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TAXONOMIC STUDIES OF SEED-BORNE MYCOFLORA OF THE SUDAN I: ASPERGILLI AND THEIR TELEOMORPHS

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ABSTRACT

In examination of some leguminous crops of the Sudan for the inidence of seed-borne fungi, many species and varieties have been isolated. Nineteen species and 11 varieties are found to belong to the genus *Aspergillus*, 5 species and 3 varieties (*Emericella*), 2 species (*Eurotium*) and one species (*Fennellia*). From these isolates, 13 species and 8 varieties of *Aspergillus* together with 4 species and 2 varieties of *Emericella* are new records to the mycoflora of the Sudan. Some of these species are new records to some of the tested crops. The species are taxonomically described, illustrated and a key to identification is given.

INTRODUCTION

In the Sudan, various seed-crops including different cultivars of legume are cultivated all year round. Under the diversity of vegetation types, climatic conditions and annual rainfall, different saprophytic and pathogenic fungi would be expected to be in association with these crops. Nevertheless, very few to negligible knowledge are known about the mycoflora of the Sudan. Very little studies were conducted on rusts, smuts, powdery mildews and leaf spotting diseases (Tarr, 1955, 1963). Agaricus, polypores, coprophilous fungi, coelomycetes and many of dematiaceous hyphomycetes have not yet investigated, and no attempt has been focused to describe them taxonomically. Only some species of *Curvularia* and *Drechslera* have been studied (Elshafie, 1985, 1986). This study is a series of papers in which some of seed-borne dematiaceous hyphomycetes will be

described. In this paper, *Aspergillus* species and their teleomorphs isolated from the seeds of Sudanese leguminous crops are described, illustrated and a key for identification is given.

MATERIALS AND METHODS

Collection of Seed Samples

In the present test, 104 seed samples from 8 of the Sudanese legumes viz: Guar (*Cyamopsis tetragonoloba*), Soybean (*Glycine max*), lentil (*Lens esculenta*), lupine (*Lupinus termis*), pea (*Pisum sativum*), fenugreek (*Trigonella foenum-graecum*), faba bean (*Vicia faba*) and cowpea (*Vigna unguiculata*) were purchased from the local markets of Khartoum and supplied by Arab Organization for Agricultural Development (AOAD) from Agadi Farm (Damazin, Blue Nile State) and Um Dom Farm (Khartoum State), National Centre for Research and from Guar Production Company. The samples represent the harvesting seasons of 1993-1996. The working samples were drawn and examined according to the International Rules for Seed Testing Association (ISTA, 1966).

Isolation of seed-borne *Aspergilli*

For the isolation of seed-borne *Aspergilli*, routine Agar Plate and Blotters (Moistened Chambers) Methods were adopted (Christensen, 1963; Hussain *et al.*, 1989; Zohri and Abdel Gawad, 1992; El-Kady and Youssef, 1993; Moslem and Parvez, 1993). In these method, 800 seeds from each samples were disinfected with mercuric chloride (0.1%, 5 minutes) and inoculated aseptically on Potato Dextrose Agar (PDA) and moistened filter papers (Blotter). The inoculated plates were incubated at 28 $\pm$ 2 °C for 1-2 weeks and were then examined using stereoscopic binocular microscope to determine the natural growth of fungi on the seeds.

Identification:

The identification of the genus *Aspergillus* and their teleomorphs was carried out with the aid of the microscope, whenever possible on the seeds. When this was not possible, the isolated fungi were inoculated on various diagnostic growth media. The isolates were incubated at 25 and 37 °C on Czapek Dox Agar (CDA) (Singh *et al.*, 1991; Moubasher, 1993), and at 25 °C on Czapek Yeast Extract Agar

(CYA) (Pitt, 1973), Czapek Yeast Extract Agar with 20% Sucrose (CY20S) (Pitt and Hocking, 1985) and Malt Extract Agar (MEA) (Blakeslee, 1915).

The identification of the isolated species was confirmed using many taxonomic papers and monographs (Raper and Fennell, 1965; Raper and Thom, 1968; Klich and Pitt, 1988; Singh *et al.*, 1991; Moubasher, 1993). Different publications of Commonwealth Mycological Institute (CMI), International Mycological Institute (IMI) and Danish Government Institute of Seed Pathology for Developing Countries were also used.

RESULTS AND DISCUSSION

Microscopic examination of the different seed samples of the leguminous crops inoculated on Potato Dextrose Agar (PDA) and moistened filter papers (Moistened Chambers) at 28 ± 2 °C revealed that the seeds of these crops were infected with 19 species and 11 varieties of the genus *Aspergillus* and 3 species and 3 varieties (*Emericella*), 2 species (*Eurotium*) and one species (*Fennellia*). From these isolates 12 species and 8 varieties of *Aspergillus*, and 4 species and 2 varieties of *Emericella* and one species (*Fennellia*) are new reports to the mycoflora of the Sudan. Some of these isolates are new records to some of the tested crops. Occurrence of this large number of fugal species and varieties under the warm conditions of the Sudan proved their adaptation to this climate as suggested by Elshafie (19985, 1986).

It is evident that the seeds of leguminous crops are infested with numerous fungi some of which are new to these crops and to the mycoflora of the Sudan. The study revealed that the seeds of these crops harbour many of the devastating pathogens which proved destructive under favourable field and storage conditions. This indicates that under the warm conditions of the Sudan different crops would be expected to be infected with many new fungal species and even new genera and taxonomic groups. Therefore the seeds for sowing purpose should be certified, treated and stored under proper conditions to reduce the spreading of these pathogens to uninfected areas. Hence, the construction of proper quarantine stations in the Sudan is badly needed. Various factors are known to cause a considerable fluctuation in the seed-borne mycoflora, therefore timely

studies are needed to evaluate the occurrence pattern of these fungi. Some of these fungi are known to produce secondary metabolites in the seeds which are found to be toxic to both man and his domestic livestock. Therefore, continuous assessment is needed to prevent the consumption of such contaminated seeds.

Key to the seed-borne species of *Aspergillus*, *Emericella* and *Eurotium* is based on that of Klich and Pitt (1988) and adopted by Moubasher (1993).

1- Aspergilla predominately biseriate 2
1- Aspergilla predominantly uniseriate 24

BISERIATE SPECIES:-

2- Metulae present or absent, with the former case predominant; conidial heads yellow green, radiate to very loosely columnar.....*A. flavus*. var. *flavus*

2- Metulae present, conidial heads small scattered and commonly fractional, grey orange.....*A.violaceo-brunneus*

3- Conidial heads in compact column 4
Conidial heads radiate to loosely columnar 5

4- Sclerotia-like masses produced on Malt Extract Agar (MEA).....*A. terreus* var. *africanus*

4- Sclerotia like masses absent.....*A. terreus* var. *terreus*

5-Conidia on CYA paler, orange grey to greyish-orange.....*A. flavipes*

5- Conidia on CYA greyish-turquoise to dark turquoise.....*A. sydowii*

6- Conidia smooth to finely roughened 7
6- Conidia consistently roughened when mature 8

7- Colonies on MEA greyish-yellow, sporulation often sparse, largest conidia often up to 7 µm diameter.....*A. oryzae*

7- Colonies on MEA grey green, largest conidia up to 3.5 µm in diameter.....*A.stellifer*

8- Colonies dark brown to black on CYA 9
8- Colonies dull green to grey green CYA 10

9- Largest conidia < 6 µm in diameter.....*A. niger* var. *niger*

9- Largest conidia > 6 µm in diameter.....*A. carbonarius*

10- Stipes brown, maximum length 200 µm in length.. .....*A. tetrazonus*

10- Stipes sinnamon brown, maximum length 200 µm in length.....*A. stellifer*
11- Colonies on MEA dark brown to black, largest conidia 5 µm in diameter
11- Colonies on MEA golden yellow dark green largest conidia 5 µm in diameter 13
12- Conidiophores > 700 µm in length..... .....*A. niger* var. *awamori*
12- Conidiophores < 700 µm in length..... ....*A. niger* var. *niger*
13- Conidiophores maximum length 500 µm.....*A. terreus* var. *aureus*
13- Conidiophores maximum length < 200 µm.....*A. nidulellus* var. *nidulans*
14- White, spicular hyphae arising above the conidial heads, readily visible under stereoscopic microscope.....*A. unguis*
14- White spicular hyphae absent 15
15- Cleistothecia absent 16
15-Cleistothecia present.....*Fennellia flavipes*
16- Stipes finely roughened to very rough, colorless, maximum length 500 µm.....*A. parasiticus*
16- Stipes thick, usually, smooth-walled, brown in age, maximum length 500 µm..... .....*A. caespitosus*
17- Cleistothecial envelope in dull shades consisting of hülle cell only.....*A. nidulans* var. *latus*
17- Cleistothecial wall consisting of interwoven hyphae, but has an envelope of hülle cells.....*A. nidulans* var. *echinulata*
18- Slow growth on all media.....*Emericella unguis*
18- Moderate to rapid growth 19
19- Ascospores with 4 short longitudinal flanges not always readily visible.....*E. quadrilineata*
19- Ascospores with less than 4 longitudindal flanges always readily visible 20
20- Ascospores convex wall echinulate; orange red in color.....*E. nidulans* var. *echinulata*
20- Ascospores convex wall echinulate, lenticular, violet blue in color.....*E. violacea*
21-Ascospores stellate.....*E. variecolor*
21-Ascospores not stellate 22

22- Cleistothecia surrounded by yellow hyphae bearing hülle cells; dark red at maturity.....*E. nidulans* var. *nidulans*

22- Cleistothecial wall composed of hülle cells only, colored.....*E. nidulans* var. *lata*

UNISERIATE SPECIES:-

23- Osmophilic, colony diameter on CY20S more than twice on CYA 24

23- Not osmophilic, colony diameter on CY20S less than twice on CYA 25

24- growth on CYA at 37°C very low, diameter < 15 mm.....*A. hollandicus*

24- No growth on CYA at 37°C.....*A. rubrobrunneus*

25- Conidial heads columnar 26

25- Conidial heads radiate splitting into columns with age 27

26- Vesicles mostly pyriform or spathulate; conidia predominantly globose, echinulate greenish to green in mass.....*A. fumigatus*

26- Vesicle subglobose, conidia globose to subglobose smooth to echinulate, yellow green.....*A. flavus* var. *columnaris*

27- Conidia predominantly ellipsoidal, maximum vesicles diameter > 45 µm.....*A. japonicus* var. *aculeatus*

27- Conidia globose to subglobose, maximum vesicles diameter < 45 µm.....*A. japonicus* var. *japonicus*

28- Yellow cleistothecia present (*Eurotium*) 29

28- Yellow cleistothecia absent 30

29- Convex surface of ascospores roughened, with conspicuous ridge of irregular height on either side.....*Eurotium amstelodami*

29- Convex surface of ascospores smooth, low or inconspicuous longitudinal ridges.....*E. rubrum*

30- Conidia hyaline when yong and brown with age, evenly space spines.....*A. japonicus* var. *japonicus*

30- Conidia yellow green, smooth echinulate.....*A. flavus* var. *columnaris*

The descriptions of the isolates are based on cultures incubated at 25 and 37°C on Czapek Dox Agar (Singh *et al.*, 1991; Moubasher, 1993) and at 25 °C on Czapek Yeast Extract Agar with 20% Sucrose

(Pitt and Hocking, 1985) and Malt Extract Agar (Klich and Pitt, 1988). The inoculated plates were incubated for 7 days in the dark (Pitt, 1973).

