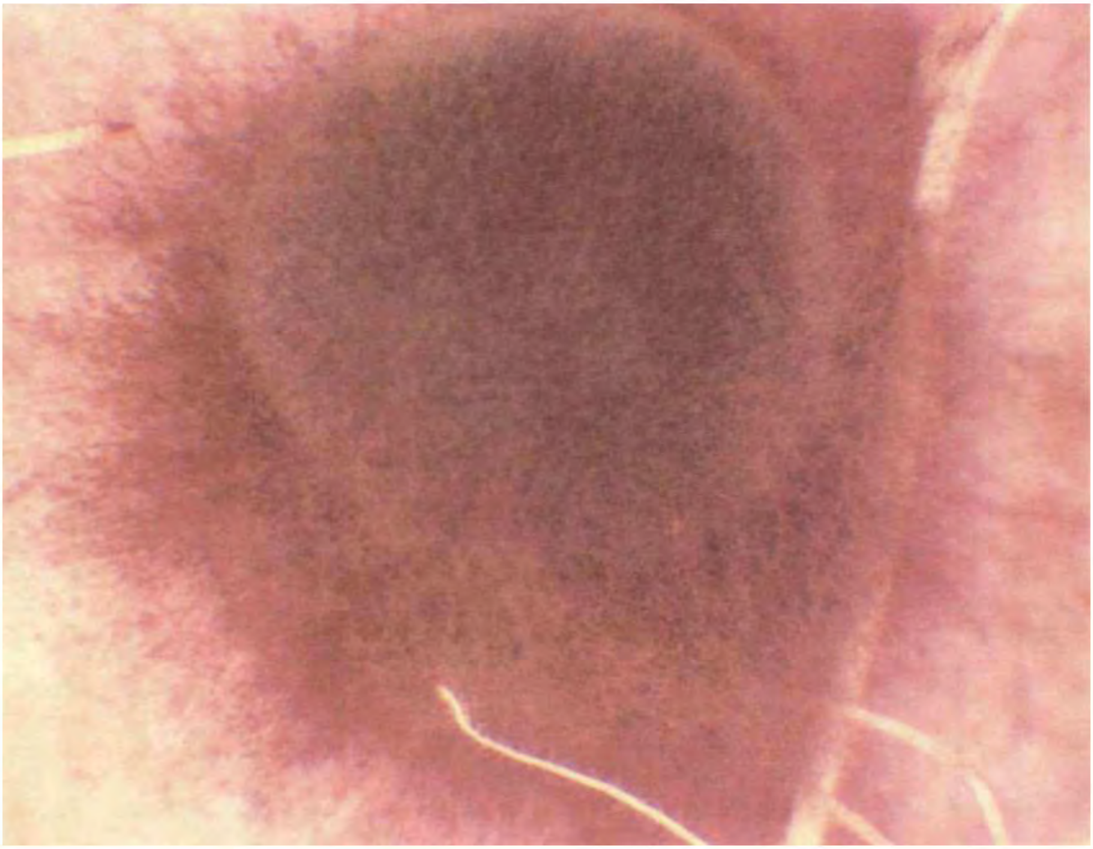

Figure 53 x11

Figure 54 x2508

Curvularia lunata (Wakker) Boedijn

(*Curvularia* species "with" *Cochliobolus* teleomorph)

Teleomorph. *Cochliobolus lunatus* Nelson & Haasis
Pseudocochliobolus pallescens Tsuda & Ueyama
Curvularia leonensis M.B. Ellis

Symptoms on grain. Colony on seed is brown, gray, or black, hairy, cottony or cushion-like and spreads loosely (Fig. 55).

Morphology. Conidiophores arise singly or in groups, simple or rarely branched, straight or sometimes geniculate near the apex, brown to dark brown, multiseptate, variable in length, up to 5-6 µm diameter. Conidia are mostly 3-distoseptate, ellipsoidal to fusiform, or often disproportionately enlarged in the third cell and markedly geniculate or hook-shaped, pale to somewhat colored, almost concolorous, 17-32 x 7-12.5 µm, and smooth (Fig. 56). Conidia are sparse in culture, and variable in shape and size among isolates.

Teleomorph is produced when compatible conidial isolates are paired in Sach's agar media (Tsuda and Ueyama 1983). Ascomata are superficial, globose to subglobose, black, 250-750 x 250-750 µm, with protruding ostiolar beaks, developing from columnar or flat stromata, firmly adhering to the substrate at the base; ostiolar beak 190-690 x 60-160 µm, with a hyaline apex. Asci are vestigial bitunicate, almost cylindrical with a short stalk, 140-215 x 12.5-19.0 µm, produced among the filamentous pseudoparaphyses, arising from the base of the locule. Ascospores are flagelliform or filiform, hyaline, tapering towards either end, 125-215 x 2.5-6.3 µm, 6-13 septate, parallel or coiled in a certain portion of the ascus.

Quick clue. Stromata are very rarely formed; conidia are 18-32 x 8-16 µm, always curved at the third cell.

Importance. *Curvularia lunata* is distributed worldwide especially in the tropics and is frequently encountered as a pathogen or saprophyte. It causes serious losses in the tropical regions but is a minor pathogen in temperate regions. *Curvularia lunata* and *C. lunatus* are known to produce the metabolites brefeldin A, D-mannitol, anthraquinone, cytochalasin B, cynadontin, and radicinol (Bohlmann et al. 1961; Combe et al. 1968; Nukina and Marumo 1976; van Eijk and Roeymans 1977; Wells et al. 1981).

Figure 55 x23

Figure 56 x1815

Curvularia lunata var *aeria* (Bat., Lima, & Vasconcelos) M.B. Ellis

(*Curvularia* species "without" *Cochliobolus* teleomorph)
Malustela aeria Bat., Lima, & Vasconcelos
Curvularia caricae-papayae Srivastava & Bilgrami
Curvularia lycopersici Tandon & Kakkar

Symptoms on grain. Colonies are floccose, brown, dark brown to black, often zonate, showing reverse alternating bands of red, yellow, or gray. Stromata are large, black, cylindrical, simple or branched, formed abundantly on grains (Fig. 57).

Morphology. Conidiophores are terminal and lateral on hyphae and stromata, simple or branched, straight or flexuous, often geniculate, septate, pale brown to brown, smooth, up to 800 µm thick. Conidia are straight to curved, ellipsoidal, obovoid or clavate, often truncate at the scar, almost always 3-distoseptate, rarely 4-distoseptate, with one or more septa sometimes thicker and darker than the others, smooth, with walls often rather thicker, 18-32 x 8-16 µm (Fig. 58). The third cell from base is frequently larger and darker than the others, end cells are usually pale brown, and intermediate cells are brown or dark brown.

(Note: Teleomorph is absent.)

Quick clue. Stromata are large, black, cylindrical, simple or branched, formed abundantly on grains.

Importance. The fungus is distributed worldwide especially in the tropics and is frequently encountered as a pathogen or saprophyte. It causes serious losses in tropical regions but is a minor pathogen in temperate regions. It produces a thermostable toxin (Bisen 1983).

Figure 57 x45

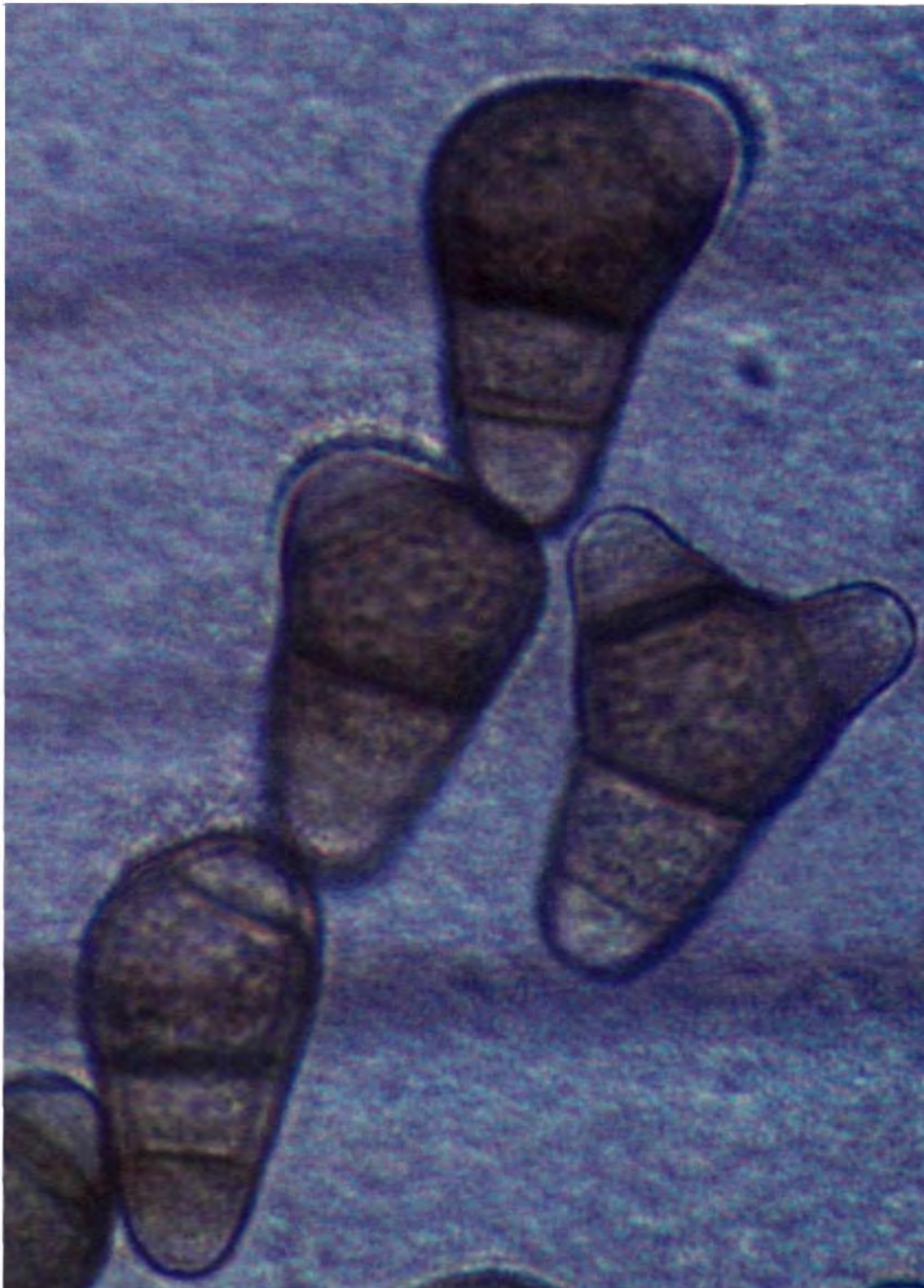

Figure 58

x 2739

Curvularia ovoidea (Hiroe & Watan) Muntanola

(*Curvularia* species "without" *Cochliobolus* teleomorph)
Brachysporium ovoideum Hiroe & Watan

Symptoms on grain. Colonies are circular to irregular, pale brown to dark brown, and velvety. Stromata are not seen (Fig. 59a, b).

Morphology. Conidiophores are straight to flexuous, multiseptate, cylindrical, smooth, pale brown, geniculate above, up to 400 µm long, 4-9 µm thick. Conidia are ovoid, 1-3 distoseptate, straight or curved, 16-29 x 10-17 µm, commonly 20-25 x 13-16 µm, brown with paler end cells (Fig. 60).

(Note: Teleomorph is absent. Tsuda et al. (1985) treated this species as a synonym of *C. lunata.)*

Quick clue. Stromata are absent and often symmetrical conidia are produced.

Importance. Occurrence of *Curvularia ovoidea* on species of *Capsicum, Pennisetum,* and *Zea* has been reported from Egypt, India, and Japan. This is a new report of *C. ovoidea* on sorghum grain from India.

Figure 59a x15

Figure 59b x59

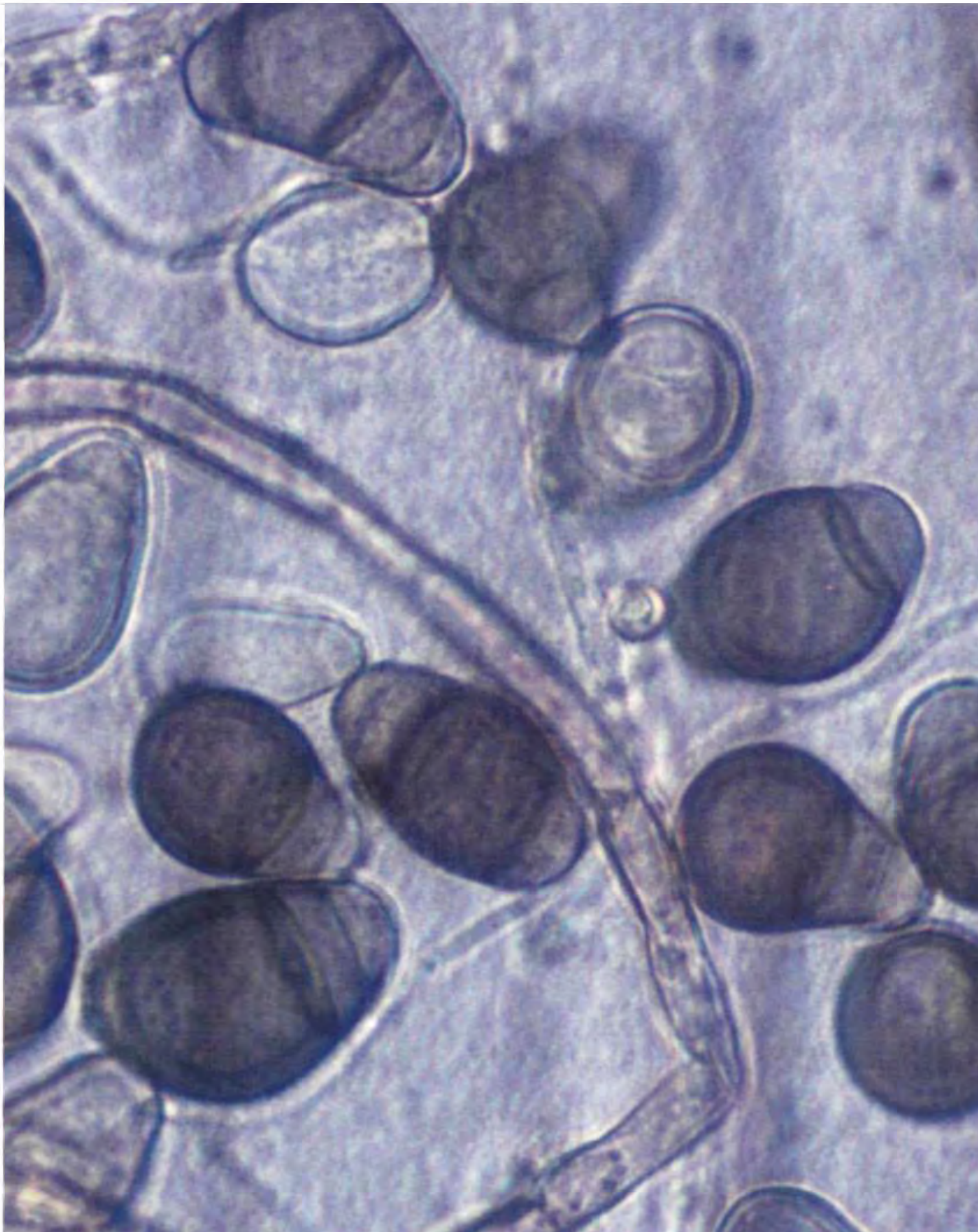

Figure 60 x2277

Curvularia pallescens Boedijn

(*Curvularia* species "with" *Cochliobolus* teleomorph)

Teleomorph. *Cochliobolus pallescens* (Tsuda & Ueyama) Sivan.

