

## SURVEY OF FUNGI ASSOCIATED WITH STORED FOOD GRAINS IN SILOS IN IRAQ

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A comprehensive survey of fungi associated with foodgrains stored in silos/godowns in Iraq was carried out with a view to identifying the problem and to determine the identity and intensity of prevalence of these fungi. Sixteen silos/godowns of stored foodgrains located in different cities from north to south of Iraq were visited and 291 samples of different varieties/types of stored wheat, barley, rough and polished rice and corn were collected. Twenty-eight different species belonging to storage molds and thirty three species of field fungi were found to be associated on or in the grain under investigation.

Species of *Aspergillus* and *Penicillium* were most predominant throughout the grains. Twelve species of *Aspergillus* including both of *A. glaucus* and *A. flavus* groups, some other apparently not reported before on stored grains along with a possible new species of *Aspergillus*, were identified. Eleven species of *Penicillium* were found to be inhabiting the grains. Species of *Rhizopus* and *Mucor* were also significantly present. Among field organisms, species of *Alternaria*, *Fusarium*, *Cladosporium*, *Curvularia*, *Stemphylium* and *Cochliobolus* with many more less common and unreported fungi were isolated. Relative prevalence of *Alternaria* species was high as compared to other field fungi.

### INTRODUCTION

According to an FAO report, 5% of all foodgrains harvested are lost before consumption due to pest and fungal diseases [1]. Fungi such as *Alternaria*, *Cladosporium*, *Fusarium*, *Helminthosporium* and *Curvularia*, to name a few, invade seeds as they are developing on the plants in the field or after they have matured, but before they are harvested [2]. For this reason, they have been designated "field fungi". These fungi may cause discoloration of the seeds, shrivelling of the kernels and weakening or death of the embryos.

Stored grains are subject to invasion and damage by another group of fungi, collectively called "storage fungi" or "storage molds". These fungi like *Aspergillus*, *Penicillium*, *Rhizopus*, *Mucor*, etc. do not invade seeds to any significant degree or extent before harvest [3]. The major types of losses caused by fungi in storage are: discoloration of the seeds, heating of the grains, increase in fatty acid value, mustiness, caking and total decay and production of toxins that if consumed may be injurious to man and domestic animals. Fungi associated with wheat flour and cereal grains have also been reported by Shahnaz

*et al.* [4, 5] and Muhammad *et al.* [6] from Pakistan.

No detailed data on a comprehensive survey of microorganisms associated with stored grains in silos/godowns in Iraq available. This perhaps is the first serious and systematic effort in Iraq to screen stored foodgrains for presence of microorganisms and identify the problem.

### MATERIALS AND METHODS

Sixteen silos/godowns located in different parts from north to south of Iraq were visited (Fig. 1). A total number of 291 samples of stored varieties/types of wheat, barley, rough and milled rice and corn were collected (three representative samples each). Samples were directly and randomly taken from the bins, gunny bags and from the floor of house-type godowns where they were placed in bulk.

In order to screen samples for fungi, thirty seeds from each sample were surface sterilized with 1% sodium hypochlorite solution for 3 min. They were subsequently rinsed in two changes of sterile distilled water and then plated on PDA medium in petridishes and incubated at 26°. Tentative identification were made and the cultures were subsequently sent to the Commonwealth Mycological

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Institute (CMI) for confirmation and specific identification, where necessary.

## RESULTS AND DISCUSSION

Microorganisms, both storage molds as well as field fungi, from unsterilized and surface sterilized grains were isolated. Twenty-four diversified genera of fungi embracing sixty different species were isolated from these grains.

Twelve species of *Aspergillus* and eleven species of *Penicillium* were isolated from different stored foodgrains and were the most prominent storage molds. Their frequency of occurrence on all grains was high. Other molds like *Rhizopus*, *Mucor*, *Acremonium*, etc. were generally heterogenous and some, it appears, may be reports on stored grains.