A. caespitosus Raper and Thom (Fig. 1).

On CYA **colony** 30-45 mm in diameter; at 37 °C 10-29 mm, low, velvety, sulcate; **conidial area** greyish-green; **mycelium** white to pale yellow; **soluble pigment** absent; **reverse** brown. exudate on the surface; **reverse** wrinkled or rhizoid, red brown. On CY20S 30-53 mm in diameter; the appearance similar to that. On CYA on MEA 25-40 mm in diameter low, dark green; **mycelium** inconspicuous, white or yellow brown near the hülle cells; **reverse** yellow to red brown; **margin** fimbriate. On CDA 33-47 mm in diameter, appearance as on CYA. **Heads** radiate on CYA and loosely columnar on MEA. **Stipes** smooth, brown with age, 45-150(commonly 61.2 m) in length. **Vesicles** spathulate to hemispherical, 7.5-15.6 m(commonly 12.5-15 mm) wide. **Metulae** 4.1-10 × 2.5-3.5 m (commonly 3.0 m)wide. **Phialides** ampulliform, 5.0-8.8 × 2.5-4.1 µm (commonly 3.0-4.1 mm).**Conidia** spherical, rough-walled, greyish-green 3.0-5.2 mm in diameter(commonly 5mm). **Ascomata** absent; hülle cells hyaline to reddish with age.

The fungus has been isolated from the seeds of soybean ,pea , fenugreek and faba bean .

A. flavus **var.** *flavus* Link. (Fig. 2).

On CYA **colony** diameter 40-67 mm, floccose, olive green to olive yellow; **sclerotia** dark brown to black; **exudate** present; **reverse** colorless to dark brown. On CY20S 54-73 mm in diameter, other characters similar to those on CYA except **exudate** absent and **reverse** bright yellow. On MEA 53-65 mm in diameter, floccose, olive to dark green; **mycelium** white, thin; **exudate** absent; **reverse** colorless. On CDA 45-55 mm in diameter, floccose, yellow green; **margin** white, thin; **reverse** colorless. **Heads** radiate to columnar

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8.

: New records for the crop (s).

with age. **Stipes** hyaline, verrucose, flexuous or straight, 533-635.1 x 8.2-12.3 µm. **Vesicles** globose to subglobose or flask-shaped, fertile on the entire surface, hyaline to yellowish, 25.6-46.2 µm in diameter. **Metulae** absent in small heads, present or absent in large ones, 5.5-143 × 5.0-8.4 µm. **Phialides** ampulliform, 7.4-10.3 × 3.3-4.1 µm. **Conidia** globose to subglobose echinulate, yellowish-green, 3.2-5.1 ýµm in diameter. **Ascomata** absent.

The fungus has been isolated from guar , soybean, lentil, lupine , pea , fenugreek, faba bean and cowpea.

A. fumigatus Fresenius (Fig. 3)

On CYA **colony** diameter 34-58 mm, at 37°C 57-66 mm, velutinous to floccose, plane or furrowed radially, greyish-turquoise to dark turquoise, **mycelium** white; **exudate** colorless; **reverse** yellow to red brown; **soluble pigment** absent. On CY20S 33-62 mm in diameter; colors and other characters as on CYA. On MEA 37-65 mm in diameter; **conidial heads** colors as on CYA; **mycelium** white, inconspicuous; **reverse** colorless to pale yellow; **soluble pigment** colored as reverse. On CDA 50-54 mm in diameter; velutinous, bluish-green to dark grey with age; **reverse** colorless to creamish-yellow. **Heads** mainly columnar, compact. **Stipes** smooth, colorless to greenish-grey, 350-500 × 5.3-8.2 mm. **Vesicles** spathulate, 12.3-28.6 µm wide. **Metulae** absent. **Phialides** ampulliform, closely packed, roughly paralleled to the axis of the stipe 7.3-8.0 × 2.13.0 **µm.** **Conidia** globose, echinulate, greenish to green in mass 3.3-4.1 µm. **Ascomata** absent.

The fungus has been recovered from the seeds of guar, soybean, lentil, lupine , pea , fenugreek, faba bean and cowpea.

A. hollandicus Samson and W. Gams. (***Eurotium amstelodami*** Mangin). (Fig. 4).

On CYA **colony** diameter 8-22 mm, at 37°C 9-13 mm, low plane, grey green to greyish-turquoise; **mycelium** white to yellow; **reverse** yellow to brown; **soluble pigment** brown. On CY20S 39-52 mm in diameter, dark green; **mycelium** colored as on CYA; **reverse** yellow beneath cleistothecia or green beneath conidia. On MEA 10-19 mm in diameter; dark green; **mycelium** inconspicuous; **cleistothecia** absent; reverse colorless. On CDA 15-25 mm in diameter; floccose, green

yellow; **exudate** absent; **margin** thin, yellow; **reverse** brown to tan brown. **Heads** radiate to loosely columnar. **Stipes** colorless to pale yellow, 280-330 × 9-12.5 µm. **Vesicles** alobose, fertile on the upper half, 10-27 µm wide. **Metulae** absent. **Phialides** ampulliform with broad neck,6.3-8.5 × 2.5-5.0 µm. **Conidia** globose to subglobose or barrel-shaped with flattened ends, finely spinulose, 2.5-6.5 µm in long axis. **Ascomata cleistothecia** globose to subglobose, yellow, 115-120 um in diameter; **asci** 10.0-12.0 µm; **ascospores** lenticular, V-shaped equatorial furrow, two irregular ridges, rough convex wall, 3.8-5.0 × 3.5-4.3 µm.

The fungus has been reported on the seeds of lentil and pea .

A. japonicus Saito **var.** ***aculeatus*** (Lizuka) Al-Musallam. (Fig.5).

On CYA **colony** diameter, 55-77 mm, at 37°C 13-25 mm; **conidial area** red brown to black with age; **mycelia** white with central floccose overlay; **reverse** peach yellow to brown; **exudate** absent; **sclerotia** absent. On CY20S 68-83 mm in diameter; other characters similar to those on CYA. On MEA 40-67 mm in diameter; **conidial area** dark brown to black, sparse sporulation; **reverse** yellowish. On CDA 45-67 mm in diameter; **conidial area** black; **mycelium** white; **reverse** colorless. **Heads** radiate, splitting into divergent columns with age. **Stipes** smooth, colorless or brown near the apices, 250-500 × 10-15 µm.**Vesicles** elongate to globose, collapsing near the base, 25-85 µm wide. **Metulae** absent. **Phialides** ampulliform with flat base, covering the three quarters or the whole vesicle, 5.0-12.0 × 2.5-5.0 µm **Conidia** predominant ellipsoidal, globose, widely spaced spines, 4.5-5.5 × 3.5-4.5 µm. **Ascomata** absent.

The fungus has been reported on the seeds of lupine .

A. japonicus Saito **var.** ***japonicus*** (Fig. 6).

On CYA **colony** diameter 45-52 mm, at 37 °C 33-42 mm; **conidial area** very dark brown; **mycelium** white; **exudate** and **soluble pigment** absent; **reverse** dull brown. On CY20S 62-74 mm in diameter; other characters similar to those on CYA. On MEA 55-64 mm in diameter; **conidial area** dark brown. On CDA 40-54 mm in diameter; **conidial area** black; **exudate** absent; **reverse** colorless. **Heads** radiate or spilt into few loose columns. **Stipes** smooth, hyaline below, slightly pigmented at the apices, sinuous, 150-350 × 8.2-10.0 µm. **Vesicles** globose, pigmented, fertile over the entire surface in

small heads, but at least the half of the surface, 10-43.0 um. wide. **Metulae** absent. **Phialides** ampulliform, 6.0-8.0 × 3.5-4.0 µm. **Conidia** globose to subglobose, hyaline when young and brown with age, evenly spaced spines, 3.0-5.0 µm. **Ascomata** absent.

The fungus has been isolated from the seeds of lupine and fenugreek .

A. nidulans (Eidam) Winter **var. *echinulata*** . **(*Emericella nidulans*** (Eidam)Vuillemin **var. *Echinulata*** (Raper and Fennell) Subramanian) (Fig. 7).

On CYA **colony** diameter 42-50 mm, at 37°C 44-58 mm, velutinous, plane to slightly sulcate, green to deep green; **mycelium** white to cream; **exudate** red to brown; **reverse** brown orange to purple red. On CY20S 33-45 mm in diameter; other characters similar to those on CYA. On MEA 40-55 mm in diameter; **colony** low, plane, velutinous, heavily sporulated, dark green; **mycelium** white, inconspicuous; **reverse** pale brown. On CDA 17-32 mm in diameter; **conidial area** dark grey to dark brown raised, granulated; **exudate** faint droplets; **reverse** brown, tan brown to reddish-brown. **Stipes** short, smooth, golden brown, 61.2-175.4 mm in length. **Vesicles** globose to subglobose, fertile on the upper half, 12.2-16.4 µm in diameter. **Metulae** each one bearing 1-2 phialides, 4.0-6.5 × 2.5-3.1 µm. **Phialides** ampulliform with very short neck, 5.0-8.2 × 2.5-4.1 µm. **Conidia** globose to subglobose, thick, finely echinulate, greenish, 2.5-4.4 µm in diameter. **Ascomata cleistothecia** reddish-black to black, 110-320 µm; **asci** ovate to subglobose, orange red; **ascospores** lenticular, two equatorial ridges, convex wall echinulate, 2.5-6.3 µm in diameter.

The fungus has been isolated from the seeds of pea and fenugreek .

A. nidulellus Samson and W. Gams **var. *nidulans*** .**(*E. nidulans*** Vuillemin **var. *nidulans*)** Eidam (Fig. 8).

On CYA **colony** diameter 40-55 mm, at 37°C 47-66 mm, velutinous or with floccose overlay, plane or sulcate, green to deep green; **mycelium** white to cream; **exudate** dull pale red to brown; **reverse** brown orange to deep purple red; **soluble pigment** similarly colored. On CY20S 38-48 mm indiameter; **conidial** and **mycelial** colors similar to those on CYA; **exudate** absent; **reverse** red brown;

soluble pigment absent. On MEA 45-62 mm in diameter; **colony** low, velutinous, plane, heavily sporulating with dark green conidia; **mycelium** white, inconspicuous; **cleistothecia** dull yellow to buff; **reverse** pale brown.On CDA 36-43 mm in diameter; **conidial area** yellow green mixed with yellowish to black cleistothecia; **exudate** absent; **reverse** tan brown to reddish-black brown. **Heads** radiate to loosely columnar. **Stipes** smooth, brown with age, sinuous, 83.8- 98.4 × 8.0-12.5 µm.**Vesicles** spathulate to hemispherical, fertile on the upper half, 4.2-12.3 µm. **Metulae** bearing two phialides each , 6.6-7.0 × 2.5-3.1 µm. **Phialides** ampulliform with very short neck, 5.0-6.3 × 2.5-3.3 µm. **Conidia** globose, greenish to deep green, echinulate, 2.5-4.1 µm in diameter **Ascomata cleistothecia** dark red with age, 143.5-266.5 µm in diameter; **hülle cells** 12.3-24.6 µm in diameter; **ascospores** lenticular, 2equatorial crest smooth convex walls purplish-red, 5.0 - 7.5 × 2.0-3.8 m.

