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Identification of Fungi Isolated from Non-chemical Banana Fruits and Farms in the Philippines

By

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Summary: Survey of fungi associated with non-chemical banana fruits and non-chemical banana farms with and without sanitation was conducted from June 2000 to May 2001 in Nueva Viscaya, Luzon, Philippines, to determine the source and origin of diverse fungal flora on banana fruits. Fungi from the developing fruits were collected by swabbing with cotton balls while the fungal flora of the banana farms were sampled using agar and slide traps.

Eighty fungal species belonging to 41 genera were collected from non-chemical banana farms, including 54 species of 25 genera on banana fruits. These were 18 species of *Aspergillus*; 10 species of *Penicillium*, 6 species of *Fusarium*, 3 species each of genus *Curvularia*, *Pestalotiopsis* and *Phomopsis*, 2 species each of genus *Colletotrichum* and *Phoma*, and the others were 1 species each of genus *Acladium*, *Acremonium*, *Annellophorella*, *Arthrinium*, *Aureobasidium*, *Basipetospora*, *Bipolaris*, *Cladosporium*, *Cylindrocarpon*, *Dactylaria*, *Diplodia*, *Drechslera*, *Gliocladium*, *Glomerella*, *Lasiodiplodia*, *Monilia*, *Mucor*, *Nectria*, *Nigrospora*, *Nuerospora*, *Oedocephalum*, *Oidiodendron*, *Plectosporium*, *Rhizopus*, *Spiromyces*, *Stemphyliomma*, *Tetraploa*, *Thielaviopsis*, *Trichoderma*, *Thysanophora*, *Ulocladium*, and *Verticillium*.

From the total of 80 fungal species collected from the banana farms, 54 species (68%) were also associated with developing banana fruits in the field while 45 species (56%) were isolated from postharvest disease lesions of non-chemical banana fruits imported into Japan from the Philippines. Comparing the mycoflora of non-chemical banana fruits imported into Japan from the Philippines and developing banana fruits in the Philippines, non-chemical banana fruits in Japan have 17 species less. The result shows that non-chemical banana farm is the origin of fungal inoculum that causes postharvest diseases of fruits, and the fungi that were isolated from the diseased non-chemical banana fruits in Japan also originated from the Philippines.

Meanwhile, the common fungi of non-chemical banana farms, the developing banana fruits in the field, non-chemical banana fruits imported into Japan from the Philippines, and recorded in the references on banana fruits are: *Acremonium strictum*, *Arthrinium phaeospermum*, *Aspergillus flavus*, *Colletotrichum musae*, *Colletotrichum gloeosporioides*, *Curvularia lunata*, *Fusarium equiseti*, *Fusarium incarnatum*, *Fusarium oxysporum*, *Fusarium solani*, *Fusarium verticillioides*, *Gliocladium roseum*, *Glomerella cingulata*, *Lasiodiplodia theobromae*, *Phomopsis* sp., *Phyllosticta musarum*, and *Thielaviopsis paradoxa*.

Key Words: banana farm, developing banana fruits, fungal inoculum, identification

Introduction

In the Philippines, small-scale banana production is conducted by traditional methods of farming. *Musa* AAA, known as "*Buñgulan*" in Filipino, is widely distributed and grown by small-scale banana farmers.

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"*Buñgulan*" is naturally grown in household backyard or hill sides without chemicals during production and postharvest activities (hereafter referred to as "non-chemical bananas")[1]. This variety is also an important commercial banana cultivar in ASEAN known as "*Pisang Ambon Lumut*" in Indonesia, "*Pisang Masak Hijau*" in Malaysia, and "*Kluai Hom Khieo*" in Thailand[2].

The traditional growing and non-use of chemicals by small-scale farmers during production and postharvest activities of non-chemical bananas makes the fruits prone to infection and postharvest diseases. It is evident that non-chemical banana fruits have low quality due to postharvest diseases[3-4] with diverse fungal flora when the products reached Japanese market[5].

Many of the causal fungi of important postharvest diseases survive in the plantations. Integration of proper cultural methods like weeding, maintaining farm sanitation, de-leafing, and burning of infected and dried leaves reduce the inoculum level of pathogens, especially *Colletotrichum musea* and *Phyllosticta musarum*, the causal organisms of anthracnose and freckle, respectively[6-8].

Sources and development of microbial communities in the fruit surfaces depend on its surrounding aerial environment. Fungal flora of the fruits and its immediate surroundings influenced biological events during disease initiation and development. Hence, this study was conducted to identify the fungal flora of developing banana fruits in the field and its immediate surroundings. This study compared the mycoflora of non-chemical banana farm and developing banana fruits in the Philippines, mycoflora of non-chemical banana fruits imported into Japan from the Philippines, and the recorded mycoflora of banana fruits in the references. Further, this study established the possible origin of pathogenic fungi to developing non-chemical bananas in the field that would eventually carry until ripening stage thus causing postharvest diseases. It is of paramount importance to establish the possible origin of diverse fungal flora of non-chemical bananas wherein 38 species are pathogenic with 7 active species pathogenic to wounded and unwounded fruits[9].

Materials and Methods

The study was conducted at non-chemical banana farm (50 mL×40 mW) from June 2000 to May 2001 in Nueva Viscaya, Philippines. The non-chemical banana farm was divided into two halves: one half with sanitation and the other half without sanitation following the farmers' traditional practices of growing non-chemical bananas. Six bunch-bearing trees growing in the area (3 in the area with sanitation and 3 in the areas without sanitation) were randomly selected and marked for sampling. Fruits were sampled 1 week after flowering and weekly thereafter until harvest. The fruit surface of each fruit bunch were lightly swabbed with 10 sterilized wet cotton balls using tweezers to avoid bruising. About 20–25 banana fingers from each fruit bunch were sampled weekly. Cotton balls were aseptically laid on the surface of 5 plates of Potato Dextrose Agar (PDA). Plates were incubated at 25℃ until it became possible to isolate colonies. Sampling was done once for rainy and dry seasons.

Fungal flora of non-chemical banana farm was surveyed using slide and agar traps. Sterilized microscope slides were coated with 0.5 mm thick clear petroleum jelly using stainless spatula. One end of the slide was clipped, string-tied, and exposed vertically for 2 hours from 11:00 am to 1:00 pm. Thereafter, the slides were retrieved, immediately covered with glass slip, and placed inside slide box to avoid adherence of other fungal spores during transport. In the laboratory, fungal spores within the area of the cover slip (2×2 cm) were counted and identified (whenever possible) under the microscope with magnification of 400x.

In addition, agar traps with PDA plates were exposed at the same time and locations of the slide traps. The agar traps were elevated using a tripod made of bamboo sticks. Thereafter, the plates were retrieved and incubated at 25℃ in the laboratory until colonies could be isolated. Slide and agar traps were positioned 1, 2 and 3 meters above the ground level. The distance between traps located on the same level was 6～7 meters away. Slide and agar traps had 6 replications for each level. Identification of fungi was done at the Laboratory of Tropical Plant Protection, Tokyo University of Agriculture (TUA) based on references and literatures available.

Results

Fungi collected from non-chemical banana farms, developing banana fruits, non-chemical banana fruits imported into Japan from the Philippines, and the recorded fungi of banana fruits in the references is listed in Table 1. Eighty fungal species were collected from non-chemical banana farms in the Philippines. Out of the 80 fungal species, 54 species (68%) were associated with developing banana fruits while 45 species (56%) were also isolated from postharvest disease lesions of non-chemical banana fruits imported into Japan from the Philippines[5]. Comparing the mycoflora of the developing banana fruits in the Philippines and that of Philippine non-chemical banana fruits in Japan, the latter has 17 fewer species.

The fungi associated with postharvest diseases of non-chemical banana fruits imported into Japan from the Philippines without available record until writing of this study are: *Aureobasidium* sp., *Aspergillus candidus*, *A. japonicus*, *A. ustus*, *Cylindrocarpon didymum*, *Dactylaria purpurella*, *Fusarium acutatum*, *Monilia* sp., *Mucor racemosus*, *Nectria* sp., *Oedocephalum* sp., *Oidiodendron* sp., *Penicillium citrinum*, *P. corylophilum*, *P. waksmanii*, *Pestalotiopsis aletridis*, *P. acaciae*, *P. karstenii*, *Phoma exigua*, *Phoma* sp., *Plectosporium tabacinum*, *Rhizopus oryzae*, *Spiromyces* sp., *Trichoderma saturnisporum*, and *Verticillium tricorpus.*

On the other hand, the common fungi of banana farms, developing banana fruits, non-chemical banana fruits in Japan, and the recorded fungi of banana fruits are: *Acremonium strictum*, *Arthrinium phaeospermum*, *Aspergillus flavus*, *Colletotrichum musae*, *C. gloeosporioides*, *Curvularia lunata*, *Fusarium equiseti*, *F. incarnatum*, *F. oxysporum*, *F. solani*, *F. verticillioides*, *Gliocladium roseum*, *Glomerella cingulata*, *Lasiodiplodia theobromae*, *Phomopsis* sp., *Phyllosticta musarum*, and *Thielaviopsis paradoxa.*

Meanwhile, the cultural and morphological characters of all the fungi described in this study were based on fungal growth on PDA. Czapek Yeast Extract Agar (CYA) and Malt Extract Agar (MEA) were the media used to describe the cultural and morphological characters of *Aspergillus.* In addition to CYA and MEA, 25% Glycerol Nitrate Agar (G25N) was used to examine the cultural and morphological characters of *Penicillium* isolates. Descriptions of fungi isolated from non-chemical banana fruits reported in Alvindia *et al.*, 2001[5] are not included in this paper. The cultural and morphological descriptions of the newly added fungi to the mycoflora of non-chemical banana fruits and farms in this study are enumerated below.

Seasonal variation of mycoflora and the pathogenicity of newly recorded fungi will be discussed later in separate reports.

1. *Acladium ramosissimum* (Berkeley & Curtis) M. B. Ellis (Fig. 1)

Colonies on PDA 14〜19 mm diameter in 7 days at 25℃, cottony, white, becoming dark gray by age; mycelia white. Aged colony powdery, irregular margin. Hyphae much branched bearing many denticles conidiophores, 5 μm thick. Conidia globose, pale to brown, 5 μm diam.

Notes: *Acladium ramosissimum* differs from *Acladium conspersum* by much branched conidiophores and shape of conidia, which are globose. This isolate of *A. ramosissimum* has smaller conidia compared to species described by Ellis (1976)[10].

Reference: Ellis (1976)[10].

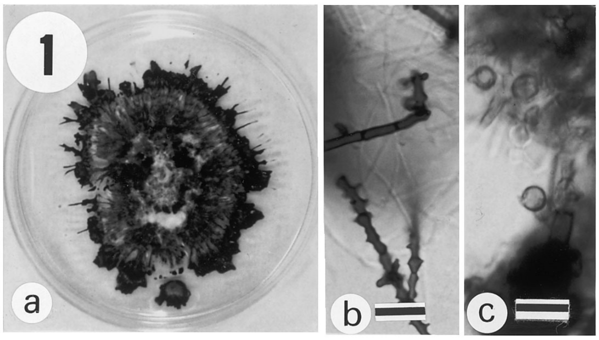

Fig. 1 a) Colony of *Acladium ramosissimum* on PDA, b) hyphae and conidiophores, c) conidia
(Scale bar: 1b = 5 μm, 1c = 10 μm)

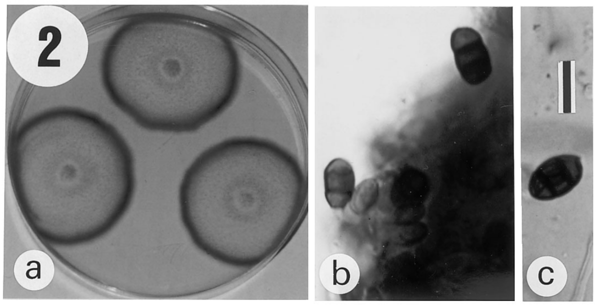

Fig. 2 a) Colonies of *Annellophorella ziziphi* on PDA, b) conidiogenesis and conidia c) mature conidia
(Scale bar = 5 μm)

2. *Annellophorella ziziphi* M. Chary & Ramarao (Fig. 2)

Colonies on PDA 42〜43 mm diameter in 7 days at 25℃, floccose, creamy white; colony margin grayish brown, reverse black. Conidiophores finely roughened, hyaline to light brown, 5 μm long. Conidia straight obovoid, hyaline when young becoming brown by age, smooth to finely rough-walled, 1〜2 septate with longitudinal and transverse septa, 10〜20 × 7.5〜10 μm.