Symptoms on grain. Colony on seed is brown, gray, or black, hairy, cottony or cushion-like and spreads loosely (Fig. 61).

Morphology. Conidiophores arise singly or in groups, simple, rarely branched, straight or sometimes geniculate near the apex, brown to dark brown, multiseptate, variable in length, up to 5-6 µm. Conidia are mostly 3-distoseptate, ellipsoidal to fusiform, or often disproportionately enlarged in the third cell, markedly geniculate or hook-shaped, pale to somewhat colored, almost concolorous, 17-32 x 7-12.5 µm, smooth (Fig. 62). Conidia are sparse in culture, and variable in shape and size among isolates.

Ascomata are superficial, globose to subglobose, black, 250-750 x 250-750 µm, with protruding ostiolar beaks, developing from columnar or flat stromata, firmly adhering to the substrate at the base; ostiolar beak 190-690 x 60-160 µm, with a hyaline apex. Asci are vestigial bitunicate, almost cylindrical with a short stalk, 140-215 x 12.5-19.0 µm, among the pseudoparaphyses, arising from the base of the locule. Ascospores are flagelliform or filiform, hyaline, tapering towards either end, 125-215 x 2.5-6.3 µm, 6-13 septate, parallel or coiled in certain portion of the ascus.

Quick clue. Conidia are usually straight or only slightly curved, hook-shaped; all conidial cells are usually pale or very pale brown.

Importance. The fungus is distributed worldwide especially in the tropics and is frequently encountered as a pathogen or saprophyte. It causes serious losses in tropical regions, but is a minor pathogen in temperate regions. The production of an unidentified toxin by this fungus has been reported (Olufolaji 1986).

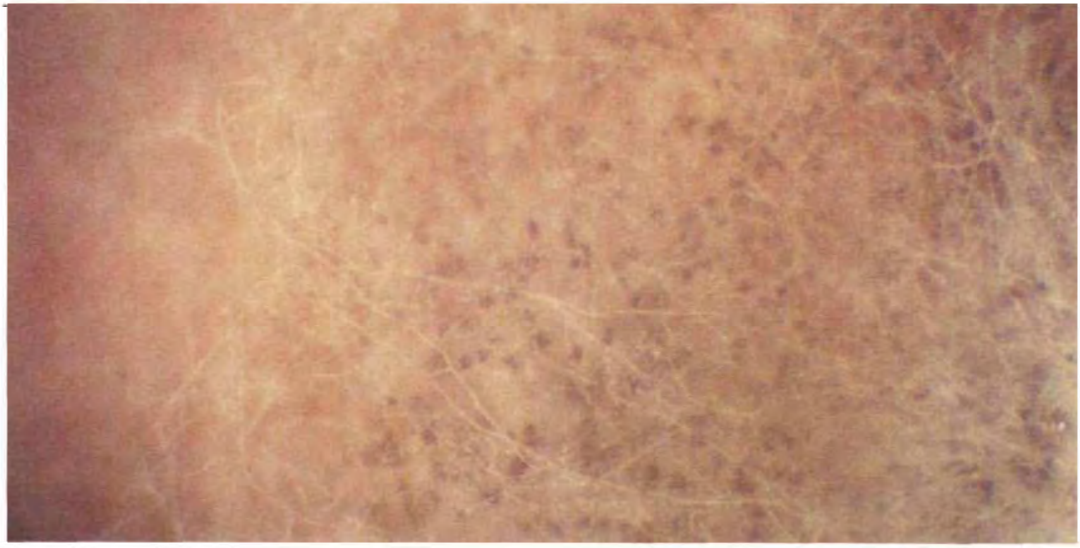

Figure 61 x53

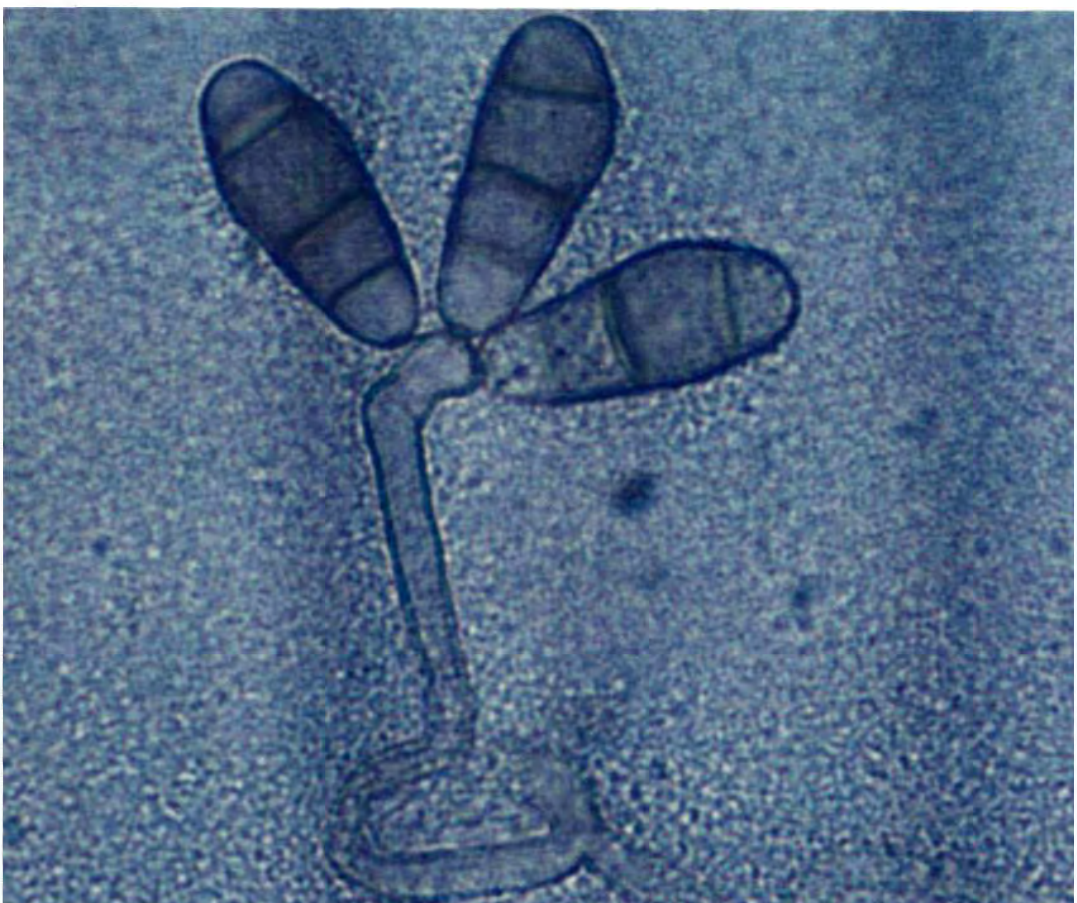

Figure 62 x2079

Curvularia trifolii (Kauffm.) Boedijn

(*Curvularia* species "without" *Cochliobolus* teleomorph)

Symptoms on grain. Colonies are effuse, brown or grayish brown, hairy or dark blackish brown, cottony, sometimes floccose (Fig. 63). Stromata are cylindrical, black, sometimes formed in old cultures.

Morphology. Conidiophores arise singly or in groups, terminally and laterally on the hyphae, simple or branched, straight or flexuous, sometimes geniculate, septate; on natural substrata rather pale brown, seldom up to 150 µm long, with a swollen base of 8-13 u.m, 5-17 µm thick just above the basal swelling, 3-5 µm at the apex; in culture pale brown to brown, smooth or verrucose, up to 400 µm long, 3-8 µm thick. Conidia are 3-distoseptate, smooth, almost always curved at the third cell from the base which is usually larger than the others. The hilum is protuberant, cell at each end is subhyaline or pale brown, intermediate cells are brown or dark brown, and the third cell from the base is often the darkest. On natural substrata conidia are 28-38 (average 33.3) µm long, 12-16 (average 14) µm thick in the broadest part whereas in culture they are 20-34 (average 27.7) µm x 8-14 (average 11.5) µm (Fig. 64).

(Note: Teleomorph is absent.)

Quick clue. Conidia are 3-distoseptate, <40 µm, almost always curved at the third cell from the base which is usually larger than the others.

Importance. The fungus has a wide host range and is distributed widely. It produces 1,4,5,8-tetrahydroxy-2,6-dimethylanthraquinone metabolite (Combe et al. 1968).

Figure 63 x31

Figure 64 x1980

Curvularia tuberculata Jain

(*Curvularia* species "with" *Cochliobolus* teleomorph)

Teleomorph. *Cochliobolus tuberculatus* Sivan.

Symptoms on grain. Colony on seed is brown, gray, or black, hairy, cottony or cushion-like and spreads loosely (Fig. 65).

Morphology. Conidiophores arise singly or in groups, terminal or lateral on hyphae, stromata, and ascomata, simple or branched, straight or flexuous, smooth, pale to mid-brown, septate, up to 300 µm long, 2-7 µm thick. Conidia are straight, ovoid, obclavate or ellipsoidal, 3-5 (sometimes 8, but mostly 3) septate, intermediate cells brown to dark brown, end cells subhyaline to pale or dark brown, mature conidia tuberculate, 23-52 x 13-20 µm (Fig. 66). Young conidia are smooth and subhyaline. First septum in the conidium is usually median, second septum often delimiting the basal cell but variations in septal formation may occur. Germination is both by bipolar and lateral germ tubes.

The species is heterothallic and the teleomorph is obtained by pairing monoconidial compatible isolates (Sivanesan 1985). Ascomata are black, globose, often borne on a columnar basal stroma or a flattened crust, 500-720 µm high, 400-490 µm wide, with a conical truncate beak up to 300 µm high, 115-140 µm wide at the base, often hairy in the globose part with simple, brown, septate hyphae. Conidiophores arise from the globose part of the ascoma but are not formed abundantly. Pseudoparaphyses are hyaline, filiform, and branched above. Asci are cylindrical, short-stalked, with 2-8 spored, vestigial bitunicate, 170-340 x 13.5 µm. The stalk is cylindrical with or without a bifurcate base, with a wall that does not stain in lactophenol cotton blue. Ascospores are filiform, hyaline, helically coiled in the ascus and often straight at one or both ends, commonly tapering at both ends but more so at the base, sometimes with a truncate apex, with hyaline mucilaginous sheath up to 4 µm thick (only visible in water mounts), not constricted, 13-23 distoseptate, 160-460 x 3-4.5 µm.

Quick clue. Conidia are straight, 3-septate, tuberculate (having tubercles) or rough-walled unlike other *Curvularia* species.

Importance. *Curvularia tuberculata* is distributed worldwide especially in the tropics and is frequently encountered as a pathogen or saprophyte. It causes serious losses in tropical regions but is a minor pathogen in temperate regions. The production of an unidentified toxin by this fungus has been reported (Olufolaji 1986). This is a new report of *C. tuberculata* on sorghum grain in India.

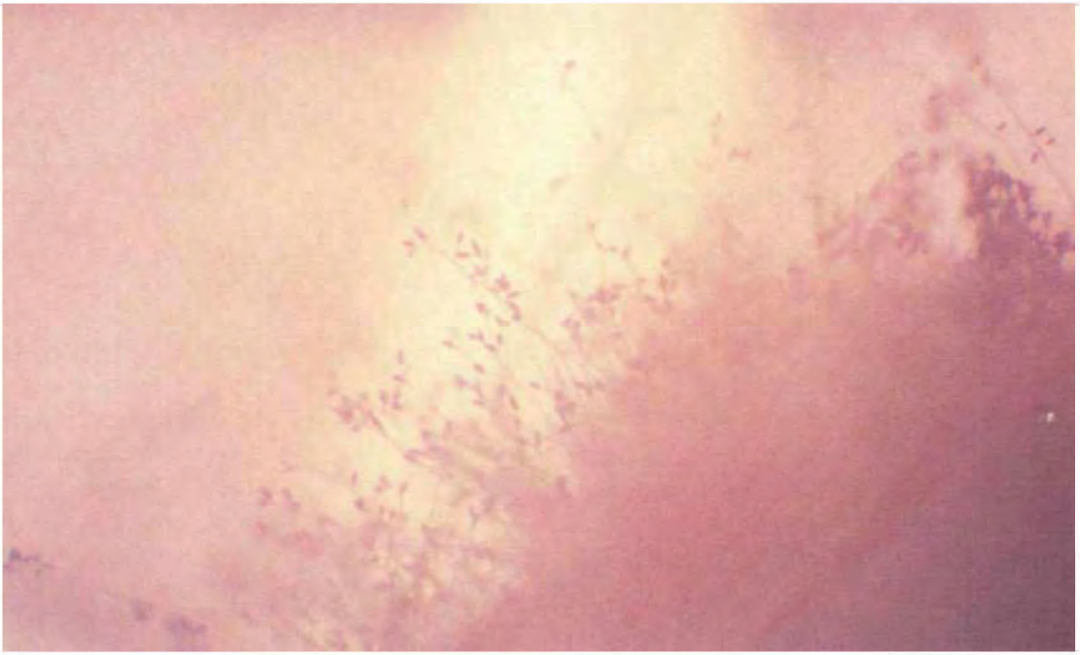

Figure 65 x48

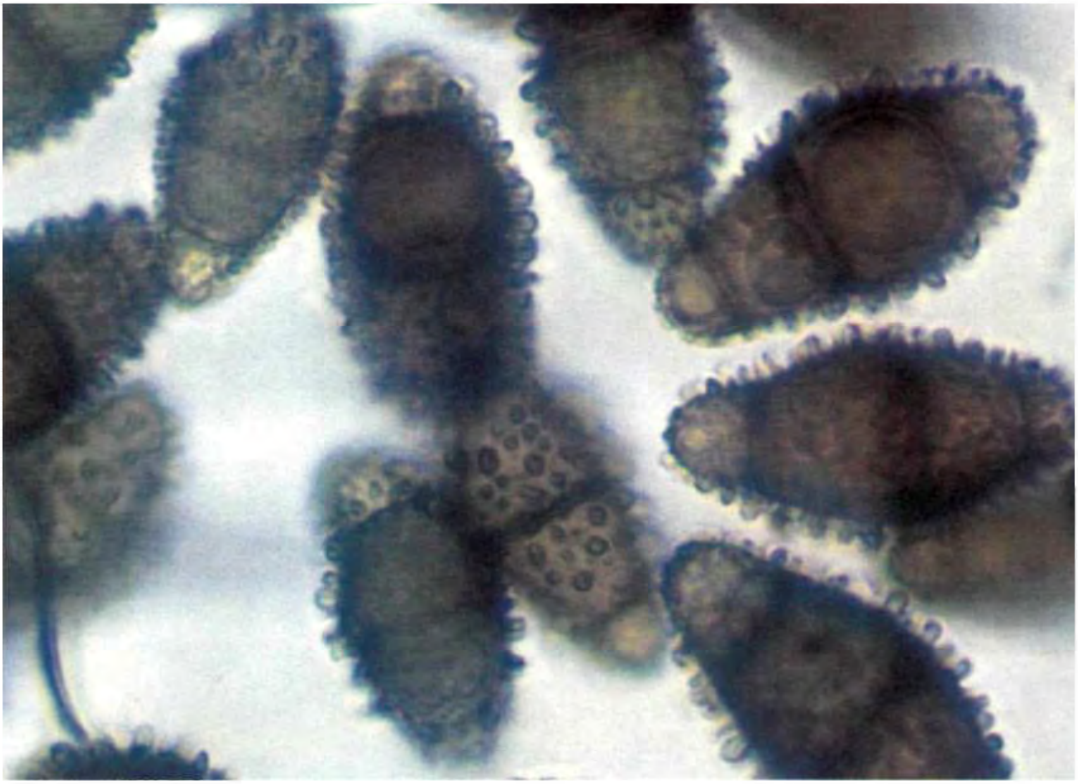

Figure 66 x1650

Epicoccum nigrum Link

Epicoccum purpurascens Ehrenb.