The fungus has been recovered from the seeds of guar , soybean , lentil, lupine , pea , fenugreek , faba bean and cowpea.

A. niger Van Tieghem (Fig. 9).

On CYA **colony** diameter 50-73 mm, at 37°C 55-68 mm; floccose, sulcate due to the varying length of stipes; **conidial area** very dark to black; **mycelium** white to dull yellow, inconspicuous; **reverse** yellow. On CY20S 56-64 mm in diameter; **colony** appearance similar to that on CYA with more densely packed aspergilla. On MEA 39-58 mm in diameter; **conidial area** black; **colony** granular to floccose; **mycelium** white and inconspicuous; **reverse** colorless.On CDA 55-68 mm in diameter; **conidial area** blackish-brown to carbon black to naked eye; **mycelium** yellow; **margin** white to pale yellow; **reverse** yellow to creamish yellow. **Heads** globose splitting into many irregular columns with age. **Stipes** smooth, thick, hyaline, yellowish to brownish near the apices, 450-500 × 13-15 µm.**Vesicles** spherical to subglobose, hyaline to brownish, 50-76.5 µm wide. **Metulae** long, closely packed, brownish, 11-13.8 × 4.2-5.5 µm. **Phialides** short, thick, ampulliform, 5.0-6.2 × 2.5-3.2 µm. **Conidia** globose to elliptical, verruculose, with irregular ridges and bars, dark brown to black, 4.0-5.0 µm in diameter. **Ascomata** absent.

The fungus has been isolated from the seeds of guar, soybean, lentil, lupine , pea, fenugreek, faba bean and cowpea.

A. niger Van Tieghem **var.** ***awamori*** (Nakazawa) AL-Mussalam (Fig. 10).

On CYA **colony** diameter 58-75 mm, at 37°C 52-67 mm, velutinous, low, brown to black; **mycelium** white; **exudate** absent; **reverse** dull yellow to dull brown. On CY20S 65-77 mm in diameter; other characters similar to those on CYA. On MEA 48-73 mm in diameter; dark brown to black, plane; **mycelium** inconspicuous; **aspergilla** uncrowded. On CDA 60-74 mm in diameter; **conidial area** blackish-brown; **mycelium** white; **reverse** pale yellow to colorless. **Heads** radiate, splitting into columns at maturity. **Stipes** smooth, thick, colorless to pigmented near the apices, 350-750 × 8.0-14.0 µm. **Vesicles** globose to subglobose, fertile over the entire surface or upper half in small vesicles, 7.5-45.0 µm. **Metulae** hyaline to subhyaline, 5.0-9.0 × 4.0-7.50 µm. **Phialides** hyaline to light brown; 5.0-10.0 × 3.5-4.0 µm **Conidia** globose to subglobose, hyaline to light brown, smooth to delicately roughened, ornamented with ridges and bars, 4.5-6.0 µm in diameter. **Ascomata** absent.

The fungus has been reported on soybean , lentil , lupine , fenugreek and cowpea.

A. oryzae (Ahlburg) Cohn (Fig. 11).

On CYA **colony** diameter 60-75 mm, at 37°C 45-65 mm, **colonies** lanose to floccose, greyish-yellow to olive brown; **mycelium** dense, white to cream; **exudate** absent; **reverse** colorless. On CY20S 65-73 mm in diameter; **colonies** floccose, olive yellow to greyish yellow; **mycelium** white, dense; **conidia** abundant; **reverse** colorless. On MEA 55-60 mm in diameter; **colonies** floccose, greyish-yellow; **mycelium** white and not dense as on CYA; **conidia** sparse; **reverse** colorless. On CDA 49-63 mm in diameter; **colonies** floccose, yellowish-green in the margin to grey green in the centre; **exudate** absent; **reverse** colorless. **Heads** radiate to loosely columnar. **Stipes** rough-walled, colorless, 200-1000 × 8.0-12.0 µm. **Vesicles** clavate to subglobose, 20-48 µm wide. **Metulae** commonly absent (uniseriate) or biseriate with both conditions present on the same head, 5.0-8.0 × 3.0-4.5 µm. **Phialides** covering the most of the vesicle surface, 8.0-15.0 × 3.0-5.0 µm. **Conidia** smooth to finely roughened, globose, ovoid, ellipsoidal, 3.0-7.0 µm in diameter. **Ascomata** absent.

The fungus has been isolated from the seeds of guar , soybean , lentil , lupine , pea , fenugreek , faba bean and cowpea.

A. rubrobrunneus Samson and W. Gams. (***E. rubrum*** Konig, Spieckermann and Bremer) (Fig. 12).

On CYA **colony** diameter 25-33 mm, at 37°C no growth, velvety, plane with umbonate centre; **conidial heads** sparse, grey green; **mycelium** and **cleisothecia** forming yellow felt; **exudate** absent; **reverse** brown. On CY20S 43-67 mm in diameter, plane or radially sulcate, velutinous with floccose overlay; **cleistothecia** and **mycelium** yellow; **reverse** bright. On MEA 17-55 mm in diameter, granular or tuft, sparse, grey green; **mycelium** yellow gold; **cleistothecia** rare, yellow gold; **reverse** yellow. On CDA 30-42 mm in diameter, velutinous, plane, greyish-green; **mycelium** and **cleistothecia** pale yellow felt; **reverse** brown to dark brown. **Heads** radiate on CY20S. **Stipes** smooth to rough, colorless to pale brown, 100-500 ×3.0-16.0 µm. **Vesicles** subglobose, 7.0-32.8 ýµm. **Metulae** absent. **Phialides** ampullifrom, covering most of the vesicle, 7.5-14.0 × 2.5-5.0 µm. **Conidia** variable in shape, spherical, ellipsoidal, apiculate, spinose, 4.5-6.5 × 4.0-6.0 µm. **Ascomata cleistothecia**, subglobose, wall of single layer of pseudoparenchyma; **asci** 9.5-17.0 µm; **ascospores** lenticular, hyaline, slight furrow, inconspicuous ridges, smooth surface, 5.0-6.0 × 3.0-4.5 µm.

The fungus has been reported on the seeds of lentil .

A. stellifer Samson and W. Gams (***E. variecolor*** Berkeley and Broome (Fig. 13).

On CYA **colony** diameter 30-45 mm, at 37°C 15-25 mm, velutinous, grey green; **mycelium** submerged, sparce; **margin** white; **exudate** absent; **cleistothecia** yellowish grey; **reverse** yellow green to black at the centre. On CY20S 25-35 mm in diameter, others characters similar to those on CYA except that the colony umbonate, green to yellowish-green. On MEA 40-55 mm in diameter, plane, zonate; **conidial area** and **cleistothecia** as on CYA; **exudate** absent; **reverse** dull yellow. On CDA 15-25 mm in diameter, velutinous, green to grey green; **margin** white; **cleistothecia** yellowish; **reverse** yellow green. **Heads** radiate to loosely columnar. **Stipes** smooth, straight, cinnamon brown, 150-260 × 3.5-5.5 µm. **Vesicles** hemispherical, 8.2-12.3 µm. **Metulae** each one bearing 2-3 phialides,

6.5-8.4 × 3.2-4.4 µm. **Phialides** ampulliform, 7.4-8.4 × 2.1-3.3 µm. **Conidia** globose, rugulose, greenish to green, 2.5-3.5 µm. **Ascomata cleistothecia** two type; aggregated 350-550 µm, segregated 150-250 µm; **asci** subglobose or elongated, stellate, 10-12 × 8.0-10 µm; **ascospores** lenticular, bearing two equatorial ridges, 2.0-3.5 µm wide, stellate, ascospore body 3.0-4.0 µm face view, 3.0-4.5 × 2.0-3.0 µm side; **hülle cells** globose to irregular, 15.4-25.0 µm in diameter.

The fungus has been reported on the seeds of fenugreek .

A. sydowii (Bain. and Sart.) Thom and Church (Fig. 14).

On CYA **colony** 20-35 mm in diameter, at 37°C 8-12 mm, velutinous, sulcate or radially wrinkled, umbonate, dark turquoise to dark green; **margin** white; **exudate** dark brown to reddish-brown; **reverse** red brown to reddish-black. On CY20S 22-35 mm in diameter, characters similar to that on CYA except **exudate** absent and **texture** somewhat floccose. On MEA 15-20 mm in diameter, color as on CYA, granular to floccose, plane; **exudate** absent; **mycelium** white; **margin** white; **reverse** colorless. On CDA 13-18 mm in diameter, **conidial area** blue green to green, raised or umbonate, radially wrinkled; **exudate** present; **reverse** grey orange with light pigment diffusing into the media. **Heads** typical radiate to globose. **Stipes** thick-walled, colorless, 100-380 × 2.0-8.2 µm. **Vesicles** globose toclavate, fertile on the entire surface, 2.5-20.0 µm in diameter. **Metulae** broad, pyriform, divergent, 3.0-5.2 × 2.0-3.5 µm. **Phialides** ampulliform, with broad neck, 4.2-7.4 × 2.1- 3.2 µm. **Conidia** globose to subglobose, echinulate, to spinose, 3.5-4.2 µm in diameter. **Ascomata hülle cells** produced in a few numbers.

The fungus has been isolated from the seeds of guar , soybean, lentil , pea , faba bean and cowpea.

A. terreus Thom **var.** ***terreus*** (Fig. 15).

On CYA **colony** 28-46 mm in diameter at 37°C 37-86 mm velutinous to lanose, plane to radially sulcate, brownish-orange; **mycelium** white; **pigment** absent; **reverse** yellow to pale brown. On CY20S 30-69 mm in diameter, color similar to that on CYA, sulcate, floccose. On MEA 37-57 mm in diameter; **conidia** sparce, pale orange; **mycelium** white, inconspicuous; **reverse** yellow to pale brown. On CDA 12-32 mm in diameter, velutinous, sulcate, umbonate, cinnamon or golden yellow; **reverse** yellowish-brown with

yellowish secretion in the media. **Heads** compact columnar. **Stipes** smooth, hyaline, straight or flexuous, 80-300 µm long. **Vesicles** spherical to hemispherical, fertile on the upper two third, 10.4-16.4 µm in diameter. **Metulae** almost parallel to the stipes, cylindrical, 5.0-6.5 × 2.0-2.5 µm. **Phialides** thin, 5.4-6.9 × 1.3-2.3 µm. **Conidia** globose to subglobose, in long chains, 1.5-2.7 µm in diameter. **Ascomata** absent.

. The fungus has been recovered from the seeds of guar , soybean, lentil, lupine , pea , fenugreek , faba bean and cowpea.

A. tetrazonus (Thom and Raper) Samson and W. Gams

(***E. quadrilineata*** (Thom and Raper) Benjamin (Fig. 16).

