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INFLUENCE OF STORAGE REGIMES UPON THE POPULATION DYNAMICS OF FUNGI ON THE STORED RICE[1],[2]

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Abstract

Survey of the fungal flora on the rough rice, or on the freshly dehulled brown and polished rice, and determining the influence of moisture contents, temperatures and storage time upon the population dynamics of fungi on the dehulled brown and polished rice packed in polyethylene bags (PE) were undertaken. From 7681 fungal isolates, 37 genera, 101 species of fungi were identified. Field fungi predominated on the rough rice and did not change its prevalence appreciably getting through storage for 2 years. Roughly, the occurrence percentage of fungi on the rough rice was not over 20%, on the brown rice not higher than 10%, and on the polished rice not more than 5%. Longer storage of the brown and polished rice in PE package resulted in the diminution of field fungi and the build up of storage fungi. After storage for 8 months at the moisture content, 15.9%, temperature, 25–35°C, the occurrence of the most prevalent fungi-*Aspergillus* on the brown rice ranged from 56 to 92.5% while at the moisture content, 14.8%, temperature, 25–35°C, population of *Aspergillus* on the polished rice ranged from 7 to 35%. At lower moisture contents (11.0–13.0%), the increase of storage fungi on the brown and polished rice was not distinctive. The combined effects of low moisture contents (less than 13%) and low temperature (less than 15°C) might decrease the risk of spoilage of the brown and polished rice by storage fungi in PE package.

Introduction

Storage fungi playing a decisive role in the deterioration of stored cereals have been recognized (Christensen and Kaufmann, 1968). Matsumoto *et al.*, (1955) conducted an extensive survey of the microflora on the long-term stored rough rice in Taiwan. Emphasis then was placed on monitoring the major causal organisms, which induced the so-called rice yellowiss. Efforts also have been concentrated on determining the mycotoxin-producing capacity by these microorganisms and their adversal effects on animals (Matsumoto *et al.*, 1955). The contamination of aflatoxin-producing strains of *Aspergillus flavus* on the stored unhulled rice has been studied thoroughly (Ling and Lee, 1967; Lo *et al.*, 1967;

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Chung *et al.*, 1971; Koh and Tseng, 1975). The contaminated aflatoxin has been proposed relating to the high incidence of the liver cancer in Taiwan (Chung *et al.*, 1971). Kuo and Chow (1978) demonstrated that the dehulled brown or polished rice could be stored at least for one year without significantly changing its quality, provided that the rice grains were packed in polyethylene bags, and sealed in vacuum or in carbon dioxide, prior to storage. Evidently, the invasion and damage of stored rice caused by insects, mites, and fungi were limited through such storage practice. However, knowledge of influence of such storage practice upon the survival and population dynamics of fungi on stored rice is not available. This paper reports two aspects of such a serial study, firstly, a systemic survey of the fungal flora on the rough, brown, and polished rice prior to storage or storage after a given period of time, secondly, influences of the moisture contents, temperatures, and storage duration upon the survival, succession, and population fluctuation of fungi on brown and polished rice.

Materials and Methods

Sources of rice

Rough rice of the Japonica variety was sampled from Taipei, Taichung, Tainan, and Pingtung areas, respectively. Status of these samples were shown in Table 1.

Table 1. *Status of the rough rice sampled from Taipei (Nankang) Taichung, Tainan, and Pingtung areas, respectively.*

Sampling locality	Crop year	Crop season	Rice variety	Moisture contents (%)	Sampling time	Storage period (year)
Taipei	1976	2nd	Japonica	14.1	Mar. 1977	0
	1977	1st	Japonica	15.7	Aug. 1977	0
Taichung	1976	2nd	Japonica	15.3	Mar. 1978	2
	1977	2nd	Japonica	13.1	Mar. 1978	1
Tainan	1976	2nd	Japonica	13.0	Mar. 1978	2
	1977	2nd	Japonica	12.7	Mar. 1978	1
Pingtung	1976	2nd	Japonica	12.5	Mar. 1978	2
	1977	2nd	Japonica	12.9	Mar. 1978	1

Isolation and identification of fungal flora on rice kernels

Part of the rough rice mentioned above was further milled to the brown or polished rice. For isolation the fungi, seeds of the rough, brown and polished rice were treated with or without surface disinfectant (1% sodium hypochlorite) which contained a few drops of Tween 20 (wetting agent), for 2 minutes. The rice seeds were rinsed with sterile distilled water for 6 times and then dried with sterile filter paper. Five seeds were

placed on 2% water agar plate. Twenty agar plates were used in each experiment, and it was repeated once. After the plates were incubated at room temperature (22–28°C) for three days, two single-hypha tips growing out from each seed were cut with flame-sterilized knife, and transferred to two individual PDA slants to establish pure cultures. Occasionally, spores growing on the rice seed were scraped with the flame-sterilized knife and transferred to PDA slants, provided that no hyphal growth could be found. The isolated fungal species could be sorting out into groups based on their culture morphology. The number of each genus of fungi divided by the total number of isolate expected to be isolated was defined as the percentage of prevalence. Identification of the fungal cultures were made by following key references (Ames, 1961; Toussoun and Nelson, 1968; Raper and Thom, 1968; Raper and Fennell, 1965; Barron, 1968; Barnett and Hunter, 1972; Ainsworth, *et al.*, Arx, 1974; Ellis, 1971, 1976).

Factors influence the population dynamics of fungi on stored hulled rice

To determine the effects of moisture contents, temperatures, and the storage periods upon the changes of population of fungi on the stored brown and polished rice, rough rice of the first crop of 1977, sampled from Taipei (Nankang) was milled to accommodate this purpose. In order to condition the moisture contents in equilibrium with a relative humidity of 75.8% with NaCl or 84.3% with KCl, each replicate sample (100 g) of the brown and polished rice was exposed in 9.2 cm Petri dish in a desicator containing a saturate solution of NaCl or KCl mentioned above, for 7–10 days, respectively. The final moisture contents of the adjusted brown rice were 13.0, 14.8, 15.9%, while the conditioned polished rice were 11.0, 13.1, and 14.8%. Each replicate sample was packed in 0.2 mm thickness polyethylene bag, and sealed with or without carbon dioxide, and then stored in 15, 25, and 35°C incubators, respectively. After storage for 4 and 8 months, fungi on the rice kernels were isolated and identified as previously described.

Results and Discussion

Rough rices sampled from Taipei (Nankang) were the second crop of 1976, and the first crop of 1977. At the time of sampling, these rice grains were not subjected to any storage practice. The rough rice then was milled to the brown or polished rice. Fungal flora and their prevalence on these various kinds of rice seeds were given in Table 2. Field fungi predominated on the rough rice of the second crop of 1976. Among them, Sphaeropsidales (pycinidia-forming fungi,like *Phoma, Denrophoma, Pyrenochaeta* etc.) were the most prevalent group of fungi encountered. Next in prevalence in descending order were that of *Fusarium, Curvularia, Alternaria,* and *Cladosporium.* Some other field fungi only possesed a minute population and their activity on the rice kernels seems not to be influential. However, several of them, such as *Arthrobotrys arthrobotryoides* (nematode-trapping fungus), *Acremoniella arta, Chlamydomyces palmarum* etc., their presence on the niche as rice seeds were samewhat unusual (Table 2).

Table 2. *Fungal flora and their prevalence on rough rice (RR), brown rice(BR), and polished rice(PR) sampled from Taipei (Nanking).*

Fungus yielded	1976, second crop				1977, first crop					
	RR		BR	PR	RR		BR		PR	
	WSD[a]	SD	SD	SD	WSD	SD	WSD	SD	WSD	SD
Absidia hyalospora	6	–	–	–	2	–	–	–	–	–
Acremoniella arta	6[b]	–	–	–	–	–	–	–	–	–
Acrocylindrium oryzae	–	–	3	–	–	–	–	–	–	–
Alternaria alternata	4	7	–	–	–	–	–	–	–	–
Alternaria tenuissima	5	11	–	–	–	–	–	–	–	–
Arthrinium saccharicola	–	–	–	–	–	2	–	–	–	–
Arthrobotrys arthrobotryoides	3	1	1	–	–	–	–	–	–	–
Aspergillus allahabadii	–	–	–	–	–	–	1	–	–	–
Aspergillus aurantiobrunneus	–	–	–	–	–	2	–	–	–	–
Aspergillus candidus	–	–	–	–	–	–	1	–	2	–
Aspergillus carneus	–	–	–	–	2	–	–	2	–	–
Aspergillus cristatus	–	–	–	–	–	–	1	–	–	–
Aspergillus flavo-furcatis	–	–	–	–	–	–	1	–	0	–
Aspergillus flavus	–	–	–	–	15	22	63	–	32	–
Aspergillus microcysticus	–	–	–	–	2	1	–	–	–	–
Aspergillus niger	–	–	–	–	2	–	–	–	–	–
Aspergillus sydowi	–	–	–	–	3	8	3	–	3	–
Aspergillus versicolor	–	–	–	–	–	–	1	–	–	–
Botrytis cinerea	–	–	1	1	–	–	–	–	–	–
Cephalosporium curtipes	3	1	–	–	–	–	–	–	–	–
Cephalosporium sp.	1	–	–	–	1	14	3	–	–	–
Chaetomium globosum	–	1	–	1	2	67	14	4	9	–
Chlamydomyces palmarum	–	4	–	–	–	–	–	–	–	–
Circinella linderi	–	–	–	–	–	–	3	–	9	–
Cladosporium cladosporioides	2	10	5	10	–	–	–	–	–	–
Cladosporium sp.	–	2	2	–	–	–	–	–	–	–
Clamydoabsidia padeni	–	–	–	1	–	–	–	–	4	–
Cunninghamella bertholetiae	–	–	–	–	163	–	6	3	–	–
Cunninghamella echinulata	–	–	–	–	–	–	18	–	–	–
Curvularia affinis	8	2	–	–	–	–	–	–	–	–
Curvularia clavata	–	–	–	–	8	4	–	–	–	–
Curvularia fallax	–	1	1	–	–	–	–	–	–	–
Curvularia lunata	15	9	1	–	39	26	36	–	4	–
Curvularia lunata var. *aeria*	1	–	–	–	4	–	–	–	–	–
Curvularia pallescens	1	7	1	–	3	–	–	–	–	–
Curvularia senegalensis	–	–	–	–	3	16	4	2	2	–
Curvularia verrculosa	–	–	–	–	–	3	–	–	–	–
Drechslera oryzae	–	–	–	–	7	–	2	–	–	–
Fusarium lateritium	–	–	–	–	23	–	–	–	–	–
Fusarium moniliforme	–	–	–	–	8	8	13	–	–	–
Fusarium oxysporum	3	16	–	–	–	–	13	–	–	–