Symptoms on grain. Colony on seed grows rapidly, often producing a yellow, amber to orange, or red/black pigmentation within but particularly surrounding the white, compact mycelium (Fig. 67). Due to these features, the fungus is occasionally confused with *Fusarium* spp and frequently mistaken as Ustilaginales.

(Note: Infected sorghum grains may become red.)

Morphology. *Epicoccum nigrum* is a mitosporic fungus. Conidiophores are compact or occasionally branched, loose, dark, smooth, short, occurring in tight clusters from the hyphae and produce a single, terminal conidium. Mature conidia are dark brown to black, mostly spherical but also pear-shaped, irregularly septate, and may appear to be very coarsely marked like a net. The septa are often hidden by the thick, rough spore wall, which appears to be covered by short, blunt projections. Conidia measure 15-25 µm in diameter and often occur in dark, cushion shaped spore masses of variable size within and on the surface of the mycelium (Fig. 68).

Quick clue. Dark spore masses look like black spots scattered over the mycelium. Individual spores resemble dark, rough soccer balls, and may be confused with spores of smuts and bunts.

Importance. Occurrence of *E. nigrum* on sorghum grains has been reported along with method(s) to kill the fungus adhering to the grains for safe use of grains for consumption (Navi et al. 1997). The fungus is distributed worldwide. It is a common saprophyte and secondary invader. Its quarantine importance is not known. Unidentified toxins have been isolated from this fungus (Schol-Schwarz 1959).

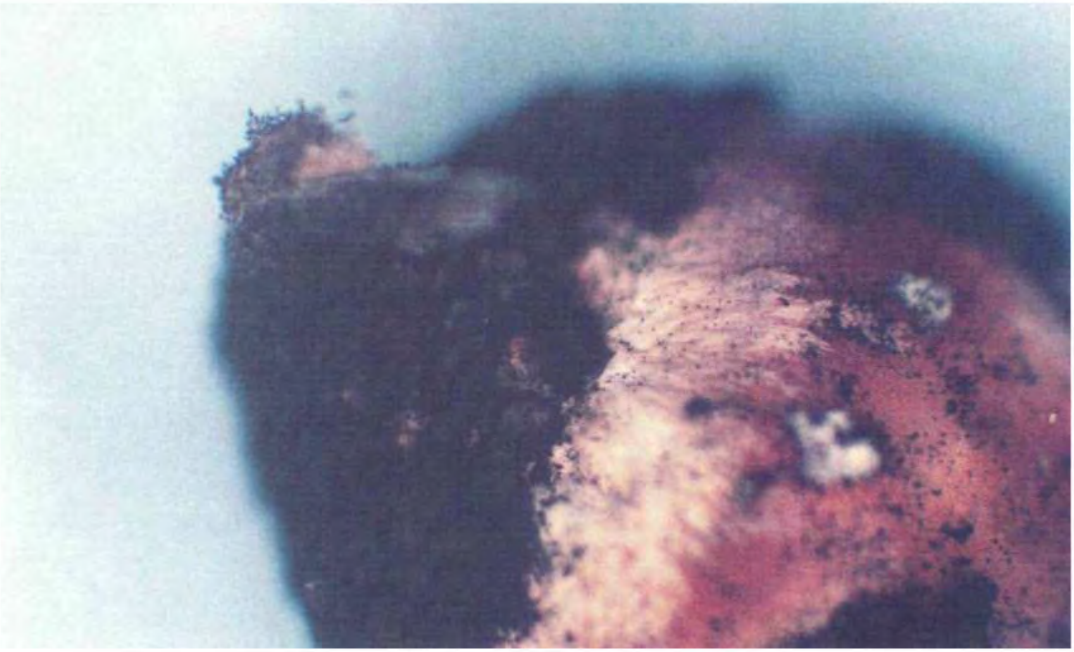

Figure 67 x21

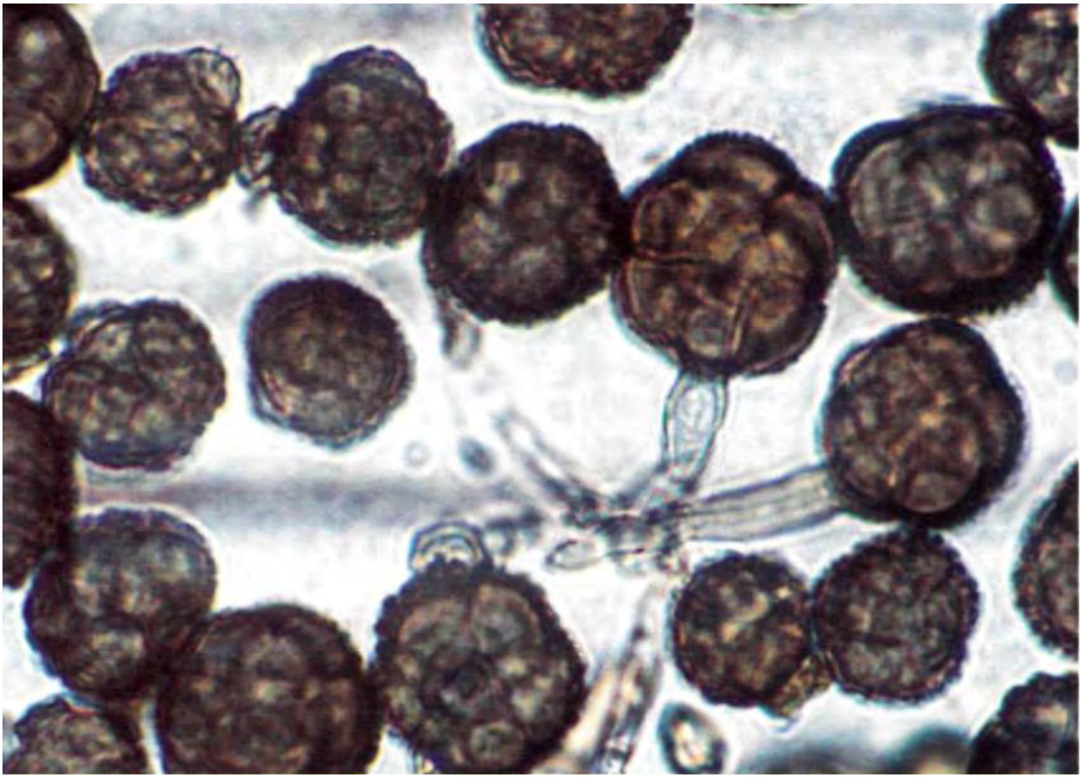

Figure 68 x1452

Exserohilum rostratum (Drechsler) Leonard & Suggs

Helminthosporium rostratum Drechsler
Drechslera rostrata (Drechsler) Richardson & Fraser
Bipolaris rostrata (Drechsler) Shoemaker

Teleomorph. *Setosphaeria rostrata* Leonard

Symptoms on grain. Colony on seed appears mid- to dark brown or golden brown with very little white, aerial mycelium. Conidiophores are formed together in a dense mat covering the seed. Infected sorghum grains show pink discoloration or are charcoal black when severely colonized (Fig. 69).

Morphology. Conidiophores are solitary or in groups, straight or bending, mid- to dark brown or olive brown, up to 200 µm long and 8 µm thick. Conidia are straight or slightly curved, tapering at both ends with one end typically wider, and the narrow end terminating in a pronounced beak. Conidia have golden brown intermediate cells, 6-16 transverse septa, hyaline or pale end cells with a thick dark septum, and measure 40-180 x 14-22 µm (Fig. 70).

Ascocarps are spherical, black, 340-600 x 330-580 µm, with pore opening and upper part surrounded with dark brown, blunt spine-like projections. Asci have a slimy sheath and are short-stalked, club-shaped to cylindrical, 1-8 spored, and measure 105-260 x 26-42 µm. Ascospores are hyaline to pale brown, straight to curved, 2-5 septate, narrowed at septa, 29-85 x 9-21 µm.

Quick clue. Conidia have a distinctive shape and are straight or slightly curved, with a pronounced beak, and visible, dark, end septa.

Importance. Infected sorghum grains show pink discoloration or are charcoal black when severely colonized. *Exserohilum rostratum* causes leaf blight of sorghum and produces glyceollin toxin (Kumar et al. 1984) and cynodontin toxin (van Eijk and Roeymans 1977).

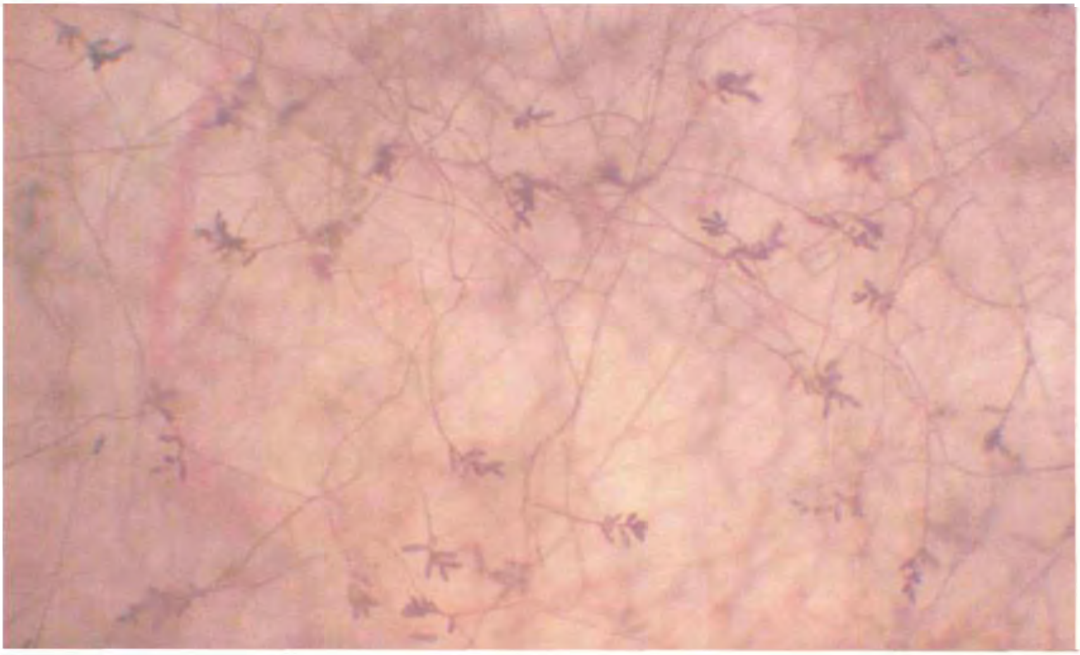

Figure 69 x48

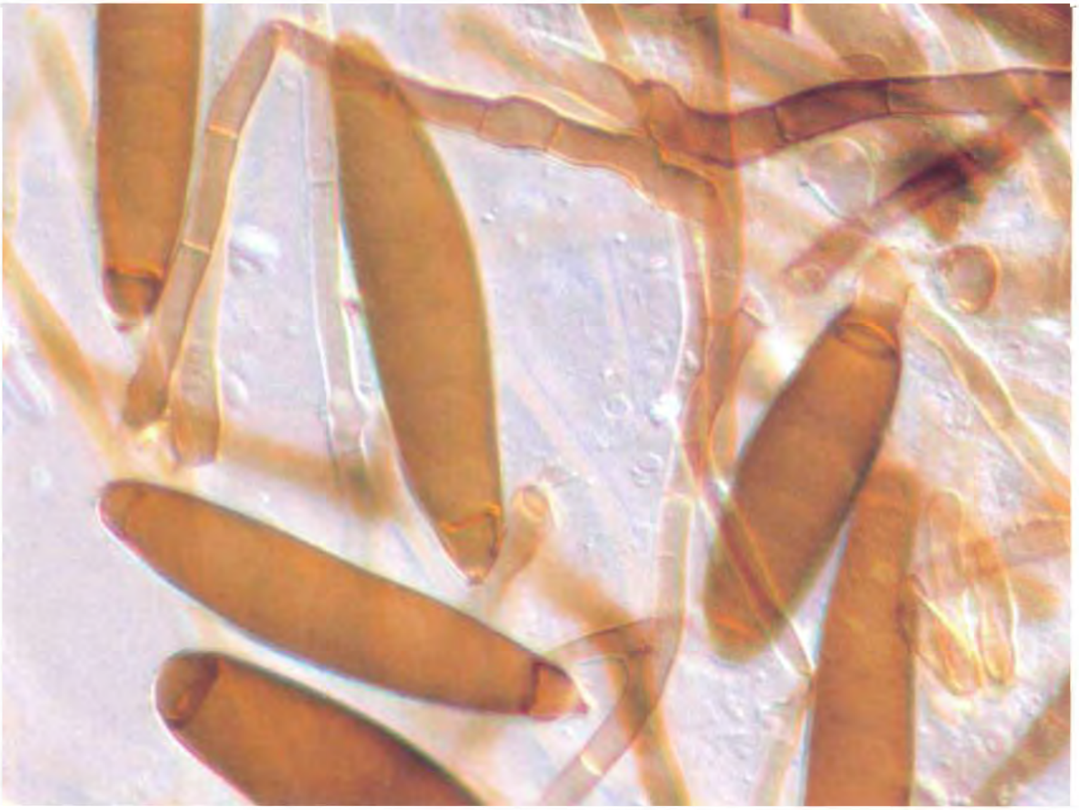

Figure 70 x729

Exserohilum turcicum (Pass.) Leonard & Suggs

Helminthosporium turcicum Pass.
Drechslera turcica (Pass.) Subram. & Jain
Helminthosporium inconspicuum Cooke & Ellis

Teleomorph. *Setosphaeria turcica* (Luttrell) Leonard & Suggs

Symptoms on grain. Colony on seed is pale to mid-dark brown with very little white, aerial mycelium (Fig. 71a, b).

Morphology. Conidiophores are single or in groups of 2-6, straight or bent, light to dark olive brown, medium to long, sometimes very long, and measure 150-300 x 7-11 µm. Conidia are straight or slightly curved, club-shaped or widest near the middle, tapering towards the ends, with a rounded apex, and basal cell swollen at the point of attachment. Conidia are pale to mid-straw colored or yellowish brown or olive gray in color, 4-9 septate, and 50-144 x 18-33 µm (Fig. 72).

(Note: Perithecia rarely occur in nature.)

Quick clue. Conidia arise from long conidiophores and are large, yellowish brown, straight, or slightly curved, narrowing towards both ends (almost cigar shaped), with the basal cell bulging at the point of attachment.

Importance. The fungus is distributed worldwide but predominantly in subtropical to temperate climates. There are quarantine restrictions for some countries. Mycotoxins produced by this fungus are monocerin, ophiobolin A (Ishibashi 1961; Nozoe et al. 1965; Canonica et al. 1966; Robeson and Strobel 1982), and ravenelin (Raistrick et al. 1936).