On CYA **colony** 45-50 mm in diameter, at 37°C 50-65 mm, velutinous, low, radially sulcate, dull green to grey green; **mycelium** white; **exudate** absent; **reverse** red brown. On CY20S 55-62 mm in diameter, low, sulcate; **mycelium** white to buff; **reverse** red brown and spreading as soluble pigment. On MEA 25-38 mm in diameter, velutinous, low; **mycelium** white, inconspicuous; **reverse** dull brownish-yellow with yellow soluble pigment. On CDA 50-65 mm in diameter, thin, floccose, orange white with few pale greenish **conidial heads**; **reverse** orange. **Heads** radiate to columna. **Stipes** smooth, brown at maturity, 30-200 × 4.1-5.3 µm. **Vesicles** flask-shaped, hemispherical, 5.0-12.4 µm in diameter. **Metulae** covering the upper half of the vesicle, 4.1-6.3 × 2.5-3.5 µm. **Phialides** dehiscing rapidly, 4.5-8.0 × 2.0-3.5 µm. **Conidia** globose, smooth to rugulose, sparce, dull green to grey green, 3.0-4.0 µm in diameter. **Ascomata cleistothecia** globose, brown red, **hülle cells** yellowish; **ascospores** red, smooth, with short crest, tow of them obvious, two quite indistinct, 4.5-5.5 × 3.0-4.5 µm.

The fungus has been isolated from the seeds of lentil , fenugreek and faba bean .

A. unguis (Emile Wiel and Gaudin) Thom and Raper (***E. unguis*** Malloch and Cain) (Fig. 17).

On CYA **colony** diameter 20-37 mm, at 37°C 12-18 mm, velutinous, irregularly sulcate, with floccose central overlay of white mycelium, greyish-green becoming olive green to brown with age; **exudate** absent; **cleistotheacia** absent; **reverse** dull brown to red brown. On CY20S 23-32 mm in diameter, olive green; **reverse**

orange brown to black with age; other characters similar to those on CYA. On MEA 25-40 mm in diameter, sparce growth, plane, grey green to dark green; **mycelium** white, inconspicuous; **exudate** absent; **reverse** cream to pale yellow. On CDA 20-36 mm in diameter, other characters similar to those on CYA. **Heads** radiate to loosely columnar on CYA, definitely columnar on MEA and with sterile, thick, white spicular hyphae arising above the **conidial heads. Stipes** simple or dichatomously branched, smooth, straight or sinuous, colorless to dull brown, 150-300 × 3,3-6.0 µm. **Vesicles** spathulate, hemispherical to flask-shaped, 5.0-12.0 µm wide. **Metulae** covering the upper half to the two third of the vesicle, 4.0-8.0 × 2.5-3.5 µm. **Phialides** ampulliform, 4.5-9.0 × 2.0-3.5 µm. **Conidia** Gglobose, smooth to echinulate or rugulose, 30-4.1 µm in diameter. **Ascomata cleistothecia** only on MEA, mature one not observed, 150-250 µm; **ascospores** lenticular, purple red, two equatorial crest, smooth, 4.0-5.5 × 3.0-3.5 µm.

The fungus has been reported on the seeds of guar , lentil , fenugreek and faba bean .

A. violaceo-brunneus Samson and W. Gams (***E. violacea*** (Fennell and Raper) Mallocch and Cain) (Fig. 18).

On CYA **colony** 45-60 mm at 37°C 33-40 mm; **conidial structures** not observed; **exudate** absent; **reverse** red to dark or brown red. On CY20S 45-47 mm in diameter, green and yellow in centre due to cleistothecia; **reverse** tan brown; other characters similar to those on MEA. On MEA 45-53 mm in diameter, grey green, yellowish in the centre due to abundant cleistothecia; wrinkled, umbonate; **margin** irregular, **exudate** present; **reverse** yellow brown. On CDA 62-70 mm in diameter, grey green to dark green, radially wrinkled; **reverse** reddish-brown in the centre to bluish-black or red towards the margin. **Heads** columnar. **Stipes** thick, sinuous, smooth, colorless to pale brown, 50-200 × 4.1-5.3 µm. **Vesicles** globose to hemispherical, 8.2-12.3 µm in diameter. **Metulae** bearing two phialides, 6.2-7.8 × 2.5-3.3 µm. **Phialides** ampulliform with short neck, 5.2-6.5 × 2.5-3.1 µm. **Conidia** globose to elliptical, smooth to finely roughened, 3.1-5.0 µm. **Ascomata cleistothecia** globose, 120-280 µm; **hülle cells** globose to subglobose dense, 12.2-22.4 µm in

diameter; **ascospores** violet blue, lenticular, echinulate, two narrow equatorial ridges, 5.0-6.2 × 4.4-5.0 µm.

The fungus has been has been isolated form the seeds of guar , lentil , lupine , pea , faba bean and cowpea

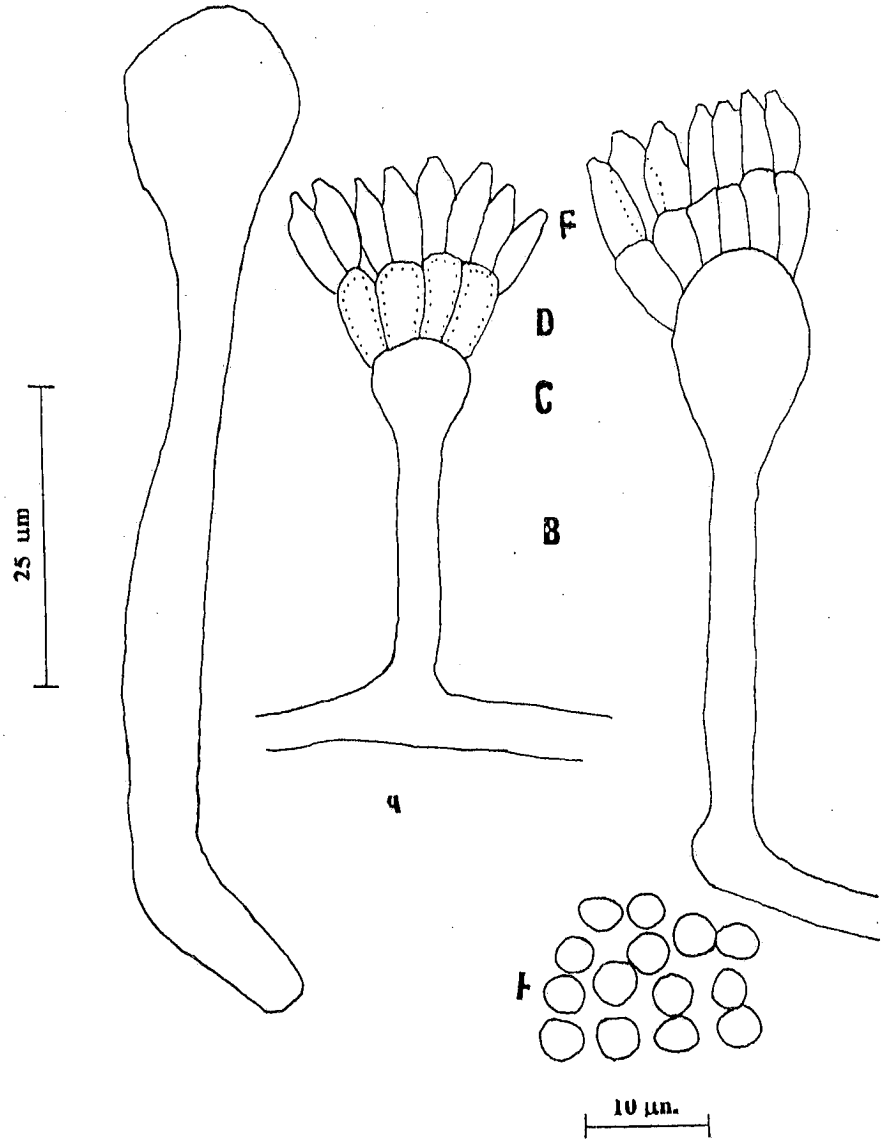

Fig. 1: *Aspergillus caespitosus.*
(A) Foot cells (B) Stipes (C) Vesicles.
(D)Metulae (E) Phialides (F) Conidia.

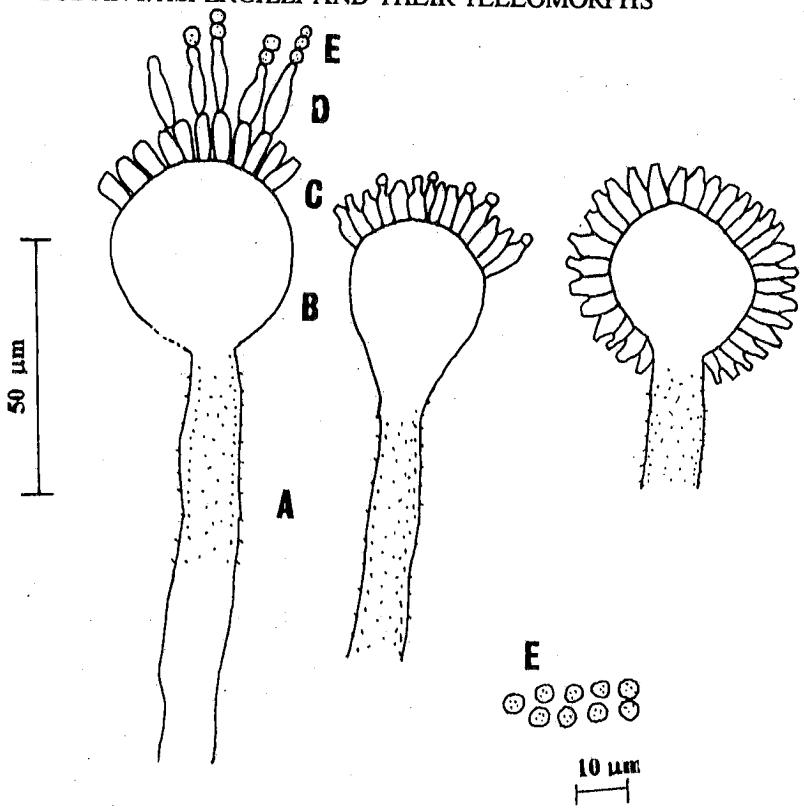

Fig. 2: *Aspergillus flavus* var. *flavus*.
(A) Stipes (B) Vesicles (C) Metulae.
(D) Phialides (E) Conidia.

