

# Occurrence of Mycotoxins under Changing Climatic Conditions

# 12

*K. Kannan*

---

## **Mycotoxins**

Mycotoxins are defined as a group of extremely toxic chemical substances that are produced by toxigenic molds. These molds commonly grow on a number of commodities include various agricultural crops and their byproducts. These potential toxic compounds can be produced before harvest in the standing crop, and can be spectacularly increased after harvest if the post-harvest conditions are favourable for further growth of these toxigenic fungi. The disease conditions occur due to the intake of the toxins called as mycotoxicosis. Intake of toxin and toxigenic fungal-contaminated grains or animal foods like egg, meat and milk that have originated from livestock fed with toxin-contaminated feeds lead to human exposure to these toxins. Mycotoxins may possess carcinogenic, immunosuppressive, neurotoxic, estrogenic or teratogenic activity. Table 12.1 lists mycotoxins that are of world-wide importance which means that they have been demonstrated to have significant impact on public health and animal productivity in a variety of countries. There are several other mycotoxins that are considered to be of regional significance.

## **Economic Importance of Mycotoxins**

The fungus, *A. flavus* grows on a wide array of agricultural commodities that include peanut, dried corn, millet, tree nuts, cotton seeds and rice (Michael and Ensley 2007). Aflatoxin contamination of agriculturally important crops lead to contrary economic effects that include lower yields for food and fibre crops (Setamou *et al.* 1997). Warm and humid climates are highly conducive for the growth of *Aspergillus* spp. and aflatoxins production (Dohlman 2003). Hence, most commodities from tropical countries, especially peanut and maize, are expected to be easily contaminated with aflatoxins. Aflatoxin contamination of human and animal feeds poses serious health

and economic risks worldwide. The FAO estimates that 25% of the world food crops are affected by mycotoxins each year and constitute a loss at post-harvest (FAO 1997). In 1998, as a consequence of aflatoxin contaminations, corn farmers lost \$40 million (AMCE 2010).

**Table 12.1 List of Mold Species and Toxins Produced**

Mold Species	Toxins Produced
<i>Aspergillus parasiticus</i>	Aflatoxins B1, B2, G1, G2
<i>Aspergillus flavus</i>	Aflatoxins B1, B2
<i>Fusarium sporotrichioides</i>	T-2 toxin
<i>Fusarium graminearum</i>	Deoxynivalenol (or nivalenol), Zearalenone
<i>Fusarium moniliforme</i> ( <i>F. verticillioides</i> )	Fumonisin B1
<i>Penicillium verrucosum</i>	Ochratoxin A
<i>Aspergillus ochraceus</i>	Ochratoxin A

According to Cardwell *et al.* (2004), annual loss was more than \$ 750 million in Africa due to aflatoxin contamination of agricultural crops. In the US, the average direct loss is estimated at \$200 million annually for corn. Ultimately, it contributes to increased costs to consumers (AMCE 2010). Plant pathologists estimated that 18.6% of grain was contaminated in the US during the year 2012, and most of the contamination was from aflatoxin. Aflatoxins contamination in grain lead to both quantitative and qualitative reduction, poses a great threat to human and livestock health as well as international trade. Coulibaly *et al.* (2008) compiled that the loss due to aflatoxin contamination costs about \$ 100 million per year including \$ 26 million loss in peanut (\$ 69.34/ha). In Japan, aflatoxin B1 was detected in the exports from 20 of 31 countries and five lots of large type raw shelled and 269 lots of small type raw shelled groundnuts were rejected as having above the regulation level (10 ppb) of aflatoxin B1 (Itoh *et al.*, 2001). Toxicogenic *Fusarium* spp. continue to pose a threat to farmers, by destroying crops or dramatically reducing yields, and to animal as well as human health, by the production of mycotoxins. There is no good way to eliminate the *Fusarium* problem, and farmers and food processors should remain alert to changing field conditions which will affect toxin levels in grains.

## Effect on Plants

Aflatoxin B1 limits plant growth by inhibiting seed germination, seedling growth and other physiological processes of plants (Sinha *et al.* 1993; Yaqub Bhat and Fazal; 2011). Toxic strains of *Aspergillus* were found to reduce the nutritional parameters of several seeds. Fat content in groundnut and soybean was reduced due to *A. flavus* and the maximum loss of protein content in groundnut was due to *A. terreus*. On the other hand, *A. niger*, *A. terreus*, *A. parasiticus* and *A. fumigatus* were found to reduce the protein content in soybean. *A. versicolor* effectively reduced the maximum amount of

Few Pages are not available

---

nivalenone, zearalenone, ergot alkaloids and many of the “second tier mycotoxins”, in terms of climate change. Global warming and other cause of climate change may strongly influence the occurrence and distribution of mycotoxin-producing fungi and mycotoxins in agricultural products in regions with temperate climate. These observations strongly indicate that climate change does affect the distribution of thermotolerant species and their mycotoxins, leading to the migration of these species to the areas with temperate climatic conditions, and the occurrence of their mycotoxins in years with warmer climates.