Table 2. Continued

Fungus yielded	1976, second crop				1977, first ctop					
	RR		BR	PR	RR		BR		PR	
	WSD[a]	SD	SD	SD	WSD	SD	WSD	SD	WSD	SD
Fusarium roseum	3[b]	4	1	–	–	–	–	–	–	–
Fusarium solani	25	3	–	–	38	6	6	–	–	–
Gonytrichum sp.	–	–	–	–	–	2	–	–	–	–
Mucor sp.	–	–	–	–	–	–	5	–	–	–
Nigrospora oryzae	1	2	1	–	–	1	–	–	–	–
Monilia sitophila	–	–	2	–	–	–	–	–	5	–
Penicillium commune	–	–	–	–	–	–	–	–	5	–
Penicillium corylophilum	–	–	–	–	–	–	–	–	–	–
Penicillium frequentans	–	–	–	–	–	–	5	–	–	–
Penicillium lanoso-coeruleum	–	–	–	–	3	–	12	–	–	–
Penicillium nigricans	–	–	–	–	–	–	–	–	–	–
Penicillium oxalicum	1	–	1	–	–	–	3	–	–	–
Penicillium purpurrescens	–	–	–	–	–	1	–	–	–	–
Penicillium purpurogenum	–	–	–	–	10	–	12	–	–	–
Penicillium rubrum	–	–	–	–	4	1	–	–	2	–
Penicillium variabile	–	–	–	–	–	–	–	–	–	–
Pyricularia oryzae	–	2	–	–	5	–	–	–	–	–
Rhizopus sp.	–	–	–	–	–	–	3	–	–	–
Schizophyllum commune	–	–	–	–	–	11	–	–	–	–
Scoleobasidium variabile	1	–	–	–	–	–	–	–	–	–
Syncephalastrum racemosum	–	–	–	–	–	–	–	–	1	–
Sphaeromyces clavisporus	1	–	–	–	–	–	–	–	–	–
Torula herbarum	4	–	–	–	2	1	–	–	–	–
Sphaeropsidales	74	69	2	–	–	–	2	–	–	–
Unidentified sp.	1	3	1	–	–	–	–	–	–	–
Streptomyces sp.	–	–	–	–	–	–	1	–	–	–

[a]WSD: Rice without surface-disinfected; SD: Rice with surface-disinfected.
[b] Number of isolates.

Field fungi also predominated on the rough rice of the first crop of 1977, but the order of predominance varied from that on the second crop of 1976. For instance, *Cunninghamella* was the most predominant genera, and next in the prevalence of *Cunninghamella* was that of *Fusarium* and *Cuvularia.* Exceptionally, storage fungi, such as *Aspergillus flavus, Chaetomium globosum, Penicillium purpurogenum* and *P. rubrum,* also appeared to a considerable number, especially yielding from the non-surface-disinfested rough or brown rice (Table 2). This event probably related to the higher moisture content (15.8%) of the rough rice sampled (Table 2, 3). In general, both the percentage of prevalence and number of fungal species (mostly field fungi) on the brown rice were much less than that on the rough rice, but much higher than that on the polished rice (Table 2, Fig. 1).

Apparently, the invasion of the rice kernels by field or storage fungi was only limited to a certain depth and could be eliminated through surface-disinfestation or through milling process.

Rough rices sampled from Taichung, Tainan, and Pingtung areas were the second crop of 1976, and of 1977. These rice kernels have been stored for 1 or 2 years in warehouse, respectively. Nevertheless, the results of the survey indicated that field fungi still prevailed on the rough rice (Table 3), though the percentage of prevalence of several genera of fungi slightly decreased comparing with that on the rough rice from Taipei (Nankang) (Fig. 1). Christensen and Lϕpez (1965) reported that the storage of the rough rice at a moisture content ranged from 13.0 to 14.8%, at 22–28°C, for 98

Table 3. Fungal flora and their prevalence on the rough rice (RR), brown rice *(BR), and polished rice (PR) sampled from Taichung, Tainan, and Pingtung areas, respectively.*

Fungus yielded	Taichung				Tainan				Pintung			
	RR		BR	PR	RR		BR	PR	RR		BR	PR
	WSD[a]	SD	SD	SD	WSD	SD	SD	SD	WSD	SD	SD	SD
	1976, second crop, stored for 2 years											
Aspergillus flavo-furcatis	–	–	–	–	–	–	–	–	4	–	–	–
Aspergillus flavus	7[b]	–	–	–	–	–	–	–	36	2	4	–
Aspergillus microcysticus	10	–	–	–	–	–	–	–	–	–	–	–
Aspergillus niger	–	–	–	–	–	–	–	–	2	–	–	–
Aspergillus sclerotiorum	5	–	–	–	–	–	–	–	–	–	–	–
Aspergillus sydowi	12	4	–	–	–	–	–	–	–	–	–	–
Aspergillus versicolor	10	–	–	–	–	–	–	–	–	–	–	–
Chaetomium globosum	6	–	2	–	–	–	–	–	–	–	4	–
Chaetomium microcephalum	–	–	–	–	–	–	–	–	–	6	–	–
Circinella linderi	–	–	–	–	–	–	–	–	–	1	–	–
Cladosporium cladosporiodies	12	4	–	–	–	–	–	–	–	–	–	–
Cunninghamella sp.	2	–	–	–	–	–	–	–	4	–	–	–
Curvularia lunata	6	–	–	–	136	99	59	10	–	–	2	–
Cuvularia lunata var. *aeria*	–	–	2	–	–	–	4	–	–	–	2	–
Cuvularia pallescens	2	–	–	–	–	–	–	–	–	–	–	–
Cuvularia senegalensis	–	–	–	–	4	–	–	–	–	–	–	–
Drechslera carbonum	–	–	–	–	–	–	–	–	–	5	–	–
Drechslera erythospila	–	–	–	–	–	–	4	–	–	–	–	–
Drechslera frumentacei	–	–	–	–	1	–	–	–	–	–	–	–
Drechslera hawaiiensis	–	–	–	–	2	2	–	–	–	–	–	–
Drechslera heterostrophus	–	–	–	–	–	–	–	–	–	4	–	–
Fusarium lateritium	4	–	–	–	13	–	4	–	–	–	–	–
Fusarium moniliforme	–	–	–	–	–	15	4	2	–	–	–	–
Fusarium roseum	1	–	–	–	8	–	–	–	–	–	–	–
Fusarium solani	9	–	–	–	11	–	–	–	–	–	–	–

Table 3. Continued

Fungus yielded	Taichung				Tainan				Pingtung			
	PR		BR	PR	RR		BR	PR	RR		BR	PR
	WSD[a]	SD	SD	SD	WSD	SD	SD	SD	WSD	SD	SD	SD
	1976, second crop, stored for 2 years											
Papulaspora sp.	4[b]	2	–	–	–	–	–	–	–	–	–	–
Penicillium frequentans	10	–	–	–	–	–	–	–	–	–	–	–
Penicillium lanoso-coeruleum	–	–	–	–	2	–	–	–	–	–	–	–
Penicillium lividum	–	–	–	–	2	–	–	–	–	–	–	–
Penicillium nigricans	–	2	–	–	–	–	–	–	–	–	–	–
Penicillium oxalicum	–	2	–	–	–	–	–	–	–	–	–	–
Penicillium raciborskii	–	2	–	–	–	–	–	–	–	–	–	–
Rhizopus sp.	–	1	–	–	–	–	–	–	20	5	–	–
Sphaeropsidales	14	–	2	–	3	42	44	–	2	–	2	–
	1977, second crop, stored for 1 year											
Absidia cylindrospora	–	6	–	–	3	–	–	–	–	–	–	–
Absidia heterospora	–	–	–	–	2	–	–	–	–	–	–	–
Alternaria alternata	5	–	–	–	–	–	–	–	10	–	–	–
Alternaria tenuissima	8	–	–	–	–	–	–	–	4	–	–	–
Aspergillus allahabadii	–	–	–	–	18	–	–	–	–	–	–	–
Aspergillus chevalieri	–	–	–	–	–	–	36	2	–	–	–	–
Aspergillus flavo-furcatis	2	–	–	–	–	–	–	–	–	–	–	–
Aspergillus flavus	2	–	–	–	1	–	–	–	20	3	2	–
Aspergillus niger	–	–	–	–	1	6	2	–	–	–	–	–
Aspergillus ruber	–	–	–	–	–	–	8	–	–	–	–	–
Aspergillus versicolor	–	–	–	–	1	–	–	–	–	–	2	–
Chaetomium globosum	–	–	–	–	–	–	–	–	–	4	–	–
Chaetomium perpulchrum	–	–	–	–	–	–	–	–	–	–	5	–
Circinella linderi	–	–	–	–	2	–	–	–	2	–	–	–
Cladosporium cladosporioides	6	–	–	–	–	–	–	–	–	–	–	–
Cladosporium sphaerospermum	–	2	–	–	–	–	–	–	–	–	–	–
Cunninghamella sp.	–	–	–	–	4	–	–	–	–	–	–	–
Curvularia lunata	74	19	18	0	0	4	0	0	26	11	2	2
Cuvularia lunata var. *aeria*	–	4	–	–	–	–	–	–	–	–	4	–
Cuvularia pallescens	1	–	2	–	–	–	–	–	—	–	–	–
Cuvularia senegalensis	–	18	2	2	–	–	–	–	–	3	–	–
Drechslera carbonum	–	32	–	–	–	6	–	–	–	–	–	–
Drechslera frumentacei	35	–	–	–	6	–	–	–	–	–	–	–
Drechslera oryzae	–	–	24	2	–	–	–	–	–	–	–	–
Drechslera phlei	–	16	–	–	–	–	–	–	–	–	–	–
Drechslera sacchari	–	22	–	–	–	–	1	–	–	–	1	–
Fusarium lateritium	3	2	2	2	6	–	2	–	2	3	–	–
Fusarium moniliforme	8	–	–	–	–	–	–	–	–	–	–	–
Fusarium roseum	14	2	–	–	3	–	–	–	–	–	–	–
Fusarium solani	10	–	–	–	1	1	1	–	4	–	–	–
Mucor sp.	–	–	–	–	–	–	2	–	–	–	–	–

Table 3. Continued

Fungus yielded	Taichung				Tainan				Pingtung			
	RR		BR	PR	RR		BR	PR	RR		BR	PR
	WSD[a]	SD	SD	SD	WSD	SD	SD	SD	WSD	SD	SD	SD
	1977, second crop, stored for 1 year											
Penicillium frequentans	–	–	–	–	–	2	–	–	4	–	–	–
Penicillium funiculosum	–	–	–	–	–	–	4	–	–	–	–	–
Penicillium lanoso-coeruleum	–	–	–	–	–	–	4	–	–	–	–	–
Penicillium nigricans	–	–	–	–	–	2	–	–	–	–	–	–
Penicillium oxalicum	–	–	–	–	2	–	–	–	–	–	–	–
Penicillium spinulosum	–	–	–	–	8	–	–	–	–	–	–	–
Penicillium variabile	–	–	–	–	–	–	–	–	3	–	–	–
Rhizopus sp.	–	–	–	–	12	6	1	–	35	–	–	–
Syncephalastrum racemosum	–	–	–	–	–	–	1	–	–	–	–	–
Sphaeropsidales	8[b]	10	2	4	1	29	6	–	3	10	10	–