Figure 71a x72

Figure 71b x237

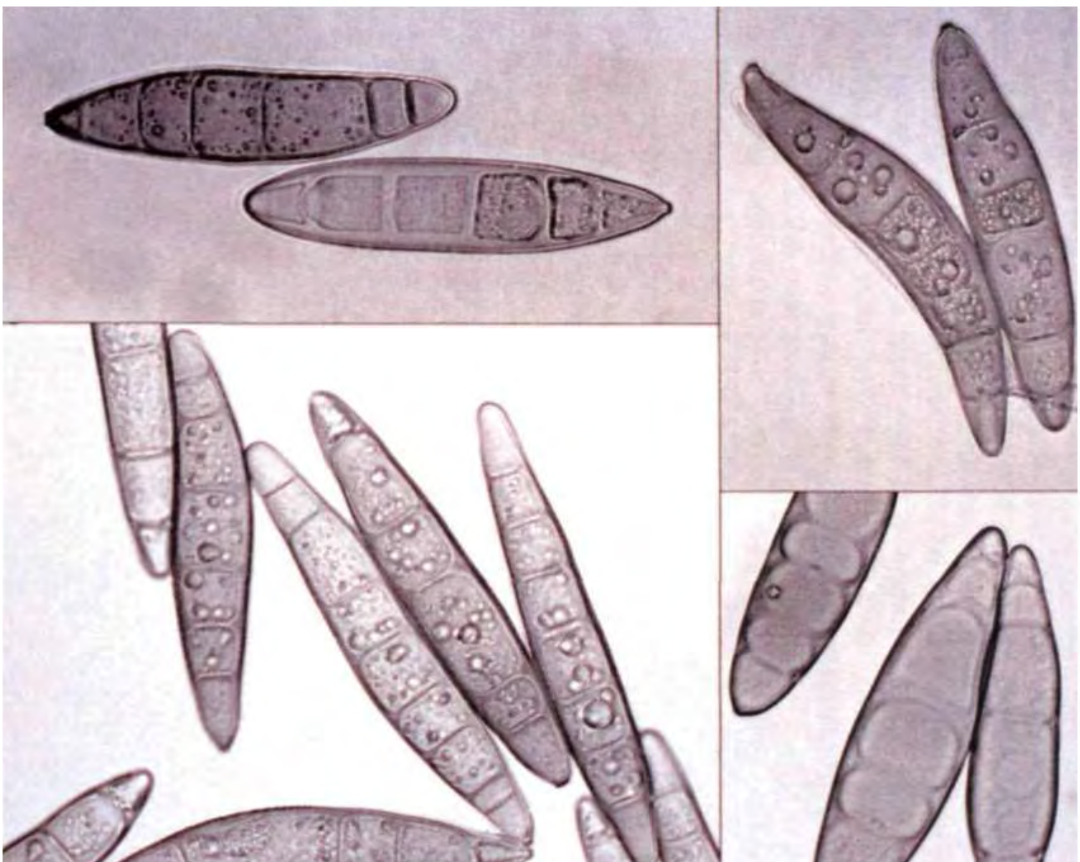

Figure 72 x2706

Fusarium moniliforme J. Sheld. Lisea fujikuroi Sawada

Fusarium verticilloides (Sacc.) Nirenberg

Teleomorph. *Gibberella fujikuroi* (Sawada) Ito
Gibberella moniliforme Wineland

Symptoms on grain. Colony on grain grows rapidly with white aerial mycelium often becoming tinged with purple, particularly on the blotting paper in the petri dish. Mycelium has a powdery appearance due to the presence of chains of microconidia. Tan to orange spore masses of irregular shape and size are occasionally present (Fig. 73).

Morphology. Abundant microconidia are formed. They are hyaline, usually one-celled but occasionally two-celled, 5-12 x 1-3 µm, oval to club-shaped, and slightly flattened at each end (Fig. 74). Macroconidia are formed infrequently. They are hyaline, delicate with thin walls, curved to almost straight, 3-7 septate, 25-60 x 2-4 µm, and have a foot-shaped basal cell (Fig. 74). Chlamydospores are never present in the mycelium or conidia.

Perithecia, which occur rarely, are spherical, blue-black, and 250-350 x 220-300 µm. Asci are oval to club-shaped with 4-8 ascospores. Ascospores are hyaline, straight, mostly one-septate, and measure 4-7 x 12-17 µm.

Quick clue. Abundant uniform microconidia are formed in long chains that can readily be observed using the scotch-tape method (see Appendix 1) under the microscope at low power (X100). Chlamydospores are never formed.

Importance. The fungus produces the mycotoxin fumonisin which is toxic to humans and livestock when heavily infected grain is consumed. It is widespread in both humid and sub-humid, temperate zones and subtropical and tropical zones. There are quarantine restrictions for this fungus in Egypt.

Figure 73 x12

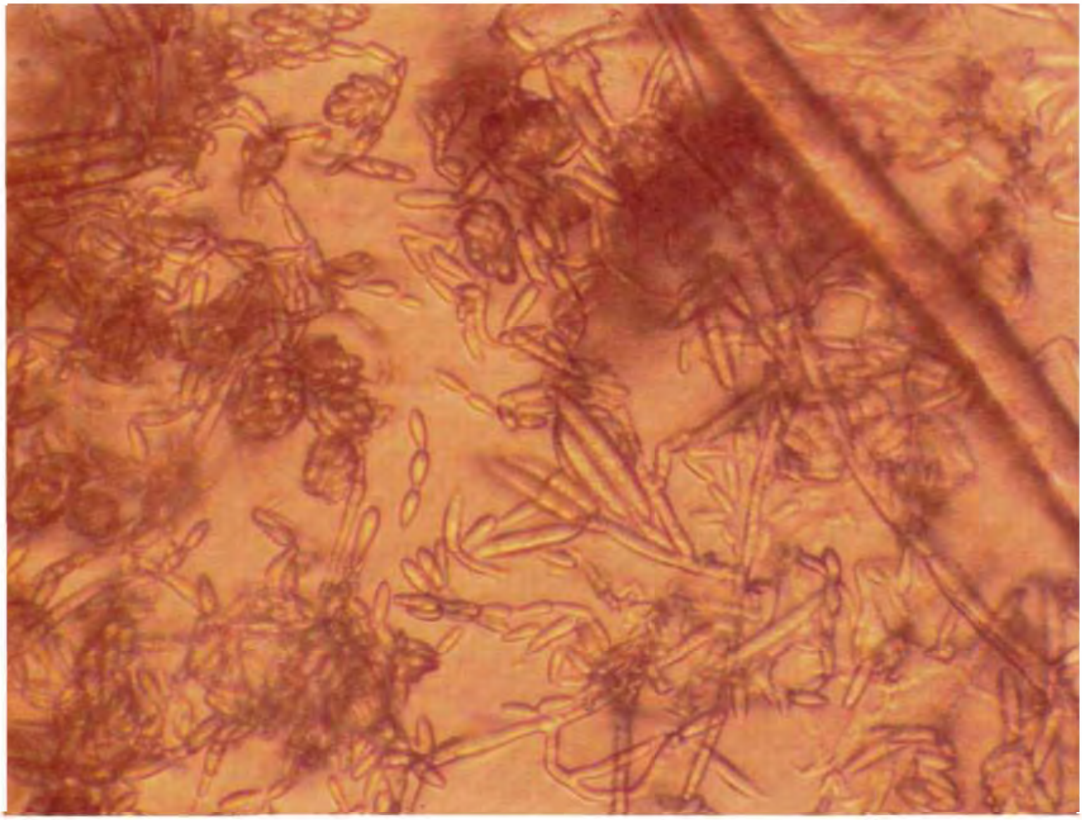

Figure 74 x594

Fusarium semitectum Berk. & Rav. [W&R, G,B,J]

Fusarium roseum LK. emend. Snyd. & Hans. Pro Parte [S&H]
Fusarium roseum LK. emend. Snyd. & Hans. var *arthrosporioides* (Sherb) Messiaen & Cassini Pro Parte [M&C]

Teleomorph. Not known.

Symptoms on grain. Colony on grain is pink or orange in color and often turns white (Fig. 75).

Morphology. Microconidia are rarely produced. However, two types of macroconidia are produced. Some are borne on mycelium and are spindle-shaped, straight to slightly curved. The other type are sickle-shaped and are borne in sporodochia. These are slightly curved, with a foot-shaped basal cell. Conidiophores are unbranched and monophialides and polyphialides are branched (Fig. 76).

Quick clue. Polyphialides are present in the aerial mycelium and spindle-shaped macroconidia are produced in the aerial mycelium.

Importance. *Fusarium semitectum* has been reported to be toxigenic (Nelson et al. 1983).

Figure 75 x25

Figure 76 x600

Gloecercospora sorghi Bain & Edgerton ex Deighton

Symptoms on grain. Black, shiny, spindle or irregular shaped sclerotia, about 0.1-0.2 mm diameter are seen on infected grains. The sclerotia are embedded in the pericarp, and often become errumpent by rupturing it (Fig. 77).

Morphology. The fungus produces dark brown to charcoal black sclerotia, and pink to reddish orange sporodochia. Sometimes only sclerotia are produced. Mycelium is scanty or abundant, white to dull white, thin, and branched. Sporodochia are pink to salmon pink and are visible to the naked eye. Each sporodochium consists of numerous hyaline conidiophores and conidia that can be seen under a compound microscope. Conidiophores are hyaline, branched or unbranched, septate, short, 5-10 μm long, with a somewhat swollen apex. Conidia are borne in a pinkish, slimy matrix, and are hyaline, elongate to filiform, 1.4-3.2 x 20-195 μm, and septate (Fig. 78).

Quick clue. Dark brown to charcoal black sclerotia, and pink to reddish orange sporodochia are seen on the grain. Hyaline, elongate to filiform conidia are produced in a slimy matrix.

Importance. The fungus is widely distributed. It causes grain discoloration and also zonate leaf spot of sorghum.

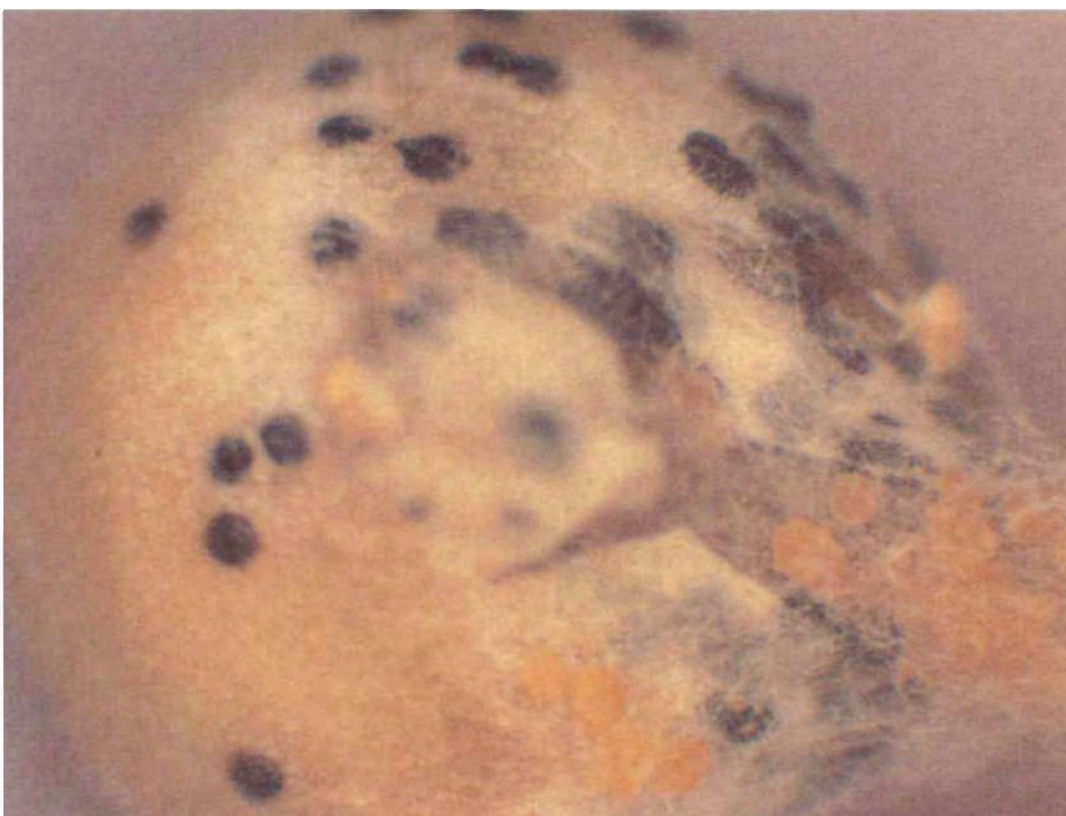

Figure 77 x27

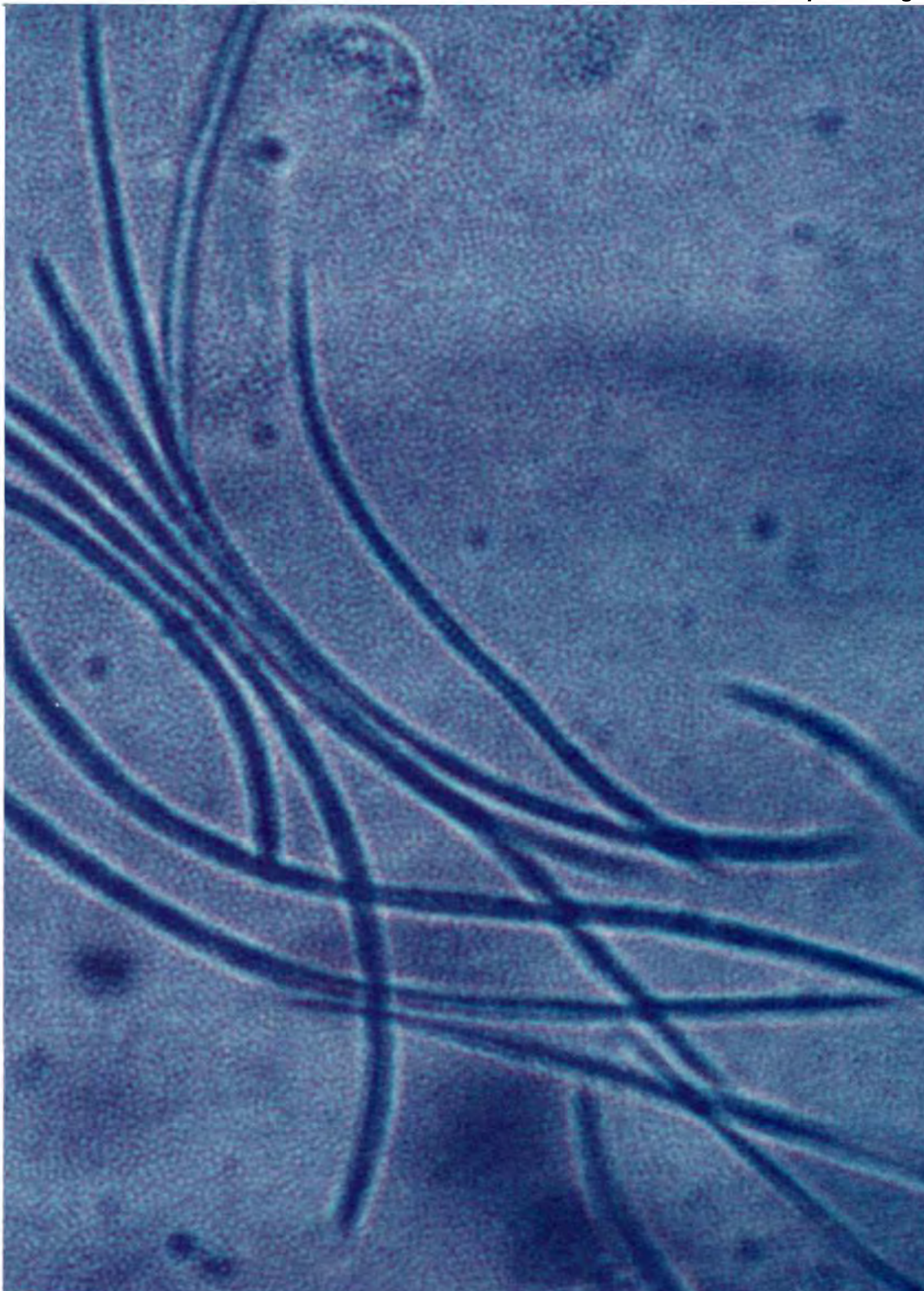

Figure 78

x1452

Gonatobotrys simplex Corda

Gonatobotrys zeae Futrell & Bain (nomen nudum)

Symptoms on grain. Colony on seed is white and usually on the surface of other fungal species, e.g., *Alternaria, Cladosporium, Curvularia,* and *Fusarium* (Fig. 79a,). Mycelium appears as a mass of strings with clusters of "flower-like" bunches of conidia (Fig. 79b).