Notes: This species has smaller conidia compared to species described by Ellis (1976)[10].

Reference: Ellis (1976)[10].

3. *Arthrinium phaeospermum* (Corda) Ellis (Fig. 3)

Colonies on PDA 60〜70 mm diameter in 7 days at 25℃, cottony, conidial areas dark, mycelia white; re-

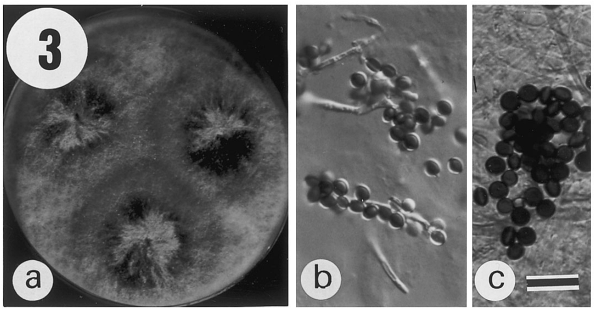

Fig. 3 a) Colonies of *Arthrinium phaeospermum* on PDA, b) conidiogenesis and conidia, c) mature conidia
(Scale bar=6 μm)

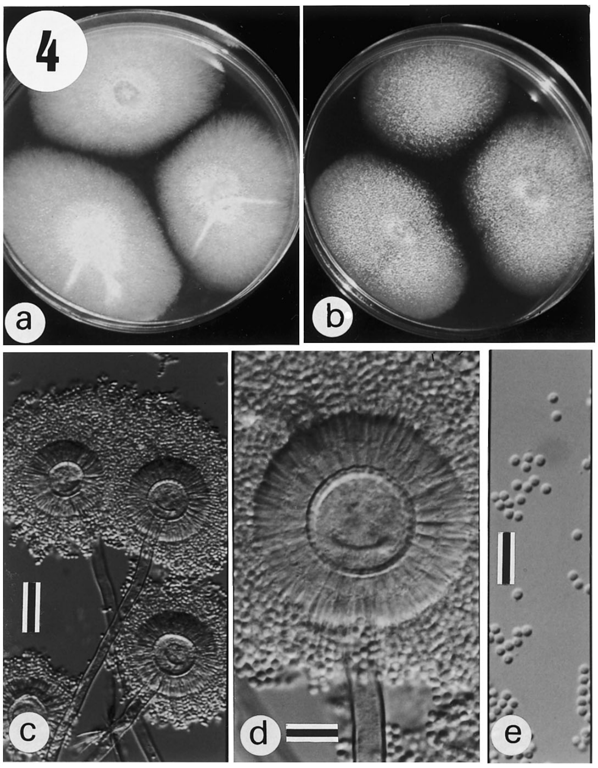

Fig. 4 a) Colonies of *Aspergillus auricomus* on CYA, b) on MEA, c) aspergilli, d) expanded view of the aspergillum, e) conidia
(Scale bar: 4c=3.5 μm; 4d=11 μm; 4e=4 μm)

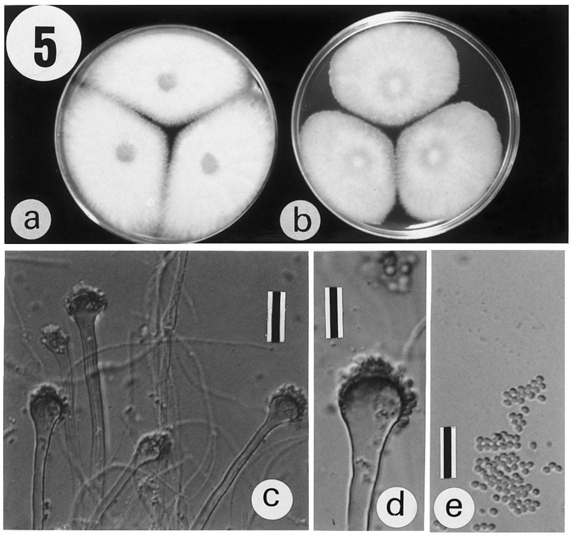

Fig. 5 a) Colonies of *Aspergillus alliaceus* on CYA, b) on MEA, c) aspergilli, d) expanded view of the aspergillum, e) conidia
(Scale bar: 4c & e=5 μm ; 4d=10 μm)

verse pale yellow. Mycelia pale brown, smooth, septated 2.5～5 μm thick. Conidia lenticular, smooth-walled, globose in face view, 5～7.5 μm diam.

Notes: This isolate of *A. phaeospermum* has smaller conidia compared to species described by Ellis (1971)[11]. *Papularia sphaerosperma* (Persoon) von Höhnel, a synonym of *A. phaeospermum*, was identified by Wardlaw[8] as one of the various fungi associated with banana fruit rots.

References: Wardlaw (1971)[8], Ellis (1971)[11].

4. *Aspergillus auricomus* (Guegen) Saito (Fig. 4)

Colonies on CYA 50～60 mm diameter in 7 days at 25℃, floccose, pale yellow with white colony margin; reverse pale to yellowish; mycelia white. Colonies on MEA similar with that on CYA, 46～55 mm diameter in 7 days at 25℃. Sclerotia produce turning golden color by age. Conidial heads radiate, stipes smooth-walled; vesicle globose, 12.5～14 μm wide. Aspergilli biseriate; phialides covering the entire vesicle surface. Conidia globose to subglobose, smooth-walled, 2.5～4 μm diam.

Notes: This species is distinguished by the production of golden sclerotia on CYA.

References: Klich and Pitt (1988)[12], Pitt and Hocking (1985)[13].

5. *Aspergillus alliaceus* Thom & Church (Fig. 5)

Colonies on CYA 55～60 mm diameter in 7 days at 25℃, granular to floccose, white; reverse uncolored; sclerotia white becoming creamy by age; mycelia white. Colonies on MEA 45～60 mm diameter in 7 days at 25℃, floccose, white; reverse uncolored; mycelia white; sclerotia white becoming creamy by age. Conidial heads columnar; stipes smooth-walled; vesicle subglobose, 12.5～14 μm wide. Aspergilli uniseriate; phialides covering the upper half to 2/3 of the vesicle surface. Conidia globose to sub-globose, smooth-walled, 2.5～4 μm diam. Neither matured ascospores

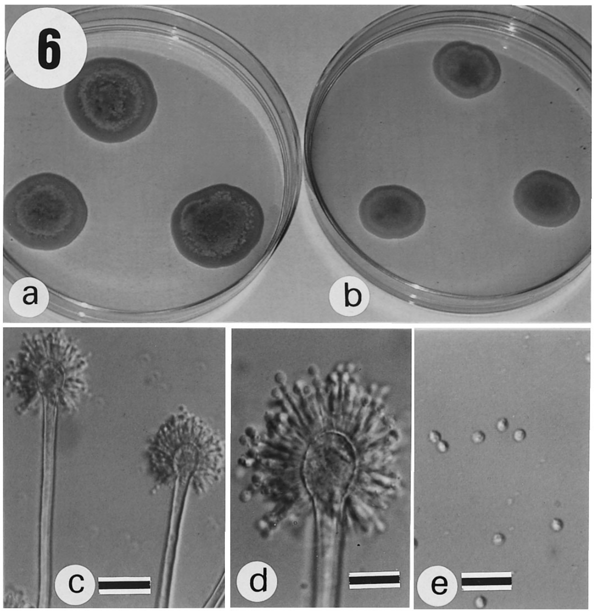

Fig. 6 a) Colonies of *Aspergillus caespitosus* on CYA, b) on MEA, c) aspergilli, d) expanded view of the aspergillum, e) conidia

(Scale bar: 6c=3μm; 6d=7μm; 6e=6μm)

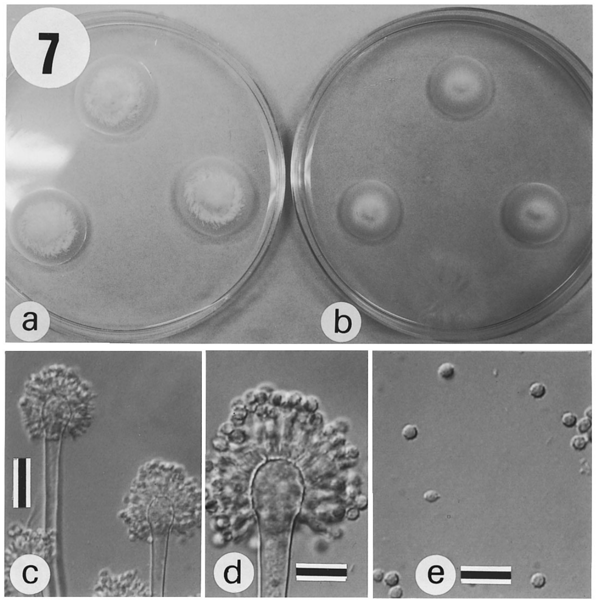

Fig. 7 a) Colonies of *Aspergillus carneus* on CYA, b) on MEA, c) aspergilli, d) expanded view of the aspergillum, e) conidia

(Scale bar: 7c=4μm; 7d=7μm; 7e=5μm)

nor cliestothecia were observed in this isolate.

Notes: This species grow fast spreading the petri plates on CYA with white superficial granular sclerotia that turned light brown by age.

References: KLICH and PITT (1988)[12], PITT and HOCKING (1985)[13].

6. *Aspergillus caespitosus* RAPER & THOM (Fig. 6)

Colonies on CYA 27〜30 mm diameter in 7 days at 25℃, white, floccose, conidia dark green becoming dark gray by age; reverse uncolored; mycelia white. Colonies on MEA 22〜30 mm diameter in 7 days at 25℃, limited production of conidia, white, with shades of light brown; reverse light yellow; mycelia white. Conidial heads radiate; stipes smooth-walled; vesicle sub-globose, 9〜15μm wide. Aspergilli biseriate; metulae covering the entire vesicle surface. Conidia globose, rough-walled, 2.5〜5μm diam.

Notes: The isolate has green conidia becoming dark gray by age on CYA. The conidial color development of this isolate differs from those described by KLICH and PITT (1988)[12], PITT and HOCKING (1985)[13].

References: KLICH and PITT (1988)[12], PITT and HOCKING (1985)[13].

7. *Aspergillus carneus* BLOCHWITZ (Fig. 7)

Colonies on CYA 22〜26 mm diameter in 7 days at 25℃; conidial areas yellowish brown with shades of pink, colonies margin pinkish, reverse pink; strong production of dark brown soluble pigment by age; mycelia white. Colonies on MEA 17〜18 mm diameter in 7 days at 25℃, yellowish conidial areas, mycelium white, reverse golden yellow. Conidial heads radiate to loosely columnar; stipes smooth-walled; vesicle clavate, 10〜14 μm wide. Aspergilli biseriate; phialides covering 2/3 part of the vesicle surface. Conidia globose to subglobose, finely rough-walled, 2.5〜4μm diam.

Notes: This species could be distinguished by pale tan to pink conidia and strong production of dark brown soluble pigment on CYA by age.

References: KLICH and PITT (1988)[12], PITT and HOCKING (1985)[13].