[a]WSD: Rice kernels without surface-disinfected; SD: Rice kernels with surface-disinfected
[b]Number of isolate

or 413 days resulted in the death of field fungi. But this is not to be true as in our test rice lots or as in the long-term stored wheat as indicated by Wallace *et al.* (1976). This discrepancy might be derived either from the different methods used for calculation of percentage of incidence or the different methods in the isolation of fungi employed. The dominance of several genera of field fungi on the rough, brown and polished rice might differ from one locality to another, for example, *Drechslera* spp. predominated on the rice seeds from Taichung and Tainan, but not to be prevalent on the rice seeds from Taipei and Pingtung areas (Table 3; Fig. 1). However, in sum, regardless of the sampling localities, the storage duration, and storage conditions, the occurrence percentage of fungi on the rough rice was not over 20%, on the brown rice not higher than 10%, and on the polished rice not more than 5% (Fig. 1). The storage fungi failed to become predominant even the kernels have been stored for one or two years, this point differed from those previous reports (Christensen, 1969; Fanse and Christensen, 1966). It has been suggested that the competition and interaction of the previous growth of field fungi on the rice kernels might restrict the subsequent development of storage fungi, if the ecological factors did not favor the latter during storage (Schroeder, 1963). The results of the effect of moisture contents of the rice seeds, the storage temperature and storage duration upon the population dynamics of fungi on the brown or polished rice packed in polyethylene bags were summarized in Table 4 and Table 5, respectively. Since the influence of carbon dioxide upon the fluctuation of fungi on the rice kernels did not exhibit a definite impact, only the average of the rice in PE package sealed in CO_2 or sealed without CO_2 was given. In the brown rice, with a beginning moisture

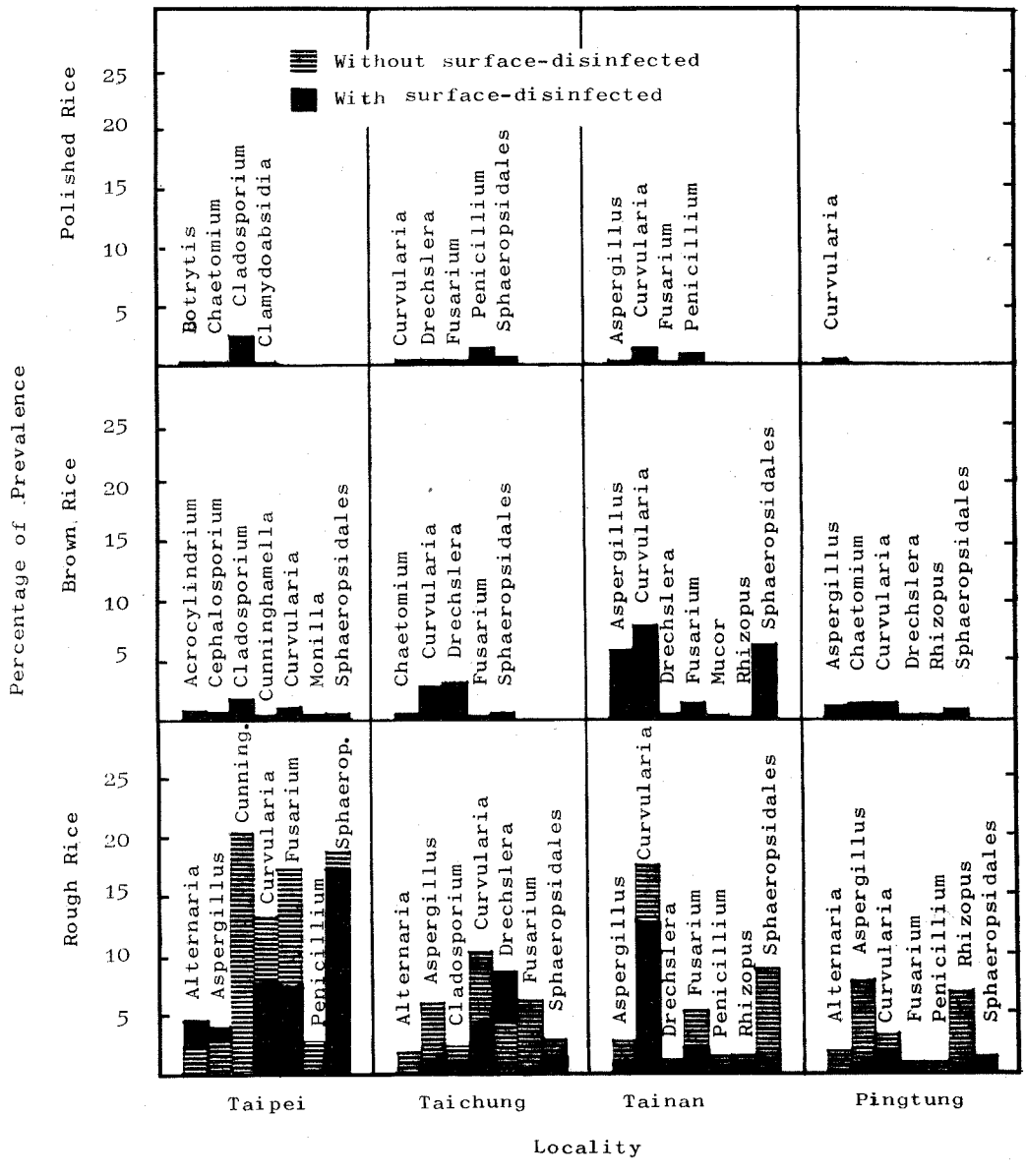

Fig. 1. Percentage of prevalence of fungi on the rough, brown, and polished rice sampled from Taipei (Nankang), Taichung, Tainan, and Pingtung areas, respectively.

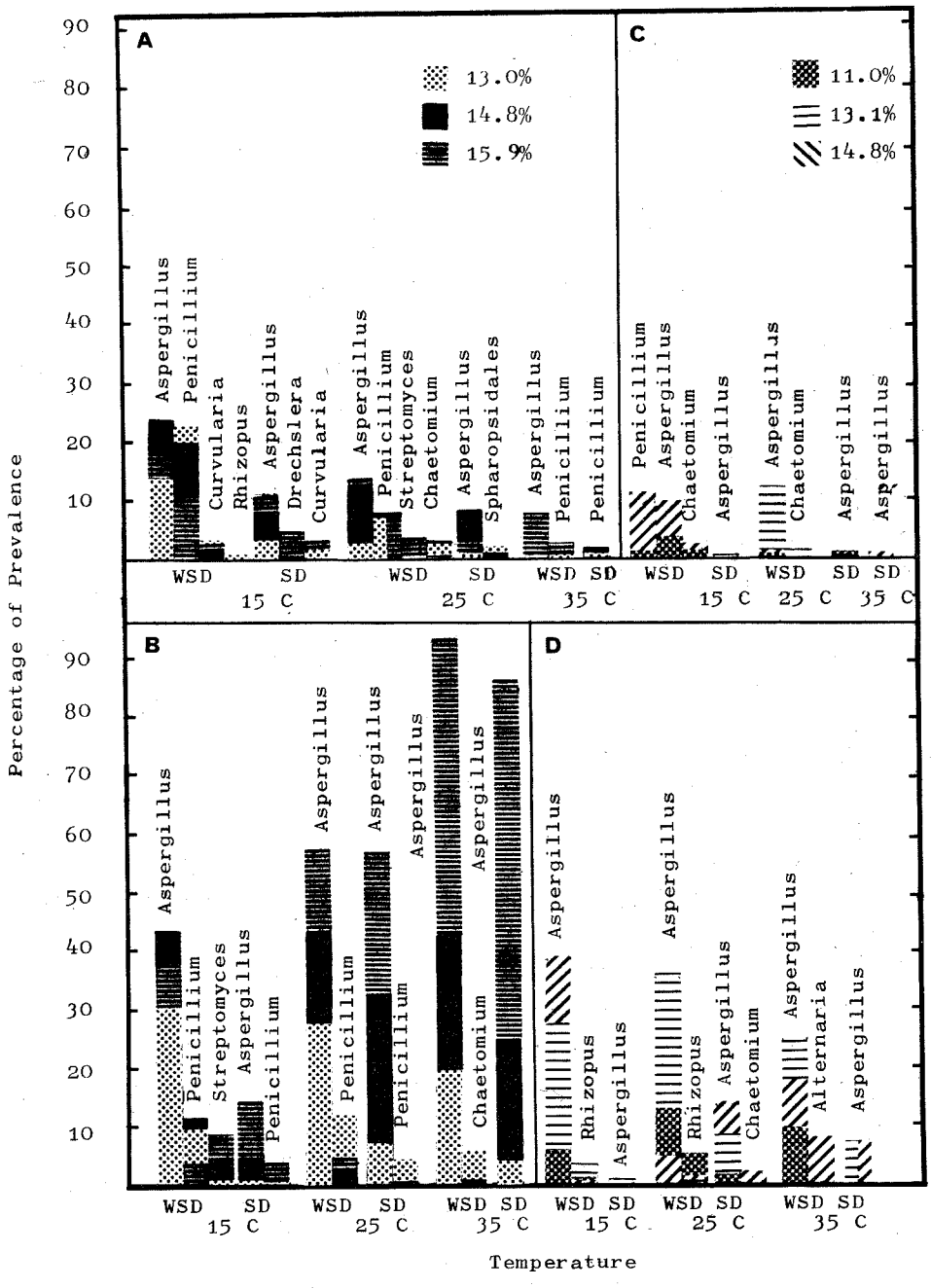

Fig. 2. Influences of moisture contents, temperatures, and storage duration on the percentage of prevalence of fungi on brown and polished rice. A–B) Prevalent genera of fungi yielding from surface-disinfected (SD) and without surface-disinfected (WSD) brown rice after stored in polyethylene package for 4 months (A) and 8 months (B), respectively. C–D) Predominant genera of fungi yielding from surface-disinfected (SD) and without surface-disinfected (WSD) polished rice after stored in polyethylene package for 4 months (C) and 8 months (D), respectively.