Maximum relative percent prevalence of *Aspergillus* species (58.1%) appeared to have been milled rice as compared to other types of grains while prevalence in barley was very low (29.9%) (Table 1). Wallace [7] has mentioned that out of 86 *Aspergillus* sp. listed by Raper and Fennell [8] at least 26 occur on stored grains as

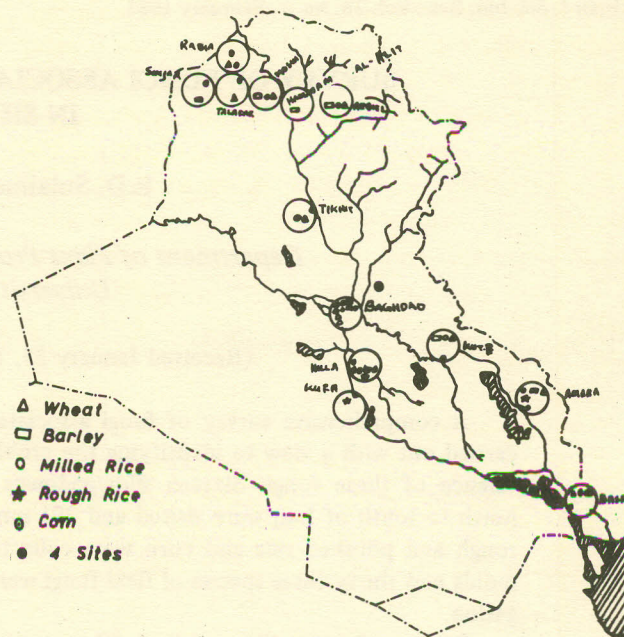


Fig. 1. Map showing location of Silos/Gowdowns in Iraq and grain available.

Table 1. Percent prevalence of the genera of fungi on different stored grains

Genera of fungi	Wheat	Barley	Milled	Rice Rough	Corn
<i>Aspergillus</i>	45.5	29.9	58.1	52.1	31.0
<i>Penicillium</i>	5.1	3.9	16.2	9.5	10.0
<i>Rhizopus</i>	16.3	14.6	8.7	8.6	13.3
<i>Mucor</i>	2.03	2.6	5.7	6.08	3.3
<i>Alternaria</i>	19.8	28.4	5.3	8.6	6.6
<i>Cladosporium</i>	4.2	2.2	1.7	0.0	0.0
<i>Curvalaria</i>	0.1	1.4	0.3	6.08	0.0
<i>Fusarium</i>	1.1	1.1	0.0	0.0	25.8
<i>Cochliobolus</i>	0.3	1.1	0.0	2.6	0.0
<i>Hendersonula</i>	0.4	1.4	0.0	0.0	0.0
<i>Stemphylium</i>	0.0	3.5	0.3	3.4	0.0
<i>Acremonium</i>	0.1	0.5	0.0	0.0	5.0
<i>Trichoderma</i>	0.1	0.0	0.0	0.0	0.0
<i>Chaetomium</i>	0.0	1.3	0.0	0.0	0.0
<i>Ulocladium</i>	1.8	0.9	0.0	0.0	3.3
<i>Phoma</i>	0.0	0.3	0.0	0.0	0.0
<i>Pyrenochaeta</i>	0.0	1.3	0.0	0.0	0.0
<i>Epicoocum</i>	0.0	5.01	0.0	0.0	0.0
<i>Mycovellosiella</i>	1.3	0.0	0.0	0.0	0.0
<i>Embellesia</i>	0.1	0.0	0.0	0.0	0.0
<i>Macrophomina</i>	0.0	0.0	0.5	0.0	0.0
<i>Trichothecium</i>	0.0	0.0	0.3	0.0	0.0
<i>Syncephalastrum</i>	0.0	0.0	3.4	0.0	0.0
<i>Khuskia</i>	0.0	0.0	0.0	2.6	0.0