8. *Aspergillus clavatus* DESMAZIERES (Fig. 8)

Colonies on CYA 50〜55 mm diameter in 7 days at 25℃; conidia light dull green becoming dark green by age; reverse uncolored; mycelia white. Colonies on MEA 43〜48 mm diameter in 7 days at 25℃, white with shades of light green; reverse uncolored. Conidial heads radiate; stipes smooth-walled; vesicle clavate, 25〜38μm wide. Aspergilli uniseriate; phialides covering the entire vesicle surface. Conidia globose to subglobose, smooth-walled, 2.5〜4μm diam.

Notes: This species could be distinguished by the formation of large clavate vesicle with closely packed phialides.

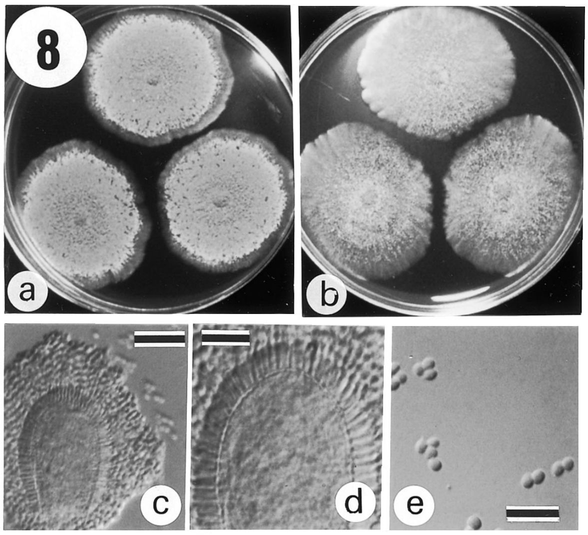

Fig. 8 a) Colonies of *Aspergillus clavatus* on CYA, b) on MEA, c) aspergillum, d) expanded view of the aspergillum, e) conidia

(Scale bar: 8c=5μm; 8d=10μm; 8e=8μm)

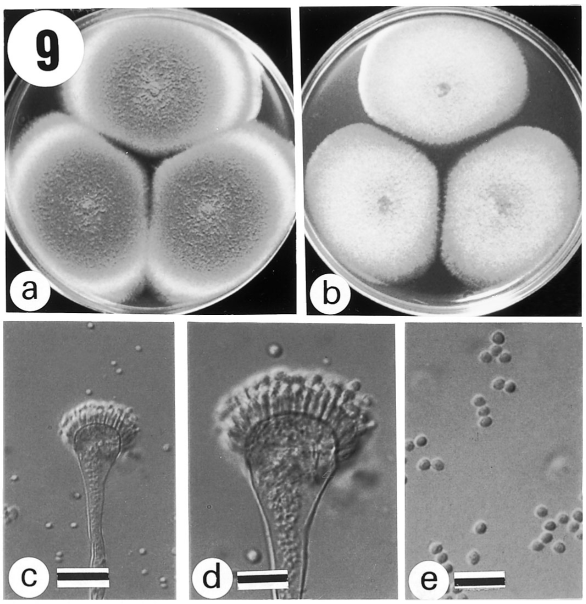

Fig. 9 a) Colonies of *Aspergillus fumigatus* on CYA, b) on MEA, c) aspergillum, d) expanded view of the aspergillum, e) conidia

(Scale bar: 9c=5μm; 9d & e=10μm)

References: Klich and Pitt (1988)[12], Pitt and Hocking (1985)[13].

9. *Aspergillus fumigatus* Fresenius (Fig. 9)

Colonies on CYA 48~55 mm diameter in 7 days at 25℃; conidia dull green becoming dark green by age; reverse uncolored; mycelia white. Colonies on MEA 45~50 mm diameter in 7 days at 25℃, white with shades of light green; reverse uncolored. Conidial heads columnar; stipes smooth-walled; vesicle sub-globose, 17.5~20 μm wide. Aspergilli uniseriate; metulae covering 2/3 of the vesicle surface. Conidia globose to subglobose, smooth to finely rough-walled, 2.5~4 μm diam.

Notes: This species is characterized by rapid growing dark green low colonies, uniseriate, with phialides in parallel position to each other. Singh (2000)[20] noted that this fungus has been isolated from decaying banana fruits in stores and in markets.

References: Klich and Pitt (1988)[12], Pitt and Hocking (1985)[13], Singh (2000)[20].

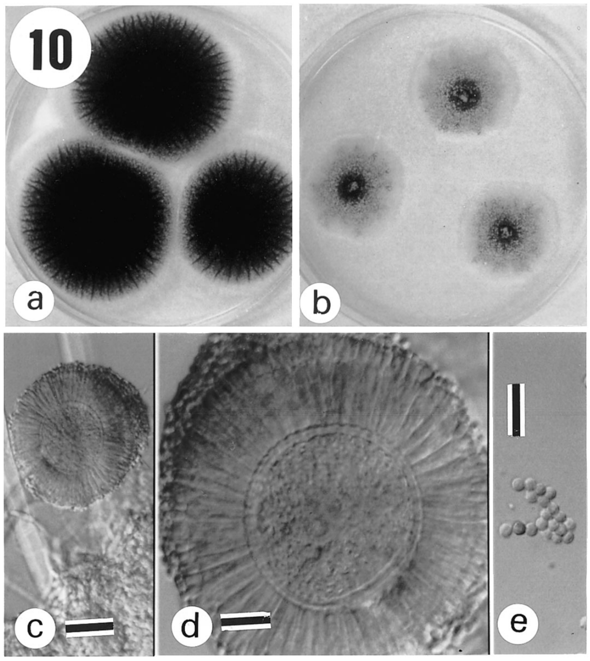

Fig. 10 a) Colonies of *Aspergillus niger* on CYA, b) on MEA, c) aspergillum, d) expanded view of the aspergillum, e) conidia

(Scale bar: 10c=2μm; 10d=6μm; 10e=3μm)

10. *Aspergillus niger* van Tieghem (Fig. 10)

Colonies on CYA 50~60 mm diameter in 7 days at 25℃; conidial areas black; reverse light brown; mycelia white. Colonies on MEA 40~50 mm diameter in 7 days at 25℃, black conidial areas; mycelia white; reverse pale yellow; individual aspergilla not crowded. Conidial heads radiate; stipes smooth-walled, uncolored; vesicle globose, 40~55 μm wide. Aspergilli biseriate; metulae covering entire vesicle surface. Conidia globose, smooth to finely roughened-wall, 4~5 μm diam.

Notes: This species is characterized by its very dark

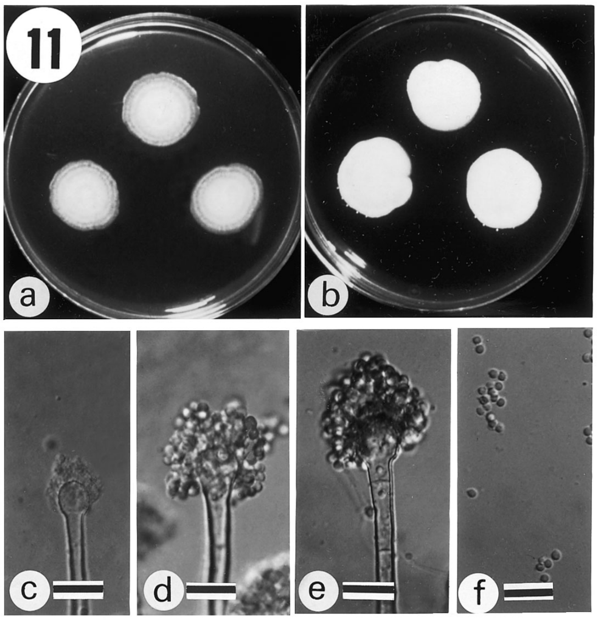

Fig. 11 a) Colonies of *Aspergillus niveus* on CYA, b) on MEA, c) aspergillum, d & e) expanded view of the aspergillum, f) conidia
(Scale bar: 11c=5μm; 11d & e=7μm; 11f=4μm)

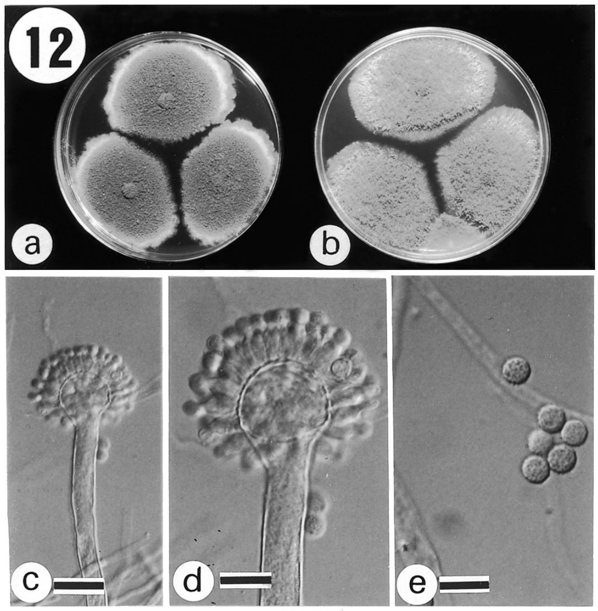

Fig. 12 a) Colonies of *Aspergillus parasiticus* on CYA, b) on MEA, c) aspergillum, d) expanded view of the aspergillum, e) conidia
(Scale bar: 12c=3μm; 12d=6μm; 12e=8μm)

colonies, biseriate aspergilla, and large vesicle. SINGH (2000)[20] noted that this fungus has been isolated from decaying banana fruits in stores and in markets.

References: KLICH and PITT (1988)[12], PITT and HOCKING (1985)[13], SINGH (2000)[20].

11. *Aspergillus niveus* BLOCHWITZ (Fig. 11)

Colonies on CYA 20～22 mm diameter in 7 days at 25℃; velutinous, conidia white to very light yellow, reverse yellowish brown; mycelia light yellow. Colonies on MEA 20～20 mm diameter in 7 days at 25℃, floccose, conidia white; mycelia white; reverse light brown. Conidial heads radiate; stipes smooth-walled, uncolored; vesicle subglobose, 10～12μm wide. Aspergilli biseriate; metulae covering two-thirds of the vesicle surface. Conidia globose to subglobose, smooth to finely rough-walled, 2.5～4μm diam.

Notes: *Aspergillus niveus* is one of the two species of *Aspergillus* that persistently produced white conidia. The phialides of *A. niveus* occupy two-thirds of the vesicle, while those of *A. candidus* are fertile over the entire vesicle surface.

References: KLICH and PITT (1988)[12], PITT and HOCKING (1985)[13].

12. *Aspergillus parasiticus* SPEARE (Fig. 12)

Colonies on CYA 58～63 mm diameter in 7 days at 25℃; velutinous, conidia dark olive green, reverse uncolored; mycelia white. Colonies on MEA 55～65 mm diameter in 7 days at 25℃, floccose, conidia dark green; mycelia white; reverse uncolored. Conidial heads radiate; stipes finely rough-walled, uncolored; vesicle globose to subglobose, 18～33μm wide. Aspergilli uniseriate; phialides covering entire vesicle surface. Conidia globose, rough-walled, 5～7.5μm diam.

Notes: *Aspergillus parasiticus* is distinguished from *A. flavus* by its dark olive green colony and bigger rough-walled conidia.

References: KLICH and PITT (1988)[12], PITT and HOCKING (1985)[13].

13. *Aspergillus puniceus* KWON & FENNEL (Fig. 13)

Colonies on CYA 32～37 mm diameter in 7 days at 25℃; velutinous, reddish brown becoming dark gray by age, reverse yellow brown; exudates pale yellow; soluble pigment golden yellow; mycelia white. Colonies on MEA 22～32 mm diameter in 7 days at 25℃, floccose, limited conidial production in brownish color; mycelia white; reverse light yellow. Conidial heads radiate; stipes smooth-walled; vesicle subglobose, brown, 7.5～12.5μm wide. Aspergilli biseriate; phialides covering about 2/3 of vesicle surface. Conidia globose, rough-walled, dark brown, 4～6.5μm diam.