Table 4. *Fungal flora and their prevalence on brown rice kernels, which were conditioned to moisture contents, 13.0, 14.8, 15.9% stored at 15, 25, 35°C for 4 months and 8 months, repsectively.*

Fungus Yielded	15° C						25° C						35° C					
	13.0%		14.8%		15.9%		13.0%		14.8%		15.9%		13.0%		14.8%		15.9%	
	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8
	Rice Kernals with Surface-disfected																	
Absidia cylindrospora	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–
Alternaria alternata	–	–	–	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–
Arthrinium Sphaerospermum	–	–	3[a]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ascotricha congoenesis	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–
Aspergillus allahabadii	–	–	2	4	–	–	–	–	2	–	–	–	–	–	–	–	–	–
Aspergillus aurantiobrunneus	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Aspergillus candidus	–	–	2	4	–	2	–	4	2	4	6	120	3	–	–	–	–	336
Aspergillus chevalieri	–	2	6	2	3	38	–	10	6	86	–	68	–	2	–	52	–	2
Aspergillus cristatus	–	–	–	2	–	–	–	–	–	2	1	–	–	–	–	2	–	–
Aspergillus fischeri series	–	2	–	–	–	2	–	–	–	6	–	10	–	7	–	–	–	–
Aspergillus flavo-furcatis	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–
Aspergillus flavus	5	–	16	4	18	6	2	6	13	18	–	6	–	–	–	–	–	–
Aspergillus microcysticus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–
Aspergillus repens	4	–	7	–	2	–	–	–	8	–	2	–	–	–	–	–	–	–
Aspergillus ruber	–	–	–	2	–	8	–	–	–	14	2	10	–	2	–	8	–	–
Aspergillus sydowi	4	–	–	–	16	–	–	8	–	–	2	8	–	–	–	–	–	–
Aspergillus versicolor	2	–	–	–	4	–	–	–	–	–	–	–	–	2	–	–	–	–
Chaetomium globosum	2	–	2	6	4	8	2	6	2	6	2	4	–	2	–	–	–	–
Chloridium viride	–	6	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	1
Curvularia lunata	5	6	–	4	6	4	–	–	–	–	–	2	–	–	–	–	–	–
Cuvularia clavata	2	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 4. Continued

Fungus yieled	15° C						25° C						35° C					
	13.0%		14.8%		15.9%		13.0%		14.8%		15.9%		13.0%		14.8%		15.9%	
	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8
	Rice Kernels with Surface-disinfected																	
Drechslera sacchari	–	–	–	–	–	–	2	–	–	–	2	–	–	–	–	–	–	–
Drechslera sp.	–	–	–	–	12	–	–	–	–	–	–	–	–	–	–	–	–	–
Fusarium moniliforme	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nigrospora oryzae	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–
Penicillium brevicompactum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–
Penicillium chrysogenum	–	–	–	–	–	2	–	4	–	–	–	–	–	–	–	–	–	–
Penicillium frequentans	2	2	–	–	–	–	–	6	–	–	–	–	–	–	–	–	–	–
Penicillium javanicum	–	–	–	–	–	12	–	–	–	–	–	–	–	–	–	–	–	–
Penicillium lanoso-coeruleum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–
Penicillium nigricans	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Penicillium notatum	–	–	–	–	–	–	–	4	–	–	–	–	2	–	–	–	–	–
Penicillium rubrum	–	–	4	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–
Sphaeropsidales	–	–	2	–	–	–	6	2	2	–	–	–	–	–	2	–	–	–
unidentified sp.	–	–	–	–	–	1	–	–	–	–	–	12	–	–	–	–	–	–
Streptomyces sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–
	Rice Kernels without Surface-disinfected																	
Absidia cylindrospora	–	10	–	8	–	16	–	9	–	6	–	8	–	8	–	7	–	–
Alternaria padwickii	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 4. Countinued

Fungus yielded	15° C						25° C						35° C					
	13.0%		14.8%,		15.9%		13.0%		14.8%		15.9%		13.0%		14.8%		15.9%	
	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8
	Rice kernels without surface-disinfected																	
Aspergillus allahabadii	–	–	–	–	–	–	–	2	–	4	–	4	–	–	–	–	–	–
Aspergillus awamori	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–
Aspergillus candidus	–	–	–	–	–	–	–	10	–	14	22	124	–	–	–	2	31	370
Aspergillus carneus	2	–	–	4	–	8	–	–	–	–	–	–	–	–	–	4	–	–
Aspergillus chevalieri	–	4	–	10	–	20	–	–	–	6	–	–	–	28	–	29	–	–
Aspergillus clavatus	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–
Aspergillus flavo-furcatis	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–
Aspergillus flavus	46	91	84	144	72	105	11	70	33	138	–	68	–	15	–	76	–	–
Aspergillus japonicus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–
Aspergillus microcysticus	–	6	–	2	–	–	–	4	–	4	–	–	–	8	–	10	–	–
Aspergillus niger	2	6	2	10	2	4	–	4	5	4	–	2	–	2	–	6	–	–
Aspergillus pulvinus	–	–	2	–	–	–	–	–	–	–	–	–	–	4	–	10	–	–
Aspergillus repens	–	–	–	–	–	–	–	–	–	–	8	–	–	2	–	–	–	–
Aspergillus ruber	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	8	–	–
Aspergillus sclerotiorum	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–
Aspergillus sydowi	4	2	2	2	–	–	–	8	10	–	1	14	–	16	–	12	–	–
Aspergillus versicolor	2	14	3	4	3	10	–	8	–	4	22	10	–	6	–	12	–	–
Carpentales brefeldianum	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–
Chaetomium globosum	2	–	5	12	–	4	8	–	8	4	2	2	2	20	2	3	2	–

Table 4. Continued

Fungus yielded	15° C						25° C						35° C					
	13.0%		14.8%		15.9%		13.0%		14.8%		15.9%		13.0%		14.8%		15.9%	
	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8
	Rice kerneld without surface-disinfected																	
Chaetomium sphaerospermum	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–
Chloridium viride	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Circinella linderi	–	2	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–
Cunninghamella sp.	–	–	–	–	2	–	–	–	1	–	–	–	–	–	–	2	–	–
Curvularia lunata	9	4	9	6	14	2	4	–	4	2	–	–	–	–	–	–	–	–
Curvularia clavata	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Curvularia oryzae	–	–	–	–	–	–	–	–	1	–	2	–	–	–	–	–	–	–
Curvularia senegalensis	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Curvularia verruculosa	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Drechslera sacchari	–	–	–	2	–	–	2	–	–	–	–	–	–	–	–	–	–	–
Drechslera stenospila	–	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Drechslera sp.	–	–	–	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–
Fusarium lateritium	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–
Fusarium moniliforme	–	–	–	–	4	2	–	–	–	–	–	–	–	–	–	–	–	–
Fusarium oxysporum	4	–	6	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–
Fusarium solani	2	–	–	–	–	–	–	–	2	–	2	–	–	–	–	–	–	–
Mucor sp.	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–
Nigrospora oryzae	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Penicillium brevicompactum	–	–	2	–	–	–	–	–	–	–	–	–	2	–	4	–	2	–
Penicillium chrysogenum	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Penecillium commune	–	–	–	4	11	–	4	–	2	–	–	–	–	–	–	–	–	–

Table 4. Continued

Fungus yielded	15° C						25° C						35° C					
	13.0%		14.8%		15.9%		13.0%		14.8%		15.9%		13.0%		14.8%		15.9%	
	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8
	Rice kerneld without surface-disinfected																	
Penecillium corylophilum	–	4	–	4	–	4	–	–	–	–	–	–	–	–	–	–	–	–
Penecillium frequentas	63[a]	25	8	12	6	4	–	18	13	12	6	–	–	–	–	–	–	–
Penecillium javanicum	–	–	–	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–
Penecillium lanoso-coeruleum	11	–	2	–	10	–	–	–	–	–	2	–	–	–	–	–	–	–
Penecillium linacinum series	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–
Penecillium lividum	7	4	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–
Penecillium notatum	–	–	24	–	16	–	24	30	12	–	8	–	–	–	–	–	6	–
Penecillium oxalicum	9	–	–	14	2	6	–	–	–	–	–	–	–	–	–	–	–	–
Penecillium purpurogenum	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–
Penecillium raciborskii	–	–	–	–	–	–	–	–	–	–	–	12	–	–	–	–	–	–
Penecillium rubrum	–	–	–	–	–	–	–	–	–	–	12	–	–	–	–	–	–	–
Penecillium steckii	–	–	–	8	–	2	–	–	2	–	–	–	–	–	–	–	–	–
Rhizopus sp.	4	2	4	6	13	4	4	4	–	–	1	2	2	–	–	2	–	–
Sphaeropsidales	–	–	–	–	–	–	2	–	–	8	–	8	–	–	–	–	–	–
Unidentified sp.	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–
Streptomyces sp.	7	4	–	18	5	32	2	4	–	6	16	–	–	–	2	–	–	–

[a]Number of isolate

Table 5. *Fungal flora and their prevalence on polished rice kernels, which were conditioned to moisture contents, 11.0%, 13.1%, 14.8% and stored at 15°C, 25°C, 35°C for 4 and 8 months, respectively.*

Fungus yielded	15° C						25° C						35° C					
	11.0%		13.1%		14.8%		11.0%		13.1%		14.8%		11.0%		13.1%		14.8%	
	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8
	Rice kernels with surface-disinfected																	
Absidia cylindrespora	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–
Aspergillus candidus	–	2[a]	–	–	–	–	–	–	–	4	–	18	–	–	–	–	2	25
Aspergillus chevalieri	–	–	–	2	–	2	–	6	–	22	–	16	–	–	–	25	–	4
Aspergillus cristatus	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–	–	–	–
Aspergillus flavus	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–	–	–	–
Aspergillus microcysticus	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Aspergillus niger	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Aspergillus ruber	–	–	–	–	–	2	–	–	–	6	–	4	–	–	–	4	–	–
Aspergillus sydowi	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Aspergillus versicolor	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetomium africanum	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetomium globosum	–	–	–	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–
Fusarium roseum	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Rhizopus sp.	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–
	Rice kernels without surface-disinfected																	
Absidia cylindrospora	–	10	–	2	–	2	–	6	–	4	–	4	–	4	–	–	–	–
Alternaria alternata	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	32
Aspergillus candidus	–	–	–	–	–	–	–	10	–	8	–	18	–	22	–	9	2	–
Aspergillus carneus	–	2	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	2

Table 5. Continued

Fungus yielded	15° C						25° C						35° C					
	11.0%		13.1%		14.8%		11.0%		13.1%		14.8%		11.0%		13.1%		14.8%	
	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8
	Rice kernels without surface-disinfected																	
Aspergillus carneus	–	2	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	2
Aspergillus chevalieri	–	–	–	–	–	68	2	8	–	14	2	16	–	10	2	34	–	58
Aspergillus cristatus	–	–	–	–	–	141	–	–	–	14	–	6	–	–	–	–	–	–
Aspergillus flavo-furcatis	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	
Aspergillus flavus	10	14	23	94	26	42	–	20	28	48	–	10	–	–	–	30	–	4
Aspergillus fischeri series	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	4
Aspergillus fumigatus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–
Aspergillus microcysticus	–	2	2	4	–	4	–	–	–	22	–	2	–	–	–	2	–	2
Aspergillus niger	–	–	–	–	–	4	–	–	–	2	2	2	–	2	–	12	–	–
Aspergillus pulvinus	2	–	–	–	–	–	–	4	–	2	–	–	–	–	–	–	–	–
Aspergillus repens	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–
Aspergillus ruber	–	–	–	–	–	10	–	4	–	10	–	4	–	2	–	4	–	–
Aspergillus sydowi	–	–	5	2	8	12	–	4	5	18	–	–	–	–	–	–	–	–
Aspergillus versicolor	2	4	11	4	2	–	–	–	12	–	2	–	–	–	–	4	–	–
Carpenteles brefeldianum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–
Chaetomium globosum	2	–	2	–	7	8	–	–	4	6	6	9	2	–	2	2	2	–
Chaetomium perpulchrum	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–
Circinella linderi	–	–	–	–	4	–	–	–	–	–	–	–	–	–	2	–	–	–
Cunninghamella sp.	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cuvularia lunata	4	2	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–
Fusarium oxysporum	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 5. Continued