Morphology. Conidiophores are erect, sometimes tall, septate, simple or occasionally branched, with inflated cells covered with a series of blunt teeth bearing conidia, inserted at intervals and terminally on the hyphae. Conidia are borne singly on the blunt teeth. They are 1-celled, hyaline, oval to subspherical, and measure 10-22 x 6-12 µm (Fig. 80).

Quick clue. *Gonatobotrys simplex* is distinguished by the cluster of large, hyaline, conidia arising from "nodes" along the length of the conidiophores, and appearing like a "string of beads".

Importance. *Gonatobotrys simplex* has worldwide distribution. Its quarantine significance is not known. It is a parasite on *Alternaria* spp and *Cladosporium* spp (Whaley and Barnett 1963).

Figure 79a x45

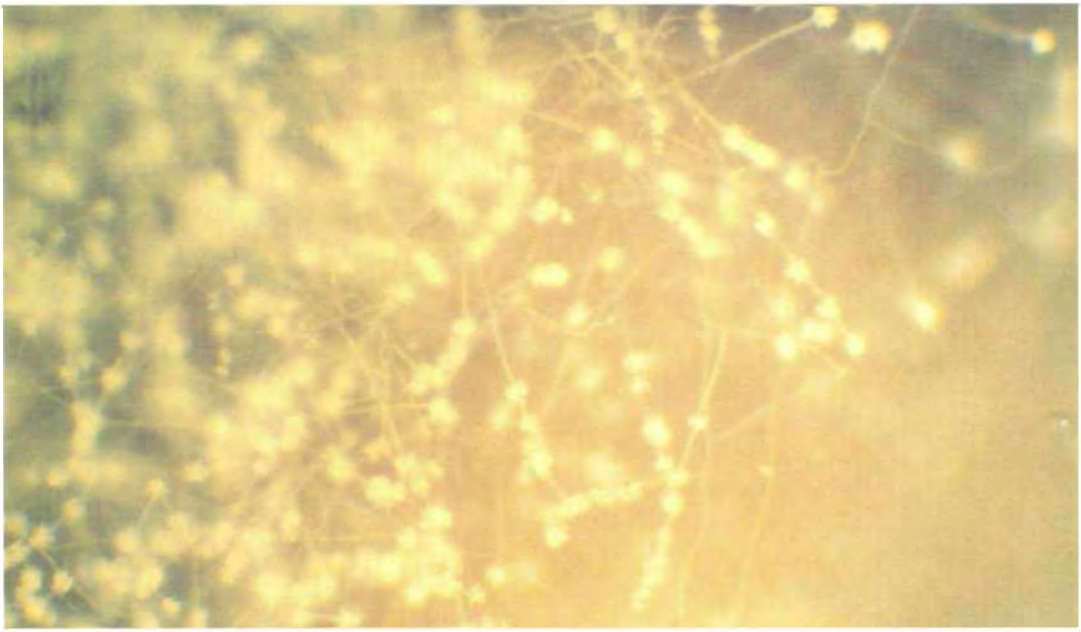

Figure 79b x58

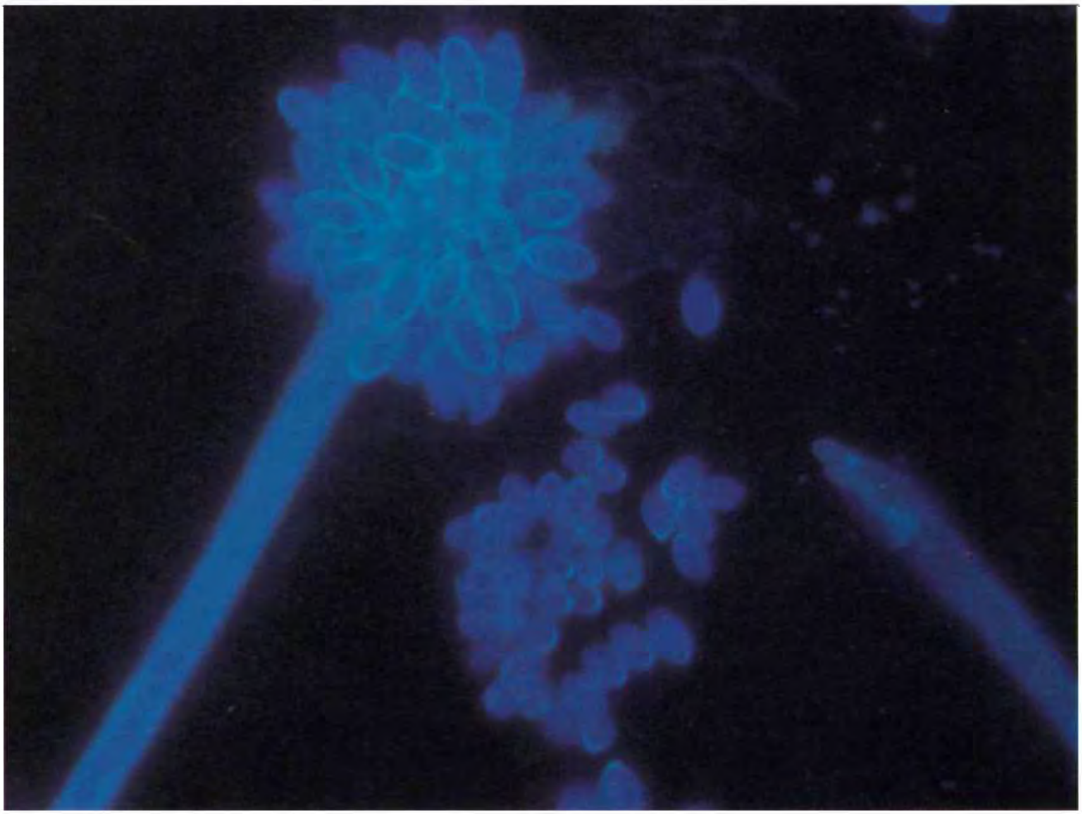

Figure 80 x2211

Nigrospora oryzae (Berk. & Br.) Petch

Teleomorph. *Khuskia oryzae* Hudson

Symptoms on grain. Colony on seed is initially white and the shiny, black conidia standing out in sharp contrast give the colonies a striking appearance under the binocular dissecting microscope (Fig. 81). In older cultures the hyphae darken and the colonies appear black, with profuse conidial production.

(Note: Infected seeds have white streaks with black spore masses near the tips.)

Morphology. Conidiophores are short, pale brown, inflated and borne at right angles to hyphae, bearing conidia singly and terminally. Conidia are smoky brown or jet black, spherical or egg-shaped, 10-16 x 10-13 µm, and commonly measure 12-14 µm in diameter (Fig. 82).

Perithecia are formed in clusters of 1-7 in series or irregular rows, up to 2 µm long. They are spherical or oval and up to 250 µm in diameter with protruding pore openings. Asci are short-stalked, club-shaped, and measure 55-75 x 8-12 µm, with 8 ascospores. Ascospores are hyaline, granular, curved, 16-21 x 5-7 µm, and tapering to the base with rounded ends. They are initially one-celled but after discharge from the ascus may develop a single transverse septum dividing the spore unequally into two cells.

Quick clue. Very dark conidia, slightly longer in the horizontal axis are borne on very short, pale brown conidiophores with a characteristic bulge.

Importance. The fungus is distributed worldwide. It occurs commonly on *Oryza* spp and maize but there are reports of isolation from air and soil (Hudson 1983). It is a new report on sorghum grain from India. *Nigrospora oryzae* produces aphidicolin metabolite (Startratt and Loschiavo 1974).

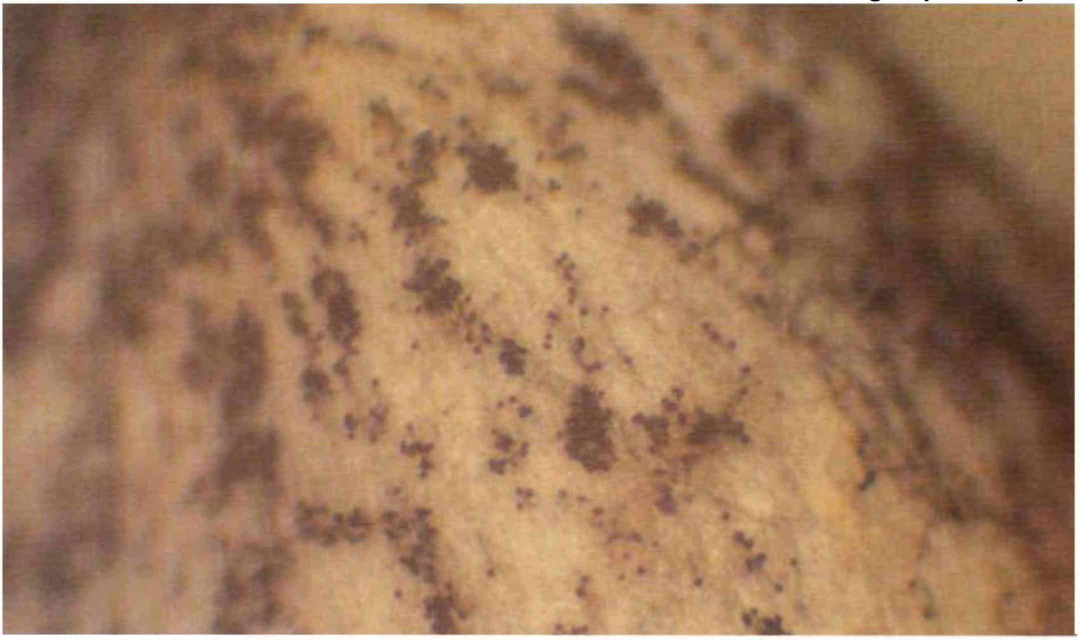

Figure 81 x46

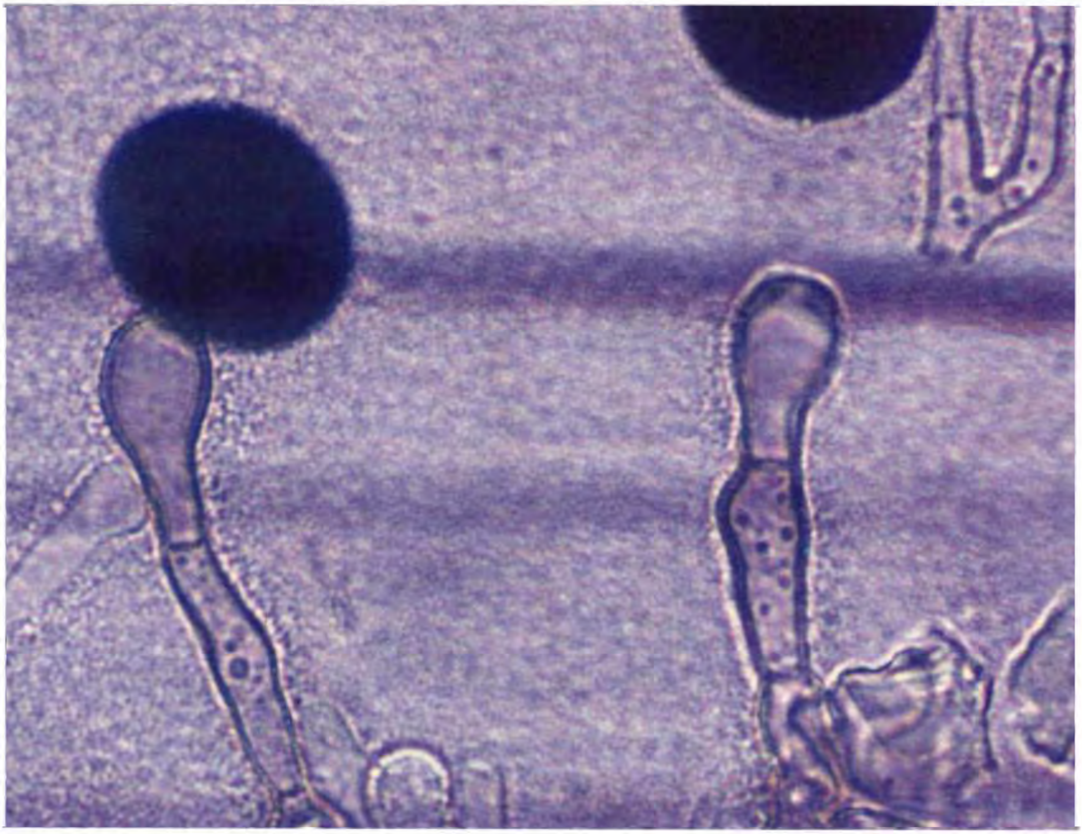

Figure 82 x1485

Penicillium citrinum Thorn.

Symptoms on grain. The fungus is readily recognized by its penicilli, which consist of 3-5 divergent and usually vesiculate metulae, bearing long, well-defined columns of conidia. Colonies are often dominated by copious, clear to yellow or brown exudate at the centers (Fig. 83). On malt extract agar, the growth is slower and usually dense, with heavy conidial production.

[Note: Lactofuchsin stain was used for microscopical observations (Carmichael 1955) (see Appendex 1).]

Morphology. Conidiophores are borne from subsurface or surface hyphae, with stipes 100-300 µm long, smooth walled, characteristically terminating in well defined verticils of 3-5 divergent metulae, less commonly with a divergent ramus, or subterminal or intercalary metulae. Metulae are usually of uniform length, 12-15 µm long, commonly spathulate or terminally vesiculate, up to 5 µm diameter; phialides are ampulliform, 7-8 (sometimes 12) µm long. Conidia are spherical to subspheroidal, 2.2-3.0 µm with walls smooth or very finely roughened, typically borne in long, well defined columns, one per metula, arranged in a characteristic whorl on each conidiophore (Fig. 84).

Quick clue. *Penicillium citrinum* is an isolated species. Occasionally isolates show a few characteristics suggesting a relationship to *P. corylophilum* Dierckx, i.e., faster growth on malt extract agar and metulae of unequal length.

