MICROBIAL DEGRADATION OF GRAINS IN STORAGE

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It remained ~~at~~ unattended field in pathological diseases of plants and plant products. We give impetus on on-field study of plant diseases but loss of storage grains is much important as far as yield is concerned. Research and technology has been utilized to a great extent in stepping up food production but all efforts to produce more food will not be of much avail until similar progress is achieved in their scientific storage. Even seed, may be produced under the rigorous system of inspection, harvested properly and processed to high purity, but can then be lost if stored under poor conditions.

Damages and consequent losses, both in quality and quantity of grains always take place in storage, are attributable to number of factors. Organisms directly responsible for causing loss in stored grains are insects, mites, rodents, fungi and bacteria. Damages due to bacteria and fungi are normally attributed to unhygenic conditions of storage and are associated with the initial high moisture content of the stored grains or absorption of moisture during storage

In India nearly 70% of the produce is retained by the ~~farmers~~ farmers in traditional way where the stored grain is not firmly protected against exposure to moisture. As such losses due to fungal spoilage of grains are quite heavy. Deterioration due to fungi can be detected on account of visible mouldy growth, formation of lumps and musty odour. In the spoilage of stored grains, bacteria do not seem to be involved normally because they require ample water to grow and grains are seldom stored under conditions where ample water is available.

The fungi that contaminate the grains or seeds may be classified into field fungi and storage fungi.

Field fungi

The fungi of this group invade the developing seed. Field fungi may cause discolouration of grains, weakening or death

of embryos, blights etc. Species of Alternaria, Cladosporium, Curvularia, Drechslera, Epicoccum, Nigrospora, Papularia etc. have been found to infect seed at or near harvest. In certain grains Aspergillus flavus, A. niger, A. parasiticus, A. fumigatus are associated with grains in the field also.

Most of the field fungi are not directly involved in grain spoilage. However, their presence is responsible for effecting the appearance and quality of the grain i.e. heavy rain prior to harvest helps in the development of black point disease of wheat (Alternaria tenuis). The disease reduces the commercial value of the grain. Infection of Drechslera oryzae and Trichoconis padwickii on paddy seeds produce brown to black lesion on infected kernels. Infection of cereals by Claviceps purpurea results into formation of sclerotia. Consumption of ergot contaminated grains have been known to develop poisonous symptoms on animals and humans. The field fungi also produce mycotoxins but the toxicity of grains differs with the fungus infecting them.

Storage fungi

The fungi of this group develop on or within the seeds in storage. The storage fungi include mainly several species of Aspergillus and Penicillium. Of these two, Aspergilli are more prevalent because they require minimum relative humidity (R.H.) of 65-88% and temperature at 8-58°c for their growth. The species differ from one another in taxonomic characters, the temperature and moisture at which they grow, mode with which they invade the grain and biochemical changes they produce in the grains. The example are Aspergillus flavus, A. candidus, A. niger, A. repens, A. ruber, A. versicolor, A. parasiticus etc. Penicillia are more prevalent in cooler climates than the Aspergilli. Penicillia require high humidity (about 80%) for the germination of their conidia. The temperature suitable for their development is between 4-48°c. The common species of Penicillia associated with grains are Penicillium

urticae, P. oxalicum, P. citrinum, P. islandium etc. Besides Aspergilli and Penicillia, some other species of fungi have also been reported in stored grains i.e. Rhizopus arrhizus, Mucor pusillus, Alternaria alternata, Cladosporium herbarum, Cephalosporium curtipes, Fusarium semitectum etc.

Harmful effects of storage fungi

(1.) Discoloration of seed or embryo :

The spores of storage fungi i.e. Aspergillus spp. are almost present on the surface of seed. Grains of wheat, paddy, maize and sorghum are invaded if the moisture content is above 13 %, oil-seeds such as soybean and groundnut are damaged by storage fungi at moisture contents above 12 and 10 % respectively. They invade and damage seeds much more rapidly. The invasion generally causes blackening of the germ. Storage fungi normally do not invade seed before storage but some species of Aspergillus such as Aspergillus flavus, A. candidus and Penicillium spp. do so in case of wheat, groundnut, cotton etc. before harvest. Some field fungi like Alternaria, Drechslera, Curvularia, Fusarium etc. may invade the seed before harvest. The invasion causes discoloration, shrivelling of seed, prolonged dormancy and quality losses. Such type of grains are termed as 'sick' or 'damaged'.

(2.) Reduction in seed germination

If the grain is stored at high humidity, storage fungi invade the grain. They slowly kill the embryos of the seeds. The whole seed lot may be rendered useless for sowing and consumption purposes. At high moisture levels, growth of the fungi and loss in seed germination is more rapid.

(3.) Biochemical changes in the seed.

Improper storage makes the seeds vulnerable to storage fungi which deteriorate the stored grains both qualitatively and quantitatively. They bring about a variety of biochemical changes. They change the starch, fatty acids, reducing sugars, non-reducing

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Sugars, insoluble nitrogen, protein contents of stored grains. In the presence of high moisture content, the seed becomes metabolically active. The level of total concentration of phenolic compounds increases significantly in infected gram seeds during storage (Dwivedi, 1990). Prasad et al. (1988) reported considerable loss in food-reserve of the seed i.e. loss of lipid, nitrogen, starch due to storage fungi. Saxena and Karan (1991) reported gradual loss of protein and carbohydrate content of sesame and sunflower seeds due to Aspergillus flavus and A. niger during storage. The decrease may be due to consumption and conversion into CO_2 and water by storage fungi.