Fungus yielded	15° C						25° C						35° C					
	11.0%		13.1%		14.8%		11.0%		13.1%		14.8%		11.0%		13.1%		14.8%	
	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8	4	8
	Rice kernels without surface-disinfected																	
Fusrium roseum	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Mucor sp.	4	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Penicillium chrysogenum	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–
Penicillium corylophilum	–	–	–	2	8	–	2	–	–	–	2	–	–	–	–	2	–	–
Penicillium frequentans	2	2	–	–	4	4	–	–	2	2	–	–	–	2	–	4	–	–
Penicillium javanicum	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–
Penicillium lanoso-coeruleum	2	–	–	–	26	–	–	–	–	–	–	–	–	–	–	–	–	–
Penicillium nigricans	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–
Penicillium notatum	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–
Penicillium oxalicum	–	2	–	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–
Penicillium purpurogenum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–
Penicillium variabile	–	–	–	–	2	2	–	–	–	2	–	–	–	–	–	–	–	–
Rhizopus sp.	3	4	4	12	2	2	4	18	1	1	2	4	2	2	–	–	–	–
Scopulariopsis brevicaulis	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–
Ulocladium botrytis	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–
Sphaeropsidales	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–
Streptomuces sp.	–	–	4	4	4	–	–	14	–	–	–	–	–	2	–	–	–	–

[a]Number of isolate

contents of 13.0, 14.8, and 15.9%, and in the polished rice, with a beginning moisture contents of 11.0, 13.1, and 14.8%, all of them decreased about 1% in moisture content throughout the test periods. Longer storage of the brown and polished rice in PE package resulted in the diminution of the field fungi and the build up of storage fungi (Table 4, 5; Fig. 2). For instance, storage fungi, *Aspergillus candidus, A. chevalier, A. flavus, A. repens, A. sydowi, A. versioclor, Penicillium frequentans, P. notatum, Chaetomium globosum* etc., increased substantially (Table 4, 5). However, the increase of the population also largely depended on the moisture contents of the rice seeds and the temperature in which the kernels were stored. After storage for 8 months at the moisture content, 15.9%, temperature, 25–35°C, occurrence percentage of the most prevalent fungi, the *Aspergillus* group on the brown rice ranged from 56 to 92.5% while at the moisture content, 14.8%, temperature, 25–35°C, population of *Aspergillus* on the polished rice ranged from 7 to 35% (Fig. 2). At lower moisture content (11–13%), temperature, 15–35°C, the increase of storage fungi and polished rice was not distinctive (Fig. 2). Generally, the lower moisture contents greatly restricted the growth and propergation of storage fungi than the temperatures did. The combined effects of low moisture contents (less than 13%) and low temperatures (less than 15°C) might decrease the risk of damage and spoilage of the brown and polished rice by storage fungi in PE package.

Table 6. *The total fungal flora and their incidence on rice kernels sampled from Taipei (Nankang), Taichung, Tainan and Pingtung areas, respectively.*

Species of fungus	Districts and incidence of fungus recorded				Total
	Taipei	Taichung	Tainan	Pingtung	
Absidia cylindrospora Hag., Skrif., u.a. Vid.-Selsk	110	6 –	3	–	119
Absidia heterospora Ling-Young	–	–	2	–	2
Absidia hyalospora (Saito) Lendn.	2	–	–	–	2
Acremoniella arta (Cda.) Sacc.	6	–	–	–	6
Acrocylindrium oryzae Saw.	3	55	–	–	3
Alternaria alternata (Fr.) Keiss.	49	–	–	10	64
Alternaria padwickii (Grang.) Ell.	3	8	–	–	3
Alternaria tenuissima (Kunze ex Pers.) Wilt.	16	–	–	4	28
Arthrinium saccharicola Stev.	2	–	–	–	2
Arthrinium sphaerospermum Fuck.	3	–	–	–	3
Arthrobotrys arthrobotryoides (Berl.) Lind.	5	–	–	–	5
Ascotricha congoenesis Ames	2	–	–	–	2

Table 6. Continued

Species of fungus	Districts and incidence of fungus recorded				Total
	Taipei	Taichung	Taina	Pingtung	
Aspergillus allahabadii Mehr. and Agn.	19	–	18	–	27
Aspergillus aurantiobrunneus (A., H., and R.) Rap. and Fenn.	4	–	–	–	4
Aspergillus awamori Nak.	2	–	–	–	2
Aspergillus carneus (v. Tiegh.) Bloch.	30	–	–	–	30
Aspergillus candidus Link	696	–	–	–	696
Aspergillus chevalieri (Mang.) Thom and Church	568	–	38	–	606
Aspergillus cristatus Rap. and Fenn.	48	–	–	–	48
Aspergillus flavo-furcatis Bat. and Maia	16	2	–	4	22
Aspergillus flavus Link	1534	9	1	67	1611
Aspergillus fischeri series	33	–	–	–	33
Aspergillus fumigatus Fres.	2	–	–	–	2
Aspergillus japonicus Saito	2	–	–	–	2
Aspergillus microcysticus Sappa	81	10	–	–	91
Aspergillus niger v. Tiegh.	77	–	9	2	88
Aspergillus pulvinus Known and Fenn.	24	–	–	–	24
Aspergillus repens de Bary	36	–	–	–	36
Aspergillus ruber (K., S. and B.) Thom and Church	108	–	8	–	116
Aspergillus sclerotiorum Hub.	2	5	–	–	7
Aspergillus sydowi (Bain. and Sart.) Thom and Church	182	16	–	–	198
Aspergillus versicolor (Vuill) Tir.	152	10	1	2	165
Botrytis cinerea Pers. ex Fr.	1	–	–	–	1
Carpenteles brefeldianum (Dodge) Shear	4	–	–	–	4
Cephalosporium curtipes Sacc.	4	–	–	–	4
Cephalosporium sp.	19	–	–	–	19
Chaetomium africanum Ames	2	–	–	–	2
Chaetomium globosum Kunze ex Fr.	279	8	–	8	295
Chaetomium microcephalum Ames	–	–	–	6	6
Chaetomium perpulchrum Ames	4	–	–	5	9
Chaetomium Sphaerosperum Penz.	1	–	–	–	1
Chlamydomyces palmarum (Cke.) Mas.	4	–	–	–	4
Chloridium viride Link ex Link	5	–	–	–	5
Circinella linderi Hess. and Fenn.	22	–	2	3	27
Cladosporium cladosporioides (Fres.) de Vries	27	22	–	–	49
Cladosporium sphaerospermum Penz.	–	2	–	–	2
Cladosporium sp.	4	–	–	–	4
Clamydoabsidia padeni Hess. and Ell.	5	–	–	–	5

Table 6. Continued

Species of fungus	Districts and incidence of fungus recorded				Total
	Taipei	Taichung	Tainan	Pingtung	
Cunninghamella bertholetiae Stad.	172	–	–	–	172
Cunninghamella echinulate Thaxt.	18	–	–	–	18
Cunninghamella sp.	9	2	2	6	19
Curvularia affinis Boe.	10	–	–	–	10
Curvularia clavata Jain	23	–	–	–	23
Curvularia fallax Boe.	2	–	–	–	2
Curvularia lunata (Wakk.) Boe.	221	117	308	43	689
Curvularia lunata var. *aeria* (B., L., and V.) Ell.	5	6	4	6	21
Curvularia oryzae Bugn.	3	–	–	–	3
Curvularia pallescens Boe.	12	5	–	–	17
Curvularia senegalensis (Speg.) Subr.	29	20	4	3	56
Curvularia verruculosa Tand. and Bilg. ex Ell.	3	–	–	–	3
Drechslera carbonum Ullst.	–	32	6	5	43
Drechslera erythospila (Drech.) Shoem.	–	–	4	–	4
Drechslera frumentacei (Mitra) Ell.	–	35	7	–	42
Drechslera hawaiiensis (Bugn.) Subr. and Jain ex Ell.	–	–	4	–	4
Drechslera heterostrophus (Drech.) Drech.	–	–	–	4	4
Drechslera oryzae (Bred. de Haan) Subr. and Jain.	2	26	–	–	28
Drechslera phlei (Grah.) Shoem.	–	16	–	–	16
Drechslera sacchari (Butl.) Subr. and Jain	8	22	1	1	32
Drechslera stenospila (Drech.) Subr. and and Jain	6	–	–	–	6
Drechslera sp.		–	–	–	19
Fusarium lateritium Nees emend. Snyd. and Hans.	19 9	30	25	5	69
Fusarium moniliforme Shel. emend. Snyd. and Hans.	52	8	21	–	81
Fusarium oxysporum Shel. emend. Snyd. and Hans.	59	– –	–	–	59
Fusarium roseum L. K. emend. Snyd. and Hans.	12	17	11	–	40
Fusarium solani (Mart.) Appl. and Wr. emend Snyd.	84	19	14	4	121
Harknesia americana (Mont.) Sutt.	6	–	–	–	6
Monilia sitophila (Mont.) Sacc.	7	–	–	–	7
Mucor sp.	13	–	2	–	15
Nigrospora oxyzae Huds.	11	–	–	–	11

Table 6. Continued

Species of fungus	Districts and incidence of fungus recorded				Total
	Taipei	Taichung	Tainan	Pingtung	
Nigrospora sacchari (Speg.) Mas.	2	–	–	–	2
Penicillium brevi-compactum Dierckx	14	–	–	–	14
Penicillium chrysogenum Thom	12	–	–	–	12
Penicillium commune Thom	34	–	–	–	34
Penicillium corylophilum Dierckx	35	–	–	–	35
Penicillium frequentans Westl.	204	10	2	4	220
Penicillium funiculosum Thom	–	–	4	–	4
Penicillium javanicum van Beyma	22	–	–	–	22
Penicillium lanso-coeruleum Thom	67	–	6	–	73
Penicillium linacinum sseries	2	–	2	–	4
Penicillium lividum Westl.	15	–	–	–	15
Penicillium nigricans (Bain.) Thom	9	2	2	–	13
Penicillium notatum Westl.	128	–	–	–	128
Penicillium oxalicum Curr. and Thom	42	2	2	–	46
Penicillium purpurogenum Stoll	16	–	–	–	16
Penicillium purpurrescens (Sopp) Rap & Thom	1	–	–	–	1
Penicillium rubrum Stoll	33	–	–	–	33
Penicillium raciborskii Zal.	12	–	–	–	14
Penicillium spinulosum Thom	–	–	8	–	8
Penicillium steckii Zal.	12	–	–	–	12
Penicillium variabile Sopp	10	–	–	3	13
Pyricularia oryzae Cav.	2	1	19	62	84
Rhizopus sp.	122	–	–	–	122
Schizophyllum commune Fr.	11	–	–	–	11
Scoleobasidium variabile Barr. and Busch.	1	–	–	–	1
Scopulariopsis brevicaulis (Sacc.) Bain.	4	–	–	–	4
Sphaeromyces clavisporus Arn.	1	–	–	–	1
Syncephalastrum racemosum Cohn ex Schr.	1	24	36	17	78
Torula herbarum (Pers.) Link ex Gray	5	–	–	–	5
Ulocladium botrytis Preu.	2	–	–	–	2
Sphaeropsidales	183	40	125	21	369
Unidentified sp.	24	–	–	–	24
Streptomyces sp.	127	–	–	–	127
Number of species identified	92	31	29	21	101
Total number of isolates	6146	539	703	293	7681

In the present experiment, 7681 fungal isolates, representing of 37 genera, 101 species of fungi have been isolated either from the rough, brown, or polished rice (Table 6), sampled from Taipei, Taichung, Tainan, and Pingtung areas. Obviously, the isolation method could recover a wide range of fungi on the rice kernels, and many of the fungi yielded are believed to be new records on the rice grains. Some of the field fungi and storage fungi were selected and microphotographed through the light and stereo microscopes and illustrated in figures 3–9. Two species of fungi, one *Arthrinium* sp., and one *Verticicladiells* sp., appear to be previously undescribed, and their final identification is in progress.