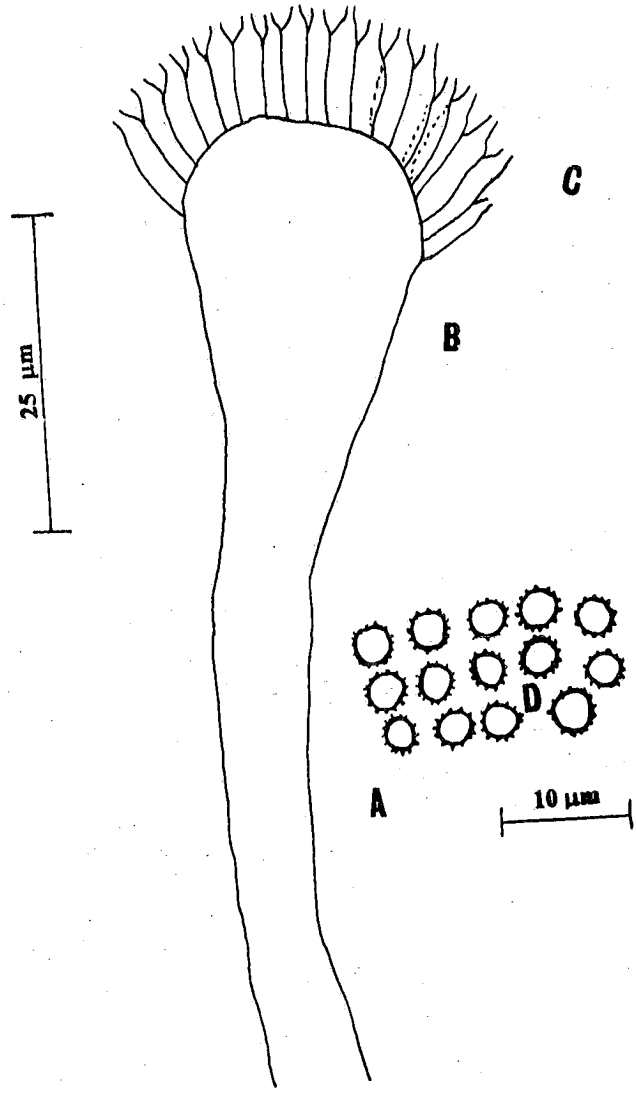

Fig. 3: *Aspergillus fumigatus*.
(A) Stipe (B) Vesicle.
(C) Phialides (D) Conidia.

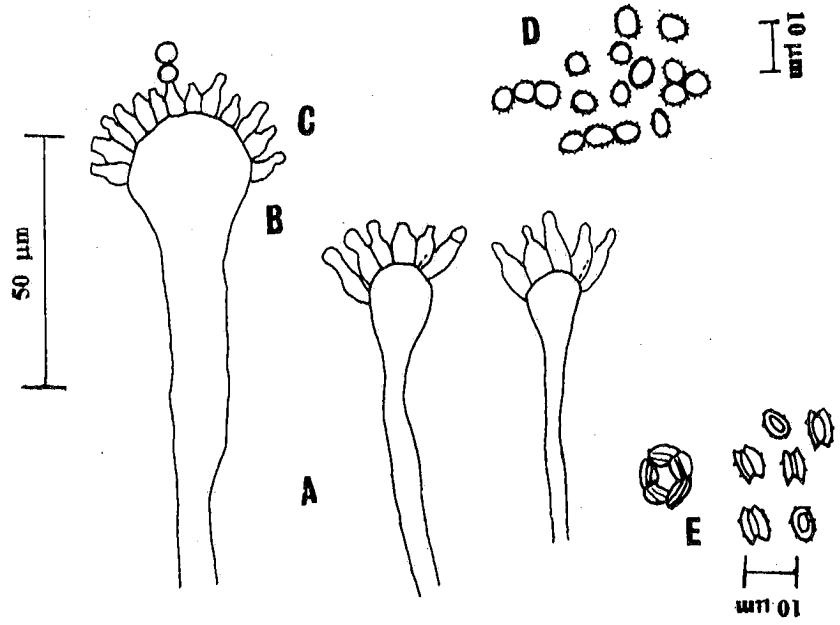

Fig. 4: *Aspergillus hollandicus* (Teleomorph: *Eurotium amstelodami*).
(A) Stipes (B) Vesicles (C) Phialides.
(D) Conidia (E) Ascus and ascospores.

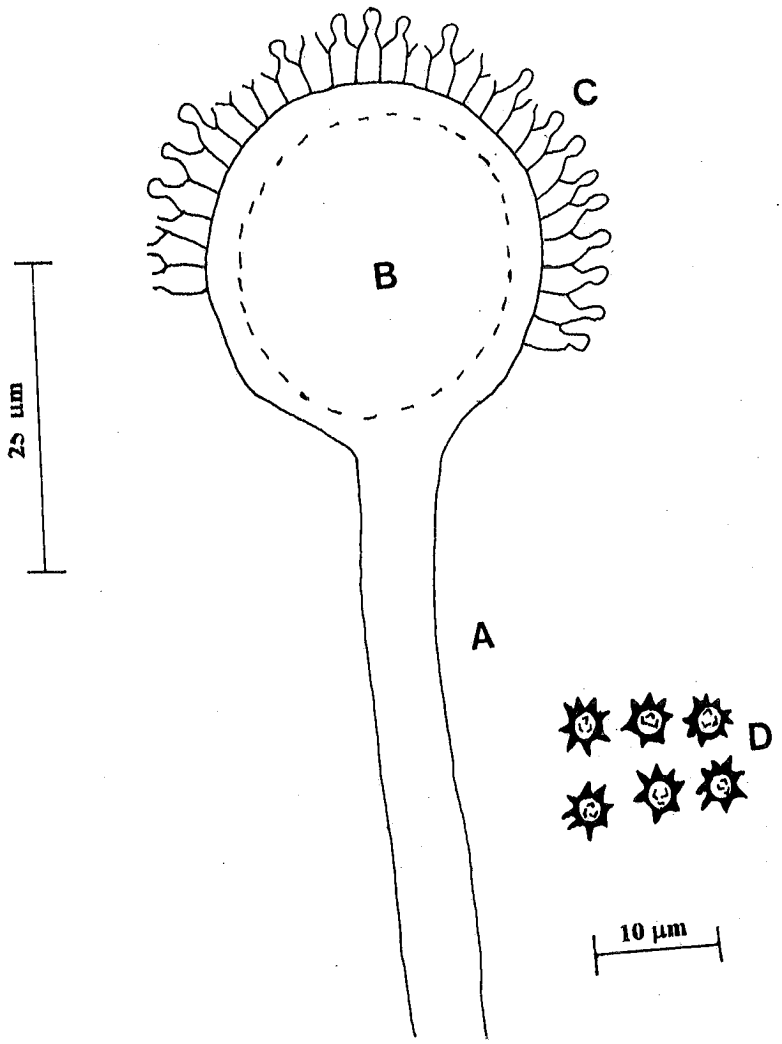

Fig. 5: ***Aspergillus japonicus*** **var.** ***aculeatus.***
(A) Stipe (B) Vesicle.
(C) Phialides (D) Conidia.

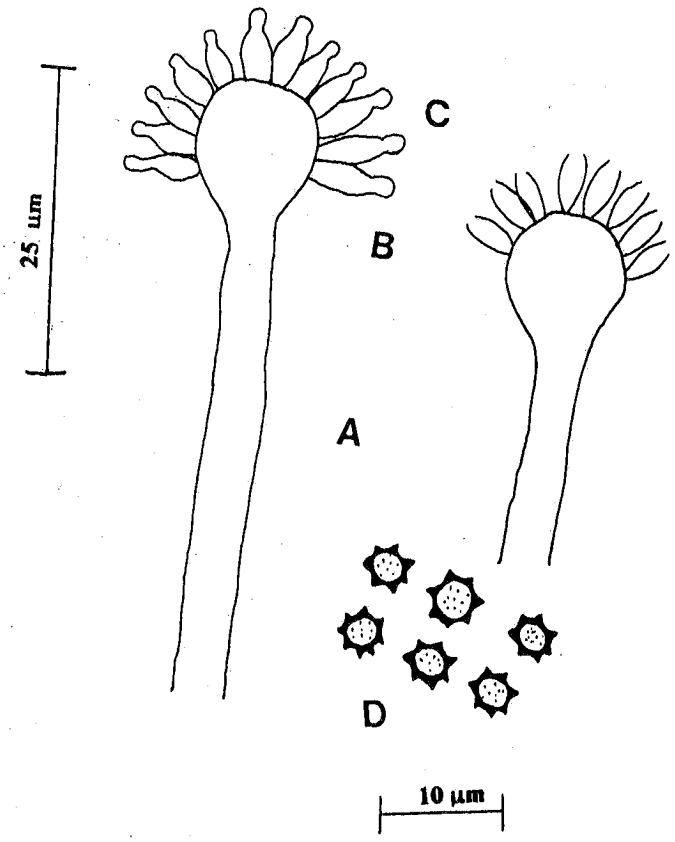

Fig. 6: *Aspergillus japonicus* var. *japonicus*.
(A) Stipes (B) Vesicles.
(C) Phialides (D) Conidia.

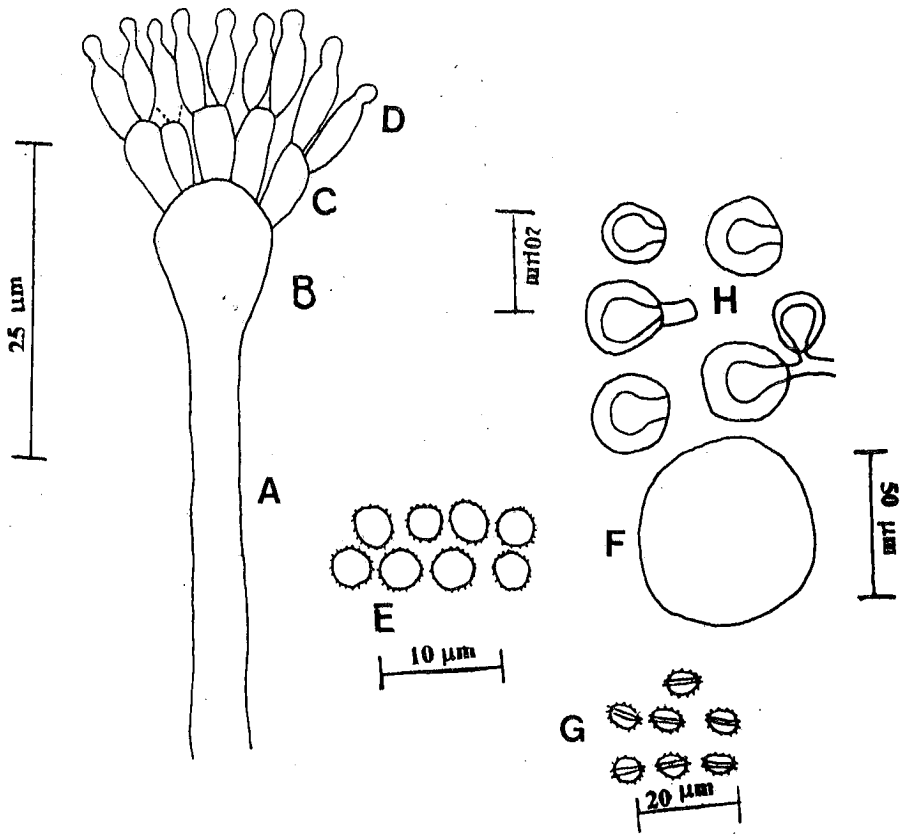

Fig. 7: *Aspergillus nidulans* var. *echinulata* (Teleomorph: *Emericella nidulans* var. *echinulata*).
(A) Stipe (B) Vesicle (C) Metulae (D) Phialides (E) Conidia.
(F) Cleistothecium (G) Ascospores (H) Hülle cells.