Notes: This isolate has dark brown, stout, short metulae and phialides compared to the species described by KLICH and PITT (1988)12), PITT and HOCKING

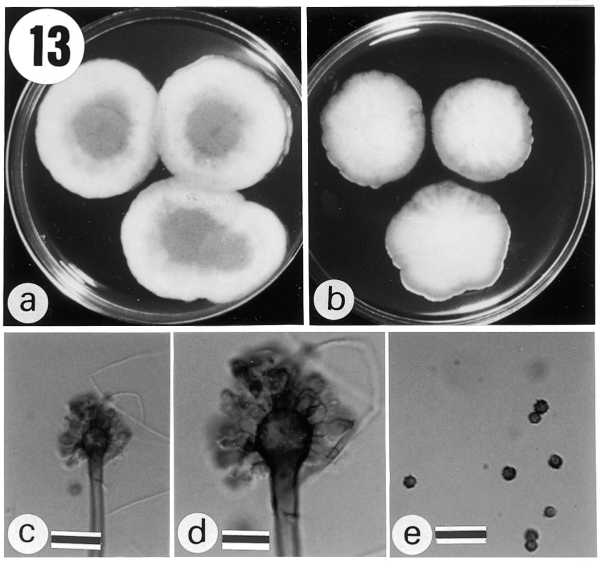

Fig. 13 a) Colonies of *Aspergillus puniceus* on CYA, b) on MEA, c) aspergillum, d) expanded view of the aspergillum, e) conidia

(Scale bar: 13c=4μm; 13d & e=8μm)

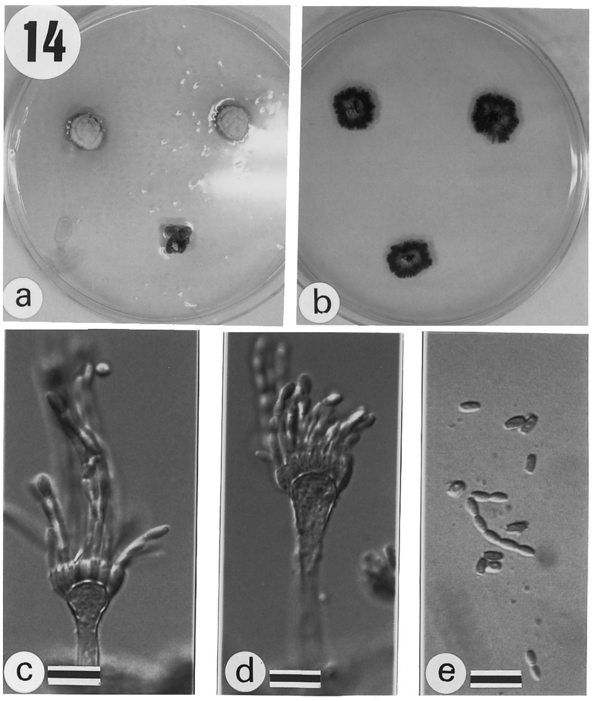

Fig. 14 a) Colonies of *Aspergillus restrictus* on CYA, b) on MEA, c) aspergillum, d) expanded view of the aspergillum, e) conidia

(Scale bar: 14c=7μm; 14d=8μm; 14e=5μm)

(1985)[13].

References: Klich and Pitt (1988)[12], Pitt and Hocking (1985)[13].

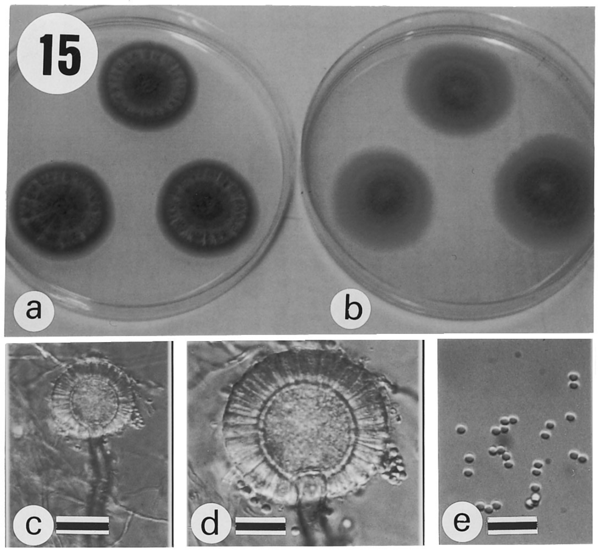

Fig. 15 a) Colonies of *Aspergillus sclerotiorum* on CYA, b) on MEA, c) aspergillum, d) expanded view of the aspergillum, e) conidia

(Scale bar: 15c=4μm; 15d & e=8μm)

14. *Aspergillus restrictus* G. Smith (Fig. 14)

Colonies on CYA 12〜17 mm diameter in 7 days at 25℃; centrally floccose, light green becoming dull green by age, reverse uncolored; mycelia white. Colonies on MEA 17〜22 mm diameter in 7 days at 25℃, low, dull to dark green; mycelia white; reverse uncolored. Conidial heads columnar; stipes smooth-walled; vesicle flask shape, 4〜12.5μm wide. Aspergilli uniseriate; phialides covering upper half of the vesicle surface. Conidia cylindrical, smooth to finely rough-walled, in chains, 5〜7.5μm diam.

Notes: The dark-green slow-growing colonies makes *A. restrictus* distinguished from other species of *Aspergillus*. The phialides of *A. restrictus are* arranged vertically on the upper half of the vesicle yielding columnar formation of cylindrical conidia in chains.

References: Klich and Pitt (1988)[12], Pitt and Hocking (1985)[13].

15. *Aspergillus sclerotiorum* Huber (Fig. 15)

Colonies on CYA 29〜30 mm diameter in 7 days at 25℃; centrally sulcate, conidial areas light olive, margin reddish brown, reverse dark reddish brown; mycelia white. Colonies on MEA 33〜36 mm diameter in 7 days at 25℃, light yellow green; mycelia pale yellow; reverse yellow. Conidial heads radiate; stipes smooth-walled; vesicle subglobose, 12.5〜25μm wide. Biseriate sometimes uniseriate formed on young aspergilla; phialides covering entire vesicle surface.

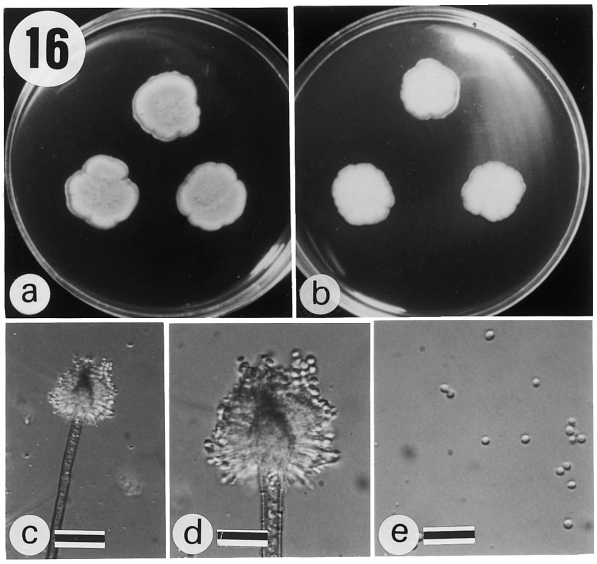

Fig. 16 a) Colonies of *Aspergillus sparsus* on CYA, b) on MEA, c) aspergillum, d) expanded view of the aspergillum, e) conidia
(Scale bar: 16c=3μm; 16d=7μm; 16e=5μm)

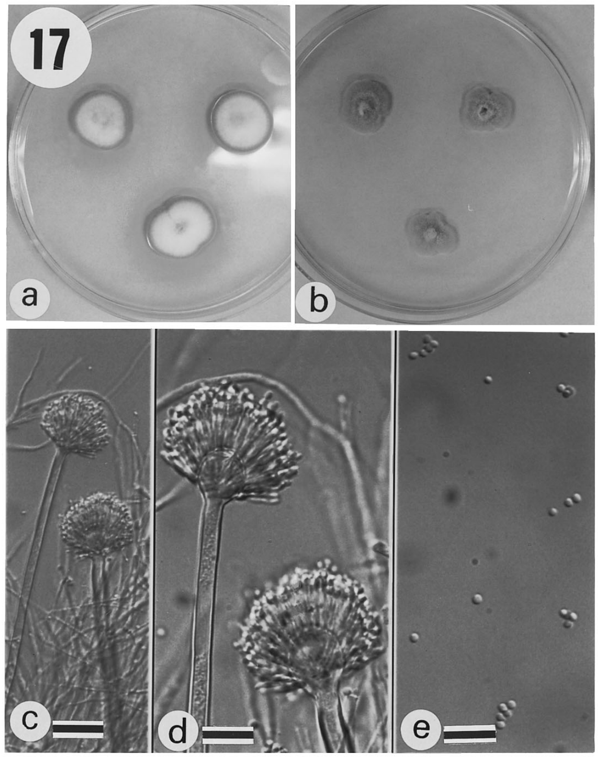

Fig. 17 a) Colonies of *Aspergillus terreus* on CYA, b) on MEA, c) aspergilli, d) expanded view of the aspergilli, e) conidia
(Scale bar: 17c=2.5μm; 17d=5μm; 17e=6μm)

Conidia globose, smooth-walled, 2.5〜4μm diam.

Notes: This isolate has distinguished reverse character on CYA. Dark brown reverse with sulcate cracks as aged, leading to formation of "cave-like space" making the colonies convexly shaped, almost unattached to the plate surface. The aspergilla of this isolate are dominantly uniseriate with compactly arranged phialides surrounding the vesicle.

References: KLICH and PITT (1988)[12], PITT and HOCKING (1985)[13].

16. *Aspergillus sparsus* RAPER & THOM (Fig. 16)

Colonies on CYA 22〜23 mm diameter in 7 days at 25℃; floccose, conidial production sparse becoming light grayish green, margin white; mycelia white; reverse dark reddish brown. Colonies on MEA 21〜22 mm diameter in 7 days at 25℃, floccose, sparse conidial production, conidial areas yellowish green; mycelia white; reverse yellow brown. Conidial heads radiate; stipes smooth-walled, reddish brown; vesicle flask-shape, reddish brown, 10〜12.5μm wide. Aspergilla biseriate; phialides covering entire vesicle surface. Conidia globose, smooth to finely rough-walled, 2.5〜4μm diam.

Notes: This species sparsely produces conidia in all media tested. The reddish brown stipes and vesicles also make this species distinguished from other.

References: KLICH and PITT (1988)[12], PITT and HOCKING (1985)[13].

17. *Aspergillus terreus* THOM (Fig. 17)

Colonies on CYA 17〜20 mm diameter in 7 days at 25℃; floccose, sulcate; conidial areas light brown, colonies margin yellowish, reverse dark golden brown; soluble pigment yellow; mycelia white. Colonies on MEA 17〜19 mm diameter in 7 days at 25℃, floccose, conidial areas light brown; mycelia white; reverse pale yellow. Conidial heads radiate; stipes smooth-walled, light colored; vesicle sub-globose, 17.5〜20μm wide. Aspergilla biseriate; phialides covering 2/3 of the vesicle surface. Conidia globose, smooth to finely rough-walled, 2.5μm diam.

Notes: The compact columnar and pale brownish conidial head, tightly spaced metulae and phialides, and very small conidia distinguish this species from others.

References: KLICH and PITT (1988)[12], PITT and HOCKING (1985)[13].