## References

- Akande, K.E., M.M. Abubakar, T.A. Adegbola and S.E. Bogoro. 2006. “Nutritional and Health Implications of Mycotoxins in Animal Feed.” *Pakistan Journal of Nutrition*, 5: 398-403.
- AMCE- Aflatoxin Mitigation Center of Excellence. 2010. *Preventing Health Hazards and Economic Losses from Aflatoxin*. Texas Corn Producers.
- Aydin, A., U. Gunsen and S. Demirel. 2008. “Total Aflatoxin, Aflatoxin B1 and Ochratoxin A levels in Turkish Wheat flour.” *Journal of Food and Drug Analysis*, 16: 48–53.
- Bock, C.H., B. Mackey and P.J. Cotty. 2004. “Population Dynamics of *Aspergillus flavus* in the Air of an Intensively Cultivated Region of South–West Arizona.” *Plant Pathology*, 53: 422–433.
- Boyd, M.L. and P.J. Cotty. 2001. “*Aspergillus flavus* and Aflatoxin Contamination of Leguminous Trees of the Sonoran Desert in Arizona.” *Phytopathology*, 91: 913–919.
- Bullerman, L.B. 1986. “Mycotoxins and Food Safety.” *Food technology*, 40: 59-66.
- Cardwell, K.F., D. Desjardins and S.H. Henry. 2004. “The Cost of Achieving Food Security and Food quality.” <http://www.apsnet.org/online/feature/mycotoxin/top.html>.
- Chavan, A.M. 2011. “Nutritional Changes in Oilseeds due to *Aspergillus* spp.” *Journal of Experimental Sciences*, 2: 23-29.
- Cotty, P.J. and R. Jaime-Garcia. 2007. “Influences of Climate on Aflatoxin Producing Fungi and Aflatoxin Contamination.” *International Journal of Food Microbiology*, 119: 109–115.
- Cotty, P.J. and C. Bock. 1997. “Aflatoxin Contamination of Commercially Grown Transgenic Bt cotton seed.” *Proceedings of the Beltwide Cotton Conference*. National Cotton Council, Memphis TN.
- Coulibaly, O., K. Hell, R. Bandyopadhyay, S. Hounkponou and J.F. Leslie. 2008. “Economic Impact of Aflatoxin Contamination in Sub-Saharan Africa”, in J.F. Leslie, R. Bandyopadhyay and A. Visconti (eds), *Mycotoxins: Detection Methods, Management, Public Health and Agricultural Trade*, pp.67-76. Wallingford, UK: CABI.

- Dohlman, E. 2003. "Mycotoxin Hazards and Regulations: Impacts on Food and Animal Feed Crop Trade," in Jean Buzby (ed.), *International Trade and Food Safety: Economic Theory and Case Studies*. Agricultural Economic Report 828. USDA, ERS.
- FAO. 1997. *Worldwide Regulations for Mycotoxins 1995: A Compendium*. FAO Food and Nutrition Paper. No. 64. Rome, Italy.
- Gimeno, A. 2004. "Aflatoxina M1 no leite. Riscos para a saúde pública, prevenção e controlo." *Alimentação Animal (Revista de la Associação Portuguesa dos Industriais de Alimentos Compostos para Animais (IACA))*, 49: 32-44.
- Giorni, P., N. Magan, A. Pietri, T. Bertuzzi and P. Battilani. 2007. "Studies on *Aspergillus* Section *Flavi* isolated from Maize in Northern Italy." *International Journal of Food Microbiology*, 113: 330-338.
- Hamilton, P.B. and J.D. Garlich. 1971. "Aflatoxin as a Possible Cause of Fatty Liver Syndrome in Laying Hens." *Poultry Sciences*, 50: 800-804.
- Hendrickse, R. 1999. "Of Sickturkeys, Kwashiorkor, Malaria, Perinatal Mortality, Heroin Addicts and Food Poisoning: Research on the Influence of Aflatoxins on Child Health in the Tropics." *Annual Tropical Pediatrics*, 19: 229-236.
- Holmquist, G.U., H.H. Walker and H.M. Stahr. 1983. "Influence of Temperature, pH, Water Activity and Antifungal Agents on Growth of *Aspergillus flavus* and *A. parasiticus*." *Journal of Food Sciences*, 48: 778-782.
- IARC- International Agency for Research on Cancer. 2002. *Some Traditional Herbal Medicines, Some Mycotoxins, Naphthalene and Styrene. Summary of Data Reported and Evaluation*. Monographs on the Evaluation of the Carcinogenic Risk to Humans. International Agency for Research on Cancer, Lyon, France. 82: 1-556.
- Ilyas, F. 2007. "Toxin Behind Livestock Deaths Identified". *The Dawn*, Islamabad, Pakistan, 61: December 26, 2007.
- Itoh, Y., S.W. Peterson, D.T. Wicklow and T. Goto. 2001. "*Aspergillus pseudotamari* a New Aflatoxin Producing Species in *Aspergillus* section *Flavi*." *Mycological Research*, 105: 233-239.
- Jarvis, B.B. 2002. "Chemistry and Toxicology of Molds Isolated From Water-Damaged Buildings." *Advances in Experimental Medicine and Biology*, 504: 43-52.
- Krishnamachari, K.A.V.R., R.V. Bhat, V. Nagarajan and T.B.G. Tilak. 1975. "Hepatitis due to Aflatoxicoses: An Outbreak in Western India." *Lancet*, 10(1): 1061-3.
- Lewis, L., M. Onsongo, H. Njapau, H. Shurz-Rogers, G. Lubber and S. Kieszak. 2005. "Aflatoxin Contamination of Commercial Maize Products during an Outbreak of Acute Aflatoxicosis in Eastern and Central Kenya." *Environmental Health Perspectives*, 113: 1763-1767.
- Lizarraga-Paulin, E.G., E. Moreno-Martinez and S.P. Miranda-Castro. 2013. "Aflatoxins and Their Impact on Human and Animal Health: An Emerging Problem", in Ramon G. Guevara-Gonzalez (ed.), *Aflatoxins - Biochemistry and Molecular Biology*. Croatia: Intech.