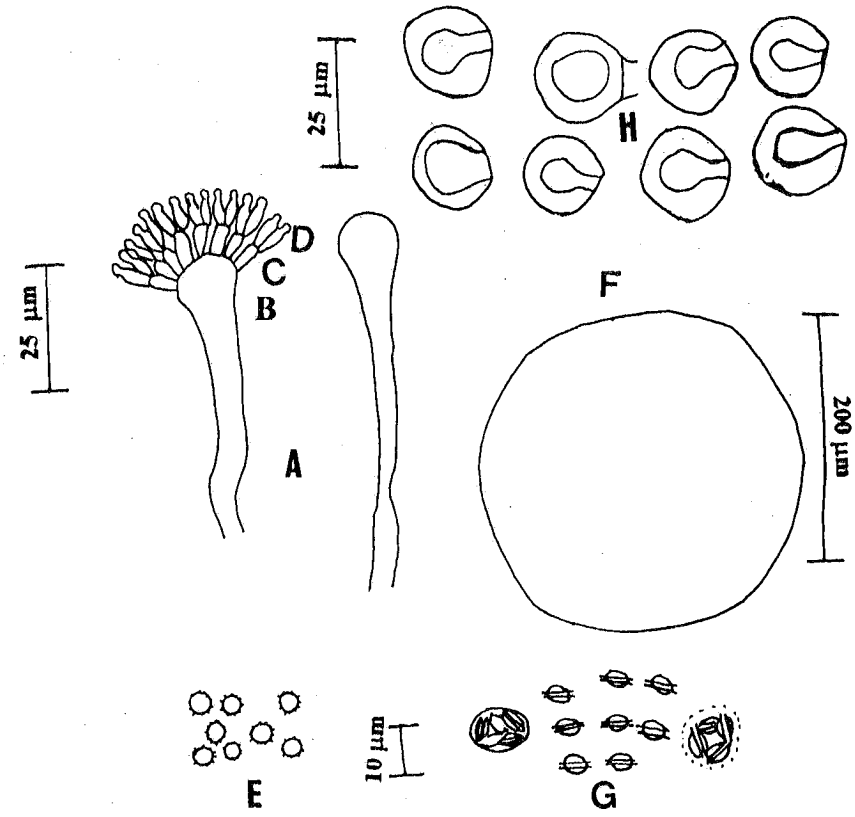

Fig. 8: *Aspergillus nidullelus* var. *nidulans* (Teleomorph : *Emericella nidulans* var. *nidulans*).
(A) Stipes (B) Vesicles (C) Metulae (D) Phialides (E) Conidia (F)Cleistothecium (G) Asci and ascospores (H) Hülle cells.

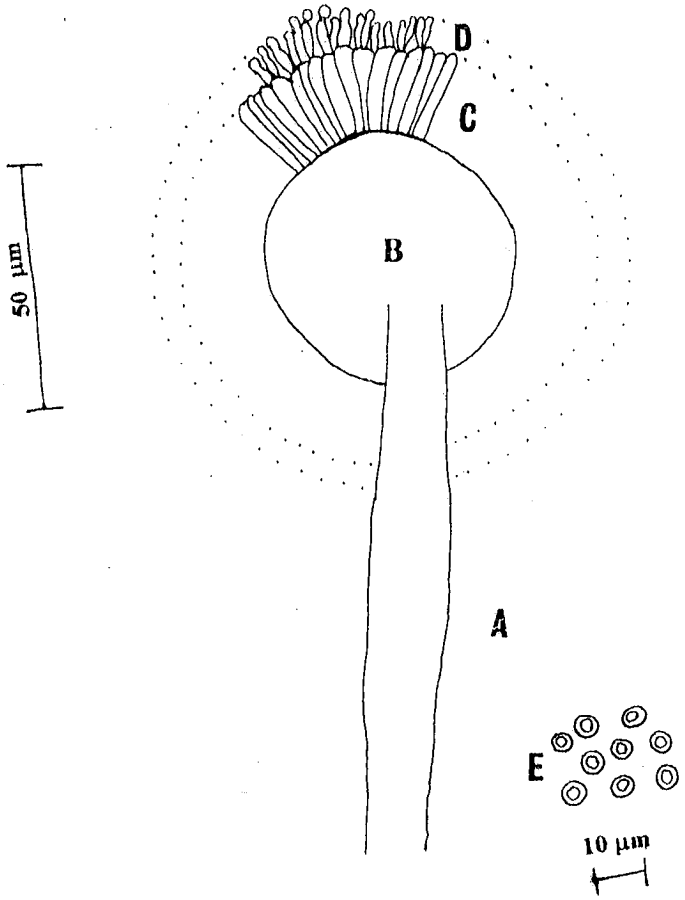

Fig. 9: ***Aspergillus niger.***
(A) Stipe (B) Vesicle (C) Metulae.
(D) Phialides (E) Conidia.

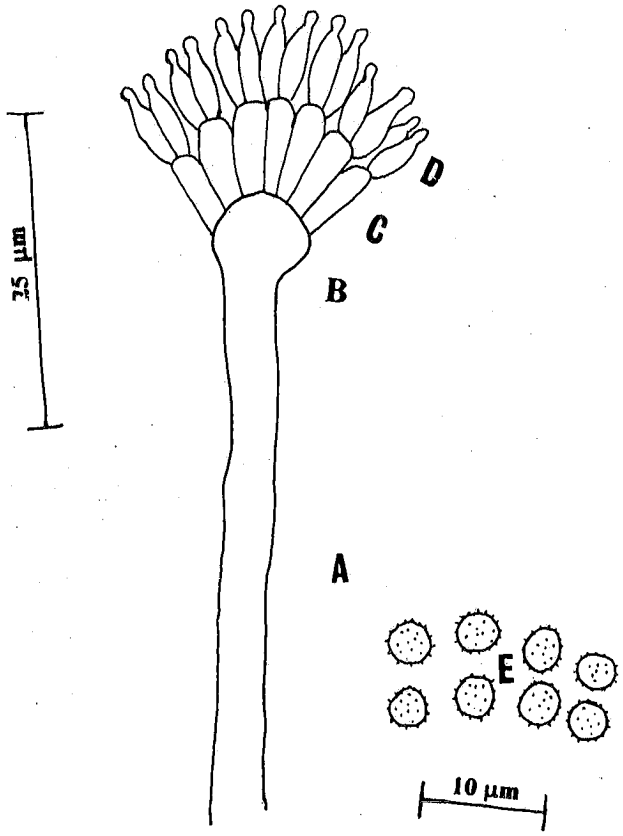

Fig. 10: *Aspergillus niger* var. *awamori*.
(A) Stipe (B) Vesicle (C) Metulae.
(D) Phialides (E) Conidia.

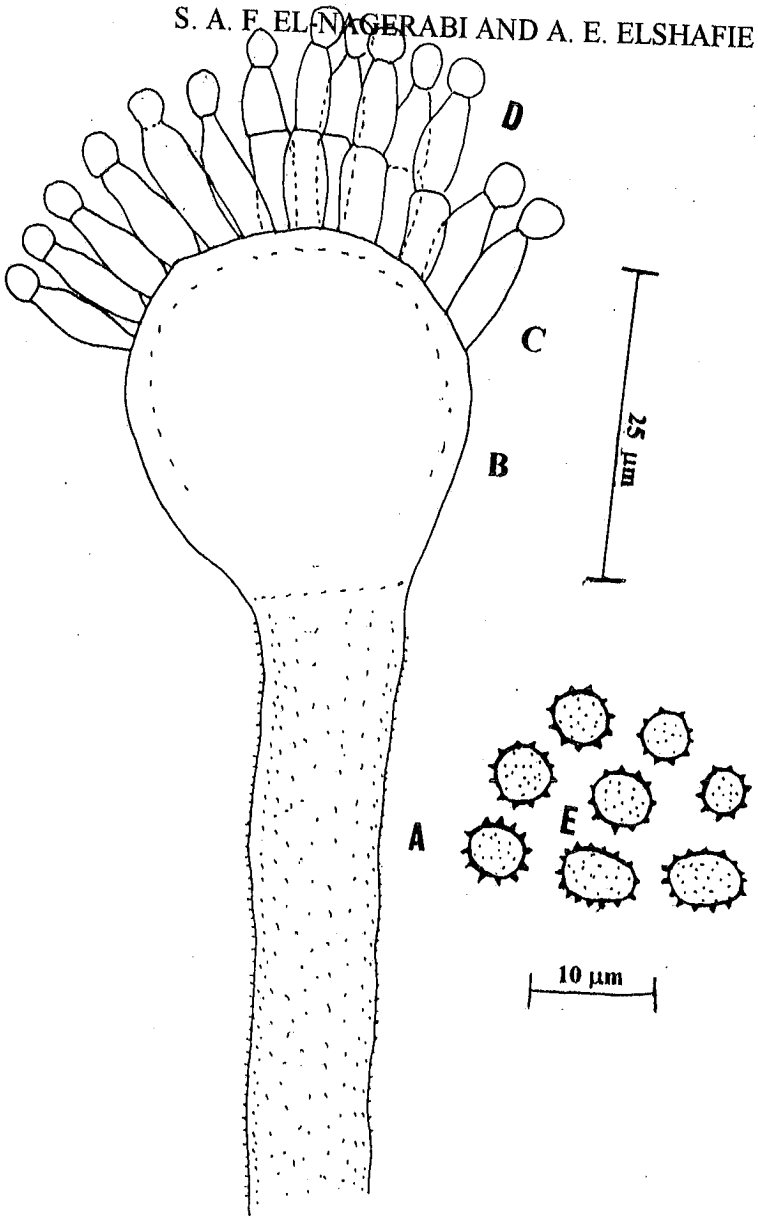

Fig. 11: *Aspergillus oryzae.*
(A) Stipe (B) Vesicle (C) Metulae.
(D) Phialides (E) Conidia.