Importance. Like several other *Penicillium* metabolites, citrinin produced by *P. citrinum* is known to be a potentially hazardous mycotoxin. Citrinin causes watery diarrhoea, increased food consumption, and reduced weight gain due to kidney degeneration in chickens, ducklings, and turkeys. The effect of citrinin on humans is not documented. However, kidney damage appears to be a likely result of prolonged ingestion. *Penicillium citrinum* may well be one of the most common eukaryotic life forms of earth. It is ubiquitous in soil, decaying vegetation, and the air. It is also a powerful biodeteriogen, commonly causing decay and losses in foods, textiles, paints, and plastics (Pitt 1991).

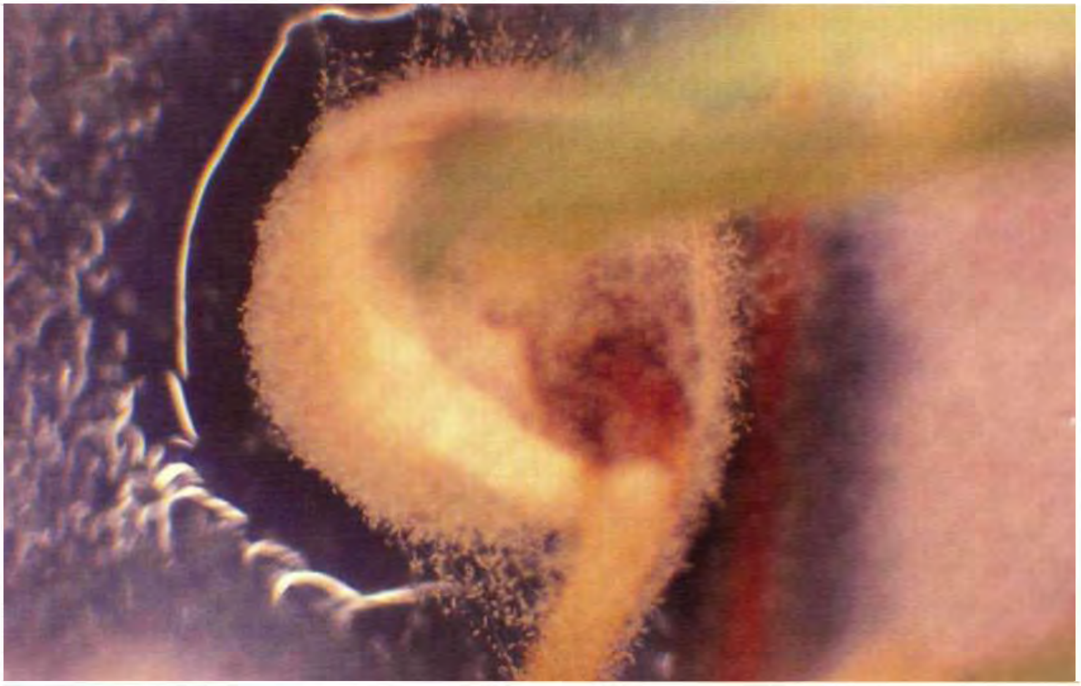

Figure 83 x20

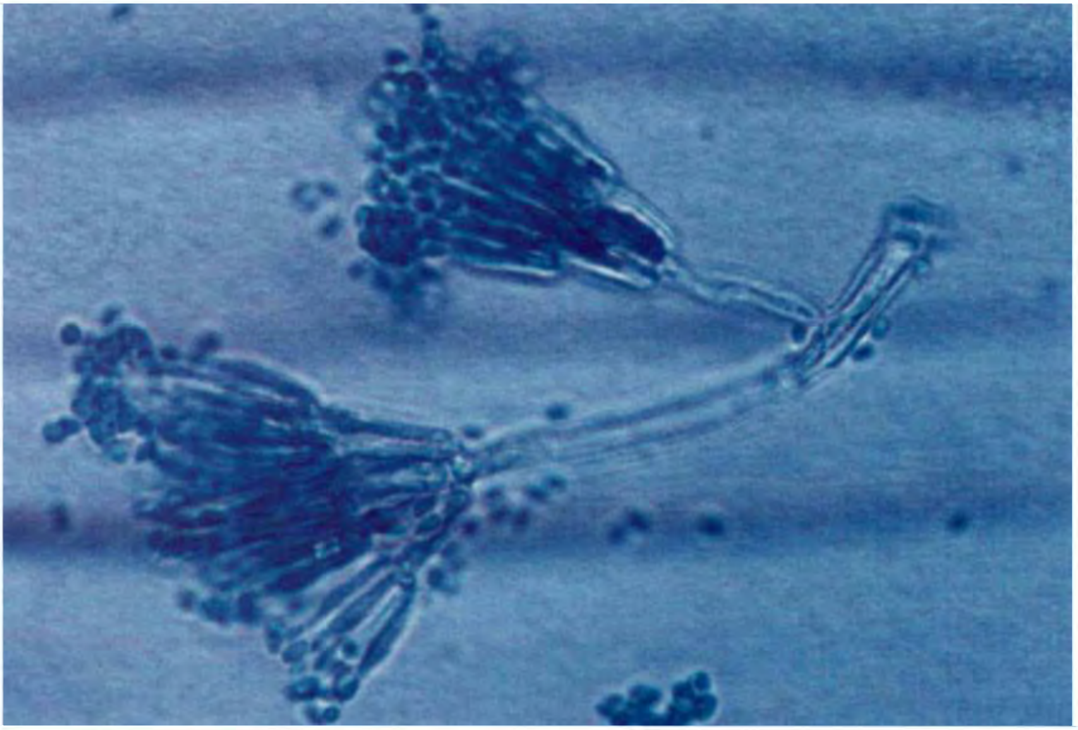

Figure 84 x1683

Penicillium griseofulvum Dierckx

Penicillium palulem Bainier
Penicillium urticae Bainier

Symptoms on grain. The fungus produces very short phialides and it bears them on highly branched conidiophores. Colonies on Czapek yeast extract agar and malt extract agar are gray with only weak greenish overtones; and surface texture is fasciculate to minutely coremial.

Morphology. Conidiophores are borne in fascicles, with stipes of indeterminate length, often sinuous, smooth walled, brownish, terminating in distinctive penicilli, sometimes terverticillate, more commonly a quaterverticillate, and not infrequently with 5 or even more branch points between stipe and phialide; rami are 15-25 (sometimes 30) µm long and ramuli are 10-15 µm long. Metulae are 7-10 µm long, sometimes apically inflated; phialides are ampulliform, closely packed, exceptionally short, 4.5-6.0 µm, abruptly tapering to short collula. Conidia are ellipsoidal, 3.0-3.5 µm long, smooth walled, borne in closely packed, disordered chains.

[Note: Lactofuchsin stain was used for microscopical observations (Carmichael 1955) (see Appendix 1).]

Quick clue. The fungus is a stable species, with little isolate to isolate variation. *Penicillium griseofulvum* has several features which set it apart from the other species, especially the highly branched conidiophores, brown walled stipes, and very short phialides. It may provide a link with the genus *Nomuraea.*

Importance. *Penicillium griseofulvum* is a very commonly occurring species, with worldwide distribution. It plays a major role in the decay of vegetation, and of seeds (cereals), food, and feed. The fungus produces the antibiotic griseofulvin (Pitt 1991) and the mycotoxins patulin, cyclopiazonic acid, and roquefortine C.

(Note: Figures could not be reproduced due to technical reasons.)

Periconia macrospinosa Lefebvre & A.G. Johnson

Symptoms on grain. Colonies are effuse, gray, brown, and hairy. The mycelium is mostly immersed but sometimes partly superficial (Fig. 85).

Figure 85 x53

Morphology. Conidiophores are very dark brown, up to 420 µm long, 7-12 µm thick at the base, and 6-10 µm immediately below the head (Fig. 86a). Conidia are 18-35 µm in diameter, coarsely echinulate; the spines are 2-7 µm long and sometimes adhere closely to one another in groups (Fig. 86b).

Quick clue. Conidia are echinulated.

Importance. *Periconia macrospinosa* has been isolated from species of *Chenopodium, Prunus, Trifolium,* and *Triticum* and soil in Australia, Canada, Europe, Hong Kong, India, Iraq, and USA (Ellis 1971). However, this is a new report of its occurrence on sorghum grain in India.

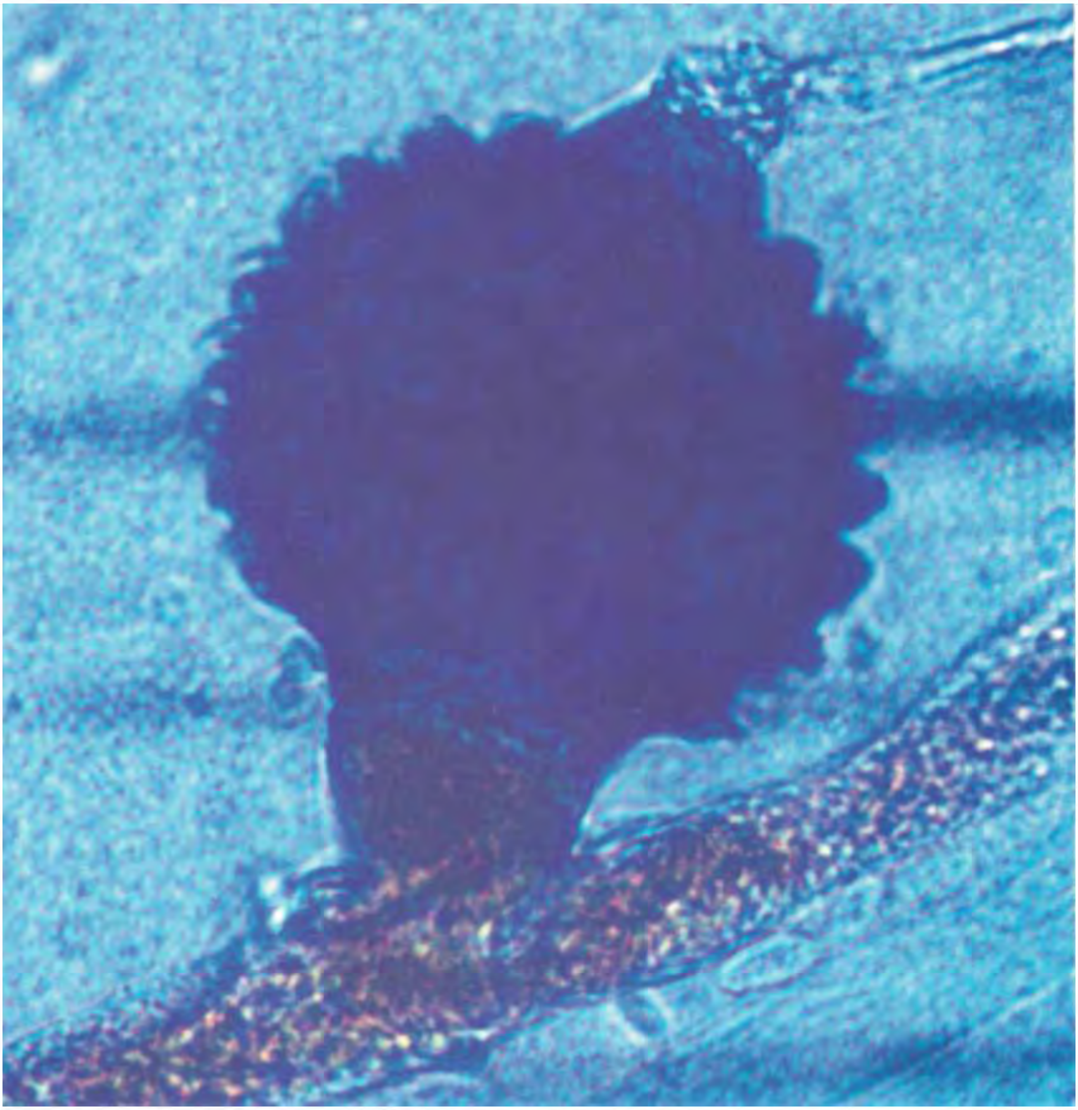

Figure 86a x3531

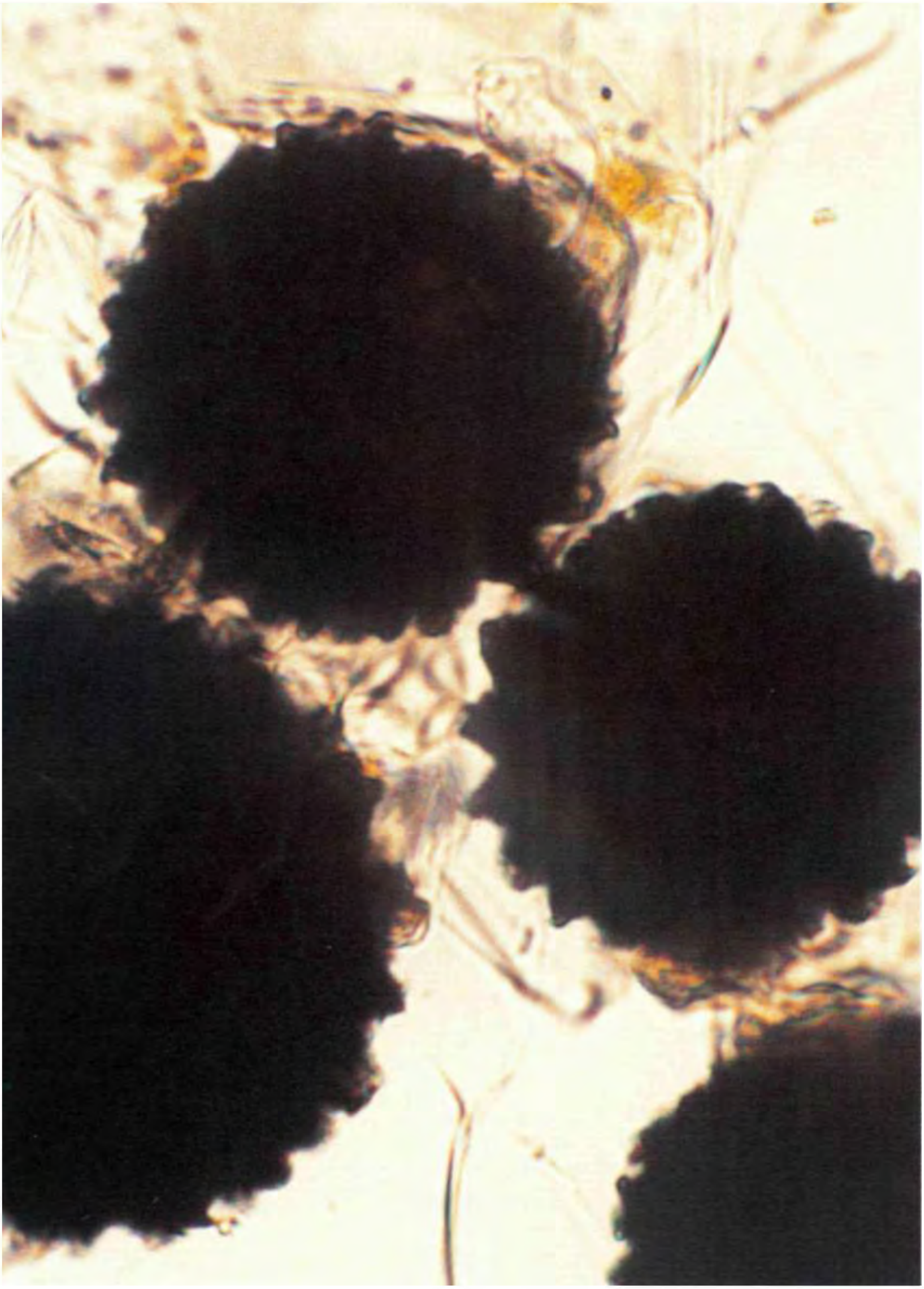

Figure 86b x3531

Phoma sorghina (Sacc.) Boerema, Dorenbosch, & van Kesteren

Phoma insidiosa Tassi

Symptoms on grain. Colony on seed has very little white or gray mycelium but produces large numbers of dark brown or black pycnidia on seed surface or on the blotting paper in the petri dish. Grains with large number of pycnidia appear shrivelled (Fig. 87).