- Mesterhazy, A. and M. Vojtovis. 1977. "Rate of *Fusarium* spp. Infection in Maize in 1972-1975." *Novenytermeles*, 26: 367-378.
- Michael, M. and P. Ensley. 2007. "Understanding Fungal (Mold) Toxins (Mycotoxins) Plant Diseases, C-45, and field crops. Lincoln and the United States Department of Agriculture.
- Miraglia, M., H.J. Marvin and G.A. Kletter. 2009. "Climate Change and Food Safety: An Emerging Issue with Special Focus on Europe." *Food Chemistry and Toxicology*, 47: 1009-1021.
- Moschini, M., F. Masoero, D.E. Diaz, A. Gallo, A. Pietri and G. Piva. 2006. "Plasma Aflatoxin Concentrations over Time in Bolus Fed Lactating Dairy Cows." *Journal of Animal Science*, 84: 74-81.
- Munkvold, G.P. and A.E. Desjardins. 1997. "Fumonisin in Maize." *Plant Disease*, 81: 556-565.
- Oguz, H. and V. Kutoglu. 2000. "Effect of Clinoptilolite on Fattening Performance of Broiler Chickens during Experimental Aflatoxicosis." *British Poultry Science*, 41: 512- 517.
- Okiki, P.A., T.I. Ojeizeh and A.O. Ogbimi. 2010. "Effects of Feeding Diet Rich in Mycotoxins on the Health and Growth Performances of Broiler Chicken." *International Journal of Poultry Science*, 9: 1136-1139.
- Olival, K.J. and P. Daszak. 2005. "The Ecology of Emerging Neurotrophic Viruses." *Journal of Neurovirology*, 11: 441-446.
- Parkin, M.D., F. Bray, J. Ferlay and P. Pisani. 2005. "Global Cancer Statistics-2002." *Cancer Journal of Clinicians*, 55: 74-108.
- Paterson, R.R.M., M. Sariah, N. Lima, M.A. Zainal Abidin and C. Santos. 2008. "Mutagenic and Inhibitory Compounds Produced by Fungi affect detrimentally their PCR-Based Diagnosis and Phylogenetic Analyses." *Current Bioactive Compounds*, 4: 245-257.
- Paterson, R.R.M. and N. Lima. 2009. "Mutagens Manufactured in Fungal Culture may affect DNA/RNA of Producing Fungi." *Journal of Applied Microbiology*, 106: 1070-1080.
- — —. 2010. "How will Climate Change Affect Mycotoxins in Food?" *Food Research International*, 43: 1902-1914.
- Reddy, K.R.N., C.S. Reddy, H.K. Abbas, C.A. Abel and K. Muralidharan. 2008. "Mycotoxigenic Fungi, Mycotoxins and Management in Rice Grains." *Toxin Review*, 27: 287-317.
- Sanders, T.H., P.D. Blankenship, R.J. Cole and R.A. Hill. 1984. "Effect of Soil Temperature and Drought on Peanut Pod and Stem Temperatures Relative to *Aspergillus flavus* Invasion and Aflatoxin Contamination." *Mycopathologia*, 86: 51-54.