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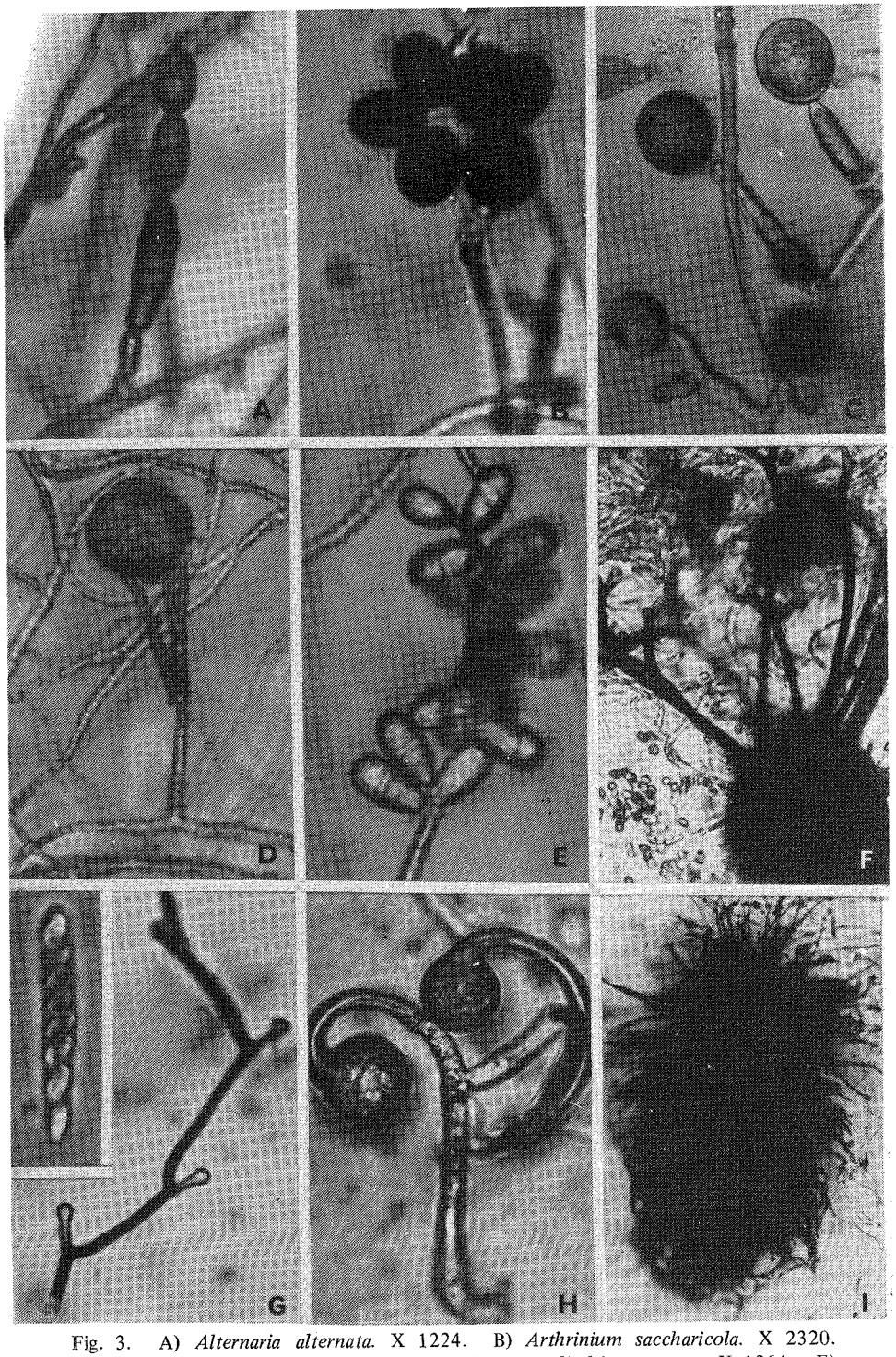

Fig. 3. A) *Alternaria alternata.* X 1224. B) *Arthrinium saccharicola.* X 2320. C) *Acremoniella arta.* X 928. D) *Acrocylindrium oryzae.* X 1364. E) *Arthrobotrys arthrobotryoid.* X 600. F) *Ascotricha congenesis. Perithecium* and *appendage.* X 509. G) *Ascotricha congenesis.* Sympodial appendage of perithecium and the 8-spores ascus. X 922. H) *Circinella linderi.* X 768. I) *Chaetomium globosum.* X 192.

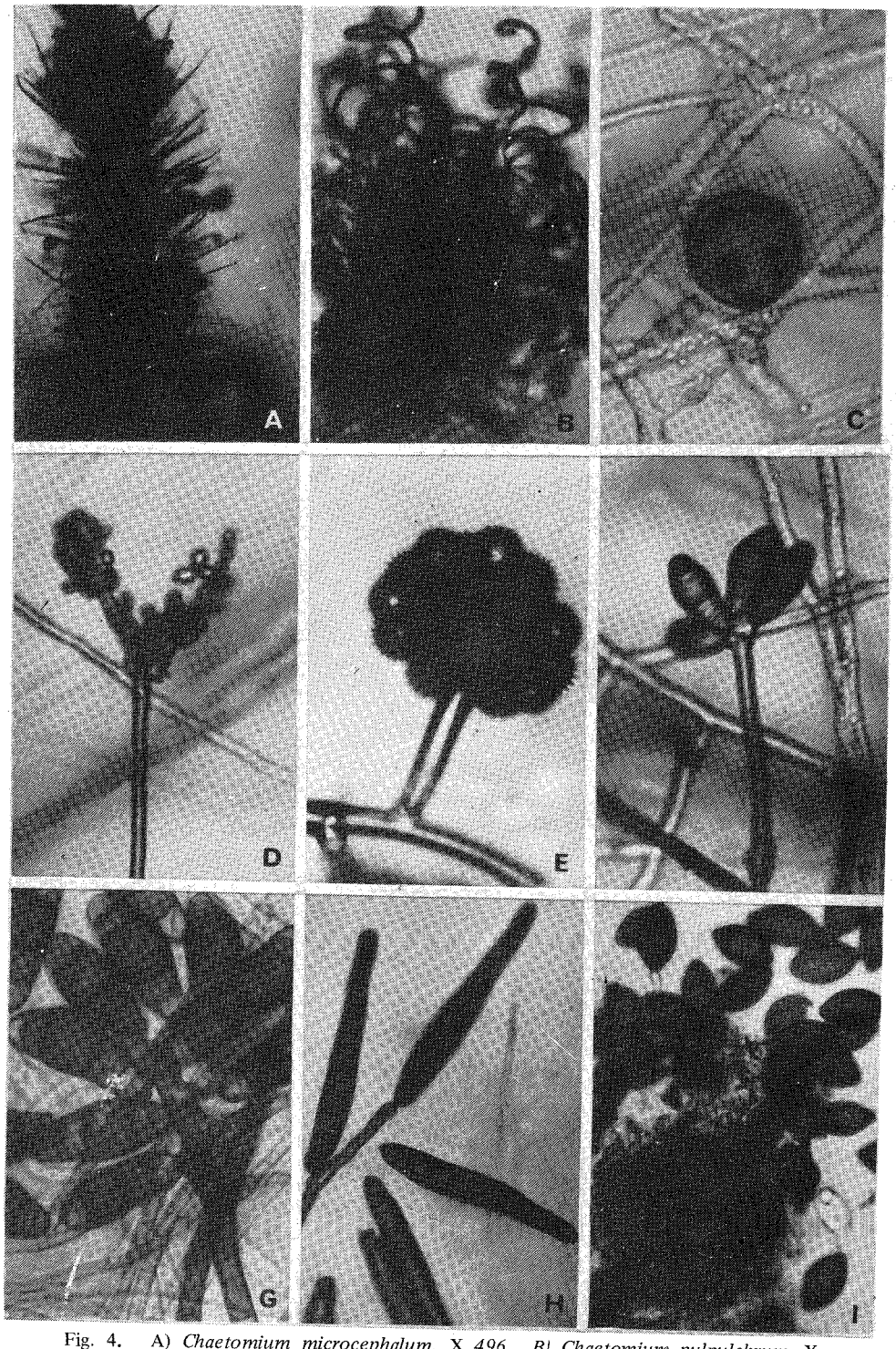

Fig. 4. A) *Chaetomium microcephalum.* X *496. B) Chaetomium pulpulchrum.* X 360. C) *Chlamydomyces palmarum.* X 1216. D) *Cladosporium cladosporides.* X 1106. E) *Cunninghamella bertholitae.* X 1214. F) *Curvularia senegalensis.* X 1248. G) *Curvularia sigmoidea.* X 1754. H) *Drechslera stenospila.* X. 682. I) *Harknesia americana.* Pycnidia and pycnidiospores, X 1901.