18. *Basipetospora rubra* COLE & KENDRICK (Fig. 18)

Colonies on PDA 38〜40 mm diameter in 7 days at 25℃; velutinous, white, plane, mycelia white; reverse pale yellow. Conidiophores unbranched, hyaline,

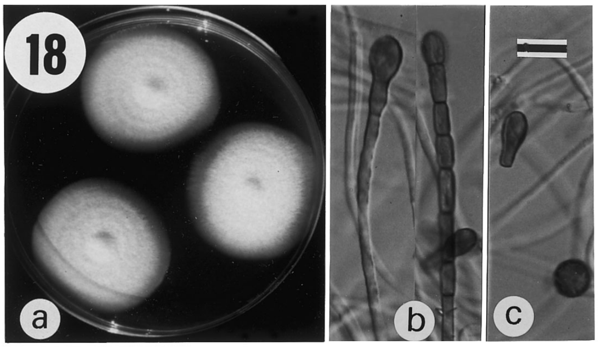

Fig. 18 a) Colonies of *Basipetospora rubra* on PDA, b) conidiogenesis, c) globose conidia and aleuriospores
(Scale bar=6 μm)

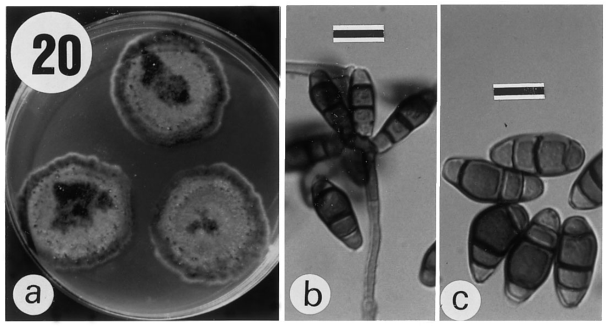

Fig. 20 a) Colonies of *Curvularia pallescens* on PDA, b) conidiophores, c) conidia
(Scale bar : 20b= 3 μm ; 20c=5 μm)

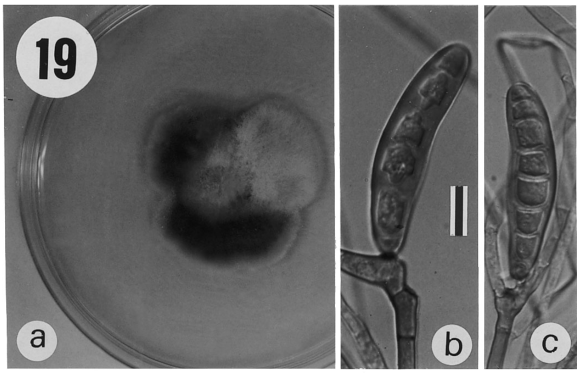

Fig. 19 a) Colony of *Bipolaris ovariicola* on PDA, b) conidiophores and conidia
(Scale bar=6 μm)

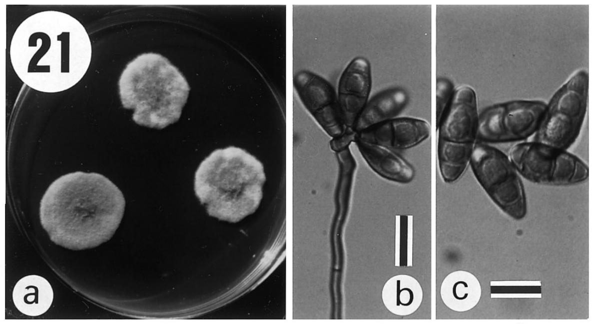

Fig. 21 a) Colonies of *Curvularia verruculosa* on PDA, b) conidiophores, c) conidia
(Scale bar: 21b=4 μm; 21c=6 μm)

rough walled, septated, 45〜100×2.5〜4 μm, conidiogenesis holoblastic. Conidia single-celled, brownish red, rough-walled, aleuriospores (12〜20×5〜10 μm), globose (10〜12 μm diam.).

Notes: *Basipetospora rubra* is the conidial state of *Monascus rubber* differs significantly from any other hyphomycetes genus so far described, both in morphology and conidium ontogeny.

Reference: Cole and Kendrick (1968)[14].

19. *Bipolaris ovariicola* Alcorn (Fig. 19)

Colony on PDA 53〜56 mm diameter in 7 days at 25℃; dark gray with reddish shades, irregular margin; aerial mycelia white to gray; reverse black. No conidiophore present, conidia arising directly from conidiogenous nodes. Conidia mostly 3〜6-septate, smooth-walled, pale brown, predominantly straight to slightly curved, cylindrical, 25〜70×12.5〜17.5 μm diam.

Notes: No conidiophores were noted on this isolate and the conidia arise directly from conidiogenous nodes. This isolate has shorter conidia compared to species described by Sivanesan (1987)[15].

Reference: Sivanesan (1987)[15].

20. *Curvularia pallescens* (Tsuda & Ueyama) Sivanesan (Fig. 20)

Colonies on PDA 38〜40 mm diameter in 7 days at 25℃; black, with almost regular margin; mycelia white. Conidiophores simple and rarely branched, straight, brown. Conidia mostly 3-septate, smooth-walled, pale to light brown, predominantly straight with few slightly curved, ellipsoidal to moderate fusiform, 23〜35×10〜15 μm.

Notes: This isolate has larger and darker conidia compared to species described by Sivanesan (1987)[15]. This fungus was noted by Wallbridge and Pinegar (1975)[19] associated with crown rot disease of bananas from St. Lucia in the Windward Islands.

References: Sivanesan (1987)[15], Wallbridge and Pinegar (1975)[19].

21. *Curvularia verruculosa* Tandon & Bilgrami ex M.B. Ellis (Fig. 21)

Colonies on PDA 34 mm diameter in 7 days at 25℃;

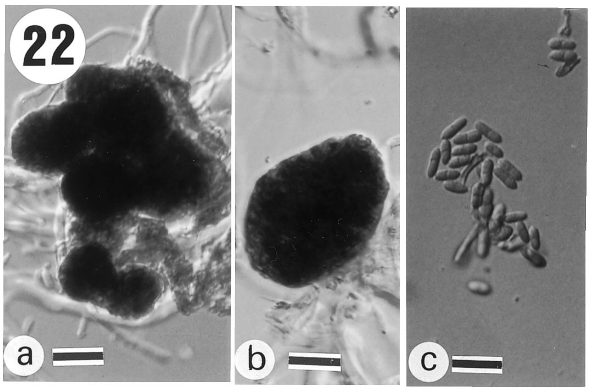

Fig. 22 a) Pycnidia in cluster of *Diplodia* sp., b) expanded view of the pycnidium, c) conidia
(Scale bar: 22a = 3 μm; 22b = 6 μm; 22c = 7 μm)

dark gray, with irregular margin; formation of ascomata on surface of the medium, 0.50 mm diam; mycelia white. Conidiophores simple, straight and curved, light brown in color. Conidia mostly 3-septate, rough-walled, pale to light brown, predominantly straight with few slightly curved, ellipsoidal to moderate fusiform, 22.5～35×7.5～15 μm.

Notes: This isolate has thin and light colored conidia compared to the species described by SIVANESAN (1987)[14]. This fungus was noted by WALLBRIDGE and PINEGAR (1975)[18] associated with crown rot disease of bananas from St. Lucia in the Windward Islands.

References: SIVANESAN (1987)[15], WALLBRIDGE and PINEGAR (1975)[19].

22. *Diplodia* sp. (Fig. 22)

Pycnidia in cluster but mostly solitary, 35～56 μm diam., mostly globose shape, thick-walled, ostiolate. Hyphae hyaline to light brown, smooth-walled. Conidia hyaline becoming light brown by age, 1 sepatate, rough-walled, obtuse apex and base, 6～9×2.5 μm.

Notes: This species of *Diplodia* has smaller pycnidia and conidia compared to the species described by WARDLAW (1972)[8] isolated from dead fruits of *Musa sapientum.*

23. *Drechslera triseptata* (DRECHSLER) SUBRAMANIAN & JAIN (Fig. 23)

Colonies on PDA 44～49 mm diameter in 7 days at 25℃; velutinous, colony center light gray with dark gray irregular margin; mycelia white. Conidiophores simple, straight to slightly curved, light brown. Conidia mostly 3-septate, smooth-walled, pale to light brown, predominantly straight with few slightly

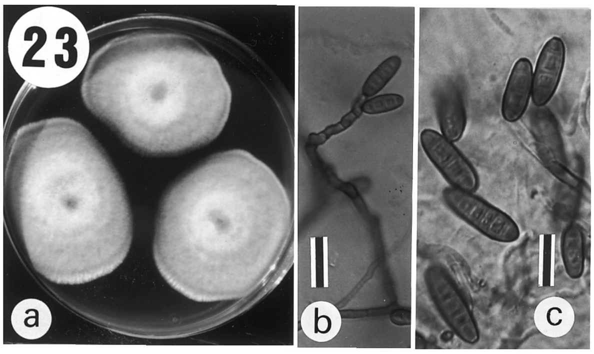

Fig. 23 a) Colonies of *Drechslera triseptata* on PDA, b) conidiophore, c) conidia
(Scale bar: 23b = 3 μm; 23c = 5 μm)

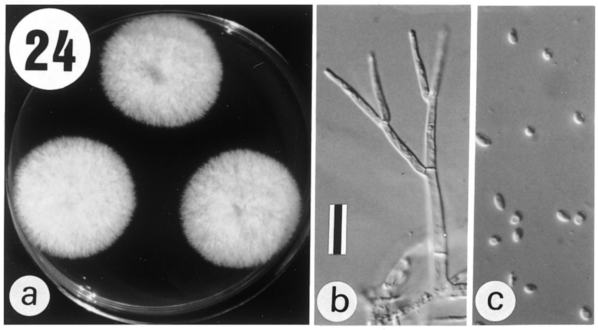

Fig. 24 a) Colonies of *Gliocladium roseum* on PDA, b) conidiophores, c) conidia
(Scale bar = 3 μm)

curved, 22.5～35×7.5～15 μm.

Notes: This isolate has thin and light colored conidia compared to species described by SIVANESAN (1987)[15]

Reference: SIVANESAN (1987)[15].

24. *Gliocladium roseum* BAINER (Fig. 24)

Colonies on PDA 37～38 mm diameter in 7 days at 25℃; white, cottony, reverse pale yellow; mycelia white. Conidiophores hyaline, smooth-walled, septated, 90×2.5～5 μm, branched with 2～3 penicilliate branches (20～28 μm long). Conidia single-celled, hyaline, smooth-walled, subglobose and ellipsoidal, 5～7.5 μm diam.

Notes: This species can be distinguished by its conidiophores that are erect and *Verticillium*-like in young culture, bearing brush-shaped conidial bearing apparatus. MARIN *et al.* (1985)[33] isolated *G. roseum* from crown rot of bananas in Latin America on Grande Naine and disease resistant hybrid bananas.

References: COOK and BAKER (1983)[16], MORQUER *et al* (1963)[17], MARIN *et al.* (1985)[33].

25. *Mucor racemosus* FRESENIUS (Fig. 25)

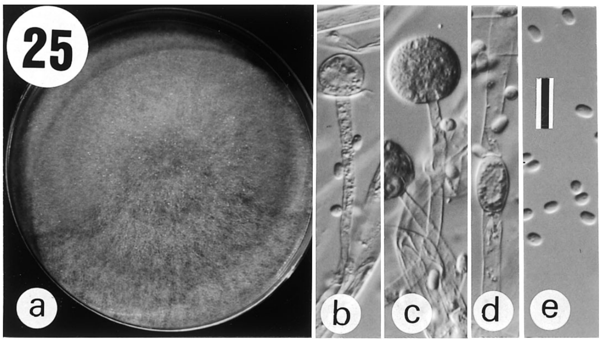

Fig. 25 a) Colony of *Mucor racemosus* on PDA, b) collumellae, c) sporangium, d) chlamydospores, e) sporangiospores
(Scale bar=15μm)

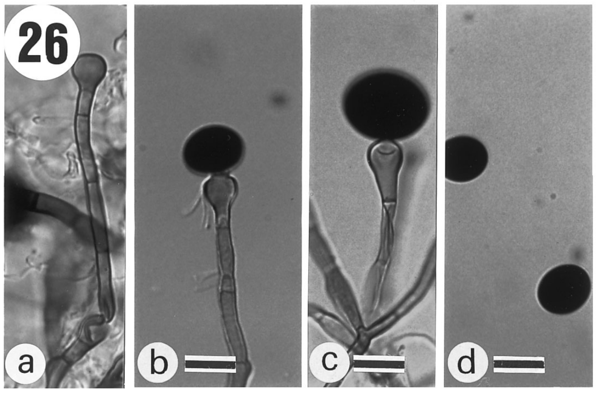

Fig. 26 a) Conidiogenesis of *Nigrospora oryzea,* b) conidiogenous cell, c) expanded view of b, d) conidia
(Scale bar: 25b=8μm; 25c=10μm; 25d=7μm)

On PDA, colony spreading over the petri plates in 7 days at 25℃; light yellowish brown, reverse pale yellow; mycelia white. Sporangiophores born from aerial mycelia, smooth-walled; sporangia light brown with encrusted walls, 17.5〜30μm diam; collumellae 8〜20μm. Sporangiospores hyaline, smooth-walled, ellipsoidal to nearly cylindrical, 2.5〜7.5μm diam. Chlamyspores abundantly formed.