- Schmidt-Heydt, M., C.E. Rüfer, A. Abdel-Hadi, N. Magan, R. Geisen. 2010. "The Production of Aflatoxin B1 or G1 by *Aspergillus parasiticus* at Various Combinations of Temperature and Water Activity Is Related to the Ratio of aflS to aflR Expression." *Mycotoxin Research*, 26: 241–246.
- Schmitt, S.G. and C.R. Hurburgh. 1989. "Distribution and Measurement of Aflatoxin in 1983 Iowa corn." *Cereal Chemistry*, 66: 165–168.
- Scott, P.M. 1997. "Multi-year Monitoring of Canadian Grains and Grain-Based Foods for Trichothecenes and Zearalenone." *Food Additives and Contaminants*, 14:333–339.
- Setamou, M., K.F. Cardwell, F. Schulthess and K. Hell. 1997. "*Aspergillus flavus* Infection and Aflatoxin Contamination of Pre-Harvest Maize in Benin." *Plant Disease*, 81: 1323-1327.
- Shearer, J.F., F.E. Sweets, N.K. Baker and L.H. Tiffany. 1992. "A Study of *A. flavus/parasiticus* Groups in Iowa Crop Fields in 1988-1990." *Plant Disease*, 76: 19-22.
- Singh, B.K., R.D. Bardgett, P. Smith and D.S. Reay. 2010. "Microorganisms and Climate Change: Terrestrial Feedbacks and Mitigation Options." *Nature Reviews Microbiology*, 8: 779-790.
- Sinha, K.K., N. Kumar and G. Prasad. 1993. "The Use of Mustard (*Brassica juncea* L.) and Gram (*Cicer arietinum* L.) Seedling Germination Inhibition Assay for Aflatoxin B<sub>1</sub>." *Mycopathologia*, 121: 175-178.
- Sinha, R.C., and Savard, M.E. 1997. Concentration of deoxynivalenol in single kernels and various tissues of wheat heads. *Canadian Journal of Plant Pathology*. 19: 8–12.
- Smith, J.E. and P.B. Hamilton. 1970. "Aflatoxicosis in the Broiler Chicken." *Poultry Science*, 49: 207-215.
- Strosnider, H., E. Azziz-Baumgartner, M. Banziger, R.V. Bhat and R. Breiman. 2006. "Public Health Strategies for Reducing Aflatoxin Exposure in Developing Countries: A Workgroup Report." *Environmental Health Perspectives*, 12: 1898-1903.
- Tirado, M.C., R. Clark and L.A. Jaykus. 2010. "Climate Change and Food Safety: A Review." *Food Research International*, 43: 1745-1765.
- Wild, C. and Y. Gong. 2010. "Mycotoxins and Human Disease: A Largely Ignored Global Health Issue." *Carcinogenesis*, 31: 71-82.
- Williams, H.J., T.D. Phillips, E.P. Jolly, K.J. Stiles, M.C. Jolly and D. Aggarwal. 2004. "Human Aflatoxicosis in Developing Countries: A Review of Toxicology, Exposure, Potential Health Consequences and Interventions." *American Journal of Clinical Nutrition*, 80:1106–1122.
- Willis, R.M., J.J. Mulvihill and J.H. Hoofnagle. 1980. "Attempted Suicid with Purified Aflatoxin." *Lancet*, 315: 1198-1199.
- Windham, G.L. and W.P. Williams. 1998. "*Aspergillus flavus* Infection and Accumulation in Resistant and Susceptible Maize Hybrids." *Plant Disease*, 82: 281-284.

- Wu, F. and A. Tritscher. 2011. "Aflatoxins a Global Public Health Problem: Aflatoxins Health Impact, Jan 2011." *World Health Organization*, pp. 1-18. [http://www.agriskmanagementforum.org/farmd/sites/agriskmanagementforum.org/files/WHO-Aflatoxin-public health issue](http://www.agriskmanagementforum.org/farmd/sites/agriskmanagementforum.org/files/WHO-Aflatoxin-public%20health%20issue).
- Yaqub Bhat, M. and M. Fazal. 2011. "Effect of *Aspergillus flavus* Metabolites on Wheat Seed Germination and Seedlings Growth." *Arab Journal of Plant Protection*, 29: 139-140.
- Yiannikouris, A. and J.P. Jouany. 2002. "Les mycotoxins dans les aliments des ruminants, leur devenir et leurs effets chez l'animal." INRA, *Production Animal*, 15: 3-16.