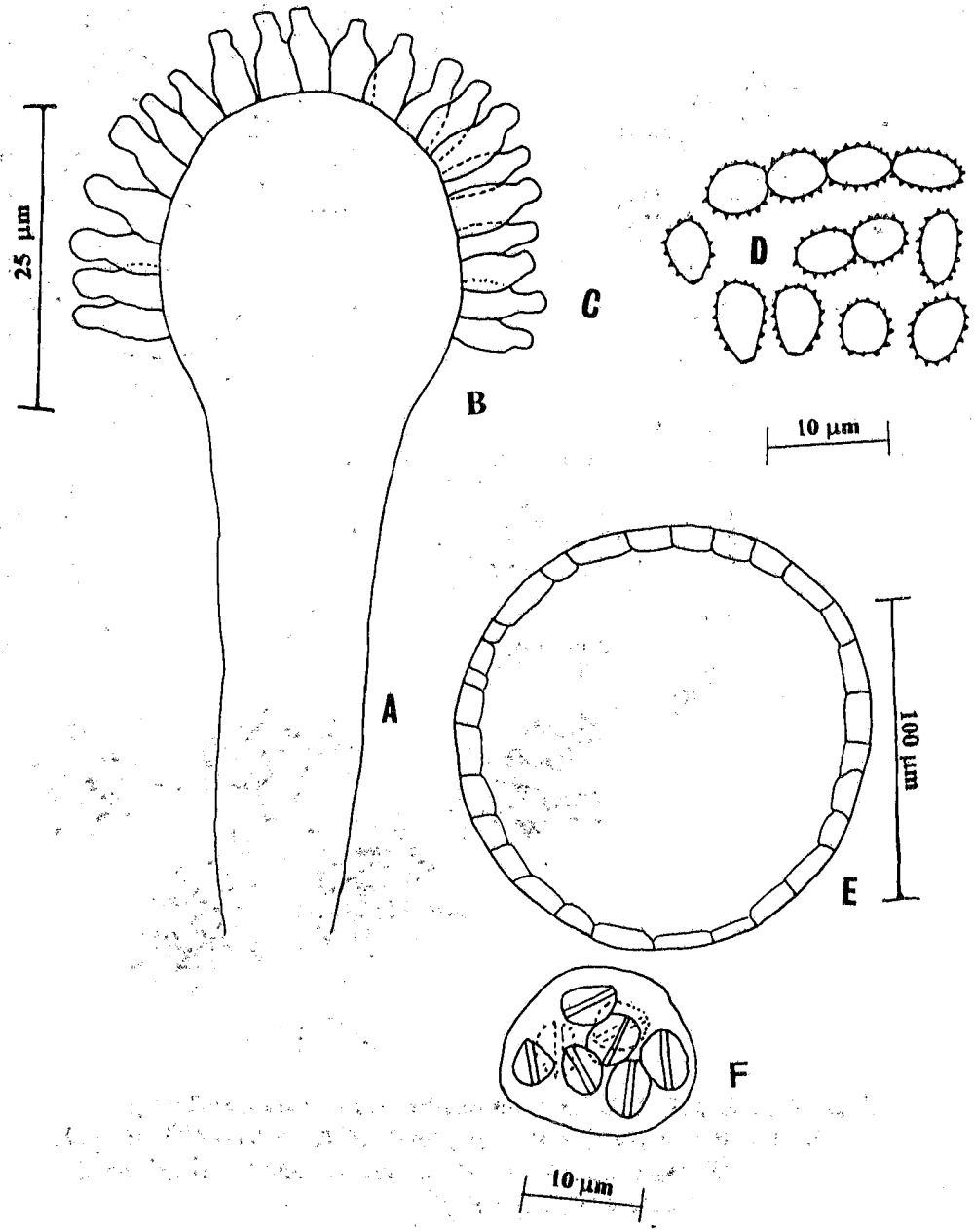

Fig. 12: ***Aspergillus rubrobrunneus*** **(Teleomorph:** ***Eurotium rubrum*****).**
(A) Stipe (B) Vesicle (C) Phialides (D) Conidia.
(E) Cleistothecium (F) Ascus and ascospores.

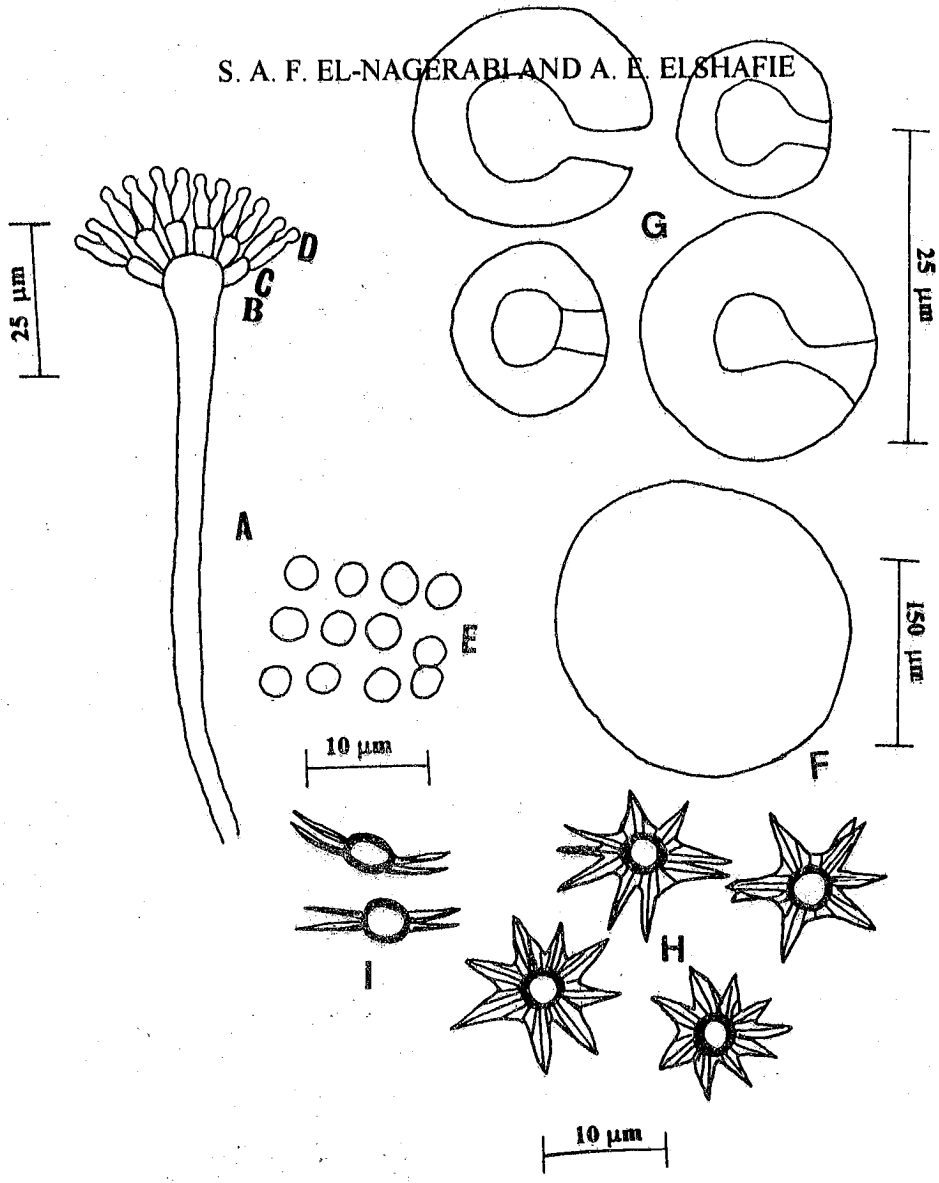

Fig. 13: *Aspergillus stellifer* (Teleomorph: *Emericella variecolor*).
(A) Stipe (B) Vesicle (C) Metulae (D) Phialides (E)Conidia (F)Cleistothecium (G) Hülle cells (H)Ascospores(Face view) (I) Ascospores (Side view).

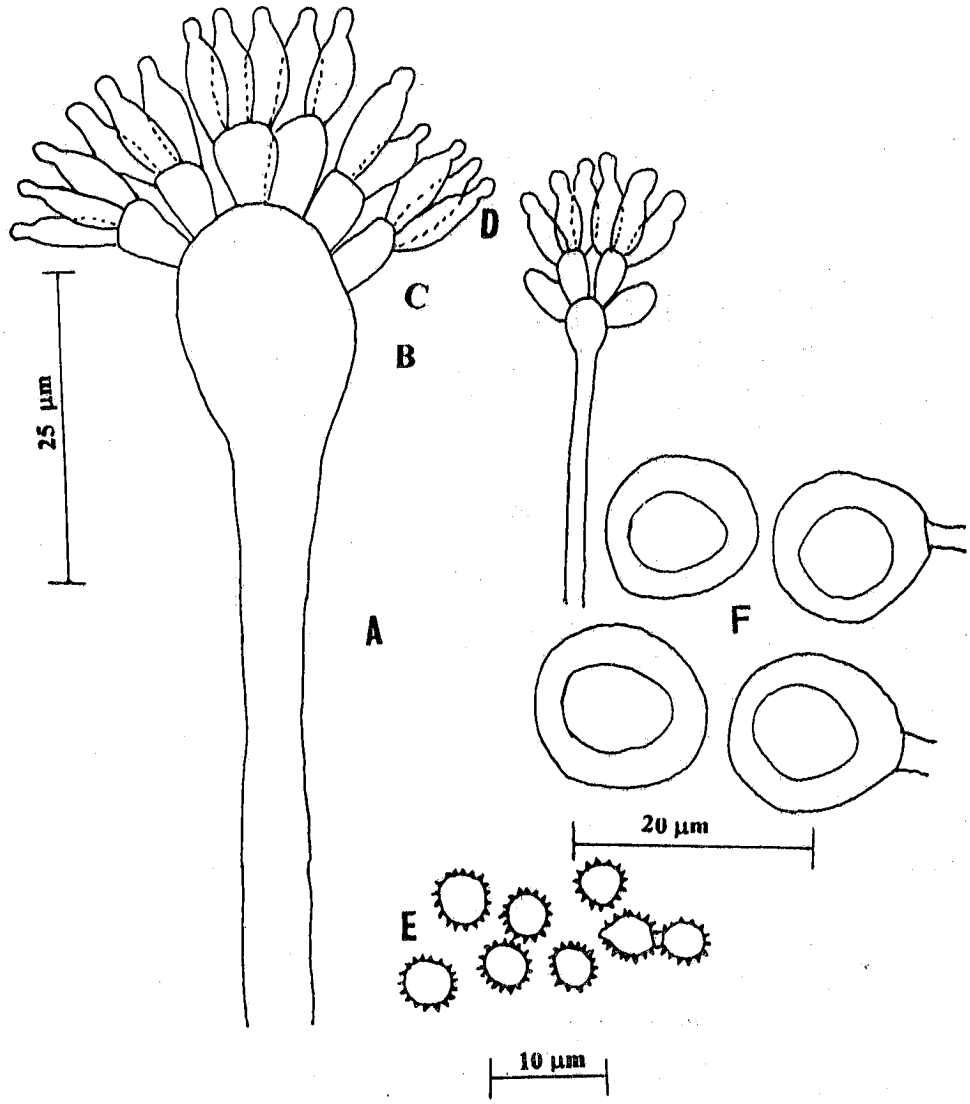

Fig. 14: ***Aspergillus sydowii.***
(A) Stipes (B) Vesicles (C) Metulae (D) Phialides
(E) Conidia (F) Hülle cells.

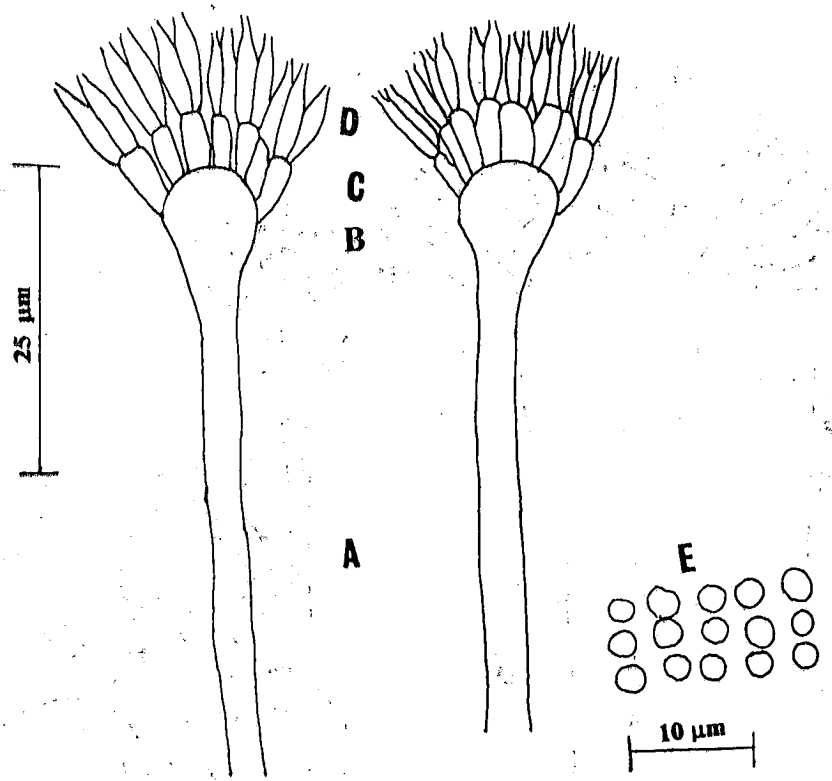

Fig. 15: *Aspergillus terreus* var. *terreus*.
(A) Stipes (B) Vesicles (C) Metulae.
(D) Phialides (E) Conidia.