reported by various investigators from different countries. On cereals, Pelhate [9] reported 19 species from France, Stankushev [10] 7 from Romania, Saponaro and Madaluni [11] 12 from Italy, Griffin [12] 10 from Australia and Wallace [13] 17 from Canada. Eight of these species, i.e. *A. amstelodami*, *A. candidus*, *A. flavus*, *A. tamarii*, *A. fumigatus*, *A. nidulans*, *A. terreus* and *A. niger* mentioned by the above investigators from different countries, have also been reported by the authors probably for the first time to be occurring on stored food cereals in Iraq. Besides, 4 other species, *A. penicilloides*, *A. quercinus*, *A. stellatus* and *A. duricaulis* not mentioned by investigators from France, Romania, Italy, Canada and Australia, have been reported to be associated with stored cereals and have not been described before from Iraq. *A. duricaulis* was universal not only in its prevalence on all grains, but its frequency of occurrence was also highly significant.

Sixty species of *Penicillium* have been reported by various investigators in different countries as occurring on stored grains. Thirty species reported from Canada, [14, 13], 31 (though not always necessarily the same as reported from Canada) from France, [9] 5 from Italy [11] and 5 from Japan, [15] occurring on cereals. The authors have isolated 7 species mentioned by the above workers and 2 others i.e. *P. islandicum* and *P. chrysogenum* on cereals which have not been listed from any of the above mentioned countries. On corn, Lichwardt [16] from U.S.A. reported 17 species while these authors isolated only *P. funiculosum*. Nine *Penicillium* species were found to be associated on stored rice in these studies.

Maximum relative percent occurrence of total *Penicillia* was observed on milled rice (16.2%). The least occurrence was noted on barley (3.9%). (Table 1).

*Mucor christianiensis*, *M. jansseni*, *M. spinescens*, *M. ramanniamus*, *M. sphaerosporus* and *M. silvaticus* have been reported from Canada by Machacek *et al.*, [4] and Wallace [13], and *M. circinelloides*, *M. griseocyanus*, *M. hiemalis*, *M. mucedo*, *M. spinosus*, *M. pusillus* and *M. racemosus* by Pelhate [9] from France, occurring on cereals. From among the above mentioned species of *Mucor* only *M. circinelloides* and *M. racemosus* were isolated on stored cereals in Iraq.

*Rhizopus arrhizus*, *R. stolonifer* and *R. tritici* were reported from Canada by Wallace and Machacek and the first two mentioned species from France by Pelhate on cereals. These species, however, were not found by the author to be associated on any stored grains in Iraq. Instead, two other species i.e., *R. oryzae* and *R. rhizopodiformis* were isolated from cereals. The last mentioned species was extremely frequent throughout the silos.

*Alternaria*, *Cladosporium*, *Fusarium*, *Helminthosporium*, [1, 17] *Curvularia* and *Stemphylium*, [14] were some of the common field fungi reported to be invading the seed before harvest and are carried into the seed. They do not cause much deterioration in storage as they require a high percentage of moisture to grow and cause damage. Most of the damage caused is either before harvest or at harvest time.

The authors have isolated the above mentioned fungi with many more which either are not reported before or very rarely mentioned to occur in the seeds. Species of *Acremonium*, *Ulocladium*, *Khuskia*, *Trichothecium*, *Epicothium*, *Pyrenochaeta*, *Embellisia* and *Mycovellosiella*, to name a few, are reported for the first time as occurring on stored grains in Iraq. These field fungi were present on most var/types of the grains and their percent occurrence in some cases was quite significant.

From the foregoing discussion on the relative prevalence of fungi on different stored foodgrains, it appears that there is apparently no set pattern for their maximum and minimum occurrence, and as Al-Heti [18] has stated this variation in percent infection and distribution in different stores (silos/godowns) could be due to differences in moisture content of the grain, in source of infection, and variation in the influence of birds, rodents, mites and insects which not only act as the vectors of fungi but also predispose them for infection.

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