Notes: *Mucor racemosus* could be differentiated from other *Mucor* species by its small collumellae and abundant production of chlamydospores.

Reference: Pitt and Hocking (1985)[13].

26. *Nigrospora oryzae* Hudson (Fig. 26)

Conidiophores 4〜5μm wide. Conidiogenous cells 6〜7.5μm diam. Conidia spherical, smooth-walled, hyaline when young becoming black by age, 11〜19μm (mostly 12.5〜15μm diam).

Notes: *Nigrospora* state of *Khuskia oryzae* Hudson has the smallest conidial size among other species of *Nigrospora*. *Nigrospora oryzae* sometimes considered synonymous with *N. sphaerica* (Saccardo) Mason, enters the cut on the crown and, although no symptoms are apparent in green fruit, rotting is evident soon after removal from the ripening room (Fitzel and Allen (1976)[35].

References: Ellis (1971)[11], Fitzel and Allen (1976)[35].

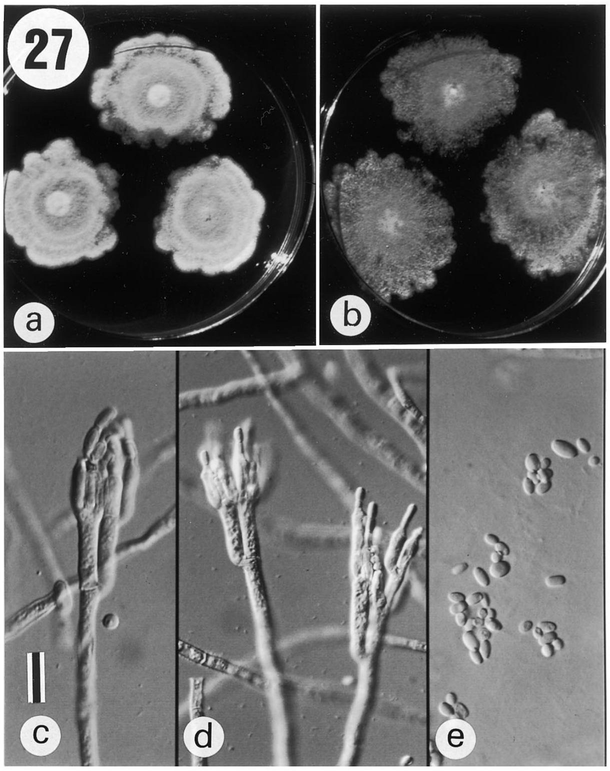

Fig. 27 a) Colonies of *Penicillium digitatum* on CYA, b) on MEA, c) penicilli, d) conidia
(Scale bar=10μm)

27. *Penicillium digitatum* (Persoon : Fries) Saccardo (Fig. 27)

Colonies on CYA 41〜50 mm diameter in 7 days at 25℃; plane, irregular margin, very light yellow green, reverse pale green; mycelia white. Colonies on MEA 35〜40 mm diameter in 7 days at 25℃, plane, irregular margin, yellow brown, reverse yellow brown; mycelia white. Colonies on G25N 7〜12 mm in 7 days at 25℃; plane, sparse; reverse pale. Conidiophores borne for aerial hyphae, rough-walled; uncolored stipes, 80〜140μm long. Penicilli terminal biverticillate; phialides ampulliform to cylindroidal. Conidia very large, ellipsoidal to cylindroidal, smooth-walled, 4〜10μm long.

Notes: The production of large metulae, phialides or conidia is the distinctive feature of *P. digitatum.*

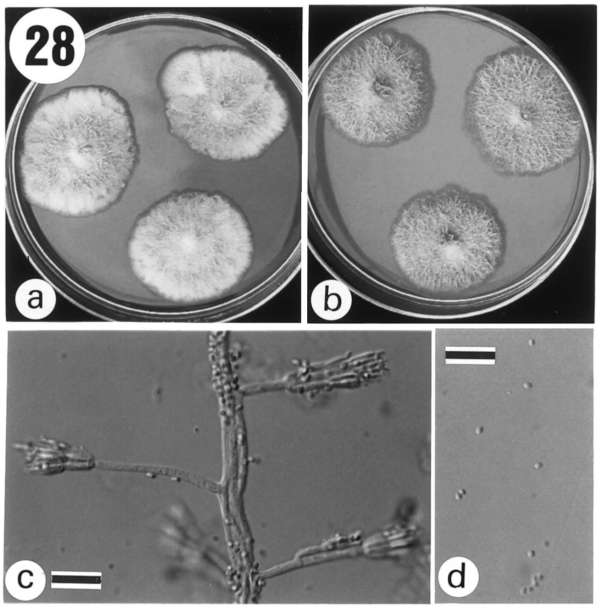

Fig. 28 a) Colonies of *Penicillium funiculosum* on CYA, b) on MEA, c) penicilli, d) conidia
(Scale bar: 28c=6μm; 28d=4μm)

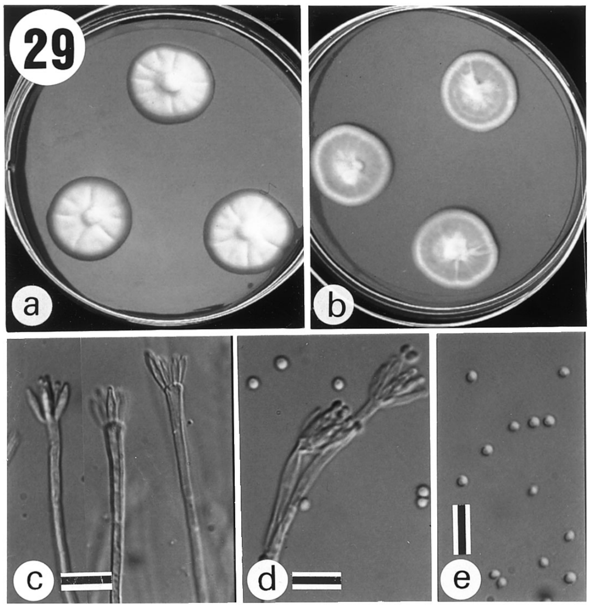

Fig. 29 a) Colonies of *Penicillium implicatum* on CYA, b) on MEA, c) simple and d) branched penicilli, e) conidia
(Scale bar: 29c=2.5μm; 29d=10μm; 29e=5μm)

Reference: PITT (1988)[18].

28. *Penicillium funiculosum* THOM (Fig. 28)

Colonies on CYA 32～40 mm diameter in 7 days at 25℃; funiculose, very light orange becoming dull green by age, reverse pale orange; mycelia white; colorless exudates formed. Colonies on MEA 35～40 mm diameter in 7 days at 25℃, almost similar with CYA. Colonies on G25N 7～10 mm in 7 days at 25℃; plane, funiculose; reverse pale. Conidiophores borne for aerial hyphae; short, smooth-walled, uncolored stipes, 10～48μm. Penicilli terminal biverticillate; metulae and phialides closely appressed; phialides acerose. Conidia subglobose to ellipsoidal, smooth-walled, 2.5～5μm.

Notes: The striking funiculose colony of this species makes them easily recognized from others. The closely packed penicilli and short conidiophores are distinguishing features of this species.

Reference: PITT (1988)[18].

29. *Penicillium implicatum* BIOURGE (Fig. 29)

Colonies on CYA 17～20 mm diameter in 7 days at 25℃; radially sulcate, light peach, reverse pale orange; mycelia white, low, and dense. Colony on MEA 17～20 mm diameter in 7 days at 25℃, floccose, dull green. Colonies on G25N 7～9 mm in 7 days at 25℃; similar to those on CYA. Conidiophores borne from surface hyphae, smooth-walled, uncolored stipes, 38～180μm. Penicilli monoverticillate or often with less metulae, vesiculate. Conidia globose to subglobose, smooth-walled, 2.5～4μm diam, borne in columns.

Notes: *Penicillium implicatum* is slow growing with dense colonies on standard media.

Reference: PITT (1988)[18].

30. *Penicillium italicum* WHEMER (Fig. 30)

Colonies on CYA 47～53 mm diameter in 7 days at 25℃; plane, light brown, conidial areas light blue, irregular margin; mycelia white; reverse reddish brown. Colonies on MEA 40～43 mm diameter in 7 days at 25℃, plane, light blue, colony margin irregular of yellow brown in color; mycelia white; reverse dark reddish brown. Colonies on G25N 13～15 mm in 7 days at 25℃; plane, reverse deep brown. Conidiophores borne from surface hyphae, smooth-walled, uncolored stipes, up to 200～350μm. Penicilli terminal terverticillate with some irregular biverticillate observed, phialides cylindroidal. Conidia subglobose to ellipsoidal, hyaline, smooth-walled, 2.5～7μm diam.

Notes: *Penicillium italicum* is readily recognized in nature as the cause of a destructive bluish gray rot of lemons or other citrus fruits.

Reference: PITT (1988)[18].

31. *Penicillium miczynskii* ZALESKI (Fig. 31)

Colonies on CYA 17～20 mm diameter in 7 days at 25℃; plane and dense, bright yellow; yellow sclerotia produced; limited production of conidia; mycelia

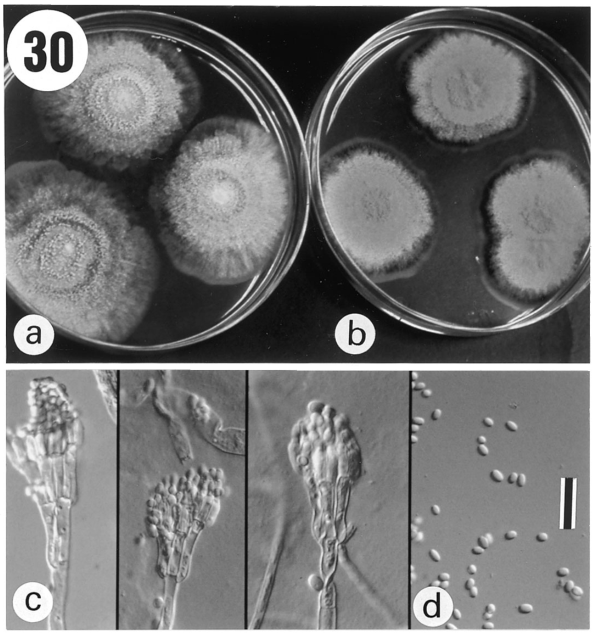

Fig. 30 a) Colonies of *Penicillium italicum* on CYA, b) on MEA, c) penicilli, d) conidia
(Scale bar=3μm)