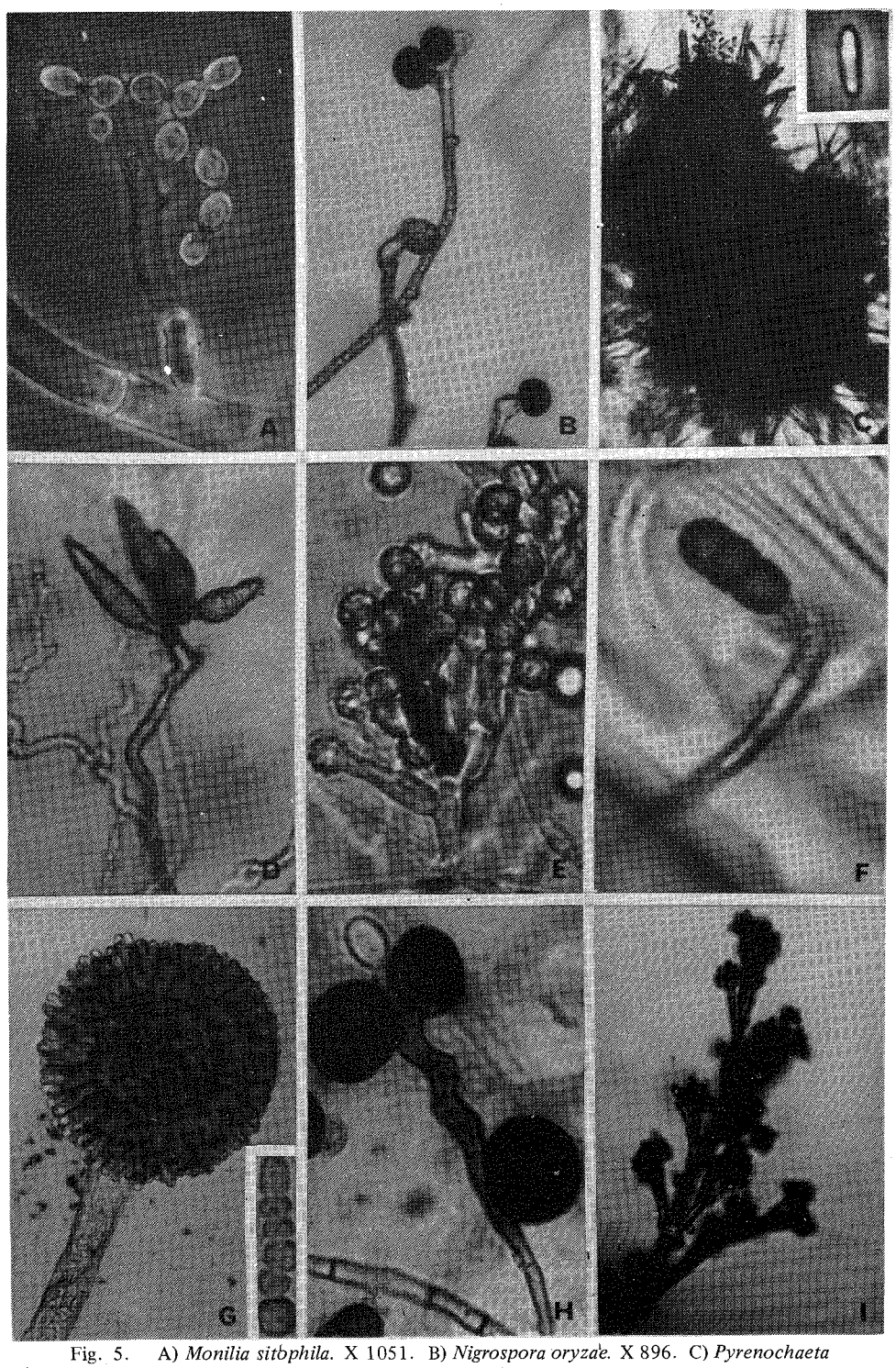

Fig. 5. A) *Monilia sitophila.* X 1051. B) *Nigrospora oryzae.* X 896. C) *Pyrenochaeta oryzae.* Pycnidia, X 144, pycnidiospore, X 2880. D) *Pyricularia oryzae.* X 870. E) *Scopulariopsis brevicaulis.* X 1920. F) *Scoleobasidium varians.* X 1800 G) *Syncephalastrum racemosum.* X 640. *Merosporangium,* X 2256. H) *Ulocladium botrytis.* X 1456. I) *Verticialadiella* sp. X 937.

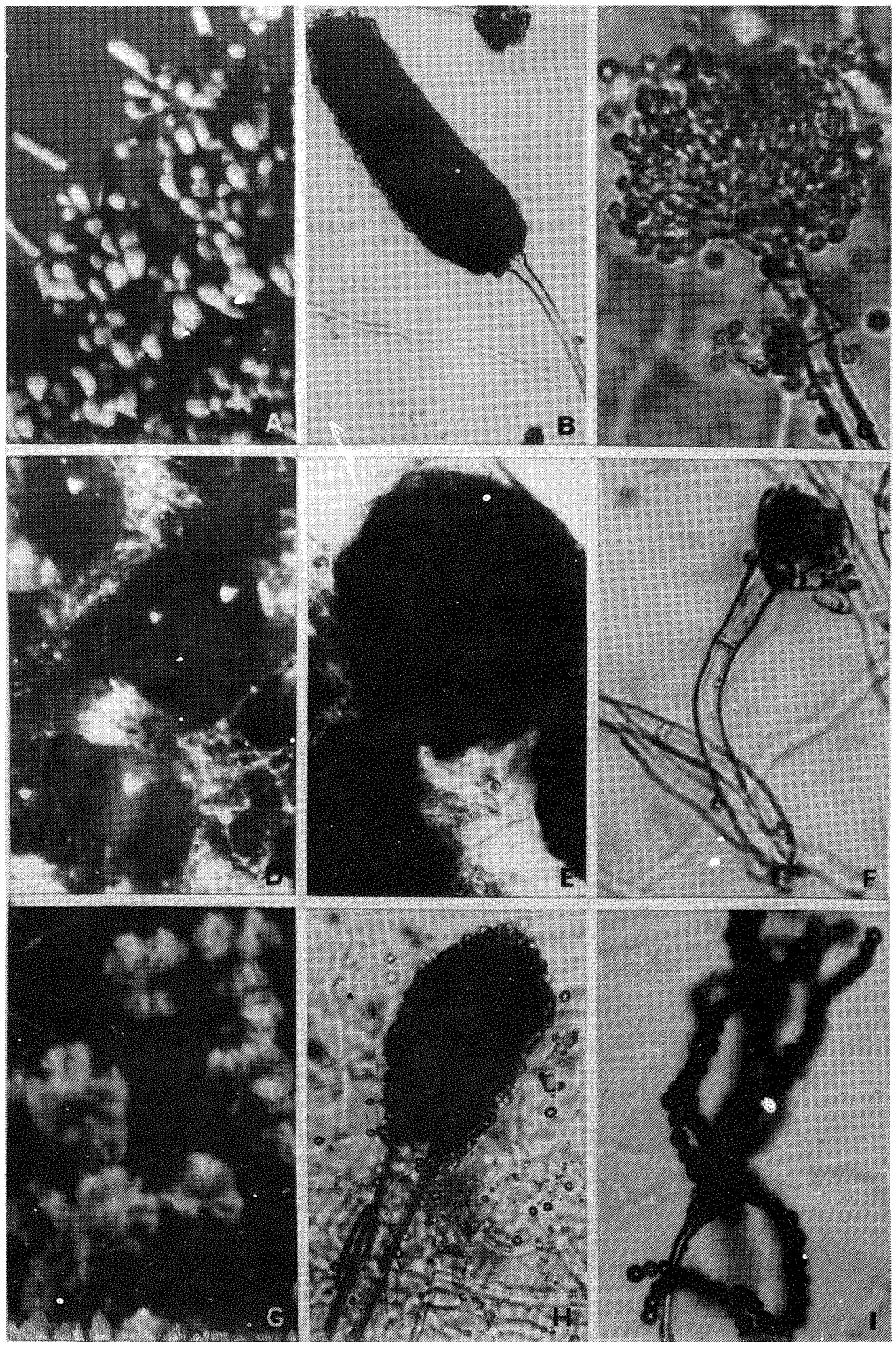

Fig. 6. A–C) *Aspergillus carneus.* X 79, 748, 1664, repectively. D–G) *A. chevalieri.* X 111, 828, 1152, 132, respectively. H) *A. clavatus.* X 768. I) *A. flavo-furcatus.* X 768.

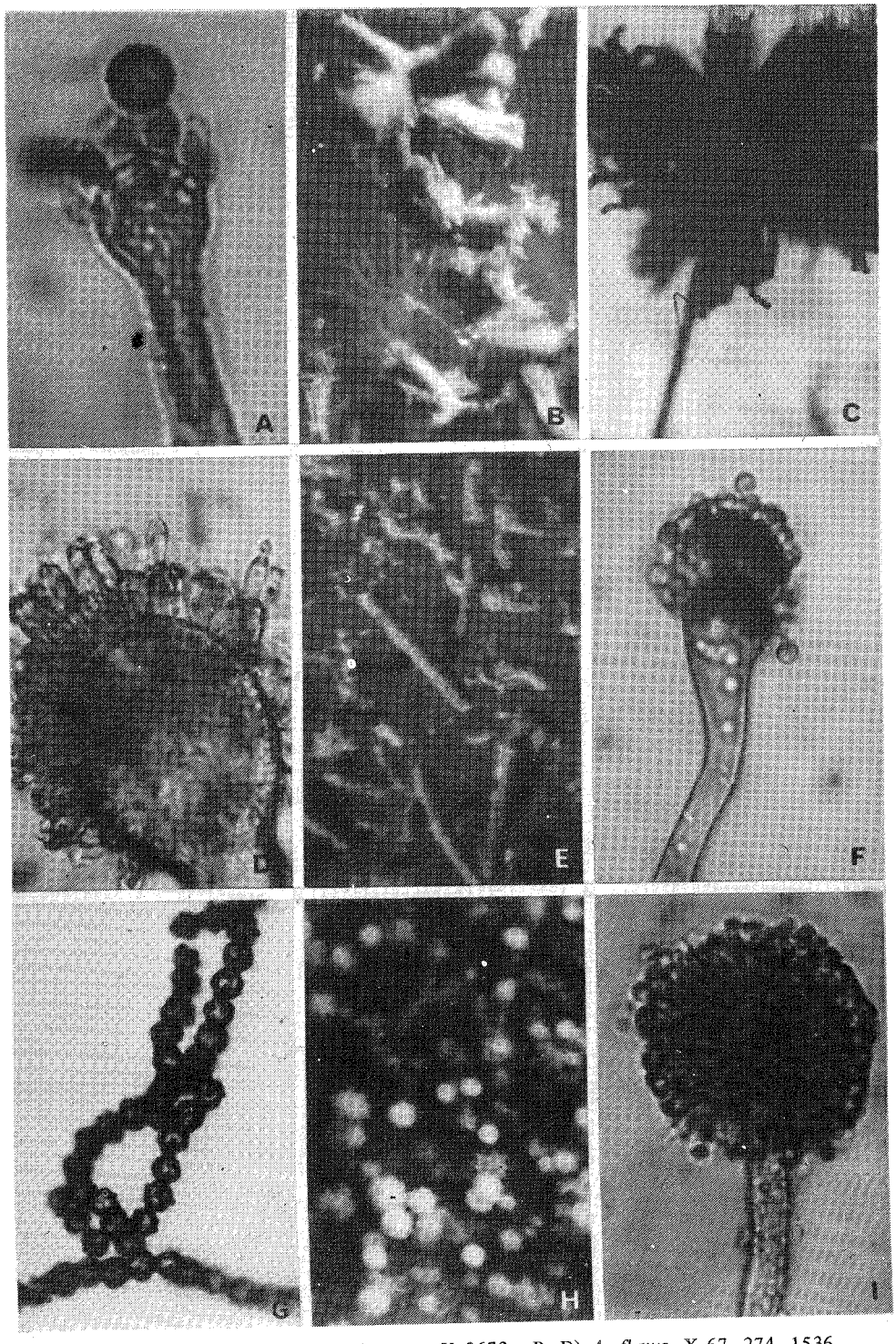

Fig. 7. A) *Aspergillus flavo-furcatus.* X 2672. B–D) *A. flavus.* X 67, 274, 1536, respectively. E–G) *A. fumigatus.* X 115, 2280, 1200, respectively. H–I) *A. versicolor.* X 116, 1680, respectively.