Morphology. Pycnidia are almost spherical, dark brown, thin-walled, and variable in size (100-300 μm diameter), with one conspicuous protruding pore opening. Conidia are released from the pycnidia in the form of a creamy colored curved tendril (Fig. 88a). Conidia are unicellular, oblong to oval, hyaline, and measure 5-8 x 2-4 μm (Fig. 88b).

Quick clue. Spherical, dark brown pycnidia release unicellular, hyaline conidia through a pronounced pore opening in the form of a curved tendril. The pycnidia of *Phoma* species often develop in compact colonies and produce spores profusely. Unicellular conidia distinguish *Phoma* species from the pycnidial fungi of the *Septoria* complex.

Importance. The fungus is distributed worldwide. It occurs as a pathogen after prolonged periods of humid weather. It is frequently observed as a secondary invader. It produces tenuaronic acid.

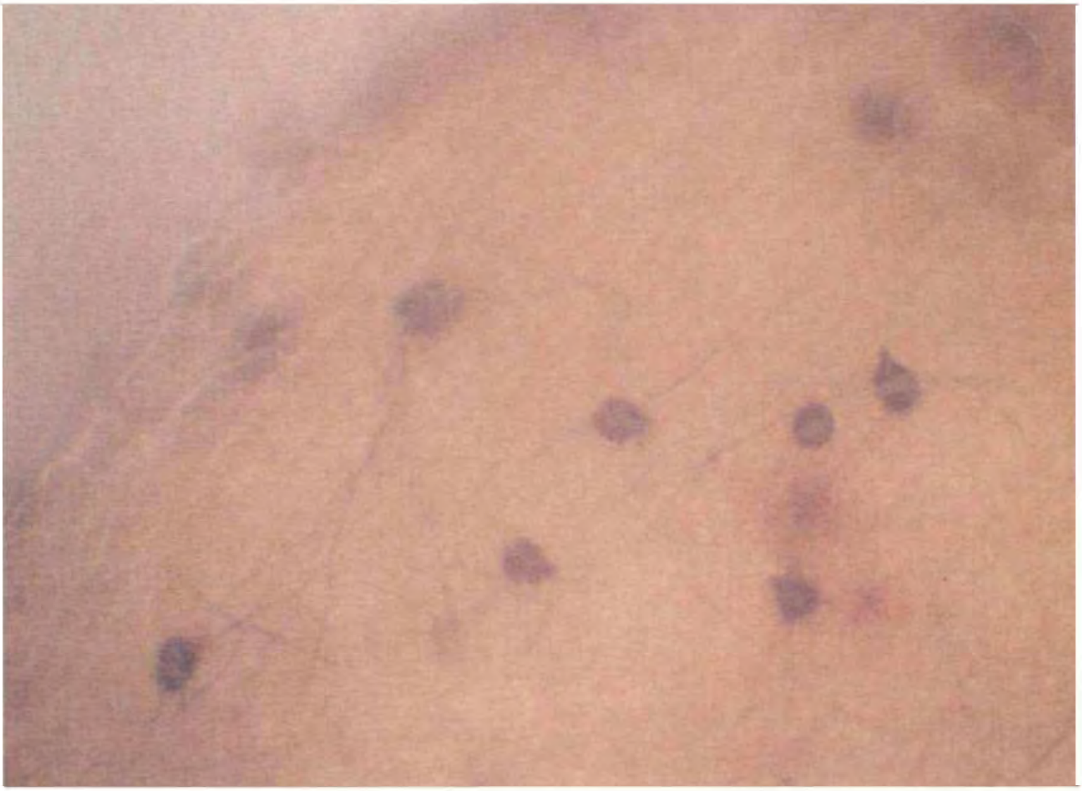

Figure 87 x58

Figure 88a x 118

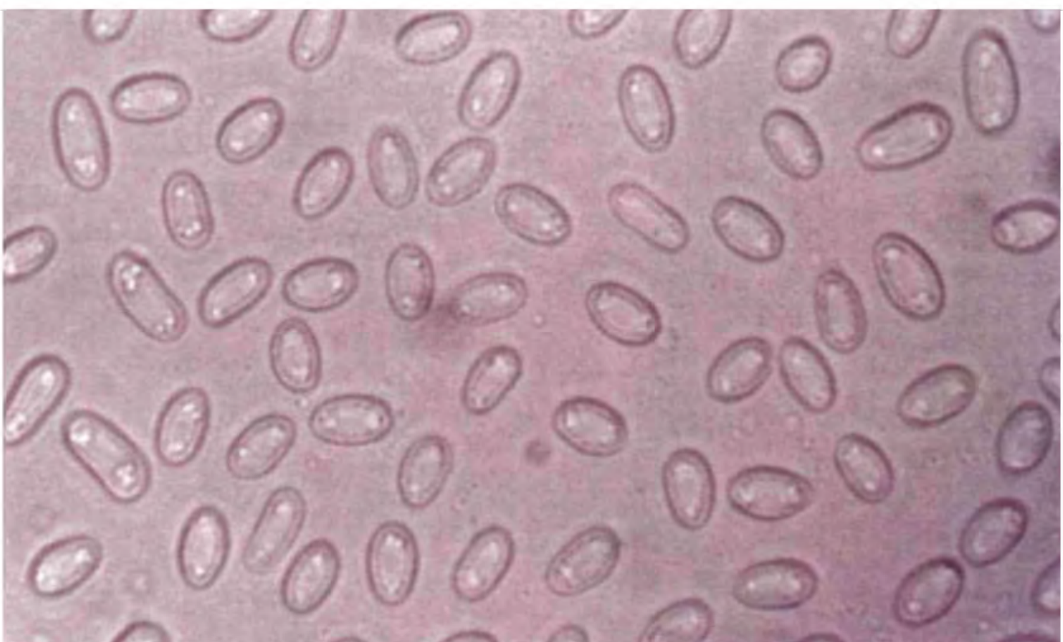

Figure 88b x4972

Rhizopus stolonifer (Ehrenb: Fr.) Lindner

Symptoms on grain. Colony on the seed spreads rapidly by means of stolons with abundant, loose, gray mycelium (Fig. 89). Stolons produce numerous, brown sporangiophores and rhizoids.

(Note; The fungus is so common on maize seeds, that tests for other pathogens often employ precautionary measures to avoid growth of *Rhizopus,* e.g., by surface sterilization of seeds with NaOCl.)

Morphology. Stolons are hyaline becoming brown towards nodes, near which a septum may occur. Rhizoids are short, brown and sometimes absent. Sporangiophores arise singly or in small groups from nodes on the stolons. They are brown, smooth or finely roughened, non-septate, 1000-3500 µm long and up to 34 µm wide. Sporangia are spherical, initially white but later black, and 100-350 µm in diameter with numerous spores (Fig. 90). Columellae are light brown, subspherical, 63-224 x 70-140 µm, and umbrella-shaped when dehisced. Sporangio-spores are yellow to dilute brown, spherical or oval, longitudinally striped, and measure 5-8 x 20-26 µm.

Quick clue. Dark, spherical sporangia can readily be seen under a dissecting microscope, enabling identification of *Rhizopus* (without removal of the lid of the petri dish). The fungus is often referred to as pin mold as the sporangia resemble black pinheads and are widely interspersed in cotton wool-like mycelium.

Importance. The fungus is distributed worldwide. It is a common saprobe and facultative parasite of mature fruits and vegetables. It is important in storage rot complex under high moisture and temperature conditions.

Figure 89 x15

Figure 90

x1980

Spadicoides obovata (Cooke & Ellis) Hughes

Symptoms on grain. Colonies are effuse, dark olivaceous brown, blackish brown or black. Stroma, setae, and hyphopodia are absent (Fig. 91).

Morphology. Mycelium is partly superficial and partly immersed. Conidiophores are macronematous, mononematous, generally unbranched, straight or flexuous, pale to very dark brown or olivaceous brown, and smooth. Conidiogenous cells are polytretic, integrated, terminal and intercalary, determinate, and cylindrical. Conidia are solitary, dry, acropleurogenous, developing through minute channels in the thick wall of the conidiogenous cell, simple, ellipsoidal, oblong, rounded at one end or obovoid and hooked at the other end, mid-pale to dark brown or reddish brown, smooth, 0-3 septate, sometimes with thick, black or dark brown bands at the septa (Fig. 92).

Quick clue. Hook-like structure of conidia is diagnostic.

Importance. *Spadicoides obovata* is reported on dead wood of magnolia *(Magnolia grandiflora* L) in USA. This is a new report of occurrence on sorghum grain in India.

Figure 91 x20

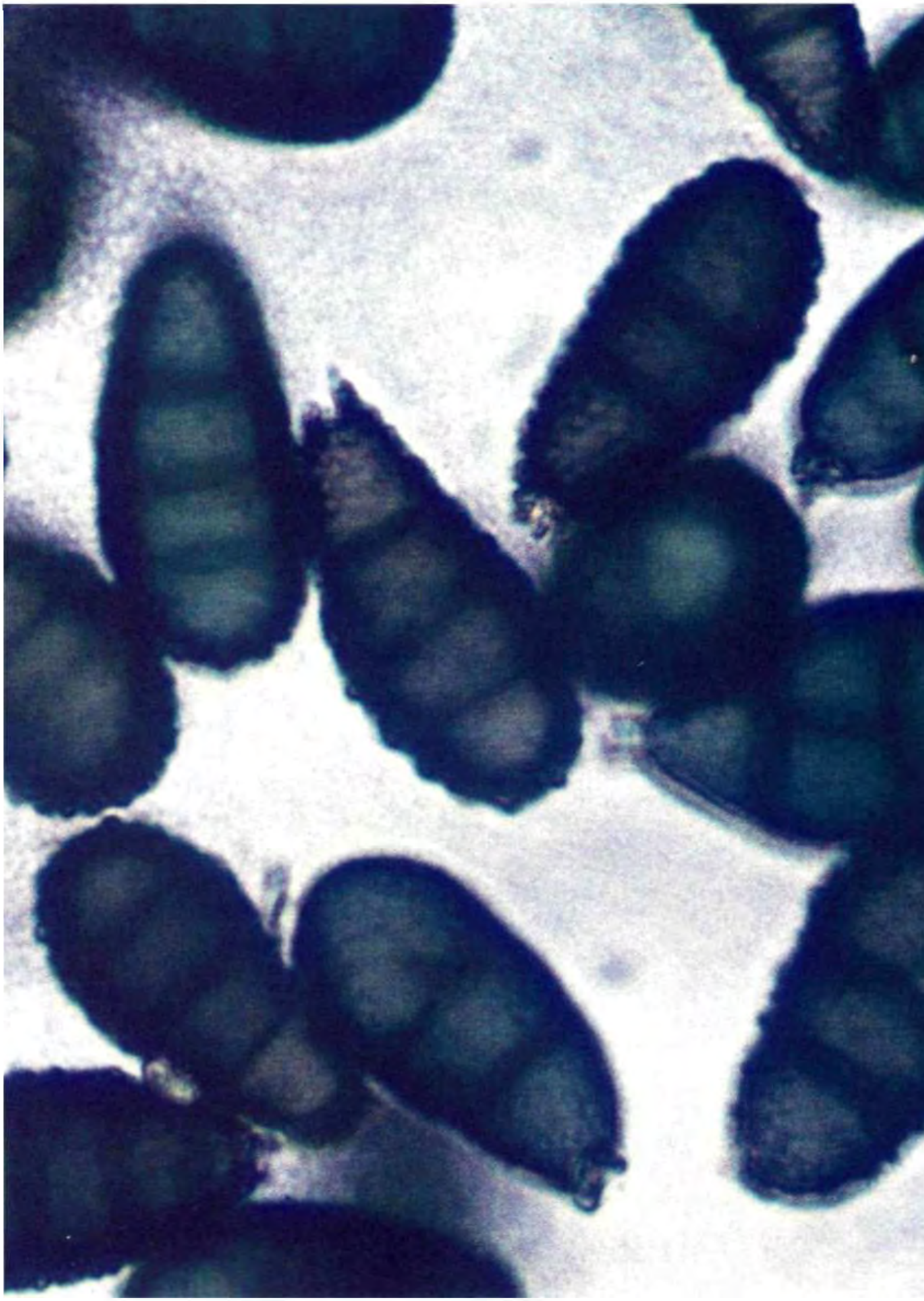

Figure 92 x3135

Torula graminis Desm.

Symptoms on grain. Colony on seed forms small, compact, olive green mounds which may coalesce and when older tend to become brown. Colonies are round or oval up to 1.5 x 0.5 µm.

Morphology. Conidiophores are short including conidiogenous cells, 2-5 µm thick, or lacking, and not readily distinguished, with conidia arising more or less directly from the vegetative hyphae. Conidia develop in long chains, which break into segments from one to many cells when mature, brown, minutely verruculose, 4-5 x 4-6 µm; cells or zero septate conidia are almost spherical but often slightly broader than long. Conidia are barrel shaped, with the end cells rounded, smooth to moderately rough surface, and dark brown to black (Fig. 93).

Quick clue. *Torula graminis* is characterized by simple or branched chains of dark conidia which break up readily and which arise more or less directly from the vegetative hyphae.

Importance. The fungus is distributed worldwide. It is a common saprophyte and secondary invader. It is predominant in wet harvests. It causes sooty head mold of wheat. Occurrence of *T. graminis* on grasses in Europe has been reported. However, this is a new report of occurrence on sorghum grain from India.

Figure 93 x792

Trichothecium roseum Link

Symptoms on grain. Colony on seed usually appears as a salmon pink crust with the production of numerous conidia (Fig. 94). Colonies can be cushion-like or powdery.

Morphology. Conidiophores are erect or suberect, produced singly or in groups, simple or sparingly branched, long, slender, hyaline, and septate. Conidia are produced in short, fragile chains. Conidia are large (12-18 x 8-10 µm), smooth, two-celled (slightly narrowed at the septum), hyaline, more or less egg-shaped, with well marked attachment point and upper cell somewhat larger than the lower one (Fig. 95).

Quick clue. Colony on seed superficially resembles the spore masses of *Fusarium* or *Gliocladium* species. The short chains of two-celled conidia at the apex of a hyaline, simple conidiophore are diagnostic.

Importance. The fungus is widespread. It is a common saprophyte and secondary invader. Its quarantine significance is not known. It causes pink rot of apple (*Malus pumila* Miller). It produces trichothecene mycotoxins, e.g., trichothecin and trichothecolon.