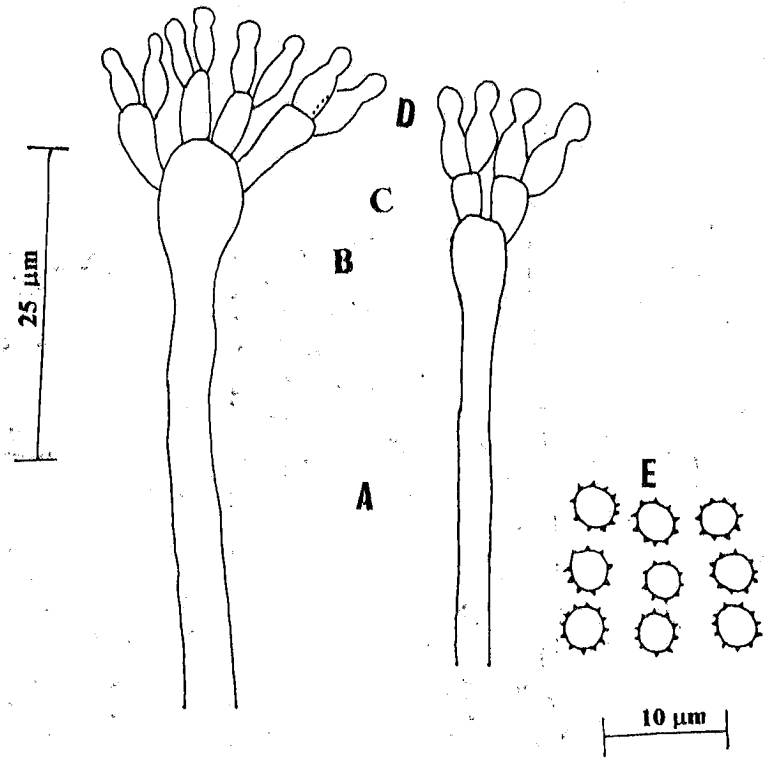

Fig. 16: Aspergillus tetrazonus.
(A) Stipes (B) Vesicles (C) Metulae.
(D) Phialides (E) Conidia.

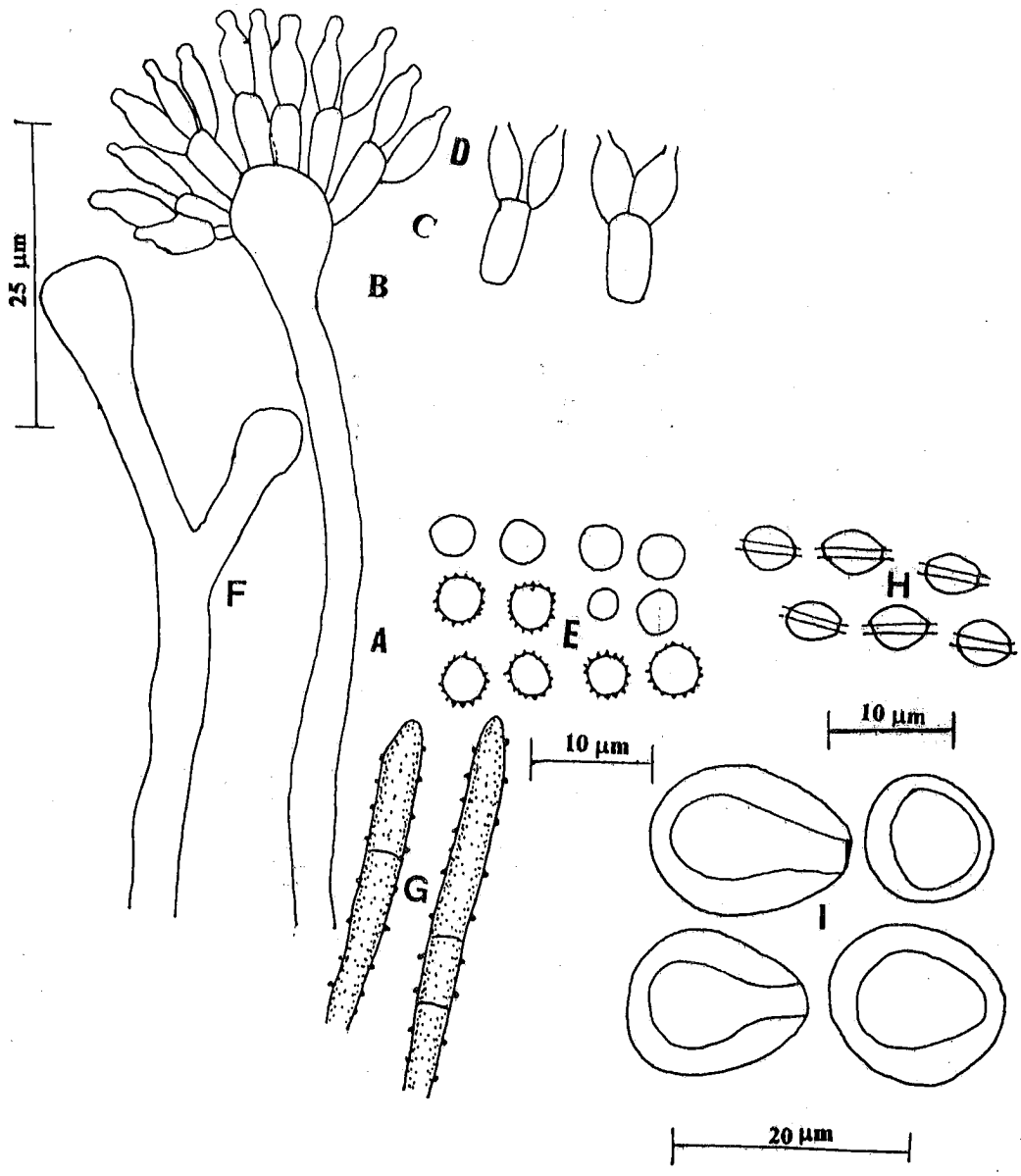

Fig. 17: *Aspergillus unguis* (Teleomorph: *Emericella unguis*).
(A) Stipe (B) Vesicle (C) Metulae (D) Phialides (E) Conidia.
(F) Dichotomous stipe (G) Sterile hyphae (H) Ascospores.
(I) Hülle cells.

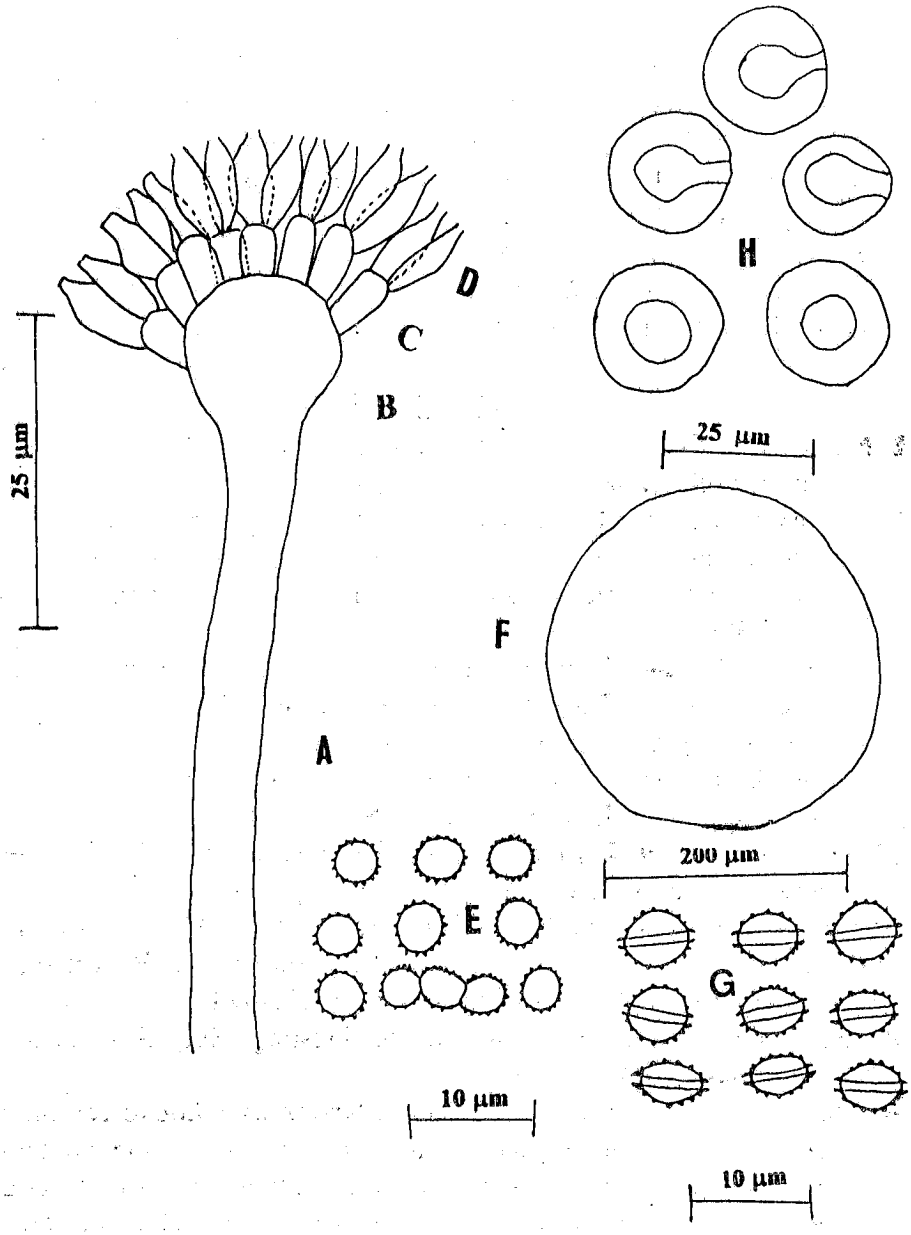

Fig. 18: ***Aspergillus violaceo- brunneus*** **(Teleomorph:** ***Emericella violacea*****).**
(A) Stipe (B) Vesicle (C) Metulae (D) Phialides (E) Conidia.
(F) Cleistothecium (G) Ascospores (H) Hülle cells.

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