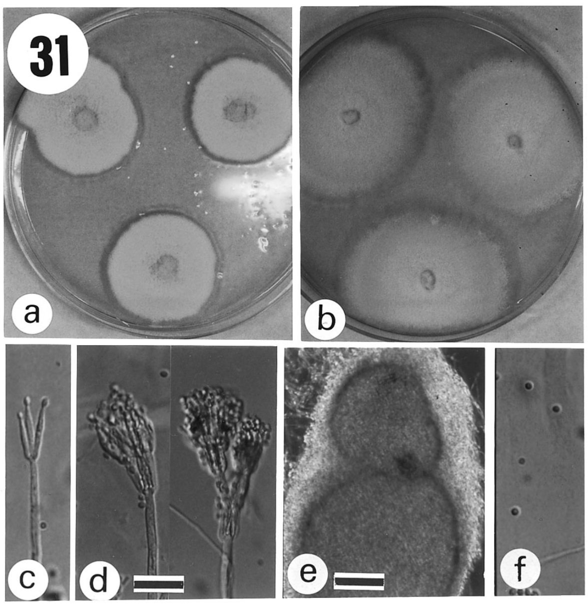

Fig. 31 a) Colonies of *Penicillium miczynskii* on CYA, b) on MEA, c) simple and d) branched penicilli, e) sclerotia, f) conidia
(Scale bar: 31c, d & f=4μm; 31e=100μm)

white; reverse reddish brown. Colonies on MEA 25~30 mm diameter in 7 days at 25℃, plane, golden yellow with shades of gray in the center; yellow sclerotia produced; limited production of conidia; mycelia yellowish; reverse dull brown. Colonies on G25N 10~15 mm in 7 days at 25℃; plane, pale yellow; sclerotia pale

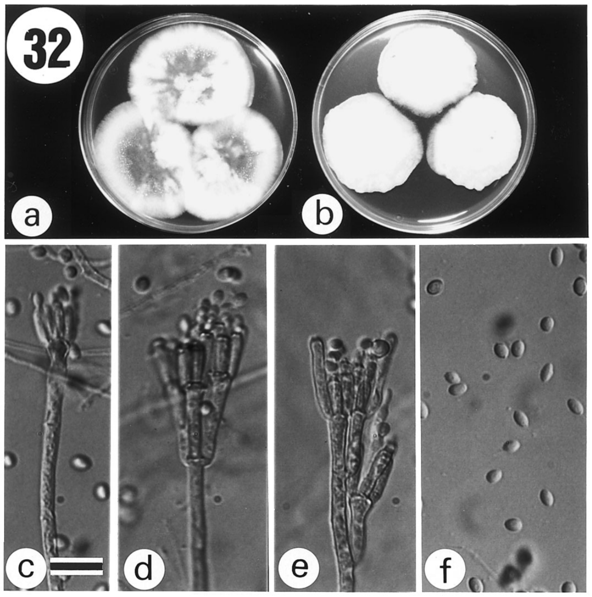

Fig. 32 a) Colonies of *Penicillium oxalicum* on CYA, b) on MEA, c, d & e) penicilli, f) conidia
(Scale bar=7μm)

yellow; limited production of conidia; reverse bright yellow. Conidiophores borne from surface hyphae, smooth-walled, stipes are delicate and easily breaks, 58~135μm. Penicilli biverticillate; metulae in verticils of 3~5, phialides ampuliform. Conidia, ellipsoidal, smooth to finely rough-walled, small, 2.5~4μm diam. Sclerotia globose to subglobose, 200~300μm diam.

Notes: This isolate of *Penicillium miczynskii* has colonies of low, dense, and yellow pigmented. Limited conidial production with abundant yellowish sclerotia on standard media was observed.

Reference: Pitt (1988)[18].

32. *Penicillium oxalicum* Currie & Thom (Fig. 32)

Colonies on CYA 50~60 mm diameter in 7 days at 25℃; outer colony zone plane but centrally wrinkled and radially sulcate, light peach; mycelia white; reverse pale yellowish brown. Colonies on MEA 53~58 mm diameter in 7 days at 25℃, plane, loosely velutinous, mycelia white; reverse uncolored. Colonies on G25N 10~13 mm in 7 days at 25℃; plane, white; reverse pale. Conidiophores borne from surface hyphae. Penicilli biverticillate; closely appressed metulae in verticils of 2~4, phialides acerose. Conidia, ellipsoidal, large, smooth-walled, 4~7.5μm diam.

Notes: *Penicillium oxalicum* is perhaps the most obviously distinctive species of *Penicillium* because the colonies grow rapidly on CYA and produce numerous large ellipsoidal conidia appearing as long closely

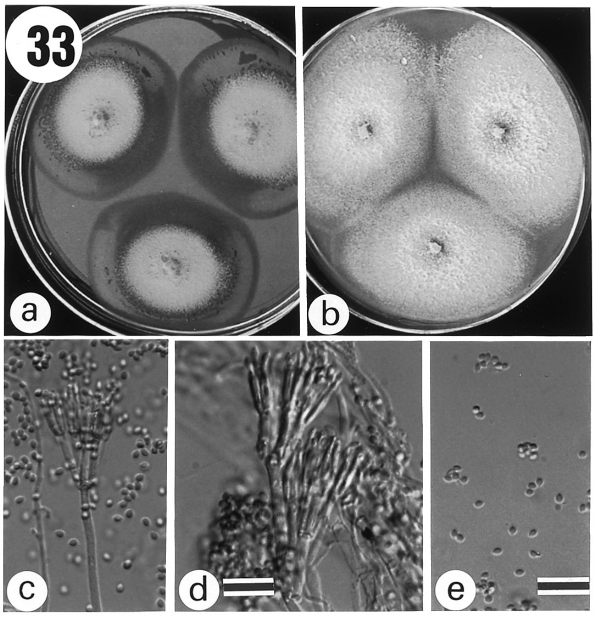

Fig. 33 a) Colonies of *Penicillium pinophilum* on CYA, b) on MEA, c) penicilli, d) expanded penicilli, e) conidia
(Scale bar: 33c & e=3μm; 33d=4μm)

packed chains under low magnification.

Reference: PITT (1988)[18].

33. *Penicillium pinophilum* HEDGCOCK (Fig. 33)

Colonies on CYA 53～58 mm diameter in 7 days at 25℃; plane, floccose, bright yellow with shades of orange; white mycelia in the margins; brown exudates; reverse pale yellow. Colonies on MEA 53～58 mm diameter in 7 days at 25℃, plane, floccose, mycelia white; reverse uncolored. Conidiophores borne from surface hyphae, stipes smooth-walled, 50～88μm. Penicilli terminal biverticillate; phialides acerose. Conidia, subglobose to ellipsoidal, smooth-walled, 4～5μm diam.

Notes: This isolate of *Penicillium pinophilum* is characterized by the production of bright yellow mycelia on CYA. It grows faster on CYA and MEA as compared to those species described by PITT (1988)[18].

Reference: PITT (1988)[18].

34. *Rhizopus oryzea* WENT & PRINSEN GEERLIGS (Fig. 34)

On PDA, colonies spreading over the Petri plates in 7 days at 25℃, grayish; mycelia grayish, reverse pale. Sporangiophores born in clusters of 1～3 from rhizoids; stipes unbranched; sporangia globose to subglobose, 48～53μm diam. Sporangiospores hyaline, smooth-walled, globose to subglobose, 5～7.5μm diam.

Notes: *Rhizopus oryzea* could be differentiated from *R. stolonifer* by its smaller sporangia and sporangiospores.

Reference: PITT and HOCKING (1985)[13].

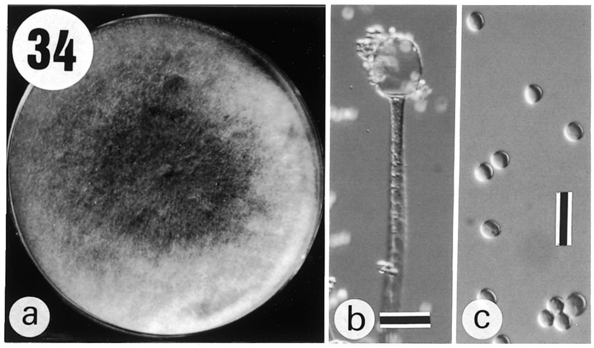

Fig. 34 a) Colony of *Rhizopus oryzea* on PDA, b) sporangium, c) sporangiospores
(Scale bar=10μm)

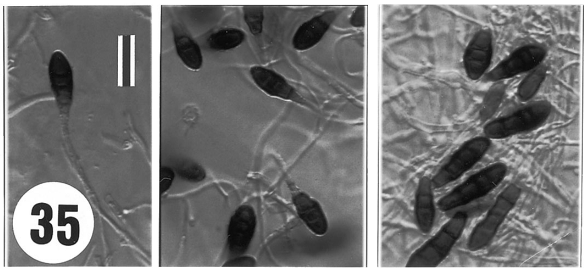

Fig. 35 a) Conidiogenesis and conidia of *Stemphyliomma valparadisiacum*
(Scale bar=5μm)

35. *Stemphyliomma valparadisiacum* (SPEGAZZINI) SACCARDO & TRAVERSO (Fig. 35)

Conidiophores hyaline, less than 2.5μm, rough-walled. Conidiogenous cells terminal monoblastic. Conidia ellipsoidal to fusiform, straight, 1～4 septate (mostly 2～3), brown, rough-walled, 12.5～28μm×7～12.5μm.

Notes: *Stemphyliomma valparadisiacum* differs from *Stemphyliomma terricola by* its thin hyphae and small conidia.

References: ELLIS (1976)[10] and ELLIS (1971)[11].

36. *Tetraploa aristata* BERKELEY & BROOME (Fig. 36)

On PDA, colonies spreading over the Petri plates in 7 days at 25℃, cottony, yellowish. Conidiophores almost unrecognized. Conidia brown, rough-walled, mostly with 4 cells to each column, 35～70×17.5～22.5μm, up to 7 septation with apical septated appendage.

Notes: The conidia of *T. aristata* are mostly 2～4 cells in each column as compared to 4～8 of *T. ellisii. Tetraploa aristata* was isolated from leaf and stem of

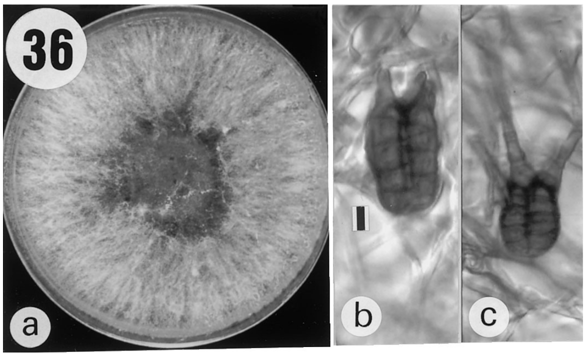

Fig. 36 a) Colony of *Tetraploa aristata* on PDA, b & c) conidia
(Scale bar＝10μm)

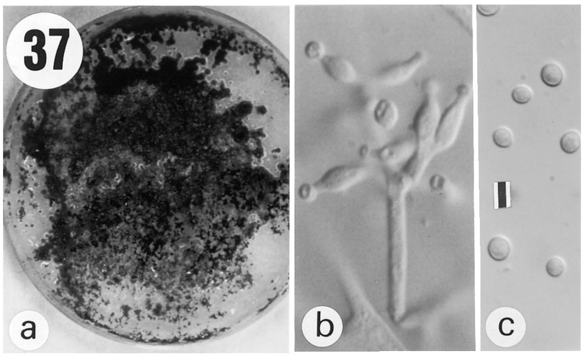

Fig. 37 a) Colony of *Trichoderma saturnisporum* on PDA, b) conidiophores, c) conidia
(Scale bar＝5μm)

Musa.

Reference: Ellis (1971)[11].

37. *Trichoderma saturnisporum* Hammill (Fig. 37)

On PDA, colony spreading over the Petri plates in 7 days at 25℃, low; cottony, conidial areas deep green; reverse bright yellow, mycelium rough-walled. Conidiophores regular to irregularly branched; phialides flask shape, straight to slightly curved, 6〜8×2.5〜3μm. Conidia globose to subglobose with few ellipsoidal, hyaline to gray, rough-walled some almost smooth, some with mucous like wing surrounding conidia, 3〜4×3μm.