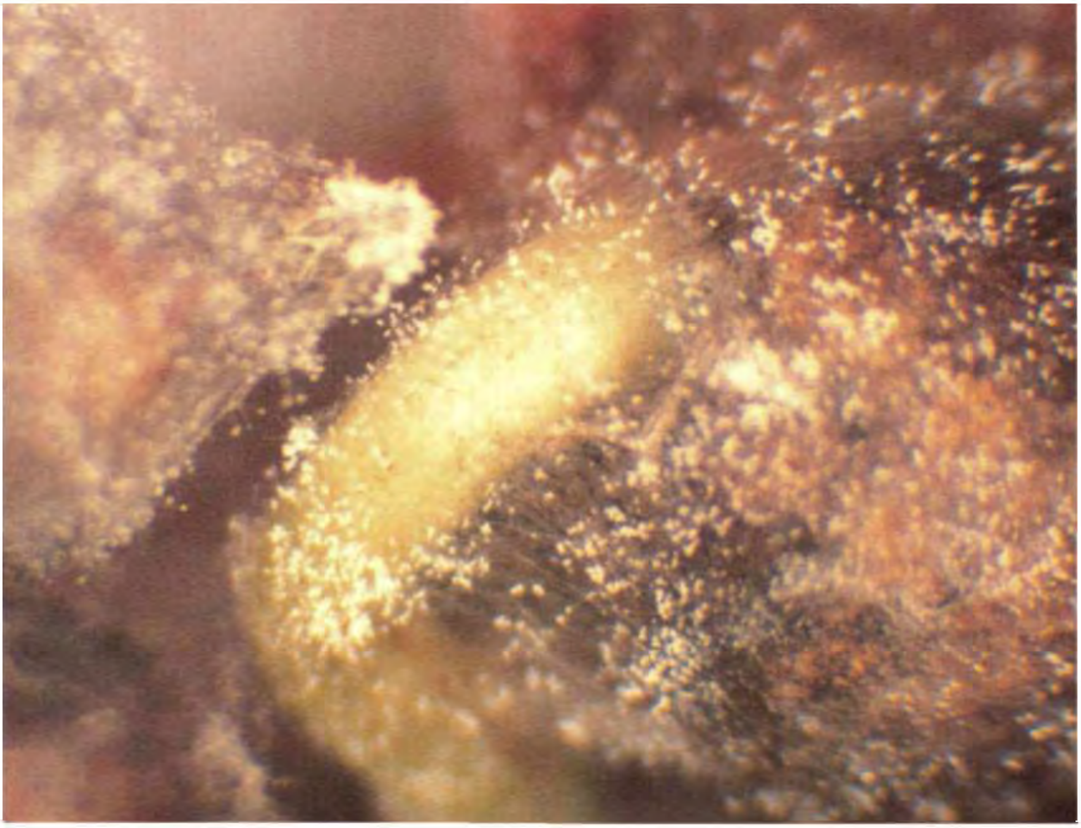

Figure 94 x66

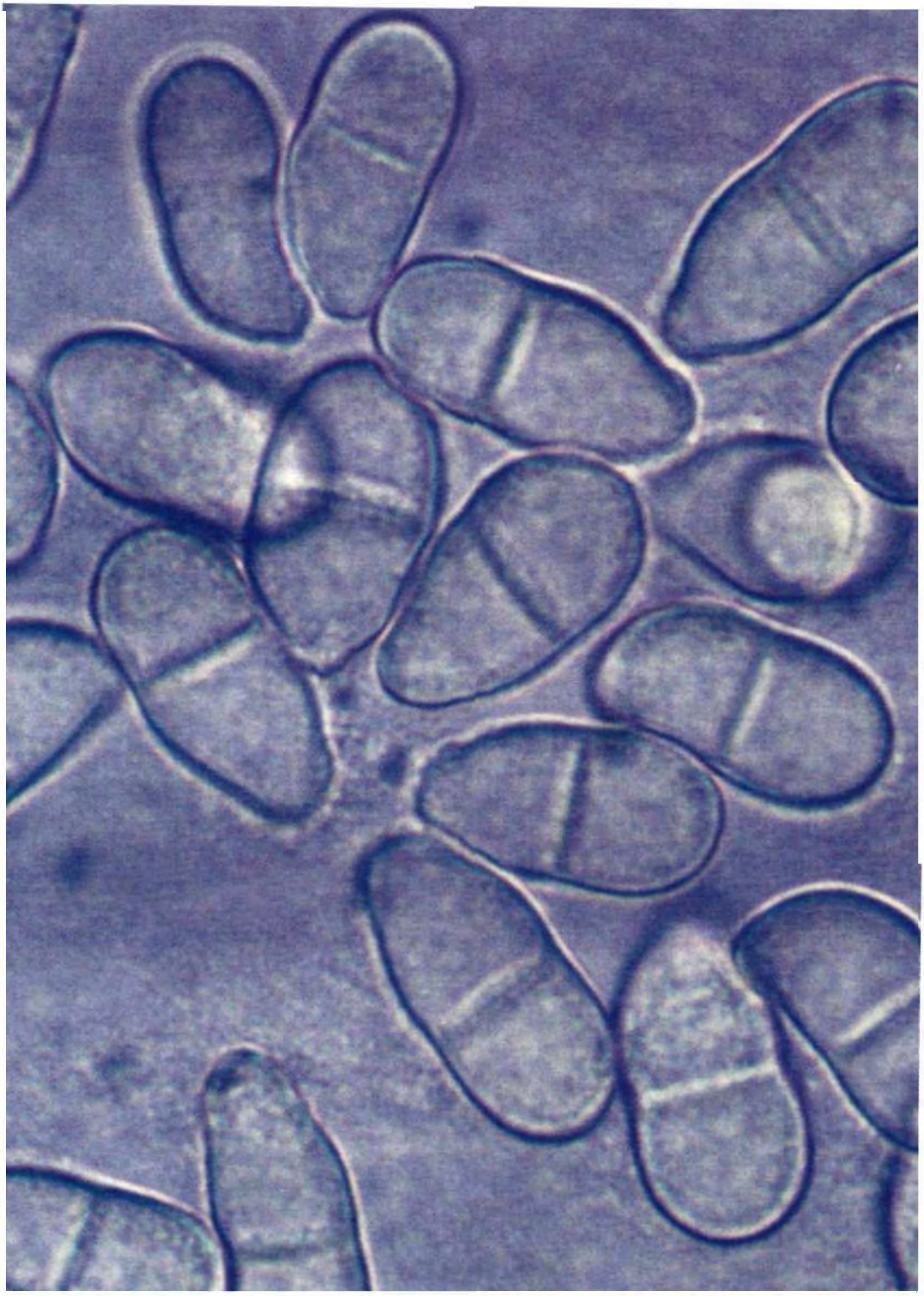

Figure 95

x3102

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Appendix 1

Identification procedures: scotch-tape method

The scotch-tape method is used to assist identification of different fungi by preserving the attachment of conidia to conidiophores. It is particularly useful for those fungi in which the conidia readily detach themselves from the conidiophore (e.g., *Cladosporium* spp) or those in which chains of conidia readily break up (e.g., *Fusarium moniliforme)* under normal procedures for slide preparation. The procedure is as follows:

1. Cut a small section of cello-tape (sticky transparent tape; scotch-tape) approximately 4 cm long.
2. Gently hold the tape at each end between the thumb and forefinger with the sticky side pointing downwards in a U shape and the least amount of tape in contact with the fingers as possible.
3. Gently place the bottom of the U onto the surface of a colony culture so that the sticky side picks up some mycelium and conidia from the colony. Contact with the colony should be very light so as to only pick up a very small amount of fungal material.
4. Place the piece of tape on top of a drop of water on a slide without touching the middle section of the tape.
5. Place a coverslip on top of the cello-tape.
6. Observe the slide under the microscope.

Microscopical observations of *Penicillium* spp

Preparation of wet mounts. Use an inoculating needle, or a nichrome or platinum wire cut to a chisel point, or a steel sewing needle, to cut out a small portion of the colony including sporing structures. With freely sporing isolates, cut a piece of colony near the margin, where penicilli are just maturing, and conidial numbers are not excessive. If sporulation is tardy, examination with the stereomicroscope can be useful. Cleistothecia should be taken from near colony centers, where the chance of obtaining mature ascospores is highest. Float the cut colony sample from the needle on to a slide with the aid of a drop of 70% alcohol. It may be necessary to tease out the mycelium with the needle and the corner of a cover slip (square coverslips are best). *Penicillium* conidia and penicilli are highly hydrophobic; the alcohol helps to set the preparation, minimizing the amount of entrapped air. When most of the alcohol has evaporated, add a drop of lactic acid (for phase or interference contrast optics) or lactofuchsin stain for bright field. Place a coverslip; if necessary, remove excess liquid from the preparation by gently blotting with facial tissue or similar absorbent paper. The preparation is now ready for examination.

Staining. A wide variety of stains are used for mycological work. However, most are time consuming to prepare, or to use, or are mild, because walls and spores of some fungi are highly resistant to stains. By far the most effective stain for preparations of Penicillia is lactofuchsin

(Carmichael 1955), which suffers from none of these faults. It consists of 0.1% acid fuchsin dissolved in lactic acid of 85% or higher purity. Young actively growing structures are preferentially stained bright pink; hence penicilli, cleistothecial initials, developing asci, and mature ascospores can be readily distinguished against a background of old mycelium.

Observation. Commence observation under a low power objective, x10 or X16, to locate the preparation on the slide, and an area of the preparation where fruiting structures are most readily observable. Then use a x40 objective to study the morphology of the fruiting structures. Measurement of lengths of fruiting structure elements and examination of conidia require the use of a x 100 oil immersion objective.

Glossary

Acervulus (pl = acervuli)	Saucer-shaped conidioma in which the hymenium of conidiogenous cells develops on the floor of the cavity from a pseudoparenchymatous stroma beneath on the integument of the host tissue which ruptures at maturity.
Acropleurogenous	Borne at the tip and along the sides.
Amphigenous	Growth all round or on two sides.
Ampulliform	Flask-like in form.
Ascoma (pl = ascomata)	An ascus-containing structure (also called ascocarp).
Ascospore	A meiospore borne in an ascus.
Ascus (pl = asci)	A sac-like cell generally containing a definite number of ascospores formed by free cell formation usually after karyogamy and meiosis; characteristic of the class Ascomycetes.
Bitunicate	An ascus in which the inner wall is elastic and expands greatly beyond the outer wall at the time of spore liberation.
Cantenulate	In chains or end-to-end series.
Chlamydospore	An asexual 1 -celled spore (primarily for perennation and not dissemination) originating endogenously and singly within part of a pre- existing cell, by the contraction of the protoplast and possessing an inner secondary and often thickened hyaline or brown wall, usually impregnated with hydrophobic material.
Clavate	Club-shaped, thickened towards the apex.
Columella	A sterile central axis within a mature fruit-body which may be unicellular or multicellular, unbranched or branched, of fungal or host origin.
Concolors	Of one color.
Confluent	Coming together; running into one another.
Conidiogenous cell	Any cell from or within which a conidium is directly produced.

Conidiophore	A single or branched hypha (fertile) bearing or consisting of conidiogenous cells from which conidia are produced.
Conidium (pl = conidia)	Any asexual spore which when mature is liberated from a conidiophore or conidiogenous cell.
Determinate	Growth ceasing with the production of terminal conidia.
Distoseptate	Having individual cells each surrounded by a sac-like wall distinct from the outerwall.
Echinulate	Having sharply pointed spines; spinose.
Ellipsoid	A conidium having an outline of an ellipse.
Erumpent	Bursting through the surface of the substratum.
Fasciculate	Hyphae having growth in fascicles.
Filiform	Thread-like.
Flexuous	Bent alternately in opposite directions.
Fusiform	Spindle-like; narrowing towards the ends.
Geniculate	Bent like a knee.
Globose	Nearly spherical.
Hyphopodium	A short branch of one or two cells on epiphytic mycelium of Meliolales.
Hilum	A mark or scar especially that on a spore at the point of attachment to a conidiogenous cell or sterigma.
Hypha	A fungus thread or filament.
Indeterminate	Continuing growth indefinitely.
Heterothallic	Two different thalli being required for sexual reproduction.
Limoniform	Lemon-like in form.
Macroconidium	The larger and generally more diagnostic conidium of a fungus which also has microconidia (and sometimes also mesoconidia); (infrequent) a large conidium.
Macronematous	Conidiophores morphologically different from vegetative hyphae.

Metula	A conidiophore branch having phialides, eg., of *Penicillium* and *Aspergillus.*
Microconidium	The smaller conidium of a fungus which also has macro-conidia.
Mononematous	Conidiophores, solitary or in tufts or loose fascicles.
Monophialide	Conidiogenous cell having one locus through which conidia are produced.
Mucilaginous	Sticky when wet; slimy.
Muriform	Being dividied by intersecting septa in more than one plane.
Mycelium	A mass or group of hyphae making up the thallus of a fungus.
Obclavate	The shape of a club upside down, thickened towards the base.
Obovoid	The shape of an egg upside down with the narrow end at the base.
Obpyriform	The shape of a pear upside down with the broad end at the base.
Ovoid	Egg-shaped, with one end narrower than the other.
Papilla	A minute rounded projection.
Papillate	Having a papilla.
Pedicel	A small stalk.
Pedicellate	Having a pedicel.
Perithecium	A closed ascocarp with a pore at the top, a true ostiole, and a wall of its own.
Phialide	A discrete or integrated, phialidic conidiogenous cell.
Phialidic	Enteroblastic and producing conidia, usually in large numbers in basipetal succession through one opening or several openings which are often provided with collarettes, and with neither the outer nor inner wall contributing towards the formation of the conidium wall.
Polyphialide	Conidiogenous cell having more than one conidiogenous locus at which conidia are produced.

Pseudoparaphyses	A little or strongly, modified terminal hypha in the hymenium of Hymenomycetes (paraphyses, pseudoparaphysis, paraphysoid, dikaryoparaphysis, and pseudophysis are synonyms or near synonyms).
Pseudoperithecium	An uniloculate ascostroma.
Pseudothecium	Contrition of pseudoperithecium.
Pycnidium (pl = pycnidia)	A frequently flask-shaped conidioma of fungal tissue with a circular or longitudinal ostiole, the inner surface of which is lined entirely or partially by conidiogenous cells.
Pyriform	Pear-shaped with the broad end uppermost.
Quaterverticillate	Hairy branching at four levels.
Rhizoid	A root-like structure consisting of anucleate, filamentous, branched, extension of chytrid thallus acting as a feeding organ.
Rostrate	Beaked or strongly attenuated at the apex.
Sclerotium (pl = sclerotia)	A firm, frequently rounded, mass of hyphae, with or without the addition of host tissue or soil, normally having no spores in or on it.
Seta (pl = setae)	A stiff hair, generally thick-walled and dark in color.
Solitary	Arising singly at one point.
Spinulose	Covered with little spines.
Sporangiophore	Thallus element (usually morphologically differentiated) subtending one or more sporangia.
Sporangium	An organ enclosing endogenously generated spore(s), the walls of the spore(s) not being derived from the supporting or containing structure.
Sporodochium	A pulvinate stroma with closely packed, relatively short conidiophore covering its upper surface.
Sterigma (pl = sterigmata)	An extension of the metabasidium composed of a basal filamentous or inflated part and an apical spore-bearing projection.
Stolon	A runner as in *Rhizopus.*

Stroma	An often cushion-like mass of fungal cells or closely interwoven hyphae.
Teleomorph	Sexual stage.
Terverticillate	Having branching at three levels, i.e., having rami bearing metulae and phialides.
Tretic	The sort of conidiogenesis in which each conidium (tretoconidium, tretic conidium, poroconidium, porospore) is delimited by an extension of the inner wall of the conidiogenous cell.
Truncated	Ending abruptly, as though with the end cut off horizontally.
Verrucose	Warted.
Verruculose	Finely warted.
Vesicle	A bladder-like sac; swollen apex of the conidiophore.

Notes

Notes

About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one-sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

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