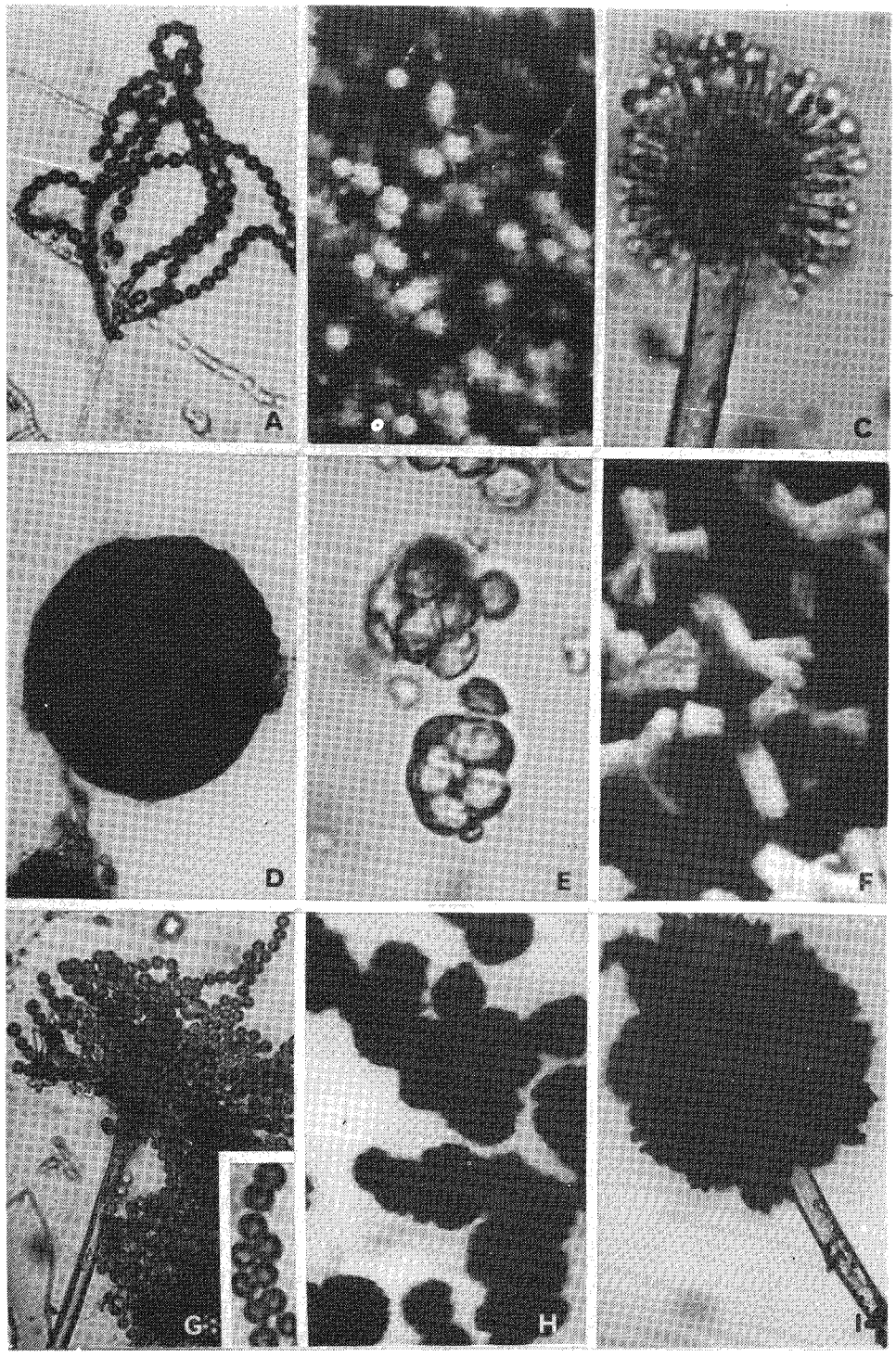

Fig. 8. A) *Aspergillus versicolar.* X 1060. B–C) *A. sydowi.* X 110, X 1817, respectively' D–E) *A. ruber.* X 1707, 2976, respectively. F) *A. sclerotiorum. X 87.* G) *A. pulvinus.* X 712, 1632, respectively H–I) *A. niger.* X 71, 410, respectively.

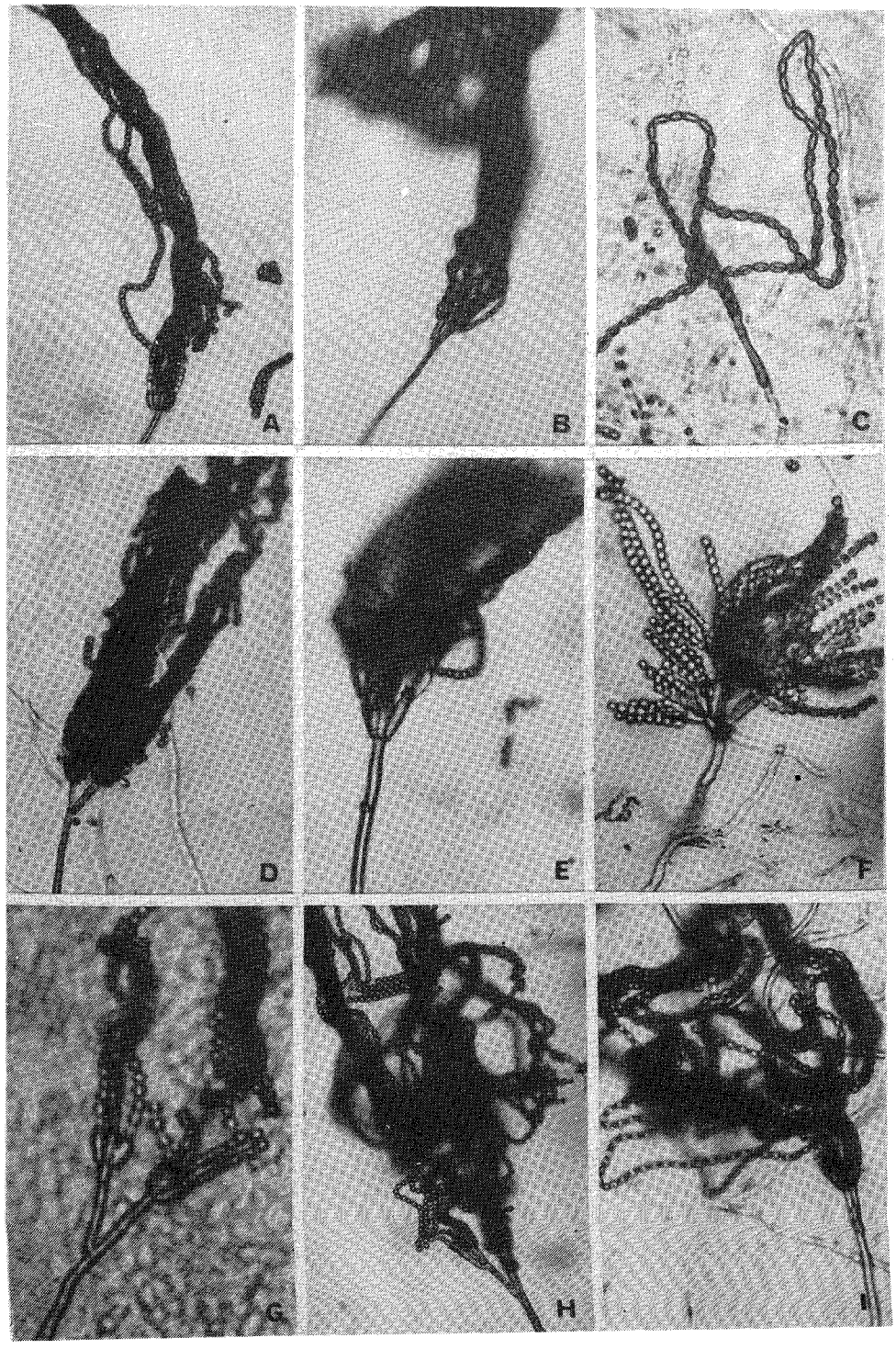

Fig. 9. A–B) *Penecillium frequentans.* X 713, 653, respectively. C) *P. lanosocoeruleum.* X 1050. D–E) *P. notatum.* X 703, 1024, respectively. F) *P. oxalicum.* X 777. G) *P. purpurogenum.* X 1541. H) *P. raciborskii.* X 485. I) *P. rubrum.* X 660.

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儲存方式對於儲存稻米上眞菌族群變化之影響

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對於稻谷，糙米，白米上之眞菌相和儲存條件，如濕度、溫度、和儲存期間，對於儲存於塑膠袋內之糙米，或白米上之眞菌族群變化之影響，曾進行探討。由 7681 個眞菌菌株，鑑定出 37 屬，101 種之眞菌。田間性眞菌，爲稻谷上之優勢菌，甚至於經爲期二年之儲存後，此優勢亦無顯著之變化。大致，在稻谷上之眞菌其出現率不超過百分之二十，在糙米上者，不超過百分之十，而在白米上者不超過百分之五。若白米或糙米置入塑膠袋密閉儲存，則經四個月後常導致田間性菌類之消失和儲藏性眞菌之滋長，而此消長和儲藏期間成正比。在含水量百分之十五，溫度攝氏二十五～三十五度，最居優勢之菌類，如 *Aspergillus* 在經儲存八個月之糙米上，其出現率在百分之五十六到百分之九十二點五之間，而在濕度百分之十四點八，溫度攝氏二十五～三十五度時，*Aspergillus* 在白米上出現頻率爲百分之七到百分之三十五。若米粒之含水量較低（百分之十一到十三）則不論在白米或糙米上之眞菌群增加之量甚微。較低之含水量（低於百分之十三）和較低之溫度（低於攝氏十五度）之綜合作用，或許可減低儲存於塑膠袋內之白米或糙米受黴腐之險。