Notes: The mucous like wing surrounding conidia are distinguishing characteristic of this species.

Reference: Gams and Bissett (1998)[44]

38. *Thysanophora penicillioides* (Roumeguère) Kendrick (Fig. 38)

Colonies on CYA 15〜19 mm diameter in 7 days at 25℃; plane, conidial areas grayish black, irregular margin in pale color; reverse pale. Colony on MEA 8〜11 mm diameter in 7 days at 25℃, plane, gray, irregular margin, conidial formation sparse; reverse pale. Conidiophores borne from surface hyphae, smooth-walled, short, 2.5〜4μm. Penicilli terminal biverticillate; phialides acerose, less than 5μm long. Conidia in chain, ellipsoidal, born in columns, smooth-walled, 5〜7μm long.

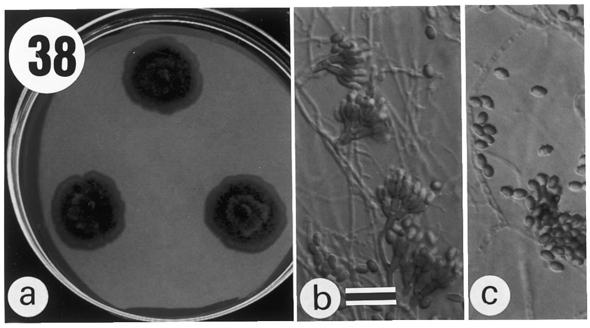

Fig. 38 a) Colonies of *Thysanophora penicillioides* on CYA, b) on MEA, c) penicilli, d) conidia
(Scale bar＝5μm)

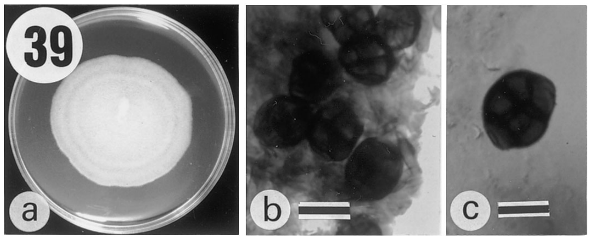

Fig. 39 a) Colony of *Ulocladium atrum* on PDA, b) conidiophores and conidia c) expanded conidia
(Scale bar : 39b＝5μm ; 39c＝10μm)

Notes: *Thysanophora penicillioides* differs from *T. longispora* by its small conidia and abnormally frequent proliferation.

Reference: Kendrick (1961)[46].

39. *Ulocladium atrum* Preuss (Fig. 39)

Colonies on PDA 35〜40 mm diameter in 7 days at 25℃; gray, with almost regular margin; mycelium white. Conidiophores smooth-walled. Two conidial shapes (a,b) formed: a) obovoid, pale to dark brown, verrucose, 1〜3 transverse and 1 or more longitudinal septa, 15〜22.5×10〜17.5μm; b) globose to subglobose, cruciately septate, 12.5〜15μm diam.

Notes: *Ulocladium atrum* is characterized by its verrucose, obovoid and spherical conidia. It differs from its closely allied species, *U. botrytis,* by its cruciately septate conidia.

Table 1 List of fungi isolated from developing banana fruits, non-chemical banana farms, non-chemical banana fruits in Japan from the Philippines, and the reported fungi on banana fruits

Fungi	Isolation in the Philippines from: Developing Fruit	Isolation in the Philippines from: Banana farm	Record of isolation from banana fruits in: Japan	Record of isolation from banana fruits in: World	Reference
Acladium ramosissimum	-	+	-	-	na**
*Acremonium strictum**	+	+	+	+	5), 8), 19)
Annellophorella ziziphi	-	+	-	-	na**
Arthrinium phaeospermum	+	+	+	+	5), 8)
Aureobasidium sp.	-	+	+	-	5)
Aspergillus auricomus	+	+	-	-	na**
Aspergillus alliaceus	+	+	-	-	na**
Aspergillus caespitosus	+	+	-	-	na**
*Aspergillus candidus**	+	+	+	-	5)
Aspergillus carneus	+	+	-	-	na**
Aspergillus clavatus	+	+	-	-	na**
*Aspergillus flavus**	+	+	+	+	5), 20)
Aspergillus fumigatus	+	+	-	+	5), 20)
*Aspergillus japonicus**	+	+	+	-	5)
Aspergillus niger	+	+	-	+	5), 8), 20)
Aspergillus niveus	-	+	-	-	na**
Aspergillus parasiticus	+	+	-	-	na**
Aspergillus puniceus	-	+	-	-	na**
Aspergillus restrictus	+	+	-	-	na**
Aspergillus sclerotiorum	-	+	-	-	na**
Aspergillus sparsus	-	+	-	-	na**
Aspergillus terreus	+	+	-	-	na**
*Aspergillus ustus**	+	+	+	-	5)
Basipetospora rubra	-	+	-	-	na**
Bipolaris ovariicola	-	+	-	-	na**
*Cladosporium cladosporioides**	+	+	+	+	5), 21)
*Colletotrichum musae**	+	+	+	+	5), 20~27), 37~43)
*Colletotrichum gloeosporioides**	+	+	+	+	5), 20)
*Curvularia lunata**	+	+	+	+	5), 20)
Curvularia pallescens	+	+	-	+	5), 19)
Curvularia verruculosa	+	+	-	+	5), 19)
*Cylindrocarpon didymum**	+	+	+	-	5)
*Dactylaria purpurella**	+	+	+	-	5)
Diplodia sp.	+	+	-	+	8)
Drechslera triseptata	+	+	-	-	na**
*Fusarium acutatum**	+	+	+	-	5)
*Fusarium equiseti**	+	+	+	+	5), 28)
*Fusarium incarnatum**	+	+	+	+	5), 28~30)
*Fusarium oxysporum**	+	+	+	+	5), 27)
*Fusarium solani**	+	+	+	+	5), 28)
*Fusarium verticillioides**	+	+	+	+	5), 31~32)
Gliocladium roseum	+	+	+	+	5), 33)

Reference: ELLIS (1976)[10].

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Table 1 Continued

Species	Isolation in the Philippines from: Developing Fruits	Banana farm	Record of isolation from banana fruits in: Japan	World	Reference
*Glomerella cingulata**	+	+	+	+	5), 20)
*Lasiodiplodia theobromae**	+	+	+	+	5), 8), 36~43)
Monilia sp.	-	+	+	-	5)
Mucor racemosus	+	+	+	-	5)
Nectria sp.	-	+	+	-	5)
Nigrospora oryzae	+	+	-	+	8), 35)
Nuerospora sp.	-	+	-	-	na**
Oedocephalum sp.	-	+	+	-	5)
Oidiodendron sp.	-	+	+	-	5)
*Penicillium citrinum**	+	+	+	-	5)
*Penicillium corylophilum**	+	+	+	-	5), 33)
Penicillium digitatum	-	+	-	-	na**
Penicillium funiculosum	+	+	-	-	na**
Penicillium implicatum	-	+	-	-	na**
Penicillium italicum	-	+	-	-	na**
Penicillium miczynskii	-	+	-	-	na**
Penicillium oxalicum	+	+	-	-	na**
Penicillium pinophilum	-	+	-	-	na**
*Penicillium waksmanii**	+	+	+	-	na**
*Pestalotiopsis acaciae**	+	+	+	-	5)
*Pestalotiopsis aletridis**	+	+	+	-	5)
*Pestalotiopsis karstenii**	+	+	+	-	5)
*Phoma exigua**	+	+	+	-	5)
Phoma sp. (1) *	+	+	+	-	5)
*Plectosporium tabacinum**	+	+	+	-	5)
Phomopsis sp. (1) *	-	+	+	+	5), 8)
Phomopsis sp. (2) *	-	+	+	+	5), 8)
Phomopsis sp. (3) *	+	+	+	+	5), 8)
*Phyllosticta musarum**	+	+	+	+	5), 6), 8), 40), 43)
Rhizopus oryzae	+	+	+	-	5)
Spiromyces sp.	-	+	+	-	5)
Stemphyliomma valparadisiacum	-	+	-	-	na**
Tetraploa aristata	-	+	-	-	na**
*Thielaviopsis paradoxa**	+	+	+		5), 8), 29), 37~43)
Trichoderma saturnisporum	+	+	+	-	5)
Thysanophora penicillioides	-	+	-	-	na**
Ulocladium atrum	+	+	-	-	na**
*Verticillium tricorpus**	-	+	+	-	5)

Note : Listing in alphabetical order
* : See species description in ALVINDIA *et. al.*, 2001[5]
** : No available literature
\+ : Isolated
\- : Not isolated

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フィリピンにおいて無農薬バナナおよび圃場から分離された菌類の同定

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(平成 14 年 2 月 28 日受付/平成 14 年 4 月 26 日受理)

要約：フィリピン産無農薬バナナに発生する菌類の由来を調べるため，無農薬バナナおよびその生産圃場に認められる菌類の調査を 2000 年 6 月から 2001 年 5 月に，フィリピンルソン島のヌエヴァヴィスカヤ州で実施した。果実の菌類は果実表面を綿棒で拭って，また，圃場の菌類は寒天トラップで採集した。

41 属 80 種の菌類がバナナ圃場の空気中で採集された，それらのうち，25 属 54 種はバナナ果実からも分離された。すなわち，18 種の *Aspergillus* 属，10 種の *Penicillium* 属，6 種の *Fusarium* 属，3 種の *Curvularia* 属，*Pestalotiopsis* 属および *Phomopsis* 属，*Colletotrichum* 属および *Phoma* 属がそれぞれ 2 種，*Acladium* 属，*Acremonium* 属，*Annellophorella* 属，*Arthrinium* 属，*Aureobasidium* 属，*Basipetospora* 属，*Bipolaris* 属，*Cladosporium* 属，*Cylindrocarpon* 属，*Dactylaria* 属，*Diplodia* 属，*Drechslera* 属，*Gliocladium* 属，*Glomerella* 属，*Lasiodiplodia* 属，*Monilia* 属，*Mucor* 属，*Nectria* 属，*Nigrospora* 属，*Nuerospora* 属，*Oedocephalum* 属，*Oidiodendron* 属，*Plectosporium* 属，*Rhizopus* 属，*Spiromyces* 属，*Stemphyliomma* 属 *Tetraploa* 属，*Thielaviopsis* 属，*Trichoderma* 属，*Thysanophora* 属，*Ulocladium* 属および *Verticillium* 属が各 1 種の各菌である。

無農薬バナナ圃場の空気中で採集した合計 80 種の菌類のうち，54 種（68%）は圃場で生長中の無農薬バナナからも検出されたが，日本に輸入された無農薬バナナのポストハーベスト病害の病斑から検出されたのは 45 種（56%）であった。フィリピンにおける無農薬バナナ果実上の菌類相と比較すると，日本に輸入後の無農薬バナナ果実上の菌類は 17 種類も少なかった。これらの結果から，圃場で生育中の無農薬バナナおよび日本に輸入された無農薬バナナのポストハーベスト病害の病原菌は，フィリピンの無農薬バナナ圃場の気中菌に由来すると考えられた。同時に，バナナ圃場と生育中のバナナ果実，および日本に輸入されたフィリピン産の無農薬バナナ果実から検出される菌類のうち，*Acremonium strictum, Arthrinium phaeospermum, Aspergillus flavus, Colletotrichum musae, Colletotrichum gloeosporioides, Curvularia lunata, Fusarium equiseti, Fusarium incarnatum, Fusarium oxysporum, Fusarium solani, Fusarium verticillioides, Gliocladium roseum, Glomerella cingulata, Lasiodiplodia theobromae, Phomopsis* sp., *Phyllosticta musarum* および *Thielaviopsis paradoxa* の各菌は，既報のバナナ病原菌と共通であった。

キーワード：無農薬バナナ，糸状菌感染源，同定，バナナ圃場

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