(4.) Increase in moisture content and heating

Development of storage fungi in stored grains increases respiration and heating of the grains in storage which sometimes reaches nearly 93°C. As they grow in stored grains, apart from material they consume, are converted into water. The moisture so produced in one corner can diffuse to other areas and render it vulnerable to spoilage. The spoiled grains form cake, become black in color and produce stinking odour.

(5.) Reduction in processing quality

Storage fungi reduce the processing quality of grains for milling as in wheat, corn and many other cereals. Musty odours often produced during spoilage of grains persist even in the preparation of food and beverages prepared from such grains. The storage fungi deteriorate the quality of seeds used for oil production and reduce the quality of seed used for starch. Vaidya and Dharamvir (1989) reported loss in oil content of stored ground-nut due to Aspergillus flavus and A. niger. The loss of oil content increased with incubation. Oil from infected sample was coloured and acrid smelling. Storage fungi of mustard inflicted unpleasant odour in oil and changed the color of oil significantly (Shivpuri, 1990).

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(6.) Enzymic activities of seeds

Storage fungi stimulate the activities of pectic enzyme complex, Cx, amylase, invertase and protease in the seeds of finger-millet (Prasad et.al., 1988). Storage fungi stimulate hydrolysis of starch and protein producing extra cellular amylase and protease besides cellulase and lipase (Prasad, 1979).

(7.) Production of mycotoxins

Fungi growing on stored grains produce highly toxic metabolites (mycotoxins). Consumption of food containing myco-toxins can lead to serious physiological disorders in humans and animals. The diseases caused by myeotoxins have been grouped under myeotoxicosis. Of the known myeotoxins, the most important are the ~~aflatoxins~~ aflatoxins.

Historically, the first idea of aflatoxin came from the serious disorder resulting death of more than 10,000 Turkey goose and other birds in England in 1960. It was Blount (1961) who established the cause of the disease as the Brazilian pea-nut supplied to the bird as feed. The feed was heavily contaminated with Aspergillus flavus. The disorder was named Turkey 'x' disease. In Aflatoxin 'A' stands for Aspergillus, 'fla' for flavus, and 'toxin' for poison. Aflatoxin are produced mainly by A. flavus and A. parasiticus. However, some other fungi have also been reported to produce aflatoxin.

The problem of aflatoxin production is confounded by the fact that A. flavus is cosmopolitan and worldwide in distribution and can attack a wide variety of substrates under storage conditions. Aflatoxin production in storage depends on several factors such as moisture content of the material, its temperature and length of time it is stored, amount of inoculum and insect mite activity.

About 18 derivatives of aflatoxin are known under the headings B_1, B_2, G_1, G_2, M_1, M_2, B_{2a}, G_{2a},

H_1, P_1 etc. These differ in their toxicity. Aflatoxin causes liver damage and liver cancer. Some other mycotoxins like Penicillic acid, Citrinin, Zearalenone, Patulin, Rubratoxin, Tremortins, Citreoviridin, Ochratoxins are also found in grains.

Control of post harvest spoilage of grains

(1.) Proper harvesting and threshing

The seed should be harvested as soon as it is possible after maturity. Weathering in the field, mechanical injury during harvesting, threshing and cleaning of damaged seed coat are done. The storage fungi invade the damaged seeds easily and grow rapidly. Unbroken seed coat prevents the attack of microorganisms, insects and mites.

(2.) Drying of the grains

At high moisture content of stored grains, development of fungi and activity of insect are maximum. For grains, the moisture content must be below 12%. The optimum moisture content for storage of many seeds against fungal spoilage is 6-8%. In order to achieve this moisture level, drying of grains is essential. There are different ways of drying i.e. sun-drying, natural-air-drying (in dry climate condition), hot-air-drying (in cool weather condition) etc.

(3.) Moisture control

The rate of deterioration of grain in storage increases as grain moisture increases. Mature seeds are hygroscopic and their moisture content will vary with the relative humidity (RH) of the atmosphere i.e. grains stored at low moisture content will regain moisture whenever the RH of the air rises above 60%. Therefore, it is necessary to use the following methods to prevent moisture from re-entering the seeds.

There are different methods for moisture control which are mentioned below:

(a) By judicious ventilation

Exhaust-fan reduces the temperature of the seed in storage. This method is not useful to humid areas where relative humidity is never low enough.

(b) Moisture vapour proofing the storage

The moisture as a gas in the air is readily absorbed by the seeds and raise their moisture content. Therefore, it must be prevented from entering the seed storage. Usually polyethylene sheet, aluminium foil, rubberised cloth, bitumen are used as moisture vapour proofing materials.

(c) Control of RH

Usually silica gel is used as dehumidifier. The air from the storage is blown through the silica gel bed. The silica gel removes a large part of water vapour and the air flows back into the storage.

(d) Moisture proof packaging

Polyethylene, Bitumen, Aluminium foil and water-proof paints are generally used as moisture proofing material of seed storage.

(4.) Storage in air-tight containers

This deprives the storage fungi and insects of oxygen and reduces the metabolism to minimum.

(5.) Irradiation treatment

Different dozes of irradiation has been found effective in killing storage fungi.

(6.) Storage at low temperature

Storage of grains at low temperature i.e. 8-10°C have been found useful in controlling the spoilage.

~~(7.) Storage under inert gas~~

(7.) Use of chemicals

Treatment of grains with propionic acid and sodium-metabisulphite were effective against infection by

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Aspergillus niger and *A. flavus* in stored groundnut (Vaidya and Dharamvir, 1989).

Treatment of grains with propionic acid at 0.5% before storage have been recommended to control fungal spoilage. Propionic acid can be used alone (pure 100%) or in combination with acetic acid, isobutyric acid or formaldehyde.